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EMASAR PHASE II

Volume IV

INDIGENOUS ARID AND SEMI-ARID FORAGE PLANTS OF NORTH AFRICA, THE NEAR AND THE MIDDLE EAST

Technical Data

ECOLOGICAL MANAGEMENT OF ARID AND SEMI-ARID RANGELANDS
IN AFRICA AND THE NEAR AND MIDDLE EAST

(EMASAR - Phase II)

Volume IV

INDIGENOUS ARID AND SEMI-ARID FORAGE PLANTS OF NORTH AFRICA,
THE NEAR AND MIDDLE EAST

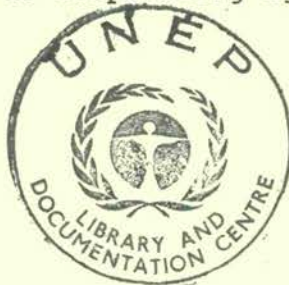
Technical Data

by

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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FOREWORD

This study has been realized as part of the International Programme for the Ecological Management of Arid and Semi-Arid Rangelands (EMASAR) at the initiative of the Food and Agriculture Organization of the United Nations (FAO) and with the support of the United Nations Environment Programme (UNEP) ^{1/}

It places at the disposal of agricultural technicians and administrators the essential known information to date on the most important forage species (grasses and legumes) indigenous to the grazing lands of North Africa, the Near and Middle East. The zones under consideration are arid (less than 250 mm rainfall, p.a.) and semi-arid (250-500 mm rainfall, p.a.) and cover the greater part of the 20 EMASAR countries contained in North Africa, the Near and Middle East regions.

The study is the first phase of a programme for the selection, testing, seed exchange and eventually improvement through a breeding programme of forage plants - the programme has two objectives : to improve the yield and agronomic characteristics of these forage plants and particularly their possible use in reseeding grazing lands and especially those depleted, degraded or endangered by desert encroachment ; to facilitate crop/livestock integration and soil conservation by introducing into the crop sequence those forage plants adapted to local conditions. It is endeavoured to proceed with this second phase in close collaboration with national and regional institutions.

The annotated list of the plants which have been treated in detail in Part II of this study and selected for their particular forage and/or soil improvement value, follows the present foreword. The majority of the information has been obtained from specialized literature which is dispersed in a multitude of publications, some of which has proved difficult to gain access to. The author's ^{2/} practical experience of grassland field conditions in the Near and Middle East was of great value to screen and assess the above information.

^{1/} The present document constitutes volume IV of the works effected under Phase two of the international programme for the ecological management of arid and semi-arid grasslands of Africa and the Near and Middle East. This programme, for which the initial letter denomination E.M.A.S.A.R. has been adopted, is executed jointly by the Food and Agriculture Organization (F.A.O.) of the United Nations and the United Nations Environmental Programme (U.N.E.P.). Volumes I, II and III, already published, concern the Sahelian countries. Volumes I and II are concerned with elements of strategy, the first dealing with development and extension in the pastoral domain, the second with education and training in the pastoral domain. Volume III concerns technical data on indigenous forage plants in dry tropical Africa, organized in the same way as for the present document, volume IV.

^{2/} Mr. Kernick has served with FAO since 1959, principally as a Pasture Specialist in Kuwait, Iran and Iraq.

For some of the species treated, much more technical information is available in the region than for others, and this has meant producing technical data sheets of somewhat unequal length. For the main part, the information included in the technical data sheets comes from the region itself but some information from outside the region is also included, where it is considered to be both relevant and objective.

Most of these species have their greatest potential use in the semi-arid zones of the region and only a few in the arid zones.

A similar study is being done at the same time on forage plants indigenous to dry parts of Africa 3/.

Some forage plants with a wide distribution but existing in, and of interest to tropical Asia and Africa, have been treated in the two studies.

During the preparation of the study, a number of other indigenous grasses and legumes were recognized as having potential in the arid and semi-arid zones of the region, but insufficient technical information was found in the literature to justify their detailed treatment. However, these grasses and legumes have been included in a subsidiary annotated list of plants which also follows the present foreword.

In regard to the method of presentation of the technical documentation assembled, each grass and legume has been treated in a technical data sheet, sometimes individually, but more often together with related species, where this is considered to benefit and/or unify the presentation.

Each technical data sheet summarizes the information on the following :

- scientific names and synonym(s),
- common names,
- botanical forms, varieties and subspecies ; collection of ecotypes ;
- existing agricultural varieties and selections,
- chromosome numbers,
- geographical distribution,
- biology and ecology,
- cultivation and agronomic techniques,
- palatability and forage value,
- forage and seed production,
- utilization and management,
- selected bibliography.

3/ Volume III : "Plantes fourragères spontanées de l'Afrique tropicale sèche - données techniques" par A. Naegelé.

Originally it was intended to cover palatable shrubs and trees also ; because of the time factor and because grasses and forage legumes have a much greater impact on crop and grassland production in semi-arid areas, this part of the work has been deferred. It is proposed to do it in a further project phase.

S.A. Risopoulos

ANNOTATED LIST OF GRASSES AND LEGUMES
WITH POTENTIAL FOR RE-SEEDING IN ARID AND SEMI-ARID AREAS OF
NORTH AFRICA AND THE NEAR AND MIDDLE EAST

1. SELECTED SPECIES

A. Perennial Grasses

Agropyron cristatum : A cool season semi-arid species that is locally distributed in the interior steppe and mountains of North Africa and the Near and Middle East. Some 215 ecotypes collected recently in North Iran and 38 ecotypes in Turkey ; successful field scale dryland plantings made with drought and frost resistant introductions from the USA in Iran and Morocco (320-350 mm rainfall, p.a.) ; several ecotypes of *A. cristatum* var *caespitosum* a valuable grazing type also collected in North Iran.

Agropyron desertorum : A cool season semi-arid species that occurs locally in the mountains of Turkey where 28 ecotypes recently collected and may also be looked for in the high mountains of N. Iraq and N.W. Iran ; successful field scale dryland plantings with drought and frost resistant introductions from the USA made in N. Iran (250-350 mm rainfall, p.a.).

Agropyron elongatum : A cool season semi-arid species that is distributed quite widely in littoral areas in N. Africa (Algeria, Morocco, Tunisia, Libya, Egypt) and in the Near East (Lebanon, Syria, Jordan, Iraq, Iran) ; successful field scale plantings made with drought and frost resistant introductions from the USA made in N. Iran (250-350 mm rainfall, p.a.) ; also shows potential for seeding on saline soils.

Agropyron intermedium : A cool season semi-arid species that occurs locally in the mountains of Turkey, Iraq, Iran, Afghanistan and W. Pakistan ; 38 ecotypes recently collected in Turkey ; successful field scale dryland plantings with drought and frost resistant introductions from the USA made in N. Iran, N. Iraq and C. Morocco (320-400 mm rainfall, p.a.).

Agropyron tauri : A cool season semi-arid species that is distributed quite widely in the mountains of N. Iran, E. Turkey and Syria ; several ecotypes collected in N. Iran ; successful nursery dryland seedings of drought and frost resistant local ecotypes made in N. Iran (320-350 mm rainfall, p.a.).

Arrhenatherum elatius : A cool season semi-arid/semi-humid species that occurs locally in the mountains of Cyprus, Lebanon, Syria, Palestine, Jordan, Turkey, Caucasus, Iraq and Iran ; a number of ecotypes collected in Turkey and Iran ; successful field scale dryland plantings made with native and introduced ecotypes in the sub-steppic (320-350 mm rainfall, p.a.) and Caspian Forest (+600 mm rainfall, p.a.) zones of N. Iran. Two other species of interest in the Near and Middle East are *A. kotschyi* and *A. palaestinum*.

Bromus tomentellus : A cool season semi-arid species that occurs locally in the mountains of Crete, Palestine, Lebanon, Turkey, Iraq, Iran and N.W. Afghanistan ; 12 ecotypes collected in N. Iran and successful field scale dryland plantings of drought and frost resistant local ecotypes made in N. Iran (250-350 mm rainfall, p.a.) ; several ecotypes of two other related species *B. cappadocicus* and *B. persicus* collected in N. Iran and seeded, along with *B. inermis* present in Iran, Afghanistan, Pakistan and N.W. India, in dryland nurseries (320-350 mm rainfall, p.a.).

Cenchrus ciliaris : A warm season arid species that occurs locally in the desert regions of N. Africa and the Near and Middle East, especially in S. Morocco, S. Arabia, S. Iran and W. Pakistan ; several ecotypes collected in S. Morocco and Libya but no systematic collection yet made in the region ; a number of cultivars of *C. ciliaris* and *C. setigerus* (closely related variety) developed for dryland seedings in the Rajasthan desert (India) ; successful field scale dryland plantings made with drought resistant local ecotypes of *C. ciliaris* in the Thal desert of W. Pakistan (200 mm rainfall p.a. with monsoonal rains in July-August) ; stoloniferous varieties of *C. setigerus* also show promise for sand dune fixation.

Cynodon dactylon : A warm season arid or semi-arid species with numerous native ecotypes tolerating both heat and cold occurring over a wide range of habitats in N. Africa (Morocco, Algeria, Tunisia, Libya, Egypt) and in the Near and Middle East (Cyprus, Turkey, Syria, Lebanon, Palestine, Jordan, Arabia, Iraq, Iran, Afghanistan, W. Pakistan) ; production of viable seeds is low for many ecotypes but very interesting ecotypes showing vigorous growth and seed setting collected in S. Israel (desert) and Afghanistan (steppe) ; the latter ecotype from Afghanistan being a non-creeping form ; successful experimental dryland seedings made in littoral zone of Egypt (150 mm rainfall, p.a.) where it shows promise also for sand dune fixation.

Dactylis glomerata subsp. *hispanica* : A cool season arid or semi-arid species that is common in semi-arid areas in N. Africa (Morocco, Algeria, Tunisia, Libya, Egypt) and in the Near East (Jordan, Syria and Lebanon) ; a number of ecotypes collected in Algeria, Libya and Jordan ; successful dryland experimental seedings have been made in the littoral zone (150 mm rainfall, p.a.) of Egypt and in the steppic zone (300 mm rainfall, p.a.) of Jordan with drought resistant local ecotypes. Other subspecies of interest include *D. glomerata* subsp. *lusitanica* in Portugal and *D. glomerata* subsp. *himalayensis* in N. India.

Festuca arundinacea : A cool season semi-arid species that occurs locally in the mountains of N. Africa (Morocco, Algeria, Tunisia and Libya) and in the Near and Middle East (Lebanon, Turkey, Syria, N. Iraq, N. Iran and Afghanistan) ; a number of ecotypes have been collected in Morocco, Algeria and Tunisia, and 30 ecotypes recently collected in Turkey ; successful field scale dryland plantings of drought resistant introductions from the USA and local introductions made in Algeria, Iraq, Iran (300-400 mm rainfall, p. a.).

Hordeum bulbosum : A cool season semi-arid species that is quite common in steppe and mountain areas of N. Africa (Algeria, Morocco, Tunisia) and in the Near and Middle East (Cyprus, Syria, Lebanon, Palestine, Jordan, Iraq, Iran, Afghanistan) ; a number of ecotypes collected in Cyprus, Turkey, Israel, Morocco, Algeria, Iran and Afghanistan ; successful dryland experimental plantings with drought and cold resistant ecotypes made in Morocco, Tunisia and Iran (320-350 mm rainfall, p.a.) ; in Tunisia an ecotype of *H. spontaneum*, a species widespread in the region, also collected and seeded in dryland nurseries (320-350 mm rainfall, p.a.).

Hyparrhenia hirta : A warm season semi-arid species that occurs in littoral, steppe and mountain areas of N. Africa (Morocco, Algeria, Tunisia, Libya, Egypt) and in the Near and Middle East (Cyprus, Syria, Lebanon, Israel, Jordan, Sinai, Turkey, Iraq and Afghanistan) ; a number of ecotypes collected in Morocco, Algeria, Tunisia, Libya and Israel ; successful experimental dryland plantings made with local cultivars in the littoral zone of Morocco (400 mm rainfall, p.a.) and Egypt (150 mm rainfall, p.a.) ; useful for erosion control on sandy rocky slopes.

Lasiurus hirsutus : A warm season arid species that is locally distributed in desert areas in N. Africa (Algeria, Morocco, Tunisia, Libya, Egypt) and in the Near and Middle East (Palestine, Jordan, Arabia, S. Iran, S. Iraq, W. Pakistan) ; no ecotypes collected in the region but a number of cultivars of *L. hirsutus* and *L. indicus* (a closely related variety) developed for dryland seeding in the Rajasthan desert (India) ; successful field scale dryland plantings made with local ecotypes of *L. hirsutus* in the Thal desert of W. Pakistan (150 mm rainfall, p.a., with monsoonal rains (July-August)) ; both *L. hirsutus* and *L. indicus* also show promise for sand dune fixation.

Oryzopsis caerulescens : A cool season semi-arid species that occurs locally in N. Africa (Morocco, Algeria, Tunisia) and in the Near and Middle East (Lebanon, Syria, Iran, Israel, Afghanistan, W. Pakistan) ; local ecotypes collected in Israel, Morocco and Cyprus ; successful experimental dryland seedings made in Tunisia (400-600 mm rainfall, p.a.).

Oryzopsis holciiformis : A cool season semi-arid species that occurs locally in Syria, Lebanon, Palestine, Jordan, Sinai, Turkey, Iraq, Iran and Afghanistan ; several local ecotypes collected in Palestine and N. Iran but no systematic collection made in the region and apparently not present in N. Africa ; successful experimental dryland seedings made with ecotypes from Palestine in Algeria, Morocco and Tunisia (320-500 mm rainfall, p.a.).

Oryzopsis miliacea : A cool season arid or semi-arid species that occurs locally in littoral, steppe and mountain areas of N. Africa (Algeria, Morocco, Tunisia, Libya and Egypt) and in the Near East (Cyprus, Turkey, Syria, Jordan, Lebanon, Sinai, Israel, Iraq) ; at least 12 ecotypes collected in Israel and a number of ecotypes also collected in Algeria, Morocco, Tunisia and Egypt ; successful dryland experimental seedings of native and introduced (USA) cultivars made in the littoral zone (400-600 mm rainfall, p.a.) of Morocco and Tunisia.

Panicum turgidum : A warm season arid or semi-arid species that occurs widely in desert and semi-desert areas in N. Africa (Morocco, Algeria, Tunisia, Lebanon, Egypt) and the Near and Middle East (Cyprus, S. Palestine, Jordan, Sinai, Arabia, S. Iran and W. Pakistan) ; no ecotypes collected yet in the region ; successful dryland experimental plantings made in Morocco (400 mm rainfall, p.a.) and in Egypt (150 mm rainfall, p.a.) where it shows promise for sand dune fixation.

Phalaris aquatica (= *P. tuberosa*) : A cool season arid or semi-arid species that occurs locally in littoral, plain and mountain areas in N. Africa (Morocco, Algeria, Libya) and in the Near and Middle East (Cyprus, Turkey, Syria, Lebanon, Jordan, Palestine, Iraq, Iran, Israel) ; a number of ecotypes collected in Algeria and Morocco, 1 in Syria, 7 in Israel and 42 ecotypes in Turkey ; some ecotypes from Morocco used to develop arid varieties in Australia ; successful dryland experimental plantings made with introduced drought resistant cultivars (Australia) in Morocco, Algeria, Tunisia, Cyprus, Jordan, Syria and Iraq (400-500 mm rainfall, p.a.).

Phalaris arundinacea : A cool season semi-arid/semi-humid species that occurs locally in mountain areas in Algeria, Syria, Lebanon, Turkey, Palestine, Iraq and Iran ; 4 ecotypes collected in Turkey and 1 ecotype in Israel ; successful dryland experimental seedings made with introduced cultivars (USA) in Morocco with more than 500 mm rainfall, p.a.

Phalaris caerulea : A cool season semi-arid/semi-humid species that occurs locally in littoral, plain and mountain areas of N. Africa (Morocco, Algeria, Tunisia, Egypt) and in the Near East (W. Turkey, Lebanon, Syria) ; several ecotypes collected in Tunisia ; successful dryland experimental plantings made with local and introduced cultivars (Australia) in Morocco and Algeria with more than 500 mm rainfall, p.a.

Phalaris truncata : A cool season semi-arid species that occurs locally in the mountains of Morocco, Turkey, Lebanon, Syria, Iraq and Iran ; a number of ecotypes collected in Algeria and Tunisia ; successful field scale dryland plantings made with local ecotypes in Algeria, Morocco and Tunisia (350-500 mm rainfall, p.a.).

Poa bulbosa : A cool season semi-arid species that is widespread in steppic areas of N. Africa, the Near and Middle East along with *P. sinaica*, a closely related arid species widespread in desert areas ; both species very palatable and *P. bulbosa* successfully seeded in dryland plantings in the southern desert of the USSR (110-224 mm rainfall, p.a.).

Secale montanum : A cool season semi-arid species that occurs locally in Turkey, Lebanon, Syria, Iraq, Iran, Algeria, Morocco, Libya ; several ecotypes collected in Iran and some 200 ecotypes in E. Turkey and planted in dryland nurseries ; successful field scale dryland plantings made in Iran and Afghanistan (320-380 mm rainfall, p.a.).

Stipagrostis plumosa : A warm season arid or semi-arid species that occurs very widely in N. Africa (Morocco, Algeria, Tunisia, Libya, Egypt) and in the Near and Middle East (Cyprus, Syria, Palestine, Jordan, Sinai, Arabia, Turkey, Iran, W. Pakistan, Afghanistan) ; no ecotypes yet collected in the region but wide diversity exists from desert to mountain habitats ; successful dryland nursery seedings made in Tunisia and adapted to planting in arid and semi-arid areas with 50-400 mm rainfall, p.a. ; other important related species of which no ecotypes yet collected include *S. ciliata*, *S. raddiana*, *S. lanata*, *S. obtusa*, *S. pungens*, *S. pennata* ; *S. ciliata* and *S. pennata* successfully seeded in dryland nurseries in Tunisia and *S. pungens* by cuttings in Libya ; the latter two species show potential for sand dune fixation.

Stipa barbata : A cool season arid or semi-arid species that occurs quite widely in steppe and mountain areas in N. Africa (Morocco, Algeria, Tunisia, Libya) and the Near and Middle East (Cyprus, Syria, Palestine, Jordan, Sinai, Turkey, Iraq, Iran) ; several ecotypes collected in N. Iran ; successful dryland nursery seedings made in Iran (250-350 mm rainfall, p.a.) and in Syria (200-300 mm, p.a.) ; other important related species of which no ecotypes yet collected include *S. lagascae* and *S. parviflora*.

B. Annual Grasses

Lolium rigidum : A cool season semi-arid/semi-humid species that occurs locally in the steppe and mountain areas of N. Africa (Morocco, Algeria, Tunisia, Libya, Egypt) and the Near and Middle East (Syria, Lebanon, Palestine, Jordan, Turkey, Iraq, Iran, Afghanistan) ; no ecotypes have been collected in the region ; successful experimental dryland plantings have been made with imported cultivars (France, Australia) in Algeria, Tunisia and Iraq (400-500 mm rainfall, p.a.).

Lolium multiflorum : A cool season semi-arid/semi humid species that occurs locally in the mountains of N. Africa (Morocco, Algeria, Tunisia, Libya, Egypt) and in the Near and Middle East (Turkey, Iran, Iraq, Palestine) ; no ecotypes yet collected in the region ; successful experimental dryland plantings made with cultivars from Australia, Germany and the USA in Algeria and Iraq (400-500 mm rainfall, p.a.). Two other native species of interest in the Near East are *L. loliaceum* and *L. persicum*.

C. Perennial Legumes

Hedysarum coronarium : A cool season semi-arid/semi-humid species that occurs locally in the littoral zone of N. Africa (Morocco, Algeria, Tunisia, Egypt) ; in Algeria and Tunisia a number of ecotypes have been collected ; successful field scale dryland seedings made in Morocco, Algeria and Tunisia (+400 mm rainfall, p.a.). Other important related species include *H. carnosum*, *H. flexuosum*, *H. humile*, *H. pallidum* and *H. spinosissimum*, which occur mainly in N. Africa (Algeria, Morocco, Tunisia) and for which a number of ecotypes have been collected in Algeria and Morocco ; both *H. carnosum* and *H. spinosissimum* well adapted to desert/steppe areas with 100-400 mm rainfall p.a.).

Lotus corniculatus : A cool season semi-arid/semi-humid species that occurs quite commonly in mountain areas in N. Africa (Morocco, Algeria, Tunisia, Libya, Egypt) and in the Near and Middle East (Turkey, Iraq, Iran, Syria, Lebanon, Palestine, S.W. Arabia, W. Pakistan, Afghanistan) ; no native ecotypes known to have been collected in the region ; successful dryland experimental seedings made with introduced cold and drought resistant cultivars (France, USA) in Algeria and Iran (+400 mm rainfall, p.a.).

Lotus creticus : A cool season semi-arid/semi-humid species that occurs locally in sandy littoral areas in Morocco, Algeria, Tunisia, Libya, Egypt, Turkey ; several native ecotypes collected in Tunisia and Morocco ; successful dryland experimental plantings have been made with local ecotypes in Tunisia (300-400 mm rainfall, p.a.) and also in Israel (200 mm rainfall, p.a.) for sand dune fixation.

Medicago sativa : A cool season semi-arid species that occurs locally in mountain and hilly areas of N. Africa (Morocco, Algeria, Tunisia, Libya) and in the Near and Middle East (Cyprus, Syria, Lebanon, Palestine, Jordan, Turkey, Iraq, Iran, Afghanistan, W. Pakistan) ; some 120 native accessions recently collected in E. Turkey ; successful dryland field plantings made in Algeria, Tunisia and Iran (350-400 mm rainfall, p.a.) with drought and cold resistant introductions from Turkey and USA.

Onobrychis viciifolia : A cool season semi-arid/semi-humid species that occurs locally in mountain areas in N. Africa (Morocco, Algeria) and in the Near and Middle East (Turkey, Iran, Afghanistan) ; a number of ecotypes have been collected with 40 ecotypes being collected in E. Turkey in 1976 ; successful field scale dryland plantings of cold and drought resistant Turkish introductions have been made in Algeria and Iran (300-400 mm rainfall, p.a.) ; several ecotypes also collected of *O. gaubae*, *O. melanotricha*, *O. persica*, *O. pinnata* and *O. scrobiculata* in N. Iran which have been successful in nursery dryland seedings (320-350 mm rainfall, p.a.).

Trifolium fragiferum : A cool season semi-arid/semi-humid species that occurs locally in mountain areas in N. Africa (Morocco, Algeria, Egypt) and in the Near and Middle East (Cyprus, Syria, Lebanon, Palestine, Jordan, Turkey, S. Arabia (Aden), Turkey, Iraq, Iran, Afghanistan, W. Pakistan) ; no systematic collection of ecotypes yet made in the region ; one ecotype collected in N. Iran ; successful dryland experimental plantings made in Algeria and Tunisia (400-600 mm rainfall, p.a.) ; well adapted to saline soils.

D. Annual Legumes

Lathyrus sativus : A cool season semi-arid species that occurs as a weed in cultivated areas of N. Africa (Morocco, Egypt) and the Near and Middle East (Cyprus, Syria, Lebanon, Palestine, Turkey, Iraq, Iran, Afghanistan) ; a number of ecotypes have been collected in Turkey and several in Iraq ; successful dryland forage yield plantings made in N. Iraq (300-400 mm rainfall, p.a.) ; *Lathyrus cicera* closely resembling *L. sativa* also of interest but no ecotypes yet collected in the region.

Medicago spp. : *M. truncatula*, *M. scutellata*, *M. laciniata*, *M. rugosa*, *M. minima*, *M. polymorpha*, *M. tornata*, *M. littoralis*, *M. rigidula*, *M. turbinata*, *M. murex*, *M. intertexta* and *M. orbicularis* are cool season arid or semi-arid species that occur locally in cultivated areas or in steppe, desert or forest areas in N. Africa (Morocco, Algeria, Tunisia, Libya, Egypt) and in the Near and Middle East (Cyprus, Syria, Lebanon, Palestine, Jordan, Arabia, Iraq, Iran, Turkey, Afghanistan, W. Pakistan) ; ecotypes of *M. truncatula*, *M. littoralis* and *M. scutellata* collected in the region and used to develop varieties in Australia and recently some 800 native ecotypes of annual native *Medicago* spp. collected in Algeria, also some 12 ecotypes in N. Iraq ; successful dryland field plantings of Australian cultivars of *M. truncatula*, *M. scutellata* and *M. littoralis* made in Algeria, Tunisia, Libya and N. Iraq (350-400 mm rainfall, p.a.).

Trifolium alexandrinum : A cool season semi-arid/semi-humid species that occurs locally in moist plains and mountain areas in Turkey, Syria, Lebanon, Israel and Egypt ; various ecotypes collected and varieties bred in Israel and Egypt ; successful dryland experimental seedings made with introductions from Israel and Egypt on clay-loam soils in Morocco and Tunisia (450-600 mm rainfall p.a. in areas with mild winters).

Trifolium resupinatum : A cool season arid or semi-arid/semi-humid species that occur locally in the moist plain and mountain areas of N. Africa (Algeria, Morocco, Egypt) and in the Near and Middle East (Cyprus, Syria, Lebanon, Palestine, Sinai, Iraq, Iran, Turkey, Afghanistan and W. Pakistan) ; some 6 ecotypes collected in Algeria and some 40 ecotypes in Turkey where breeding work has started ; successful dryland experimental plantings have been made in Algeria and Tunisia (450-600 mm rainfall, p.a.).

Trifolium subterraneum : A cool season semi-arid/semi humid species that occurs locally in moist plain and mountain areas in N. Africa (Algeria, Morocco, Egypt) and in the Near and Middle East (Cyprus, Syria, Lebanon, Israel, Turkey, Iraq, Iran) ; ecotypes collected in the region and used to develop varieties in Australia ; successful dryland experimental seedings made with introduced cultivars from Australia on acid soils in Algeria and Tunisia (450-600 mm rainfall, p.a.) ; ecotypes of *T. hirtum*, *T. cherlei* and *T. tomentosum* also collected in the region and varieties of the latter two species also developed in Australia.

Vicia spp. : *V. atropurpurea*, *V. dasycarpa*, *V. ervilia*, *V. monantha*, *V. narbonensis*, *V. pannonica*, *V. sativa* and *V. villosa* are cool season semi-arid/semi-humid species that occur locally in moist plains, steppe and mountain areas in N. Africa (Morocco, Algeria, Tunisia, Libya, Egypt) and in the Near and Middle East (Cyprus, Syria, Lebanon, Turkey, Israel, Jordan, Sinai, Arabia, Iraq, Iran, Afghanistan and W. Pakistan) ; various ecotypes of *V. sativa* collected in Algeria, Morocco, Tunisia, Cyprus and Israel and varieties developed in Morocco ; a large number of ecotypes of *V. sativa*, *V. narbonensis*, *V. villosa* and *V. villosa* ssp. *dasycarpa* have also been collected in Turkey and breeding work is underway ; successful dryland plantings of *V. sativa*, *V. narbonensis*, *V. villosa* and *V. villosa* ssp. *dasycarpa* have been made in Morocco, Algeria, Tunisia, Cyprus, Syria and N. Iraq (400-600 mm rainfall, p.a.) with introductions from Turkey, Greece, Europe and the USA.

2. SUBSIDIARY SPECIES

A. Perennial Grasses

Aeluropus littoralis : A cool season arid or semi-arid species that is widespread on saline flats in the littoral, interior steppe and desert areas of N. Africa, the Near and Middle East along with *A. repens* a closely related species ; both species palatable and adapted to low rainfall conditions (100-200 mm rainfall, p.a.) and can be multiplied by cuttings.

Chrysopogon gryllus : A cool season semi-arid species that is widespread in the steppe and lower mountain areas in Lebanon, W. Syria, N. Iraq, E. Turkey and N.W. India ; a number of ecotypes collected in Turkey and this palatable species also successfully seeded under dryland conditions (300-400 mm rainfall, p.a.) in N.W. India and harvested for hay.

Cymbopogon schoenanthus : A cool season arid species widespread in desert areas extending from Morocco to Pakistan ; resists overgrazing strongly, is palatable except to cattle, sets abundant seed and has been recommended for dryland seeding in S. Morocco.

Digitaria commutata : A cool season arid species that is present in N. Africa, Egypt, Arabia, Iran, Afghanistan, Pakistan (Baluchistan) and N.W. India, produces fine palatable forage and seeds well, also growing in areas with less than 150 mm rainfall, p.a.

Panicum antidotale : A cool season arid or semi-arid species that occurs occasionally in desert and steppe areas in N. Africa and the Middle East ; a palatable species, useful for soil fixation and successfully seeded in dryland test plants in Pakistan under 150 mm rainfall, p.a.

Pennisetum dichotomum : A cool season arid species that is widespread in desert areas of N. Africa, the Near and Middle East and also in the lower mountains of C. and S. Iran where a number of different ecotypes occur ; adapted to low rainfall conditions (50-150 mm rainfall, p.a.) and valuable for soil fixation on stony and sandy sites.

Puccinellia capillaris : A cool season semi-arid species that along with the closely related species *P. distans* occurs on salt flats in steppic areas, often flooded in winter in N. Africa, the Near and Middle East ; a few native ecotypes of *P. capillaris* and *P. distans* collected in Algeria, Tunisia and Turkey and successful dryland plantings of *P. capillaris* made in W. Australia under 375 mm rainfall, p.a.

B. Perennial Legumes

Argyrolobium uniflorum : A cool season semi-arid species that occurs in steppic areas in N. Africa ; very palatable and drought resistant and recognized as having a value for dryland seeding on sandy soils in Libya in areas with 150-200 mm rainfall, p.a.

Astragalus charborasicus : A cool season semi-arid species that occurs along with the closely related species *A. kotschyanus* in the high plateaux zone of E. Turkey and N. Iran ; both species very palatable, resist overgrazing strongly and *A. charborasicus* has been successfully seeded in dryland nursery plantings in the sub-steppic zone of N. Iran with 320-350 mm rainfall, p.a.

Astragalus siliquosus : A cool season semi-arid species that occurs in the Anatolian plateaux of Turkey, the upper forest zone of Iraq and the northern Zagros plateaux in Iran, generally on waste land or in fallow fields ; palatable species and successful dryland plantings made in the steppic and sub-steppic zones of N. Iran with 250-350 mm rainfall, p.a., and also in Lebanon near the coast.

Trigonella elliptica : A cool season semi-arid species that occurs along with the closely related species *T. cachemiriana* and *T. griffithii* in the xerophilous forest zone of Iran and Afghanistan ; all are palatable species, having seeds that sometimes germinate with difficulty but some successful dryland nursery seedings made in the sub-steppic zone of Iran with 320-350 mm rainfall, p.a.

C. Annual or Biennial Legumes

Melilotus indica : A cool season semi-arid species that occurs widely in steppe and littoral areas of N. Africa and the Near and Middle East ; very palatable and drought and frost resistant, and successful dryland seedings made in the littoral zone of Morocco, and adapted to areas with 300-400 mm annual rainfall in the Near East.

Melilotus officinalis : A cool season semi-arid species that occurs in the mountains of the Near and Middle East ; a considerable number of native ecotypes collected in Turkey and successful dryland nursery plantings made in the sub-steppe zone of N. Iran with 320-350 mm rainfall, p.a.

Melilotus segetalis : A cool season semi-arid and semi-humid species that occurs in the mountains of N. Africa ; adapted to soils with moderate salinity (0.1-0.3 % NaCl) and recommended for dryland seeding in Morocco in areas with 500-600 mm rainfall, p.a.

Ornithopus sativus : A cool season semi-arid species that occurs spontaneously in Morocco, Algeria, Tunisia and Turkey ; palatable and drought resistant and adapted to light sandy soils and areas with more than 500 mm rainfall, p.a.

Scorpiurus muricatus : A cool season semi-arid species that occurs widely in steppe, desert and lower mountain areas throughout N. Africa, the Near and Middle East ; very palatable and nutritious and successful dryland nursery seedings made in N. Iraq with 300-400 mm rainfall, p.a.

Trigonella foenum-graecum : A cool season semi-arid/semi-humid species that occurs occasionally throughout the lower mountain zone of N. Africa, the Near and Middle East ; very palatable, frost and drought resistant, and successful dryland seedings made in Morocco (450-600 mm rainfall, p.a.) and in N. Iraq (350-400 mm rainfall, p.a.).

INTRODUCTION

1.1 The Region

The region which includes North Africa and the Near and Middle East, comprises some 20 EMASAR countries (see Fig. 1) and has been classified by FAO (1974 A) and FAO/UNEP (1975) as having low rainfall in that most of the land can be termed either arid or semi-arid by Meigs' definition. This is clearly shown in the area and rainfall data in Table 1 below :

Table 1 Land classification in North Africa and the Near and Middle East, according to Mean Annual Precipitation.

	(A)			(B)		(A+B)
	Total land surface '000 km ²	Land with < 100 mm p.a. '000 km ²	% total	Land with 100-400 mm p.a. '000 km ²	% total	% total
North Africa ^{1/}	5,751	4,864	85	563	11	96
Near East ^{2/}	3,705	3,033	79	589	16	95
Middle East ^{3/}	3,100	518	18	2,132	69	87
Total :	12,556	8,445	67	3,374	27	94

^{1/} Algeria, Egypt, Libya, Morocco and Tunisia.

^{2/} Bahrain, Cyprus, Iraq, Jordan, Kuwait, Oman, People's Democratic Republic of Yemen, Qatar, Saudi Arabia, Syria, United Arab Emirates, Yemen arab Republic.

^{3/} Afghanistan, Iran and Pakistan.

Meigs (1952) has actually classified the region from the point of view of climate into three zones - extremely arid, arid and semi-arid - and a modification of his map showing this main zonation together with the demarcation of winter and summer rainfall in respect to the EMASAR countries of the region is depicted in Fig. 2 below.

In general terms the extremely arid zone normally receives less than 50 mm of rainfall per year, the arid zone less than 250 mm rainfall per year and the semi-arid zone less than 500 mm rainfall per year. All the northern and a little of the southern part (Yemen and Oman) of the region benefit from a marked winter rainfall season while the southern extremities of the Sahara, and particularly the desert area of Pakistan, benefit from a marked summer rainfall season ; the remaining intervening area which is considerable in extent, receives no marked seasonal rainfall.

Meigs (1952) also points out that there are marked variations in winter and summer temperatures within the region. For instance, a large part of the littoral and also desert (Sahara, Arabia, Pakistan) zones of the region have warm or mild winters with the temperature of the coldest month being at or below 10°C , while that of the coldest month in the interior steppe and mountain zones with cold winters is at or sometimes just below 0°C ; in general winter temperatures are also more extreme in the high plateaux zones of the Middle East (Iran, Afghanistan, Pakistan) where the temperature of the coldest month is frequently below 0°C for long periods.

In regard to summer temperatures in the region, the greater part of the littoral, steppe and mountain zones have warm summers with temperature of the hottest month being at or below 30°C while, that of the hottest month in the desert zone is also close to or in excess of 35°C ; in very hot desert areas (Sahara, S. Iraq, Kuwait, Saudi Arabia (Rub-al-Khali), Iran (Dasht-i-kavir), Pakistan (Sind)), the temperature of the hottest month is in excess of 40°C .

In general in the region the relative humidity is higher throughout the year in the littoral zone, while in the interior desert, steppe and mountain areas, it is variable in the winter and spring but drops to 20-30 % in the summer.

From an agroclimatological point of view, which has important implications for dryland farming in the region, de Brichambaut (1958) has given example of three different variations of the Mediterranean climate in the Near and Middle East which have their close counterparts in North Africa and which are depicted in Table 2 below.

In that part of the region which receives winter and spring rainfall the growth of cool season forage species is favoured and especially is this so in the littoral zone with mild winters.

The growth of warm season species is favoured most in that part of the region with mild winters and also benefitting from either summer rainfall or high relative humidity in the summer due to close proximity to the sea; some warm season species are also equally adapted to grow well in that part of the region receiving no marked seasonal rainfall.

TABLE 2

<i>Climatic region</i>	<i>Characteristics</i>	<i>Subdivisions (mm rainfall)</i>	<i>Corresponding agricultural regions</i>	<i>Examples</i>
<i>Littoral and Sub-littoral</i>	-Mild winters	0 to 250	Egyptian coast	Alexandria
	-Mean Jan. temp. 12.5°C or more	250 to 400	Libyan coast Gaza strip	Gaza
	-(M-m) = 15-25°C	above 400	Coast north of Gaza to north of Lattakia (Coastal mountains Nablus, etc...)	
	-High relative humidity throughout the year			
	-Considerable cloud			
	-Dew often abundant			
<i>Semi-continental</i>	-Mild or cool winters	0 to 300	Egyptian desert, Nile delta, Sinai, Central and southern Jordan Valley, Southern Israel and Eastern fringe of Israel,	Jericho (hot)
	-Mean Jan. temp. to 12°C (except Jericho 15°C and Basrah 13.2°C		Broad eastern strip of coastal mountain ranges (Djeboul, Damascus, Mafrqa, Jiza),	Damascus (cool)
	-(M-m) = 25-35°C		Gulf region in Iraq and Iran.	
	-Variable relative humidity and cloud fairly high in winter			
	-Rare or slight frosts for more than 2 months			
		300 to 450	Amman and plain to south and south-west, North Bekaa and Jordan Valley, North-western Syrian plain (Aleppo, Homs)	Aleppo (cool)
		above 450	Jerusalem and to the north, Irbid, Ajlun, Salt and environs, Lebanese and Syrian mountains (central Bekaa Valley).	

1/ M = mean maximum temperatures of the hottest month
m = mean minimum temperatures of the coldest month

TABLE 2 (cont'd)

<i>Climatic region</i>	<i>Characteristics</i>	<i>Subdivisions (mm rainfall)</i>	<i>Corresponding agricultural regions</i>	<i>Examples</i>
<i>Continental</i>	-Cool or cold winters	0 to 350	Steppes and deserts in central and eastern Syria, eastern Jordan, Central western and north-western Mesopotamia, High plateaux and mountains in eastern Iran.	Rutbah (cool)
	-Mean Jan. temp. between under 0°C and 10°C			
	-(M-m) ^{1/} = more than 35°C			
	-Very variable relative humidity and cloud, very low in summer (10 to 20 per cent at 3 p.m.)	350 to 500	Plains in north-eastern Syria and northern and north-western Iraq, Mountains in northern and north-western Iran.	Mosul (cool)
	-Frost during 2 to 4 months			
	-Great variations of temperature	above 500	Mountain valleys in the Kurdistan in Syria, Iraq and Iran, North of Elburz mountains.	

^{1/} M = mean maximum temperatures of the hottest month
m = mean minimum temperatures of the coldest month

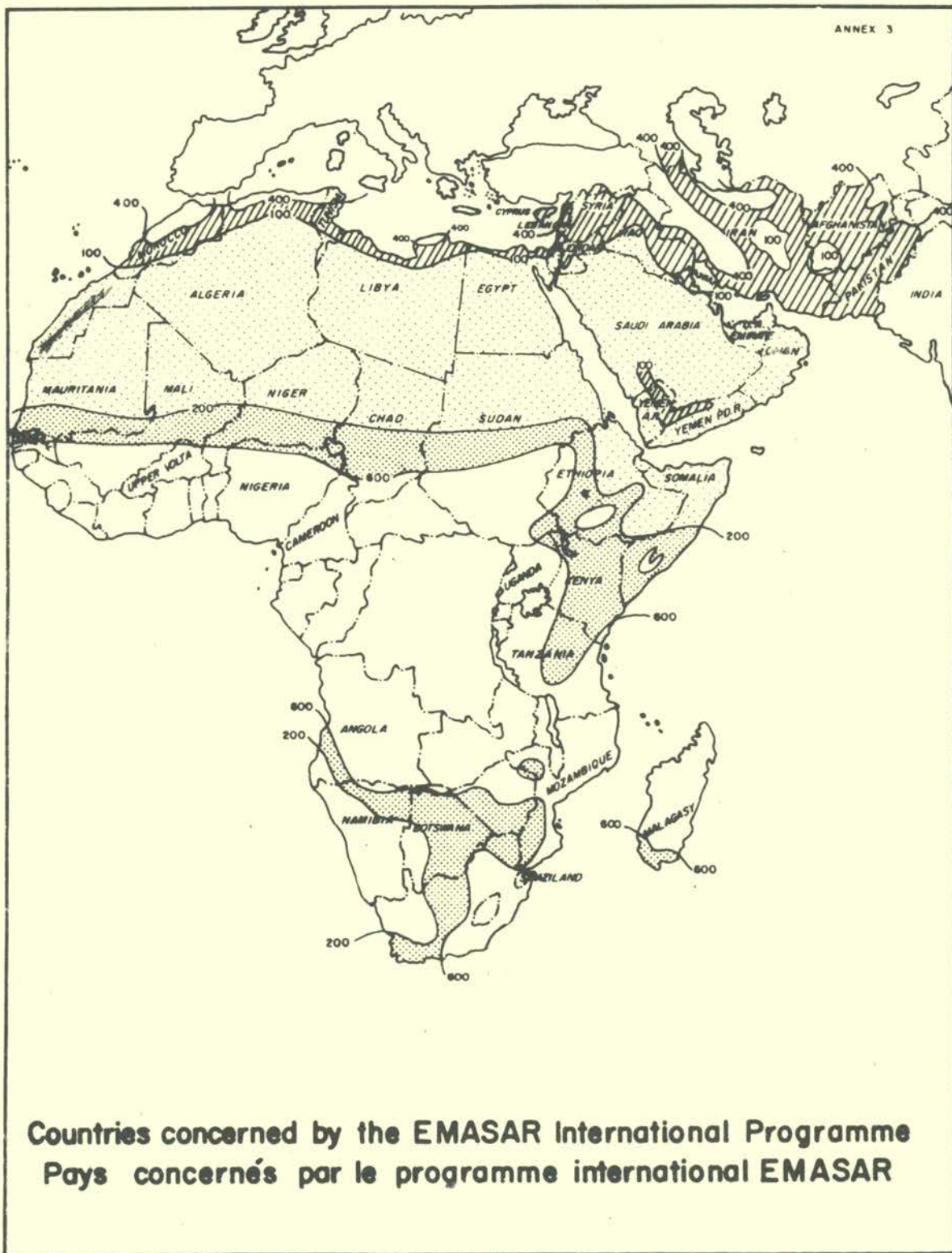


Fig. 1

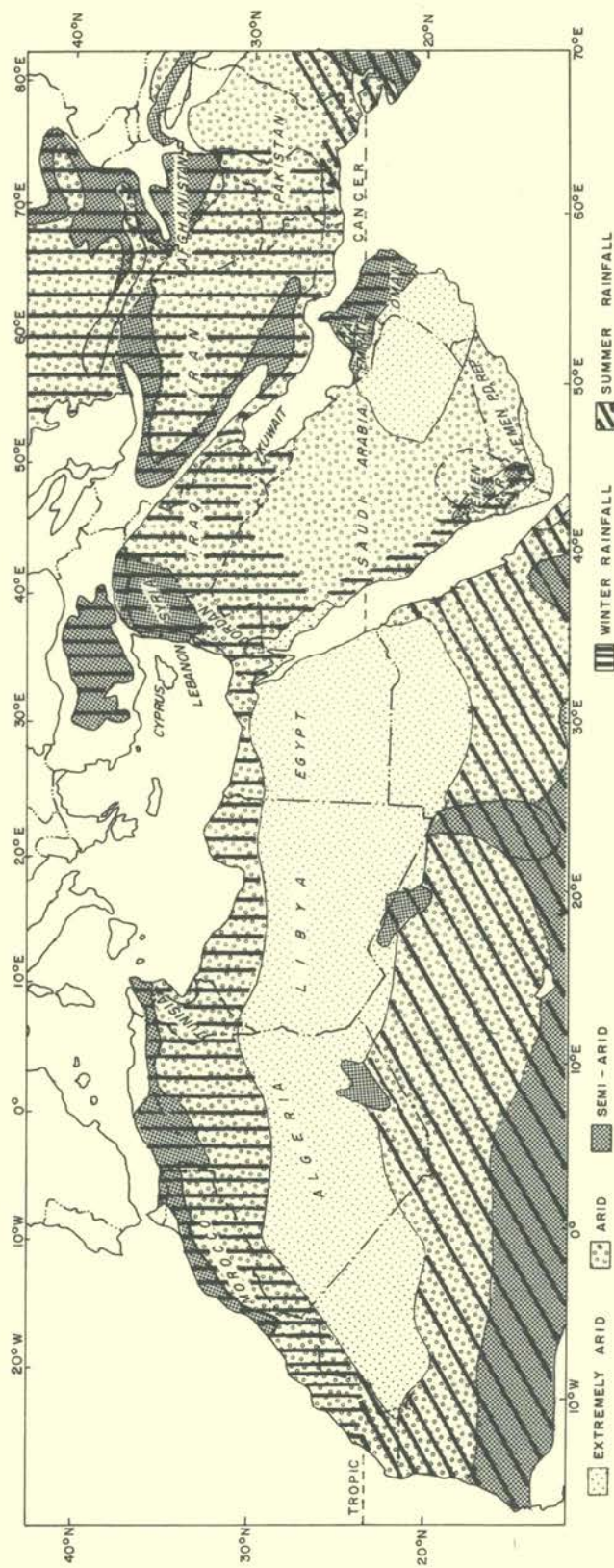


Fig. 2

Climatic zones of North Africa, the Near and Middle East
 (modified after Eastern Hemisphere distribution of arid homoclines,
 UNESCO, 1952, map 393)

1.2. Technical Possibilities

The greatest potential for the use of many of the promising indigenous grasses and legumes treated in detail in Parts I and II undoubtedly lies in the semi-arid winter rainfall areas of the region receiving 250-500 mm annual rainfall.

Here there are two main situations where their increased use in dryland cultivation could produce considerable increases in forage production.

The first, which offers the greatest potential, concerns the replacement of the fallow in the predominantly cereal-fallow rotation with annual forage crops. It has been estimated (Somaroo, 1977) that about 40 million hectares of land are fallowed each year in the region and a replacement of even part of this fallow area with productive forage crops could have an enormous impact on livestock production.

At the present time in the region most interest centres around the possibilities of introducing annual self-seeding pasture legumes (annual Medicago and Trifolium spp.) in rotation with cereals which have been successful in establishing a stabilized and integrated crop - livestock system in the semi-arid areas (300-500 mm annual rainfall) of S. and W. Australia (Geytenbeek, 1974). The system utilizing Australian varieties of annual Medicago spp. has already been introduced on an experimental scale in Algeria, Tunisia and Libya and the results to date indicate that it could be highly successful.

However, apart from economic and social constraints, its long term success in the region as a whole is likely to depend on the identification, collection and multiplication of indigenous varieties of annual Medicago and Trifolium spp. that are better adapted to the wide variations in rainfall, temperature and soil conditions that exist ; adaptation to cold winter temperatures, especially prevalent in the Near and Middle East, will also be of special importance.

In areas where annual Medicago and Trifolium spp. cannot be utilized because of unsuitable climatic or edaphic factors the cultivation of annual Vicia or Lathyrus spp. could provide a viable alternative. A number of species are already known and cultivated by farmers in the region and some have been tested in dryland crop rotations in Syria (Van der Veen, 1967).

Vicia and Lathyrus spp. alone or in mixture with cereals, may also need to be planted in dryland rotations suited to annual Medicago and Trifolium spp. to provide an alternative forage resource in the spring, when these species must be protected from grazing to ensure adequate seed production.

There are also opportunities for utilizing short-lived (2-3 years) legumes such as Astragalus siliquosus, Hedysarum coronarium and Onobrychis viciifolia and grasses such as Lolium multiflorum in longer term dryland crop rotations in areas with at least 500 mm annual rainfall. Notable examples are the cultivation of Hedysarum coronarium in the littoral zone of N. Africa with mild winters, Lolium multiflorum in the high plateaux zone of Algeria and Onobrychis viciifolia in the Anatolian plateaux of Turkey and sub-steppic zone of Iran with cold winters.

The second situation where forage crops can be utilized to greater effect is for re-seeding depleted grasslands or marginal lands unsuited to crop production.

In areas of the region with mild winters and an annual rainfall at or above 450 mm considerable success on a field scale has been achieved with seeding perennial species of Dactylis, Festuca, Medicago, Oryzopsis, Phalaris and Trifolium. Notable examples are Dactylis glomerata subsp. hispanica, Festuca arundinacea, Phalaris truncata and Trifolium fragiferum in the high plateaux zone of Algeria and Festuca arundinacea, Medicago sativa and Oryzopsis holciformis in the central steppic zone in Tunisia.

In areas of the region with cold winters and an annual rainfall between 250-500 mm or above 500 mm considerable success on a field scale has been achieved with seeding perennial species of Agropyron, Dactylis, Bromus, Medicago, Phalaris, Secale and Trifolium. Notable examples are Agropyron desertorum, A. elongatum, Bromus tomentellus, Secale montanum and Medicago sativa in the steppic and sub-steppic zones (250-350 mm annual rainfall) and Dactylis glomerata, Phalaris aquatica (= P. tuberosa) and Trifolium fragiferum in the Caspian Forest zone (+600 mm annual rainfall) of N. Iran and Agropyron intermedium in the Midelt region (320-350 mm annual rainfall) in Morocco.

In the Midelt region of Morocco some six thousand hectares of established re-seeded A. intermedium range is now reported (Calembert, 1977) to be under controlled grazing management.

In arid winter areas with 250 mm annual rainfall or less, the upper limit being close to the 240 mm annual rainfall reported by de Brichambaut and Wallen (1963) as being the limit for dryland farming under normal conditions in the Near and Middle East, the possibilities for re-seeding indigenous grasses and legumes appear to be more limited.

Of the few perennial grasses so far tested those showing the most potential are Stipa barbata, well adapted to dryland seeding in steppic areas of N. Iran and Syria with 200 mm annual rainfall, and Poa bulbosa which has been successfully seeded on a large scale under 200 mm annual rainfall in the Samarkand desert of S. USSR.

There appears to be also considerable potential for re-seeding indigenous perennial warm season grasses in areas receiving the benefit of summer rainfall or winter rainfall coupled with high relative humidity, particularly during the summer period due to close proximity to the sea.

Notable examples in such situations are the successful large scale re-seeding of depleted ranges with Cenchrus ciliaris and Lasiurus hirsutus in the Sind desert (150 mm annual rainfall with monsoonal summer rains) of Pakistan and the experimental seeding of Cenchrus ciliaris in the littoral zone (200 mm annual rainfall, high summer relative humidity) in S. Morocco.

In the arid and extremely arid desert areas of the region, particularly those areas with no marked seasonal rainfall, seasonal resting of ranges to promote natural re-seeding of indigenous grasses and legumes where a remnant cover of these species is still present is likely to offer a greater potential for improvement than artificial re-seeding.

However, where no remnant cover is present, it may still be worthwhile to carry out re-seeding of indigenous grasses and legumes in the most favourable habitats such as wadis, depressions and flats which receive the benefit of run-off from rainfall.

Apart from the notable experimental success of the dryland seeded Oryzopsis miliacea, Phalaris aquatica (= P. tuberosa) and Medicago sativa in run-off situations in the winter rainfall (80-100 mm p.a.) region of the Negev desert, the most promising species for seeding in desert areas with no marked seasonal rainfall are likely to be the perennial grasses Cynodon dactylon, Cymbopogon schoenanthus, Lasiurus hirsutus, Hyparrhenia hirta, Panicum antidotale, Panicum turgidum and Pennisetum dichotomum.

Except for Hyparrhenia hirta, all these grasses together with Cenchrus setigerus, Stipagrostis pennata, S. pungens and the perennial legume Lotus creticus also show considerable promise for sand dune fixation in desert areas.

1.3. Follow-up Action

In regard to follow-up action it is apparent from the large number of grass and legume species treated in this study that it will be necessary to concentrate future development activities on a limited number of species considered to merit high priority by individual governments in the region.

For some of these species, particularly semi-arid/semi-humid grasses and legumes, satisfactory varieties, strains or ecotypes may have already been developed and their introduction into agricultural practice will therefore depend on their increased multiplication and probably also additional testing in farm scale demonstrations trials to obtain farmer acceptance.

For other species, particularly arid zone grasses and legumes, which have so far received much less attention, it will first be necessary to organize as wide a collection of native ecotypes of high priority species as possible in the region.

As an immediate follow up to this action, it will also be essential to organize the selection, evaluation and testing of the priority species ecotype collections, so that after a minimum three year period, multiplication of some of the most promising ecotypes could proceed so as to permit larger scale field testing and eventual introduction into agricultural practice.

It is suggested that these activities could best be fostered initially through dialogue between individual countries and the EMASAR Secretariat, FAO, Rome, leading to the formulation of an appropriate action programme involving the participation of local and regional institutions in the development of valuable forage germplasm in the region.

As envisaged by EMASAR, which is jointly supported by UNESCO (MAB programme) and UNEP (Environmental programme), one of the main elements of an action programme would be the implementation of individual country or sub-regional field projects as required whose main objective would be :

- to collect and establish at a research centre(s) the most interesting indigenous forage species and their ecotypes ;*
- to select and then evaluate, after initial seed increase, the potential forage production of forage species ecotype collections under varying ecological conditions ;*
- to study the phenology, agronomy and nutritive value of individual ecotypes in forage species collections ;*
- to multiply the seeds of promising varieties already developed and also finally selected forage species ecotypes from collections, for larger scale field testing in demonstration projects ;*
- to publish catalogues of forage species collections and to promote seed exchange between interested countries.*

1.4. Conclusion

The indigenous forage species (grasses and legumes) which are treated in detail, in Parts I and II of this study, have been selected as having more value in the arid and semi-arid zones of the region on the basis of the technical information available in specialist reports and publications covering research and practical studies with individual species.

However since much of the data presented in the data sheets comes from experimental studies often undertaken on a limited scale, this study should be considered as a preliminary assessment of the potential use of selected species in the region. As such comments and additions would be welcome from the EMASAR countries concerned in order to correct any errors and omissions, and these should be sent to the following address :

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PART ONE

GRASSES

FAMILY GRAMINEAE (= POACEAE)

PERENNIAL SPECIES

1. *Agropyron* spp.
2. *Arrhenatherum* spp.
3. *Bromus* spp.
4. *Cenchrus* spp.
5. *Cynodon dactylon* (L.) Pers.
6. *Dactylis* spp.
7. *Festuca arundinacea* Schreb.
8. *Hordeum* spp.
9. *Hyparrhenia hirta* (L.) Stapf
10. *Lasiurus* spp.
11. *Oryzopsis* spp.
12. *Panicum turgidum* Forssk.
13. *Phalaris* spp.
14. *Poa* spp.
15. *Secale montanum* Guss.
16. *Stipa* spp.
17. *Stipagrostis* spp.

TECHNICAL DATA

SHEET No 1

GRAMINEAE (= POACEAE)

Agropyron spp.

1.1. Genus and Species

The genus *Agropyron* is one of the most important genera used as forage in the temperate regions of the world.

The *Agropyron* genera belong to the tribe *Hordeae* which include wheat, rye, barley and other forage grasses, but were originally considered to belong to the same tribe as wheat namely *Triticum* (Heath et al., 1973).

In North Africa and the Near and Middle East there are seven indigenous *Agropyron* spp. of importance which are *A. cristatum* (L.) Gaertn., *A. desertorum* (Fisch.) Schult., *A. elongatum* (Host) Beauv., *A. intermedium* (Host) P. Beauv., *A. tauri* Boiss. et Bal., *A. trichophorum* (Link) Richt. and *A. sibiricum* (Willd.) Beauv.

1.2. Synonyms

- *A. cristatum* (= *Bromus cristatus* L.)
- *A. desertorum* (= *Triticum desertorum* Fisch. ex Link)
- *A. elongatum* (= *Triticum elongatum* Host)
- *A. intermedium* (= *Triticum intermedium* Host)
- *A. tauri* (= *A. cognatum* (non Hack.) Rawl)
- *A. trichophorum* (= *Triticum trichophorum* Link)
- *A. sibiricum* (= *Triticum sibiricum* Willd.)

1.3. Common Names

- | | | |
|--------------------------|---------|--|
| - <i>A. cristatum</i> | English | Crested Wheat Grass, Fairway
Crested Wheat Grass (Canada, USA). |
| - <i>A. desertorum</i> | English | Standard Crested Wheatgrass (USA),
Desert Wheatgrass (Canada, USA). |
| - <i>A. elongatum</i> | English | Tall Wheat Grass (USA). |
| | Arabic | Gazzof, Jossoof (Saudi Arabia). |
| - <i>A. intermedium</i> | English | Intermediate Wheat Grass (Canada,
USA). |
| - <i>A. trichophorum</i> | English | Stiff Hair Wheat Grass,
Pubescent Wheat Grass (Canada, USA). |
| - <i>A. sibiricum</i> | English | Siberian Wheatgrass (USA). |

1.4. Brief Description

- *A. cristatum* is a long lived leafy tufted perennial bunchgrass with a dense mass of fibrous roots ; flowering stems up to 60 cm high and widely spreading spikelets with glumes somewhat centered and gradually tapering into curved awns. (Fig. 1 and 2)
- *A. desertorum* is a variable deep rooted long-lived bunch grass with flowering stems up to 50-100 cm tall, and a somewhat flattened slender bristly spike, which is very closely related to *A. cristatum* from which it differs in having no pubescence on the upper surface of the leaves.

For a period shortly after its introduction into the USA up until 1950, when it was subdivided (Swallen and Rogler 1950) into *A. desertorum* and *A. cristatum*, crested wheat grass was thought of as one species, *A. cristatum*. In fact a number of species make up the so called crested wheatgrass complex and involve mechanical admixtures from seed or hybrids between closely related species (Heath et al., 1973)

- *A. elongatum* is a tall deep rooted perennial bunch grass growing to a height of 80-140 cm with long loose seed heads (Fig. 3)
- *A. intermedium* is a variable and erect perennial sod forming grass, which grows to a height of 50-100 cm, with flat light green leaves that are generally glabrous, but in the case of some strains pubescent on the upper surfaces ; it is closely related to *A. trichophorum* from which it differs in not having short stiff hairs on the heads and seeds (Fig. 4)
- *A. sibiricum* is a long lived bunch grass similar in appearance to *A. cristatum* but the stems are finer, and the heads slightly smaller, narrower and more compressed.
- *A. tauri* is a long lived caespitose bunchgrass growing to a height of 50 cm with unawned slightly curved, compressed spikelets.
- *A. trichophorum* is a long lived tufted perennial sod forming grass developing short thick rhizomes after two to three years and growing to a height of 70-140 cm, and with stiff hairs on the heads and seeds (Fig. 5)

1.5. Varieties

Botanical varieties and forms :

A number of botanical varieties or forms of *A. cristatum*, *A. elongatum* and *A. intermedium* occur in North Africa and the Near and Middle East.

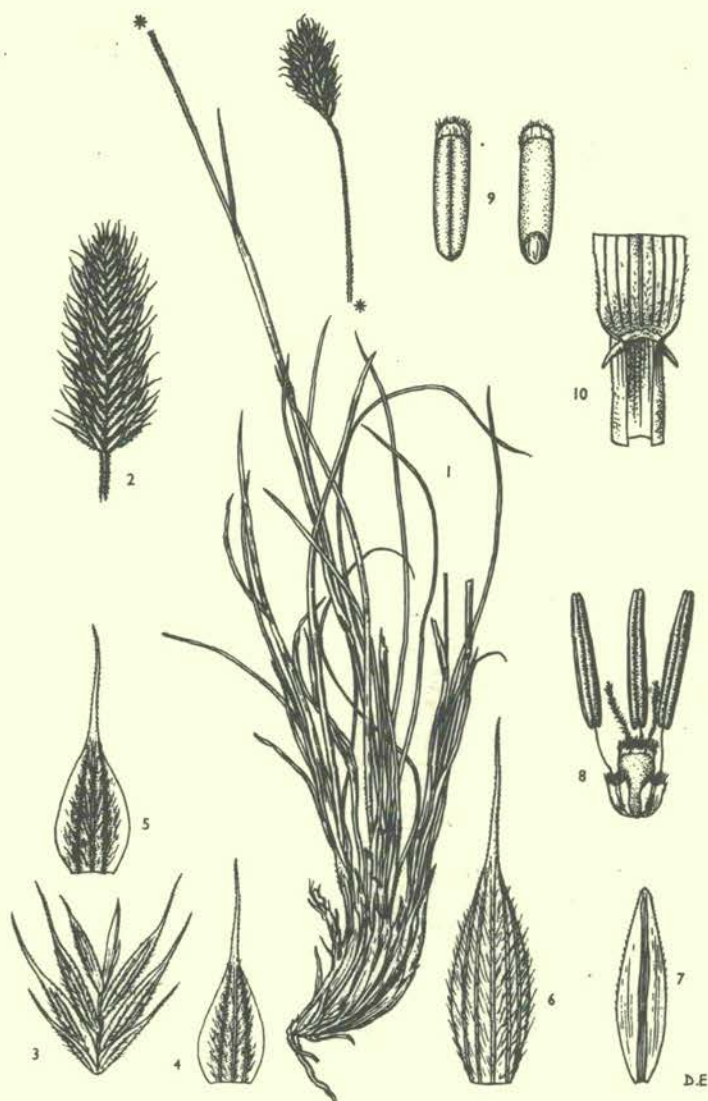


Fig. 1 - *Agropyron cristatum* (L.) Gaertn.

1. Habit, $\times \frac{2}{3}$. 2. Inflorescence, $\times 2$. 3. Spikelet, $\times 4$. 4. Lower glume, $\times 8$.
 5. Upper glume, $\times 8$. 6. Lemma, $\times 8$. 7. Palea, $\times 8$. 8. Flower, $\times 8$.
 9. Grain, $\times 8$. 10. Ligule, $\times 3$.

(After Flora of Iraq, Gramineae, vol. 9, 1968, p. 213, plate 70)

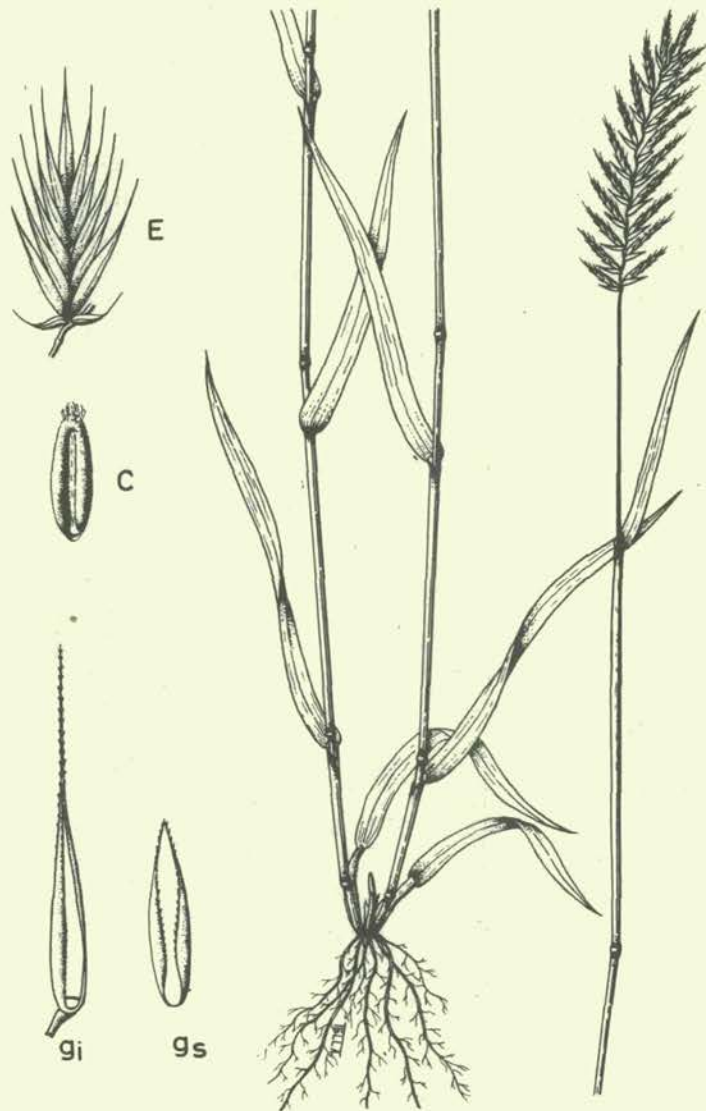


Fig. 2 - *Agropyron cristatum*

Plant, x1. E : Spikelet, x4. gi : Inferior glumella, x8.
gs : Superior glumella, x8. c : Caryopsis, x8.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas
Madrid, 1965, p. 35)

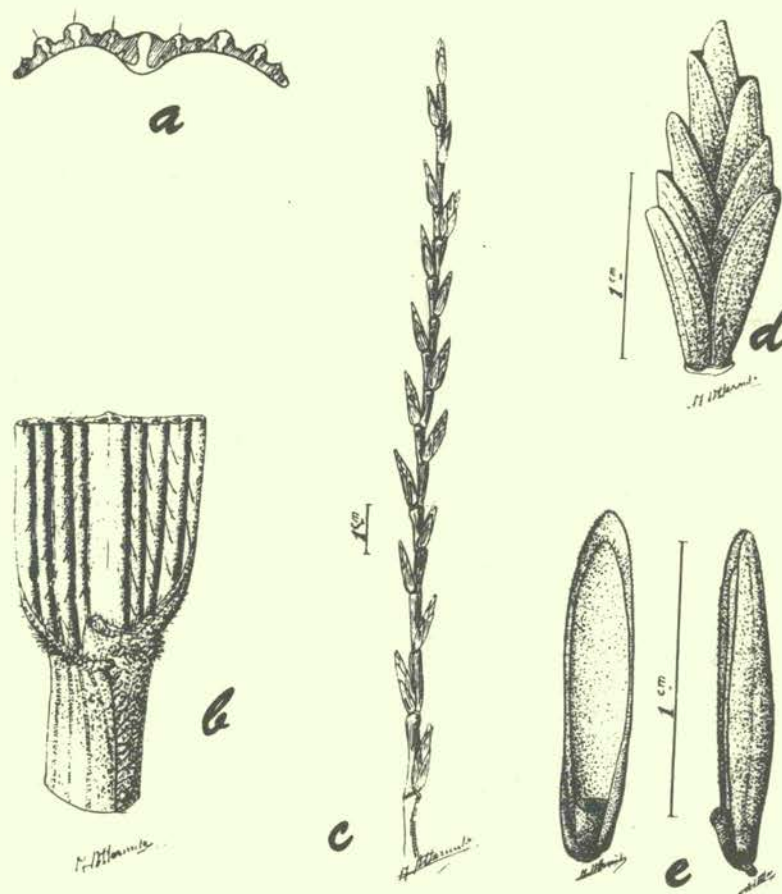


Fig. 3 - *Agropyron elongatum* (Host) Beauv.

a) Cross section of the leaf. b) Ligule and auricles. c) Raceme.
d) Spikelet. e) Seed.

(After Service de l'Expérimentation Agricole en Algérie, Fiche technique,
1957, p. 3)



Fig. 4 - *Agropyron intermedium* (Host) P. Beauv.

Plant, x1. E : Spikelet, x3. gi : Inferior glume, x3. gs : Superior glume, x3. Inferior glumella, x3. L : Ligule, x3.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas, Madrid, 1965, p. 31)

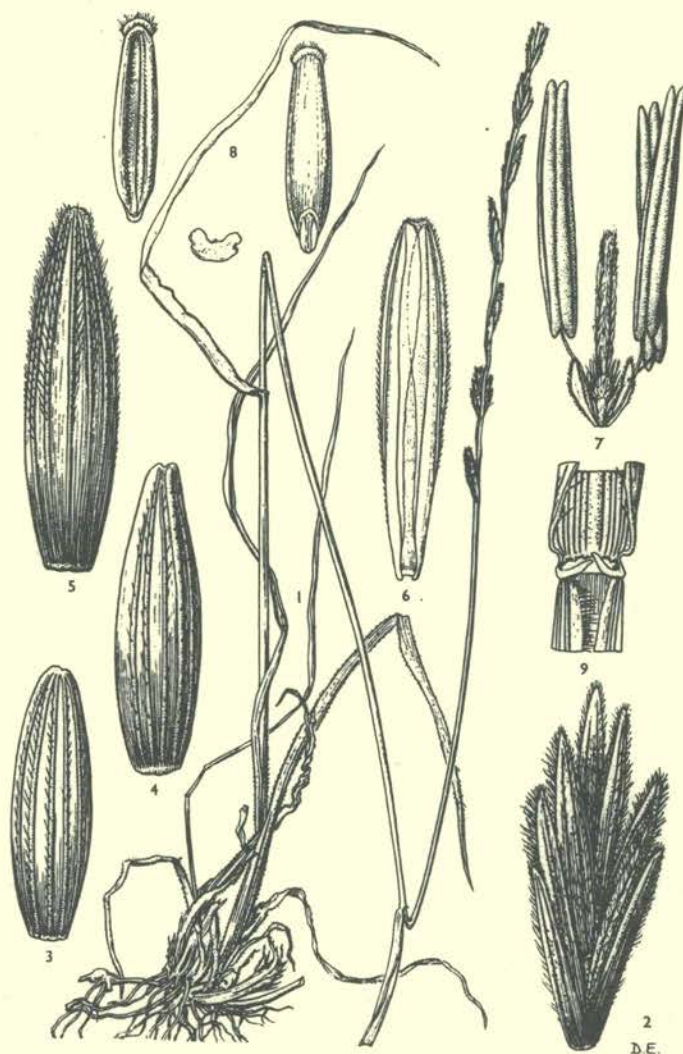


Fig. 5 - *Agropyron trichophorum* (Link) Richt.

1. Habit, $\times \frac{2}{3}$. 2. Spikelet, $\times 4$. 3. Lower glume, $\times 6$. 4. Upper glume, $\times 6$.
5. Lemma, $\times 6$. 6. Palea, $\times 6$. 7. Flower, $\times 8$. 8. Grain, $\times 6$. 9. Ligule, $\times 4$.

(After Flora of Iraq, Gramineae, vol. 9, 1968, p. 223, plate 75)

In North Africa Maire (1955) mentions the following for *A. cristatum* :

- var. *brachyatherum* Maire
having spikelets with 3-4 flowers and narrow heads,
- f. *pauciflorum* Maire
the type form,
- f. *multiflorum* Maire
having spikelets with 7-10 flowers broad heads ;

and for *A. elongatum* :

- var. *typicum* Fiori et Paol.
which is the type variety and occurs frequently,
- var. *glabrum* Maire
which has glabrous sheaths and occurs frequently,
- var. *puberulum* Maire
which has hairy inferior sheaths and occurs rarely,
- var. *scirpeum* (Presl) Fiori et Paol.
which has distinctly shortened glumes and lemmas and occurs rarely.

In Egypt (UAR) Tackholm (1956) records *A. elongatum* as occurring in sandy moist places but the species was later taxonomically revised (Tackholm 1974) and renamed as follows :

Elymus elongatus Host (Runem.) = *Agropyron elongatum* (Host) Beauv. ssp. *haifensis* (Meld) Henein et Runem. (= *Elytrigia elongata* v. *haifensis* (Meld in Rech.)). The new sub-species still closely resembles *A. elongatum* and may presumably be considered as a close variant of it.

In N. Iran Parsa (1950) mentions the following botanical varieties of *A. cristatum* :

- var. *imbricatum* (M.B.) Boiss. et Hoh.
which has hairy spikelets and occurs in the Elburz Mountains, Kuh Dushtek (2,400 m), Kandavan (3,000 m) and Azerbaidjan,
- var. *velutinum* Grossheim
which has soft and densely hairy plants with bearded spikelets and occurs in N.W. Azerbaidjan (1,400-1,500 m),
- var. *incanum* Nabêlek
which has plants covered with short grey hairs and occurs in W. Kurdistan,
- var. *caespitosum* Bornm.
the leaves of which form a dense tuft and which has larger leaves and bigger spikelets than *A. cristatum*.

A. intermedium :

- var. *villiferum* (Beck) Hayek
occurs west of Teheran in the Kuché Djaru Steppe (1,800 m),
- var. *villosum* Stapf = *A. savignii* Not. Prosp.
a less glabrous and more robust variety occurring west of Hamadan

A. elongatum :

- var. *polystachyum* Bornm. et Gauba
which is glaucous and without stolons and occurs between Ghazvin and Teheran on saline steppe at Mardabad (1,400 m).

Native ecotypes :

A number of native ecotypes of *A. cristatum*, *A. cristatum* var. *caespitosum*, *A. tauri* and *A. aucheri* (considered to be a variety of *A. trichophorum* and *A. intermedium* ; *A. aucheri* Boiss. also given as a synonym of *A. trichophorum* (Bor and Guest, 1968)) have been collected (Pabot, 1967) in N. Iran (Azerbaijan, the Elburz and Zagros Mts) and planted at Homand in the sub-steppic zone (1,960 m elevation, 320-350 mm annual rainfall), and more recently a large collection comprising some 215 different populations of *A. cristatum* has been collected (Dewey and Asay, 1974) in Iran north of the 35° latitude which showed significant variation in maturity, height, texture, rhizome development and seed size between and within populations.

In N. Iraq Bor and Guest (1968) also record that though native ecotypes of *A. cristatum* and *A. desertorum* have not been recorded so far, they may be looked for in the northern extremities of the mountains, possibly in the sub-alpine zone.

In Turkey Hertzsch (1970) records that 17 ecotypes of *A. cristatum*, 3 ecotypes of *A. desertorum*, 16 ecotypes of *A. elongatum* and 36 ecotypes of *A. intermedium* were collected in the different climatic zones of the country during the period 1965-69 ; in 1970 Hertzsch (1971) reports that 36 ecotypes of *A. cristatum*, 28 ecotypes of *A. desertorum* and 38 ecotypes of *A. intermedium*, all of Turkish origin, were planted in dryland nurseries at Izmir (W. Turkey) for evaluation.

Agricultural varieties :

The majority of dryland experimental plantings of *A. cristatum*, *A. desertorum*, *A. sibiricum*, *A. elongatum*, *A. trichophorum* and *A. intermedium* in North Africa and the Near and Middle East have been made with seeds of varieties (cultivars) introduced from Canada or the USA. The most important of these are mentioned by Hanson (1965) and Heath et al. (1974) and are the following :

- *A. cristatum* :
 - 'Fairway' a cultivar with short fine stems and small seeds and awns and developed in Canada ; introduced into the lower mountain zone of Iraq (Hussein 1975),
 - 'Parkway' a cultivar which has superior forage and seed production to 'Fairway' and developed in Canada ;
- *A. desertorum* :
 - 'Nordan' a cultivar superior to the 'Commercial' variety in quality of seed and seedling vigour and developed in the Northern Great Plains (USA),
 - 'Summit' a cultivar which yields more forage than 'Fairway' crested wheat grass and developed in Canada ;
- *A. sibiricum* :
 - 'P 27' is a cultivar with less vigorous seedlings than those of 'Nordan' Standard crested wheat grass and developed in Washington State (USA) and released in 1953 ;
- *A. elongatum* :
 - 'Alkar' a tall late maturing cultivar with coarse blue green leaves which has large seeds and good seedling vigour ; developed in Washington State (USA) and released in 1959,
 - 'Largo' a tall late maturity cultivar with a high percentage of bluish-green plants developed in New Mexico (USA) and released under the designation A-1876 in 1937,
 - 'Jose' a true green cultivar with high forage quality developed in New Mexico (USA) and released in 1965,
 - 'Nebraska 98526' an erect tall cultivar with deeply veined bluish-green leaves and coarse stems developed in Colorado (USA),
 - 'Orbit' is a winter hardy cultivar especially adapted to wet saline soils, developed in Canada and released in 1966 ;
- *A. trichophorum* :
 - 'Topar' a vigorous growing productive and late maturing cultivar developed in the Northwest of the USA and released in 1953 ; has been introduced in the lower mountain zone of Iraq (Hussein 1975),
 - 'Mandan 759' a long lived and productive cultivar developed in North Dakota (USA),
 - 'Luna' a vigorous fast establishing and productive cultivar developed in New Mexico (USA) and released in 1963 ; some seedheads are glabrous and hence similar to *A. intermedium* but all the basal leaves are hairy,

- 'Trigo' an aggressively rhizomatous cultivar more productive than other varieties ; developed in New Mexico and California in the USA,
- 'Greenleaf' a vigorous highly productive cultivar developed in Canada ;
- *A. intermedium* :
 - 'Amur' a vigorous growing leafy but slow sod forming cultivar developed in New Mexico (USA) and released in 1952,
 - 'Chief' a greyish-green cultivar which is more productive than 'Ree' (now discontinued) ; developed in Canada and released in 1961,
 - 'Greenar' a vigorous mild sod forming late maturing dark green leafy cultivar developed in Washington State (USA) ; introduced into lower mountain zone of Iraq (Hussein 1975),
 - 'Oahe' a selection from 'Ree' and a uniformly blue-green vigorous rhizomatous cultivar developed in South Dakota and released in 1961,
 - 'Tegmar' a dwarf type developed in Idaho primarily for erosion control seeding and released in 1968.
 - 'S Late' a selection developed in Nebraska and released in 1969.

In the Kazakh region of the Southern USSR the drought resistance of 30 cultivars of *A. cristatum* and *A. sibiricum* has also been recently measured (Bukhteeva 1971). Drought resistance fluctuated more in *A. cristatum* than *A. sibiricum* in which drought resistance was relatively high in all populations examined.

The most drought resistant cultivars of *A. cristatum* were Karabalyskil 202 and Saratovskil K 28140 and of *A. sibiricum* Ural'skil K 33843 and Saratovskil K 27969.

1.6. Number of Chromosomes

A. cristatum $2x = 14$, $4x = 28$; in Iran hexaploid types found in Azerbaidjan (Dewey and Asay 1975) ;

A. desertorum $2x = 28$;

A. sibiricum $2x = 28$;

A. elongatum $2x = 14$, $4x = 56$, $5x = 70$;

A. trichophorum $6x = 42$, 43 ;

A. intermedium $6x = 42$;

A. tauri not known.

1.7. Geographical Distribution

- *A. cristatum* is distributed in C. and E. Europe (from Switzerland to the Crimea), Turkey, Lebanon, Caucasus, Iraq, Iran, Afghanistan, N. C. and E. Asia (Siberia to Tibet), N. Africa (Morocco, Algeria) also cultivated in the USSR, USA, Canada, Hungary and S. America (Andes) ;
- *A. desertorum* is distributed in E. Europe (S.W. USSR , Don, Volga), Ciscaucasia and Turkmenia to Balkhash) and is naturalized in the USA where successful introductions were made with seeds received from the USSR in 1906 ; it is also cultivated in N. Europe and N. America ;
- *A. sibiricum* is distributed from C. Europe to Siberia with a closely similar occurrence in this region to *A. cristatum* ;
- *A. elongatum* is distributed in saline meadows and littoral areas from S. Europe to Asia, Algeria, Morocco, Egypt (UAR), Syria, Iran, Iraq ;
- *A. trichophorum* is distributed in E. Europe (Ukraine, Crimea), Turkey, Caucasus, Iraq, Iran, W. Pakistan, Afghanistan, C. Asia (Turkmenia to Tian Shan), China, and cultivated in N. America ;
- *A. intermedium* is distributed in C., S. and E. Europe (Germany to the Balkans, S. W. USSR including the Crimea), Caucasus, Iraq, Iran, W. Pakistan, C. Asia (Turkmenia to Pamir-Alai) and cultivated in N. America ;
- *A. tauri* is distributed fairly widely in N. Iran (Tabriz, E. Sanandaj, Qasvin, Karadj, Sahr-Kard), Turkey (Taurus Mountains), Syria.

1.8. Biology and Ecology

Germination, growth and establishment :

A. cristatum, *A. desertorum*, *A. sibiricum*, *A. trichophorum*, *A. intermedium* and *A. tauri* are all cool season species propagating themselves by seed. Seed germination studies in Iran indicate that the seeds of all these species germinate very readily at soil temperatures between 15-20° C ; below this threshold range of temperature germination is retarded (AGP : SF/IRA 10, Tech. Rep. no. 1, 1970).

In the sub-steppic zone of Iran seeds of *A. desertorum* and *A. elongatum* have also shown delayed germination in some instances with some seeds germinating later in the second or third year when soil moisture conditions are more favourable.

In the steppic (at 1,300 m elevation, 200 mm annual rainfall), and sub-steppic (at 1,960-2,050 m elevation, 320-350 mm annual rainfall) zones of N. Iran spring growth of seeded *A. cristatum*, *A. desertorum*, *A. elongatum*,

A. trichophorum, *A. intermedium* and *A. tauri* (the last three species not seeded in the steppic zone) has been vigorous ; summer growth is minimal but more pronounced in the higher, cooler, xerophilous forest zone. Further re-growth occurs in the autumn, its extent depending on the incidence of autumn rain.

At 1,960 m elevation in the sub-steppic zone of Iran at Homand vegetative growth in the spring for *A. cristatum*, *A. cristatum* var *caespitosum*, *A. desertorum*, *A. elongatum*, *A. trichophorum*, *A. intermedium* and *A. tauri* starts in mid-March, the boot stage at the beginning of May, flowering in Mid-June and seed production in early July. *A. cristatum* has been the earliest to grow in March, followed, over a 7-10 day period, by *A. tauri*, *A. trichophorum*, *A. desertorum*, *A. elongatum* and *A. intermedium*, in that order.

In the lower mountain zone (400-500 mm annual rainfall, 600-800 m elevation) of N. Iraq germination of seeds of *A. cristatum*, *A. elongatum*, *A. trichophorum* and *A. intermedium* has reached 95-100 % in both autumn and spring dryland plantings but in some cases frost heaving has damaged autumn seedlings (Hussein, 1975).

In the sub-steppic zone (350-380 mm rainfall, 1,500 m elevation) of Afghanistan near Kabul good establishment and growth of *A. elongatum* and *A. trichophorum* was obtained from autumn dryland seeding (October) but supplementary irrigation was necessary to ensure a satisfactory seed set (Rouffie, 1969).

In the steppic zone (250-375 mm annual rainfall, 700-1,500 m elevation) in E. Lebanon broadcast spring seeded (March) experimental dryland plantings have produced a ground cover of 75-100 % for *A. elongatum*, 50-75 % for *A. cristatum*, 25-50 % for *A. trichophorum* and 5-25 % for *A. intermedium* 7 1/2 months later in November (El-Moursi, 1969).

In the littoral zone of N. Africa (400-600 mm annual rainfall) where the winters are generally mild (minimum 10°C) and the summers cooler than in the interior steppe region autumn and spring growth is vigorous ; Corriols (1965) records that all these species seeded at the beginning of December gave a 100 % germination by mid-December, made rapid growth in the spring, remained green during the summer and produced a very good re-growth at the end of October.

In Morocco Giscard (1961) records that *A. elongatum* in particular makes quick growth at the onset of the first rains in the autumn ; 40 mm has been sufficient to produce an abundant growth of leaves in both Algeria and Morocco. Growth is generally stationary in January-February but spring growth is vigorous and plants tillered strongly reaching a height of 140 cm in their second year at Sefrou (Morocco).

Villax (1963) states that *A. desertorum* is one of the first *Agropyron* spp. to flower in dryland plantings in Morocco and that a rainfall of 200-300 mm is sufficient to assure vegetative growth in the Mediterranean region. *A. elongatum* is later maturing than all the other *Agropyron* spp. with different native and introduced varieties flowering over a long period from May-July ; it also produces green forage in spring when other *Agropyron* spp. are tending to dry up. Figures 6 and 7 show dryland seeded plants of *A. elongatum* in April and July in Algeria, and Fig. 8 *A. trichophorum* in Morocco.

In Morocco *A. elongatum*, *A. trichophorum* and *A. intermedium* have also grown vigorously in the spring when seeded in the autumn in the steppic zone (280-320 mm annual rainfall, 1,700 m elevation) in the Midelt region.

Climate and soils :

A. cristatum, *A. desertorum*, *A. sibiricum*, *A. elongatum*, *A. trichophorum*, *A. intermedium* and *A. tauri* are all very resistant to cold temperatures (below 0°C) and also to drought. They are well adapted to dryland seeding in the semi-arid regions of North Africa and the Near and Middle East with 350-400 mm annual rainfall and some, in particular *A. cristatum*, *A. desertorum*, *A. elongatum*, *A. trichophorum* and *A. intermedium* show considerable promise for dryland seeding in areas with 250-300 mm annual rainfall.

A. elongatum, which also shows promise for seeding on saline/alkaline soils in N. Iran (steppic zone, 200 mm annual rainfall), has generally proved to be the most drought resistant species followed by *A. desertorum*, *A. cristatum*, *A. trichophorum* and *A. intermedium*, while *A. sibiricum* in Iran has performed better on the drier and poorer sites in adaptability row plantings.

A. cristatum, *A. desertorum*, *A. sibiricum*, *A. elongatum*, *A. trichophorum*, *A. intermedium* and *A. tauri* are adapted to a wide range of soils (Whyte et al., 1959) but do best on well drained productive soils. *A. cristatum* and *A. desertorum* exhibit a low tolerance to alkali soils and will not persist under prolonged flooding (Heath et al., 1974). In contrast, *A. elongatum* is adapted to both saline and alkaline soils, while *A. trichophorum* and *A. intermedium* are also well adapted to alkaline soils ; in N. Iran native ecotypes of *A. intermedium* are also found on stony and even saline soils. In N. Iran *A. sibiricum* has also shown good adaptation to the poorer, drier soils while *A. tauri* is well adapted to stony limestone soils.

Ecological characteristics :

Ecologically Pabot (1967) states that *A. cristatum* is quite localized in the vegetation of N. Iran and, except for *A. cristatum* var *caespitosum*, the local ecotypes are not very productive or an important component of the native vegetation ; this also appears to be the case in Afghanistan and elsewhere in the Near and Middle East.



Fig. 6 - Dryland *A. elongatum* in April

(After Service de l'Expérimentation Agricole en Algérie, Fiche Technique, 1957, p. 4)

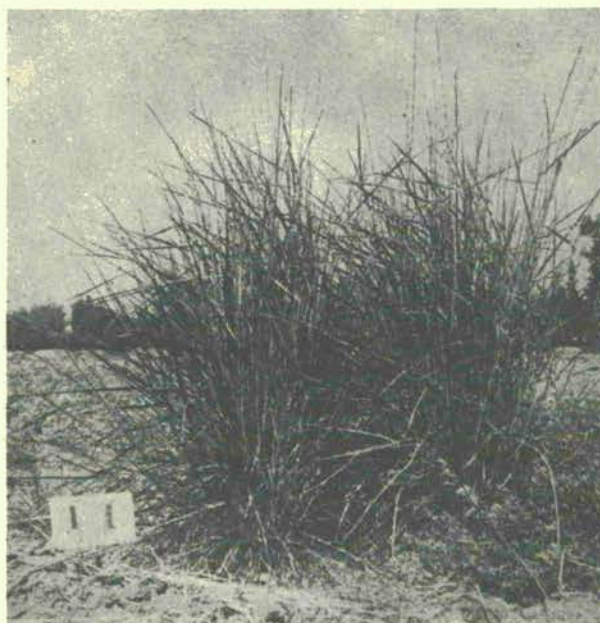


Fig. 7 - Dryland *A. elongatum* in July

(After Service de l'Expérimentation Agricole en Algérie, Fiche Technique, 1957, p. 4)

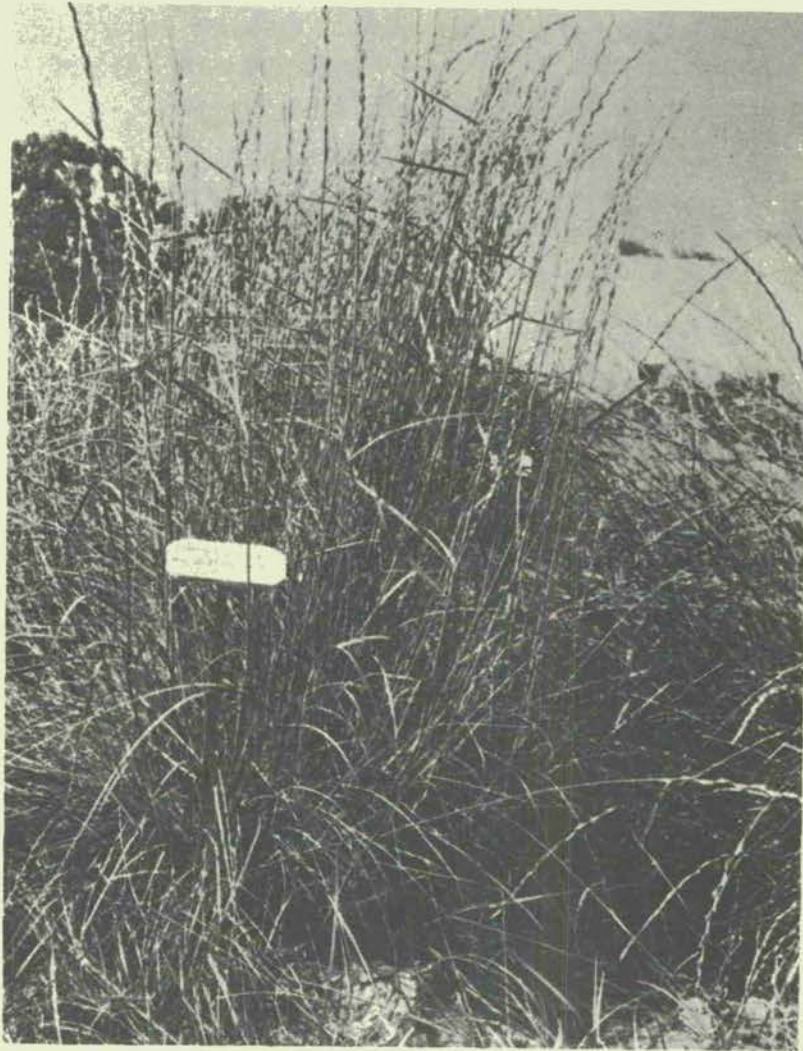


Fig. 8 - *Agropyron trichophorum*

(After la Culture des plantes fourragères dans la région méditerranéenne occidentale, 1963, p. 320, Fig. 79)

Interesting native forms of *A. trichophorum* and *A. intermedium* are likely to be found in the forest zone in the Irano-Turanian region of the Near and Middle East ; Bor and Guest (1968) record both these species in the forest zone of N. Iraq (1,300 - 1,800 m elevation).

In N. Iran Pabot (1967) mentions that native ecotypes of *A. aucheri* (closely related to *A. trichophorum* and *A. intermedium*) are very common and abundant on cultivated lands, marginal lands or even on certain depleted natural rangelands in the sub-steppic and xerophilous forest zones but that they generally have few leaves and a low productivity with only the most caespitose and leafy ecotypes meriting collection.

In N. Iran *A. tauri* is also mentioned by Pabot (1967) as forming one of the principal types of vegetation on ranges that are not too depleted in association with *Hordeum fragile*, *Bromus persicus*, *Oryzopsis molinioides* and cushion like or semi-woody perennials on steep stony slopes on non-steppic mountains.

In N. Africa Maire (1953) mentions that *A. cristatum* occurs on rocky and calcareous soils in the interior steppes and mountains from 1,400 - 2,800 m elevation and also as a constituent of the *Stipa tenacissima* steppe in the southern Atlas Mountains at Tamalout, while *A. elongatum* is recorded on maritime sands and salty moist soils in the littoral and interior zones ; it is also recorded by Mousterde (1966) in similar habitats in Syria and Lebanon.

In Egypt (UAR) *A. elongatum* occurs in dense stands on or near the seashore where it is associated with *Paneratium maritimum* and an ecotype of *Cynodon dactylon* at 15 m elevation ; here the sub-soil is well drained and moist throughout the year and plants were found to be more vigorous than further inland on a north facing slope at 60 m elevation (Ibrahim 1968).

1.9. Cultivation Techniques

Time of seeding :

In the sub-steppic zone (1,960-2,050 m elevation, 320-350 mm annual rainfall) at Homand and Firuzkuh the best time of seeding for *A. cristatum*, *A. desertorum*, *A. elongatum*, *A. trichophorum*, *A. intermedium* and *A. tauri* has proved to be in the autumn (October-December) or in the spring (31 March - 15 April) ; in actual practise at Homand (1,960 m elevation) autumn seedings have been successful in 4 years out of 9, and spring seedings in 7 years of 9.

In the steppic zone (1,300 m elevation, 200 mm annual rainfall) at Nowdehak the best time of seeding for *A. cristatum*, *A. desertorum* and *A. elongatum* has proved to be the autumn (October-December; November is the

safest all-round month) ; recent seeding trials in the Zarand-Saveh region south-east of Teheran, in the steppic zone, appear to support this conclusion (Moghaddam, 1975).

In the steppic zone of Lebanon (700-1,500 m elevation, 250-375 mm annual rainfall) both spring (March) and autumn (November) seeding of *A. cristatum*, *A. elongatum*, *A. trichophorum* and *A. intermedium* have been successful (El Moursi, 1969).

In the steppic zone (1,700 m elevation, 250-320 mm annual rainfall) of Morocco (Midelt region), in the high plateaux of Algeria and in the littoral zones (400-600 mm annual rainfall) of Morocco, Algeria and Tunisia, the best time of seeding for *A. cristatum*, *A. desertorum*, *A. elongatum* and *A. intermedium* has proved to be the autumn (September-October).

Land preparation :

A firm, compact, weed-free seed-bed is required for seeding all the previously mentioned *Agropyron* spp., which involves ploughing the soil to a depth of 10-15 cm and then discing, sometimes dragging (iron bar) and then rolling it.

Seed rates and method of seeding :

Seed rates, row spacings and methods of seeding have varied between countries but the following have been reported :

- | | |
|--|--|
| <u>Iran</u> | A seed rate of 5-10 kg/ha - 10 kg/ha is preferred (Peymani and Tarifi, 1974) - has proved sufficient for obtaining dryland nursery of field stands for all the previously mentioned <i>Agropyron</i> spp. The seeds have been drilled at a depth of 1-2.5 cm in nursery rows spaced 50 cm apart (2 row McCormick Orchard drill) or in field plantings for <i>A. desertorum</i> , <i>A. elongatum</i> and <i>A. trichophorum</i> in rows spaced 15-20 cm apart (John Deere Grain drill) ; |
| <u>Iraq</u> | For <i>A. cristatum</i> , <i>A. trichophorum</i> and <i>A. intermedium</i> a seed rate of 7-15 kg/ha has been drilled on level land in rows 50 cm apart, and 10-23 kg/ha has been broadcast on sloping land in contour furrows spaced 100-200 cm apart and on steep land on the berm of contour trenches ; shallow depth of planting for seeds preferred in all cases ; |
| <u>Algeria</u>
<u>Morocco</u>
<u>Tunisia</u> | For <i>A. cristatum</i> , <i>A. desertorum</i> , <i>A. elongatum</i> , <i>A. trichophorum</i> and <i>A. intermedium</i> a seed rate of 8-12 kg/ha has been broadcast or drilled ; when drilled a row spacing of 30-80 cm has generally been used but close drilling at 15-20 cm spacing using a grain drill has also been employed. |

Dryland seeding success :

On a field scale so far *A. desertorum* and *A. elongatum* have provided the most successful dryland seedings in the steppic and sub-steppic zones of N. Iran, and *A. cristatum* and *A. intermedium* the most successful in the sub-steppic zone of Morocco where fields stands have been maintained under grazing use for 2-3 years or more. Figure 9 shows a field stand of *A. desertorum* in the steppic zone of Iran.

Fertilizer application :

Fertilizer trials using nitrogen and phosphorous applied at various rates to established dryland wheatgrass stands in the sub-steppic zone of Morocco (Midelt region) have not given a significant vegetative response (Otmane, 1974). In one year in the sub-steppic zone of Iran at Homand, 30 kg/ha of N seeded with *A. desertorum* in the autumn improved the vigour and height of establishing seedlings.

1.10. Forage Value

Palatability :

A. cristatum, *A. desertorum*, *A. sibiricum*, *A. elongatum*, *A. trichophorum*, *A. intermedium* and *A. tauri* are all palatable species and are well grazed by cattle and sheep particularly in the vegetative stage ; *A. elongatum* produces rather coarser leaves than the other *Agropyron* spp. but is well utilized when the leaves are young and has been reported in Algeria as being grazed by native sheep when dry in summer.

In the sub-steppic zone of Iran in palatability grazing tests with native sheep, *A. cristatum*, *A. desertorum*, *A. trichophorum* and *A. tauri* were well grazed in the vegetative stage (spring and autumn), fairly well grazed in the boot and flowering stages and, except for *A. tauri* (fairly well grazed), poorly grazed in the seed production stage ; in contrast, *A. elongatum* was only fairly well grazed in the vegetative stage and poorly grazed in the boot, flowering and seed production stages.



Fig. 9

Part of stand of *Agropyron desertorum* seeded in Autumn 1967 at Nowdehak.
May 1969.

(After Pasture and Fodder Crops Investigation, Iran, Tech. Rep. No 1,
1970, p. 85, Fig. 19)

Nutritive value :

The forage value of the above mentioned *Agropyron* spp. has been assessed in a number of countries and the following data is reported :

IRAN

(a) Sub-steppic zone (Homand) - Percentage of Dry Matter

<u>Species</u>	<u>Vegetative Stage</u>		<u>Boot Stage</u>		<u>Flowering Stage</u>		<u>Seed Production Stage</u>	
	<u>Crude Protein</u>	<u>Crude Fibre</u>	<u>Crude Protein</u>	<u>Crude Fibre</u>	<u>Crude Protein</u>	<u>Crude Fibre</u>	<u>Crude Protein</u>	<u>Crude Fibre</u>
<i>A. cristatum</i>	11.5	26.8	11.5	29.8	5.5	30.9	4.2	34.4
<i>A. tauri</i>	17.9	23.5	12.4	31.1	6.8	34.1	--	--

(b) Caspian Forestry Zone (Sangh Dah)

<u>Species</u>	<u>Phenological Stage</u>	<u>Dry Matter %</u>	<u>Crude Protein %</u>	<u>Ca %</u>	<u>P %</u>
<i>A. elongatum</i>	before flowering	29.0	7.5	0.35	0.25
<i>A. intermedium</i>	before flowering	30.0	12.5	0.61	0.27
<i>A. cristatum</i>	at the beginning of flowering	35.0	10.6	0.73	0.25

TUNISIA

(a) Littoral Zone (Tunis) - Percentage Digestible Constituents

<u>Species</u>	<u>Date Sampled</u>	<u>Protein</u>	<u>Fats</u>	<u>Cellulose</u>	<u>Non-N Extract</u>	<u>Metabo-lizable Energy/Kg</u>	<u>Forage Units (FU)/Kg</u>
						<u>Green Matter</u>	
<i>A. cristatum</i>	28.4.56	4.82	1.55	8.60	7.47	851c	0.21
	7.5.56	2.29	0.79	5.67	4.51	520c	0.14
<i>A. trichophorum</i>	7.5.56	2.38	1.19	8.37	7.46	762c	0.20

In Tunisia Corriols (1965) has also estimated the forage value of dryland *A. cristatum* at 0.18 forage unit/kg and 36 g of digestible protein/kg green forage, while he also records the following forage unit production for *A. cristatum* and *A. desertorum* :

	<u>Second Year Forage Units/ha</u>	<u>Third Year Forage Units/ha</u>
<i>A. cristatum</i>	1,500	800
<i>A. desertorum</i>	1,000	700

ALGERIA (a) Littoral Zone (Algiers)

Analysis of Green Forage of *A. elongatum* in Spring Vegetative Stage

Water		:	78.6 %
<u>% Crude Composition Dry Basis</u>			<u>% Digestible Constituents</u>
Fats	3.00		3.48
Albumin	11.60	}	9.98
Non Albumin	3.66		
Sugars	9.31		
Cellulose	23.40		13.94
Non N-Extract	34.47		24.50
Ash	14.56		0
Crude Energy Total	per 100		58.52
<u>Number of Forage Units</u>			
Per 100 kg dry			67.3
Per 100 kg green			14.4
<u>Mineral Matter</u>			
Ash total % dry			14.56
CaO			0.631
MgO			0.144
P ₂ O ₅			0.578
Alkalinity m. equivalents			29.6
Alkalescence m. equivalents		+	53.0
P/Ca			1.07

MOROCCO

Percentage Composition

Species	Date Sampled	Water	Ash	Protein	Non-N Extract	Fats	Cellulose
<i>A. elongatum</i>							
green matter	30.5.50	51.50	3.49	3.74	27.76	2.38	11.18
dry matter	30.5.50	0	7.19	7.72	57.22	4.80	23.67

1.11 Forage and Seed Production

Forage yields :

In the sub-steppic zone of Iran the following dryland forage yields in June are reported (AGP:SF/IRA 10, Tech. Rep. No 1, 1970) for nursery and/or field stands of *A. cristatum*, *A. desertorum*, *A. elongatum*, *A. intermedium*, *A. tauri* and *A. trichophorum* at Homand (320-350 mm annual rainfall, 1,960 m elevation) :

Nursery stands								
Species	1966		1967		1968		1969	
	Age of stand in years	DM yield kg/ha	Age of stand in years	DM yield kg/ha	Age of stand in years	DM yield kg/ha	Age of stand in years	DM yield kg/ha
<i>A. cristatum</i> (introduced from the USA)	3	1,900	4	830	5	1,020	6	1,670
<i>A. desertorum</i> (introduced from the USA)	6	960	7	1,740	--	--	1 ⁺	894 ⁺
<i>A. elongatum</i> (introduced from the USA)	5	1,140	6	1,740	--	--	1 ⁺	880 ⁺
<i>A. intermedium</i> (introduced from the USA)	--	--	--	--	--	--	1 ⁺	700 ⁺
<i>A. tauri</i> (introduced from the USA)	3	3,380	4	1,410	5	1,980	6	4,160
<i>A. trichophorum</i> (introduced from the USA)	6	840	7	40	--	--	1 ⁺	900 ⁺
Spring rainfall (March-May) mm	175.4		148.6		188.6		282.9	
+ figure obtained from field stands								

In the littoral zone (400-600 mm annual rainfall) Corriols (1965) reports the following production of forage units in Tunisia for dryland *A. cristatum*, *A. desertorum*, *A. trichophorum* and *A. intermedium* of USA origin :

Species	Second year : Forage Units	Third year : Forage Units
<i>A. cristatum</i>	1,500	800
<i>A. desertorum</i>	1,000	700
<i>A. trichophorum</i>	2,000-3,500	1,800
<i>A. intermedium</i>	2,800	1,500

Corriols (1965) also records the following forage production data for dryland *A. cristatum*, *A. desertorum*, *A. trichophorum* and *A. intermedium* of USA origin in the littoral zone (400-600 mm annual rainfall) of Tunisia :

1955-56 (664.7 mm rainfall)				1956-57 (492.2 mm rainfall)			
<u>Second Year</u>				<u>Third Year</u>			
kg/ha green matter	kg/ha dry matter	kg/ha digestible protein	Forage Units/ ha	kg/ha green matter	kg/ha dry matter	kg/ha digestible protein	Forage units ha
<i>A. cristatum</i>							
8,443	2,955	303	1,519	4,999	1,749	179	899
<i>A. desertorum</i>							
5,557	1,944	200	1,000	3,999	1,399	143	719
<i>A. trichophorum</i>							
18,775	6,946	431	3,755	8,888	3,288	204	1,777
<i>A. intermedium</i>							
14,220	5,261	327	2,844	7,888	2,918	181	1,577

In Algeria green forage yields of 8,000-12,000 kg/ha have been recorded for *A. elongatum* at a height of 20-40 cm in the early spring, while Barbut (1954) reports a full spring yield of 27,000 kg/ha for a native variety of *A. elongatum* in the littoral zone (Algiers), and Gallacher (1972) 28,000-38,000 kg/ha in the high plateau zone (Medea) for a native and introduced variety.

In the steppic zone (Midelt region) of Morocco Otamane (1974) reports that a three year old dryland field stand of *A. cristatum* has yielded 300 % more forage than the adjacent *Artemisia herba-alba* range.

Seed yields :

In the sub-steppic zone of Iran seed production of *A. cristatum*, *A. desertorum* and *A. elongatum* in field stands has varied from 10-120 kg/ha under dryland conditions ; in some years hot dry winds during flowering have seriously interfered with seed set leading to poor seed production. Seed yields were generally highest in the second and third years and declined thereafter. Seed yields of *A. elongatum* were greatly improved under irrigation at Karadj in the steppic zone (1,320 m elevation, 225 mm annual rainfall) where flowering occurred 2-3 weeks earlier. Seed production of dryland *A. elongatum* and *A. trichophorum* has also been greatly improved in the steppic zone (1,000-1,500 m elevation) in Afghanistan near Kabul with supplementary irrigation (Rouffie 1969).

In Algeria dryland seed yields for *A. elongatum* of 250-300 kg/ha have been recorded in the littoral zone and high plateau region, and Barbut (1955) records a seed yield of 170 kg/ha for a native variety of *A. elongatum*.

1.12. Utilization

Time of use and weed control :

It is generally recommended that utilization of all the previously mentioned *Agropyron* spp. should not take place until the autumn of the second year to allow proper rooting and establishment.

In Algeria, Morocco and Tunisia it is considered important to weed between the rows of established *Agropyron* spp., and in the case of *A. elongatum* to cut off the old stems in the summer before autumn re-growth commences.

In Iran it has proved necessary to control weeds particularly *Hulthemia persica* which can adversely affect developing field stands of *Agropyron* spp. ; deep cultivation and spraying of *H. persicus* when in full flower (spring) with 2,4D ester, prior to autumn seeding of *Agropyron* spp. has provided effective control.

Grazing and conservation of hay :

The best time to graze *Agropyron* spp. is the early spring (March-April) when the plants are leafy and palatable ; grazing them at this time enables the grazing pressure to be taken off the native ranges which are not yet ready to graze.

Agropyron spp. can also be utilized for hay, but if hay or seed production is required grazing should not continue beyond the end of March ; a palatable leafy hay crop can be obtained if all the *Agropyron* spp. previously mentioned are cut before flowering when their forage value is still relatively high.

Stocking rate :

In the Midelt region of Morocco Fallon (1974) reports that an established dryland stand of *A. cristatum* can be stocked at approximately 1 sheep unit (SU) per ha yearlong compared to 0.3 sheep unit (SU) for native *Artemisia herba-alba* range ; for *A. intermedium* the stocking rate has been in excess of 2 sheep units (SU) per hectare yearlong. Lamb production per ewe was also substantially increased and during April-October the live-weight gain for native lambs grazing seeded *A. cristatum* was nearly three times greater than for lambs grazing native range ; native cattle grazing *A. cristatum* at this time also recorded substantial weight gains.

Soil conservation :

Because of their spreading rhizomes and strong root habit *A. elongatum*, *A. trichophorum* and *A. intermedium* as well as *A. tauri* are valuable species for erosion control. Pabot (1967) mentions that *A. tauri* is a useful species for stabilizing shifting limestone slopes in N. Iran, while Ibrahim (1965) reports that *A. elongatum* is a valuable sand binder in N. Egypt (UAR) where it is recommended for sand dune fixation together with *Acacia saligna* and *Cynodon dactylon*.

Pasture longevity :

Although few if any seeded dryland stands of all the previously mentioned *Agropyron* spp. have been maintained for longer than 5-7 years in North Africa and the Near and Middle East evidence from similar semi-arid areas in the USA, such as Idaho (Hull 1972), indicate that stands of *A. cristatum* and *A. desertorum* can be maintained for up to 25 years under grazing use, although *A. elongatum* has proved short lived in dryland seedings in Idaho (Douglas et al 1960).

Further evaluation :

In the future more attention needs to be paid to the collection and selection of native ecotypes of promising *Agropyron* spp. and their evaluation under grazing use since some promising material exists particularly in the Near and Middle East.

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TECHNICAL DATA

SHEET No 2

GRAMINEAE (= POACEAE)

Arrhenatherum spp.

2.1. Species

In North Africa and the Near and Middle East there are three indigenous *Arrhenatherum* spp. useful for forage which are :

- *A. elatius* (L.) P. Beauv. ex J.S. et C.B. Presl,
- *A. kotschy* Boiss., and
- *A. palaestinum* Boiss.

2.2. Synonyms

- *A. elatius* (= *Avena elatior* L.)
- *A. kotschy* (= *A. palaestinum* (non (L.) Boiss.)
- *A. palaestinum* (= *A. elatius* var *palaestinum* Boiss.).

2.3. Common Names

- | | | |
|---------------------|---------|---|
| - <i>A. elatius</i> | English | False Oat Grass,
Tall Oat Grass,
French Rye Grass,
Meadow Oat Grass, |
| | French | Avoine Elevée,
Fenasse,
Fromental,
Ray-Grass français, |
| | Arabic | Azekkoun (Morocco), |
| - <i>A. kotschy</i> | Arabic | Sha'ferug (Iraq). |

2.4. Brief Description

- *A. elatius* is a loosely tufted perennial with stout culms, glabrous or hairy at the nodes growing to a height of 150 cm with glabrous or sparsely hairy lemmas and short to long awns (10-20 mm) ; (Fig. 1) ;
- *A. kotschy* is a loose tufted perennial with glabrous culms, often with a bulbous base and reaching a height of 100 cm, with hairy lemmas and straight awns ; (Fig. 2.) ;
- *A. palaestinum* is an erect tufted perennial with glabrous culms and always a bulbous base, well developed spikelets, and lemmas covered with long hairs up to the middle ; (Fig. 3).



Fig. 1

Arrhenatherum elatius (L.) P. Beauv. ex J.S. et C.B. Presl

1. Habit, $\times \frac{2}{3}$. 2. Spikelet, $\times 4$. 3. Lower glume, $\times 4$. 4. Upper glume, $\times 4$.
5. Florets, callus, portion of lower lemma dorsal view, $\times 4$. 6. Lower lemma, $\times 4$. 7. its palea, $\times 4$. 8. Flower, $\times 4$. 9. Grain, $\times 4$. 10. Ligule, $\times 4$.

(After Flora of Iraq, vol. 9, Gramineae, 1968, p. 324, plate 118)



Fig. 2 - *Arrhenatherum kotschyi* Boiss.

1. Habit, $\times \frac{2}{3}$. 2. Spikelet, $\times 4$. 3. Lower Glume, $\times 4$. 4. Upper Glume, $\times 4$. 5. Spikelet with Glumes removed, $\times 4$. 6. Lower Lemma, $\times 4$. 7. its Palea, $\times 4$. 8. Flower with rudimentary ovary, $\times 16$. 9. Upper floret seated on rhachilla, $\times 4$. 10. its Lemma, $\times 4$. 11. its Palea, $\times 4$. 12. Flower, $\times 16$. 13. Grain, $\times 3$. 14. Ligule, $\times 4$.

(After Flora of Iraq, Vol. 9, Gramineae, 1968, p. 326, plate 119).

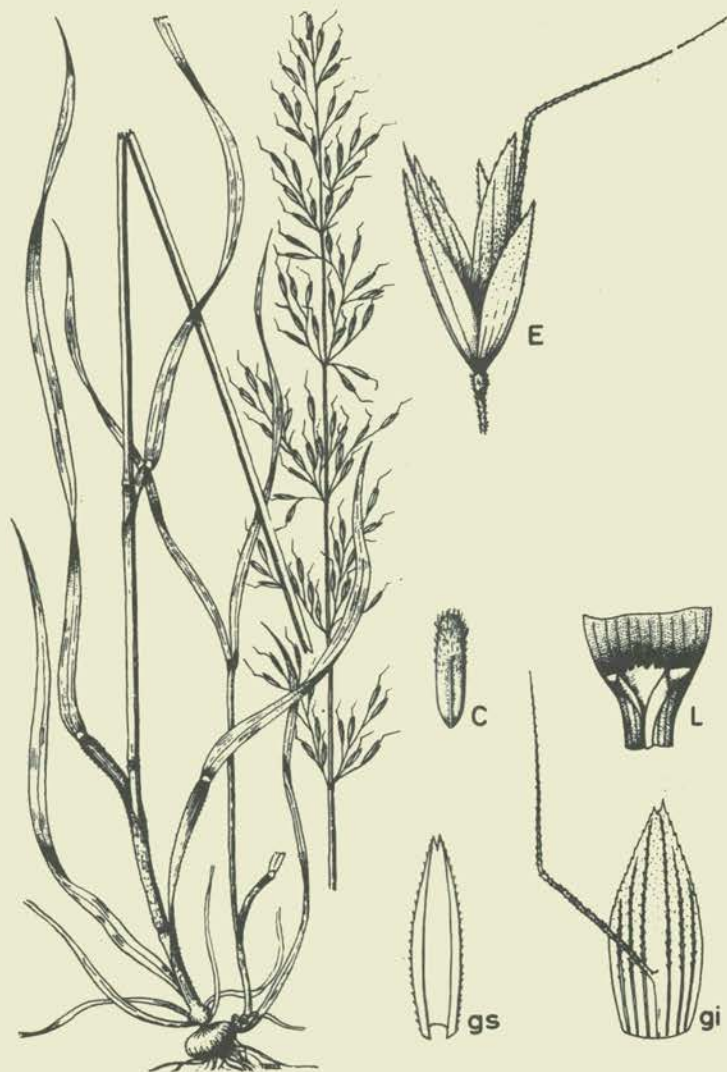


Fig. 3 - *Arrhenatherum elatius* var *bulbosum*

Plant, x1. E : Spikelet, x5. gi : Inferior Glumella, x5.
gs : Superior Glumella, x5. C : Caryopsis, x5. L : Ligule, x5.

(After Introduccion al Estudio de las Especies Pascícolas Espanolas,
Madrid, 1965, p. 51)

2.5. Varieties

Botanical forms and varieties :

A. elatius is a polymorphous species with a variety of botanical forms or types occurring. In North Africa Maire (1953) records the following botanical sub-species varieties and forms :

- ssp. *erianthum* (Boiss. et Reut.) Trabut in B. et T.
(= *A. precatoria* Thuill. ; *A. erianthum* Boiss. et Reut. ;
Avena hispanica Lange ; *A. elatius* var. *bulbosum* Coss. et
Dur.) (Fig. 3)
with long inferior lemmas softly villous on the margins in the
middle ; present throughout Algeria and Morocco ;
- f. *villinode* Maire et Weiller, nov. nom.
type sub-species with naked nodes ; present throughout Algeria
and Morocco ;
- f. *Riofrioi* (Sennen) Maire et Weiller
(= *A. erianthum* var. *Riofrioi* S. et Ma.)
with glabrous nodes ; present here and there but more rare than
the type sub-species ;
- ssp. *eu-elatius* Maire in M., C.
with inferior glabrous lemmas ; present in the Rif and Grand
Atlas in Morocco ;
- var. *vulgare* Koch.
(= *Avena elatior* var. *vulgaris* Fr.)
with inferior internodes, not swollen and glabrous nodes ;
present in the Rif and Grand Atlas in Morocco ;
- var. *bulbosum* (Willd.) Koch.
(= *Avena precatoria* Thuill. ; *A. bulbosa* Willd.)
with inferior swollen tuberos internodes ; rare but present
in the Rif and Grand Atlas in Morocco and also recorded by
Parsa (1950) in N. Iran ;
- f. *lasiarthrum* Maire et Weiller, nov. nom.
type variety with hairy nodes ; present throughout Algeria
and Morocco ;
- f. *glabrinode* Maire et Weiller, n. forma
with glabrous nodes ; present in Algeria and Morocco.

2.6. Number of Chromosomes

- *A. elatius*, $4x = 28$,
- for *A. kotschyi* and *A. palaestinum* not known.

2.7. Geographical Distribution

A. elatius is distributed in Europe, Cyprus, Lebanon, Syria, Palestine, Jordan, Turkey, Caucasus, Iraq, Iran, India, C. Asia (Turkemenia), Macaronesia (Canaries), North Africa (Morocco, Algeria) and introduced into North and South America, Japan, Australia, New Zealand, and South Africa ;

A. kotschyi is distributed in Palestine, Lebanon, Syria, Turkey, Transcaucasus, Iraq, Iran and Afghanistan ;

A. palaestinum is distributed in Rhodes, Palestine, Lebanon, Syria, Jordan, Turkey and Iraq.

2.8. Biology and Ecology

Growth and development :

A. elatius, *A. kotschyi* and *A. palaestinum* are all cool season species propagating themselves by seed.

In the mediterranean region Villax (1963) records that *A. elatius* grows fairly well where the winters are mild and humid. Under dryland conditions growth is active after the onset of autumn rains and growth continues up till late spring or early summer ; in the littoral zone *A. elatius* also withstands the heat and dry periods well. In the summer when the forage starts to dry up *A. elatius* benefits from supplementary irrigation.

In the sub-steppic zone of Iran *A. elatius* is one of the earliest grasses to grow in dryland plantings along with *Agropyron cristatum*, *Bromus tomentellus* and *Hordeum bulbosum* ; vegetative growth begins in early March, the heading (boot) stage in early April, flowering in mid-June and seed production in early July. Some vegetative growth occurs in July and August which is more pronounced in the xerophilous forest zone (2,600 m elevation) but plants of *A. elatius* are largely dormant until the end of September when the amount of re-growth depends on the incidence of autumn rains.

Under dryland conditions growth and development of *A. elatius* has also been excellent in the Caspian Forest zone of Iran which has generally adequate spring and summer rainfall and maximum summer temperatures of $25-30^{\circ}\text{C}$. ; here growth of plants is continuous from March to November and plants have not been damaged by winter temperatures of -2 to 5°C . in January.

Climate and soils :

A. elatius resists cold temperatures fairly well although in the sub-steppic zone of Iran developing seedlings in dryland plantings have proved sensitive to late spring frosts.

In Iran *A. elatius* has proved well adapted to dryland cultivation in the sub-steppic, xerophilous forest and Caspian Forest zones where annual rainfall varies from as low as 320 mm in the sub-steppic zone at Homand (1,960 m elevation) to more than 600 mm in the Caspian Forest zone at Sang Deh (1,200 m elevation).

A. elatius is well adapted to light to heavy calcareous soils but it is not suited to acid soils or soils liable to waterlogging or flooding.

Ecological characteristics :

Ecologically *A. elatius* is found here and there in forest clearings and mountain pastures generally in humid habitats up to an elevation of 3,000 m in North Africa and the Near and Middle East.

In North Africa Maire (1953) records that *A. elatius* is more rare in the semi-arid areas preferring the more humid localities.

In the Near East Pabot (1959) records *A. elatius* as occurring in the Cedar Zone (1,500 - 2,000 in elevation) of Lebanon and also in the mountains of Syria adjacent to Lebanon ; he also records *A. palaestinum* as being present but rare in the high Mediterranean zone (1,000-1,500 m elevation) in Lebanon.

Mouterde (1966) also records *A. kotschyi* as occurring in the mountains and interior of Lebanon and Syria, while Kasapligil (1956) records *A. palaestinum* in rocky places and in wadis on terra rossa soil at an elevation of 200-725 m in Jordan.

In Iraq Bor and Guest (1968) record *A. elatius* as occurring mainly in the upper forest zone in clearings, in sheltered gullies or open places in oak scrub on limestone or on boulder scree at 800-1600 m elevation, where it flowers and fruits from May-July ; *A. kotschyi* is also recorded in the upper forest zone on steep rocky limestone slopes at 900-1800 m elevation where it flowers and fruits from May-June.

In Iran Parsa (1950) records *A. elatius* as being present in the mountains of the western region, while he records *A. kotschyi* in the Elburz mountains at an elevation of 2,400-2,600 m, in rocky places at Guilan between Rasht, and Ghazvin at 600 m elevation in the region of Arak and Hamadan, and on calcareous schist in the region of Meshandagh at an elevation of 2,000 m in N.W. Azerbaidjan.

2.9. Cultivation Techniques

Time of seeding :

In the sub-steppic zone of Iran the best time of seeding *A. elatius* has proved to be the spring (31 March-15 April) ; spring seeding is also recommended in the Caspian Forest zone (Kernick, 1971, Dumancic, 1974).

Land preparation :

A well prepared, firm, fine seed-bed is required for planting which has involved ploughing to a depth of 10-15 cm, following by a discing, dragging and rolling in the sub-steppic zone, while deeper ploughing (40 cm depth) followed by two discings have proved necessary on the heavier soil in the Caspian Forest zone.

Seed rate and method of seeding :

In the sub-steppic zone of Iran on calcareous brown soil, a seed rate of 5-10 kg/ha for *A. elatius* has proved sufficient for establishing fields stands either with a McCormick Orchard Drill at 50 cm spacing, or with a John Deere Drill at a spacing of 15-20 cm ; rice hulls have been mixed with the seed of *A. elatius* in the drill, with the seed-setting lever in the fully open position, to ensure uniform seeding. Seeds have emerged well from a depth of seeding of 1-3 cm.

In the Caspian Forest zone Dumancic (1975) records that *A. elatius* has been successfully broadcast seeded in mixture with *Dactylis glomerata* and *Medicago sativa* where it formed 30 % of the mixture.

In the Mediterranean region Villax (1963) also recommends seeding *A. elatius* in mixture with other species amongst which he considers *Dactylis glomerata*, *Medicago sativa* and *Trifolium pratense* to be especially suitable. Villax (1963) records that *A. elatius* can also be established by cuttings spaced 40-60 cm apart in and between the rows.

In mixture the seed rate for *A. elatius* can be reduced to 9-13 kg/ha (Whyte et al., 1959) but when seeded alone Villax (1963), in Morocco, recommends a seed rate of 20-30 kg/ha seeded in lines spaced 50-70 cm apart.

Fertilizer application :

In Morocco Villax (1963) recommends the application of fertilizer to dryland plantings of *A. elatius*, and he records that it responds to nitrogen fertilizer. In the Caspian Forest Dumancic (1975) reports that 200 kg/ha of superphosphate (46 % P_2O_5) and 150 kg/ha of ammonium nitrate (23 % N) were applied at seeding to a mixture of *A. elatius* with *Dactylis glomerata* and *Medicago sativa*, followed in subsequent years by 80 kg/ha of urea (46 % N) applied in April.

2.10. Forage Value

Palatability :

In Morocco Villax (1963) records that *A. elatius* is a little bitter to the taste in the green state and is not grazed readily by live-stock. However in Iran *A. elatius* has proved to be one of the most palatable of all the dryland grasses tested in the sub-steppic zone at Homand (AGP: SF/IRA 10, Tech. Rep. 1, 1970).

In palatability grazing tests with native sheep *A. elatius* was very well grazed in the vegetative, boot, flowering and seed production stages in the spring and early summer and was well grazed in the summer and autumn in the vegetative stage. The stems and leaves of *A. elatius* were generally smooth and soft throughout its life cycle and were clearly relished by live-stock. Studies in the USA have also shown *A. elatius* to be palatable to both sheep and dairy cattle (Heath et al 1973).

Nutritive value :

The nutritive value of *A. elatius* is also considered to be high particularly in the hay stage (Villax 1963). In the Caspian Forest zone Dumancic (1975) records the following chemical composition data for dryland *A. elatius* seeded at Sang Deh.

Chemical Composition

Phenological Growth Stage	Dry Matter %	Crude Protein %	Ca %	P %
Beginning of Flowering	25,5	10,7	0.31	0.25
End of Flowering	33.0	7.5	1.00	0.25

2.11. Forage and Seed Production

Forage yields :

In the sub-steppic zone of Iran the following forage yields have been recorded (AGP:SF/IRA 10, Tech. Rep. 1, 1970) for nursery and/or field stands of dryland *A. elatius* :

Yield kg/ha DM		
<u>Year</u>	<u>1968</u>	<u>1969</u>
Age of stand in years	2	3
	2.800 <u>1/</u>	2.090 <u>1/</u>
		700 <u>2/</u>
Spring rainfall (March-May) mm:	188.6	282.9

	<u>1/</u> nursery stands	
	<u>2/</u> field stand	

In the Caspian forest zone Dumancic (1975) records over a two year period (1972-1973) green forage yields varying from 12,840-37,350 kg/ha for a mixture of *A. elatius* with *Dactylis glomerata* and *Medicago sativa* in nursery plots at Sangh Deh, and green forage yields varying from 39,430-66,100 kg/ha for a mixture of *A. elatius* and *Medicago sativa* in field plots at Darzi Kola ; in both years annual rainfall exceeded 500 mm and was well distributed in the spring and summer.

In the littoral zone (500-600 mm annual rainfall) of Morocco at Rabat Villax (1963) records average green forage yields varying from 20,000-40,000 kg/ha for dryland *A. elatius* in experimental plantings.

Seed yields and seed cleaning :

Villax (1963) records average seed yields for experimental dry-land stands of *A. elatius* varying from 300-600 kg/ha.

Seed production can present difficulties since the seed heads mature unevenly unless a non-shattering variety of *A. elatius* is grown. Cleaning of the seed is also difficult although processing facilitates cleaning. Fortunately processing is facilitated by the ease with which the caryopses thresh free from the hull (Heath et al., 1973).

2.12. Utilization

Time of use and establishment :

In the sub-steppic zone of Iran where *A. elatius* is seeded in the spring, field stands have not been utilized until the following spring to ensure good establishment.

However, in the littoral zone of N. Africa, as reported for *Hordeum bulbosum*, where seeding is carried out after the first autumn rains, *A. elatius* could be cut for hay in the spring which would still give time for the plants to root strongly.

Grazing and conservation for hay :

A. elatius can be utilized for pasture but is likely to prove most valuable for hay production in dryland plantings. In the USA Heath et al. (1973) report that *A. elatius* is less valuable for pasture than other grasses because of its tendency to produce heads throughout the season ; in some instances its successful use for pasture appears to depend on rotational grazing scheduled to keep animals off the grass during the critical heading period. *A. elatius* also does not persist under close continuous grazing.

Pasture longevity :

A. elatius under favourable conditions can prove to be a long-lived species but in many parts of the USA it has been used as a rapidly developing short-lived (2-3 years) grass. Experience available in North Africa and the Near and Middle East is of too short duration to indicate the longevity of *A. elatius* and even for nursery stands in Iran, data is only available for 2-3 years.

Further evaluation :

In the future more attention needs to be given to the collection, testing and evaluation of native ecotypes of *A. elatius*. It may also be worthwhile to give some attention to the collection and evaluation of ecotypes of *A. kotschyi* and *A. palaestinum* since the latter species in particular may be more drought resistant than *A. elatius*.

2.13. Specific Reference

ILIEV, A.
1966

Tall oatgrass with non-shattering seeds.
Nauch. Trud. Vissh Selskostrop Inst. Plovdiv,
15(1): 151-161.

TECHNICAL DATA

SHEET No 3

GRAMINEAE (= POACEAE)

Bromus spp.

3.1. Species

In the Near and Middle East there are four indigenous *Bromus* spp. of importance for forage which are :

- *B. cappadocicus* Boiss. et Bal.,
- *B. inermis* Leyss.,
- *B. tomentosus* Trin.,
- *B. tomentellus* Boiss.

3.2. Synonyms

- *B. tomentellus* (= *Zerna tomentellus* Boiss.),
- *B. tomentosus* (= *B. persicus* Boiss.).

3.3. Common Names

- | | | |
|-------------------------|---------|--|
| - <i>B. inermis</i> | English | Awnless Brome,
Hungarian Brome,
Smooth Brome. |
| | French | Brome de Hongrie,
Brome sans arête. |
| - <i>B. tomentellus</i> | English | Smooth Mountain Brome Grass,
Russian Brome Grass. |

3.4. Brief Description

- *B. cappadocicus* is a caespitose bunchgrass reaching a height of 60 cm which is very similar to *B. tomentellus* but less robust with thinner leaves and spreading fruit bearing pedicels ;

- *B. inermis* is a tall rhizomatous bunchgrass reaching a height of 50-100 cm with long wide dark green leaves (Fig. 1) ;

- *B. tomentellus* is a densely caespitose bunchgrass with strong fibrous roots reaching a height of 20-60 cm, with a mixture of sterile and fertile glabrous shoots and a spreading concentrated panicle (Fig. 2) ;

- *B. tomentosus* is a glaucous caespitose bunchgrass with stout short running rhizomes taller than *B. tomentellus*, reaching a height of 70 cm and with abundant densely hairy, sometimes glabrous foliage (Fig. 3).



Fig. 1 - *Bromus inermis* Leyss

(After Prairie grasses identified and described by vegetative characters,
Canad. Dept. Agric., publication n. 1413, 1971, p. 75)



Fig. 2 - *Bromus tomentellus* Boiss.

1. Habit, $\times \frac{2}{3}$. 1a. Reticulate basal fibres enlarged. 2. Spikelet, $\times 2$.
3. Lower glume, $\times 3$. 4. Upper glume, $\times 3$. 5. Lemma, $\times 3$. 6. Palea, $\times 3$.
7. Flower, $\times 9$. 8. Grain, $\times 3$. 9. Ligule, $\times 4$

(After Flora of Iraq, vol. 9, Gramineae, 1968, p. 163, plate 55)

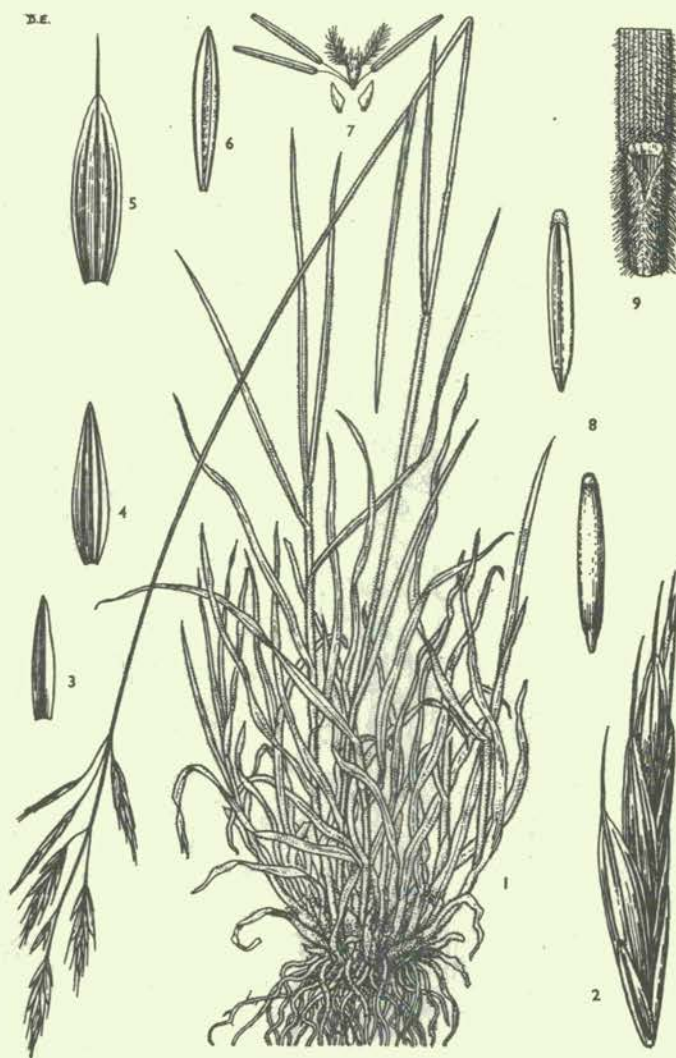


Fig. 3 - *Bromus tomentosus* Trin.

1. Habit, x1. 2. Spikelet, x3. 3. Lower glume, x3. 4. Upper glume, x3.
4. Lemma, x3. 5. Palea, x3. 7. Flower, x3. 8. Grain, x3. 9. Ligule, x4.

(After Flora of Iraq, vol. 9, Gramineae, 1968, p. 165, plate 56)

3.5. Varieties

Botanical varieties and forms :

Several botanical varieties of *B. inermis* and *B. tomentellus* have been noted in the Middle East. Bor (1960) and Kitamura (1960, 1964) mention the following botanical varieties for *B. inermis* in Afghanistan, N. Pakistan and N.W. India :

- var. *confinis* (Nees ex Steud) Stapf in Hook.f. (= *B. confinis* Nees ex Steud)
present at Kunawar in the Himalaya and at Kuram ;
- var. *inermis*
present in Kashmir ;
- var. *villosa* Mert. et Koch.
present at Karakoram at 3,800 m elevation.

Parsa (1950) also mentions the following botanical varieties of *B. tomentellus* for Iran :

- var. *glabratus* Bornm.
with a naked indumentum ; present in the Damavand region of the Elburz Mts at 2,700-2,800 m elevation ;
- var. *nivalis* Bornm.
with a short panicle ; present at Kandavan and Asadbar in the Elburz Mts.
- var. *tauricolus* Nabêlek.
with a shorter and more rigid stem and pink spikelets ;
present chiefly in W. Kurdistan region of Turkey and perhaps in N.W. Iran.

Pabot (1967) points out that *B. tomentellus* is a variable species and comprises several varieties and probably numerous ecotypes ; those present in the Khorrasan region of Iran are less hairy and their leaves remain green much longer in the summer.

Native ecotypes :

A dozen native ecotypes of *B. tomentellus* have been introduced under dryland conditions in the sub-steppic zone of Iran (Homand, 1,960 m elevation) and enough seeds have been produced to permit field plantings to be established ; two native ecotypes of *B. tomentellus* have also been collected in the mountains of Lebanon (Pabot, 1959).

Several native ecotypes of *B. cappadocius* collected in N. Iran have also been introduced in dryland nurseries in the sub-steppic zone of Iran (Homand, 1,960 m elevation) along with a number of native ecotypes of *B. tomentosus*.

Pabot (1967) states that there are two distinct forms of *B. persicus* (= *B. tomentosus*): one very hairy found in the mountains to the north of Karadj, the other almost glabrous and with less dense foliage occurring in the region of Damavand.

Agricultural varieties :

In regard to agricultural varieties of *B. inermis* Villax (1963) considers that they can be classed into two types : those from Europe, originally from Hungary, which support the drought and also the heat, and those from Siberia that are adapted to the forest regions in Sweden and Canada.

Several exotic agricultural varieties of *B. inermis* have been introduced under dryland conditions in North Africa and the Near and Middle East.

In Tunisia Corriols (1963) reports that the varieties INIA 441 and 2075 of *B. inermis* from Spain and No 8468 from Portugal have done well in dryland test plantings at Tunis.

In the lower mountain zone of Iraq Hussain (1975) records for *B. inermis* promising results with the variety "Manchar" originally from Manchuria, and introduced from the USA, while the varieties "Lincoln", "Mandan", "Southland" and "Elsberg", also from the USA, have performed fairly well in the sub-steppic and Caspian forest zones of Iran.

In the USA a variety, P-2447, of *B. tomentellus* has also been developed from an introduction originally from the USSR in 1934, but has not been released (Hanson, 1965).

3.6. Number of Chromosomes

- *B. cappadocius*, $2x = 42$;
- *B. inermis*, $2x = (28, 42, 49), 56 (54-58)$;
- *B. tomentellus* and *B. tomentosus* : not known.

3.7. Geographical Distribution

B. tomentellus is native to Turkey, Asia Minor, and the USSR, and is also distributed in Palestine, Lebanon, Syria, Iraq, Iran and Afghanistan ; its southern limit goes through the northern mountains of Iraq as shown in the distribution map (Fig. 4) ;

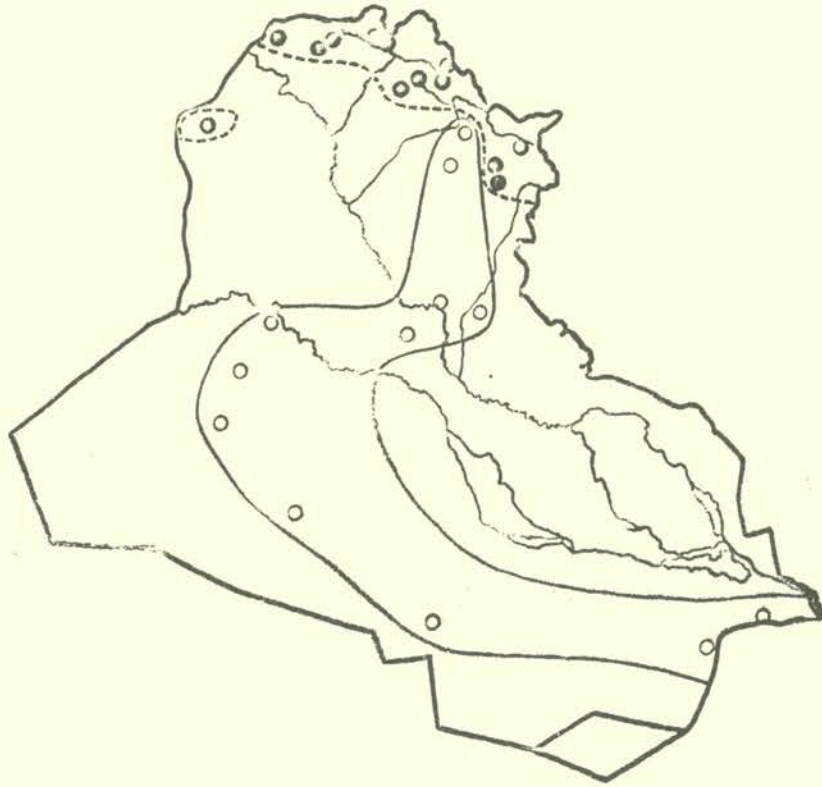


Fig. 4 - Distribution Map of *B. tomentellus* (●),
B. sericeus (o) in Iraq.

(After Candollea, 25 (2), p. 251)

B. cappadocicus is distributed in E. Turkey and N. Iran ;

B. inermis is distributed in Europe and temperate Asia and is present in N.W. Iran, Afghanistan, Pakistan and N.W. India ;

B. tomentosus is distributed in the Caucasus, Iraq, Iran and probably also in Turkey.

3.8. Biology and Ecology

Germination, growth and establishment :

B. tomentellus, *B. cappadocicus*, *B. inermis* and *B. tomentosus* are all cool season species propagating themselves by seed.

In the sub-steppic zone (1,960-2,050 m elevation) at Homand and Firuzkuh, the main growth period of these *Bromus* spp. is in the spring period (March-June), although spring growth of *B. tomentellus* is earlier than for the other species. Vegetative growth starts in mid-March, heading (boot) in early April, flowering in mid-June and seed production at the end of June or early July. A little summer growth occurs but plants remain largely dormant until the autumn.

The foliage of *B. inermis* and also of some native ecotypes of *B. tomentellus* remains green throughout the summer period. Autumn growth which is small depends on the incidence and amount of early rains (September-October).

In general, *B. tomentosus* shows less vigorous growth than the other *Bromus* spp. and appears to require more moisture. The germination of seeds of *B. tomentellus*, *B. cappadocicus* and *B. tomentosus* is generally excellent, even from hand seedings, but *B. inermis* sometimes shows delayed germination which leads to the formation of irregular or patchy stands.

According to Pabot (1967) overgrazing seems to impede the flowering of *B. tomentellus*, but it is not easily grazed out and it can form 50 cm broad green tufts in the dry steppe. The production of seeds of *B. tomentellus* is often variable, depending on the year, the spikes sometimes being devoid of seeds due to scalding by hot dry winds.

In the Bekaa valley of Lebanon, El-Moursi (1969) records that dryland seeded *B. inermis* planted in March produced a ground cover of 75-100 percent by November.

In Tunisia Corriols (1965) reports a 100 % germination of seeds of *B. inermis* in dryland test plantings in the littoral zone at Tunis after seeding in mid-December ; heading and seed formation occurred from the end of May to mid-June and plants remained green throughout the summer period until growth re-commenced at the end of September. In the north of Tunisia

at higher elevation, growth in summer in dryland conditions continues a little longer than in the littoral zone.

Villax (1963) also mentions that growth of dryland *B. inermis* in North Africa continues up until the commencement of the summer dry period ; during the summer the plants remain in a dormant state although they respond well to supplementary irrigation.

Climate and soils :

In regard to climate and edaphic conditions *B. tomentellus* and also *B. cappadocicus*, *B. inermis* and *B. tomentosus* are very resistant to cold and drought and *B. tomentellus* in particular has shown promise even for planting in the steppic zone (1,300 m elevation, 200 mm annual rainfall) in N. Iran. *B. tomentellus* is also adapted to a wide range of soils but does not like soils which are too skeletal or located on too steep slopes.

In Iran *B. inermis* has proved most adapted to the xerophilous forest zone (+400 mm annual rainfall, 2,600 m elevation) and to the Caspian forest zone (+600 mm annual rainfall, 1,200 m elevation) where it grows well on calcareous clay soils.

In North Africa Villax (1963) also records that *B. inermis* is well adapted to clay-loam soils that are fairly fertile although it also performs well on poor even sandy soils.

Ecological characteristics :

Ecologically *B. tomentellus*, *B. cappadocicus*, *B. inermis* and *B. tomentosus* appear to be restricted largely to the non-steppic mountains of the Near and Middle East where the annual rainfall is in excess of 400 mm.

In Lebanon Pabot (1959) records *B. tomentellus* as being abundant in the sub-alpine zone (2,000-2,500 m elevation) and also common in the Cedar zone, while in Syria Pabot (1957) also records *B. tomentellus* as occurring in the mountains adjacent to Lebanon.

In both the mountains of Lebanon and Syria Mouterde (1966) records that *B. tomentellus* flowers from April to June or later at the higher elevations.

In Iran *B. tomentellus* is common in most of the mountains of the west and north-west from 1,000 up to 3,400 m elevation (Pabot, 1961). Here *B. tomentellus* is often found growing on stony lands or non-steppic mountains in association with *Festuca ovina* and herbaceous perennials in particular those that are semi-woody or cushion like.

B. cappadocicus is found in Anatolia in Turkey and in N.W. Iran it occurs at lower elevation on the Moghan hills and up to approximately 2,000 elevation.

Parsa (1950) reports that *B. inermis* occurs in N.W. Iran in Azerbaidjan in the region of Zandjanab and Tabriz, while it also occurs at high elevation up to 3,800 m in the mountains of Afghanistan and W. Pakistan.

B. tomentosus according to Pabot (1967) is very common on stony slopes of certain regions of the Elburz Mts between 1,800-3,000 m elevation where it is found growing on steep stony slopes with *Agropyron tauri*, *Hordeum fragile*, *Oryzopsis molinioides* and cushion-like or semi-woody perennials ; it appears, unlike *B. tomentellus* and *B. cappadocicus*, to need an annual rainfall of at least 400 mm.

Despite its relatively low productivity Pabot (1967) considers that *B. tomentellus* to be one of the most promising grasses for re-seeding uncultivated mountain lands especially if the desired purpose is to obtain pastures able to maintain themselves over many years and to regenerate spontaneously.

B. cappadocicus can also be considered as an alternative to *B. tomentellus* at elevation of less than 1,000 m.

3.9. Cultivation Techniques

Time of seeding :

B. tomentellus, *B. cappadocicus*, *B. inermis* and *B. tomentosus* have all been seeded in dryland nursery plantings and/or adaptability test rows (3 m) in the xerophilous forest and sub-steppic zone, while *B. tomentellus*, *B. inermis* and *B. tomentosus* have been seeded on a field scale in the sub-steppic zone and *B. tomentellus* also in the steppic zone of N. Iran (AGP:SF/IRA 10, Tech. Rep. No 1, 1970).

In North Iran the best time of seeding for all the *Bromus* spp. mentioned has proved to be the spring (31 March-15 April) in the sub-steppic zone but equally successful stands of *B. tomentellus* were obtained from autumn (November) as well as spring seeding in the steppic zone.

In the lower mountain zone of N. Iraq, Hussain (1975) also records that the best time of seeding for dryland *B. inermis* was in the spring (last week of February and first week of March) and in the Bekaa plain of Lebanon, El-Moursi (1969) also records good results from seeding dryland *B. inermis* in early March.

In the Mediterranean region Villax (1963) records that *B. inermis* under dryland conditions is always seeded after the first autumn rains.

Land preparation :

For seeding *Bromus* spp. a firm well prepared seed-bed is required which in the steppic and sub-steppic zone has involved ploughing, discing, dragging and rolling the soil ; the weed *Hulthenia persica* (Rosaceae) has proved troublesome but effective control was obtained by spraying the ester of 2-4 D in the spring when the weed was in full flower and before seeding of *Bromus* spp. took place.

Seed rate and method of seeding :

Planting of *Bromus* spp. is normally done by direct seeding ; vegetative propagation has also proved useful for establishing ecotype or variety collections in nurseries. *B. inermis* and *B. tomentellus* are sometimes sown in mixture with other grasses, legumes or herbs and seed rates, spacing and/or mixtures which have been reported from various countries are the following :

<u>Morocco</u>	<i>B. inermis</i>	20-25 kg/ha of seeds broadcast or seeded in lines 30-70 cm apart ; depth of seeding 2-3 cm <u>or</u> cuttings 50 cm apart in and between the lines.
<u>Iraq</u>	<i>B. inermis</i>	15 kg/ha of seeds drilled in lines spaced 50-60 cm apart on level land ; depth of seeding 1-2 cm, <u>or</u> 10-15 kg/ha of seeds broadcast in contour furrows spaced 1-2 m apart or on the berm of contour trenches spaced 4 m apart on sloping and steep land.
<u>Iran</u>	<i>B. tomentellus</i> , <i>B. cappadocicus</i> , <i>B. inermis</i> and <i>B. tomentosus</i>	5-10 kg/ha of seeds drilled in lines spaced 15-20 or 50 cm apart ; depth of seeding 1-2 cm, <u>or</u> cuttings 50 cm apart in and between the rows ; in mixture 10 kg/ha of seeds of <i>B. tomentellus</i> and 10 kg/ha of seeds of <i>Onobrychis sativa</i> or <i>Poterium sanguisorba</i> .

For *B. tomentellus* in N. Iran Peymani and Tarifi (1974) also report that for dryland seeding 10 kg/ha is the preferred seed rate. Since the seed of *B. tomentellus* is fluffy it first must be passed through a hammer mill ; alternatively the seeds can be mixed with rice hulls and the seed rate setting of the drill left in a fully open position.

For *B. tomentellus*, *B. inermis* and *B. tomentosus* drilling in N. Iran has been done using a conventional grain drill (John Deere), pitter seeder (Massey-Harris) or Orchard Drill (McCormick). The following figures 5, 6 and 7 show established dryland seeded field stands of *B. tomentellus* at Firuzkuh (sub-steppic zone) and Nowdehak (steppic zone) and of *B. inermis* at Homand (sub-steppic zone).



Fig. 5

Part of a stand of *Bromus tomentellus*
planted at Firuzkuh in autumn 1967. May 1969.

(After Pasture and Fodder Crops Investigations, Iran, Tech.
Rep. No 1, 1970, p. 83, Fig. 15)



Fig. 6 - A dense 2 year old stand of *Bromus tomentellus* seeded in autumn at Nowdehak. May 1969.

(After Pasture and Fodder Crops Investigation, Iran, Tech. Rep. No 1, 1970, p. 85, Fig. 20)



Fig. 7 - Experimental sheep grazing a stand of *Bromus inermis* planted at Homand in the spring of 1968. Smooth brome was the most readily grazed of the grasses ; June 1969.

(After Pasture and Fodder Crops Investigation, Iran, Tech. Rep. No 1, 1970, p. 93, Fig. 36)

3.10

Forage Value

Palatability :

B. tomentellus, *B. cappadocicus*, *B. inermis* and *B. tomentosus* are all palatable to livestock and particularly sheep. In N. Iran, palatability grazing tests with native sheep in the sub-steppic zone at Homand showed that *B. inermis* was more palatable than *B. tomentellus* and *B. tomentosus* being well grazed in the vegetative, boot and flowering stages and also fairly well grazed in the seed production stage ; *B. tomentellus* was fairly well grazed and *B. tomentosus* well grazed in the boot stage but both species were poorly grazed in the flowering and seed production stages.

Nutritive Value :

The chemical composition of *B. inermis* and *B. tomentellus* at different phenological growth stages at Homand is given below :

Percent of Dry Matter

Species	<u>Vegetative</u>		<u>Boot</u>		<u>Flowering</u>		<u>Seed Production</u>	
	Crude Protein	Crude Fibre	Crude Protein	Crude Fibre	Crude Protein	Crude Fibre	Crude Protein	Crude Fibre
<i>B. inermis</i>	16.7	19.9	-	-	7.8	28.1	5.8	29.9
<i>B. tomentellus</i>	17.7	23.7	15.2	24.8	7.5	29.5	-	-

However in the USA both Sosulski (1960) and Sosulski and Patterson (1961) report that among a number of grasses tested in regard to digestibility and intake by native sheep *B. tomentellus* had the highest apparent digestibility and rate of consumption at flowering. The following data over a 2 year period on energy content, percentage chemical composition, apparent digestion coefficients and daily consumption for forage of *B. inermis* (variety Manchur) and *B. tomentellus* (from the USSR) fed to native sheep as recorded by Sosulski and Patterson (1961) is given below :

(a) Average Energy Content and Percentage
Chemical Composition of Forage Fed to Wethers

	<u>calories/g</u>	<u>Ash</u>	<u>Ether</u> <u>Extract</u>	<u>Fibre</u>	<u>Protein</u>	<u>N.F.E.</u>	<u>Lignin</u>
	<u>1956</u>						
<i>B. tomentellus</i>	4.340	7.3	1.4	33.6	10.0	47.8	6.5
<i>B. inermis</i>	4.369	6.5	1.0	36.8	7.9	47.9	8.7
	<u>1957</u>						
<i>B. tomentellus</i>	4.381	7.9	2.1	34.7	10.1	45.2	6.5
<i>B. inermis</i>	4.216	8.5	1.6	36.7	8.5	44.7	8.8

(b) Average Apparent Digestion Coefficients
and Daily Consumption per Sheep

	<u>Digestion Coefficients</u>			<u>Daily Consumption</u>		
	<u>DM</u> <u>%</u>	<u>OM</u> <u>%</u>	<u>Energy</u> <u>%</u>	<u>DM</u> <u>g.</u>	<u>OM</u> <u>g.</u>	<u>Energy</u> <u>Calories</u>
	<u>1956</u>					
<i>B. tomentellus</i>	67.5	70.4	66.0	744	689	3,228
<i>B. inermis</i>	56.6	59.1	54.7	629	588	2,745
	<u>1957</u>					
<i>B. tomentellus</i>	65.3	67.2	63.4	559	515	2,451
<i>B. inermis</i>	54.2	56.2	53.2	492	451	2,126

In North Africa Villax (1963) and Corriols (1965) also report that the following chemical composition data for forage of dryland *B. inermis* :

Morocco

Percentage Chemical Composition

<u>Species</u> <u>and Variety</u>	<u>Nature</u> <u>of Forage</u>	<u>Water</u>	<u>Protein</u>	<u>Fats</u>	<u>Carbohydrates</u> <u>soluble fibre</u>	<u>Ash</u>
<i>B. inermis</i> (French Variety)	Hay	11.3	14.0	1.3	21.3 38.0	14.0

Tunisia

Percentage Digestible Products

Species and Variety	Date Sampled	Protein	Fats	Cellulose	Non-N Extract	Metabolizable	Forage Units/kg Green Matter
						Energy/kg	
<i>B. inermis</i> (Spanish Variety)	17.4.56	2.30	0.94	6.09	5.04	566 c	0.16
	17.5.56	2.74	0.92	6.05	4.88	574 c	0.16

3.11. Forage and Seed Production

Forage yields :

In the sub-steppic zone of N. Iran at Homand the following spring (June) dryland forage yields have been reported (AGM:SF/IRA 10, tech. Rep. 1, 1970) for nursery and on field stands of *B. tomentellus*, *B. inermis* and *B. tomentosus* :

Nursery Stands

	1966		1967		1968		1969	
	Age of stand in years	DM yield kg/ha	Age of stand in years	DM yield kg/ha	Age of stand in years	DM yield kg/ha	Age of stand in years	DM yield kg/ha
<i>B. tomentellus</i>	4	1,550	5	650	6	820	7	4,850
<i>B. inermis</i>	3	1,150	4	670	5	700	6	900
							2 ⁺	620 ⁺
<i>B. tomentosus</i>	-	-	-	-	-	-	2 ⁺	270 ⁺
Spring Rain-fall (March-May) mm :	174,5		148,6		188,6		282,9	
+ Figure obtained from field stands								

In the littoral zone of Tunisia, at Tunis, Corriols (1965) also records the following experimental dryland forage production data for three varieties of *B. inermis* over a two year period :

1955-56 (664,7 mm rainfall) <u>Second Year Stand</u>					1956-57 (492,2 mm rainfall) <u>Third Year Stand</u>				
Variety	green matter kg/ha	dry matter kg/ha	digestible protein kg/ha	Forage Units/ ha	green matter kg/ha	dry matter kg/ha	digestible protein kg/ha	Forage Units/ ha	
No 441 261 (INIA Spain)	17,109	4,448	427	2,737	7,554	1,964	188	1,208	
2.075 261 (INIA Spain)	13,665	3,552	341	2,186	6,221	1,617	155	995	
8.468 (Portugal)	14,443	3,755	361	2,310	6,999	1,819	174	1,119	

In the littoral zone (500-600 mm annual rainfall) of Morocco, at Rabat, Villax (1963) also reports average green forage yields of dryland of *B. inermis* varying from 14,000-28,000 kg/ha and hay yields from 3,500-7,000 kg/ha under experimental conditions.

Seed yields and seed harvesting :

In the sub-steppic zone of N. Iran, at Homand (1,960 m elevation, 320-350 mm annual rainfall) the seed yield of *B. tomentellus* and *B. inermis* has varied from 50-120 kg/ha, and for *B. tomentellus* in particular hot dry winds have adversely affected the seed yield of this species and also *B. tomentosus* in some years.

Seed production under irrigation in the steppic zone at Karadj (1,300 m elevation), where flowering occurs 3-4 weeks earlier in the spring, greatly increased the seed yields of *B. inermis* compared to that obtained in dryland plantings at Homand, but the seed yields of *B. tomentellus* and *B. tomentosus* were not affected.

In the littoral zone (500-600 mm annual rainfall) of Morocco, at Rabat, experimental seed yields of *B. inermis* have varied from 300-500 kg/ha (Villax, 1963).

No data on field scale seed harvesting methods for *Bromus* spp. is available in the region, but in the USA Heath et al. (1973) state that the seed of *B. inermis* should be allowed to ripen fully before harvesting with a combine harvester ; to reduce the amount of green material entering the seed bags with the seed, the crop is harvested when the culms have dried below most of the seed heads but before shattering occurs.

3.12

Utilization

Time of use and grazing management :

B. tomentellus, *B. cappadocicus*, *B. inermis* and *B. tomentosus* are best utilized for grazing but under dryland conditions grazing should not take place before the autumn of the second year to ensure good establishment.

In the steppic and sub-steppic zone of N. Iran early spring (March) grazing of *B. tomentellus* is considered beneficial since it delays the formation of flowering stems and promotes tillering of new leaves. For *B. inermis* early spring grazing is not generally recommended in order to allow the primary tillers to develop to the point of maximum production.

Grazing and conservation for hay :

B. inermis provides also an adequate hay crop as well as pasture and in N. Africa Villax (1963) recommends cutting for hay at the formation of the panicles.

Pasture longevity :

Villax (1963) points out that in the second year forage production is generally superior to that of the first year, but thereafter the production gradually diminishes ; in the north of the Mediterranean region the longevity of *B. inermis* stands has been 15-20 years in some instances, while in the south stands have only lasted 3-4 years.

Soil conservation :

Both *B. tomentellus* and *B. inermis* are also considered to be useful for soil conservation. Woods et al. (1953) in the USA report that *B. tomentellus* produced high root yields in mixture with *Medicago sativa* under dryland conditions and was valuable for soil conservation , while Heath et al. (1973) report that *B. inermis* has proved useful in mixture with other sod-forming grasses for the re-vegetation of eroded slopes and terraces.

Further evaluation :

In the future more attention needs to be paid to the collection, multiplication and evaluation of native ecotypes of the *Bromus* spp. previously mentioned. *B. tomentellus* in particular seems to offer a good potential since it is long-lived and well adapted to the harsh environment of much of the mountain zone of the Near and Middle East.

TECHNICAL DATA

SHEET No 4

GRAMINEAE (= POACEAE)

Cenchrus spp.

4.1. Genus and Species

The 25 species of the genus *Cenchrus* are distributed in warm, predominantly tropical and sub-tropical areas of the world, mostly in arid and semi-arid regions.

In North Africa and the Near and Middle East there are two indigenous *Cenchrus* spp. of particular importance, which are *C. ciliaris* L. and *C. setigerus* Vahl.

4.2. Synonyms

- *C. ciliaris* (= *Pennisetum ciliare* L.)
- *C. setigerus* (= *C. biflorus* Roxb.)

4.3. Common Names

- | | | |
|-----------------------|---------|---|
| - <i>C. ciliaris</i> | English | Buffel Grass (Australia) ;
African Foxtail (Africa) ;
Anjan Grass,
Dhamnan Grass (India). |
| | French | <i>Pennisetum cilié</i> . |
| | Arabic | Kram Kram, Regina (Tunisia) ;
Bougouiba, Shoultel Far, Sibouss
(Morocco) ;
Subat, Subbat, Hamra, Gharaz
(Saudi Arabia) ;
Gharaz (Qatar) ;
Hada, Drab, Hemri Rigl-el-Ghoraab,
Khafoor (Egypt, UAR). |
| - <i>C. setigerus</i> | English | Black Kolukatti Grass, Mada Dhamnan
Grass, Anjan Grass (India) ;
Birdwood grass (Australia). |
| | Arabic | Haniteeb, Yaraab, Yarrah, Yerrah,
Yerro (Egypt, UAR). |

4.4. Brief Description

C. ciliaris is a tufted or rhizomatous tussock grass growing to a height of at least 30-80 cm with flowering stems, branching at the base, with whitish or pinkish panicles and groups of spikelets enclosed by hairy bristles (Fig. 1, 2 and 4) ;

C. setigerus is a tufted grass, sometimes annual, without rhizomes, growing to a height of 70-100 cm with flowering stems ; rather similar to smaller non-rhizomatous types of *C. ciliaris* but of more erect habit (Fig. 3 and 4). *C. setigerus* differs from *C. ciliaris* in having hard spiny bristles or burrs which are fused on the outside with the lower part of the involucre : in India the involucre is coloured dark purple, but is straw coloured in East Africa.

4.5. Varieties

Botanical varieties and forms :

A number of botanical varieties of *C. ciliaris* are recorded by Maire (1952) in N. Africa which are the following :

- var. *genuinus* (Leeke) Maire et Weiller comb. nov.
(= f. *ciliare* var *genuinus* (Leeke),
hairs on plants are red-brown or pinkish ; common throughout N. Africa ;
- var. *pallens* (Fenzl ex Leeke) Maire et Weiller comb. nov.
(= f. *ciliare* var *pallens* Fenzl (ex Leeke)
hairs on plants yellow or ordinarily very pale ; common in Algeria and the central Sahara ;
- var. *leptostachys* (Leeke) Maire et Weiller
(= *P. ciliare* var *leptostachys* (Leeke) Maire et Weiller
hairs on plants pink, inflorescence elongated, slender, pauciflorous ; present in Algeria ;
- var. *setigerus* (Vahl) Maire et Weiller comb. nov.
(= *P. ciliare* var *setigerus* Leeke, l.c., *C. setigerus* Vahl)
hairs on plants pink or pale pink, spikelets nearly uniflorous, inflorescence pauciflorous and very loose ; present in Algeria, Morocco.

Native ecotypes :

Pabot records that the native ecotypes of *C. ciliaris* occurring in Iran are very variable and sometimes cannot be easily distinguished from certain varieties of *Pennisetum orientale*. He recommends that they first be collected and grouped from the various regions of Iran in order to compare them with each other, as well as with introduced exotic varieties. Pabot (1961) also considers that the Khuzistan ecotype of *C. ciliaris* should be studied and multiplied.

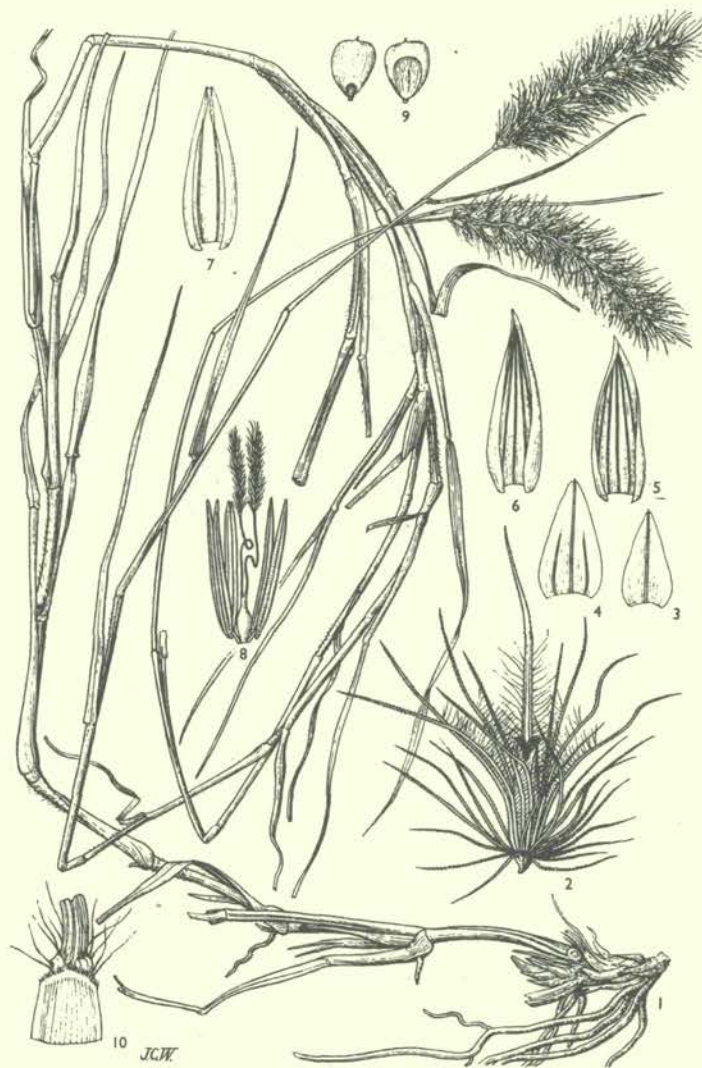


Fig. 1 - *Cenchrus ciliaris* L.

1. Habit, $\times \frac{2}{3}$. 2. Spikelet with involucre, $\times 4$. 3. Lower glume, $\times 6$.
4. Upper glume, $\times 6$. 5. Lower lemma, $\times 6$. 6. Upper lemma, $\times 6$. 7. its palea, $\times 6$. 8. Flower, $\times 6$. 9. Grain, $\times 8$. 10. Ligule, $\times 8$.

(After Flora of Iraq, vol. 9, Gramineae, 1968, p. 475, plate 182)



Fig. 2 - *Cenchrus ciliaris* Linn.

1. Plant, $\times \frac{1}{2}$. 2. Spikelet with supporting bristles (sterile branches).
3. Lower glume. 4. Upper glume. 5. Lower lemma. 6. Upper lemma. 7. Palea
of upper lemma. (all $\times 4$).

(After Grasses of Burma, Ceylon, India and Pakistan
1960, p. 288, Fig. 33)

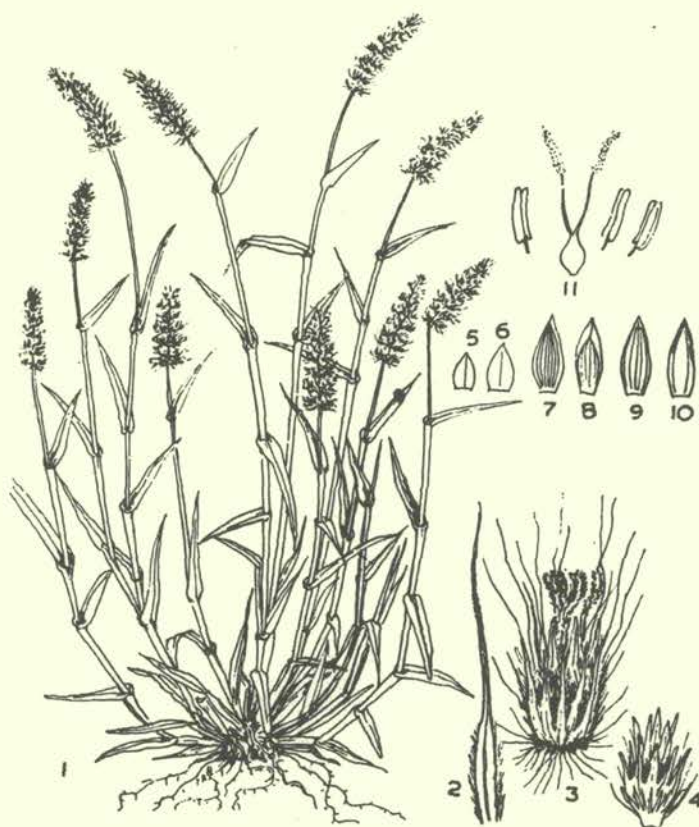


Fig. 3 - *Cenchrus setigerus*

1. Plant, $\times \frac{1}{3}$. 2. Bristle, $\times 10$. 3. Spikelets with their involucels.
4. Involucel. 5. First glume. 6. Second glume. 7. Third glume.
8. Palea of third glume. 9. Fourth glume. 10. Ovary and stamens.

(After Forage Crops of India, p. 184, fig. 12)

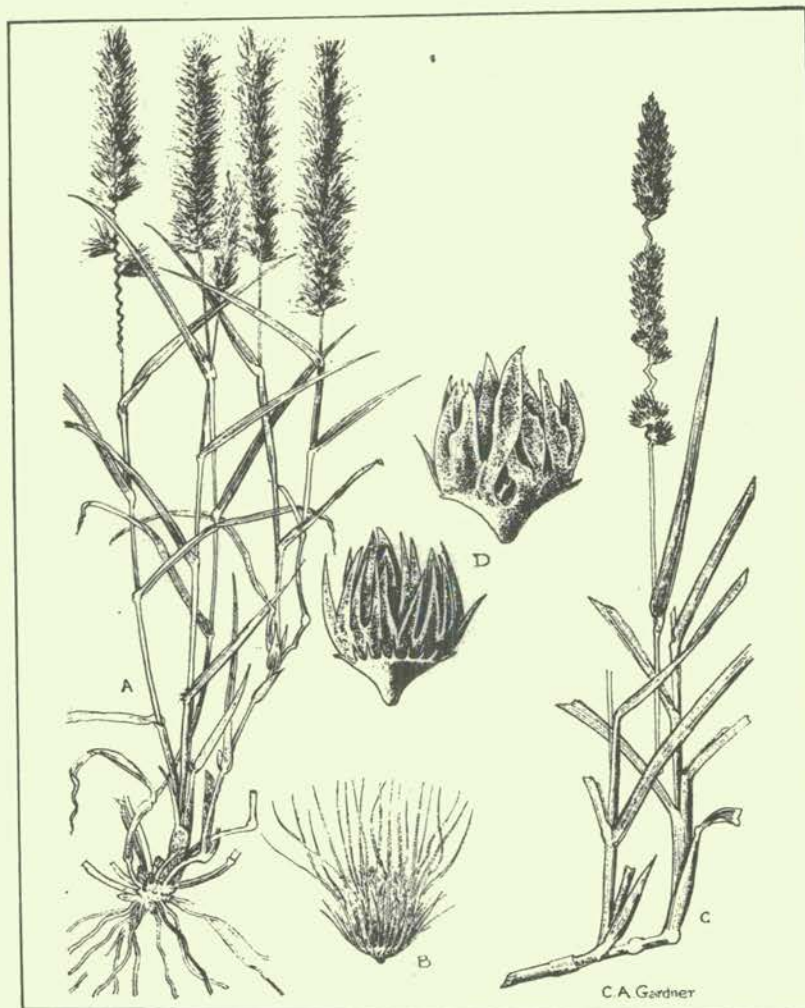


Fig. 4 - (a) *Cenchrus ciliaris*, (b) *Cenchrus setigerus*
(After J. Dept. Agric. West. Austr., No 4, 1955, Fig. 1, p. 82)

Patil and Singh (1963) and Patil et al (1964) also record the isolation of some 53 distinct types within a collection of *C. ciliaris* and *C. setigerus* made in Western India ; in N. W. India various growth forms of *C. setigerus* also occur from prostrate to erect.

Agricultural strains, cultivars and varieties :

At the Central Arid Zone Research Institute, Jodhpur, India and also at the Indian Agricultural Research Institute, New Delhi, a number of strains of both *C. ciliaris* and *C. setigerus* have been developed that are specifically adapted to the arid regions of Rajasthan and the alpine and sub-alpine regions of the Himalaya slopes (Dabadghao and Shankarnarayan, 1973).

In the Rajasthan desert strains 214, 262, 303, 357 and 358 of *C. ciliaris* and strain 1548 of *C. setigerus* have shown the greatest adaptation (Puri and Paliwal, 1976) ; strains 19, 49, 115, 159, 170 and 280 of *C. setigerus* have also been tested under minimal irrigation in the sub-desertic zone of Iran (Kaul et al, 1974).

For the purpose of selection of strains of *C. ciliaris* giving higher seed yield the breadth of the spike may be a good index as well as the weight of caryopses (Chakravarty and Kalkani, 1966).

Several strains of *C. ciliaris* have also been developed for dry-land seeding in the Thal desert of W. Pakistan and one strain has also been noted that remains green 2-3 weeks longer after normal winter dormancy (Khan, 1971) ; the imported varieties 'Molopo' and 'Biloela' from Australia have also performed well in the Sind desert of W. Pakistan (AG/DP/PAK/71/001 Term. Rep. 1975).

In Morocco native strains of *C. ciliaris* have proved a little longer lived but a little less productive than varieties such as 'Blue Buffel' and T. 4464, from the USA in dryland test plantings (Giscard, 1961).

Cultivars of *C. ciliaris* grown and/or developed in Australia and described by Barnard (1972) belong to two major types :

- (a) Tall vigorous, stoloniferous cultivars often with bluish leaves and hard stems which are regarded as suitable for cattle grazing ;
- (b) Late-growing less vigorous non stoloniferous cultivars with finer and softer stems, and more suitable for sheep.

Among the tall growing cultivars are the following :

- 'Biloela' selected in Queensland from Tanzania introductions; leaves are bluish and is a good seed producer ;

- 'Molopo' originating from South Africa, more rhizomatous, later flowering and poorer seed producer than 'Biloela' but more cold tolerant ;
- 'Boorara' has slightly finer stems and more leafy than 'Biloela' ;
- 'Lawes' originating from South Africa, differs from 'Biloela' by its wider leaves ;
- 'Nunbank' originating from Uganda and is rather similar to 'Lawes' ;
- 'Tarewinnbar' originating from Kenya differs from 'Biloela' in having green leaves without any bluish tint, more robust stems and purplish ears ;
- 'Higgins grass' developed in Texas, USA, is reputed to combine good persistence with high yields of forage and seed.

Among the low-growing cultivars are the following :

- 'Gayndah' originating from Kenya and produces numerous tillers ;
- 'West Australian' an old introduction with numerous tillers and narrow leaves ;
- 'American' introduced as commercial seed from the USA and is similar to Gayndah but is less dense and flowers earlier ;
- 'Chipinga' originating from Rhodesia and has bluish foliage ;
- 'Mbalambala' originating from Kenya and has a semi-prostrate habit forming broad tufts with numerous tillers that are liked by cattle.

A commercial variety of *C. setigerus* has also been developed from naturalized introductions in the Northern Territory of Australia (Milton Moore, 1970).

4.6. Number of Chromosomes

- *C. ciliaris*, $2x = 32, 34, 36, 40, 44, 52$ and 54 have been found ; apomictic but with some sexuality permitting the use of apomictic male parents and sexual female parents in breeding programmes.

- *C. setigerus*, $2x = 36, 34$ and 37 , irregular, and hexaploids with $2x = 54$ also found ; apomictic but being pseudogamous pollination is required for the development of the endosperm.

According to Delisle (1963) the evidence for apomixis in both *C. ciliaris* and *C. setigerus* as well as the presence of intermediates between these two taxa suggests that both are members of a single agamic complex. Hybridization of sexual *C. ciliaris* and *C. setigerus* at the Texas Agricultural Experiment Station, USA, has also resulted in a vast array of sexual and apomictic types (Bashaw et al., 1970).

4.7. Geographical Distribution

C. ciliaris is distributed in Sicily, Palestine, Syria, Jordan, Sinai, Egypt (UAR), Arabia, Kuwait, Bahrain, Iran, Iraq, Afghanistan, India, Morocco, Algeria, Tunisia, Libya, Macaronesia, tropical Africa, S. Africa and introduced into Australia and N. America ;

C. setigerus is distributed in Algeria, Morocco, Tunisia, Libya, Egypt (UAR), Arabia, S. Iran, Pakistan, N.W. India, tropical Africa and introduced and naturalized in N.W. Australia.

4.8. Biology and Ecology

Growth and establishment :

C. ciliaris and *C. setigerus* are both warm season species propagating themselves by seed and well adapted to drought but not cold ; in Morocco introduced varieties of *C. ciliaris* have been winter killed by prolonged freezing, but where frost is not too severe only the aerial foliage is affected and re-growth from the base of the plants occurs in the spring (Giscard, 1961).

In the littoral zone of N. Africa (400-600 mm annual rainfall) spring growth of *C. ciliaris* is excellent and continues into the summer and sometimes even into the autumn and winter if temperatures are mild (Villax, 1963). Growth is also rapid after spring seeding and seed production occurs before the end of summer. In Egypt (UAR) Tackholm et al. (1941) record that plants of *C. ciliaris* flower from December to May.

In contrast *C. setigerus* has grown poorly under dryland conditions in Morocco (Giscard, 1961) reaching a height of only 30-40 cm in the littoral zone (400-600 mm annual rainfall) ; in Libya maximum growth of a native strain of *C. setigerus* occurred under dryland seeding conditions in the hot season (July-August) (Goam, 1959). In N. Africa Maire (1952) records that indigenous *C. setigerus* flowers in the spring and summer in the littoral zone and after the rains in the Sahara.

In the Thal desert (150-300 mm annual rainfall) of Pakistan, the main growth pattern of dryland *C. ciliaris* on sandy soils follows the incidence of rainfall (February-April and July-September) ; growth is dormant at the end of May-June (dry period) and in the winter (November-January). The degree of growth is also highly correlated with monthly rainfall, 40-50 mm giving substantial growth in any one month and even in the following month if there is no rainfall (Khan, 1970). After the monsoon there is an abundance of seeds available.

In the Thal desert stands of *C. ciliaris* seeded in July usually flower in August and late sowings (August) in mid-March on receipt of spring showers ; spring germinated seedlings flower within 4 weeks. Depending on moisture conditions the tussocks of established plants sprout at the end of January and produce inflorescence by mid-March and the fruits start maturing at the end of April (Khan, 1969).

Seed characteristics :

The seeds of both *C. ciliaris* and *C. setigerus* are dimorphic producing both large and small seeds (Lahiri and Kharabanda, 1961). The small seeds exhibit low germination. On germination they produce two independent seedlings. Lahiri and Kharabanda (1962, 1963) have also found water soluble germination inhibitors in the glumes which can be regarded as an adaptation to variations in rainfall from year to year (Bogdan, 1977).

Root development :

Root studies in the Rajasthan desert have shown *C. setigerus* to have in general a less well developed root system than *C. ciliaris* and therefore possibly to be less drought resistant.

Climate and soils :

C. ciliaris is well adapted to seeding in the littoral areas of N. Africa with mild winters ($3-7^{\circ}\text{C}$) and at least 400 mm annual rainfall and to other areas of N. Africa and the Near and Middle East such as S. Morocco, Sahara, Arabia, S. Iran and W. Pakistan with at least 200 mm annual rainfall and benefitting also from some summer rainfall (July-August) or the humid influence of close proximity to the sea ; an example of the latter case is at Agadir in S. Morocco where *C. ciliaris* has been successfully seeded in the littoral zone (250 mm rainfall) where it benefits from the increased humidity emanating from the Atlantic Ocean (Ionesco, 1977).

In Australia Fitzgerald (1955) also reports that the growth of dryland seedlings of *C. ciliaris* benefits from heavy dews which are prevalent in coastal areas.

C. setigerus is best adapted to seeding in arid and semi-arid sub-tropical areas with at least 200 mm rainfall such as occurs in parts of S. Morocco, the Sahara, Arabia, S. Iran and W. Pakistan which benefit also from some summer rainfall.

Both *C. ciliaris* and *C. setigerus* are adapted to a wide range of soils especially those that are light and sandy and also to rocky and stony soils. However, *C. ciliaris* does not tolerate well flooding on soils with poor internal drainage ; in contrast *C. setigerus* is reported (Bogdan, 1977) to grow on black heavy clays in Kenya with impeded drainage and is found on granite and basalt soils in Egypt (UAR) (Tackholm, 1974).

Ecological characteristics :

Ecologically *C. ciliaris* is a very important but spasmodic component of the vegetation throughout N. Africa and the Near and Middle East but in most cases it has been severely depleted through over-grazing. Pabot (1967) reports that in the Khuzistan and Fars regions of Iran it is practically only found on rocky and stony slopes (up to 800 m elevation) which serve as its last refuge.

In Libya it is reported (Oram, 1959) to persist more on deep coastal sandy soils where it is often found growing in association with *Hyparrhenia hirta* and *Lasiurus hirsutus*.

In the Tunisian steppe le Houerou (1969) records *C. ciliaris* as a spasmodic component in the *Artemisia campestris* and *Echiochilon fruticosum* alliance (0-800 m elevation, 200-400 mm annual rainfall). In Jordan Kasapligil (1956) records *C. ciliaris* as occurring in the Kerak district and in the Jordan Valley at an elevation of 200-300 m.

In Syria Pabot (1957) records *C. ciliaris* as being present in the Jordanian zone where the Mediterranean climate is more warm and dry.

In Saudi Arabia *C. ciliaris* has been reported (Kingery, 1972) south of the Rub Al Khali in sandy rocky wadis in association with *Panicum turgidum*, *Salvadora persica* and *Calotropis procera* (75-250 mm rainfall) ; in sand dune massifs in association with *Cyperus conglomeratus*, *Calligonum comosum*, *Moltkia ciliata* and *Cornulaca monacantha* (less than 50 mm annual rainfall), and in the mountains (900-1,800 m elevation, 280-300 mm annual rainfall) on sandy loam to clay soils in association with *Acacia etbaica* and *Hyparrhenia hirta*.

In the Khuzistan region (200-300 mm annual rainfall) of Iran Pabot (1961) records *C. ciliaris* growing on sandy soils in association with *Aristida plumosa*, *Heliotropium persicum* and *Poa bulbosa*, while in the Sind Desert of Pakistan it is recorded (AGP:DP/PAK/71/001, Term. Rep. 1975) as growing in the lower foothill slopes (100-200 m elevation) with deep sandy soils in association with *Prosopis cineraria*, *Indigofera oblongifolia* and *Cassia holocericea*.

In India *C. setigerus* is found within a rainfall range of 125-1,250 mm and occurs on light sandy and heavy soils with a pH of about 7.5. It appears to favour situations where the soil is not too dry and is one of the principal species of the *Dichanthium/Cenchrus/Lasiurus* vegetation cover in the Rajasthan desert (Dabadghao and Shankarnarayan, 1973).

In N. Africa Maire (1952) records *C. ciliaris* and *C. setigerus* as occurring in rocky and arid habitats from the littoral zone up to the Saharan mountains.

4.9. Cultivation Techniques

Time of seeding :

In areas of the Mediterranean region with mild winters dryland seeding of *C. ciliaris* can be carried out after the first autumn rains but it is normally done at the end of the winter or beginning of spring (Villax, 1963).

In the Sind and Thal deserts of W. Pakistan seeding is carried out during the monsoon rains (end of July to mid or end August) ; sowing is not recommended before the rains as most seeds will be eaten by ants or removed by winds (AGP:DP/PAK 71/001, Term. Rep., 1975). In the Rajasthan desert (India) there has, however, been a fair amount of success from premonsoonal sowings of *C. ciliaris* in June combined with harrowing, and pelleting of seeds is under trial (Dabadghao and Shankarnarayan, 1973) ; in the Rajasthan desert *C. setigerus* is generally seeded during the monsoon (July-August).

Vegetative propagation :

C. ciliaris and *C. setigerus* can also be propagated vegetatively. Cuttings with roots, or stem cuttings in the case of varieties rooting at the node e.g. Giant Pusa Anjan (*C. ciliaris*), can be utilized and Rossiter and Delgadillo (1971) advocate propagation from tuft splits or rhizomes. Stem cuttings must be buried horizontally about 2-4 cm below the soil surface and in Morocco cuttings of *C. ciliaris* are normally planted 40-60 cm apart in and between the rows (Villax, 1963).

In the Thal desert of W. Pakistan tufts of *C. ciliaris* have also been planted on sand dunes to assist stabilization at a spacing of 150 x 150 cm, 300 x 150 cm, and 300 x 300 cm ; tufts planted during rainfall or 24 hours later gave an 80 % establishment success, but tufts that had been over-grazed prior to transplanting did not give a good survival rate compared to tufts dug out with a 20 cm long root system and a good amount of aerial foliage (Khan, 1969).

Land preparation :

The seed-bed for both *C. ciliaris* and *C. setigerus* must be well prepared to remove weed competition and ploughing and/or discing plus harrowing is normally required to obtain a firm, compact seed-bed (Daz, 1973) ; in Australia a heavy tandem disc has proved useful for cultivating compact, hard soils (Fitzgerald, 1955). A further weeding 3-4 weeks after seeding in the Rajasthan desert has been found essential for good establishment (Chakravarty and Verma, 1972).

Seed rates and spacing :

Seed rates and spacings used for dryland seeding in various countries do not differ substantially but the following have been reported :

<u>Morocco</u> (littoral zone)	for <i>C. ciliaris</i> 5-7 Kg/ha of seed in lines spaced 30 cm apart ; depth of sowing 1-3 cm.
<u>India</u> (Rajasthan desert)	for <i>C. ciliaris</i> and <i>C. setigerus</i> 5 kg/ha of seed in lines or 5-6 m shallow furrows spaced 50-75 cm apart ; depth of sowing 1-2 cm.
<u>Pakistan</u> (Sind and Thal deserts)	for <i>C. ciliaris</i> 2 kg/ha of seed sown at the bottom of shallow furrows spaced 30-40 cm apart or 4 kg/ha of seed broadcast on the surface and covered to a depth of 1 cm.

Intercropping with legumes :

At Jodhpur (300 mm annual rainfall) in the Rajasthan desert (India) trials with three annual legumes planted at a seed rate of 6-12 kg/ha in alternate rows (50 cm spacing) with *C. ciliaris* under dryland conditions showed that *Cyamopsis tetragonoloba* ('Guar') and *Phaseolus acontifolius* ('Moth') were the most suitable legumes for annual intercropping with *C. ciliaris* (Daulay et al., 1968).

Seed germination and seeding methods :

In the Rajasthan desert optimum germination has occurred from seeding *C. ciliaris* and *C. setigerus* at a depth of 1-2 cm and germination continued up to 28 days after sowing (Chakravarty and Verma, 1968) ; in test plantings in the desert of Egypt (UAR) seeds of *C. ciliaris* have exhibited delayed germination and also low germination percentages (Abd-El-Rahman and EL-Monayeri, 1967).

The seed of *C. ciliaris* and *C. setigerus* is normally sown as burrs containing 1-3 spikelets in India and W. Pakistan. In Australia Bryant (1961) records that naked caryopses of *C. ciliaris* germinated in the soil if they had been freshly mixed with superphosphate immediately before sowing ; even a 12-hour delay in sowing the superphosphate mixed seed reduced the germination. However, Bogdan (1977) reports that sowing the seeds in the involucre for both *C. ciliaris* and *C. setigerus* has given better results than sowing naked caryopses.

In Australia Fitzgerald (1955) reports that a hammer mill can be used to remove the bristles of *C. ciliaris* seed when seeding mechanically, while mixing the seed with sand or sawdust ensures an even distribution.

In Australia Fitzgerald (1955) reports that strip planting of *C. ciliaris* with strips spaced 40 m apart is effective and natural seeding eventually fills in the area not seeded.

In the Rajasthan desert of W. India the normal method of sowing seeds of *C. ciliaris* and *C. setigerus* is to broadcast them by hand on the surface or in lines or furrows, and mixing the seeds with moist sand and spreading it along the furrow bottoms ensures proper placement and soil cover (Chakravarty, 1966). Broadcasting the seeds of *C. ciliaris* has not given such good results as planting them in lines or furrows (Chakravarty et al., 1966).

In contrast large areas of range in the Thal desert (150-200 mm annual rainfall) of W. Pakistan have been successfully seeded by broadcasting seed of *C. ciliaris* over disced ploughed land and covering it with a light brush drag (French, 1968). However, Khan (1971) states that best results are achieved by shallow seeding with a mechanical seeder ; a specialized mechanical seeder has been developed at Perth in Australia and is commercially available.

Superior seeding results with *C. ciliaris* in the Thal desert have also been obtained on sandy loam to clay flats compared to re-seeding on slopes or dune crests (Khan, 1966), Fig. 5.

4.10. Forage Value

Palatability :

Both *C. ciliaris* and *C. setigerus* have been found to be palatable at all stages of growth to sheep but palatability feeding tests with cattle in the Rajasthan desert have shown both species to have a higher palatability in the flowering and seed production stages than in the vegetative and flowering stages (Dabadghao and Murwaha, 1962).

Nutritive value :

The young growth of *C. ciliaris* is more nutritious and in Australia young leaves of *C. ciliaris* can have a protein content of 18 percent on a dry matter basis, as the following chemical composition data obtained for dryland plantings in Queensland (Fitzgerald, 1955) shows :

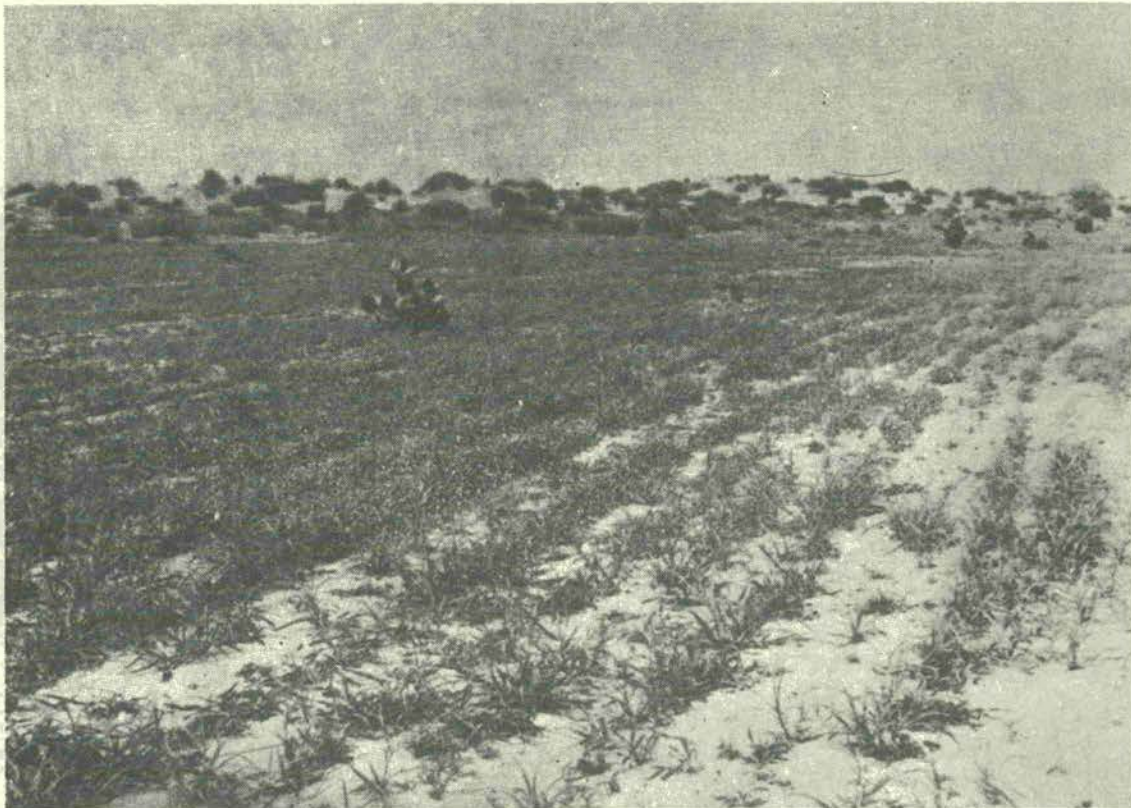


Fig. 5 - A successfully reseeded range with *Cenchrus ciliaris*
Chikken, Thal, Sown June/July 1969.

(After Pak. J. For. July 1970, p. 341, fig. 7)

Percentage Chemical Composition Dry Basis

	<u>Protein</u>	<u>Fat</u>	<u>Carbohydrates</u>	<u>Fibre</u>	<u>Ash</u>	<u>Cao</u>	<u>P2O5</u>
Young Growth	18.0	1.6	40.7	27.0	12.7	.950	.670
Stemmy leaf, with ripe seed	8.3	0.8	43.7	38.5	8.7	.272	.157
Dry stemmy plants	5.6	1.2	52.8	30.4	10.0	.250	.154

In India a protein content of 11 percent has been recorded (Narayan and Dabadghao, 1973) for young forage of *C. ciliaris* and *C. setigerus* which has also a well balanced ratio of calcium and phosphorous.

In the Rajasthan desert (300 mm annual rainfall) dryland strains of *C. ciliaris* have given protein contents on a dry matter basis ranging from 8.07 to 12.38 % ; highest protein content coming from the second cutting and the lowest from the fifth cutting. Phosphorous contents varied from 0.402 to 0.665 % (Mondal and Chakravarty, 1968). Chakravarty (1966) reports a crude protein content varying from 5-11 percent of the dry matter for different cuttings of dryland *C. setigerus* in the Rajasthan desert with the dry matter content varying from 25-40 percent and the phosphorous content from 0.21 to 0.64 percent.

Mondal and Gupta (1966) also report the following copper, iron and manganese contents for two strains (Nos 220 and 226) of *C. ciliaris* and two strains (Nos 431 and 550) of *C. setigerus* :

<u>Date of cutting</u>	<u>Copper</u> ppm				<u>Iron</u> ppm				<u>Manganese</u> ppm			
	<u>C. ciliaris</u>		<u>C. setigerus</u>		<u>C. ciliaris</u>		<u>C. setigerus</u>		<u>C. ciliaris</u>		<u>C. setigerus</u>	
Strain	220	226	431	550	220	226	431	550	220	226	431	550
25.8.1964	24	28	56	58	40	28	44	53	110	107	88	107
3.9.1964	20	20	56	56	26	26	31	40	127	94	58	70
14.11.1964	20	12	64	56	26	26	33	36	106	112	102	75
22.1.1965	28	16	64	64	40	41	35	54	70	110	75	94
12.4.1965	28	17	66	66	40	36	28	44	110	127	127	118

In India the crude fibre digestibility of *C. ciliaris* has varied from 35 to 59 percent (Narayan and Dabadghao, 1972).

Daz (1975) also reports the following average nutritional values for *C. ciliaris* and *C. setigerus* in native stands in the Rajasthan desert :

Percentage of Dry Matter Yield				
	Crude protein	Phosphorous	Digestible protein	Total Available digestible protein kg/ha
<i>C. ciliaris</i>	12.82	0.517	8.60	522.15
<i>C. setigerus</i>	8.77	0.602	4.89	168.87

In Morocco the following chemical composition data has been reported (Villax, 1963) for *C. ciliaris* grown at Rabat :

Percentage Composition						
	Water	Protein	Fat	Carbohydrates soluble	fibre	Ash
Green forage	80	2.0	0.7	8.9	6.2	2.2
Hay	20	8.2	2.7	35.5	24.7	8.9

Foury (1956) also gives the following chemical composition data for dryland seeded *C. ciliaris* sampled at Rabat in June :

	Water	Ash	Protein	Non-N Extract	Fats	Cellulose
	%	%	%	%	%	%
Green matter	70.76	3.24	2.99	13.00	0.99	9.02
Dry matter	0	11.09	10.23	44.45	3.39	30.34

Giuliani (1974) has also recorded some chemical composition data for naturally occurring plants of *C. ciliaris* in the dry state in south-West Morocco :

% of dry constituents				
Ether Extract	Cellulose	Crude Protein	Non-N Extract	Ash
1.52	30.22	5.24	55.71	7.31

4.11. Forage and Seed Production

Forage yields :

In the Rajasthan desert (Jodhpur) dryland plantings of *C. ciliaris* and *C. setigerus* have produced in 2-3 cuttings 1,620 kg/ha and 1,060 kg/ha DM respectively on sandy soils (300 mm annual rainfall) and 4,130 kg/ha DM on sandy loam soils (450 mm annual rainfall); Narayan and Dabadqhao (1972) record a yield of 9,110 kg green forage/ha/year for *C. ciliaris* in areas receiving less than 300 mm annual rainfall, while Chakravarty (1966) records a yield of 5,000 kg green forage/ha/year for *C. setigerus* in three to four cuttings from August to April. An application of 22 kg/ha of nitrogen has increased the forage yield of both dryland seeded *C. ciliaris* and *C. setigerus* by 24-47 percent (Chakravarty, 1970, Faroda, 1974).

In the Rajasthan desert intercropping of *C. ciliaris* with the legumes *Cyamopsis tetragonoloba* ('Guar') or *Phaseolus acontifolius* ('Moth') has also increased the forage yield of *C. ciliaris* in the mixture by 20-30 percent compared to the yield of *C. ciliaris* grown alone (Daulay et al 1968).

In the Thal desert of W. Pakistan (225 mm annual rainfall) individual dryland seedings of *C. ciliaris* have increased the air dry forage yield of native range from 29 kg/ha to 1,750 kg/ha after seeding; the percent cover being nil for *C. ciliaris* before seeding but rising to 14-17 % after seeding (Khan, 1970).

The result of cutting trials on re-seeded *C. ciliaris* has also indicated that cutting at a height of 5 cm gave a significantly higher air dry forage yield in October than cutting at heights of 10, 15, 20 or 25 cm, and cutting at a height of 10 cm was significantly better than cutting to a height of 25 cm; these cutting treatments also extended growth into the dry dormant period (Khan, 1970).

In Morocco, at Rabat (400-600 mm annual rainfall) hay yields on experimental plots of 5,000-10,000 kg/ha have been reported (Villax, 1963).

Seed Yields and seed harvesting :

In the Rajasthan desert (300 mm annual rainfall) at Jodhpur the seed yield of dryland plantings has reached 120 kg/ha for *C. ciliaris* and 170 kg/ha for *C. setigerus* when the plants were left to mature seed without cutting beforehand. Chakravarty (1966) considers that an average seed yield of 200 kg/ha can be obtained for *C. setigerus* under arid conditions, but the seed yield can be further increased by about 30 percent by the application of nitrogen and phosphate fertilizer combined with irrigation; under irrigation *C. setigerus* produces seeds almost the year round in the Rajasthan desert, but under dryland conditions only during September-October.

In Morocco at Rabat (400-600 mm annual rainfall) Villax (1963) records experimental dryland seed yields varying from 100-300 kg/ha.

For the harvesting of small quantities of seed hand stripping into a container is satisfactory, but large scale harvesting presents problems because the seeds ripen unevenly and shatter readily. Chakravarty (1966) recommends a simple scoop or tray with separating fingers attached to the front of a pick-up or tractor such as been used for successfully harvesting seeds of *C. ciliaris* in Australia (Stevens, 1957)

4.12. Utilization

Time of use and establishment :

It is preferable not to graze *C. ciliaris* and *C. setigerus* in the first year of establishment and to allow them to produce seeds in the second year of establishment (Ahuja, 1970). In Australia, Fitzgerald (1955) also recommends no grazing of newly seeded stands of *C. ciliaris* for the first 12 months to ensure good establishment.

Grazing and conservation for hay or silage :

C. ciliaris and *C. setigerus* both provide excellent pasture for grazing or they can be conserved as hay or silage.

For hay production both species should be harvested during the flowering stage and in the Rajasthan desert it has proved profitable to harvest hay and seed from the same crop (Chakravarty, 1970).

In the littoral zone of Morocco Villax (1963) records that dryland seeded stands of *C. ciliaris* on good soils can furnish one to two cuts for forage or seed production per year ; alternatively they can provide three to four grazings (April-May, July-September, October-November and sometimes even in January.

Pasture management and longevity :

In India Auja (1970) recommends dividing the seeded area of *C. ciliaris* or *C. setigerus* into four pasture allotments and harvesting the forage for hay from one allotment by rotation every year, while grazing the other three allotments by rotation according to the carrying capacity of the pasture.

C. ciliaris and *C. setigerus* persist well under close grazing but it is preferable to rotationally graze the pastures in order to provide adequate rest periods ; overgrazing must be avoided and periodically the pasture should be allowed to set seed before it is grazed in order to thicken the stand.

In the Sind desert a grazing pressure equivalent to an offtake of 50-75 percent of the biomass is considered essential to maintain stands of *C. ciliaris* for at least 5 years ; in the Rajasthan desert re-seeding of *C. ciliaris* stands has often proved necessary every third or fourth year (Chakravarty, 1970).

Grazing capacity and utilization :

Average grazing capacity of native stands of *C. ciliaris* in the Rajasthan desert has varied from 1-2.5 sheep and 1 cattle per hectare on a year-long basis (Chakravarty, 1970), compared to 6 sheep/ha for re-seeded *C. ciliaris*.

Daz (1975) also reports the following utilization data for dry-land seeded *C. ciliaris* and *C. setigerus* under three years grazing use in the Rajasthan desert :

On sandy soils (Jodhpur)

On sandy loam soils (Palé)

	Average No of sheep days	Average forage production kg/ha DM	Average grazing capacity sheep units	Average No of sheep days	Average forage production kg/ha DM	Average forage capacity sheep units
<i>C. ciliaris</i>	661	629.2	4.46	1,115	1,496.6	7.53
<i>C. setigerus</i>	321	353.6	2.53	889	1,137.4	6.04

On tall *C. ciliaris* pastures in northern Australia mixed grazing with sheep and cattle has proved beneficial to pasture utilization (Purcell and Stobbs, 1965) ; for mature stands Fitzgerald (1955) recommends grazing first with cattle to remove heavy growth followed by sheep to graze the aftermath.

Soil conservation :

C. setigerus is also considered to be a useful species for erosion control on sandy soils, particularly the stoloniferous varieties.

Further evaluation :

In the future more attention needs to be paid to the collection and selection of native ecotypes of *C. ciliaris* and *C. setigerus* and their evaluation under grazing use since much promising material exists in the region.

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TECHNICAL DATA

SHEET No 5

GRAMINEAE (= POACEAE)

Cynodon dactylon (L.) Pers.

5.1. Synonyms

Cynodon dactylon (= *Panicum dactylon* L.)

5.2. Common Names

- English Devil grass, Star grass, Creeping finger grass, Bermuda grass, Wire grass (USA) ; Bahmas grass, Hariah grass (India) ; Couch grass (Australia) ; Scutch grass (Jordan, Libya).
- French Gros chiendent, Chiendent pied de poule, Herbe des Bermudes.
- Arabic Adjezmir, Endjil, Kezmir, Nedjib, Zabak (Morocco) ; Azezmir, Najem, Negem, Nejem (Tunisia) ; Ndgil, Nejzeel, Nejzim (Libya) ; Nigeel (baladi) Nisheel Takabalt, Moddeid, Meddaad, Motteit (Egypt UAR) ; Shirsh-un-unjil (Jordan) ; Al-Nagil, Al-Thayel (Syria) ; Irq An-Najil, Najin, Najir, Rashshad (Iraq) ; Rishad, Rashad, Thayyil (Saudi Arabia) ; Najeel (Qatar) ; Nigil (Yemen).

5.3. Brief Description :

Perennial grass creeping extensively by scaly pale-white rhizomes or by strong flat stoloniferous stems, the old bladeless sheaths of the stolons and the lowest one of the branches often forming conspicuous pairs of dog's teeth ; flowering culms flattened usually erect or ascending, variable, 10-40 cm tall ; leaves short narrowly linear or lanceolate, soft with flat blades, glabrous or pilose on the upper surfaces, the ligule is a conspicuous ring of white hairs, spikes 2-8, slender 2-5 cm long digitately arranged on the summit of the erect penduncle ; spikelets compressed, sessile, arranged on one side ciliated on the keel ; fruit (caryopsis) free (Fig. 1 and 2).

5.4. Varieties

Botanical varieties :

Several botanical varieties of *C. dactylon* occur in North Africa and the Near and Middle East. Maire (1953) records the following in North Africa :

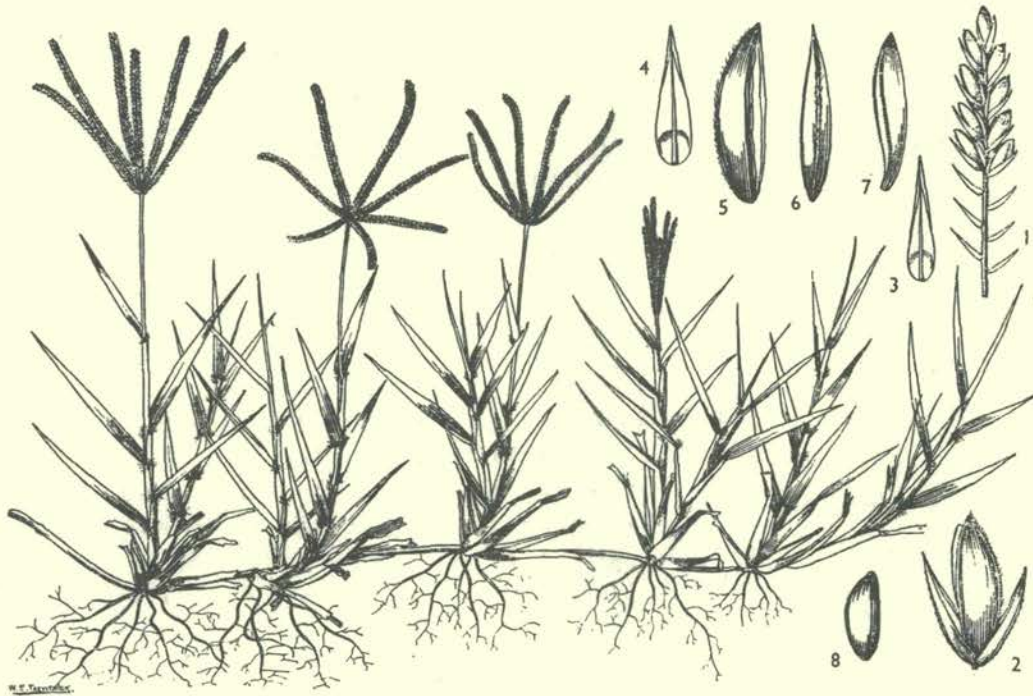


Fig. 1 - *Cynodon dactylon* (Linn.) Pers.

Plant, x1. 1. Portion of spike with persistent lower glumes, x2.
2. Spikelet. 3. Lower glume. 4. Upper glume. 5 and 6. Side and back
views of lemma. 7. Palea. 8. Grain. (all x8.)

(After Grasses of Burma, Ceylon, India and Pakistan, 1960, p. 470, fig.52)

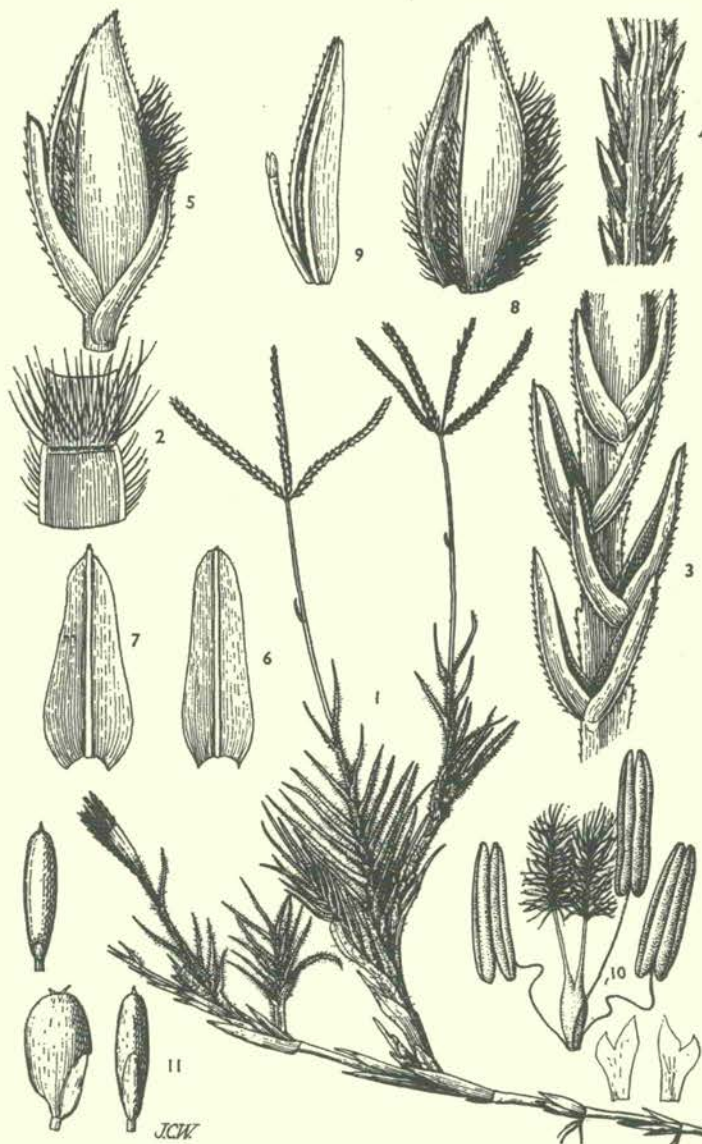


Fig. 2 - *Cynodon dactylon* (L) Pers. var. *villosus* Regel

1. Habit, $\times \frac{2}{3}$. 2. Ligule, $\times 10$. 3. Portion of spike after florets have fallen, $\times 24$. 4. Portion of spike showing rhachis, $\times 12$. 5. Spikelet, $\times 20$. 6. Lower glume, $\times 28$. 7. Upper glume, $\times 28$. 8. Lemma, $\times 20$. 9. Palea showing rhachilla produced, $\times 20$. 10. Flower, $\times 28$. 11. Grain, $\times 30$

(After Flora of Iraq, Vol. 3, 1974, p. 457, plate 174).

- var. *genuinus* Maire et Weiller,
the type species which is glabrous and occurs commonly in
Algeria, Morocco, Tunisia and Libya ;
- var. *hirsutissimus* (Lit. et Maire) Maire, C.,
which is non-glabrous and rare, but occurs in Algeria ; also
recorded by Mousterde (1966) in the mountains of Lebanon.

Keith (1965) also records a further type in Libya :

- var. *minor* (Beck.) Asch. et Gr. introduced into Tripolitania
in 1926.

In the Near East Townsend and Guest (1974) record the following
varieties in Iraq :

- var. *dactylon* with more or less glabrous racemes ;
- var. *villosus* Regel with densely villous racemes, very rare in
Iraq, only once found in the desert region.

Bogdan (1977) points out that var. *dactylon*, a tetraploid ($2n=36$),
is the most widely distributed type; it is a common weed of arable land throu-
ghout the world in warm temperate areas, in sub-tropical areas and to a les-
ser extent in the tropics.

Harlan and de Wet (1969) have divided *C. dactylon* into 6 varie-
ties which are, apart from var. *dactylon*, the following :

- var. *afghanicus* a diploid ($2n=18$) or tetraploid known only in
Afghanistan ;
- var. *aridus* a diploid ($2n=18$) distributed from South India to
Palestine and Sinai and sparingly southwards in the drier
parts of East Africa to the Karoo of South Africa ;
- var. *coursii* a tetraploid ($2n=36$) which is endemic to Madagas-
car ;
- var. *polevansii* a tetraploid ($2n=36$) known only from Baberspan,
South Africa ;
- var. *elegans* a tetraploid ($2n=36$) the common indigenous form
or *C. dactylon* of Southern Africa found mostly south of
12° S.

Botanical races :

Harlan and de Wet (1969) also further divide var *dactylon* into three major races that are reasonably distinct for the most part, but that blend and hybridize too freely to be established as botanical varieties.

In the tropical race plants are small (usually 20 cm tall), fine leaved, turf forming and have little or no winter hardiness. They are well suited to monsoonal climates with heavy rains, leached acid soils and prolonged dry seasons.

The temperate race is similar in appearance but is rather moderately or strongly winter hardy, is less suited to high rainfall and acid soils, and may be somewhat taller and more vigorous. The hardier forms penetrate to 53° N in Eurasia and to 4,000 m elevation in the Himalayas. Harlan (1970) also reports that the seed set of some native ecotypes collected in the desert of Palestine has been excellent.

The seleucidus race, which Harlan et al (1970) report originates from the areas of Turkey, Iran, Iraq, Syria, Afghanistan, Pakistan, Uzbekistan SSR, and Turkmenistan SSR covering the domain of the old Seleucid Empire, has plants that are strikingly coarse, vigorous, bluish in colour frequently rather hairy and strongly winter hard and the spikelets are more closely spaced on the raceme than in the temperate or tropical races. The vigour, winter hardiness, and productivity of the seleucidus race makes it especially valuable for grazing and hay production.

The key to the origin of the seleucidous races appears to be in Afghanistan where genetic interaction is conspicuous. Plants of var *afghanicus* are large, robust, bluish with remarkably long fast growing stolons forming loose or sparse growth and have abundant seed-heads and excellent seed set. The winter hardy diploid race of this variety has been collected in the lowland steppes at Baghlan and Herat and the tetraploid race at Lashkar Gan and Kandahar ; neither race has rhizomes.

Harlan et al (1970) also report that seed collections covering both the temperate and seleucidus races of var *dactylon* have been made in Kashmir, Pakistan, Iran, Iraq, Israel, Turkey, Greece, Bulgaria, Italy and Germany, and accessions grown in uniform nurseries in Stillwater, Oklahoma (USA), where some hybrids were produced between the major races and varieties ; a scatter diagram showing some morphological characters of these races is depicted in Figure 3.

Native ecotypes :

In the northern coastal region of Egypt (UAR) Ibrahim (1968) mentions that there are many native ecotypes of *C. dactylon* that are specific in their requirements for different habitat factors, such as soil alkalinity

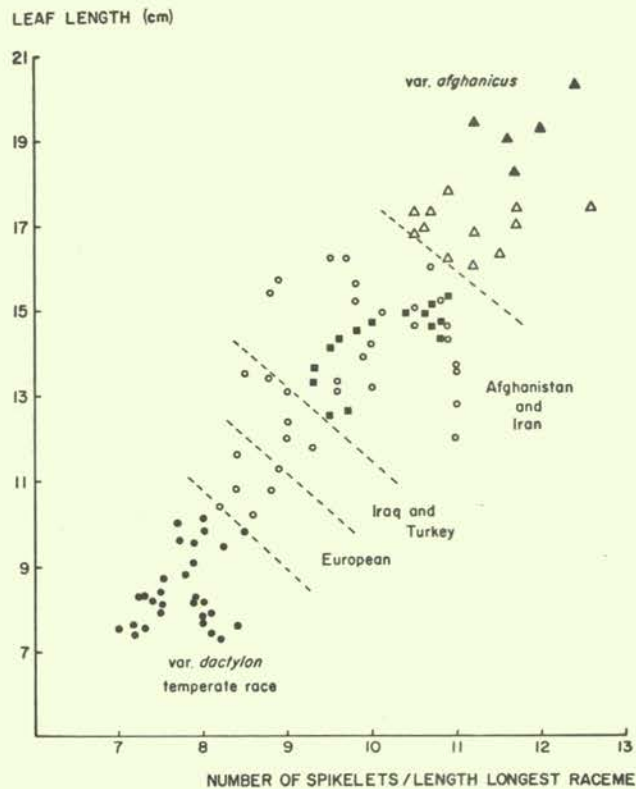


Fig. 3 - Scatter diagram showing some morphological characters of the temperate (closed circles) and seleucidus (open circles) races of var. *dactylon*, var. *afghanicus* (diploid - open triangles and tetraploid closed triangles) and of artificial hybrids (closed squares).

(After Euphytica, 19, 1970, p. 466, fig. 1)

and salinity, soil temperature and moisture, intensity of light and intensity of grazing and he considers that *C. dactylon* is a good example of the importance of studying the adaptation of ecotypes belonging to a given species.

In N. India Ramakrishnan and Gupta (1973) also report a differential response to N. P. and K. for three different edaphic ecotypes of *C. dactylon* naturally occurring at Malla, Shuwalet and Chanigarh ; the soils of these three sites differed markedly with respect to available nutrients.

Agricultural varieties and cultivars :

In the USA a hybridization programme for improving the grazing and forage production of *C. dactylon* has been underway at Georgia Experiment Station since 1947 and has led to the release of improved hybrid cultivars such as 'Coastal', 'Midland', 'Suwannee', 'Tift', 'Alicia', 'Greenfield', and 'Coastcross'. Most of these hybrids have been developed by crossing native forms with types of var *elegans* from Kenya and they show good adaptation to sub-tropical areas with over 500 mm annual rainfall.

These varieties would however be unsuited to dryland cultivation in the semi-arid areas of North Africa and the Near and Middle East with cold winters and there is a need to develop varieties of *C. dactylon* for this region utilizing the many promising native ecotypes which are well adapted to these conditions.

In regard to this question Harlan (1970) states that only a tiny fraction of the germplasm of *C. dactylon* has been studied and even less has been utilized.

5.5. Number of Chromosomes

C. dactylon is essentially a tetraploid with the chromosome number $2x=36$, although diploid forms exist. Amongst tetraploids $2x=18$, 30, 40 and 54 have been observed (Malik and Tripathi, 1968) and Burton (1947) states that various chromosome fragments found during mitosis make the counting of chromosomes difficult.

5.6. Geographical Distribution

C. dactylon is distributed in W, C. and S Europe, Cyprus, Turkey, Caucasus, Iraq, Iran, Syria, Lebanon, Palestine, Jordan, Egypt (UAR), Arabia, Afghanistan, Pakistan, N. Africa (Morocco, Algeria, Tunisia, Libya), C. Asia, W. Siberia, India, China, Formosa, Korea, Japan, Malaysia, Indo-China, Philippines, Australia, Tasmania, New Zealand, Polynesia, Macronesia, tropical Africa, Madagascar, N.S. and C. America ; believed to have originated as a native of tropical Africa from which it spread to Asia and Europe.

The distribution of the collections of seleucidous and modified seleucid collections of *C. dactylon* var *dactylon* made by Harlan et al. (1970) in Europe and the Near and Middle East is shown in the map in Fig. 4.

5.7. Biology and Ecology

Growth and development :

C. dactylon makes little growth during cold weather and in Central Tunisia Naegelé (1972) records that growth of *C. dactylon* is poor during cold periods and that frosts turn the foliage yellow. In Israel Horowitz (1972) records that growth of *C. dactylon*, when the mean monthly temperature in February is just above 10° C. and the absolute minimum is not less than 1° C., is almost negligible but plants remain alive and there is active re-growth in the spring ; growth of new rhizomes only occurs when temperatures exceed 15-20° C. Heath et al (1973) report that improved varieties of *C. dactylon* developed in the USA are not very cold tolerant and temperatures of - 2 to - 3° C. usually kill the stems and leaves back to ground level.

C. dactylon makes its best growth when mean temperatures are above 24° C. ; very little growth occurs when these temperatures drop 6-9 degrees (Heath et al, 1973). Bogdan (1977) also records that high air temperature at about 37° C. are required for maximum photosynthetic activity as is typical for a grass species with C4 pathway of photosynthesis.

C. dactylon withstands long periods of drought but produces little growth during dry weather. Wheeler (1950) reports that in dry areas *C. dactylon* can remain dormant for as long as 6-7 months depending on the length of the dry or cold seasons.

In Egypt (UAR) Ibrahim (1968) records that once *C. dactylon* is established in favourable sites its presence secures grazing during the summer and also during dry spells and as a sod forming species tolerates prolonged grazing throughout the year.

In central Tunisia Naegelé (1972) also reports that *C. dactylon* provides for a greater part of the year the basic daily forage ration of sheep flocks grazing on the native range. He also records that *C. dactylon* remains green throughout the summer season if benefitting from late thunderstorms ; in one year a late thunderstorm at the end of July produced numerous new shoots and stems in August.

C. dactylon appears to flower and fruit throughout the year in many places, and in Iraq Townsend and Guest (1968) record that *C. dactylon* flowers from March to November, and Ibrahim (1968) considers that in Egypt (UAR) the native *C. dactylon* reaches its peak of growth on sandy soils probably because of the better availability of soil moisture from the deeper layers.

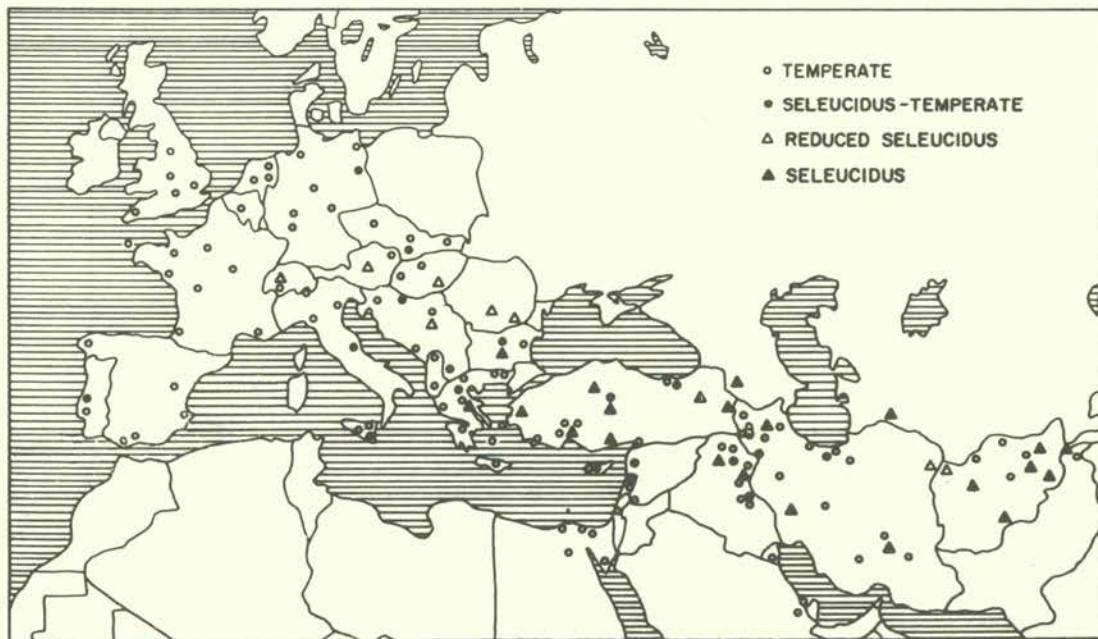


Fig. 4

Distribution of seleucidus and modified seleucidus collections studied.
Each dot represents one to several accessions.

(After Euphytica, 19, 1970, p. 468, Fig. 2)

Germination and seed production :

C. dactylon is a warm season (thermophilous) species propagating itself largely by rhizomes but occasionally by seed.

In Portugal Moreira (1974 - 75) reports that a collection of native ecotypes of *C. dactylon* showed a low number of seeds per year but that propagation by seeds has occurred in some cases ; seeds collected from different sites also showed different germination percentages.

Tackholm et al. (1961) also report that seed production of native ecotypes of *C. dactylon* is apparently rare in the south of Egypt (UAR), but increases in the coastal region ; studies also showed that seed production varied significantly between the different ecotypes.

Climate and soils :

Native ecotypes of *C. dactylon* present throughout North Africa and the Near and Middle East grow well in semi-arid areas with 200-400 mm of annual rainfall and also in arid areas with only 100 mm annual rainfall. Le Hou  rou (1969) has classified *C. dactylon* in the Tunisian steppe as supporting warm to cold winters and rainfall as low as 100 mm.

C. dactylon is adapted to a wide range of soils from sands to heavy clays and grows on any moderately well drained soil providing it has an adequate supply of moisture and plant nutrients.

Villax (1963) records that *C. dactylon* is well adapted to cultivation on poor dry soils in Morocco where other grasses do not grow well. In the USA Heath et al. (1973) records that better growth of improved varieties of *C. dactylon* has occurred in heavy soils probably because they are more fertile and retain soil moisture better ; excellent growth has also been obtained on deep sands with good fertilization.

C. dactylon also tolerates flooding for long periods but makes little or no growth on water logged soils. *C. dactylon* is also well adapted to both alkaline and saline soils and appears indifferent to soil reaction also tolerating acid soils.

Ecological characteristics :

Ecologically, *C. dactylon* is a very widespread species in native ranges in North Africa, the Near and Middle East occurring in the steppe, deserts and mountains where it grows as far north as the 40^o latitude and is found at 1,000 m elevation in Pakistan at Karakoram (Kitamura, 1964) at 1,660 m elevation in N. Iran in the Elburz Mts. (Parsa, 1950), at 2,250-2,350 m elevation in Afghanistan at Kindukush (Kitamura, 1960) and at 1,800-3,000 m elevation in the mountains south of Taiz in Saudi Arabia (Kingery, 1972).

Rattray (1960) records *C. dactylon* as being a common component sometimes in association with *Oryzopsis miliacea* and *Hyparrhenia hirta* in the coastal region running from Tunisia to Egypt (UAR) from sea level up to 200 m elevation with a winter rainfall of 200-400 mm.

In the coastal region of Egypt (UAR) Ibrahim (1968) considers that *C. dactylon* is most productive in the association of *Plantago albicans* and *Echiochilon fruticosum*, the association of *Artemisia herba-alba* and *Asphodelus microcarpus*, and the association of *Achillea santolina*.

In the Tunisian steppe Le Hou  rou (1969) records *C. dactylon* as a component of 22 different plant associations where the annual rainfall varies from 180-300 mm and the elevation from sea level up to 1,200 m.

In Saudi Arabia, Kingery (1972) records *C. dactylon* occurring in association with *Juniperus procera*, *Olea chrysophylla*, *Tricholaena teneriffae*, *Dodonea viscosa* and *Rosa abyssinica* on granitic lithosolic soils with an annual rainfall of 300-500 mm in the mountains south of Taiz, while in Qatar Obeid (1975) records *C. dactylon* as being an important associate of *Ziziphus nummularia* in the north.

In Iraq Townsend and Guest (1969) record *C. dactylon* as an occasional in the lower forest zone, and also as quite common (locally abundant) in the steppe and desert regions, particularly on the alluvial plains.

In Pakistan *C. dactylon* is also recorded (AG:DF/PAR 71/001, Term. Rep. 1975) as occurring on the alluvial Indus plain where it grows on alkaline clay or clay loams in association with *Salsola vermiculata*, *Capparis aphylla* and *Alhagi maurorum* from sea level up to 500 m elevation.

On saline sites throughout the Near and Middle East *C. dactylon* is also a common associate of *Alhagi maurorum*.

5.8. Cultivation Techniques

Time of seeding or propagation :

In Egypt (UAR) Ibrahim (1968) reports that *C. dactylon* is normally propagated by seeds or cuttings in the autumn to permit an establishment of plants to take place before the winter period. Seeds of introduced varieties from the USA have given good germination but plants have proved hard to establish and have been greatly affected by rust (*Puccinia* spp.). Propagation in the autumn have given better results than early spring because of the better and more regular availability of moisture.

In the littoral zone of Morocco Villax (1963) recommends vegetative propagation of native ecotypes of *C. dactylon* by cuttings at a spacing of 50-70 cm in and between the rows because seed germination is unreliable.

In India Narayan and Dabadghao (1972) record that *C. dactylon* as a dry land forage crop is normally planted at the commencement of the monsoon. The germination of the planted seeds is generally slow and uneven and the seedlings lack vigour and often get smothered by other grasses. The propagation is therefore mostly effected by planting rooted slips.

Seed germination :

Moreira (1974) reports that seed germination of native ecotypes of *C. dactylon* was improved by treatment of seeds with 0.2 % KNO_3 solution and best germination took place with daily alternating temperatures of 20/35° C.

Heath et al. (1973) also mention that 5-10 kg/ha of seed is sufficient to establish good stands of the common variety of *C. dactylon* in the USA, but since the seeds are very small seeding methods recommended for small seeded grasses and legumes should be followed. The poor seeding habits of improved varieties such as 'Coastal Suwanee', 'Midland', 'Alicia' and 'Coast-cross-1' make it mandatory that they be established from vegetative material.

Land preparation and weed control :

In India the common method is to prepare the land by two or three ploughings and then to plant the slips in plough furrows 30-60 cm apart. Freshly dug out root stocks of *C. dactylon* which are kept moist should be used for planting. Planting is best done in drizzly weather as the slips then strike root better ; after planting the slips are pressed in by the feet. On sandy soils the slips should be planted 10-13 cm deep in rows, taking care to leave the tips above the ground surface (Narayan and Dabadghao, 1972).

Narayan and Dabadghao (1972) also recommended rolling the soil lightly after planting is completed ; side dressings of nitrogenous fertilizer have also proved beneficial for hastening germination but the area should be cultivated at suitable intervals to keep down weeds.

In the USA much the same procedure as outlined above has been used for propagating *C. dactylon* vegetatively on a field scale. However, Heath et al. (1973) record that a spring tooth harrow is an excellent tool for digging up sprigs of *C. dactylon* for planting and they also mention that good mechanical planters have been developed for planting sprigs ; immediately after planting, sprigs of *C. dactylon* have been covered with a tandem disc harrow followed by a cultipacker roller to firm the soil. Weed control is also considered essential for quick establishment and herbicides have been applied immediately after planting the sprigs.

5.9. Forage Value

Palatability :

C. dactylon is readily eaten by all types of livestock. In Egypt (UAR) Ibrahim (1968) mentions that the palatability of native of *C. dactylon* is considered to be quite high especially during the summer.

Nutritive value :

In India *C. dactylon* is accepted to be one of the most nutritious grasses as the following data (Sen and Ray, 1964) show :

	Green Matter (on DM basis)		Hay (on DM basis)	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%
Crude protein	10.4	59	11.1	54
Ether extract	1.8	21	1.4	27
Crude fibre	28.2	-	18.4	54
Ash	11.8	-	12.5	-
N. free extract	47.8	76	56.6	46
Calcium	0.77	-	-	-
Phosphorous	0.59	-	-	-
Potassium	2.08	-	-	-
Digestible crude protein		6.0		5.9
Total digestible nutrients		42.6		38.7

In Morocco, Villax (1963) reports that the nutritive value of *C. dactylon* is considered to be fair to good up until flowering and he reports the following chemical composition data :

Percentage Chemical Composition

	<u>Water</u>	<u>Protein</u>	<u>Fats</u>	<u>Carbohydrates</u>		<u>Ash</u>
				<u>Soluble</u>	<u>Fibre</u>	
Green forage	75.0	2.0	0.6	14.7	4.6	3.3
Hay	20.0	6.4	1.9	46.8	14.9	10.0

Foury (1956) also records the following chemical composition data for *C. dactylon* at Rabat in Morocco :

Percentage Chemical Composition

<u>Date of sampling</u>	<u>Water</u>	<u>Ash</u>	<u>Protein</u>	<u>Non-N extract</u>	<u>Fats</u>	<u>Cellulose</u>
9.5.1950						
Green matter	52.50	3.51	2.98	30.43	0.97	9.66
Dry matter	0	7.39	6.25	64.08	2.05	20.23
19.1.1951						
Green matter	75.00	3.71	1.96	14.69	0.58	4.66
Dry matter	0	12.44	7.85	58.74	2.32	18.65

In Algeria Killian (1954) has recorded the following chemical composition data for native *C. dactylon* in native range :

Percentage Chemical Composition

	Protein	Reducing sugars	Non reducing sugars	Crude fibre	N	P ₂ O ₅	CaO	K ₂ O
Dry sample from prededing year 11/53	0.50	0.49	0.83	25.1	0.53	0.16	1.25	0.66
Dry sample from prededing year 6/53	0.66	0.60	0.18	73.0	1.03	0.50	1.04	1.04
Green sample after rain 4/53	1.10	0.46	0.65	68.0	1.23	0.38	1.12	1.12
Sample in flower after rain 6/53	0.75	0.90	0.70	59.9	0.75	0.46	-	-
Winter 11/48				18.7	4.08	0.90	2.02	2.02

Heath et al (1973) also mention that genotype has affected the nutritive value of *C. dactylon* in the USA. Dry matter digestibility (DMD), an excellent index of nutritive value, is a heritable character. The in-vitro DMD of five-week old forage from 500 genotypes in a *C. dactylon* world collection grown at Tifton, Georgia, USA varied from 40 to 69 %.

Bogdan (1977) also mentions that a high content of hydrocyanic acid (HCN) has been recorded in the coastal variety of *C. dactylon* in the USA but no harmful effects on cattle were observed ; high amounts of prussic acid glucosides are also recorded (Heath et al, 1973) for Star introductions of *C. dactylon* from Africa.

5.10. Forage and Seed Production

Forage yields :

In the littoral zone of Morocco at Rabat (500-600 mm annual rainfall) experimental green forage yields have varied from 6,000-12,000 kg/ha/year under dryland conditions (Villax 1963).

In the littoral zone of Egypt (UAR) with 150 mm rainfall or less, on compact calcareous soils Ibrahim (1968) records that the forage yield of dryland *C. dactylon* is low even with supplementary irrigation.

In India Narayan and Dabadghao (1972) report that yields of *C. dactylon* vary from 1,800-2,200 kg/ha green forage per cutting under rainfed conditions and that 4-5 cuttings can be taken per year ; with supplementary irrigation yields are 2.5 times greater.

Forage yields can be greatly increased by the application of nitrogen fertilizer and Narayan and Dabadghao (1972) recommend an application of 112-135 kg/ha of ammonium sulphate or sodium nitrate nearly in the season.

Heath et al (1973) also remark on the excellent drought performance of the coastal variety of *C. dactylon* which in a year with only 380 mm rainfall at Tifton, Georgia, USA, gave 6,000 kg/ha of hay, when fertilized with 100 kg/ha of N.

Seed Yields :

Seed production as stated earlier, varies considerably according to the variety or ecotype but Villax (1963) records a seed yield of 100-200 kg/ha presumably for the 'Common' variety of *C. dactylon*, under dryland conditions, in the littoral zone of Morocco. In the USA dryland seed yields of the common variety have varied from 112-224 kg/ha (Heath et al, 1973).

5.11. Utilization

Pasture management :

For pasturing Narayan and Dabadghao (1972) record that close grazing of *C. dactylon* in India to a height of 10-15 cm ensures a nutritious forage but total forage production can be reduced under this intensive use.

Normally dryland *C. dactylon* in India is ready for the first cutting three or four months after planting and subsequent cuts can be taken at 60-70 day intervals.

Conservation for hay or silage :

In India Narayan and Dabadghao (1972) report that hay from *C. dactylon*, when it is properly made and stored, keeps well for nearly two years.

Heath et al. (1973) recommend that to make good silage *C. dactylon* should be managed as for hay and cut every 4-6 weeks, when it should be chopped as short as possible and then be well packed in an air tight silo without wilting ; the addition of 40 kg of ground corn or citrus pulp per ton of chopped *C. dactylon* improves the silage quality.

However, Bodgan (1977) reports that the ensiling of *C. dactylon* can meet with limited success since the grass is difficult to compress leading to a pH of about 5 in the ensiled crop and fermentation is not then of the lactic acid type.

Carrying capacity and grazing utilization :

In regard to carrying capacity Theriez and Skouri (1970) report that the carrying capacity of native *C. dactylon* ranges in central Tunisia (Fig.5) with an average annual rainfall of 380 mm has been shown to be close to 1 native sheep/ha year along to keep adult ewes in good condition even in a dry summer without any feed supplement.

In central Tunisia at Ousseltia, Froment (1970) also reports the following utilization data over a 2-year period for a native range dominated by *C. dactylon* :

	<u>MAY-OCTOBER</u>			<u>NOVEMBER-APRIL</u>			<u>YEAR</u>		
	grazing days/ha	ewe ha	Forage units/ ha	grazing days/ha	ewe ha	Forage units/ ha	grazing days/ha	ewe ha	Forage units/ ha
1964-1965 (383,6 mm rainfall)	120	1.50	108	488	0.37	635	608	0.60	742
1967-1968 (302,1 mm rainfall)	283	0.66	255	720	0.25	936	1003	0.36	1258

Soil conservation :

C. dactylon is also a valuable species for soil conservation since it is a good soil binder, especially on sands. Ibrahim (1968) reports that several ecotypes of *C. dactylon* can be used for fixing sand dunes along with trees, such as *Acacia saligna* and *A. cyanophylla*. In India Dalal and Ullah (1966) report that *C. dactylon* has been used to stabilize the sides of water courses.

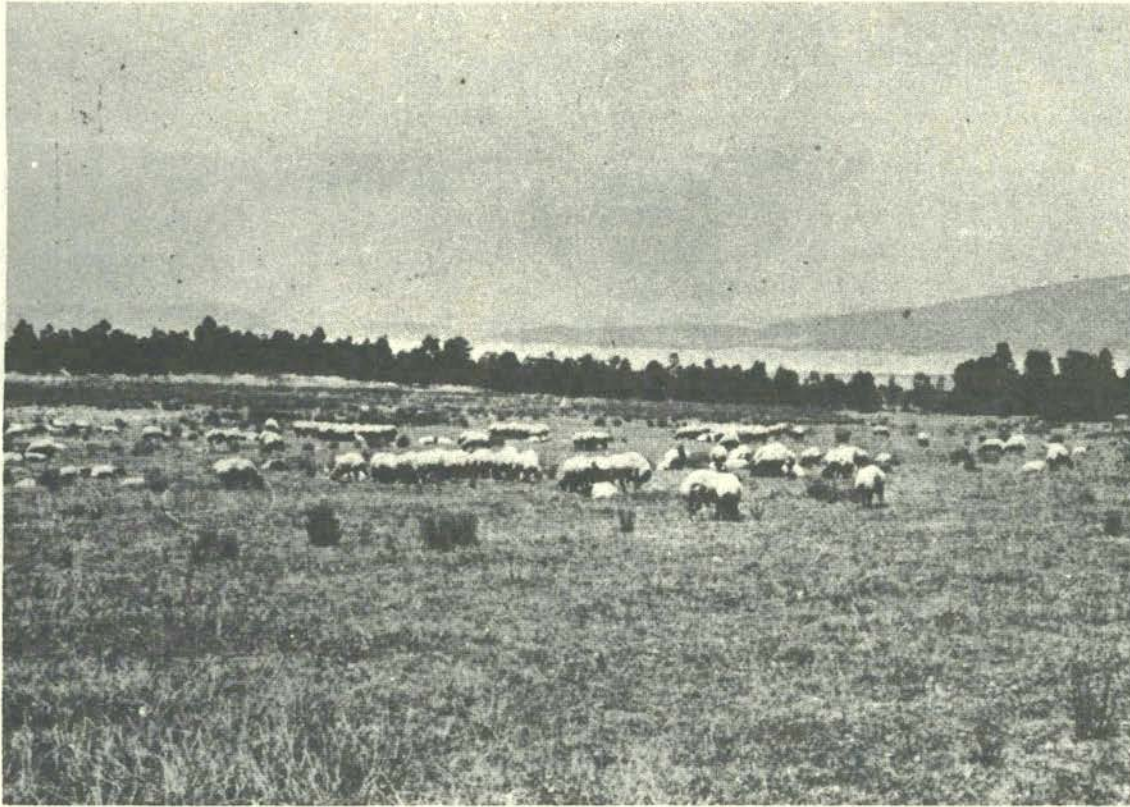


Fig. 5

A flock of sheep on natural range based on
Cynodon dactylon at Ousseltia. February 1970.

(After Aménagement des parcours et leurs relations avec les cultures
fourragères en Tunisie centrale, Rapport technique 2, 1970, FAO,
Rome, p. 107, photo 1)

Further evaluation :

In the future, more attention needs to be paid to the development of non-rhizomatous varieties of *C. dactylon* which could be used for dryland pasture seeding in the region since they can be more easily eradicated and they will not become a weed infestation on land used for rotation pastures.

5.12. Specific References

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TECHNICAL DATA

SHEET No 6

GRAMINEAE (= POACEAE)

Dactylis spp.

6.1. Species and Subspecies

In North Africa and the Near and Middle East there is one important indigenous species *Dactylis glomerata* L. and three subspecies forming part of the *D. glomerata* complex which are *D. glomerata* L. ssp. *hispanica* (Roth) Koch., *D. glomerata* spp. *himalayensis* Domin. and *D. glomerata* spp. *lusitanica*

6.2. Synonyms

- *D. glomerata* (= *Bromus glomeratus* (Linn.) Scop., *Festuca glomerata* (Linn.) All., *Trachypoa vulgaris* Bubani)
- *D. glomerata* spp. *hispanica* (= *D. glomerata* L. var *hispanica* (Roth.) Koch., *D. woronowii* Ovez.)

6.3. Common Names

- | | | |
|---|---------|--|
| - <i>D. glomerata</i> | English | Cocksfoot (United Kingdom, Australia) ;
Orchard Grass (USA) ;
Rough Cocksfoot (Jordan). |
| | French | Dactyle aggloméré,
Dactyle pelotonné. |
| | Arabic | Affar Doukna, Lachicha, Mahoun, Nedjina, Nichia (Morocco) ;
Adem, Niscia, Nischia, Nishia, (Libya) ;
Rijl-El-Deek (Syria). |
| - <i>D. glomerata</i> subsp. <i>hispanica</i> | English | Mediterranean Orchard Grass. |

6.4. Brief Description

- *D. glomerata* is a strongly tufted compact grass reaching a height of 60-120 cm with spreading stems and a branching panicle and seeds enclosed in slightly awned glumellas (Fig. 1) ;

- *D. glomerata* subsp. *hispanica* (Roth.) Nym., is a tufted grass with a short praemose rhizome glaucous leaves, spiciform panicle, growing up to 70 cm tall (Fig. 2) ;

- *D. glomerata* subsp. *lusitanaica* is a tufted grass with large erect tufts and stems 70-130 cm tall and with scabrous leaves and stiff panicles.

- *D. glomerata* subsp. *himalayensis* Domin. is a tufted grass awned and with more acuminate lemmas than *D. glomerata* (Fig. 3).

6.5. Varieties

Botanical forms and varieties :

A number of botanical forms and varieties of *D. glomerata* and *D. glomerata* subsp. *hispanica* have been noted in N. Africa, where Maire (1955) mentions the following :

D. glomerata :

- var. *typica* Posp.
with long branching inferior panicles naked at the base ;
present throughout Morocco, Algeria, Tunisia, Cyrenaica and Tripolitania in humid places ;
- f. *aspera* Podp.
with glumes and lemmas hairy on the backs ; rare but present in Morocco ;
- f. *scabra* (Opiz) Hayek
with glumes and lemmas scabrous at the bottom ; present throughout Morocco, Algeria, Tunisia, Cyrenaica, Tripolitania in humid places ;
- f. *ciliata* Peterm
with long glumes and lemmas ciliated at the bottom ; present throughout Morocco, Algeria, Tunisia, Cyrenaica and Tripolitania ,
- var. *spicata* Pamp.
with compact branches and spiciform panicle ; common in Cyrenaica ;
- f. *intermedia* Pamp., l.c.
with short panicles, common in Cyrenaica ;
- var. *Sibthorpii* (Hackel) Boiss.
(= *D. hispanica* var. *Sibthorpii* Hack.)
with 8-10 flowered spikelets and glumes scabrous on the back ;
present in Algeria ;
- var. *tetuanensis* Maire in M., C.
with very slender stems and slender creeping rhizome ; present in Morocco.

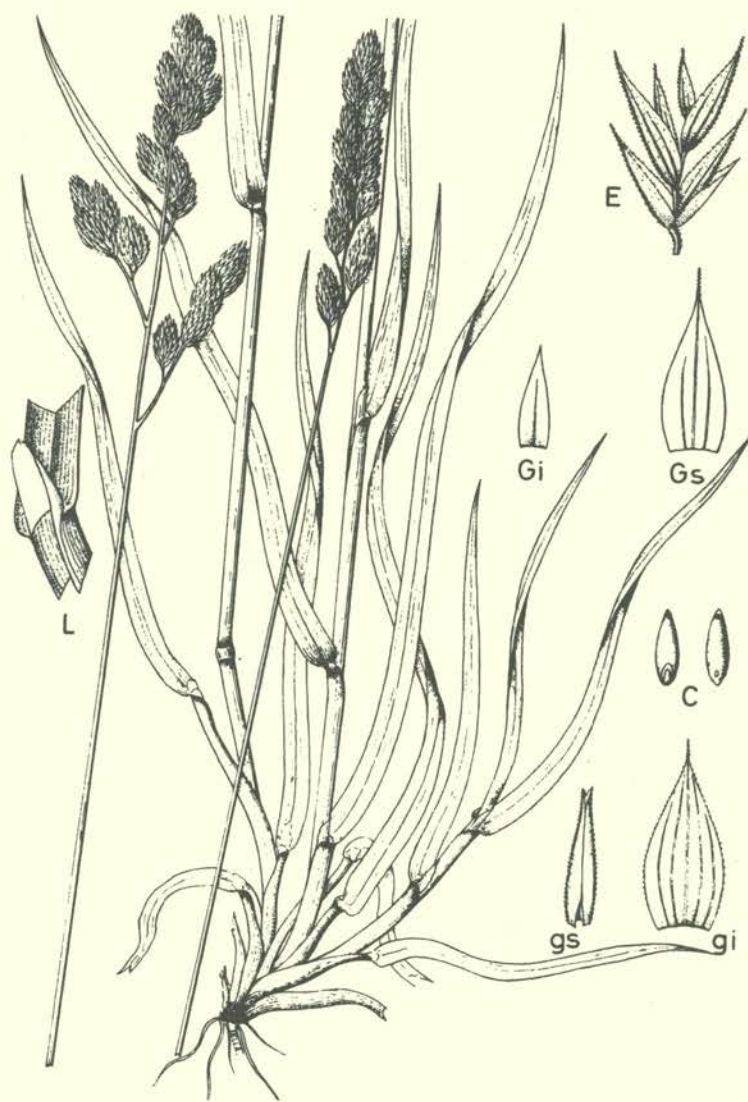


Fig. 1 - *Dactylis glomerata*

Plant, x1. Spikelet, x5. Gi : Inferior glume, x5. Gs : Superior glumella, x5. gs : Superior glumella, x5. C : Caryopsis, x5. L : Ligule, x2.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas,
Madrid, 1965, p. 89)

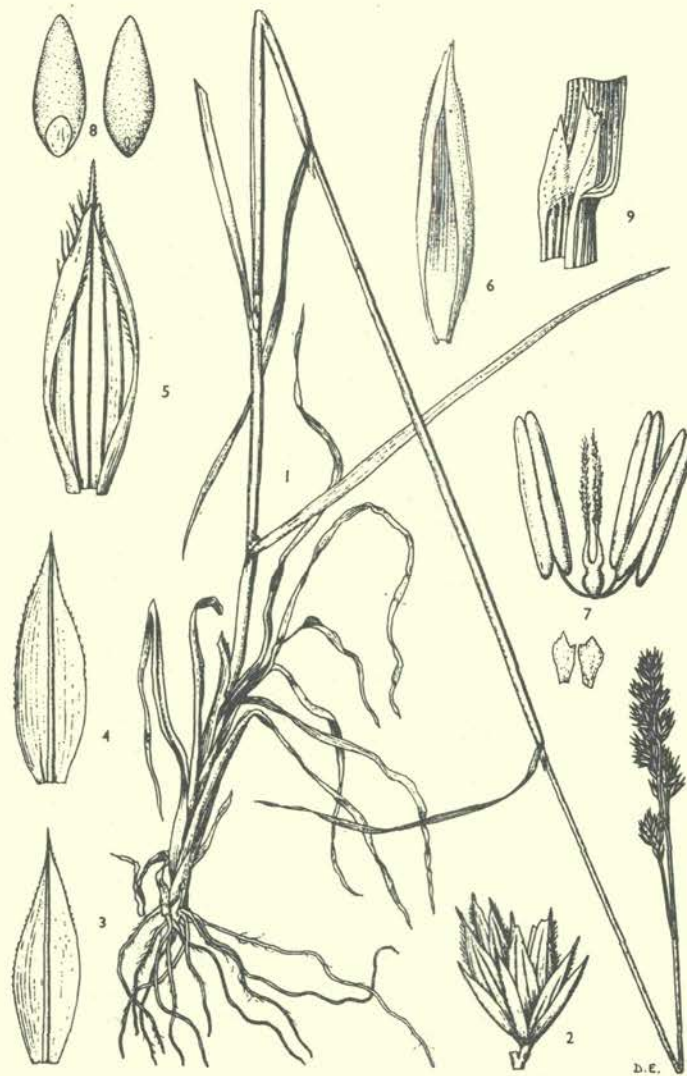


Fig. 2 - *Dactylis glomerata* L. subsp. *hispanica* (Roth) Koch.

1. Habit, $\times \frac{2}{3}$. 2. Pair of spikelets, $\times 4$. 3. Lower glume, $\times 10$.
4. Upper glume, $\times 10$. 5. Lemma, $\times 10$. 6. Palea, $\times 10$. 7. Flower, $\times 15$.
8. Grain, $\times 8$. 9. Ligule, $\times 4$.

(After Flora of Iraq, Vol. 9, 1965, p. 77, plate 26)



Fig. 3 - *Dactylis glomerata* Linn. subsp. *himalayensis* Domin

1. Plant and inflorescence, $\times \frac{1}{2}$. 2. Spikelet in side view. 3. Lower glume.
4. Upper glume. 5. Lowest lemma. 6. Ligule. 7. Stamens, ovary and
lodicules. 8. Grain showing left, the hilum and right, the embryo. all, $\times 8$.

(After Grasses of Burma, Ceylon, India and Pakistan,
1960, p. 531, fig. 58)

D. glomerata subsp. *hispanica* :

- f. *australis* Briq.
with an elongated panicle and clusters of inferior spikelets, sometimes shortly pedicelled ; present in the littoral zone of Morocco, Algeria and Tunisia ;
- f. *spiciformis* (Hochr)
with an elongated panicle and folded straight leaves ; present in the Saharan Atlas ;
- f. *Hackelii* Asch. et Gr.
(= *D. hispanica* var. *maritima* Hack, *D. glomerata* var. *maritima* (Hack.) Richt.)
with a short panicle and relatively large leaves ; present in Morocco, Algeria and Tunisia ;
- f. *capitellata* (Link) Maire et Weiller
(= *D. glomerata* var. *microstachya* Webb, *D. juncinella* Boiss.)
with long mucronate lemmas hairy on the backs ; present in the dry mountains of Morocco, Algeria and Tunisia.

Keith (1965) also notes that Maire et Weiller mention var. *biantha* Hayek as occurring in Cyrenaica, in the steppe south of Magroun.

In the Mediterranean region Borril (1961) also reports that the morphological trend in *Dactylis* L. is towards a reduction in plant size and the occurrence of small leaves, short ovate panicles and florets with lobed lemma apices which taxonomically belong to *D. glomerata* subsp. *hispanica* ; extreme polymorphism of *D. glomerata* is also reported (Borril, 1961) in Crete.

Native ecotypes :

In the Near East Hertzsch (1970) records that 113 ecotypes of *D. glomerata* have been collected in the various regions of Turkey during the period 1965-69 and assembled at Izmir on the west coast of Turkey ; in a later report (Hertzsch, 1971) 259 Turkish ecotypes were recorded as being planted in nurseries at Izmir.

In North Africa Villax (1963) records that there are a number of native ecotypes of *D. glomerata* present notably in Morocco, and a number of native ecotypes of *D. glomerata* subsp. *hispanica* have been collected and tested under dryland conditions. In Algeria Barbut (1955) mentions that the ecotypes No 204, 244, 415 and 416 as being promising, while Maignan (1970) records that three ecotypes collected from Talinet, Ain Yagout and Bourraguia in Algeria have given promising results in the high plateaux zone of Algeria.

Oram (1959) also records that two indigenous strains of *D. glomerata* subsp. *hispanica* exist in Tripolitania, one prostrate and confined to the coastal belt, the other more erect and vigorous and found on hill slopes.

Long (1955) also mentions that there are a number of native ecotypes of *D. glomerata* subsp. *hispanica* adapted to different habitats existing in the littoral zone of N. Egypt, and Grassi (1953) reports that some of those have been collected and successfully planted under dryland conditions in the N.W. coastal zone of Egypt.

In Jordan Hopkinson (1975) also reports that several ecotypes of *D. glomerata* subsp. *hispanica* have been collected in the Karak region and have been tested in dryland plantings. In Jordan Long (1955) has recommended that a collection of native ecotypes should be made from material existing in the vegetation in the region of Mafraq.

In regard to native ecotypes of *D. glomerata* subsp. *hispanica* a sharp distinction should be drawn between those occurring in the lowland steppes of N. Africa and the Near East and those occurring in the mountains of N. Africa and the Near and Middle East under quite high rainfall conditions.

For instance Pabot (1967) believes that the ecotypes of *D. glomerata*, including subsp. *hispanica*, occurring in N. Iran are not as drought resistant as the native ecotypes of *D. glomerata*, particularly subsp. *hispanica*, that occur in the steppes of Jordan and Syria.

Agricultural varieties and cultivars :

Corriols (1965) reports that the Moroccan varieties Nos 615 and 1862 of *D. glomerata* subsp. *hispanica* have been tested under dryland conditions in the littoral zone of Tunisia and FAO No 2461 also from Morocco has been tested in the littoral zone of Libya (Oram, 1959).

Neal-Smith (19559) also records that 100 native accessions of *D. glomerata* subsp. *hispanica* have been collected in N. Africa and the Near East and material collected in Morocco and Algeria, in particular, has been utilized to produce the varieties 'Berber', 'Currie', and 'Kasbah'. Plant material which was used to develop 'Kasbah' was in fact collected in Morocco in an area with an annual rainfall of 280 mm.

The variety 'Berber' was also selected from a range of Moroccan plant material and is considered to be more persistent and productive than 'Currie' which was developed from an Algerian introduction.

Another variety of *D. glomerata* subsp. *hispanica* named 'Porto' derived from an introduction from Porto in Portugal has also been developed in Tasmania, and Wright and Neal-Smith (1971) report the introduction and evaluation of Portuguese material of *D. glomerata* subsp. *lusitanica* in Australia. For many growth characteristics the variety 'Currie' tends to be intermediate with respect to the extreme Mediterranean and north European types

of *D. glomerata* and Gallacher (1972) has recommended this variety for dryland seeding in the high plateaux zone of Algeria (450-600 mm annual rainfall).

In Morocco Villax (1963) reports that for *D. glomerata* the varieties INRA 4333/59, 4338/59, 4356/59, 7408/60 and 7411/60 have been developed from indigenous plant material at Rabat.

In general varieties of *D. glomerata* introduced from Europe and the USA have not proved promising under dryland conditions in the steppe regions of N. Africa and the Near East where native ecotypes of *D. glomerata* subsp. *hispanica* have proved better adapted to the long hot dry summer.

However, in the Caspian forest zone (+600 mm annual rainfall) Kernick (1971) reports that the varieties 'Aries' and 'Taurus' of *D. glomerata* from France have grown fairly well in dryland plantings, and Villax (1963) also mentions that the French varieties 'Germinal', 'Floreal' and 'Prairial' of *D. glomerata* perform fairly well in the littoral zone of Morocco.

6.6. Number of Chromosomes

D. glomerata : $4x = 28$, irregular (27-39), 42 ;

Borril and Lindner (1971) report that for collections of *D. glomerata* made in Sierra Nevada, Spain, and Kerrata, Algeria, *D. glomerata* subsp. *hispanica* is a tetraploid ; *D. glomerata* subsp. *lusitanica* is a diploid ($2n = 14$).

6.7. Geographical Distribution

D. glomerata is indigenous to Europe, North Africa and temperate Asia and is cultivated in most temperate regions of the world ;

D. glomerata subsp. *hispanica* is distributed in the Mediterranean region from Spain to the Crimea and also in Turkey, Jordan, Syria, Iraq, Iran, Caucasus, N. Africa (Morocco, Algeria, Tunisia, Libya and Egypt (UAR) and C. Asia (from Turkmenia to Amur Darya) : Chrtek and Hadac (1970) also record that *D. glomerata* subsp. *hispanica* ranges from the Mediterranean region to Iran and central Asia, but they point out that in Iraq it is only found in the northern mountains in areas with 800-1,000 mm annual rainfall (Fig. 4, distribution map in Iraq) :

D. glomerata spp. *lusitanica* appears to be restricted to Portugal but its exact distribution is not yet known (Stebbins, 1961).

6.8. Biology and Ecology

Growth and development :

D. glomerata, *D. glomerata* subsp. *hispanica* and *D. glomerata* subsp. *himalayensis* and *D. glomerata* subsp. *lusitanica* are all cool season species that propagate themselves by seed.

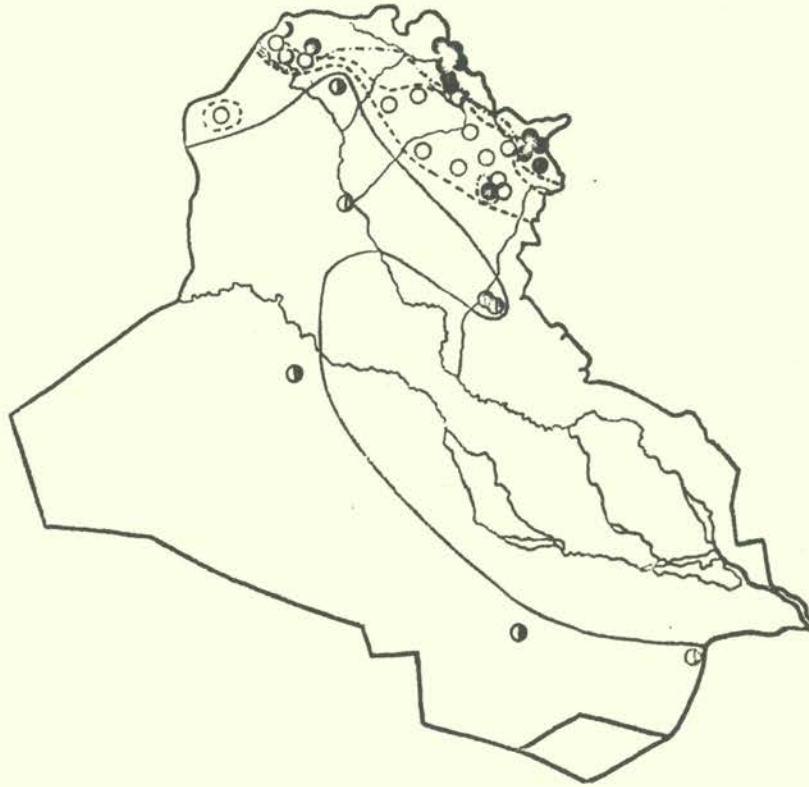


Fig. 4 - Distribution of *Dactylis glomerata* subsp. *hispanica* (●)
in Iraq

(After Candollea 25, 1970, p. 253, map 4)

In the littoral zone of the Mediterranean region Villax (1963) reports that both *D. glomerata* and *D. glomerata* subsp. *hispanica* grow well under dryland conditions although their growth is largely restricted to the winter and spring when moisture conditions are favourable.

In the littoral zone of Tunisia, at Tunis, Corriols (1965) records that various exotic and indigenous varieties of *D. glomerata*, when seeded at the middle to the end of December, gave 50-100 % emergence and for most formation of the inflorescence took place between the end of April and end of May.

Pearse (1955) also records that growth of *D. glomerata* subsp. *hispanica* was good in the northern coastal zone of Egypt when seeded in the autumn (November).

However, Villax (1963) states that introduced varieties of *D. glomerata* are susceptible to fungal diseases in N. Africa and he recommends cultivation of adapted selected varieties such as those developed at Rabat in Morocco.

In dryland nursery plots, in the sub-steppic zone of Iran at 1,960 m elevation, growth of native and introduced varieties (European) have been largely restricted to the spring when moisture and temperature conditions are most favourable. However, the same varieties of *D. glomerata* have grown well in the temperate climate of the Caspian Forestry zone (+600 mm annual rainfall) where growth is continuous during spring and summer due to the benefit of summer rains (July-August).

Growth of both *D. glomerata* and *D. glomerata* subsp. *hispanica* ceases in summer in both the littoral and interior steppe regions of N. Africa and the Near and Middle East and does not begin again until the first rains and cooler temperatures of the autumn (October).

D. glomerata subsp. *hispanica* appears to be more truly summer dormant than *D. glomerata*. For instance Knight (1966) records that in a Mediterranean type climate in Australia hybrids between Mediterranean and N. European types of *D. glomerata* responded to summer showers when Mediterranean varieties were still dormant and N. European varieties were severely affected by drought. Some of the hybrids and the N. European varieties also became dormant when the Mediterranean varieties were growing. More hybrids than N. European plants survived the summer and in some cases their survival was as good as that of the best Mediterranean plants.

In N. Africa and the Near and Middle East flowering of *D. glomerata* subsp. *hispanica* in the littoral steppe or mountain zones takes place from March to July. In the littoral zone of N. Egypt Ibrahim (1968) reports that *D. glomerata* subsp. *hispanica* produces a good quantity of seeds even in dry years and the germination of the seeds is also very high ; plants also persist well under continuous grazing.

Climate and soils :

In the Tunisian steppe Le Hou  rou (1969) records that native plants of *D. glomerata* subsp. *hispanica* are adapted to cold to warm winters and to a wide range of annual rainfall from 200-600 mm.

In Iran Pabot (1967) also mentions that naturally occurring plants of *D. glomerata* and *D. glomerata* subsp. *hispanica* are not rare in mountain ranges with 400 mm of annual rainfall in the north and west, and some plants can be found growing up to 3,200 m elevation.

D. glomerata appears to be well adapted to dryland cultivation in the littoral zones of N. Africa and the interior mountain regions of N. Africa and Middle East, while *D. glomerata* subsp. *hispanica* has proved adapted to dryland cultivation under an annual rainfall varying from as low as 50 mm in the N. coastal zone of Egypt, to 300-400 mm in the steppe of Jordan and central Tunisia, and up to 450-600 mm in the high plateaux zone of Algeria and the littoral zones of Morocco and Tunisia.

D. glomerata does best on fertile loams and clays, while *D. glomerata* subsp. *hispanica* is adapted to a wide range of soils and also grows well on skeletal, rocky and sandy soils.

Ecological characteristics :

Ecologically *D. glomerata* occurs throughout the mountain and littoral region of N. Africa and the Near and Middle East in humid places, while *D. glomerata* subsp. *hispanica* is an important but scattered component of the steppe vegetation in N. Africa and the Near East and occurs also in the mountains of the Middle East.

In N. Africa Maire (1955) records *D. glomerata* as occurring in forest, clearings and humid places from the littoral up to 2,500 m elevation, while *D. glomerata* subsp. *hispanica* is more common in the semi-arid areas.

In the Tunisian steppe Le Hou  rou (1969) records *D. glomerata* subsp. *hispanica* as being present in the following plant associations : *Pinus halepensis/Quercus ilex* (400-600 mm annual rainfall, 800-1,500 m elevation) ; *Pinus halepensis/Helianthemum ellipticum* (200-300 mm annual rainfall, 700-1,000 m elevation) ; *Tetraclinis articulata/Quercus coccifera* (375-450 mm annual rainfall, 100-500 m elevation) ; *Artemisia herba-alba/Helianthemum hirtum* spp. *ruficomum* (250-300 mm annual rainfall, 600-900 m elevation) ; *Artemisia campestris/Lolium perenne* (450-550 mm annual rainfall, 1,100-1,200 m elevation) ; *Artemisia campestris/Minuartia geniculata* (300-400 mm annual rainfall, 800-1,200 m elevation) and *Artemisia herba-alba/Asparagus albus* (200-300 mm annual rainfall, 400-500 m elevation).

In Libya Le Hou  rou (1969) also records *D. glomerata* subsp. *hispanica* in the association of *Lygeum spartum* and *Achillea santolina* on the coastal plain south and east of Benghazi.

In Egypt Ibrahim (1968) mentions that *D. glomerata* subsp. *hispanica* is dominant in the association of *Thymelaea hirsuta* and *Gymnocarpos decandrum* which is characterized by skeletal shallow soils ; it also invades shallow soils in the association of *Plantago albicans* and *Echiochilon fruticosum* but is rarely found in the association of *Artemisia herba-alba* and *Asphodelus microcarpus*.

In N. Egypt Ayyad and Ammar (1973) also records that *D. glomerata* subsp. *hispanica* prefers low-lying sites or rocky ridges at Burg El-Arab.

In Jordan Long (1957) records *D. glomerata* subsp. *hispanica* as being present in the *Artemisia herba-alba* association in the Karak region from 600-1,600 m elevation. In Jordan Kasapligil (1956) mentions *D. glomerata* (almost certainly spp. *hispanica*) as occurring in the steppe region from 750-1,500 m elevation, sometimes in association with *Ephedra alata*, *Hordeum bulbosum* and *Stipa parviflora*.

In Lebanon Pabot (1959) records *D. glomerata* as being common in the lower Mediterranean zone (750-1,150 mm annual rainfall, 10-500 m elevation), the upper Mediterranean zone (900-1,500 mm annual rainfall, 1,000-1,500 m elevation) and in the Cedar zone (800-1,100 mm annual rainfall, 1,500-2,000 m elevation).

Mouterde (1966) also records *D. glomerata* subsp. *hispanica* as being present in the Cedar zone of Lebanon, while Pabot (1957) in Syria records *D. glomerata* subsp. *hispanica* as being present in the Syrian zone which separates the Mediterranean zone from the steppic zone.

In the N. Iraq Bor and Guest (1968) record that *D. glomerata* subsp. *hispanica* is present on rocky hillsides, sometimes in the oak forest from 800-2,000 m elevation.

In N. Iran Parsa (1950) mentions that *D. glomerata* occurs at Kandavan and Karadj in the Elburz Mts. in N.W. Azerbaidjan, at Tabriz and Zorab, in Kurdistan, in the region of Hamadan from 1,000 up to 2,000 m elevation, while *D. glomerata* subsp. *hispanica* is recorded as occurring at Gatchesar, 2,200 m elevation and at Kandavan at 2,800 m elevation in the Elburz Mts.

In Pakistan Kitamura (1964) also records *D. glomerata* as occurring in the Himalaya up to 2,500 m elevation. *D. glomerata* subsp. *lusitanica* has been recorded (Stebbins, 1961) as occurring in the pine and oak forests of central Portugal.

6.8. Cultivation Techniques

Time of seeding :

Both *D. glomerata* and *D. glomerata* subsp. *hispanica* can be established by seeds and cuttings but the former is easier and more economic.

In the Mediterranean region Villax (1963) records that dryland seeding of *D. glomerata* are normally made after the first autumn rains but Hussain (1975) reports that in the lower mountain zone of Iraq, spring seeding (last week of February/first week of March) has given the best results.

Spring seeding (March-April) has also given the best results for dryland *D. glomerata* in the steppic and Caspian Forestry zones of Iran (AGP: SF/IRA 10, Tech. Rep. 1, 1970; Dumancic, 1975).

Seed rate and method of seeding :

Seeding techniques vary from country to country but the following have been reported for *D. glomerata* and *D. glomerata* subsp. *hispanica* :

<u>Tunisia</u>	<i>D. glomerata</i> subsp. <i>hispanica</i> : 10 kg/ha of seeds broadcast in lines spaced 50 cm apart ; depth of seeding : 1-2 cm ;
<u>Morocco</u>	<i>D. glomerata</i> : 12-16 kg/ha of seeds broadcast or drilled in lines spaced 50-70 cm apart ; depth of seeding : 1-2 cm <u>or</u> cuttings spaced 40-60 cm apart in and between the lines ;
<u>Algeria</u>	<i>D. glomerata</i> subsp. <i>hispanica</i> : 10-15 kg/ha of seeds broadcast in lines spaced 50 cm apart ; depth of seeding : 1 cm <u>or</u> cuttings 50 cm apart in and between the rows (nursery plots only) ;
<u>Iraq</u>	<i>D. glomerata</i> : 5 kg/ha of seeds drilled in lines spaced 50-60 cm apart on flat land ; depth of seeding : 1-2 cm <u>or</u> 3.5 kg/ha of seeds broadcast in furrows spaced 1-2 cm apart <u>or</u> on the berm of contour trenches spaced 4 cm apart on sloping or steep land ;
<u>Iran</u>	<i>D. glomerata</i> : 15 kg/ha of seeds broadcast ; depth of seeding : 1-2 cm.

In central Tunisia at Ousseltia Naegelé (1972) records that *D. glomerata* subsp. *hispanica* has been seeded in furrows in mixture with *Medicago sativa* and *Oryzopsis holciiformis* using a buffel grass seeder, developed in Australia, and this method has given good results for dryland plantings.

In the Caspian forest zone Dumancic (1975) also reports that *D. glomerata* has been seeded in mixture with *Lolium perenne*, *Arrhenatherum elatius* and *Medicago sativa* where it has formed 15-20 % of the mixture.

Land preparation :

For good establishment success a firm, fine, compact weed free seed-bed is required for the small seeds of both *D. glomerata* and *D. glomerata* subsp. *hispanica*. This has generally entailed ploughing the soil to a depth of 10-15 cm followed by discing, harrowing and smoothing it with an iron bar and then consolidating it with a cultipacker roller.

Fertilizer application :

In the high plateaux zone of Algeria Maignan (1970) reports that a fertilizer application of 30 kg/ha N in October followed by another 30 kg/ha

N in January has benefitted establishment and subsequent forage yields of *D. glomerata* subsp. *hispanica* in a season (September-May) with 561.4 mm rainfall.

Dumancic (1965) also reports that in the Caspian Forest zone, 100-150 kg/ha P_2O_5 and 40-60 kg/ha N have been applied at seeding to dryland *D. glomerata* in mixture with other grasses and legumes followed by 30-60 kg/ha N in May in subsequent years.

6.9. Forage Value

Palatability

D. glomerata, *D. glomerata* subsp. *hispanica*, *D. glomerata* subsp. *himalayensis* and *D. glomerata* subsp. *lusitanica* are all palatable to live-stock. In N. Egypt Ibrahim (1968) mentions that *D. glomerata* subsp. *hispanica* is highly palatable to all livestock throughout its life cycle and produces many basal leaves.

In the sub-steppic zone of Iran palatability grazing tests with native sheep showed that *D. glomerata* was well grazed in the vegetative, boot, flowering and seed production stages in the spring.

Nutritive value

The nutritive value of *D. glomerata* is also good as the following chemical composition data from various countries shows :

Tunisia : at Tunis (Corriols, 1965)

Species and variety	Percentage Digestible Products Green Matter Basis				Metabolizable Energy/kg green matter	Forage Units/kg green matter
	Protein	Fats	Cell.	Non-N Extract		
<i>D. glomerata</i> (Variety 615 from Morocco) dryland culti- vation-sampled 12.4.1956	1.64	0.83	5.10	2.77	413 c	0.11

Morocco : (a) at Rabat (Villax, 1963)

Percentage composition						
Species	Water	Protein	Fats	Carbohydrates soluble fibre		Ash
<i>D. glomerata</i> (dryland cultivation)						
Green forage	81.8	3.2	0.4	8.4	4.6	1.6
Hay	20.0	14.0	1.9	36.8	20.3	7.0

(b) at Souss (Giuliani, 1974)

Percentage composition : dry basis					
Species	Crude Protein	Ether extract	Non-N extract	Cellulose	Ash
<i>D. glomerata</i> (native range)					
Green state	10.65	2.58	47.74	30.90	8.15
Dry state	3.74	1.32	51.51	35.49	7.94

Iran : at Sangh Deh (Dumancic, 1975)

Percentage chemical composition					
Species	Phenological stage of growth	Dry matter	Crude Protein	Ca	P
<i>D. glomerata</i> (dryland cultivation)	Full flowering				
	Nursery	29.9	14.4	0.52	0.25
	Field	28.5	10.0	0.31	0.25

6.10. Forage and Seed Production

Forage yields :

In the sub-steppic zone of Iran at Homand (1,960 m elevation, 320-350 mm annual rainfall) the forage yield of a 5 year old dryland nursery stand of *D. glomerata* amounted to 2,980 kg/ha DM In June in a year with a spring (March-June) rainfall of 282.9 mm (AGP:SF/IRA 10, Tech. Rep. 1, 1970).

In the Caspian forest zone (+600 mm annual rainfall) of Iran *D. glomerata* in mixture with either *Lolium perenne* or *Medicago sativa* has given green forage yields varying from 15,000-38,000 kg/ha/year over a 3 year period without fertilization ; spring fertilization in May with 30-80 kg/ha N gave yield increases of 30-50 % in some years (Dumancic, 1975).

In the littoral zone (400-600 mm annual rainfall) of Tunisia, at Tunis, Corriols (1965) records the following forage production data for *D. glomerata* variety 615 from Morocco which substantially outyielded 9 exotic and 1 local variety and showed only a 1 % summer mortality over a 2 year period :

1955-56 (664.7 mm rainfall) 2nd year				1956-57 (492.2 mm rainfall) 3rd year			
Green forage kg/ha	Dry matter kg/ha	Digestible protein kg/ha	Forage Units/ha	Green forage kg/ha	Dry matter kg/ha	Digestible protein kg/ha	Forage Units/ha
27,386	7,394	520	4,381	14,220	2,417	270	2,275

In the littoral zone (500-600 mm annual rainfall) of Morocco, at Rabat, Villax (1963) records that experimental green forage yields of *D. glomerata* have varied from 20,000-40,000 kg/ha and hay yields from 5,000-10,000 kg/ha.

In the high plateaux zone of Algeria Maignan (1970) and Gallacher (1972) record an experimental green forage yield for a native variety of *D. glomerata* subsp. *hispanica* of 18,000 kg/ha in a season (September-May) with 561.4 mm of rainfall.

Seed yields :

In regard to seed production Villax (1963) reports that experimental seed yields of *D. glomerata* in the littoral zone of Morocco, at Rabat, have varied from 200-400 kg/ha.

Gallacher (1972) also mentions that harvesting of seeds of *D. glomerata* subsp. *hispanica* is often difficult with a combine harvester and he recommends cutting the crop with a reaper and binder for transporting for forage and drying, and then later threshing.

6.11. Utilization

Time of use and establishment :

In Morocco Villax (1963) states that it is preferable not to graze dryland *D. glomerata* in the first year to assist establishment and he recommends grazing *D. glomerata* before the formation of the panicles and cutting it for hay before flowering.

Pasture and grazing use :

D. glomerata and *D. glomerata* subsp. *hispanica* are both ideal for grazing utilization and in the high plateaux zone of Algeria Gallacher (1972) considers that *D. glomerata* subsp. *hispanica* is a very good species for dryland seeding in mixtures for long term pastures for sheep.

Grazing management :

In N. Egypt Ibrahim (1965) states that *D. glomerata* subsp. *hispanica* responds to protection from grazing becoming vigorous, and since it is a climax species it has an important role to play in range rehabilitation and improvement. However although *D. glomerata* subsp. *hispanica* persists under continuous heavy grazing rotational grazing is required to maintain the pasture in a fully productive state over many years.

Number of fodder cuts :

In the high plateaux zone of Algeria Maignan (1970) reports that two cuts have been taken from dryland stands of *D. glomerata* subsp. *hispanica*, one at the end of March and another at the end of April.

In the Caspian Forest Zone of Iran Dumancic (1975) records that three cuts a year have been taken from *D. glomerata* in mixture with other grasses and legumes under dryland cultivation over a three year period.

Further evaluation :

In the future more attention needs to be paid to the collection of drought resistant ecotypes of *D. glomerata* subsp. *hispanica* which show much promise for seeding in semi-arid steppe areas of N. Africa and the Near East.

6.12. Specific References

- | | |
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TECHNICAL DATA

SHEET No 7

GRAMINEAE (= POACEAE)

Festuca arundinacea Schreb.

7.1. Synonym

Festuca arundinacea (= *Bromus arundinaceus* (Schreb.) Roth)

7.2. Common Names

English	Tall Fescue, Reed Fescue, Alta Fescue (USA) ; Reed Fescue Grass (Jordan).
French	Fétuque roseau, Fétuque élevée.
Arabic	Ikrish (Jordan).

7.3. Brief Description

Tall deep rooted tufted perennial growing to a height of 80-160 cm ; glabrous forming thick tufts and more or less rhizomatous ; stems thick, spreading, very rich in basal leaves, leaves long 30-60 cm, 5-15 mm wide, pointed ; inflorescence in the form of a panicle 10-40 cm long with numerous branches and spikelets ; spikelets broad and mostly loose with 4-9 flowers ; the lemmas 7-10 mm long, awnless or more usually with a short awn, 1-4 mm long. (Fig. 1 and 2).

Morphologically *F. arundinacea* can be distinguished from *F. elatior* L. by the presence of a number of small hairs on the auricle visible to the naked eye.

The seeds of *F. arundinacea* are similar in size and shape to seeds of *Lolium perenne* L., but are somewhat darker in general appearance due to a slight purple tinge on the glumes or chaff and a dark purple tinge on the caryopsis.

7.4. Varieties

Botanical forms and varieties :

Some botanists such as Cuenod et al. (1954) and Maire (1955) consider *F. arundinacea* to be a subspecies of *F. elatior* and they report the following forms and varieties of *F. elatior* var *arundinacea* as occurring in North Africa :

- var *Uechritziana* Hack.
with glabrous stems under the panicle ; very rare ;
- var *genuina* Hack.
with smooth stems ; rare but present in Algeria, Tunisia, Morocco, Libya and the northern part of the Mediterranean basin ;



Fig. 1 - *Festuca arundinacea* Schreb.

- | | | | |
|----------------------------------|---------------------------|------------------------------|------------------------------|
| 1. Habit, $\times \frac{2}{3}$. | 2. Spikelet, $\times 2$. | 3. Lower glume, $\times 6$. | 4. Upper glume, $\times 6$. |
| 5. Lemma, $\times 6$. | 6. Palea, $\times 6$. | 7. Flower, $\times 10$. | 8. Ligule, showing |
| auricles, $\times 3$. | | | |

(After Flora of Iraq, Vol. 9, 1968, p. 83, plate 29)



Fig. 2 - *Festuca elatior* ssp. *arundinacea*

Plant, x1. Spikelet, x4. gi : Inferior glumella, x4. gs : Superior glumella, x4. C : Caryopsis, x4. L : Ligule, x4.

(After Introduccion al Estudio Especies Pascicolas
Espagnolas, Madrid, 1965, p. 100)

- subvar. *vulgaris* Hackel (= *F. arundinacea* Schreb. sensu stricto)
with rounded or lightly mucronated lemmas ; present in Morocco ;
- subvar. *mediterranea* Hackel
with clearly auricled lemmas ; common in Algeria, Morocco, Tunisia and Libya ;
- var. *glaucescens* Boiss (= *F. elatior* var *fenas* (Lag.) Hack.,
F. fenas (Lag.) Gen. et Sp.)
with smooth stems, narrow panicle and leaves narrowly rolled up
when dry ; present in Morocco and Algeria and also recorded by
Mouterde (1966) in Lebanon ;
- subvar. *genuina* St.-Yves (= *F. elatior* var *fenas* subvar *typica*
Hack.)
with rounded or lightly mucronated lemmas and inferior secondary
branch of the panicle carrying spikelets almost from
the base ; present in Morocco and Algeria ;
- subvar. *tunetana* St.-Yves
with awned lemmas and inferior secondary branch of the panicle
for a large part naked at the base ; common in north and central
Morocco ;
- var. *cirtensis* St.-Yves
with scabrous stems under the large panicle and the ovary
having long hairs at the summit ; common in Morocco (Atlas
Mts.) ;
- f. *mucronata* Lit. et Maire in L. et M.
with rounded or lightly mucronated lemmas ;
- var. *atlantigena* St.-Yves
with smooth stems under the panicle and stiff narrow panicle ;
present in Morocco ;
- f. *pseudo-Mairei* Lit. et Maire in L. et M.
with rounded or sparsely mucronated lemmas ; common in Morocco
(Atlas Mts.) ;
- f. *laeviglumis* R. Lit.
with awned lemmas, smooth on the back, except the bottom, which
is a little scabrous ; present in Morocco ;
- var. *minutiflora* (St.-Yves) R. Lit.
- *F. elatior* var *glaucescens* subvar *minutiflora*
with spikelets having small purple plumes ; present in Morocco ;
- subvar. *Duvalii* R. Lit.
with longer spikelets than the type form ; present in Algeria ;
- var. *Letourneuxiana* St.-Yves
with large panicle and stems a little convoluted when dry ;
common in Algeria, Morocco (Atlas Mts.) and in Tunisia ;

- subvar *Pitardii* St.-Yves
with awned strongly scabrous lemmas ; common in Morocco (Atlas Mts.) ;
- f. *leiantha* R. Lit.
with smooth lemmas but a little scabrous at the bottom ; present in Algeria ;
- subvar. *pseudo-vulgaris* St.-Yves
with rounded or very abruptly mucronated lemmas ; present in Morocco and Algeria.

Native ecotypes :

In Turkey Hertzsch (1970) records that 28 ecotypes of *F. arundinacea* have been collected in various parts of the country and established in dryland nurseries at Izmir (W. Turkey).

In Iran Pabot (1967) states that the Iranian ecotypes are rare, little palatable and generally localized in humid places, and he adds that it seems preferable to utilize exotic varieties that have already been introduced and which have undergone a selection process.

Agricultural varieties and cultivars :

In North Africa and the Near and Middle East most dryland plantings of *F. arundinacea* have been made either with exotic varieties introduced from the USA, or with varieties developed in N. Africa (Algeria, Morocco, Tunisia).

Amongst the Moroccan varieties Ionesco et al. (1969) mention that the varieties 4111, 4112 and 4302 have been selected for multiplication, while Villax (1963) records the varieties CRA/INRA 4476/59, 4480/59, 4481/59, 4495/59 and 4496/59 as being very productive. Barbut (1955) also mentions the selection No. 352 from Constantine (Algeria) which is a very good seed producer.

In Tunisia Le Houerou (1965), Le Houérou and Froment (1969) and Corriols (1965) mention the selection "Soliman" collected and multiplied from a natural population as performing as well as exotic varieties under dryland conditions and that local selections are practically free of rust ; two other selections, "Grombalia" and "Djebibina", both collected from natural populations and multiplied, are also mentioned by Semadeni (1965).

Corriols (1965) also records that the foliage production of "Grombalia" is excellent and superior to that of the variety No. 171 from Israel which, together with No. 618 from Morocco, have proved more productive than the other varieties tested under dryland conditions in Tunisia.

The following exotic varieties of *F. arundinacea* have also been tested under dryland conditions in Algeria, Tunisia and Iran :

<u>Country</u>	<u>Variety</u>	<u>Origin</u>
Algeria (high plateaux zone)	"Alta"	USA
	"Goar"	USA
	"Kenwell"	USA
Tunisia (littoral zone)	"KY 31"	USA
	"INIA 26"	Spain
	"462"	Italy
Iran (sub-steppic zone)	"Goar"	USA
	"KY 31"	USA
	"Manade"	France

Villax (1963) considers that of all the varieties of *F. arundinacea* mentioned from the USA, "KY 31" grows best in the Mediterranean region.

In regard to cultivars of *F. arundinacea* adapted for use under dryland conditions in the USA, and some of which have been utilized in N. Africa and the Near and Middle East, Heath et al. (1973) give the following information :

- "Alta", a medium to early maturing type and adapted to dry summer conditions ; developed in Oregon and released in 1940 ;
- "Goar", an early type maturing and adapted to alkaline soils ; developed in California and released in 1946 ;
- "Fawn", an early maturing type with good seedling vigour and improved palatability, developed in Oregon and released in 1964 ;
- "KY 31", a medium maturing type with wide adaptability and good winter growth ; developed in Kentucky and released in 1942 ;
- "Kenmont", a medium maturing type with good mid-season growth ; developed in Kentucky and Montana and released in 1963 ;
- "Kenwell", a late maturing type with improved disease resistance and palatability, developed in Kentucky and released in 1965.

7.5. Number of Chromosomes

Principally allogamous $n = 21$; $2n = 6x = 42$, $2n = 10x = 70$; a naturally cross pollinated species ; Heath et al. (1973) report that some 33 % of the plants will produce some seed with selfing, and a few plants are highly self-fertile. Numerous investigators have also succeeded in producing intergeneric hybrids between *F. arundinacea* and *Lolium* spp. suggesting some degree of relationship between these two genera (Heath et al., 1973).

7.6. Geographical distribution

F. arundinacea is distributed in almost the whole of Europe and in Cyprus, Syria, Lebanon, Palestine, Jordan, Turkey, Caucasus, Iran, Iraq, W. Pakistan, Afghanistan, C. Asia, Japan, Macaronesia, N. Africa, Morocco, Algeria, Tunisia, Libya and introduced into Australia, New Zealand and N. America.

7.7. Biology and Ecology

Growth and development :

F. arundinacea is a cool season species propagating itself by seed which grows well under dryland conditions in the Mediterranean region. Villax (1963) states that *F. arundinacea* is much less exacting in its requirements than *Dactylis glomerata* and it supports well the vigorous winter.

This is supported by Giscard (1961) who records that two selections from the USA and the local selection of *F. arundinacea* have given excellent growth and results in the mountainous parts of the provinces of Fès, Meknes, Rabat and Marakesh in Morocco, and also in the region of Bazer, St. Arnaud and Trezel in Algeria

Under dryland conditions vegetative growth of established dryland *F. arundinacea* begins after the first autumn rains and in Algeria continues during the winter even in the high plateaux zone, as well as in the littoral zone, depending on the prevailing temperatures (Agricultural Experimentation Service, 1957).

Semadeni (1965) records that at Tunis in the littoral zone the growth of the two seeded selections "Grombalia" and "Djebibina" are characterized by a winter and spring growth cycle which commences after the first autumn rains. The vegetative growth period has lasted for 80 days but during the first month the growth phase was slow becoming more rapid when the stems obtained a height of 4-5 cm in mid-February ; by early March the selection "Djebibina" was at the end of the heading stage.

It is recognized that the foliage of *F. arundinacea* becomes very lignified during the heading stage although the degree of lignifications varies for different varieties.

Corriols (1965) also records that varieties of *F. arundinacea* in the littoral zone of Tunisia have a fairly continuous autumn-winter beginning of spring growth period if they are utilized frequently enough with 3-6 week rest periods between cuttings.

Both Villax (1963) and Giscard (1961) draw attention to the more rapid autumn-winter growth of cuttings of *F. arundinacea* in Morocco compared to seedings.

In the littoral zone of N. Africa flowering usually takes place in April but vegetative growth stops at the end of the spring or early summer ; Corriols (1965) records that the leaves of *F. arundinacea* remain green throughout the summer dormant period and Villax (1963) reports that *F. arundinacea* will continue to grow in summer in Morocco if given some supplementary irrigation.

In the sub-steppic zone of Iran at Homand (1,960 m elevation) vegetative growth starts in mid-March, the heading (boot) stage in early May, flowering in mid-June and seed production at the end of June or early July ; summer growth is largely dormant with some growth occurring in October depending on the incidence of autumn rains. Plants generally set abundant seeds particularly in the xerophilous forest zone where dryland adaptability row plantings showed excellent seed set at Plour (2,600 m elevation).

Corriols (1965) also reports that the seed production of *F. arundinacea* is excellent in the littoral zone of Tunisia and Giscard (1961) records that abundant seed production occurs in Morocco at the beginning of the summer and that seed maturity coincides with the onset of summer dormancy in plant growth.

Corriols (1965), however, draws attention to two major drawbacks for dryland *F. arundinacea* which are the rather poor seed germination of certain local varieties and a great sensitivity of the young plants, particularly the selection "Grombalia", to cold temperatures of -3°C in the winter ; nevertheless these varieties have resisted very well flooding for up to 60 days and are very resistant to trampling even by cattle.

Climate and soils :

In N. Africa *F. arundinacea* has proved well adapted to dryland seeding in the littoral and high plateaux zone with 450-600 mm annual rainfall ; Ionesco et al. (1969) consider that an annual rainfall in excess of 450 mm is required for dryland cultivation in Morocco with a mean winter temperature of 0°C . However, *F. arundinacea* has proved well adapted to the Midelt region of Morocco with only 250-320 mm annual rainfall (Otmane, 1974).

In Iran *F. arundinacea* shows good adaptability for dryland seeding in the xerophilous forest zone (+400 mm annual rainfall) and medium adaptability for seeding in the sub-steppic zone (320-350 mm annual rainfall).

F. arundinacea is also resistant to cold and drought and is adapted to a wide range of soils with a pH range of 4-10 (Lapeyronie, 1965) although it prefers those that are heavy and humid ; it also tolerates flooding and is tolerant of poor drainage particularly in the winter period. *F. arundinacea* also grows moderately well on soils with some salinity (about 20 mmhos) according to Le Houerou (1965) and in the steppic zone of N. Iran it also shows some promise for seeding on alkaline/saline soils with a high water table (AGP:SF/IRA 10, Tech. Rep. 1, 1970).

Ecological characteristics :

Ecologically *F. arundinacea* appears to be fairly rare throughout N. Africa, the Near and Middle East, and to be restricted to humid places where it is spontaneous on heavy soils often periodically inundated during the winter. Maire (1965) records that *F. arundinacea* in North Africa occurs in most grasslands and by the borders of streams from the littoral zone up to 2,500 m elevation in the mountains, but it is not present in the Sahara.

In Tunisia Lapeyronie (1965) states that *F. arundinacea* forms in association with *Oenanthe globulosa* an interesting pastoral type in humid places in the north ; Lapeyronie (1965) also notes that in Tunisia it is commonly associated with *Juncus maritimus* in wet sites.

In Lebanon Mousterde (1966) records that *F. arundinacea* occurs on Mt. Faraya, Mt. Qamoula, Mt. Zahlé and Mt. Ta'nail and in Syria on Mt. Har, near Homs, and on Mt. Mzerib and on Mt. Er Raha in the Jezeirah District ; he also records var. *glaucescens* as being present close to the sea or on saline land.

In Jordan, Kasapligil (1956) records *F. arundinacea* as occurring in the Kerak district (1,550 m elevation) on calcareous sandy clay and by the side of a swampy creek near Amman.

In Iran Parsa (1950) records *F. arundinacea* as being present in Dashte-Arjan Mts. in the south and in Azerbaidjan-Deylaman and Tchahik, and Gharnghtatch Forest in the north.

7.8. Cultivation Techniques

Time of seeding :

In the littoral zone of N. Africa *F. arundinacea* has normally been seeded in dryland plantings after the first autumn rains (Villax, 1963) ; in Tunisia Le Houerou (1965) and Le Houérou and Froment (1969) recommend seeding during the second half of September before the arrival of the autumn rains and not later than 10-20th October.

In the sub-steppic zone of Iran at Homand (1,960 m elevation) the best time for seeding dryland *F. arundinacea* has proved to be in the spring (31 March-15 April).

Land preparation :

The choice of land is important and Le Houérou (1965) and Le Houérou and Froment (1969) recommend utilizing heavy textured soils with only a little slope and they indicate also a preference for utilizing bottom lands or flat plains that are free of serious weed infestation. The absence

of weeds is considered important since the young plants of *F. arundinacea* develop slowly during the establishment period and are vulnerable to competition.

A good, firm, friable, weed-free seed-bed is required to aid moisture retention and promote seed germination.

In Tunisia Le Houérou (1965) and Le Houérou and Froment (1969) recommend choosing a well worked fallow or cropped land on which the previous crop has been clean cultivated, and at least 1 harrowing or discing, followed by 1-2 rollings and 1 light harrowing is required for seed-bed preparation at the beginning of September.

Under field planting conditions in the sub-steppic zone of Iran, at Homand, ploughing to a depth of 15 cm, discing with a disc or spring toothed harrow, dragging with an iron bar and rolling have been required to prepare a good seed-bed for dryland *F. arundinacea*.

Seed rate and method of seeding :

The amount of seeds sown and the row spacing used have varied from country to country but the following have been reported :

Morocco : Giscard (1961) recommends a seed rate of 5 kg/ha, Ionesco et al. (1959) 15 kg/ha in rows spaced 30-50 cm apart, and Villax (1963) 15-20 kg/ha in rows spaced 60-80 cm apart ; depth of seeding : 2-3 cm ;

Algeria : The Agricultural Experimentation Service (1957) recommends a seed rate of 10 kg/ha, and Le Houérou (1971) 12-15 kg/ha planted in rows spaced 80 cm apart ;

Tunisia : Le Houérou (1965) and Le Houérou and Froment (1969) recommend a seed rate of 15 kg/ha drilled in lines spaced 30-50 cm apart ; depth of sowing shallow, and Lapeyronie (1965) recommends a seed rate of 10 kg/ha in lines spaced 40-50 cm apart ;

Iran : Peymani and Tarifi (1974) recommend a seed rate of 10 kg/ha drilled or planted at the side of 5-10 cm deep furrows ; depth of seeding : 0.5-2 cm.

In Tunisia Le Houérou and Froment (1969) report that at Sidi Thabet (450 mm annual rainfall) dryland *F. arundinacea* has been planted for seed production at a seed rate of only 3 kg/ha in rows spaced 75 cm apart.

Vegetative propagation :

Field scale planting of *F. arundinacea* using a mechanical drill has been carried out in the littoral zone of Tunisia and the sub-steppic zone of Iran. Since the seeds are small, care is needed in drilling to obtain a

uniform stand. Le Houérou and Froment (1969) recommend the use of an additional operator to watch that the drill spouts do not become blocked and the discs of the drill are normally raised to sow the seed shallowly, which are then covered by two passes with a cultipacker roller.

In Iran the use of rice mills in mixture with the seeds of *F. arundinacea* in both the John Deere Green drill and the McCormick Orchard drill has given good results. The seed setting lever of the drill in both cases is left in the fully open position.

For the establishment of cuttings of dryland *F. arundinacea* Giscard (1961) recommends a spacing of 50-60 cm and Villax (1963) a spacing of 50-70 cm in and between the rows in Morocco. Cuttings of *F. arundinacea* have also been established at a spacing of 50-70 cm in and between the rows in the sub-steppic zone of Iran at Homand, but the technique is mainly useful for nursery establishment of ecotype and variety collections.

Fertilizer application :

Fertilizer has not normally been applied to dryland plantings of *F. arundinacea* either at seeding or at a later stage, except in N. Africa. Le Houerou (1971) has commented on the need to apply adequate nitrogen to dryland plantings of *F. arundinacea* to obtain good forage production.

In Tunisia Le Houerou (1965) and Le Houérou and Froment (1969) recommend the following fertilizer application :

At sowing : 5-15 kg/ha N)
 5-15 kg/ha P_2O_5) localized in the lines
 - end of November : 20 kg/ha N
 - end of January : 20 kg/ha N
 - end of March : 20 kg/ha N

During the 2nd and following years :

- end of September: 30 kg/ha N
- end of November : 30 kg/ha N
- end of February : 30 kg/ha N
- end of March : 30 kg/ha N

In Tunisia Lapeyronie (1965) has also recommended the following basic fertilizer application for establishing dryland *F. arundinacea* :

50 kg/ha of N in the form of ammonium nitrate
100-150 kg/ha P_2O_5 in the form of superphosphate (16 or 45 % P_2O_5)
and where soil potassium level is markedly low :
50-100 kg/ha K_2O

At seeding an application of 20 kg/ha of P_2O_5 on the seeding rows is also recommended.

In Algeria Le Houerou (1971) has recommended a basis application of 100-150 kg/ha of P_2O_5 before seeding dryland plantings of *F. arundinacea* followed by an application of 90-120 kg/ha N per year divided into 3-4 applications during the following three years.

In the high plateaux zone (450-600 mm annual rainfall) of Algeria Maignan (1970) reports the application of 150 kg/ha of P_2O_5 as a basic dressing before seeding in September/October dryland experimental plantings of *F. arundinacea*, followed by an application of 50 kg/ha N in October and again in January/February in the following years.

7.9. Forage Value

Palatability :

F. arundinacea is considered to be a palatable species especially in the vegetative stage and well accepted by livestock particularly cattle ; in Algeria Gallacher (1972) records *F. arundinacea* selection "Soliman" as being good cattle fodder. In the sub-steppic zone of Iran spring palatability grazing tests with sheep showed that dryland *F. arundinacea* was well grazed in the vegetative and heading (boot) stages and fairly well grazed in the flowering and seed production stages ; in the summer vegetative stage it was poorly grazed but was fairly well grazed in the autumn vegetative stage.

It is generally accepted that the foliage of *F. arundinacea* becomes progressively coarser as the plants approach maturity, and in the USA the forage quality of dryland *F. arundinacea* is considered to be somewhat poorer in late spring and during the summer than most other grasses (Van Keuren, 1970). Contributing factors which govern the quality of the forage of *F. arundinacea* appear to be the age of the leaves, fertility of the soil on which it is grown, season of the year and genetic variation (Heath et al., 1973).

Ergot poisoning :

In Morocco Giscard (1961) has also reported occasional ergot poisoning of livestock grazing *F. arundinacea* in some years when the weather is misty at the end of the spring. The poisoning is provoked by *Claviceps purpurea* which attacks *Triticum vulgare* and more often *Secale cereale* ; ergot poisoning in association with the grazing of *F. arundinacea* has also been reported in the USA (Yates, 1968 ; Yates et al., 1968).

Nutritive value :

The nutritive value of *F. arundinacea* is good and Ionesco et al. (1969) record in Morocco a forage value at heading of 0.13-0.16 and even 0.19 forage units per kg green forage, 16-32 g digestible protein per kg green forage and 32 % DM, and 0.54 forage units per kg green matter, 27 g digestible protein per kg green matter and 89 % DM for the hay. The following

chemical composition data is also recorded in Algeria, Morocco, Tunisia and Iran :

Algeria (a) Littoral Zone (Algiers), (Service de l'Expérimentation Agricole en Algérie, 1957)

Chemical analysis of green forage in the spring vegetative stage

Chemical analysis of green forage in the spring vegetative stage		
Water :	78.6 %	
	<u>% Crude Composition Dry Basis</u>	<u>% Digestible Constituents</u>
Fats	2.5	3.0
Protein (Albumin)	9.24	} 9.34
Protein (Non-albumin)	4.69	
Sugars	23.81	17.40
Cellulose	21.15	13.03
Non-N Extract	27.25	19.92
Ash	11.36	-
Crude Energy Total per 100		62.69
<u>Number of Forage Units</u>		
per 100 kg dry		72.09
per 100 kg green		15.4
<u>Mineral Matter</u>		
Ash total % dry		11.36
CaO		2.72
MgO		0.94
P ₂ O ₅		1.120
NaCl		2.34
Alkalinity		175.0
Alcalescence m. eg. v. %		= +96.7

Morocco (a) Littoral Zone (Rabat) (Villax, 1965)

Percentage Chemical Composition

	<u>Water</u>	<u>Protein</u>	<u>Fats</u>	<u>Carbohydrates</u>		<u>Ash</u>
				<u>Soluble</u>	<u>Fibre</u>	
Green forage	80.6	2.8	0.8	8.6	4.6	2.6
Hay	20.0	11.6	3.5	35.2	18.9	10.8

(b) Littoral Zone (Rabat) (Foury, 1956)

Line Selection Meknès

Date Sampled	State of Forage	Percentage Chemical Composition					
		Water	Ash	Protein	Non-N Extract	Fats	Cellulose
12.5.50	Green matter	78.00	2.36	2.53	11.73	0.90	4.46
	Dry matter	0	10.72	11.50	58.28	4.19	20.31
22.6.50	Green matter	51.50	4.59	5.56	25.77	1.85	10.73
	Dry matter	0	9.48	11.46	53.15	3.52	22.39
30.1.51	Green matter	73.94	3.70	3.45	12.62	0.85	5.44
	Dry matter	0	14.29	13.26	48.33	3.30	20.91
3.11.52	Green matter	73.55	4.63	3.55	11.42	0.98	5.86
	Dry matter	0	17.50	13.47	43.14	3.71	22.18
9.3.53	Green matter	80.60	2.62	2.82	3.55	0.84	4.57
	Dry matter	0	13.51	14.49	44.03	4.35	23.57
23.4.53	Green matter	74.76	2.32	2.87	12.97	0.84	6.24
	Dry matter	0	9.20	11.41	51.35	3.35	24.69

Line Selection Meknès

Date Sampled	Mineral Composition - % of Dry Matter					
	CaO	MgO	P ₂ O ₅	K ₂ O	Na ₂ O	Alcalinity
3.11.52	0.852	0.009	0.867	1.407	0.004	- 5.7
9.3. 53	0.709	0.010	0.656	3.061	0.055	- 1.9

Tunisia (a) Littoral Zone (Tunis) (Corriols, 1965)

Variety	Date Sampled	Percentage Digestible Products					
		Protein	Fats	Cell.	Non-N Extract	Energy kg green matter	Units/kg green matter
"KY 31" selection 618 Morocco	16.12.55	0.76	0.36	1.99	2.20	210 c	0.05
	23. 3.56	2.45	0.73	4.70	3.68	455 c	0.13
	14.12.55	1.13	0.55	0.78	2.94	294 c	0.07
	23. 3.56	2.00	1.26	4.61	5.82	553 c	0.16

1. Composition and Nutritive Value of the 1st cut of the varieties

"Grombalia" (A) and "Djebibina" (B)

Stage of Growth & Date of Sampling	Dry matter %		Mineral matter %		Organic matter total (% DM)		Digestible Protein (g/kg DM)		Forage Units (% DM)		Total Protein (% DM)		Digestible organic matter (g/kg DM)	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Rosette (23 Nov.)	15.8	15.8	13.7	15.7	86.3	84.3	247	223	68	66	30.8	28.1	604	590
Rosette (8 Dec.)	17.4	15.8	15.3	15.3	84.7	84.7	230	197	66	66	28.9	25.5	593	593
Rosette (22 Dec.)	16.1	14.7	13.2	13.3	86.8	86.7	178	169	68	68	23.0	22.0	608	607
Beginning of Heading (25 Jan.)	16.6	16.9	11.9	12.5	88.1	87.5	126	113	69	65	17.2	15.7	617	595
Heading (22 Feb.)	20.8	19.1	11.9	10.3	88.1	89.7	95	72	65	62	13.7	11.1	599	592
End of Heading (9 March)	19.9	21.3	10.4	10.5	89.6	89.5	62	77	62	59	10.0	11.7	591	573

2. Digestible Organic Matter expressed as a percentage
of the Total Organic Matter

Stage of Growth and Date of Sampling	"Grombalia" % DOM	Stage of Growth and Date of Sampling	"Djebibina" % DOM
Rosette (23 November)	70	Rosette (23 November)	70
Rosette (8 Decmeber)	70	Rosette (8 December)	70
Rosette (22 January)	70	Rosette (22 January)	70
Heading (stem 2 cm above the level of tillering) (22 February)	70	Heading (Stem 4 cm above the level of tillering) (22 February)	68
Heading (stem 5 cm above the level of tillering) (9 March)	68	Heading (stem 11 cm above the level of tillering) (9 March)	66
Heading (stem 10 cm above the level of tillering) (date not given)	66	Heading (stem 20 cm above the level of tillering) (date not given)	64

3. Forage Units

Stage of Growth and Date of Sampling	<u>"Grombalia"</u>		<u>"Djebibina"</u>	
	Forage Units/ kg/DM	Forage Units/ kg/DM	Forage Units/ kg/DM	Forage Units/ kg/DM
Rosette (23 November)	0.68	0.11	0.66	0.10
Rosette (8 December)	0.66	0.12	0.66	0.10
Rosette (22 December)	0.68	0.11	0.68	0.10
Beginning of Heading (25 January)	0.69	0.11	0.65	0.11
Heading (22 February)	0.65	0.14	0.62	0.12
End of Heading (9 March)	0.62	0.12	0.59	0.13

4. Digestible Protein

Stage of Growth and Date of Sampling	<u>"Grombalia"</u>			<u>"Djebibina"</u>		
	Total Protein kg/DM	Dig. Protein kg/DM	Coeff.Dig. Total Protein	Total Protein kg/DM	Dig. Protein kg/DM	Coeff.Dig. Total Protein
Rosette (23 November)	338 g	247 g	80.3 %	281 g	223 g	79.5 %
Rosette (8 December)	289 g	230 g	79.8 %	251 g	197 g	78.6 %
Rosette (22 December)	230 g	178 g	77.6 %	220 g	169 g	77.0 %
Beginning of Heading (25 January)	172 g	126 g	73.3 %	157 g	113 g	72.0 %
Heading (22 February)	137 g	95 g	69.2 %	111 g	72 g	64.8 %
End of Heading (9 March)	130 g	62 g	62.0 %	117 g	77 g	65.8 %

(c) Littoral Zone (Tunis) (Theriez, 1967, 1968)

1. Net Energy Value of Local Varieties (averages and extremes)

Stage of Growth	<u>Forage Units per kilogramme</u>		
	Organic Matter	Dry Matter	Green Forage
<u>1st Growth</u>			
Vegetative	0.78	0.66 (0.61-0.70)	0.12 (0.10-0.15)
Heading	0.77	0.63 (0.59-0.67)	0.13 (0.11-0.14)
Emergence of Inflorescence	0.64	0.57	0.15
Formation of Seeds	0.62	0.57	0.23
<u>Re-Growth</u>			
Heading	0.77	0.67 (0.55-0.70)	0.12 (0.11-0.13)
Emergence of Inflorescence	0.69	0.62 (0.57-0.67)	0.17 (0.14-0.19)

2. Digestible Protein Content of Local Varieties (averages and extremes)

Stage of Growth	<u>Grams of Digestible Protein per kilogram</u>	
	Dry Matter	Green Matter
<u>1st Growth</u>		
Vegetative	140 (122-166)	26 (22 - 31)
Heading	108 (87-123)	20 (18 - 26)
Emergence of Inflorescence	84	26
Seed Formation	71	28
<u>Re-growth</u>		
Heading	90 (68-122)	16 (14 - 18)
Emergence of Inflorescence	50 (29 - 70)	12 (10 - 14)

3. Mineral Content in grams per kilogram dry matter

Stage of Growth	Phosphorous	Calcium	Magnesium	Potassium	Sodium
Vegetative	3.1	8.7	2.0	28.2	5.4
Heading	3.0	8.2	1.6	25.2	-
Emergence of Inflorescence	2.3	5.5	1.4	-	3.4

Iran (a) Sub-steppic Zone (Homand) (AGP:SF/IRA 10, Tech. Rep. 1, 1970)

Stage of Growth	<u>Chemical Composition : % of Dry Matter Spring Period 1967</u>	
	Crude Protein	Crude Fibre
Vegetative	16.7	20.0
Flowering	10.3	27.2
Seed Production	9.9	25.9

(b) Caspian Forest Zone (Sang Deh) (Dumancic, 1971)

Stage of Growth	<u>Chemical Composition</u>			
	Dry Matter	Crude Protein	Ca	P
Beginning of Flowering	33.8	10.6	0.45	0.25
Full flowering	22.0	10.6	0.47	0.27

7.10. Forage and Seed Production

Forage yields :

In the littoral zone of Tunisia Corriols (1965) records the following experimental green forage yields for four varieties of *F. arundinacea* :

Variety	<u>1955-56</u>	<u>1956-57</u>
	(664.7 mm rainfall)	(492.2 mm rainfall)
	Second Year	Third Year
	Green Matter kg/ha	Green Matter kg/ha
KY 31	4,445	11,332
INIA 261	10,720	16,998
Morocco (local)	27,385	15,554
Israel 171.1	50,940	31,219

More detailed production data is also given by Corriols (1965) for the 1955-56 season for these four varieties of *F. arundinacea* which is given below :

Variety	Green Matter kg/ha	Hay (1)	Dry Matter kg/ha	Crude Protein kg/ha	Digestible Protein kg/ha	Forage Units/ ha
KY 31	4,455	890	700	109.8	74.1	400
INIA 261	10,720	2,145	1,983	246.5	155.4	1,072
Morocco (local)	27,385	5,477	5,533	684.6	427.2	3,012
Israel 171.1	50,940	10,180	8,529	1,018.8	733.5	5,094

At Sidi Thabet, near Tunis, Le Houerou (1965) reports experimental green forage yields for *F. arundinacea*, variety "Soliman", of 10,000-20,000 kg/ha (1,000-2,000 forage units/ha) from 2 cuts in the first year and from 20,000-60,000 kg/ha (2,000-6,000 forage units/ha) from 3-4 cuts in subsequent years (2nd to 5th year).

(1) Yield of hay estimated at 20 % of green yield

In Tunisia, at Tunis, Semadeni (1968) also reports the following experimental forage production yields for the "Grombalia" and "Djebibina" varieties of *F. arundinacea* when cut at different times during the growing season.

Date of Sampling	Days	<u>"Grombalia"</u> kg/ha DM	<u>"Djebibina"</u> kg/ha DM
<u>1st Growth</u>			
23 November	33	470	1,090
8 December	48	950	1,810
22 December	62	1,420	2,580
25 January	96	2,680	4,320
22 February	124	3,750	6,520
9 March	139	7,150	9,520
<u>Re-growth</u>			
16 March	113	6,160	6,910
23 March	105	5,220	6,090
31 March	99	2,990	3,240
5 April	70	1,860	1,960
14 April	51	1,920	1,790
21 April	43	1,220	1,090

In these trials the forage production of the variety "Djebibina" was always greater than that of the "Grombalia" variety.

In the high plateaux zone of Algeria Maignan (1970) and Gallacher (1972) report average green forage yields for experimental plantings of various varieties of *F. arundinacea* varying from 17,500-28,200 kg/ha/year in three cuts over a two-year period ; the local varieties Si Lakhdar (Algeria) and "Soliman" (Tunisia) substantially out yielded varieties "Goar" and "Alta" from the USA and "S170" from France in both years.

In Morocco at Rabat Villax (1963) and Ionesco et al. (1969) record experimental dryland green forage yields ranging from 15,000 to 50,000 kg/ha depending on the rainfall ; under irrigation green forage yields can reach 60,000-80,000 kg/ha and 7,000 to 8,000 forage units/ha.

Seed yields and harvesting :

In regard to seed production Villax (1963) indicates an average seed yield of 200 kg/ha for dryland plantings of *F. arundinacea* which can rise to 600 kg/ha under irrigation.

In the high plateaux zone of Algeria Maignan (1970) records that *F. arundinacea* variety "Soliman" has given under dryland conditions a seed yield varying from 264 (1) to 480 (2) kg/ha over a 2 year period (1st year (1) 547 mm, 2nd year (2) 614 mm rainfall) when fertilized with 45 kg/ha P_2O_5 and 77 kg/ha N. Gallacher (1972) also records that harvested seeds of *F. arundinacea* variety "Soliman" have given a germination percentage varying from 76-94 % but that since the seeds are small harvesting can be a problem for normal combine harvesters which have not sufficient adjustments ; however, with a reaper and binder the plants can be cut and transported for drying and later threshing.

7.11. Utilization

Time of use and establishment :

To ensure good establishment under dryland conditions it is recommended to commence grazing of *F. arundinacea* only in the autumn of the second year, and Le Houérou (1965) and Le Houérou and Froment (1969) recommend in Tunisia cutting of *F. arundinacea* in the first year followed by alternative cutting and grazing on a rotational basis in subsequent years. Ionesco et al. (1969) record that in Morocco dryland of *F. arundinacea* can furnish 2-3 cuts the first year and 4-5 cuts in subsequent years.

Use for grazing, hay and silages :

Villax (1963) states that in the Mediterranean region *F. arundinacea* can be utilized for grazing, direct green feed (soiling, zero grazing) or for conservation as silage or hay ; Gallacher (1972) reports in Algeria that *F. arundinacea* makes good quality silage and baled hay.

Grazing management :

Established plants of *F. arundinacea* require fairly hard grazing use to prevent coarseness of the foliage occurring and to encourage the production of new tender shoots and leaves ; proper grazing use would entail leaving 5-10 cm of growth after a grazing cycle is completed.

Corriols (1965) records that southern local varieties of *F. arundinacea* in Tunisia produce foliage which is relatively tender if the utilization is frequent enough.

However, Villax (1963) reports that *F. arundinacea* is sensitive to overgrazing in the early growth stages and he recommends cutting the first

growth and then grazing the subsequent re-growths. Lapeyronie (1965) also points out that taking a late cutting should be avoided because it promotes lignification of the leaves.

Liveweight gain of cattle on pasture :

In Tunisia Le Houerou (1971) reports that 10-18 month old steers weighing 150-200 kg have made daily gains of 700 g when pasturing dryland *F. arundinacea* with a conversion rate of 6-7 forage units per kilogram of liveweight gain.

Conservation as hay :

F. arundinacea makes excellent hay and in Tunisia Lapeyronie (1965) states that pasturing should stop at the end of January if a hay crop is required ; harvesting the crop for hay should take place at the beginning of flowering to obtain hay of good feeding value which is considered by Lapeyronie (1965) to be excellent for feeding cattle and horses in Tunisia.

Conservation use :

Gallacher (1972) considers *F. arundinacea* to be a useful species for seeding in wet areas and on drainage lines in the high plateaux zone (450-600 mm annual rainfall) in Algeria where in these situations it can be utilized in mixture with *Trifolium fragiferum* for intensive grazing.

F. arundinacea is also well recognized for its soil conservation value because of its penetrating root system and tolerance to adverse soil conditions.

Pasture longevity :

Ionesco et al. (1969) report that the longevity of a seeded dryland pasture of *F. arundinacea* in Morocco is perhaps 5-10 years.

Further evaluation :

However, further demonstration and development studies, particularly utilizing well adapted and productive native varieties, are probably needed before this species can receive wider recognition and agronomic use.

7.12. Specific References

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TECHNICAL DATA

SHEET No 8

GRAMINEAE (= POACEAE)

Hordeum spp.

8.1. Species

In North Africa and the Near and Middle East there are four species of forage importance which are *H. bulbosum* L., *H. fragile* Boiss., *H. spontaneum* C. Koch. and *H. violaceum* Boiss. et Huet.

8.2. Synonyms

- *H. bulbosum* (= *H. nodosum* Ucria non L.)
- *H. fragile* (= *Psathyrostachys fragile* Boiss. Nevski)
- *H. spontaneum* (= *H. ithaburensis* Boiss., *H. spontaneum* var. *ithaburensis* Boiss.)
- *H. violaceum* (= *H. secalium* (non Schreb), *H. pratense* var. *nodosum* Griseb)

8.3. Common Names

- | | | |
|------------------------|---------|--|
| - <i>H. bulbosum</i> | English | Bulbous Barley, Bulbous Wild Barley ; |
| | French | Orge Bulbeuse ; |
| | Arabic | Kurram, Kurraym, Subbeil (Jordan)
Qurram (Syria). |
| - <i>H. spontaneum</i> | English | Barley Grass, Wild Barley ; |
| | Arabic | Sha'ir barri (Jordan, Iraq). |

8.4. Brief Description

- *H. bulbosum* is a strongly caespitose heavy tillering perennial, developing tillers from bulbils at or below the soil surface and reaching a height of 80-150 cm with a bearded spike and the central spikelet attaining a length of 3 cm (Figs 1 and 2) ;
- *H. fragile* is a robust caespitose perennial species growing to a height of 60 cm with a curved base covered with the remains of the old leaf sheaths and with long awns on the spikelets (Fig. 3) ;
- *H. spontaneum* is a tall glabrous smooth annual species growing to a height of 70 cm with triplets of awned spikelets (Fig. 4) ;
- *H. violaceum* is a broadly caespitose perennial species growing to a height 15-80 cm with a bulbous base, scabrous glumes and bristly awned spikelets.

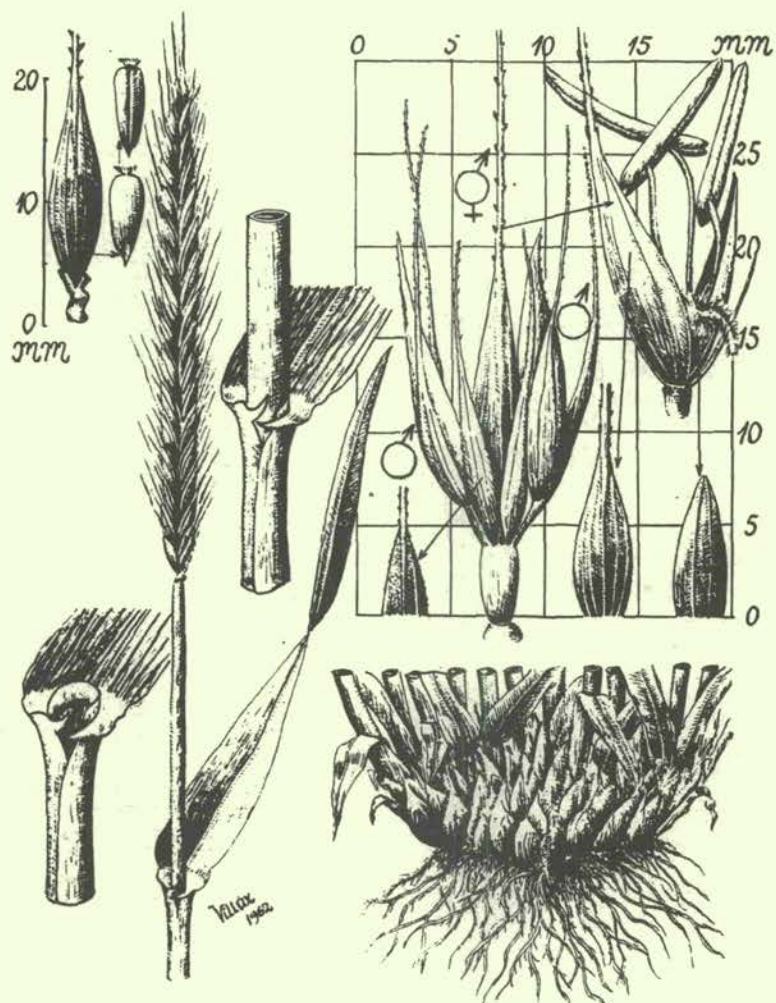


Fig. 1 - *Hordeum bulbosum* (Orig. - Rabat 1962)

(After La Culture des plantes fourragères dans la région Méditerranéenne occidentale, 1963, p. 323, Fig. 80)

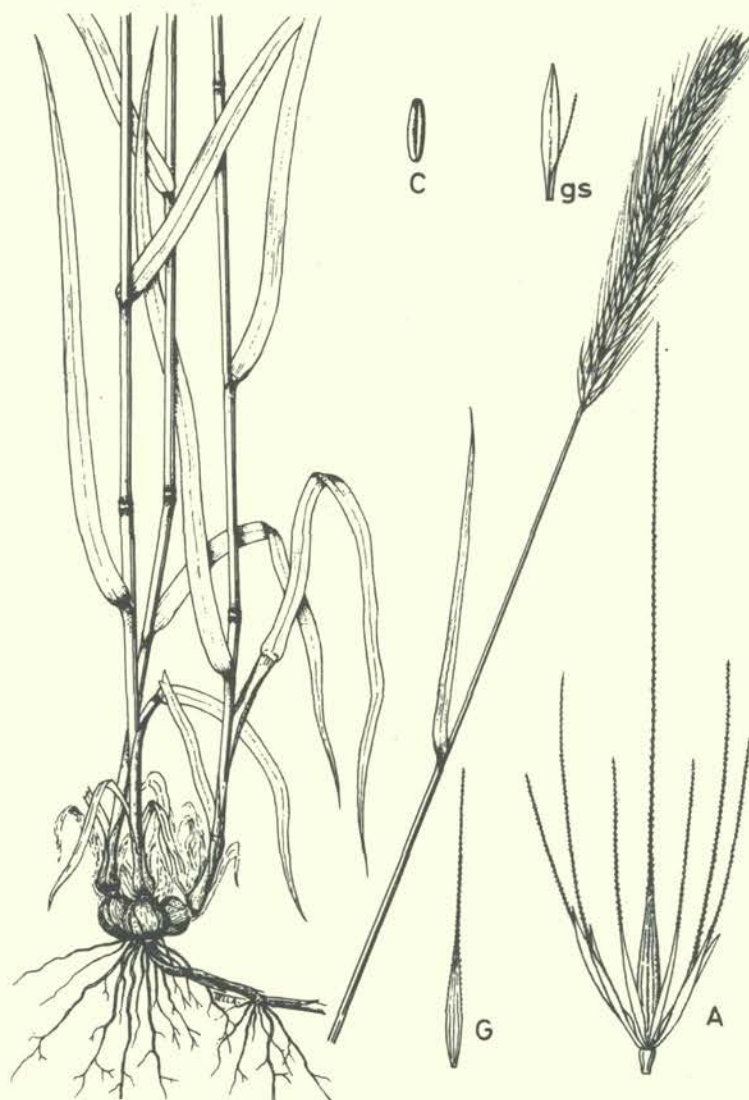


Fig. 2 - *Hordeum bulbosum*

Plant, x1. A : Group of spikelets, x3. G : Glume of the central flower, x3.
gs : superior glumella of the central flower, x2. C : Caryopsis, x3.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas,
Madrid, 1965, p. 111)

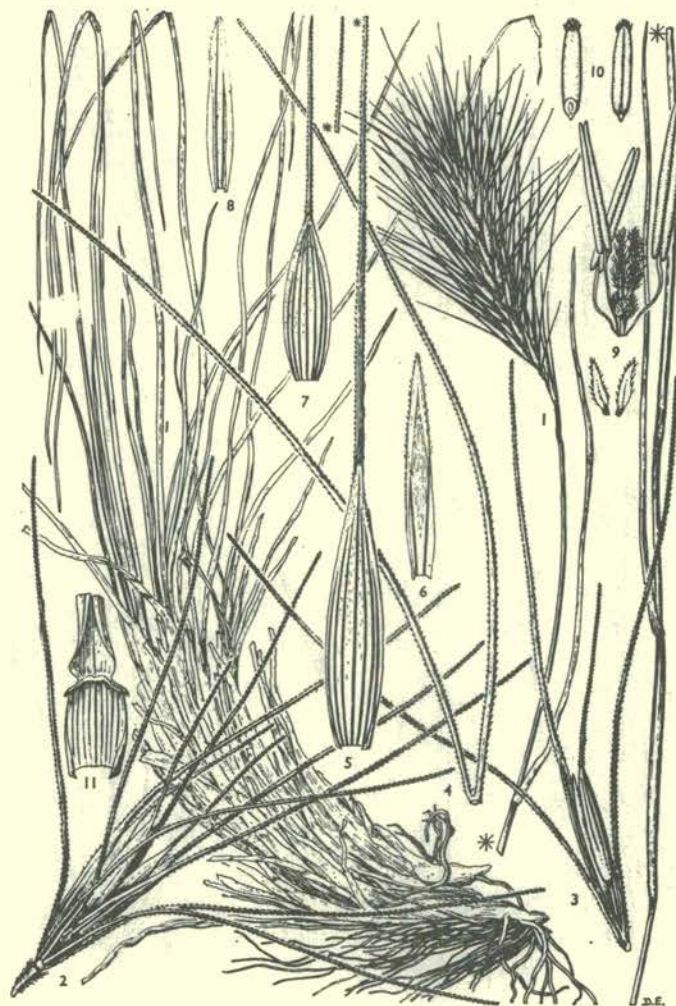


Fig. 3

Psathyrostachys fragilis (Boiss.) Nevski (= *Hordeum fragile* Boiss.)

1. Habit, $\times \frac{2}{3}$. 2. Triad of spikelets, $\times 2$. 3. Central spikelet, $\times 2$.
 4. Glumes, $\times 4$. 5. Lower glumes, $\times 4$. 6. its palea, $\times 4$. 7. Upper lemma, $\times 4$.
 8. its palea, $\times 4$. 9. Flower, $\times 4$. 10. Grain, $\times 2$. 11. Ligule showing
 auricles, $\times 3$.

(After Flora of Iraq, Gramineae, vol. 9, 1968, p. 259, plate 89)

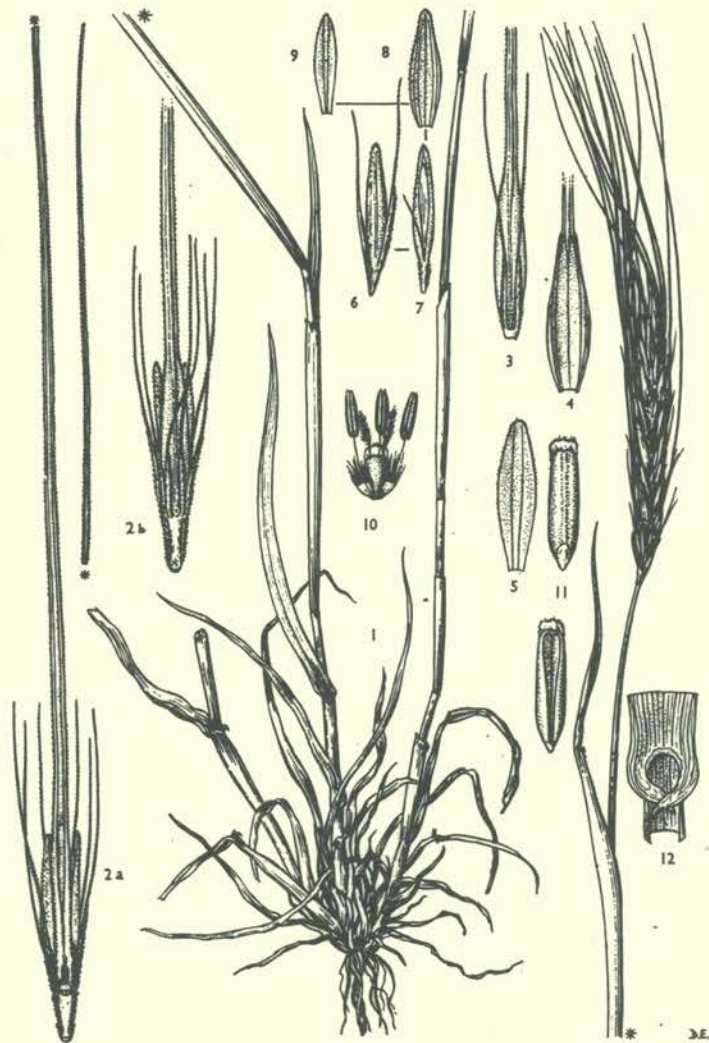


Fig. 4 - *Hordeum spontaneum* C. Koch

1. Habit, $\times \frac{2}{3}$. 2a. Triplet of spikelets, abaxial view, $\times 2$. 2b. The same, adaxial view, $\times 2$. 3. Sessile spikelet, $\times 2$. 4. Lemma of same, $\times 2$. 5. Palea, $\times 2$. 6. Lateral spikelet, $\times 2$. 7. The same with glumes removed, showing the production of rhachilla, $\times 2$. 8. Lemma, $\times 2$. 9. Palea, $\times 2$. 10. Flower, $\times 2$. 11. Grain, $\times 2$. 12. Ligule, $\times 2$.

(After Flora of Iraq, Gramineae, vol. 9, 1968, p. 253, plate 87)

8.5. Varieties

Botanical forms and varieties :

A number of forms and varieties of *H. bulbosum* and *H. spontaneum* exist in N. Africa and the Near and Middle East. Maire (1955) mentions the following in N. Africa :

- *H. bulbosum* :
 - var. *genuinum* Maire et Weiller
type species ; common in Algeria and in the north, west and centre of the Grand Atlas Mountains (Morocco) ;
 - var. *lycium* Boiss.
rare but present in Algeria ;
- *H. spontaneum* :
 - f. *genuinum* Maire et Weiller
with glabrous leaves ; present in Cyrenaica ;
 - f. *eriphyllum* Maire in M., C.
with hairy leaves ; present in Libya.

In Iraq Bor and Guest (1968) record the following for *H. spontaneum* :

- var. *spontaneum*
with lateral spikelets rounded obtuse at the apex ; present in pastures, steppic plains, on sandy soil, in dry conglomerate hills, on gravel in wadis or as a weed in crops ;
- var. *proskowetzii* Nab.
with spikelets mucronate or shortly aristate ; present in coppiced oak scrub or limestone, stony and rocky mountain slopes, dry hill slopes and also as a weed in cultivated land.

In Iran Parsa (1950) records the following for *H. spontaneum* :

- var. *ischnatherum* (Cosson) Thellung (= *H. ischnatherum* Körn.)
with yellow heads ; present in the south-west in Lorestan ;
- var. *turcomanicum* Vav. et Orl.
with black heads ; present in the north-east in Turkmanestan.

Native ecotypes and varieties :

During the period 1965-68 it is reported (AGP:SF/TUR 8, Tech. Rep. 1, 1970) that 95 ecotypes of *H. bulbosum*, 7 ecotypes of *H. spontaneum* and 6 ecotypes of *H. violaceum* were collected in various regions of Turkey and assembled at Izmir (W. Turkey).

In N. Iran several native ecotypes of *H. bulbosum*, *H. fragile* and *H. violaceum* have also been collected and planted in dryland nurseries in the sub-steppic zone at Homand (Pabot, 1967).

Pabot (1967) reports that the Iranian varieties of *H. bulbosum* are well adapted to prolonged drought as well as low winter temperatures, and he has collected seeds of several ecotypes which have been planted in dryland nurseries in the sub-steppic zone of Iran (1,960 m elevation, 320 mm annual rainfall).

Seeds of local varieties of *H. bulbosum* have also been collected in Israel, Cyprus, Morocco and Algeria. Some of these varieties notably M 51 from Israel, 2.047 from Cyprus, and 620 and 1.850 from Morocco have also been tested under dryland conditions in the littoral zone (400-600 mm annual rainfall) of Tunisia (Corriols, 1965).

In Algeria the local variety 412 of *H. bulbosum* along with the local variety 401 of *H. spontaneum* have also been tested under dryland conditions in the littoral zone (400-600 mm annual rainfall) (Barbut, 1955).

In the southern desert (50-100 mm annual rainfall) of Israel seven local varieties of *H. bulbosum* and one local variety of *H. spontaneum* have been tested under dryland conditions in a situation which received good run-off from rainfall (Tadmor et al., 1970).

8.6. Number of Chromosomes

H. bulbosum : $2x = 14$, $4x = 28$; *H. spontaneum* : $2x = 14$.
For *H. violaceum* not known.

Katznelson and Zohary (1967) report that for *H. bulbosum* diploid forms occur in W. and C. Mediterranean and tetraploid forms in E. Mediterranean and the Middle East.

8.7. Geographical Distribution

H. bulbosum is native to the Mediterranean region, Transcaucasus and Turkestan also present in Algeria, Morocco, Tunisia, Cyprus, Turkey, Syria, Lebanon, Jordan, Iraq, Iran and Afghanistan. *H. bulbosum* ranges from the Mediterranean region to Central Asia and tropical Africa. A distribution map for *H. bulbosum* in Iraq is given in Fig. 5 ;

H. spontaneum is distributed in S.E. Europe (Balkans), Cyprus, Syria, Palestine, Jordan, Egypt, Turkey, Caucasus, Iraq, Iran, Afghanistan, W. Pakistan, N.W. India, C. Asia (Turkemenia to Tian Shan), N. Africa (Libya) ; its distribution in the Near and Middle East is shown in Fig. 6.

H. fragile is distributed in Turkey, Caucasus, Iraq, Iran and Afghanistan.



Fig. 5

Distribution of *Hordeum bulbosum* L. (o) and
Eremopyron bonaepartis var *bonaepartis* (o)
(After Candollea, 25, 1970, p. 257, map 6)

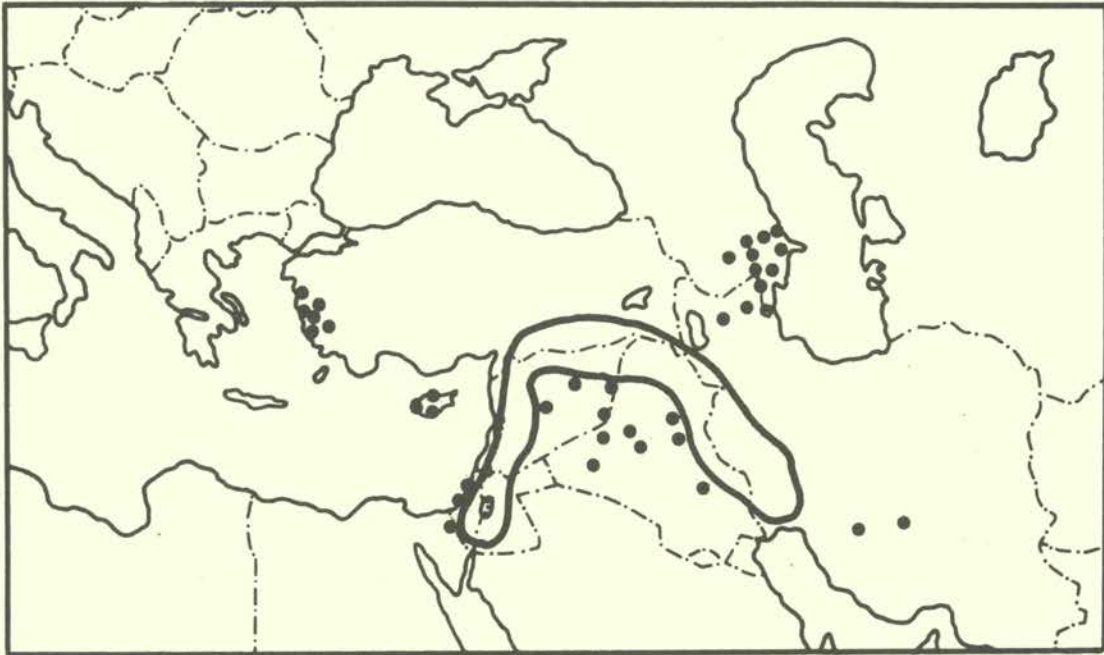


Fig. 6 - Distribution of *Hordeum spontaneum*
(After Dictionary of cultivated plants and their centres of diversity,
Wageningen, 1975, p. 81)

H. violaceum is distributed in Armenia, Iran and Afghanistan.

8.8. Biology and Ecology

Growth and development :

H. bulbosum, *H. spontaneum*, *H. fragile* and *H. violaceum* are all cool season species propagating themselves by seed. In the Mediterranean region *H. bulbosum* develops well after the first autumn rains. Dryland seeded stands make their main growth in the autumn, with growth continuing in winter and a further peak in the spring ; in the summer the plants are completely dormant and do not respond to supplementary irrigation (Villax, 1963).

In the sub-steppic zone of N. Iran the main growth of dryland seeded *H. bulbosum*, *H. fragile* and *H. violaceum* is in the spring with vegetative growth commencing in early March, booting in early April, flowering in mid-June and seed production in early July. In North Africa, Lebanon and Syria native stands of *H. bulbosum* flower from April to July.

The seeds of *H. bulbosum* germinate very quickly after planting, often with only 20-30 mm rainfall. However the seeds are strongly awned, shatter readily and are not easy to collect.

Climate and soils :

H. bulbosum is very drought resistant succeeding in dryland cultivation with 320-350 mm annual rainfall in the sub-steppic zone of Iran. However, the Mediterranean varieties are probably not as cold tolerant as those varieties occurring in the Irano-Turanian region (N. Iraq, N. Iran and Afghanistan), (Pabot, 1967).

H. bulbosum prefers deep clay or loam soils according to Villax (1963), but in fact occurs on a variety of soils under natural conditions.

Ecological characteristics :

H. bulbosum is very common in the Mediterranean and Near and Middle East, mostly in very depleted steppic rangelands, in forests or on formerly cultivated lands. Chrtek and Hadac (1970) state that *H. bulbosum* ranges from the Mediterranean region to Central Asia and tropical Africa, and occurs in secondary steppe, in the oak and *Cousinia*-steppe regions with more than 300 mm annual rainfall.

In Lebanon Pabot (1959) records *H. bulbosum* as being common in the high Mediterranean zone (1,000-1,500 m elevation) and in the Cedar zone (1,500-2,000 m elevation), while in Syria Pabot (1957) also records *H. bulbosum* as being common along with other grasses such as *Poa bulbosa* and *Dactylis glomerata* ssp. *hispanica* in the western part of the Syrian zone.

8.9. Cultivation techniques

Time of seeding :

In the littoral and sub-steppic zone of Morocco (see Fig. 7 re-seeded stand) and the littoral zone of Tunisia *H. bulbosum* has been seeded on an experimental scale after the first autumn rains, while in the sub-steppic zone of Iran (1,960 m elevation) both autumn (November) and spring (March) seedings of *H. bulbosum*, *H. fragile* and *H. violaceum* have proved successful in nursery and test row plantings.

In the southern desert of Israel (80-100 mm annual rainfall) 4 month old seedlings of *H. bulbosum* have been successfully transplanted in December under run-off conditions (Tadmor et al., 1970).

Seed rate and method of seeding :

H. bulbosum, *H. fragile* and *H. violaceum* can all be propagated vegetatively and by seed.

In Morocco for *H. bulbosum* a seed rate of 30-40 kg/ha sown in lines spaced 50-70 cm apart or broadcast on the surface is recommended ; alternatively planting may be effected by cuttings spaced 40-60 cm apart in and between the lines (Villax, 1963).

In the sub-steppic zone of Iran 5-10 kg/ha of seed has proved sufficient for *H. bulbosum*, *H. fragile* and *H. violaceum* and field row plantings of the former two species have been in 50 cm wide rows with a two row McCormick Orchard drill.

Vegetative propagation :

Vegetative propagation of all three *Hordeum* spp. has proved useful for establishing ecotypes in nurseries.

8.10. Forage Value

Palatability :

H. bulbosum is very palatable to livestock particularly in the vegetative stage and this is also true for *H. fragile* and *H. violaceum*. In the sub-steppic zone of Iran palatability tests with native sheep showed that *H. bulbosum* was very well grazed in the flowering stage, but was not grazed in the seed production stage, while *H. fragile* was well grazed in the vegetative stage (spring and autumn), fairly well grazed in the boot stage, poorly grazed in the flowering stage and was not grazed in the seed production stage. *H. spontaneum* is considered to be quite palatable to livestock when young but is poorly utilized in the boot and flowering stages.

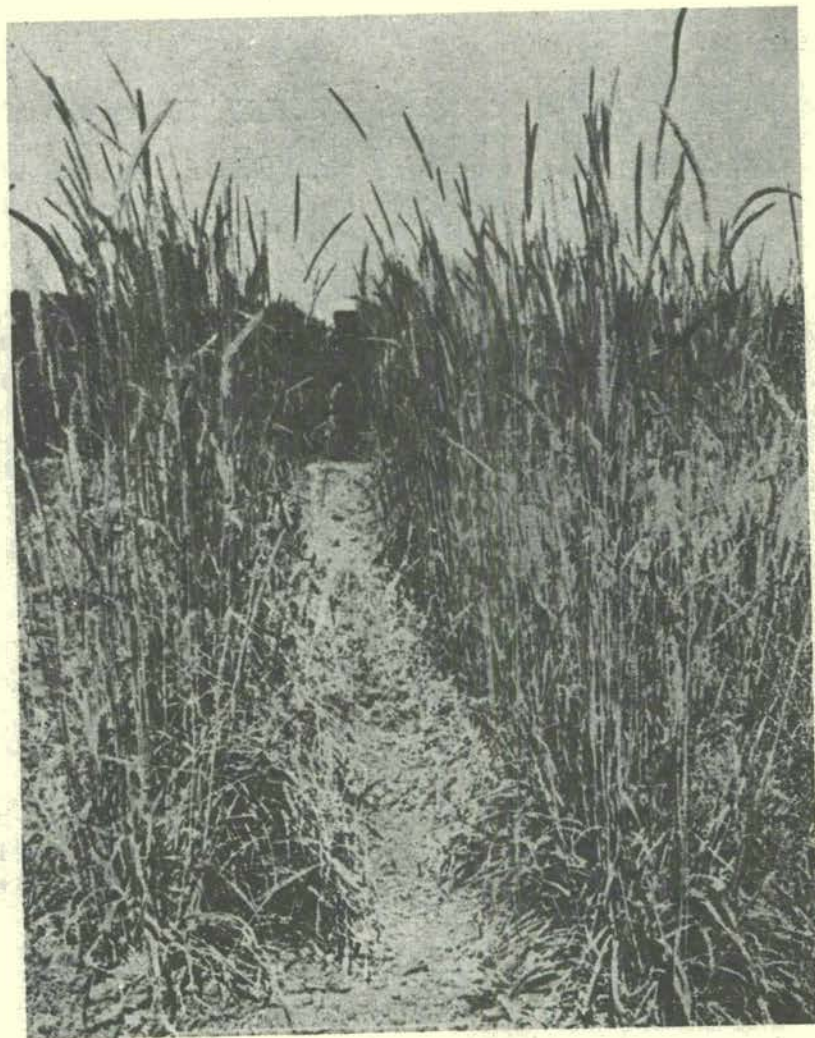


Fig. 7 - Re-seeded *Hordeum bulbosum* at Fès, Morocco (350 mm annual rainfall)

(After Cah. Rech. Agron. 7, Rabat, 1956, photo p. 35)

Nutritive value :

The nutritive value of the forage at different phenological stages of growth of both dryland seeded *H. bulbosum* and *H. fragile* in the sub-steppic zone of Iran (Homand) is given below :

Variety	Stage of Growth	Crude Fibre	Crude Protein
<i>H. bulbosum</i>	Vegetative	22.1	19.2
	Boot	26.9	12.5
	Flowering	34.5	6.0
	Seed Production	38.9	3.2
<i>H. fragile</i>	Vegetative	23.3	19.6
	Boot	28.0	16.1
	Flowering	32.3	8.3
	Seed Production	33.8	8.5

Corriols (1965) also gives the following nutritive value data for Moroccan varieties of *H. bulbosum* in Tunisia :

Date	Percentage Digestible Products					
	Protein	Fats	Cellulose	Non-N Extract	Metabolizable Energy per kg green matter	Forage units (equivalent 1 kg of oat grain)
28.12.55	1.01	0.36	2.44	2.04	230 c	0.05
11.04.56	1.21	0.60	5.55	4.61	472 c	0.12

8.11. Forage and Seed production

Forage yields :

In the sub-steppic zone of Iran (1,960 m elevation) nursery of *H. bulbosum* and *H. fragile* have given the following dry matter production over a 4 year period in June :

Species	1966		1967		1968		1969	
	Age of stand in years	DM yield kg/ha	Age of stand in years	DM yield kg/ha	Age of stand in years	DM yield kg/ha	Age of stand in years	DM yield kg/ha
<i>H. bulbosum</i>	4	1,880	5	1,140	6	950	7	2,530
<i>H. fragile</i>	4	2,300	5	2,400	6	2,890	7	4,710
Spring rainfall (March-May) mm	175.4		148.6		188.6		282.9	

In the southern desert (80-100 mm annual rainfall) of Israel under run-off farming conditions Tadmor et al. (1970) report that seven local varieties of *H. bulbosum* gave average forage yields varying from 900-2,600 kg/ha DM and one variety of *H. spontaneum* 3,100 kg/ha DM over a 6 year period.

Nasibov (1971) also reports that re-seeding of *H. spontaneum* in the Azerbaidjan pastures in Southern USSR has increased the forage yield by 26 %.

In Tunisia Corriols (1965) also reports the following forage production data for two varieties (one from Cyprus and one from Morocco) of *H. bulbosum* in experimental plantings at Tunis (Littoral zone) :

Variety	1955-56 (664,7 mm rainfall) Second year				1956-57 (492,2 mm rainfall) Third year			
	Green matter kg/ha	Dry matter kg/ha	Dig. protein kg/ha	Forage units/ha	Green matter kg/ha	Dry matter kg/ha	Dig. protein kg/ha	Forage units/ha
Morocco No. 620	22,108	3,979	243	2,210	15,109	2,719	166	1,510
Cyprus No. 2047	29,108	5,239	320	2,910	18,442	3,319	202	1,844

In the littoral zone (500-600 mm annual rainfall) of Algeria green forage yields under dryland conditions of 26,100 kg/ha for *H. bulbosum* (variety 412) and 38,600 kg/ha for *H. spontaneum* have been reported (Barbut, 1955).

Under 500-600 mm annual rainfall in the littoral zone of Morocco, Villax (1963) reports experimental yields for *H. bulbosum* at Rabat varying from 14,000-28,000 kg/ha green forage and 3,500-7,000 kg/ha of hay.

Seed yields :

In Morocco experimental dryland seed yields have varied from 200-400 kg/ha and Villax (1963) states that precautions must be taken to ensure the spikes do not detach themselves easily before the seed is harvested.

In the sub-steppic zone of Iran seed production of *H. fragile* has been poor.

8.12. Utilization

Use for pasture or hay :

H. bulbosum can be cut for hay or pastured. When utilized for hay it should be cut at the beginning of flowering and not later when the stems become fibrous. In the Mediterranean region *H. bulbosum* should be pastured in the early autumn and winter and in the sub-steppic zone of Iran in the early spring (March).

Time of use and establishment :

Villax (1963) recommends leaving the first growth to cut later or for the production of seeds thus allowing the plants of *H. bulbosum* to root strongly ; at the same time he states that the plants support well grazing and trampling by livestock.

Pasture longevity :

H. bulbosum is considered to be a short lived species under dryland utilization remaining for no more than 3-4 years ; re-seeding is then required to perpetuate the pasture.

Soil conservation value :

H. fragile may be considered as a very valuable species for erosion control, since it resists overgrazing well and provides robust plants with a strong rooting system. In Iran Pabot (1967) considers that *H. fragile* is a very valuable plant for fixing dry slopes in the mountains subject to erosion. *H. violaceum* is also a useful species for erosion control and has been re-seeded for this purpose in Azerbaidjan in southern USSR (Prilicko et al., 1972).

Further evaluation :

Both *H. fragile* and *H. violaceum* provide good spring and autumn grazing in Iran, but more work is needed to overcome the problem of seed production for *H. fragile*. *H. spontaneum* also provides good early spring forage in steppic areas even in dry seasons and it could prove valuable to collect genetic material for inclusion in plant breeding programmes for crossing with other more interesting perennial *Hordeum* spp.

8.13. Specific References

- | | |
|-------------------------------------|--|
| KATZNELSON, J. & ZOHARY, D.
1967 | Diploid and tetraploid <i>Hordeum bulbosum</i> L.
<i>Israel J. Bot.</i> , 16(2): 67-72. |
| SMITH, D.F.C.
1972 | <i>Hordeum</i> spp. in grassland.
<i>Herb. Abstr.</i> , 42(3): 213-223. |

TECHNICAL DATA

SHEET No 9

GRAMINEAE (= POACEAE)

Hyparrhenia hirta (L.) Stapf

9.1. Synonym

Hyparrhenia hirta (= *Andropogon hirtus* L.)

9.2. Common Names

English	Blue Stem (Morocco) ; South African Blue Stem (South Africa) ;
French	Barbon hérissé (Morocco) ;
Arabic	Aamar, Amad, Elmad, Gousmir elmad, Hafer, Hamra, Hamrette errass, Nzimi, Nzoumi, Seibouss, Sibouss (Morocco) ; Himar, Namas, Safsoof, Hemeira (Saudi Arabia) ; Garaz (Qatar) ; Senan (Jordan) ; Safsoof, Hemeira, Homareet, Hemaar, Hamra, Sabat, Sabad, Sabt (Egypt/UAR) .

9.3. Brief Description

Strongly rooting tufted perennial, reaching a height of 50-100 cm, up to 180 cm when in flower ; with branching culms and glabrous nodes ; leaves 1-3 cm broad, convolute, reaching almost to the inflorescence ; stems vertical glabrous with 3-10 internodes ; spikelets only 1 mm broad varying from scantily hairy to densely villous, rarely glabrous ; ligule membranous ; inflorescences in loose panicles each with 4-20 spikes and each spike containing a dozen spikelets ; awns up to 3 cm long.

9.4. Varieties

Botanical forms and varieties :

In North Africa and the Near East several botanical forms or varieties of *H. hirta* occur in the native flora. In Algeria and Morocco Maire (1953) mentions the following :

- f. *typica* (Asch. et Gr.) Maire et Weiller comb. nov.
(= *Andropogon hirtus* f. *typicus* Asch. et Gr.,
= *Andropogon hirtus* var. *genuinus* Hack.)

Type species and present in Algeria, Morocco, Tunisia, Tripolitania and Cyrenaica :

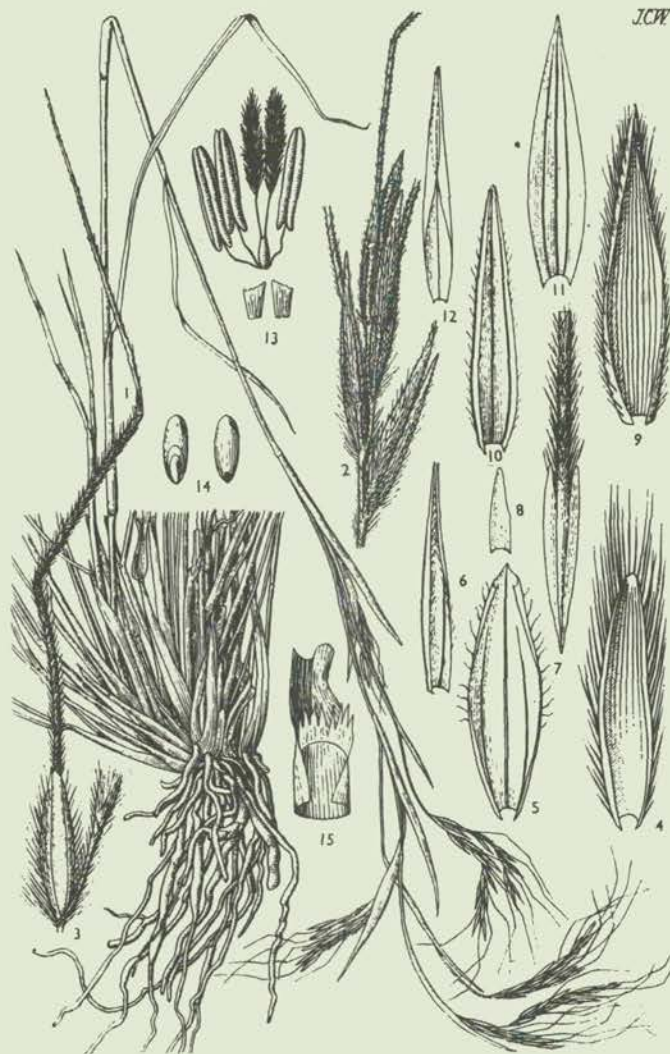


Fig. 1 - *Hyparrhenia hirta* (L.) Stapf

1. Habit, $\times \frac{2}{3}$. 2. Portion of the inflorescence showing the lower homogamous spikelets, $\times 5\frac{1}{2}$. 3. Pair of spikelets, $\times 5\frac{1}{2}$. Sessile spikelet : 4. Lower glume, $\times 8$. 5. Upper glume, $\times 8$. 6. Lower lemma, $\times 8$. 7. Upper lemma with base of awn, $\times 8$. 8. its palea, $\times 8$. Pedicelled spikelet : 9. Lower glume, $\times 8$. 10. Upper glume, $\times 8$. 11. Lemma, $\times 8$. 12. Palea, $\times 8$. 13. Flower, $\times 8$. 14. Grain, $\times 4$. 15. Ligule, $\times 4$.

(After Flora of Iraq, Vol. 9, Gramineae, 1968, p. 533, plate 204)

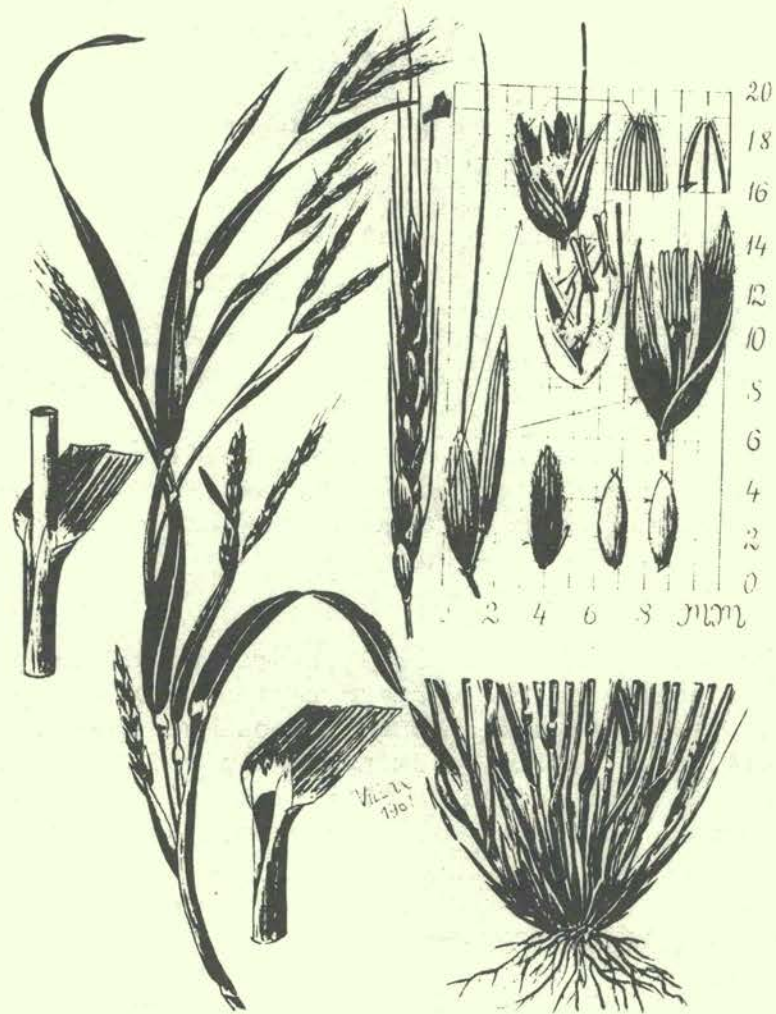


Fig. 2 - *Hyparrhenia hirta* (Orig. - Rabat 1962)

(After La Culture des plantes fourragères dans la région méditerranéenne occidentale, 1963, p. 128, plate 19)

- *f. pubescens* (Vis.) Maire et Weiller comb. nov.
(= *A. pubescens* Vis.,
= *A. hirtus* f. *pubescens* Hack l.c.,
= *A. hirtus* var. *longiaristatus* Wilk.)
with narrow leaves (1-2 mm) and slender plants with a short
panicle slightly branching ;
- *f. podotrichus* (Hochst.) Stapf.
(= *A. podotrichus* (Hochst.) Stapf.,
= *A. hirtus* var. *podotrichus* (Hochst.) Hack.)
with long, hairy peduncles in paired clusters ; present in
Morocco.

In Egypt (UAR) Tachkolm (1974) mentions v. *glabriglumis* Opphr.
with a kneed awn up to 3 cm long while in Lebanon and Syria Mouterde (1966)
mentions

- var *pubescens* Vis. Maire et Weiller
(= *Andropogon pubescens* Visiani.)
with more upright leaves and less branching panicles.

Native ecotypes :

In Morocco a number of distinct ecotypes have been recognized
as occurring naturally in the western region, Haouz, Souss and the Saharan
Atlas (Villax, 1963), and seeds of four local ecotypes No.142 in Algeria, No.
2554 in Tunisia, No. 1143 in Palestine and a local type from Tripoli in Libya
have been collected and seeded in test plots under dryland conditions in their
countries of origin (Corriols, 1965 ; Oram, 1959 ; Tadmor et al., 1970).

9.5. Number of Chromosomes

H. hirta : $2x = 30$, $3x = 44$; according to Bogdan (1977) the chromosome num-
ber can be 30, 40 or 60 with irregular numbers of 44 and 45 being encountered.
Also McWilliam et al. (1970) report the species exhibits widespread apomixis.

9.6. Geographical Distribution

H. hirta is distributed in West and South Europe, Cyprus, Syria,
Lebanon, Palestine, Jordan, Sinai, Egypt (UAR), Arabia, Turkey, Iran, Iraq,
Afghanistan, North-west India, North Africa (Morocco, Algeria, Tunisia, Libya,
Central Sahara), Macaronesia (Canary) extending to South Africa and Australia ;
also introduced on an experimental scale in the USA, and Australia.

9.7. Biology and Ecology

Growth and development :

H. hirta is a warm season species propagating itself by seed and is extremely drought resistant as well as resisting to some extent the cold.

After the seedlings are well established growth is always very satisfactory and will continue throughout the year in Morocco in a year with a mild winter ; plants remain green well into summer and right through the dry summer if given a single irrigation (Whyte et al., 1959).

In cases where the upper foliage is killed by frost, re-growth will occur at the beginning of the spring (Villax, 1963). If it is not too cold it will continue to grow in the spring and even flower and produce some seed. However flowering is generally continuous over a long period - in Syria and Lebanon Mouterde (1966) reports that it flowers all the year - and this makes it difficult to harvest seeds in large quantities. In W. Australia Humphries (1965) reports that about half the florets are imperfect and never set seed, while under dryland conditions seed set by the potentially fertile remainder may be poor in some seasons.

Humphries (1965) also records that *H. hirta* is extremely deep rooted with a maximum root penetration of 3 m on deep sands in W. Australia.

Temperature and seed germination :

Germination of the seeds is slow and it requires warm temperatures after autumn rains in the Mediterranean region ; if autumn rains are late, germination will be retarded until late winter or early spring (Villax, 1963). In Israel germination of seeds has been retarded at a temperature of 5 °C ; removal of the floral envelopes, which contain a germination inhibitor, from mature and stored seed has increased the percentage of germination (Waisel and Adler, 1959).

Climate and soils :

Ecologically *H. hirta* is well adapted to steppic and littoral regions receiving from 200-500 mm annual rainfall and where winter temperatures are moderate.

H. hirta is adapted to a wide range of soils including poor and stony soils and also rocky sites but being a psammophytic species (Long, 1957), prefers well drained and sandy soils ; in the Tunisian steppe Le Houerou (1969) records *H. hirta* as liking calcareous sands, while in the Mediterranean zone of Egypt (UAR) Ibrahim (1968) reports that *H. hirta* occurs naturally on well drained sandy soils and on shallow rocky north facing slopes where it becomes more abundant than on other exposures.

Ecological characteristics :

In North Africa *H. hirta* is mentioned by Maire (1953) as occurring in the plains and in the beds of rivers on rocky sites (Fig. 3) up to an elevation of 1,800 m, and also in the mountains up to 2,600 m, especially on rocky sites and in gullies.

In Lebanon and Syria Mousterde (1966) records *H. hirta* as occurring in rocky pastures, while in Jordan Kasapligil (1956) records *H. hirta* as occurring on dry rocky or stony places in the steppe from 100 m up to 625 m elevation.

In the littoral zone of Egypt *H. hirta* is found growing in association with *Plantago albicans* and *Echiochilon fruticosum* and also in the transitional zone of *Thymelaea hirsutus* and *Gymnocarpus decandrum* (Ibrahim, 1968), while in Libya it occurs in sandy coastal wadis often in association with *Cenchrus ciliaris* (Oram, 1959).

In Tunisia Le Houerou (1969) records *H. hirta* as a member of the psammophytic group of species occurring in the steppic association of *Artemisia campestris/Minuartia geniculata* (300-400 mm annual rainfall), *Artemisia campestris/Eragrostis papposa* (250-300 mm annual rainfall) and *Artemisia campestris/Aristida plumosa* (200-300 mm annual rainfall) and also in the forest association of *Pinus halepensis/Helianthemum ellipticum* (200-300 mm annual rainfall).

In Lebanon Pabot (1959) records *H. hirta* as growing in the littoral zone (0-500 m elevation, 700-1000 mm annual rainfall) with a diverse herbaceous vegetation dominated by *Quercus calliprinos* and *B. infectoria*.

In Jordan Long (1957) records *H. hirta* as occurring in the association of *Poterium spinosum* on nubian sandstone (+300 mm annual rainfall zone) in company with other psammophytic species such as *Aristida adscensionis* and *Helianthemum sessiliflorum*.

In Saudi Arabia Kingery (1972) records that *H. hirta* is founded growing in association with *Acacia etbaica* and *Cenchrus ciliaris* on lithosolic sandy-clay loams in the mountains south of Jeddah (900-1,800 m elevation, 280-300 mm annual rainfall) and also on sandy or gravelly soils in the mountains and foothills in the E. Asir Province (1,800-2,500 m elevation, 250-300 mm annual rainfall) in association with *Acacia seyal*, *Euryops arabicus*, *Cenchrus ciliaris*, *Aristida sahelica* and *Andropogon distachyus*.

In N. Iraq *H. hirta* occurs in the steppe region (300-400 mm annual rainfall) on rocky limestone escarpments often in association with *Cymbopogon olivieri* (Kernick, 1976), while it is also found in S. Iran (200 mm annual rainfall) where it occurs often in association with *Cymbopogon laniger* and is considered by Pabot (1967) to have probably been one of the dominant grasses there along with other *Cymbopogon* and *Cenchrus* spp. in former times. In southwest Iran *H. hirta* is not found above 1,000 m but is recorded in the Elburz Mountains at an elevation of 1,100 m (Parsa, 1950).



Fig. 3 - *Hyparrhenia hirta* on a rocky site
in the steppe zone of Tunisia.

(After photo from photographic records in the publication division of FAO,
Rome)

9.8. Cultivation Techniques

Time and method of seeding :

In the Mediterranean region it is recommended to seed *H. hirta* in the autumn after the first rains (Villax, 1963). Experience in Morocco has indicated that *H. hirta* must often be seeded at a low density so that there are not too many seedlings competing for the limited moisture and nutrients available on the poor soils to which it shows high adaptation.

Under such conditions and for dryland plantings it is necessary to sow the species in lines spaced 70-120 cm apart or to plant the seed in pockets 50-70 cm apart in and between the lines ; generally a seed rate of 12-15 kg/ha is recommended and a depth of seeding of 2-3 cm (Villax, 1963).

Fig. 4 shows an established plant of *H. hirta* seeded in a line at Rabat in the littoral zone of Morocco (500-600 mm annual rainfall).

Vegetative propagation :

H. hirta can also be established by transplanting seedlings or mother plants and this technique has been successful in Egypt (UAR). In Israel four month old seedlings have been successfully established, after transplanting in December at an interrow and within row spacing of 100 cm and 20 cm respectively, in a desert valley under run-off farming conditions with only 100 mm annual rainfall (Tadmor et al., 1970).

Other studies from transplanting tussocks of *H. hirta* in Israel (Litav, 1972) on natural mounds on slopes have led to the conclusion that *H. hirta* is a thermophilous species since transplants established on a 30° S-facing slope grow normally while those on a N-facing slope made little or no growth as long as winter conditions prevailed.

9.9. Forage Value

Palatability :

H. hirta is considered to provide good palatable grazing when young but becomes hard and impalatable if allowed to flower. In Jordan Kasapligil (1956) mentions that *H. hirta* is a highly palatable grass. However there appears to be considerable variation in the palatability of *H. hirta* in natural stands according to Gintzberger (1977) who reports that stands on sandstone soils in the high plateaux zone of Algeria are very palatable, while those on the sandy crusty soils in the littoral of Libya are not very palatable ; tetraploid forms are also reported to be more palatable than diploid forms. The nutritive value of *H. hirta* is fair to good as the following analysis of forage grown at Rabat in Morocco shows (Foury, 1954 ; Villax, 1963) :

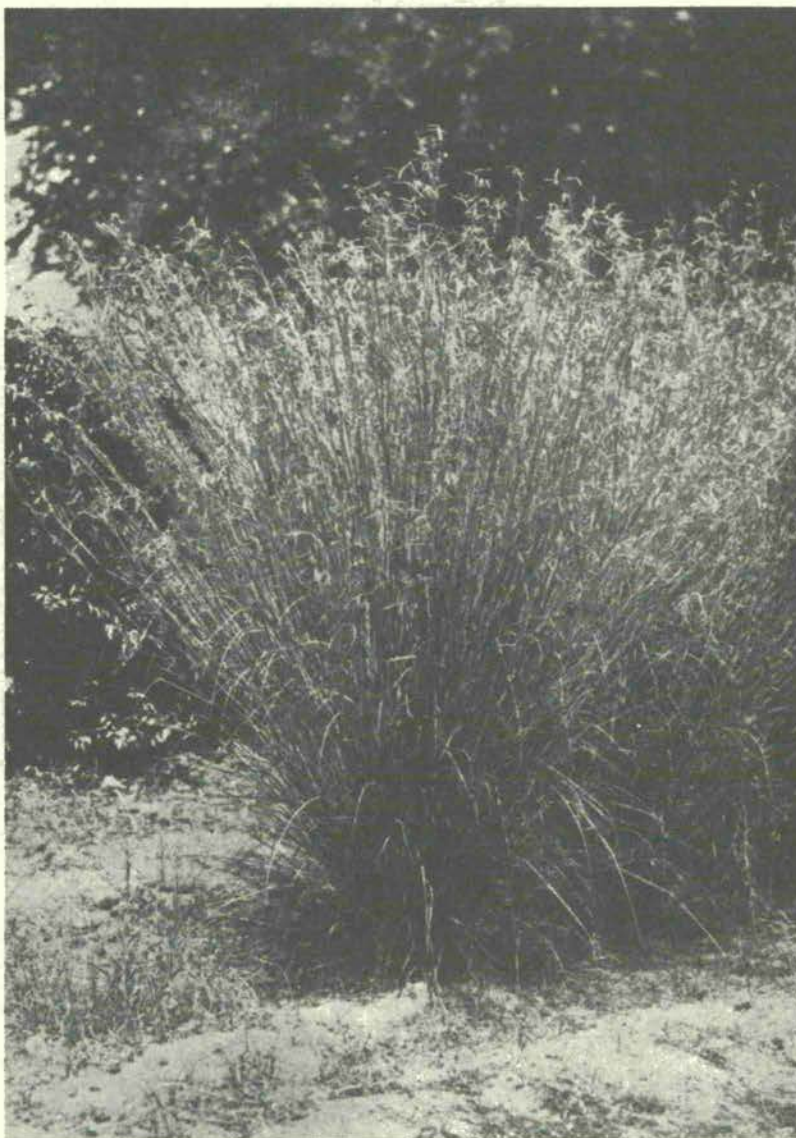


Fig. 4 - Established plant of *H. hirta*
seeded in a line at Rabat.

(After Service de la Recherche Agronomique, Rabat, 1956, p. 4)

	Percentage Composition					
	Water	Ash	Protein	Non-N Extract	Fats	Cellulose
4.4.50						
Green Matter	63.00	1.88	1.55	15.73	0.64	12.20
Dry Matter	0	5.90	4.37	49.03	2.00	38.45
14.12.50						
Green Matter	52.72	3.39	4.03	26.03	0.97	15.86
Dry Matter	0	7.18	8.53	49.73	2.06	32.50
17.6.52						
Green Matter	70.70	2.20	2.46	15.98	0.62	8.04
Dry Matter	0	7.52	8.40	54.50	2.12	27.46
	Average Percentage Composition					
	Water	Protein	Fats	Carbohydrates Soluble Fibre		Ash
Green Forage	80	1.0	0.4	9.8	7.6	1.2
Hay	20	3.5	1.6	39.4	30.8	4.7

9.10. Forage and Seed Production

Forage yields :

In the littoral zone of Morocco (500-600 mm annual rainfall) under dryland conditions, Villax (1963) reports average green forage yields of 14,000-28,000 kg/ha and hay yields of 3,500-7,000 kg/ha in experimental plantings.

In the southern desert of Palestine (100 mm annual rainfall) under run-off farming conditions transplanted *H. hirta* in a desert valley gave an annual average forage yield of 2,700 kg/ha DM over a six year period (Tadmor et al., 1970).

Seed yields :

The harvesting of seeds of *H. hirta* is a delicate operation because the seed heads ripen unevenly and the spikelets shed their seed on ripening. Villax (1963) reports seed yields from experimental plantings of *H. hirta* of 100-300 kg/ha in the littoral zone of Morocco.

9.11. Utilization

Type of use and management :

H. hirta can be utilized for both hay or silage giving a feed product of fair quality. The first cut is normally taken at the formation of the panicles and the resultant crop can be utilized in the form of hay or silage. The re-growth after cutting for hay or silage is normally grazed, and re-growth after grazing is generally very rapid. In Egypt it is recorded (Ibrahim, 1968) that the density and vigour of *H. hirta* decreases if it is left ungrazed for three years.

Livestock performance on pasture :

In Australia sheep have gained weight on seeded *H. hirta* in the summer and it has proved highly resistant to overgrazing owing to the formation of a dense basal tuft ; even when grazed continuously at a stocking rate of 10 wethers/ha *H. hirta* remained undergrazed (CSIRO, 1959, Humphries, 1959). Rossiter (1966) also reports that the use of *H. hirta* on deep coastal sands in Western Australia increases herbage and animal production considerably : the incorporation of *H. hirta* in an annual pasture has increased the yearlong carrying capacity from 6 to 12 Merino wethers/ha (Humphries, 1967).

Soil conservation value :

H. hirta is an excellent species for erosion control on sandy rocky slopes.

Further evaluation :

More studies are needed on seed production, seeding techniques, palatability and utilization before this species can receive wider recognition and agronomic use.

9.12. Specific References

- | | |
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SERVICE DE LA RECHERCHE
AGRONOMIQUE
1956

Hyparrhenia hirta.
Fiche technique no. 3. Rabat. Maroc. p. 5.

TECHNICAL DATA

SHEET No 10

GRAMINEAE (= POACEAE)

Lasiurus spp.

10.1. Genus

The nomenclature of the genus presents one of those difficulties which arise from time to time to plague the taxonomist. The genus was variously described as *Triticum*, *Saccharum*, *Rottboellia* and *Elyonurus* by Forsskal, Vahl and Munro respectively, but Boissier ultimately transferred it to *Lasiurus* (Dabadghao and Shankarnarayan, 1973).

10.2. Species

There are three *Lasiurus* spp. of forage importance namely *L. hirsutus* (Forssk.) Boiss. which is widespread in North Africa and the Near and Middle East and two species *L. ecaudatus* Saty. et Shank. and *L. indicus* Henr. which are restricted to N.W. India or Pakistan.

10.3. Synonyms

L. hirsutus (= *Elyonurus hirsutus* (Vahl.) Munro ex. Benth,
Saccharum hirsutum Forssk.,
Rottboellia hirsuta Vahl.)

10.4. Common names

<i>L. hirsutus</i>	English	Sewan Grass (India) ; Karera (Pakistan) ;
	Arabic	Thunda al musaih, Dha'ah, Hadhid, Sammat, Hada (Saudi Arabia) ; Hada, Samaat (Egypt/UAR) ; Hazma (Yemen Republic) ;
<i>L. indicus</i>	English	Sewan Grass, Sevin Grass (India).

10.5. Brief Description

L. hirsutus, *L. ecaudatus* and *L. indicus* are all pale-yellow tussocky bushy desert grasses with variable growth habit and erect stems sometimes only reaching a height of 20-60 cm but often growing 120-150 cm tall with a spread of 240-270 cm ; in bushy form a plant is often composed of 200 or more yellow green tillers ; the inflorescence is pale-yellow when young, whitish when mature and the spikelets are awnless.

The key to the three species of *Lasiurus* is given below (Dabadghao and Shankarnarayan, 1973) :

- L. hirsutus* : culms glabrous below the inflorescence, lower glumes 8 mm long ;
- L. ecaudatus* : culms very densely hirsute below the inflorescence, lower glume of sessile spikelet including tail 12 mm long ;
- L. indicus* : culms very densely hirsute below the inflorescence, lower glume of sessile spikelet including tail 12 mm long.

L. hirsutus also has an aspect of *Pennisetum divisum* Forssk. ex J. Griel Henrard (= *P. dichotomum* (Forssk.) Del. from which it differs by its silky (not glabrous) rough spike (Tackholm, 1974).

Bogdan (1977) considers that *L. indicus* Henr. should be included with *L. hirsutus*, although in India it has been separated from it by the presence of dense hairs on the stem just below the inflorescence and on parts of the internodes, and in addition it is cited (Dabadghao and Shankarnarayan, 1973) as having an indumentum on the internode and peduncle. Bogdan (1977) further points out that the character of hairiness on the stems and internodes in the eastern part of the area of *L. hirsutus* distribution in fact occasionally occurs in other areas of *L. hirsutus* distribution and for this reason he feels it is hardly necessary to give *L. indicus* a separate species status.

10.6. Varieties

Growth forms :

Shankarnarayan and Dabadghao (1973) state that *L. hirsutus* has a variable growth habit in natural stands in north-western India with forms ranging from erect to procumbent and some types being more leafy than others.

Native ecotypes and strains :

At the Central Arid Zone Research Institute at Jodhpur in the Rajasthan desert of northwest India, several strains of *L. indicus* have been developed. For instance strain 318 performs well even under extreme arid conditions and is reported to yield 5,000-6,000 kg/ha DM and to respond to fertilizer application (Prasad and Singh, 1973). Chakravarty and Kackhar (1970) also report variations in the morphology and forage production of 22 ecotypes of *L. indicus* from W. Rajasthan and 1 ecotype from Kuwait, and state that strain 319 proved the most promising.

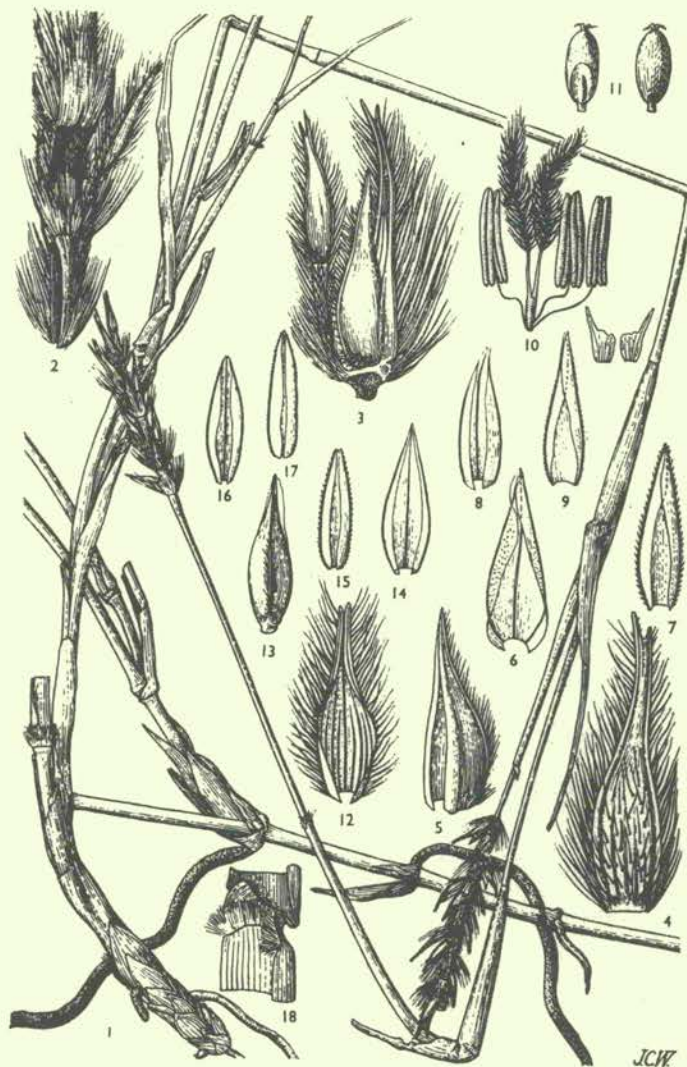


Fig. 1 - *Lasiurus hirsutus* Forssk. Boiss.

1. Habit, $\times \frac{2}{3}$. 2. Portion of the inflorescence, $\times 3$. 3. Pair of spikelets, $\times 4$. Sessile spikelet : 4. Lower glume, $\times 4$. 5. Upper glume, $\times 4$. 6. Lower lemma, $\times 4$. 7. Its palea, $\times 4$. 8. Upper lemma, $\times 4$. 9. Its palea, $\times 4$. 10. Flower, $\times 4$. 11. Grain, $\times 4$. Pedicelled spikelet : 12. Lower glume, $\times 4$. 13. Upper glume, $\times 4$. 14. Lower lemma, $\times 4$. 15. Its palea, $\times 4$. 16. Upper lemma, $\times 4$. 17. Its palea, $\times 4$. 18. Ligule, $\times 4$.

(After Flora of Iraq, Vol. 9, 1968, p. 537, plate 206)

There must also exist a number of different ecotypes of *L. hirsutus* in the desert regions of North Africa and the Near and Middle East stretching from the Sahara to Arabia and the Sind Desert.

10.7. Number of Chromosomes

For *L. hirsutus* : $2x = 56$;
for the other two species mentioned not known.

10.8. Geographical Distribution :

L. hirsutus is locally distributed in desert areas in north-west India, Pakistan, S. Iran, S. Iraq, Saudi Arabia, the Gulf States, Kuwait, Yemen, Palestine, Jordan, Egypt (UAR), Libya, Tunisia, Algeria, Morocco and Somalia. In contrast, *L. indicus* has a restricted distribution and is found only in desert areas in the Sind (West Pakistan) and Rajasthan (Northwest India) ; *L. ecaudatus* occurs only in Western Rajasthan. The distribution of *L. indicus* in Western Rajasthan is shown in the map below (after Gupta and Saxena, 1970).

10.9. Biology and Ecology

Seed characteristics and depth of rooting :

Both *L. hirsutus* and *L. indicus* are warm season species propagating themselves by seed ; the seeds of both species are dimorphic and large seeds have better germination than small ones (Lahiri and Kharbanda, 1962-63). Both species are not frost tolerant but are strongly drought resistant and deep rooted ; on sandy soils in the Rajasthan desert 65 % of the roots of *L. indicus* were found to penetrate deeper than 150 cm, while *L. hirsutus* showed the best distribution of roots with 34.21 % in the surface zone, 41.15 % in the middle zone and 24.21 % in the deeper zone (Dabadghao and Shankarnarayan, 1973).

Growth and development :

Both species grow well in the spring and early and mid-summer in desert areas but are largely dormant during the latter part of the summer. During the winter the old stems remain alive and produce nodal as well as basal shoots in the following season.

In parts of Southern Arabia, Pakistan and Northwest India growth of new shoots and seedlings of *L. hirsutus* is greatly promoted by summer rainfall during the monsoon season (July-August) and the same applies to *L. indicus* in the Sind and Rajasthan desert. In these areas the growth pattern of both species follows closely the incidence and pattern of rainfall (spring showers and monsoonal summer rains) ; in dry periods in the

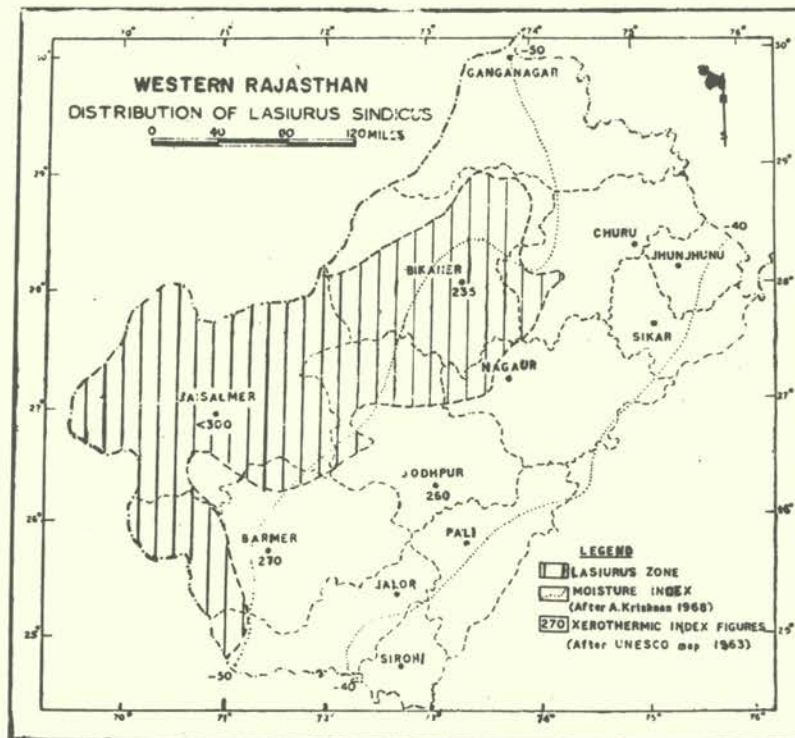


Fig. 2 - Distribution of *Lasiurus sindicus*
(Western Rajasthan)

(After Ann. Arid Zone, Jodhpur, vol. 9, No. 3, 1970, p. 194)

latter part of May and latter in the winter (end November) the plants are largely dormant.

Climate and soils :

Both *L. hirsutus* and *L. indicus* are very well adapted to arid desert regions with sandy soils and with an annual rainfall of 50-250 mm. *L. hirsutus* has also been successfully re-seeded in the Thal desert (West Pakistan) in areas with 150 mm of annual rainfall, while both *L. hirsutus* and *L. indicus* have been successfully re-seeded in the Rajasthan desert (Northwest India) in areas with 200-400 mm annual rainfall.

Ecological characteristics :

L. hirsutus under natural conditions is commonly found growing in sandy desert areas with 50 mm of annual rainfall or less in Algeria, Morocco, Tunisia, Libya and Egypt (UAR) in association with scattered *Acacia* spp. and also *Aristida* spp., *Panicum turgidum* and *Pennisetum dichotomum*, and often in wadis (Rattray, 1960) ; in Egypt (UAR) *L. hirsutus* is recorded (Kassas and El Abyad, 1962) as occurring in 13 different plant communities, its presence value ranging from 50-100 % in 9 of these plant communities.

On sandy coastal plains in Kuwait *L. hirsutus* occurs on sandy hummocks in association with *Panicum turgidum* and on sand dunes in association with *Pennisetum dichotomum* (Kernick, 1965). In Saudi Arabia *L. hirsutus* is found growing in a range of habitats, including sandy silty soils (50 mm annual rainfall 350-500 m elevation) in association with *Acacia* spp. and *Panicum turgidum*, and in the south on basalt with sandy and silty deposits (150-250 mm annual rainfall, 900-1,800 m elevation) in association with *Acacia hamulosa*, *Indigofera spinosa* and *Commiphora myrra* (Kingery, 1972).

In Pakistan *L. hirsutus* is a common associate with *Acacia senegal* and *Ziziphus nummularia* in the Sind Desert (50-500 m elevation) on limestones and shales (Term. Rept. AG:DP/PAR/71/001, 1975), while in the southern desert of Iraq (100-150 mm annual rainfall) it is sometimes found growing in association with *Ziziphus nummularia* in sandy runnels or wadis (Kernick, 1976).

In the Rajasthan desert in Northwest India *L. hirsutus* is one of the principal species of the *Dichanthium/Cenchrus/Lasiurus* vegetation cover and the dominant species in arid areas with as little as 12.5 mm of rainfall (Dabadghao and Shankarnarayan, 1973).

L. indicus in the Rajasthan desert is found most typically on hummocky sandy plains where its cover exceeds 25 % and occurs also on flat sandy and gravelly interdunal areas with less than 300 mm annual rainfall, where it is found growing in association with *Eleusine compressa*, *Dactyloctenium indicum*, *Cenchrus biflorus*, *Aristida* spp., *Indigofera cordifolia* and *Ziziphus nummularia* (Raheja, 1966).

However in both the Sind and Rajasthan deserts *L. indicus* does not usually cover sand dunes appreciably where *L. hirsutus* tends to predominate in its place.

10.9. Cultivation Techniques

Method of propagation and time of planting :

Both *L. hirsutus* and *L. indicus* can be established by seeds or cuttings. In the Rajasthan and Sind deserts planting is normally carried out in July-August during the period of the monsoon rains, but a pre-monsoon (May-June) sowing of *L. indicus* has given fair success when spring rain has been adequate.

Land preparation :

In the Rajasthan desert prior to planting the land is ploughed twice, dragged and harrowed once with a toothed harrow ; on virgin land two or three ploughings, two harrowings and a final dragging have been required. If the area to be planted is extensive the land may simply be opened up with furrows spaced 120-150 cm apart. In the Thal desert sandy areas to be re-seeded have been first disced and harrowed to eliminate weeds and other grasses and to prepare an adequate seed-bed (Khan, 1971).

Seed rate and method of seeding :

For dryland re-seeding 3-6 kg/ha of unhusked seed of *L. hirsutus* or *L. indicus* is drilled or broadcast in rows spaced 60-75 cm apart and at a depth of 1-2 cm (Chakravarty et al., 1966 ; Chakravarty and Verma, 1973 ; Narayanan and Dabadghao, 1972); germination of both husked and unhusked seeds of *L. indicus* under similar conditions has varied from 36.2 % to 75 % (Gupta and Saxena, 1970). Pelleting seed of *L. indicus* has also proved successful (Chakravarty and Bhabhi, 1969).

If furrows are utilized for planting Ahuja (1970) recommends furrows of 8-10 cm depth in which the seeds are placed at a depth of no more than 2-3 cm under the soil.

Vegetative propagation :

In dry areas with 150 mm annual rainfall or less seedlings or rooted slips (cuttings) of both *L. hirsutus* and *L. indicus* have been planted in the Sind and Rajasthan deserts ; for *L. indicus* in particular this has been the preferred method of establishment because seed germination is often low (Ahuja, 1970). Verma and Chakravarty (1969) also found that the survival rate of seedlings was much higher than for rooted slips.

For the establishment of seedlings or rooted slips a spacing of 40-60 cm between rows and between plants, and a row spacing of 75 cm and a 30-40 cm

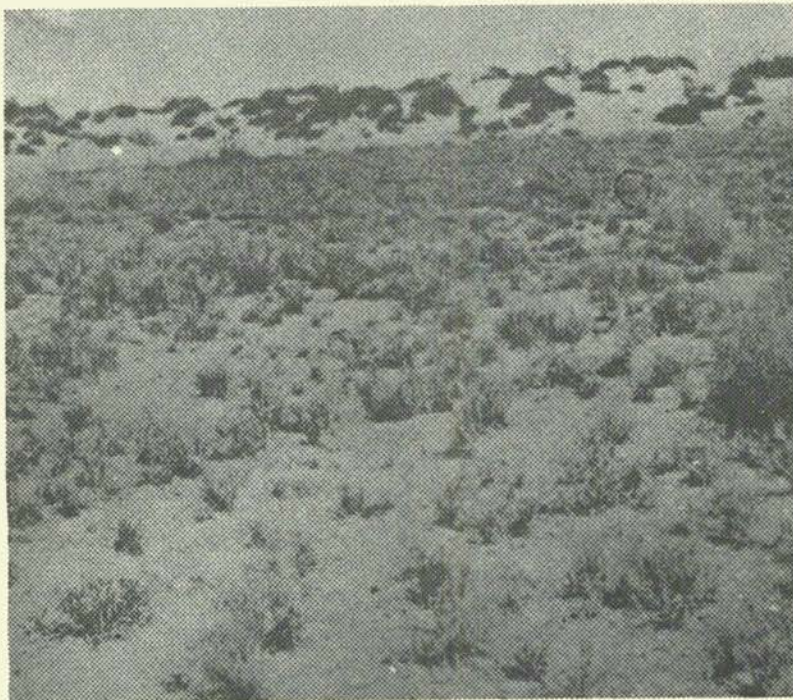
spacing between the plants has been used.

In the Thal desert tufts of *L. hirsutus* have also been planted on sand dunes to assist stabilization at a spacing of 150 x 150 cm, 300 x 150 cm and 300 x 300 cm ; tufts planted during rainfall or 24 hours later gave an 80 % success, but tufts that had been overgrazed prior to transplanting did not give a good survival rate compared to tufts dug out with a 20 cm long root system and a good amount of aerial forage (Khan, 1969).

Interplanting with legume species :

At Jodhpur (300 mm annual rainfall) in the Rajasthan desert trials with three annual legumes planted at a seed rate of 6-12 kg/ha in alternate rows (50 cm spacing) with *L. indicus* under dryland conditions showed that *Cyamopsis tetragonoloba* (Guar) and *Phaseolus acontifolius* (Moth.) were the most suitable legumes for annual intercropping with *L. indicus* and increased the forage yield of *L. indicus* in the forage mixture by 20-30 percent as compared to the yield of *L. indicus* grown alone (Daulay et al., 1968).

Fig. 3 below shows a dryland re-seeded stand of *L. hirsutus* in the Thal desert of Pakistan :



(After Pak. J. For., 1971, vol. 21, No 1, p. 94, Fig. 4)

10.10. Forage Value

Palatability :

L. hirsutus, *L. indicus* and *L. caudatus* are all palatable grasses relished by livestock. Bor (1960) states that *L. indicus* is a valuable fodder grass relished by camels, cattle and sheep.

Palatability feeding tests involving native cattle in the Rajasthan desert have indicated that *L. indicus* is very palatable in the seed production stage (early and dead ripe states), but less so in the pasture, pre-flowering and flowering stages (Dabadghao and Murwaha, 1962).

Nutritive value :

In India *L. hirsutus* is reported (Narayanan and Dabadghao, 1973) to be quite nutritious with 9 % protein in the young green state and a high calcium and somewhat low phosphorous content as the following chemical composition data shows :

	Percentage Composition on a Dry Basis							
	Crude Protein	Ether Extract	Crude Fibre	Ash	N-free Extract	Ca	P	K
Hay (post flowering stage)	5.9	0.3	38.0	11.0	44.8	1.09	0.06	—

However similar protein but somewhat higher phosphorous contents have been recorded (Kernick, 1976) in the desert of Kuwait as the following data shows :

	Date	Composition Percentage of Dry Matter					
		Ash	Crude Protein	Crude Fibre	Ca	P	K
New green leaves and stems	1.5.62	15.330	9.450	40.010	0.864	1.287	1.564
Yellow green leaves	15.8.62	8.570	6.830	33.200	0.520	0.210	1.410

In Kuwait the forage of *L. hirsutus* is mainly grazed by sheep and goats but also by camels.

L. sindicus also shows a similar protein status to *L. hirsutus* with a protein content varying from 8-14 % (Bhimaya and Ahuja, 1967) and Das (1975) gives the following average nutritional values for re-seeded *L. sindicus* in the Rajasthan desert :

Percentage of Dry Matter			
Crude Protein	Phosphorous	Digestible Protein	Total Available Dig. Protein kg/ha
9.05	0.557	5.15	287.31

In the Rajasthan desert, where five cuttings have been taken from *L. sindicus* in a year under dryland conditions (300 mm annual rainfall), the protein content has varied from 14 % in the first cut to 7-8 % in the second, third, fourth and fifth cuts, while the phosphorous content varied from 0.390 to 0.637 % being highest in the fifth cut ; the yield of protein varied from 30.9 to 215.5 kg/ha being 6-7 times higher in the second and third cuts than in the fourth and fifth cuts which were closely similar (Mondal and Chakravarty, 1968).

Minor element status :

Mondal and Gupta (1966) also report the following copper, iron and manganese contents for two strains (Nos. 317 and 351) of *L. sindicus* seeded under dryland conditions in the Rajasthan desert and cut five times during the growing season :

Date of Cutting	Copper ppm		Iron ppm		Manganese ppm	
<u>Strain :</u>	<u>317</u>	<u>351</u>	<u>317</u>	<u>351</u>	<u>317</u>	<u>351</u>
25.8.64	64	52	33	24	63	102
3.9.64	56	54	22	23	63	98
14.11.64	72	58	22	19	78	97
12.1.65	68	60	26	19	94	97
12.4.65	68	64	36	28	68	73

10.11. Forage and Seed Production

Forage yields :

Under dryland conditions in the Rajasthan desert (300-400 mm annual rainfall) in India, re-seeded stands of *L. hirsutus* average 10,000-11,000 kg/ha of green forage in four to five cuttings in a year (Narayanan and Dabadghao, 1972).

In the Thal desert of West Pakistan (225 mm annual rainfall) individual seedlings of *L. hirsutus* have increased the air dry forage yield of native range from 29 kg/ha before seeding to 1,750 kg/ha after seeding ; the percent cover and composition being nil before seeding but rising to 55-67 % for *L. hirsutus* after seeding (Khan, 1971). Clipping studies (Khan, 1969) have also shown that cutting plants of *L. hirsutus* to a stubble height of 5 cm as compared to 10 cm or more in the Thal desert, increased the forage yield threefold ; in the Rajasthan desert clipping *L. hirsutus* at a 15 cm stubble height and at an interval of 30 days was found to be the best management (Dabadghao et al., 1973).

For seeded stands of *L. sindicus* in the Rajasthan desert the maximum yield of air dry forage recorded (Ahuja, 1970) has been 3,600 kg/ha. At Jodhpur in a year with 300 mm annual rainfall *L. sindicus* has produced 1,620 kg/ha DM in 2-3 cuts, while in a year with 248.1 mm rainfall the yield was 990 kg/ha DM ; in the latter year *Cenchrus ciliaris* produced only 590 kg/ha DM indicating the greater drought resistance of *L. sindicus* under arid conditions. An application of 22 kg of nitrogen has also increased the forage yields 24 to 47 %, and interrow weeding 3-4 weeks after seeding *L. sindicus* has led to forage yield increases of 80 % from weeding alone (Chakravarty, 1970).

Seed yields :

Abundant seed is produced by *L. hirsutus* and a well established dryland stand in the Rajasthan desert averages about 280 kg/ha of seeds ; for seed production the grass is usually planted in rows 90 cm apart and two seed crops can be secured in a year, one in the autumn and another in the following spring.

For *L. sindicus* seed production has averaged 115 kg/ha at Jodhpur under dryland conditions (300 mm annual rainfall) and has been highest when the re-seeded stand has not been cut beforehand.

10.12. Utilization

Time of use and establishment :

To assist establishment under dryland conditions both *L. sindicus* and *L. hirsutus* should not be utilized in the first year. In the second year grazing should be arranged to facilitate seed production and shedding of seeds to ensure regeneration.

Type of use and regeneration :

L. hirsutus, *L. ecaudatus* and *L. indicus* can be utilized for pasture, hay or cut green and fed directly to livestock. To assist regeneration from fallen seed, Ahuja (1970) recommends in the Rajasthan desert dividing the re-seeded pasture area for *L. indicus* into four allotments ; forage from one allotment is then harvested as hay and grazing is carried out in the other three allotments by rotation depending on the carrying capacity. It has also proved profitable to harvest hay and seed from the same pasture stand.

Stocking rate and liveweight gain on pasture :

As seeded pasture in the Rajasthan desert *L. hirsutus* has a year-long carrying capacity of 12 sheep/ha, and 3 ha of re-seeded *L. hirsutus* is estimated to support one adult animal (cattle) yearlong, and 3-6 kg liveweight increase in 14 days was recorded when heifers were grazed at 2-4 ha per animal continuous grazing was preferred to deferred grazing (Gupta and Saxena, 1970).

Pasture longevity and grazing management :

Under proper utilization *L. indicus* re-seeded has maintained itself for ten years or more in the Rajasthan desert. In the Thal desert, Khan (1966) recommends that a stubble height of 10 cm for *L. hirsutus* should be left after each grazing. If this is done re-seeded stands of *L. hirsutus* will persist for many years.

Soil conservation value :

L. hirsutus, *L. indicus* and *L. ecaudatus* are all useful sand binding species and as such can be used for fixing sand dunes.

Further evaluation :

More attention needs to be given to the collection of native ecotypes of *L. hirsutus*, particularly in the desert region of North Africa and the Near East, and evaluating their potential for re-seeding.

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TECHNICAL DATA
SHEET No 11

GRAMINEAE (= POACEAE)

Oryzopsis spp.

11.1. Species

There are four *Oryzopsis* spp. of forage importance which have been tested under dryland planting conditions in North Africa and the Near and Middle East. These species are *O. miliacea* L. Asch. et Schweinf., *O. holciformis* (M.B.) Hack., *O. molinioides* (Boiss.) Hack. ex Paulsen and *O. coerulescens* Desf.

11.2. Synonyms

- *O. miliacea* (= *Agrostis miliacea* L., *Piptatherum miliaceum* (L.) Coss.)
- *O. holciformis* (= *Agrostis holciformis* M.B., *Piptatherum holciformis* M.B. Roem. et Schult.)
- *O. molinioides* (= *Piptatherum molinioides* Boiss.)
- *O. coerulescens* (= *Milium coerulescens* Desf. *Piptatherum coerulescens* Desf. P.B.)

11.3. Common Names

- | | | |
|--------------------------|---------|--|
| - <i>O. miliacea</i> | English | Smilo (USA),
Many Flowered Millet Grass
(Jordan, Libya) ; |
| | French | Faux Millet, Petit Millet
(Algeria, Morocco, Tunisia) ; |
| | Arabic | Hachich Safi, Sibouss, Mairdja
(Morocco);
Hemmar, Hemri, Homri, Bahma,
Bohma, Sabat, Sabad, Sabt,
Safsoof, Rees (abu)El hossein
(el-hosny), Sabal (Zibl) abu
el-hossein, Sabat el-maya
(hosny) (Egypt (UAR);
Himar (Jordan). |
| - <i>O. holciformis</i> | English | Ricegrass. |
| - <i>O. coerulescens</i> | English | Bluish Millet Grass (Libya). |

11.4. Brief description

- *O. miliacea* is a tufted long-lived rhizomatous bunchgrass growing to a height of 80-150 cm with flowering stems sometimes branching from a decumbent base and numerous short pedicelled awned spikelets (Fig. 1 and 2) ;
- *O. holciformis* is a caespitose bunchgrass with a woody base and erect, smooth, glabrous culms reaching 80-120 cm in height and somewhat glaucous and with awned spikelets containing at maturity jet black shining seeds (Fig. 3) ;
- *O. molinioides* is a caespitose bunchgrass with erect, tall, smooth, glabrous and slender culms reaching a height of 40 cm and with small spikelets covered with golden hairs on the dorsal surface (Fig. 4) ;
- *O. coerulescens* is a caespitose bunchgrass growing to a height of 40-80 cm and having bluish-green foliage and awned spikelets.

11.5. Varieties

Botanical forms and varieties :

A number of botanical forms or varieties have been noted of *O. miliacea*, *O. holciformis*, *O. molinioides* and *O. coerulescens* in North Africa or in the Near and Middle East.

In North Africa Maire (1953) mentions the following for *O. miliacea* :

- f. *typica* (Fiori) Maire et Weiller com. nov. (= *Milium multiflorum* var. *typicum* Fiori)
type variety ; common from the littoral zone to the Sahara ;
- f. *Thomasii* (D.C. et Duby) Asch. et Gr. (= *Milium Thomasii* D.C. et Duby)
rather rare but present in Tunisia, also recorded by Mousterde (1966) in Syria and Lebanon ;
- f. *pauciflora* (Bég. et Vacc) Maire et Weiller com. nov.
(= *Oryzopsis pauciflora* Bég. et Vacc)
present in the Tripoli Oasis.

For *O. coerulescens* Keith (1965) also mentions the following variety in Libya :

- var. *grandis* Pamp.
present at Ain Mara in Cyrenaica.

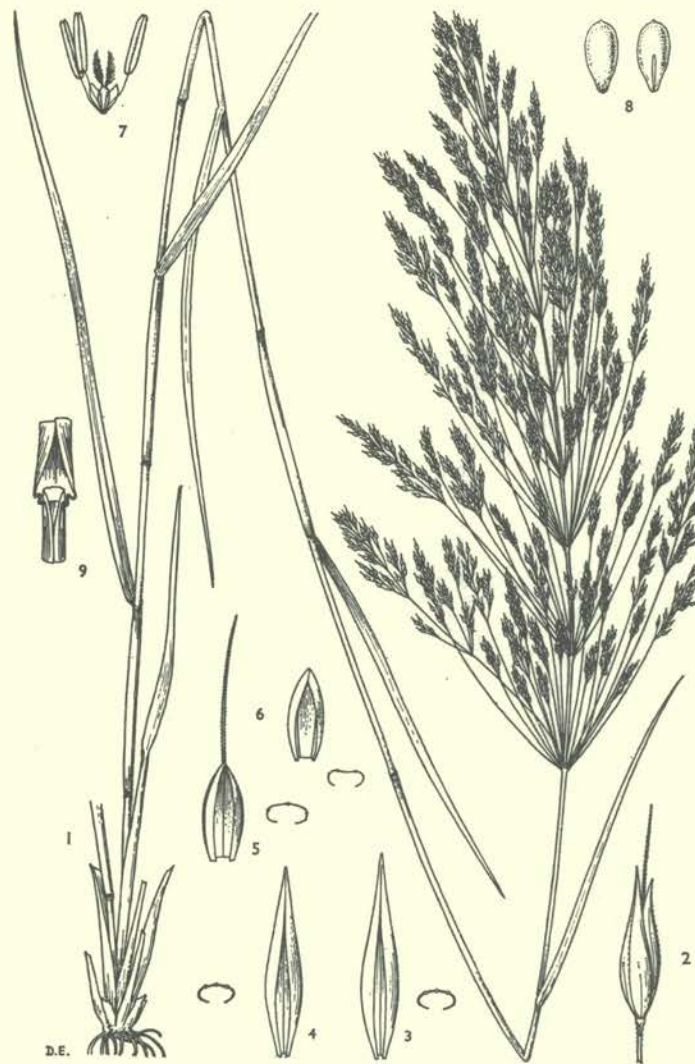


Fig. 1 - *Oryzopsis miliacea* (L.) Aschers. et Schweinf.

1. Habit, $\times \frac{1}{3}$. 2. Spikelet, $\times 6$. 3. Lower glume, $\times 8$. 4. Upper glume, $\times 8$.
5. Lemma, $\times 8$. 6. Palea, $\times 8$. 7. Flower, $\times 8$. 8. Grain, $\times 8$. 9. Ligule, $\times 3$.

(After Flora of Iraq, vol. 9, Gramineae, 1968, p. 415, plate 156)



Fig. 2 - *Oryzopsis miliacea*

Plant, x1. E : Spikelet, x10. gi : Inferior glumella, x10. gs : Superior glumella, x10. C : Caryopsis, x10. L : Ligule, x2.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas, Madrid, 1965, p. 177)



Fig. 3 - *Oryzopsis holciiformis* (M.B.) Hack.

1. Habit, $\times \frac{2}{3}$. 2. Pair of spikelets, $\times 2$. 3. Lower glume, $\times 6$. 4. Upper glume, $\times 6$. 5. Lemma from the back, $\times 6$. 6. Palea, $\times 6$. 7. Flower, $\times 6$. 8. Ligule, $\times 3$.

(After Flora of Iraq, Vol. 9, Gramineae, 1968, p. 413, plate 155)

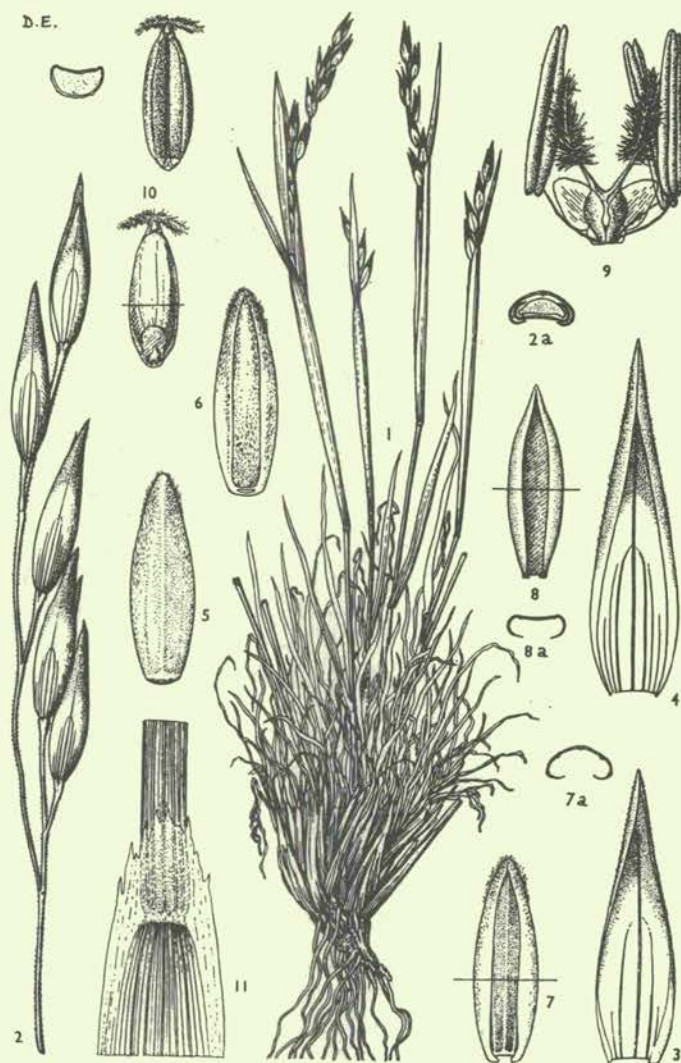


Fig. 4 - *Oryzopsis molinioides* (Boiss) Hack. ex Paulsen

1. Habit, $\times \frac{2}{3}$. 2. Portion of inflorescence, $\times 3$. 3. Lower glume, $\times 6$.
 4. Upper glume, $\times 6$. 5. Fruit, adaxial view, $\times 6$. 6. Fruit, abaxial view,
 $\times 6$. 7. Lemma, abaxial view, $\times 6$. 7a. Cross section of same, $\times 6$. 8. Palea,
 adaxial view, $\times 6$. 8a. Palea, abaxial view, $\times 6$. 9. Flower, $\times 10$. 10. Grain,
 $\times 6$. 11. Ligule, $\times 4$.

(After Flora of Iraq, Vol. 9, Gramineae, 1968, p. 417, plate 157)

O. holciformis is apparently not present in North Africa but several forms or varieties have been recorded in the Near and Middle East.

In Lebanon Mouterde (1966) mentions the following variety :

- var *blancheana* Desv. Bnm. (= *Piptatherum blancheanum* E. Desv.)

while in Iran Parsa (1950) records the following variety :

- var *longiglumis* Hausskn.
present in the Elburz Mountains and at Arak.

For *O. molinioides* Parsa (1950) also mentions the following variety in Iran :

- var *pubiflora* Hackel.
present in the Elburz Mountains and Kerman.

Native ecotypes :

In Morocco, Algeria, Tunisia, Cyprus, Egypt (UAR) and Israel a number of native ecotypes of *O. miliacea* have been collected and evaluated in dryland plantings.

Several native ecotypes of *O. holciformis* have also been collected in Palestine and Iran, while a number of native ecotypes of *O. coerulescens* have also been collected in Morocco, Cyprus and Palestine. In Iran several native ecotypes of *O. molinioides* have been collected and planted in a dryland nursery in the sub-steppic zone (1,960 m elevation) at Homand.

In the Near East Pabot (1967) points out that there are many native ecotypes or forms of the *O. holciformis* type adapted to various mountain climates and even sub-alpine climates such as are found in Iran and Afghanistan.

Indigenous growth types :

Nahve (1957) reports that in Israel there are three indigenous types of *O. miliacea* which are distinguished on the basis of morphological, phenological and ecological differences a) xerophytic desert type (Negev), b) an erect northern grey-seeded type and c) a semi-prostrate northern brown seeded type.

The northern brown seeded type appears to be highly calciphilous and capable of establishing itself under difficult conditions, e.g. on the embankment of recently prepared roadways, consisting almost extensively of soft limestone.

This type seems to be most suitable for pasture purposes and is adapted to highly calcareous soils in the Mediterranean region. Both northern types grow together in similar habitats and no transitional forms are found.

The desert type is more variable and in several places forms occur with a more prostrate habit, broader leaves and darker seeds than the common desert type ; these forms resemble the northern brown-seeded type in many respects.

Varieties of *O. miliacea* from Morocco, Cyprus and California ("Commercial", "Smilo", originally developed from material collected in the Mediterranean region and grown in Israel) seem to be morphologically intermediate between the various types.

Combination by breeding of the good forage properties of the northern brown seeded type and the drought resistant Negev type could result in a very useful pasture plant well suited to dry and poor habitats where the establishment of other perennial grasses such as *Phalaris tuberosa* has so far been unsuccessful.

A number of growth types of *O. holciformis* have also been recognized in Israel (Katznelson, 1974) which are the following :

- type 1 : very leafy, usually prostrate to semi-erect, strong vegetative during heading ;
- type 2 : leafy, semi-erect, moderate growth during heading ;
- type 3 : leafy, erect, some growth during heading ;
- type 4 : very stemmy, erect, few vegetative shoots developing during heading.

(Fig. 5, photographs of types 1 to 4).

Although *O. holciformis* grows in the mountains from Lebanon to the Himalayas Pabot (1965) states that it is in Afghanistan that *O. holciformis* exhibits its greatest morphological variation. Because of its good palatability and weak resistance to overgrazing it has become rare and in Iran it has only been found in rocky places north of Khorramabad and up to the area of Kazerun.

Agricultural varieties and cultivars :

Improved varieties of *O. miliacea* have been developed in Morocco, Cyprus and Israel and of *O. holciformis* in Israel. In Morocco Villax (1963) records that the varieties INRA 4200/59 and INRA 4222/59 of *O. miliacea* developed at Rabat are worthy of mention. In Israel a new variety "Ran" of *O. holciformis* has recently been developed (Katznelson, 1974).

Pabot (1967) also states that the varieties of *O. holciformis* used for dryland seeding in the mediterranean climate of North Africa and Palestine do not appear to be adapted to the cold winters of Iran.

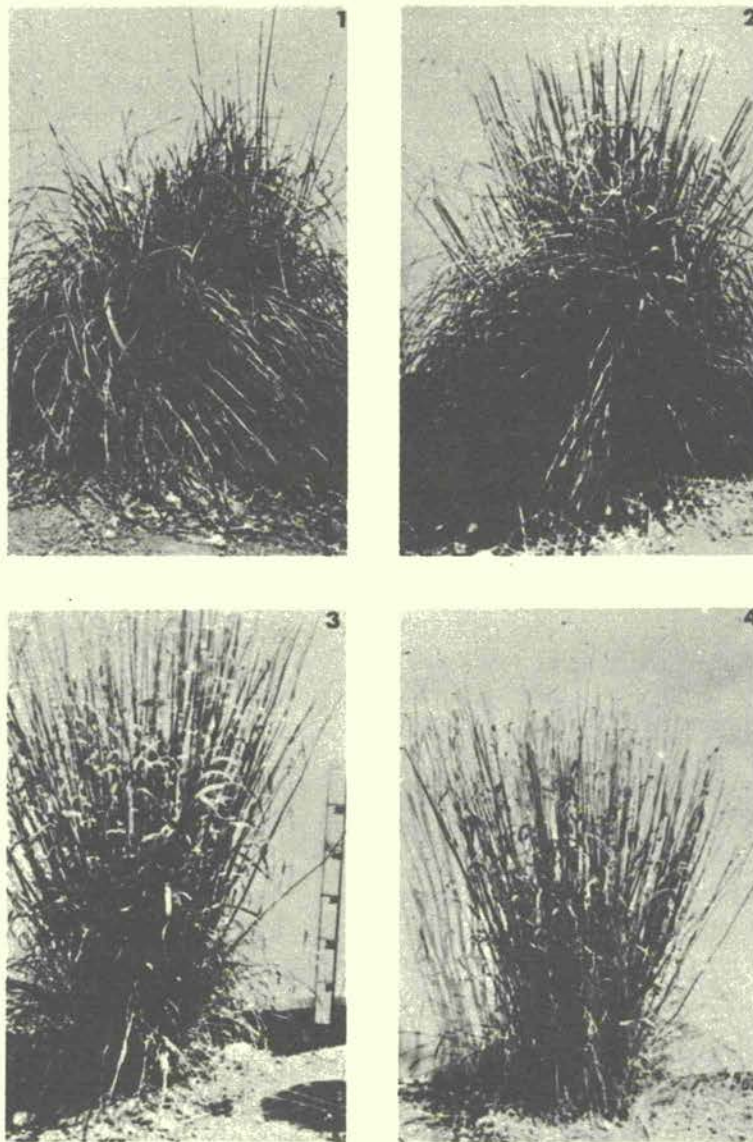


Fig. 5 - Growth types 1 - 4 of *Oryzopsis holciformis*

(After Israel J. Agric. Res., Vol. 22, 1974, p. 105)

11.6. Number of Chromosomes

O. miliacea : $2x = 24$; *O. holciformis* : $2x = 24$;
For *O. molinioides* and *O. coerulescens* not known.

11.7. Geographical Distribution

O. miliacea is distributed in Mediterranean Europe (Spain and Portugal to the Balkans), Cyprus, Turkey, Iran, Iraq, Syria, Lebanon, Palestine, Jordan, Sinai, Egypt (UAR), N. Africa (Morocco, Algeria, Tunisia and Libya) and introduced in N. America, Central Europe and S. Africa. *O. holciformis* is distributed in Central and South-East Europe (Hungary, Roumania, the Balkans to the Crimea), Syria, Turkey, Armenia, Caucasus, Iran, C. Asia (Turkmenia, Tian Shan). *O. coerulescens* is distributed in the Mediterranean basin, in Lebanon, Syria, Iran, Afghanistan, Pakistan (Baluchistan) and N. Africa (Algeria, Morocco, Tunisia).

11.8. Biology and Ecology

Seed characteristics :

O. miliacea, *O. holciformis*, *O. molinioides* and *O. coerulescens* are all cool season species propagating themselves by seed.

Germination of the seeds requires relatively warm temperatures ; in Israel temperatures of 4-10 °C have markedly retarded the onset of germination of *O. holciformis* and the time taken to reach 80 % germination (Ellern and Tadmor, 1966).

According to Giscard (1961) seed germination of *O. miliacea* in Morocco may take several weeks or months, and Lapeyronie (1968) has shown that seeds of *O. miliacea* spp. *thomasi* exhibit delayed germination probably due to the presence of soluble inhibitors in the external layers of the caryopses and also that seed dormancy tends to increase with age ; in the field the soluble inhibitors in the caryopses are removed through leaching by rain which may be insufficient in dry years.

In N. Iran Pabot (1961) states that the seeds of *O. holciformis* are easy to harvest and germinate easily. However in the sub-steppic zone of Iran seeds of *O. holciformis* have exhibited delayed germination particularly in dry seasons with many seeds only germinating in the second or third year after sowing (AGP;SF/IRA, Tech. Rep. 1, 1970). However Corriols (1965) reports that although germination of seeds of *O. coerulescens* is sometimes capricious, the germination of *O. miliacea* and *O. holciformis* seeds in the littoral zone of Tunisia, where autumn rains are generally reliable, has been excellent ; seeds of *O. miliacea* have given a 100 % germination after 15 days.

Growth and development :

In the Mediterranean region growth of *O. miliacea*, *O. holciformis* and *O. coerulescens* occurs after the first autumn rains and sometimes in the winter if temperatures are mild with strong growth also taking place in the spring. Corriols (1965) records that winter and spring growth of *O. holciformis* in the littoral zone of Tunisia is excellent with the production of dense leafy foliage generally reaching a height of 80 cm ; the panicles usually start to appear at the end of January or early February and flowering occurs from April to June ; after a cut in January or February *O. holciformis* re-grows rapidly and flowers within 6-8 weeks before the onset of the dry season (Villax, 1963).

In Tunisia flowering of *O. holciformis* has proved very sensitive to the dry sirocco winds which can cause scalding and poor seed set, but Froment (1970) reports an abundance of fertile grains for *O. holciformis* in C. Tunisia.

In the autumn in Tunisia the young and basal leaves of *O. miliacea* are soft and little lignified but later the stems quickly thicken and lignify especially at the nodes giving an aspect of small bamboo stems (Corriols, 1965). In the following season the tufts regrow with difficulty at the base under the last season's old stems and animals have trouble in grazing the new growth. The stems of *O. coerulescens* are also stiff but more slender than those of *O. miliacea* and break easily.

Growth of *O. miliacea*, *O. holciformis* and *O. coerulescens* stops in the littoral zone of Africa at the end of June but plants resist well the summer drought in a dormant state with *O. holciformis* and *O. coerulescens* remaining green throughout the summer period. Vegetative growth of all three species is vigorous in the autumn after the first rains. *O. miliacea* also tolerates shading well and grows well under trees.

In the sub-steppic zone (1,960 m elevation) of Iran dryland seeded plants of *O. holciformis* commence their spring vegetative growth in mid-March, heading (boot) in early May, flowering in mid-June and seed production in late June or early July. A little vegetative growth occurs in summer, more pronounced in the xerophilous forest zone (2,600 m elevation), but plants are largely dormant. In October a small amount of vegetative growth occurs depending on the incidence of autumn rains.

In the semi-arid zone (500 mm annual rainfall) of N. Israel it has been reported (Katznelson, 1974) that the amount of winter re-growth of *O. holciformis* is greatly dependent on the time of harvest ; yields of recurring winter and spring growth were highest when harvesting was restricted to the preceding July-October period.

Climate and soils :

In the Mediterranean region the native varieties of *O. miliacea*, *O. holciformis* and *O. coerulescens* from N. Africa and Palestine have proved well adapted to seeding under dryland conditions with 300-600 mm annual rainfall ; Le Houerou (1969) records that under natural conditions in the steppe *O. miliacea* and *O. coerulescens* are found where the annual rainfall is in excess of 200 mm. Both *O. miliacea* and *O. holciformis* resist the rigorous winter well and even frosts in the littoral zone of North Africa and Corriols (1965) records that young plants of *O. holciformis* in Tunisia resist cold temperatures of -3°C and also the drought.

In the sub-steppic zone of Iran native varieties of *O. holciformis* and *O. molinioides* have proved well adapted to seeding under dryland conditions in the sub-steppic and xerophilous forest zones of Iran with 320 to +400 mm annual rainfall and they are very resistant to cold and drought.

In regard to edaphic conditions *O. miliacea*, *O. holciformis*, *O. molinioides* and *O. coerulescens* are all well adapted to light calcareous soils and Pabot (1961) reports that *O. molinioides* is practically indifferent to the nature of the sub-soil being found on granitic as well as limestone soils.

O. miliacea is also reported (Ionesco et al., 1969, Villax, 1963) to prefer clay soils with good fertility although Le Houerou (1965) and Le Hou  rou and Froment (1969) record that the species develops equally well on both light and heavy soils.

Ecological characteristics :

Ecologically *O. miliacea*, *O. holciformis*, *O. coerulescens* and *O. molinioides* occur naturally in semi-arid steppic conditions in N. Africa and the Near and Middle East.

In the Tunisian steppe Le Houerou (1969) mentions that *O. coerulescens* occurs as a scattered component in the association of *Moricandia* ssp. *suffruticosa*, *Reseda alphonsi* and *Diploaxis harra* in the region of Gafsa (200-300 mm annual rainfall), while *O. miliacea* is mentioned as occurring in the association of *Tetraclinus articulata* and *Quercus coccifera* in the region of Tunis, Cap Bon and Bou Fichta (375-450 mm annual rainfall) and also in the association of *Nerium oleander* and *Pennisetum elatum* in central Tunisia.

Maire (1953) records that *O. miliacea* under natural conditions in N. Africa is found in a diversity of habitats including arid sites, under maquis and bush, under trees in forest clearings and even in brackish places. In the littoral zone of Egypt it occurs in gullies at 30 m elevation (Ibrahim, 1968) while it is common in the Pine and Cypress forest zone (500-600 m elevation) of Jordan (Kasapligil, 1956).

In Lebanon Pabot (1959) also records that *O. miliacea* and *O. holciformis* are present in the lower mediterranean zone (10-500 m elevation), while *O. holciformis* is also recorded in the Cedar zone (1,500-2,000 m elevation).

In Iran under natural conditions Pabot (1967) records that *O. holciformis* grows in various regions of the Zagros and Elburz Mountains from 1,500-2,500 m elevation, but it never forms abundant populations and seems much affected by overgrazing and deterioration of the micro-climate.

Pabot (1961) further states that ecologically *O. holciformis* appears to be plainly calciphilous and in Iran in the forest belt it does not develop far from trees and even under relative shade ; *O. holciformis* in Iran thus seems to require a much more temperate micro-climate than other mountain grasses.

Over 2,500 m elevation in Iran *O. holciformis* is replaced by *O. molinioides* which is probably a less palatable species but adapted to high altitude (Pabot, 1967). In Afghanistan Linchevsky and Prozorovsky (1949) record *O. molinioides* as being present in southern Pamiro-Alai, in the alpine and sub-alpine zone growing in association with other grasses such as *Alopecurus seravschanicus* and *Poa bucharica*.

11.9. Cultivation Techniques

Time of seeding :

In the Mediterranean region *O. miliacea*, *O. holciformis* and *O. coerulescens* can be seeded after the first autumn rains (Villax, 1963) but in Tunisia Le Houerou (1965) and Le Hou  rou and Froment (1969) recommend seeding *O. miliacea* in mid-September to take advantage of the early rains and warmer temperatures. However, Lapeyronie and Semadeni (1968) report that their experience in Tunisia indicates that seeding *O. miliacea* in the spring is generally preferable.

In effect the growth from autumn seeding is slow due to low temperatures and competition from weeds. The choice of land is therefore important and should be free of weeds if good success is to be achieved especially for autumn plantings.

Vegetative propagation :

In the sub-steppic region of Iran because the seed germination of *O. holciformis* in autumn seeding has proved slow and uneven, nursery stands have been established with cuttings of native plants spaced 50 x 50 cm ; in Morocco a spacing of 30 x 30 cm is recommended for *O. miliacea* and vegetative propagation is considered useful for establishing various ecotypes in nurseries.

Seed treatment :

Pabot (1967) points out that because seed multiplication of native ecotypes of both *O. holciformis* and *O. molinioides* has proved difficult in Iran it is necessary to find some technique to facilitate the germination of the seeds so that larger scale seeding could prove practical.

In Tunisia Lapeyronie and Semadeni (1968) recommend treatment of the seeds of *O. miliacea* with sulphuric acid or hot water to assist germination, and Froment (1970) records 80 days after sowing 76 % germination for seeds of *O. miliacea* soaked in sulphuric acid for 24 hours then rinsed and dried, followed by further immersion in hot water and drying compared to 2 % germination for untreated seeds.

Land preparation and seeding :

Since the seeds of *Oryzopsis* spp. are generally very small the preparation of a very fine, firm, clean seed-bed is required. This has entailed in Tunisia one heavy harrowing or disking at the beginning of September followed by two rollings and a further light harrowing in mid-September.

For *O. miliacea* seeds are sown shallowly (1 cm deep) and lightly covered with soil ; in Tunisia Thiault (1961) reports good success from broadcasting seeds of *O. miliacea* after the passage of a harrow in a season with less than 200 mm rainfall and Froment (1970) also recommends surface sowing.

Seed rates and spacing :

Seed rates and row spacings recommended for *O. miliacea* have varied from 8-12 kg/ha of seeds in lines spaced 40-60 cm in Morocco to 15-20 kg/ha of seeds broadcast in lines spaced 30-40 cm apart in Tunisia. Higher seed rates of 20-40 kg/ha have also been recommended in Tunisia (Lapeyronie and Semadeni, 1968, Froment, 1970). For *O. holciformis* Gallacher (1970) recommends a seed rate of 10 kg/ha in the high plateaux zone of Algeria, and the same seed rate has been used in the sub-steppic zone of Iran.

Intercultivation with legumes :

Under dryland conditions in Tunisia it is also recommended (Le Hou  rou, 1965, Le Hou  rou and Froment, 1969) to cultivate *O. miliacea* in association with either *Medicago sativa*, *Onobrychis viciifolia* or *Lotus creticus*. In this case 10 kg/ha of seeds of *O. miliacea* is planted with 5 kg/ha of seeds of one of the above mentioned legumes.

In Cyprus *O. miliacea* has also been cultivated in mixture with *M. tribuloides* in experimental pastures, but is more often seeded alone in upland areas (Fig. 6).



Fig. 6

Dryland seeded plot of *O. miliacea*
planted on the contour near Rhizokarpaso

(After Report on pasture research, survey and development in Cyprus,
Government of Cyprus, 1958, p. 64, plate 12)

Fertilizer application :

When *O. miliacea* is cultivated in mixture with legumes the application of nitrogen fertilizer is not recommended, but at least 40 kg/ha of P_2O_5 are normally required in Tunisia because the soils are deficient in phosphorous.

In Tunisia Le Houerou (1965) and Le Hou  rou and Froment (1969) recommend the following fertilizer application for *O. miliacea* seeded alone :

at seeding	:	5-15 kg/ha N	} localized in the lines
	:	5-10 kg/ha P_2O_5	
end of February	:	20 kg/ha N	
end of March	:	20 kg/ha N	
end of September	:	20 kg/ha N	

In the high plateaux zone of Algeria Maignan (1970) recommended the following fertilizer application for *O. holciformis* :

before seeding	:	45 kg/ha P_2O_5
(July)		
at the beginning		
of the autumn		
each year	:	22 kg/ha N

11.10. Forage Value :

Palatability :

O. miliacea, *O. holciformis*, *O. molinioides* and *O. coerulescens* are all palatable to livestock particularly sheep and goats, but also cattle.

However *O. miliacea* in Tunisia has proved to be more palatable to sheep when young and it is accepted more readily before the formation of the panicles ; after this stage the rapid lignification of the stems and roughness of the older leaves tends to reduce its acceptability. Trials in Tunisia with sheep have shown that *O. miliacea* from the beginning to the end of the heading stage is as well accepted as *Phalaris truncata*, *Bromus catharticus* and *Festuca arundinacea* at the same stage of growth as the following data shows :

	Daily Consumption 1/ by Sheep in Grams DM				
	<i>Oryzopsis miliacea</i>	<i>Phalaris truncata</i>	<i>Bromus catharticus</i>	<i>Festuca arundinacea</i>	Total Daily Consumption DM (g)
18-21	690-830	280-645	540-610	390-425	1900-2510
March	595-760	590-640	560-165	720-520	2465-1885
19-22	405-415	575-605	495-485	660-695	2135-2260
March	500-495	630-640	760-600	650-420	2540-2155
20-23	830-380	575-455	425-1030	735-505	2565-2820
March	510-715	490-290	520-870	705-480	2225-2355
Average Consumption (in g)	590-675	520-555	550-625	645-475	2305-2330
% of the total consumed	25.3-29.0	22.8-28.5	23.9-26.8	28.0-20.4	100-100
1/ In each column the first figure refers to the consumption of the first day and the second figure to that of the second day					

In the sub-steppic zone of Iran dryland seeded *O. holciformis* has proved quite palatable to native sheep in short term grazing palatability tests being well grazed in the flowering and seed production stages. *O. holciformis* in Tunisia and *O. coerulescens* in Morocco are both well accepted by livestock in the vegetative stage (Corriols, 1965, Foury, 1950).

Nutritive value :

The nutritive value of *O. miliacea* is considered to be fair and closely comparable to *Festuca arundinacea*. The following data for cultivated *O. miliacea* is given by Villax (1963) for Morocco and by Corriols (1965) and Lapeyronie and Semadeni (1968) for Tunisia :

Morocco

	% Chemical composition				
	Water	Protein	Fats	Carbohydrates Soluble	Fibre
Green forage	80	2.8	0.6	9.4	4.9
Hay	20	11.2	2.5	37.7	19.7

Tunisia

Date Sampled	<u>Local Variety (from Bordy Chakir)</u>					
	% Digestible Products					
	Protein	Fats	Cellulose	Non-N Extract	Metabolizable Energy/kg green matter	Forage Units/kg green matter
14.12.55	1.62	0.53	3.59	2.97	342 c	0.09
28.12.55	4.44	1.37	8.27	3.66	707 c	0.19
23. 3.56	1.85	0.85	5.66	3.67	477 c	0.18
2. 5.56	2.34	1.33	8.68	4.71	680 c	0.18

<u>Analysis of second year growth</u> (first cut ; height of plants 30-60 cm) Stems and Leaves							
(1) Coefficients of Digestibility							
<u>Total Dry Matter</u>				<u>Digestible Matter corresponding to total dry matter</u>			
Ash %	Organic Matter %	Crude Protein %	Crude Fibre %	Dry Matter %	Organic Matter %	Crude Protein %	Crude Fibre %
15.2	84.8	16.5	28.1	65.0	68.0	74.0	64.5
(2) Digestible Protein Content and Energy Value							
Digestible protein g/kg green matter		Digestible protein g/kg dry matter		Forage Units/kg green matter		Forage Units/kg dry matter	
34		122		0.18		0.63	

Le Houérou (1965) and Le Houérou and Froment (1969) also report the following average data for the nutritive value of *O. miliacea* in Tunisia :

- forage units/kg green matter : 0.16
 - Digestible protein in green matter : 31 %
 - Forage units/kg dry matter : 0.65
 - Digestible protein/kg dry matter : 130 g
- the coefficient of utilization is of the order of 65 % (in vitro digestibility).

Foury (1956) also gives some chemical composition data for *O. miliacea* occurring naturally at Rabat :

% chemical composition						
Date Sampled	Water	Ash	Protein	Non-N Extract	Fats	Cellulose
5.5.50						
Green matter	56.50	2.05	1.77	26.71	0.68	12.26
Dry matter	0	4.68	4.07	61.48	1.58	28.19
3.11.52						
Green matter	63.40	2.88	4.44	19.17	1.97	9.14
Dry matter	0	7.89	12.12	52.35	2.67	24.96
5.3.53						
Green matter	72.10	3.11	3.89	13.19	0.26	6.85
Dry matter	0	11.15	13.06	47.21	3.11	24.56
21.4.53						
Green matter	77.07	2.11	3.83	9.97	0.87	6.10
Dry matter	0	0.22	16.93	43.44	3.82	26.59

In Tunisia Corriols (1965) states that *O. holciformis* has a good nutritive value with a higher nitrogen free extract than for other *Oryzopsis* spp. and he gives the following chemical composition data :

% Digestible Products						
Date Sampled	Protein	Fats	Cellulose	Non-N Extract	Metabolizable Energy/kg green matter	Forage Units/kg green matter
28.12.55	2.14	0.98	7.78	4.40	602 c	0.17
2.5.56	2.48	0.82	7.19	5.41	619 c	0.17
11.4.57	1.72	1.18	5.47	9.53	721 c	0.19

In Morocco Foury (1956) gives the following chemical composition data for *O. coerulescens* occurring naturally at Rabat :

% Chemical Composition						
Date Sampled	Water	Ash	Protein	Non-N Extract	Fats	Cellulose
10.6.49						
Green matter	68.00	2.84	3.52	16.20	0.99	8.47
Dry matter	0	8.88	11.00	50.47	3.11	26.54
5.6.50						
Green matter	72.50	2.31	3.46	14.98	1.29	5.46
Dry matter	0	9.05	12.60	53.78	4.71	19.86
5.2.51						
Green matter	81.35	2.06	2.89	8.88	0.85	3.97
Dry matter	0	11.08	15.52	47.53	4.57	21.30

In Tunisia Corriols (1965) gives the following chemical composition data for dryland seeded *O. coerulescens* at Tunis :

% Digestible Products						
Date Sampled	Protein	Fats	Cellulose	Non-N Extract	Metabolizable Energy/kg green matter	Forage Units/kg green matter
28.12.55	2.23	0.91	6.61	2.58	490 c	0.18
24.3.56	3.76	0.51	6.69	1.54	489 c	0.18
11.4.56	2.32	1.22	5.44	5.86	742 c	0.20

11.11. Forage and Seed Production

Forage yields :

In Tunisia Le Houerou (1965) and Le Houerou and Froment (1969) state that the dryland forage yields of *O. miliacea* are comparable and even superior to those of *Festuca arundinacea* on good deep soils being of the order of 10,000-20,000 kg/ha green forage in one or two cuts in the first year and 20,000-50,000 kg/ha green forage in the second year.

Le Houerou and Froment (1969) also record that in Tunisia the yield of *O. miliacea* is some 29 % superior to that of *O. holciformis*, which

at Ousseltia (500 m elevation) in the steppic zone gave an average of 5,400 kg/ha and between 900-1,000 forage units/ha over a two year period (rainfall from September to May was 331 mm in the first year and 327 mm in the second year).

Lapeyronie and Semadeni (1968) also record the following production data for dryland *O. miliacea* at Tunis in Tunisia

Month	Green Matter kg/ha	Dry Matter kg/ha
14.1 First cut : heading (6-12 cm height)	16,200	3,020
30.3 Second cut : heading (30-40 cm height)	17,100	3,600
12.6 Third cut	5,600	2,650

Thiault (1961) has also recorded excellent dryland forage yields of *O. miliacea* in central Tunisia at Djebel Mansour where 7,200 kg/ha green forage was obtained in April, equivalent to 1,080 forage units/ha in a season with less than 300 mm rainfall.

In the high plateaux zone of Algeria Maignan (1970) and Gallacher (1972) have recorded in a season with 547 mm of rainfall a total green forage yield of 21,300 kg/ha in three cuts for *O. holciformis* during the period mid-December to mid-April.

In the sub-steppic zone (1,960 m elevation, 320-350 mm annual rainfall) of Iran at Homand, the following dryland forage yields were recorded for *O. holciformis* in June in nursery plots (AGP:SF/IRA 10, Tech. Rep. No. 1, 1970) :

	Age of stand in years	DM yield kg/ha	Age of stand in years	DM yield kg/ha
	6	3,790	7	4,690
Spring rainfall (March-May) mm	188.6		282.9	

The greater resistance to drought of *O. miliacea* compared to *O. holciformis* is shown in the southern desert (100 mm annual rainfall) of Israel where under run-off farming conditions transplanted *O. miliacea* varieties (including eight local and one imported variety "Smilo") averaged 3,900 kg/ha DM over a 6 year period, while *O. holciformis* failed to survive (Tadmor et al., 1970)

In regard to the comparative production of various varieties of *O. miliacea*, *O. holciformis* and *O. coerulescens* Corriols (1965) reports the following forage production data in the littoral zone of Tunisia at Tunis :

Forage Units/ha			
Species	First Year	Second Year	Third Year
<i>O. miliacea</i>	4,000	4,000-5,000	4,000
<i>O. holciformis</i>	--	8,000	8,000
<i>O. coerulescens</i>	3,000-4,000	3,000-4,000	3,000-4,000

Species and Varieties	1955-56 (664.7 mm rainfall) Second Year				1956-57 (492.2 mm rainfall) Third Year			
	kg/ha green matter	kg/ha dry matter	kg/ha dig. protein	forage units/ ha	kg/ha green matter	kg/ha dry matter	kg/ha dig. protein	forage units/ ha
<i>O. miliacea</i> Morocco (local)	38,662	10,438	966	5,799	13,332	3,599	333	1,999
Tunisia (Bord- Chakir, local)	34,485	9,310	862	5,172	21,658	5,847	541	3,248
<i>O. holciformis</i> Israel No 646	46,550	14,430	977	8,379	17,220	5,338	361	3,099
Israel No 2130	48,272	14,946	1,013	8,688	8,776	2,720	184	1,579
<i>O. coerulescens</i> Israel No 624	21,597	5,615	561	3,023	7,999	2,079	207	1,119
Israel No 2129	33,163	8,622	862	4,624	12,109	3,148	314	1,695

Seed yields :

In Morocco Villax (1963) reports seed yields for dryland *O. miliacea* varying from 100-200 kg/ha ; the seeds are not difficult to harvest since they do not shatter readily. Seeds of *O. holciformis* have been actively multiplied in Tunisia (Corriols, 1965) and Froment (1970) records a seed yield of 45 kg/ha in one year at Ousseltia (C. Tunisia).

11.12. Utilization

Time of use and establishment :

Dryland stands of *O. miliacea*, *O. holciformis* and *O. coerulescens* should not be utilized before the autumn of the second year to allow good rooting and establishment to take place.

Corriols (1965) states that for *O. miliacea* in Tunisia the young plants in the first year are avoided by livestock which leads to a good natural development of the stand without resorting to the need for additional seeding.

Litav and Seligman (1969) also report that in Israel re-seeded *O. holciformis* is a weak competitor with annual weeds in the year of establishment.

Grazing management :

O. holciformis is considered to be sensitive to overgrazing so that adequate rest periods between grazing should be provided. From harvesting studies in Israel it is concluded that grazing of *O. holciformis* should be avoided in early summer if longevity of the pasture and production early in the season are required (Katznelson, 1974).

Type and period of utilization :

O. miliacea, *O. holciformis* and *O. coerulescens* can be utilized from December to June in the littoral zone of North Africa and Villax (1963) records that *O. miliacea* in Morocco can be utilized for grazing, hay or silage.

In Tunisia Le Hou  rou (1965) and Le Hou  rou and Froment (1969) recommend that three or four cuts or four to five grazings can be obtained from dryland *O. miliacea* in the second and subsequent years.

However, a cut should always be taken at the end of the summer period to eliminate the woody stems that develop at the end of the spring. This ensures good grazing of the autumn re-growth occurring at the base of the tufts which is much appreciated by livestock.

Further evaluation :

Both *O. miliacea* and *O. holciformis* in particular, present most interesting and promising material for selection and domestication in the region, but much further work is needed before the *Oryzopsis* spp. mentioned can receive wider recognition and agronomic use.

11.13. Specific References

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TECHNICAL DATA

SHEET No 12

GRAMINEAE (= POACEAE)

Panicum turgidum Forssk.

12.1 Synonym

Panicum turgidum (= *Panicum nubicum* Fig. et De.)

12.2. Common Names

English Turgid Panic Grass
Murat (India)

Arabic Bokkar, Ben rockba, Merkeba (Morocco),
Dharm halfah, Hailama, Thaman, Thumam, Tumam
(Saudi Arabia),
Shoosh, Abu rockba, Sabat, Sabad, Thammam,
Tabath, Dorran, Kabath, Kabas (Egypt, UAR) ;
Afasu, Merekba, Purukbah, Um Marukbah (Libya);
Girram, Bukar (Jordan);
Tumam (Qatar);
Namam (Yemen Democratic Republic).

12.3. Brief Description

A glaucous perennial with woody culms, prostrate or erect, much branched forming low dense bushes, but often reaching 100 cm or more ; roots very thick, felty and covered with a sheath of sand ; stems glabrous, glaucous, thickened, branching at the nodes with clusters of brown empty leaf sheaths at the swollen nodes ; inflorescence in a lax, pale, few flowered panicle on a few stiff branches carrying a small number of spikelets ; spikelets short, pedicelled, erect, turgid, ovate, the flower glume nearly as long as the spikelet (Fig.1).

12.4. Varieties

Variation within the species :

Preliminary studies on the variation within the species have shown more or less continuous variation throughout its range of distribution, and particularly in the Middle East there appear to be high grain yielding forms (Williams and Farias, 1972).

Growth forms and ecotypes :

It appears almost certain that there are several growth forms and a number of ecotypes of *P. turgidum* present in the desert regions of North Africa and the Near and Middle East stretching from the Sahara to Arabia and the Sind desert. These forms may range from prostrate to erect types and some could be more leafy than others. The need to collect seeds of these ecotypes and to evaluate their re-seeding potential is evident since this species is an important desert grass growing in areas with only 50-100 mm of annual rainfall.

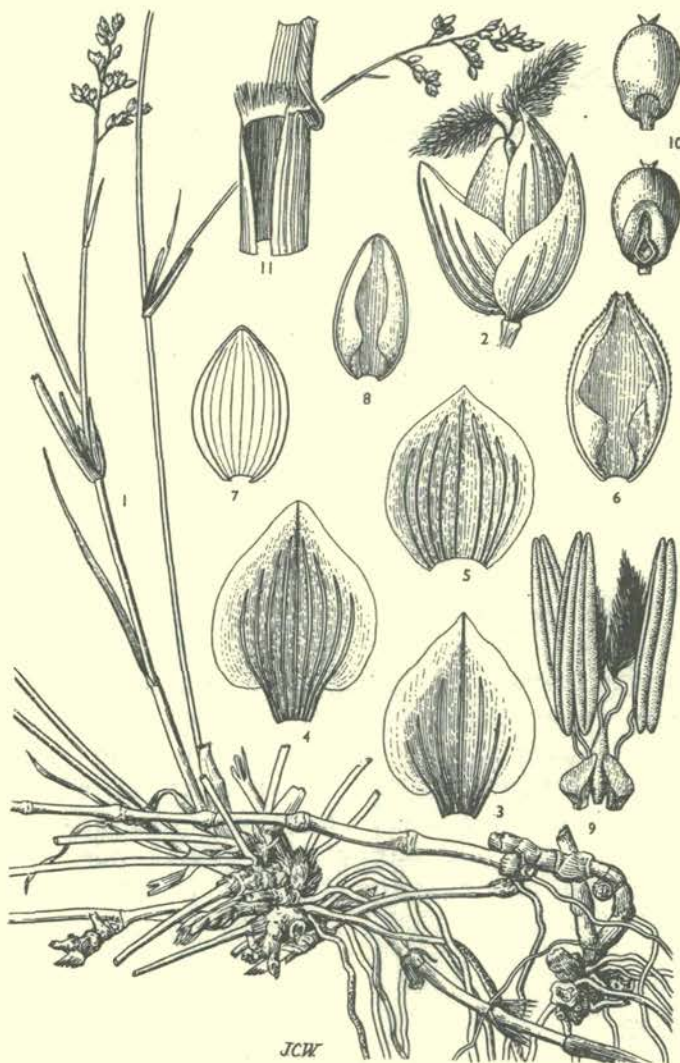


Fig. 1 - *Panicum turgidum* Forssk.

1. Habit, $\times \frac{2}{3}$. 2. Spikelet, $\times 8$. 3. Lower glume, $\times 10$. 4. Upper glume, $\times 10$. 5. Lower lemma, $\times 10$. 6. Its palea, $\times 10$. 7. Upper lemma, $\times 10$. 8. Its palea, $\times 10$. 9. Flower, $\times 15$. 10. Grain, $\times 10$. 11. Ligule, $\times 12$.

(After Flora of Iraq, Vol. 9, Gramineae, 1968, p. 491, plate 188)

12.5. Number of Chromosomes

P. turgidum : $2x = 18$.

12.6. Geographical Distribution

P. turgidum is distributed in Cyprus, S. Palestine, Jordan, Sinai, Egypt, Arabia, Kuwait, Bahrain, S. Iran, Pakistan, N. Africa (Morocco, Algeria, Sahara, Tunisia, Libya), and also in the Sahelian zone stretching from Mauritania to Somalia.

A distribution map based on published information (after Williams and Farias, 1972) shows the main areas covered by *P. turgidum* in North Africa and the Near and Middle East and a subsidiary map (after Bor, 1968) shows the main distribution of *P. turgidum* in Iraq :

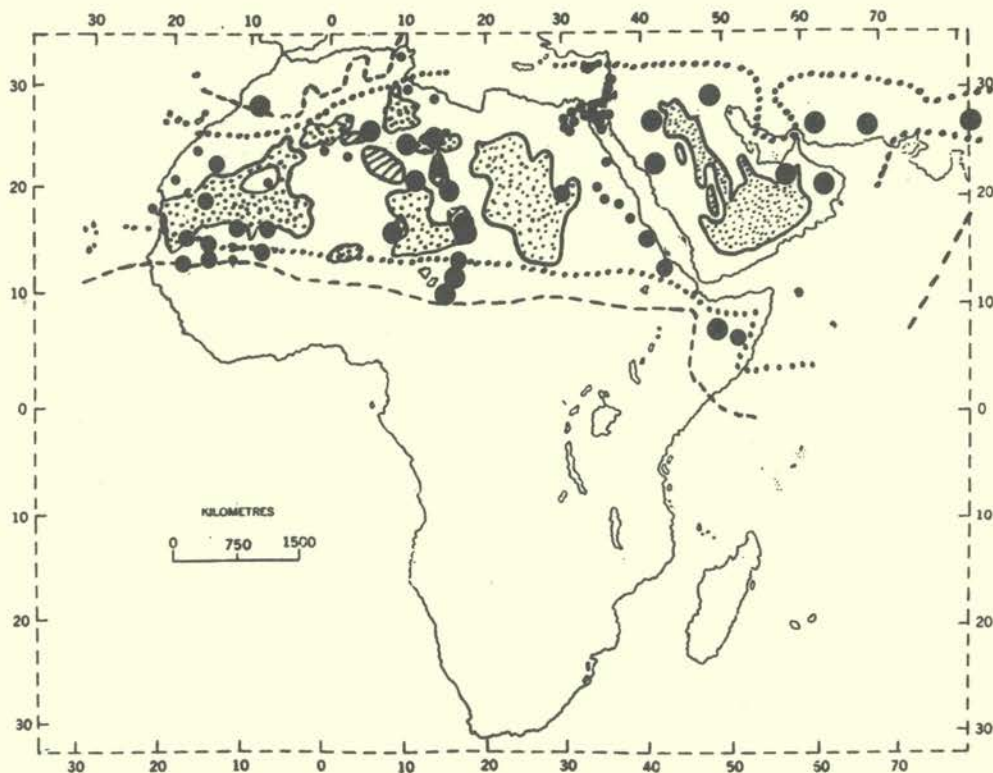


Fig.2

(After Econ. Bot., vol. 26, 1972, p. 14, Fig. 1)

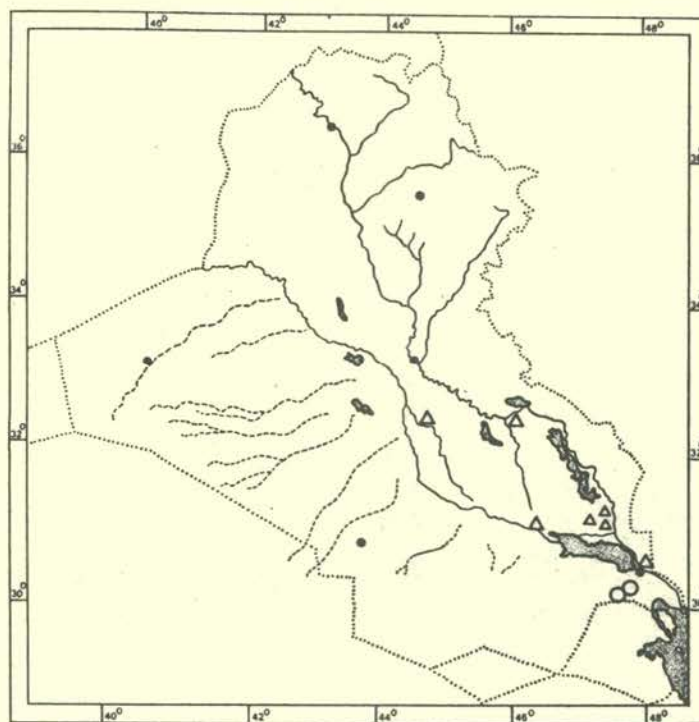


Fig. 3

Distribution in Iraq of *Panicum turgidum* Forssk. (O) and *P. repens* L. (Δ)

(After Flora of Iraq, Vol. 9. Gramineae, 1968, p. 487, map 4)

12.7. Biology and Ecology

Propagation and depth of rooting :

P. turgidum is a warm season species, propagating itself by seed, that grows slowly but is well adapted to drought because of its deep fibrous root system ; on coastal sands in Kuwait roots were found to reach a depth of 180-200 cm.

Growth and development :

Winter temperatures will retard growth and in native stands of *P. turgidum* in the coastal region of Egypt (UAR) an absolute minimum of 4°C has been recorded over a 12 year period (Migahid and El Shourbagui, 1958).

In the Eastern Desert of Egypt (UAR) where great fluctuations of temperature and relative humidity occur *P. turgidum* grows well in areas where the average rainfall is only 22.7 mm during the winter. During May-October no rain falls and the maximum temperature rises to 40°C. Under these extreme conditions *P. turgidum* produces a large volume of palatable growth and a high output of seeds which are often eaten by birds. Migahid and El Shourbagui (1958) state that dry plants in Egypt (UAR) may produce new shoots and flowers in autumn, even before the onset of the rainy season.

In Libya Keith (1965) records that growth of *P. turgidum* is good in wadi beds with an annual rainfall as low as 25-50 mm and plants flower and fruit in March-April ; however in camel areas the flower and seed stalks of *P. turgidum* are much browsed and thus have little opportunity to produce seed.

In the coastal region of Kuwait with similar climatic conditions *P. turgidum* reaches its maximum growth in the spring when warm temperatures of 25-30°C prevail and the plants remain green until late in August, and the shoots persist though becoming dry in late summer. In the autumn (October) there is generally a new flush of growth when plants produce new shoots from the nodes ; new growth benefits from dew and light precipitation at this time.

P. turgidum is a tussock forming plant which leaves some undecomposed material as litter which helps in building up the soil.

Growth of transplants :

In Egypt (UAR) transplants of *P. turgidum* established in the north western coastal zone (end November) tended to dry out progressively from the tip of the base of the leaf blades during the first month after transplanting ; average height at this time was about 46 cm and the percentage survival was 100 %. Sprouting from the lower nodes of the transplants took place from end of February to beginning of April but the percentage

survival decreased to 47 %. New culms, bearing leaves and terminal buds - the latter started to produce inflorescence - appeared at the beginning of May. By October the whole shoot of the new plants were well developed and green with an average height of 80 cm and still with a survival rate of 47 %. After seed dispersal the annual growth cycle ceased with the onset of cold weather.

On saline sites the growth pattern of *P. turgidum* transplants was similar, but the survival percentage was lower.

Seed germination :

Germination experiments with seeds of *P. turgidum* in Egypt (UAR) have shown that no germination takes place below a temperature of 15°C ; the optimum temperature recorded was 30°C and even then germination did not exceed 25 %. Superficial surface seeding in pots of sandy soil also gave the highest germination, while practically no germination occurred at seeding depths of 3 and 5 cm (Migahid and El Shourbagui, 1958). In Israel the germination of *P. turgidum* dispersal units (caryopsis enclosed with palea and lemma) was improved when they were dessicated, preferably at a high temperature (30°C) prior to planting in moist petri dishes (Koller and Roth, 1963).

Climate and soil :

P. turgidum appears to be especially adapted to sandy interior desert regions receiving an annual rainfall of 50-250 mm and to tolerate appreciable soil salinity (Park, 1956, Migahid and El Shourbagui, 1958) as well as sand accumulation.

Ecological characteristics :

P. turgidum is commonly found on sand dunes and wadis, in desert valleys and in sandy and rocky desert plains stretching from the Sahara in N. Africa to the Sind desert in Pakistan.

In Egypt (UAR) *P. turgidum* is very common in the Sinai desert and along the Red Sea coastal zone but is not recorded in the semi-desert of the northwest Mediterranean littoral zone. In Egypt *P. turgidum* often occurs in association with *Pennisetum dichotomum* but is represented in 14 different plant communities in the deserts of Egypt (UAR) (Kassas and El Abyed, 1962).

In the Sind desert of Pakistan on wind blown sand (50-100 m elevation, 200 mm annual rainfall) *P. turgidum* occurs in association with *Cenchrus pennisetiformis* and *Calligonum polygonoides* (Term. Rep. AG:DP/PAK 71/001, 1975)

In Kuwait on sand dunes plants of *P. turgidum* are scattered and generally have a bushy straggly form, but in valley bottoms where the sand is shallower and more compact the plants are smaller and more closely spaced (Kernick, 1965) ; common associates on deep sands are *Pennisetum dichotomum*, *Lasiurus hirsutus* and *Cyperus conglomeratus*. The latter species is also a common associate of *P. turgidum* on sand dunes in Qatar (Obeid, 1975).

In Saudi Arabia *P. turgidum* is an especially common component of the desert vegetation where it grows in deep and shallow sandy plains in the north and north-east with 50-100 mm annual rainfall ; here on sand dunes it often occurs in association with *Pennisetum dichotomum* and *Calligonum comosum* and in wadis with *Lasiurus hirsutus*. Again *P. turgidum* is found on the Red Sea coastal plains and in the interior valleys as well as in mountains in the south rising to 1,400-2,100 m elevation with 150-250 mm annual rainfall, where it occurs in association with *Pennisetum* spp. and *Acacia* spp. (Kingery, 1972).

In central Tunisia *P. turgidum* is also found as a relic community growing in association with *Acacia tortilis* and is also common in the sandy desert zone of Algeria and Morocco often in wadis (Rattray, 1960) and in the desert regions of Libya where it is found growing in association with *Acacia raddiana*, *Aristida* spp., *Pennisetum* spp. and *Lasiurus hirsutus* (Le Houerou, 1965).

12.8. Cultivation Techniques

Time of seeding and seeding success :

In Morocco *P. turgidum* has been successfully seeded at the end of February on an experimental basis under dryland conditions (500-600 mm annual rainfall) at Salé (Giscard, 1961). The resultant plants reached a height of 150 cm after several months.

In the Rajasthan desert of India near Jodhpur direct seeding of *P. turgidum* has also been successful under 300 mm annual rainfall (Dabadghao and Shankarnarayan, 1973).

Vegetative propagation :

Although transplanting of young and adult plants of *P. turgidum* has not proved successful in Morocco (Giscard, 1961) transplanting in the autumn (November) in the north-west coastal zone of Egypt (UAR), (Migahid and El Shourbagui, 1958) and in the monsoon season (June to end of August) in the Sind desert of West Pakistan (Term. Rep. AG:DP/PAK/71/001, 1975) has been successful.

In Egypt (UAR) transplants were raised in pots (20 cm in height) filled with sandy soil and planted with seeds of *P. turgidum* collected from native stands in July. 20-25 seeds were planted in each pot and irrigated every day. After 15 days seedlings were thinned to 2 per pot and kept in the open to become adapted to the climate. Due to slow growth transplanting was only possible 5 months later in December when plants had developed good rooting.

Success of planting under desert conditions was influenced by climate and habitat factors. Best results were achieved in an alluvial catchment with deep soil receiving run off. Here growth was rapid and the

survival rate high. On elevated plateaux or sand dunes growth was limited by strong winds and moving sand ; high salinity also retarded growth.

In Figs 4-7 below the growth of *P. turgidum* 4 months after transplanting is shown on a site with shallow sandy soil and on a site with deep alluvial soil in the north-west coastal region of Egypt (UAR), (Migahid and El Shourbagui, 1958) :



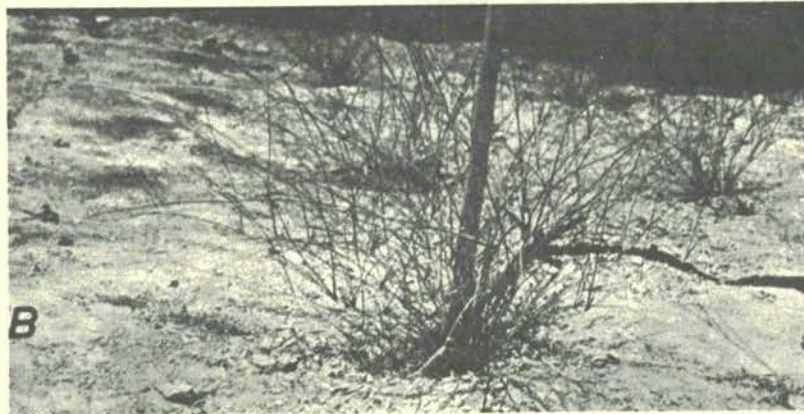
a) close up of individual plants



b) general aspect

Fig. 4 and 5 - Transplanted (April) *Panicum turgidum*
on deep alluvial soil in August

(After Bull. Inst. du Désert d'Egypte, vol. 3(1), 1961, p. 81, Fig. 5 B and C)



a) close up of individual plant



b) general aspect

Fig. 6 and 7 - Transplanted (April) *Panicum turgidum*
on shallow sandy soil in August

(After Bull. Inst. du Désert d'Egypte, vol. 3(1), 1961, p. 79, Fig. 5 B and C)

Response to fertilizer application :

Little information is available on response of *P. turgidum* to fertilizer but sand culture experiments have indicated that plants of *P. turgidum* from Palestine and Arabia yield up to twice as much forage as plants from Mauritania when low amounts of phosphorous and potassium are applied ; there was little response from nitrogen (Williams and Farias, 1972).

12.9. Forage Value

Palatability :

P. turgidum is considered to be very palatable to camels and also to sheep and goats when young. In Western Rajasthan the highest palatability of *P. turgidum* for cattle has proved to be the vegetative and ripe stages and the lowest in the pre-flowering stage (Das, 1975).

Nutritive value :

The chemical analysis for *P. turgidum* forage sampled during different seasons in Kuwait (Kernick, 1965) is given below :

Composition - Percentage of Dry Matter							
	Date Sampled	Ash	Crude Fibre	Crude Protein	K	P	Ca
Green leaves and stems	11.6.61	9.070	41.360	6.830	0.125	0.088	0.677
Yellow green leaves and stems	24.6.61	9.000	39.880	6.220	1.055	0.003	0.750
Standing hay yellow stems empty seed-heads	18.10.61	7.760	39.660	5.520	0.011	0.014	0.572
New green leaves and shoots	29.1.62	7.710	37.730	13.910	0.016	0.399	0.588

Digestibility :

In western Rajasthan in the arid zone of India digestion trials with native sheep have been carried out to ascertain the nutritive value of *P. turgidum* (Purohit and Mathur, 1970). In the trial lasting 28 days *P. turgidum* showed high palatability and high digestibility coefficients of nutrients although the calcium and phosphorous levels were somewhat low. The chemical composition was found to be as follows :dry matter 94.95 %, crude protein 5.12 %, crude fibre 40.37 %, N free extract 42.97 %, calcium 0.48 % and phosphorous 0.11 %, while the digestibility was as follows : digestible crude protein (DCP) 2.6 %, digestible crude fibre (DCF) 25.8 %, digestible N free extract (DNFE) 24.34 %, and total digestible nutrients (TDN) 52.63 %

12.10. Forage and Seed Production

Forage yields :

In Kuwait forage production of native stands of *P. turgidum* has varied from 50 kg/ha DM in January-February, to 150 kg/ha DM in May-July to 200 kg/ha DM in October in a year with 63.99 mm of rainfall (Kernick, 1965).

Seed harvesting :

No information is available on seed production of native stands although seed has been collected in Jordan (Park, 1952), Morocco (Giscard, 1961), and Egypt (UAR), (Migahid and El Shourbagui, 1958). Giscard (1961) reports that seeds mature at different times over an extended period and shatter rapidly making harvesting of large quantities difficult, nevertheless seeds harvested from experimental plantings in Morocco have given excellent germination.

12.11. Utilization

Potential for seeding desert range :

Park (1952) considers that *P. turgidum* might prove to be a valuable species for rehabilitation of desert ranges in the Near and Middle East as well as elsewhere.

Grazing use :

In regard to grazing use the young growth is very palatable and good utilization can be expected at this stage.

Soil conservation value :

P. turgidum is valuable as a soil binder on sand dunes (Maheshwari and Singh, 1965). According to Ibrahim (1965) it has been used on a small scale for sand dune fixation in North Sinai, Egypt (UAR).

Further evaluation :

More studies are needed on palatability, seed harvesting and seeding techniques before this species can receive wider recognition and agronomic use.

12.13. Specific References

- | | |
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TECHNICAL DATA

SHEET No 13

GRAMINEAE (= POACEAE)

Phalaris spp.

13.1. Genus

According to Anderson (1961) 15 species of forage interest have been identified within the germs *Phalaris* and he gives keys, synonyms, descriptions, illustrations and distributions for these species.

13.2. Species

There are four species of *Phalaris* which are considered to have an important forage value in North Africa and the Near and Middle East. These species are *P. tuberosa* L., *P. arundinacea* L., *P. coerulescens* Desf. and *P. truncata* Guss.

An interesting taxonomic problem has developed regarding the incorrect naming of the species commonly referred to as *P. tuberosa* var *stenoptera* (Hack.) Hitch in the USA and *P. tuberosa* L. in Australia ; other incorrect names for the species have been *P. bulbosa* L. and *P. nodosa* Murr.

All these scientific names were antedated by *P. aquatica* L. published in 1755, which is the oldest available legitimate name. This scientific name has priority according to the International Code of Nomenclature and should therefore be used in all future reference to this species.

13. 3. Synonyms

- *P. aquatica* (= *P. tuberosa* L., *P. bulbosa* L., *P. nodosa* (L.) Murr.)
- *P. arundinacea* (= *Balclutha arundinacea* Dum)

13.4. Common Names

- | | | |
|-------------------------|---------|---|
| - <i>P. aquatica</i> | English | Peruvian Winter Grass (Peru) ;
Harding Grass, Perennial Canary
Grass, Bulb Canary Grass (USA) ;
Toowoomb'ba Canary Grass (Australia) |
| | French | Alpiste Tubereux, Alpiste bulbeux
ou Nouveux (Morocco, Tunisia). |
| | Arabic | Kurram, Kurrayn (Jordan). |
| - <i>P. arundinacea</i> | English | Reed Canary Grass (USA). |
| | French | Alpiste roseau (Morocco). |

- | | | |
|--------------------------|---------|-----------------------------|
| - <i>P. coerulescens</i> | English | Sunolgrass (USA). |
| | French | Alpiste bleuâtre (Morocco). |
| - <i>P. truncata</i> | French | Alpiste tronquée. |

13.5. Brief Description

- *P. aquatica* is a broadly caespitose tufted grass with two to four tubers at the base, glabrous stems reaching a height up to 180 cm with the inflorescence in the form of a dense panicle and yellowish-brownish glossy seeds (Fig. 1 and 2) ;

- *P. arundinacea* is a robust rather coarse sod-forming grass that spreads extensively by rhizomes, attaining a height of from 60-200 cm, with flowers borne in semi-dense panicles and grey to grey-black waxy seeds (about 3 mm long) (Fig. 3) ;

- *P. coerulescens* is a robust caespitose long-lived bunchgrass attaining a height of up to 150 cm with three or more round bulblike enlargements at the base of the stem with the inflorescence in the form of a panicle. (Fig.4) ;

- *P. truncata* is a caespitose sod-forming grass with rhizomes and attaining a height of 150 cm with bulbils at the base of the stem.

13.6. Varieties

Botanical forms and varieties :

Various botanical forms or varieties of *P. aquatica* and *P. truncata* are present in North Africa and Maire (1953) mentions the following :

- *P. aquatica*
 - var *genuina* Maire et Weiller n. nom.
type species with glabrous glumes, frequent in the south and Saharan Atlas but rare in Cyrenaica ;
 - var *hirtiglumis* (Trabut) Maire et Weiller, comb. nov.
(= *P. aquatica* x *hirtiglumis* Traut in B. et T.,
P. elongata Br.-Bl.)
glumes hairy at least on the keel and leaves up to 15 mm wide ; present in the Grand Atlas ;
 - var *alata* (Trabut) Maire et Weiller, comb. nov.
(= *P. aquatica* var. *alata* Traut)
probably a hybrid variety (*P. bulbosa* x *P. coerulescens*)
glumes have a large keel ; present in Algeria ;

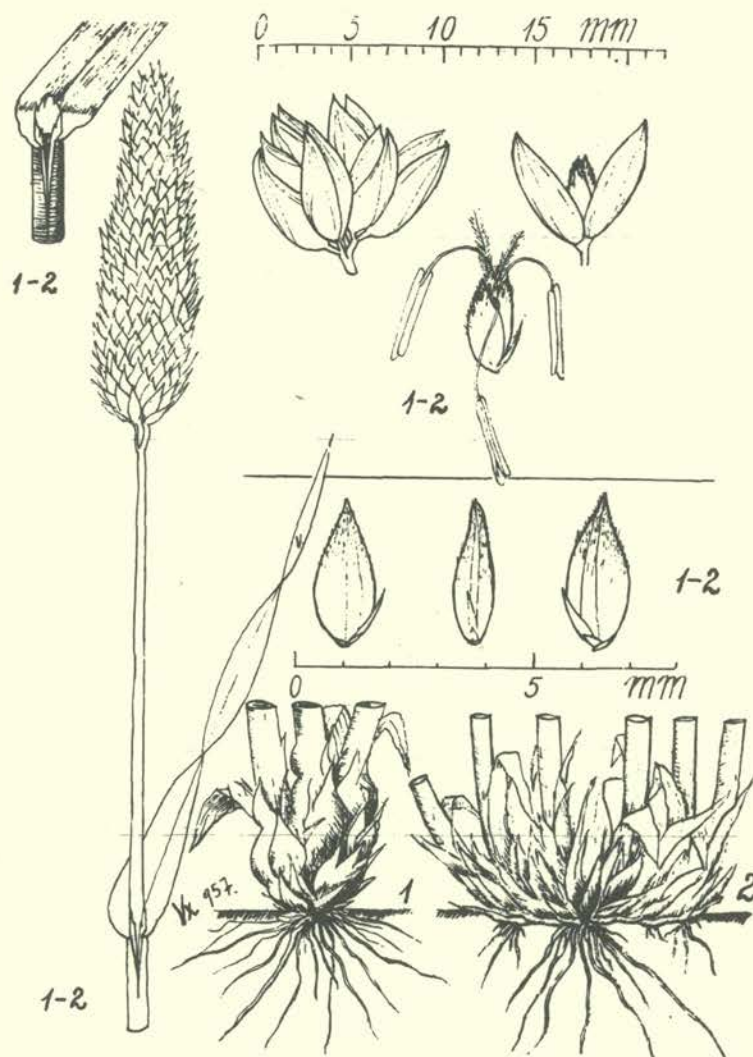


Fig. 1

Phalaris tuberosa (= *P. aquatica*) (1)

et

Phalaris tuberosa var *stenoptera* (= *P. aquatica* var *stenoptera*) (2)

(After la Culture des plantes fourragères dans la région méditerranéenne occidentale, 1963, p. 217, plate 50)

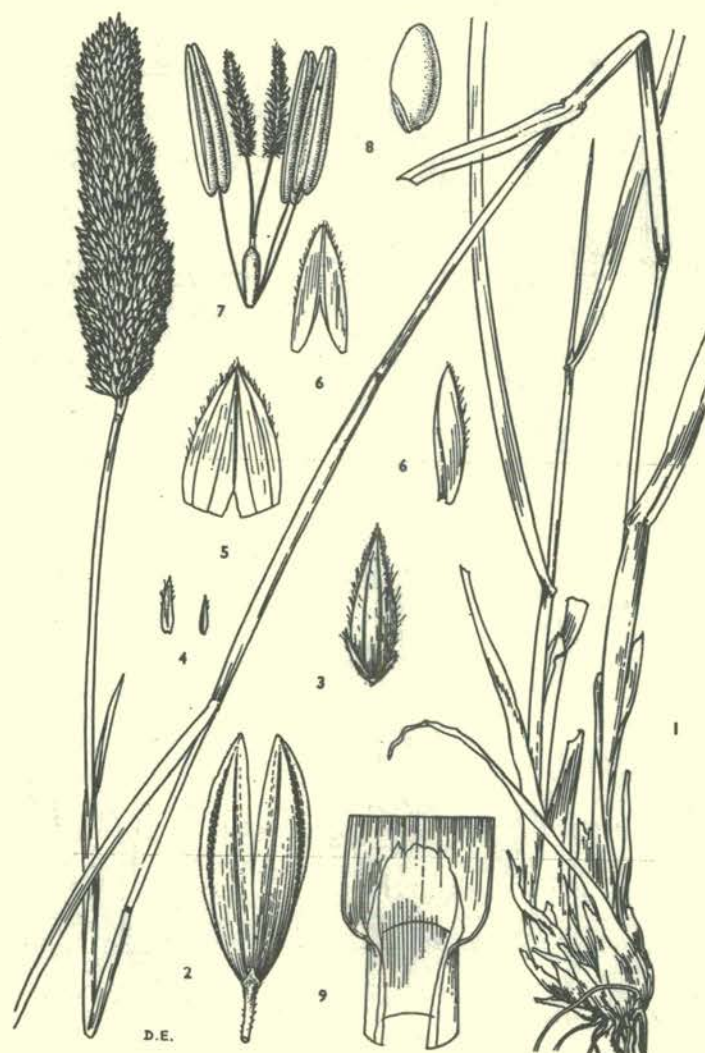


Fig. 2

Phalaris tuberosa L. (= *P. aquatica* L.)

1. Habit, $\times \frac{2}{3}$. 2. Spikelet, $\times 6$. 3. Lemmas, $\times 6$. 4. Empty lemmas, $\times 6$.
 5. Fertile lemma, $\times 6$. 6. Palea, $\times 6$. 7. Flower, $\times 6$. 8. Grain, $\times 6$.
 9. Ligule, $\times 2$

(After Flora of Iraq, Gramineae, vol. 9, 1968, p. 369, plate 141)



Fig. 3 - *Phalaris arundinacea*

Plant, x1. E : Spikelet, x8. C : Caryopsis, x8. F : Florets, x18.
L : Ligule, x3.

(After Introduccion al Estudio de las Especies
Pascicolas Espanolas, Madrid, 1965, p. 143)



Fig. 4 - *Phalaris coerulescens*

Plant, x1. G : Group of three sterile and one fertile spikelet, x5.
C : Caryopsis, x5. F : Florets, x10.

(After Introduccion al Estudio de las Especies
Pascicolas Espanolas, Madrid, 1965, p. 146)

- var *clausonis* Maire et Trabut in M. C.
with two sterile lemma ; present in Algeria but rare.
- *P. truncata*
 - var *typica* Maire et Weiller n. nom.
type species with glabrous glumes ; present in the North and centre of Tunisia and also the mountains of Algeria and Morocco ;
 - var *villiglumis* Trabut inéd
with soft hairy glumes ; present in Algeria ;
 - var *augustata* Trabut in B. et T.
with oblong glumes and tronquated wings and aspect of *P. aquatica* from which it differs by non-bulbous stems and two sterile lemma ; present in the mountains of Algeria and also recorded by Keith (1965) in Cyrenaica in Libya.

Villax (1963) also mentions a further botanical variety of *P. aquatica* in North Africa which is :

- var *stenoptera* (Hack.) Hitch
with many bulbils at the base of the stems ; present in Morocco.

Native ecotypes :

In the spontaneous populations of *P. aquatica* in North Africa and the Near East there are a number of ecotypes of varying growth habit, some of which are pasture types, others intermediate pasture/hay and some such as those from Palestine, which are very drought resistant (Villax, 1969). A number of native ecotypes of *P. aquatica* have been collected in Algeria and Morocco and one strain also from the northern Jezairah in Syria (Draz, 1972).

A variety of *P. aquatica* var *stenoptera* has been located in Morocco (de Brichambaut, 1952) and seeds of several local populations of *P. coerulescens* (Nos. T1 and T2) and *P. truncata* (No. 2.569) have also been collected and tested in Tunisia (Corriols, 1965).

Agricultural varieties :

Various varietal selections of *P. aquatica* have been developed in Rabat, Morocco, amongst which INRA Nos. 4055/59, 4088/59, 4102/59 and "E" are considered promising (Villax, 1963) ; at Algiers (Algeria) one developed variety No. 2 has been tested (Barbut, 1955).

In Australia a commercial variety of *P. aquatica* named "Sirocco" has been developed from an introduction from Morocco which has more vigorous seedlings than the commercial "Australian" variety ; a variety named "Seedmaster

or "Siro Seedmaster" and another variety "Sirosa", high yielding non-shedding derivations have also been developed recently in Australia (Leigh and Noble, 1972 ; Milton Moore, 1970).

Several varieties of *P. aquatica* have also been developed in Peru (de Brichambaut, 1952) and in Mexico "Comun" and "Wintergreen" are mentioned (Hernandez et al., 1973), while in Israel (Katznelson, 1974) the variety "Noy" is considered to be very productive.

In the USA the varieties P 11740 and P 14893 of *P. aquatica* var *stenoptera* have been developed from selections introduced from Italy and Australia (Hanson, 1965) ; seeds of P 11740 are available in quantity.

Selections of *P. aquatica* var *hirtiglumis*, English name, Kolea-grass, have also been increased in California, USA, from introductions received from Morocco ; one has been given the variety name "Perla" but exists only in the form of breeder seed (Hanson, 1965).

A number of varieties of *P. arundinacea* have been developed in Canada and the USA ; in Canada "Frontier" and "Grove" are two leafy varieties and "Castor" similar to "Frontier" has high seed retention, while in the USA "Ioreed", "Auburn", "Rise" and "Vantage" are all available commercially, the latter two varieties having superior seed retention (Heath et al., 1973). In the USSR one variety of *P. arundinacea* "Chernovitskii" is also mentioned (Shebalina et al., 1974)

A sterile hybrid, *P. aquatica* x *P. arundinacea*, English name Ronphagrass, has also been developed in South Africa and hybrid lines have also been developed and tested in Australia (Leigh and Noble, 1972).

13.7. Number of Chromosomes

P. aquatica and *P. aquatica* var *stenoptera* : $2n = 4x = 28$;

P. arundinacea : $2n = 4x = 14, 28, 27-31, 42$ (irregular) ;

P. coerulescens : $2n = 4x = 14, 28$;

P. truncata : $2n = 4x = 12$.

A highly fertile allopolyploid of the cross *P. aquatica* x *P. minor* with the highest chromosome number recorded in the genus ($2n = 4x = 56$) has been synthesised in Australia (Bor, 1960). It has been described as *P. daviesii* S.T. Blake and is distinguished by a very long ligule (6-10 mm long), relatively large spikelets and tufted perennial habit.

In the USA a variety P 11994 of *P. coerulescens* has been developed from an introduction from Australia but has not been released due to poor seed production and agronomic performance (Hanson, 1965).

13.8. Geographical distribution

P. aquatica is distributed in Mediterranean Europe, Aegean Isles, Cyprus, Turkey, Caucasus, Syria, Lebanon, Palestine, Jordan, Iraq, Iran, North Africa (Morocco, Algeria, Libya), Marcaronesia and introduced into cultivation in N.W. India, E. and S. tropical and S. Africa, Australia and the USA ;

P. arundinacea is distributed in Europe, Syria, Turkey, Iran, C. Asia (Turkmenia to Tian Shan), Siberia, Kamchatka, China, Japan, Manchuria, Korea, Formosa, N. India, Shri Lanka, Malay Islands, N. Africa (Algeria), E. tropical Africa, Mauritius, N. America and introduced into cultivation in Australia, S. Africa, New Zealand and the USA :

P. coerulescens originates in the Mediterranean basin and is distributed in Southern Europe, Egypt (UAR), Tripolitania, N. Africa (Morocco, Tunisia, Algeria), Canary Isles and Madeira Isles ; (Fig. 5) ;

P. truncata originates in the Mediterranean basin and is distributed in Portugal, Spain, Italy, Sicily, Turkey and N. Africa (Algeria, Morocco and Tunisia) (Fig. 5).

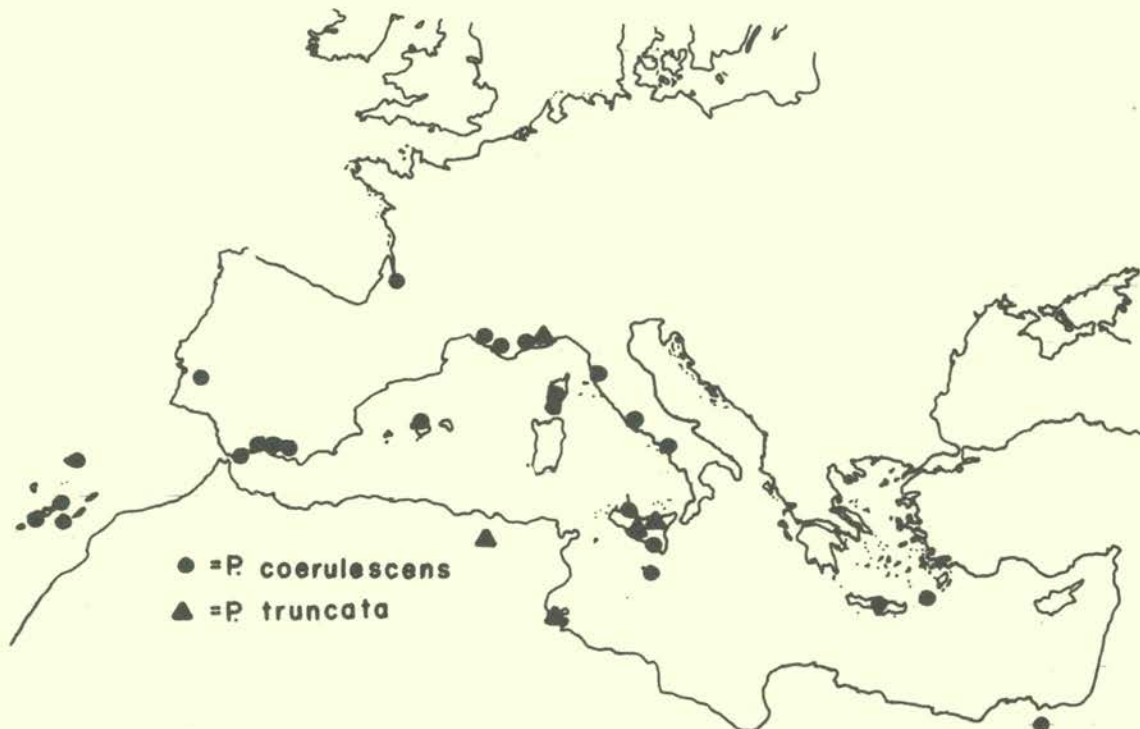


Fig. 5 - Geographical distribution of
P. coerulescens and *P. truncata*

(After Iowa State Coll., J. Sci 36, 3, 1961, p. 31, fig. 5)

13.9. Biology and Ecology

Growth and development :

P. aquatica, *P. aquatica* var *stenoptera*, *P. arundinacea*, *P. coerulescens* and *P. truncata* are all cool season species propagating themselves by seed ; *P. arundinacea* and *P. truncata* also spread by rhizomes.

All the above mentioned species grow well in the autumn and winter in the Mediterranean region being able to resist temperatures inferior to 0°C ; in Morocco *P. aquatica* and *P. aquatica* var *stenoptera* have survived three winters under snow at an elevation of 2,000 m (Giscard, 1963). However above ground foliage of *P. aquatica* in Morocco can be winter killed by prolonged freezing temperatures (Ionesco et al., 1969).

In the Mediterranean region growth of all the previously mentioned *Phalaris* spp. is strong in the spring (see Fig. 6 of dryland plant of *P. truncata*) but can benefit from irrigation during dry periods. Growth ceases completely in the summer with plants remaining in a dormant state until autumn (beginning of October) when re-growth occurs with the onset of cooler temperatures and autumn rains.

In the littoral zone of Tunisia (500-600 mm annual rainfall) plants of *P. aquatica*, *P. coerulescens* and *P. truncata* have remained green from the end of September to the end of May ; *P. truncata* supports well the summer dry period up till the beginning of July and regrows vigorously in autumn reaching a height of 70 cm at the beginning of January, while *P. coerulescens* dries up a little earlier in summer and starts growth a little later than *P. aquatica* in the autumn (Corriols, 1965).

In Morocco *P. arundinacea* has proved susceptible to lodging and has also been attacked by rust which has totally destroyed the foliage (Giscard, 1961). However in Australia the hybrid *P. aquatica* x *P. arundinacea* has proved interesting since unlike *P. aquatica* it is not summer dormant and produced extra forage when significant rains fell in summer (Myers and Squires, 1968).

Seed maturation :

Seeds of some *Phalaris* spp. particularly *P. aquatica* do not mature uniformly in the panicle, the last to mature being those at the base of the panicle. Under dryland conditions seed set can be adversely affected if seed development coincides with high temperatures ; in India it is reported (Narayan and Dabadghao, 1972) that seed set of *P. aquatica* has been good in the cool mountains but not in the hot plains. De Brinchambaut (1952) also records that seed production of *P. coerulescens* in Morocco is much weaker than for *P. aquatica* because only one spikelet in seven is fertile. Seed shattering can also be a problem and occurs especially in the case of *P. arundinacea*.

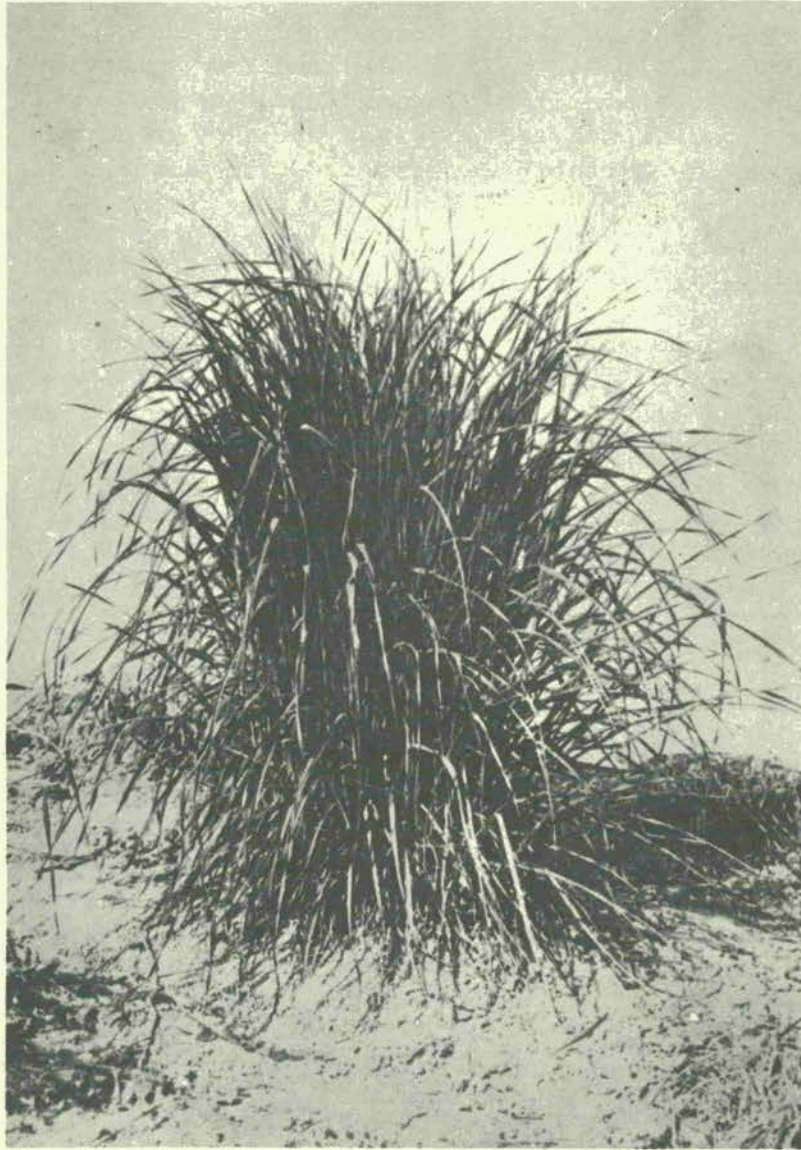


Fig. 6

A seeded dryland plant of *P. truncata* in Southern Italy showing vigorous spring growth

(After Annal. della Facoltà di Agraria, Università di Perugia, vol. 26, 1971, photo p. 354)

Adaptability in dryland plantings :

In the Near East region plants of *P. aquatica*, *P. coerulescens* and *P. truncata* have established well in dryland test plantings in the steppic zone (300-400 mm annual rainfall) of Jordan (Bailey, 1967), while plants of *P. aquatica* have shown good growth and survival over a three year period under dryland conditions in the Northern Jezzeira (+400 mm annual rainfall) in Syria (Draz, 1972).

Survival of varieties and ecotypes :

In the steppic zone (380-400 mm annual rainfall) of Northern Iraq *P. aquatica* variety "Sirocco" has exhibited a better survival rate (30 %) than *Agropyron elongatum* (25 %) at the end of the first year under dryland conditions probably because it is more truly summer dormant (Radwan, 1975).

Mckell et al. (1970) have also shown for ecotypes of *P. aquatica* from Algeria and Morocco tested under dryland conditions in the province of Madrid, Spain, that survival can depend on the nature of ecotype and its ability to make early autumn growth.

Climate and soils :

P. aquatica, *P. aquatica* var *stenoptera*, *P. arundinacea*, *P. coerulescens* and *P. truncata* are all winter growing grasses well adapted to a sub-tropical winter climate with more than 500 mm of annual rainfall ; *P. aquatica* and *P. truncata* appear to be the most drought resistant species and *P. truncata* in North Africa is adapted to a rainfall as low as 350 mm. Le Houérou (1965) and Le Houérou and Froment (1969) state that *P. truncata* is markedly more productive than *P. aquatica* in the 350-500 mm annual rainfall zone in Tunisia.

The following is a summary of the edaphic requirements of the above mentioned *Phalaris* spp. :

- *P. aquatica* and *P. aquatica* var *stenoptera* :
adapted to deep clay or loam soils but also succeed on poor and light soils ; stand water logged soils and flooding ;
- *P. arundinacea* :
adapted to non-calcareous fertile moist sands, clays or loams ; stands very well water logged soils and flooding ;
- *P. truncata* :
adapted to well drained calcareous and clay soils.

Ecological characteristics :

In North Africa *P. aquatica*, *P. aquatica* var *stenoptera* (Morocco only), *P. truncata* and *P. coerulescens* are found growing spontaneously in local habitats in the humid littoral zone, plains and mountains, although Keith (1965) records that the latter two species are rare in Libya.

In Tunisia *P. truncata* is reported (Le Hou  rou, 1969) to form a major association with *Cynara cardunculus* and *Medicago tunetana* on formerly cultivated soils (400-500 mm annual rainfall, 800-1,200 m elevation) and also as a scattered component in the steppic association of *Artemisia herba-alba*/*Malope malachoides* (400-500 mm annual rainfall, 850-1,200 m elevation).

In Lebanon and Syria *P. aquatica* and *P. coerulescens* are found in moist places in the littoral and mountain zones and *P. arundinacea* by the banks of canals and streams ; flowering takes place from March-August (Mouterde, 1966).

In Jordan *P. aquatica* has been reported (Kasapligil, 1966) also in the *Pinus halepense* forest (600 m elevation) and also as an associate of the plant association of *Ononis leisosperma*/*Hypericum triquetrifolium* on former crop land (200-300 m elevation, Irbid region, 1,200 m elevation, Ajbun region and in the districts of Kar  k, Tafila and Shaubak) and also as an associate with *Artemisia herba-alba* and *Ononis leisosperma* on the fallows of the arid zone in southern Jordan (Long, 1957).

In Iraq *P. aquatica* is found in the Amadiyah district of the lower mountain zone (600-800 m elevation), (Al Rawi, 1964).

In Turkey *P. arundinacea* occurs mainly in central and E. Anatolia, while *P. aquatica*, *P. truncata* and *P. coerulescens*, being of Mediterranean origin, are found mainly in W. and S. Turkey (Baytop, 1969).

In Iran *P. arundinacea* is recorded (Parsa, 1950) as occurring in the north at 1,500-2,800 m elevation in the mountains of Azerbaidjan and also in the Elburz Mountains (Kandavan and Karadj).

13. 10. Cultivation Techniques

Time of seeding :

In the littoral zone of N. Africa *P. aquatica*, *P. aquatica* var *stenoptera*, *P. arundinacea*, *P. coerulescens* and *P. truncata* are normally sown after the first autumn rains ; for *P. aquatica* and *P. aquatica* var *stenoptera* this is also the case in Cyprus.

Land preparation and seeding :

Since the seeds are small they require a well prepared, consolidated weed free seed-bed, worked to a fine surface tilth. The seeds are normally broadcast by hand when there is ample surface moisture and seeds can also be sown mechanically ; in Australia *P. aquatica* has been distributed from a pasture seed box mounted behind the fertilizer box of a standard seeder and a band seeder attachment has done an excellent job on a well prepared trash free seed-bed (Meakins, 1973). In Australia seeding *P. aquatica* in furrows has proved a useful technique on flat low rainfall plains.

Seed rates, spacing and companion crop :

The seed rates, spacing and companion crop vary as between countries but the following have been recommended :

- Tunisia 10-15 kg/ha of *P. aquatica* or *P. truncata* with 20-30 kg/ha of *Hedysarum coronarium* in lines spaced 30-40 cm apart ;
- Morocco 3-5 kg/ha (Giscard, 1961),
12-16 kg/ha (Villax, 1963),
12-25 kg/ha (Ionesco et al., 1969) of *P. aquatica* or *P. aquatica* var *stenoptera* in lines spaced 50-70 cm apart (60-80 cm apart for *P. aquatica* var *stenoptera*) ; depth of sowing 1-2.5 cm, and 8-12 kg/ha of *P. arundinacea* spaced 70-100 cm apart, depth of sowing 1-2 cm ;
- Algeria 10 kg/ha for *P. aquatica*, *P. truncata* (Fig. 7) and *P. coerulescens* (Gallacher, 1972).
- Cyprus 2-4 kg/ha of *P. aquatica* or *P. aquatica* var *stenoptera* with 4 kg/ha of *Medicago truncatula* in lines spaced 30-70 cm apart.

The low seed rates used for *P. aquatica* and *P. aquatica* var *stenoptera* in Cyprus are similar to those used for the variety "Sirocco" in New South Wales, Australia where 1.1-2.2 kg/ha are seeded in mixture with 1.1-2.2 kg/ha of *Medicago sativa* and 3.3-4.4 kg/ha of *Trifolium subterraneum* or *Medicago truncatula* (Meakins, 1973).

Seed germination :

The germination percentage of the seeds of *P. aquatica* and *P. aquatica* var *stenoptera* seldom exceeds 60 % (de Brichambaut, 1952) in Morocco and the seeds germinate slowly. In contrast the seeds of *P. arundinacea* in Morocco exhibit a germination percentage of 70-80 % and germinate readily.

Weed control :

In the first year of establishment Villax (1963) recommends weeding between the lines of seeded *P. aquatica*, *P. aquatica* and *P. arundinacea* depending on the need ; this may be especially necessary for *P. arundinacea* because the young plants establish slowly.

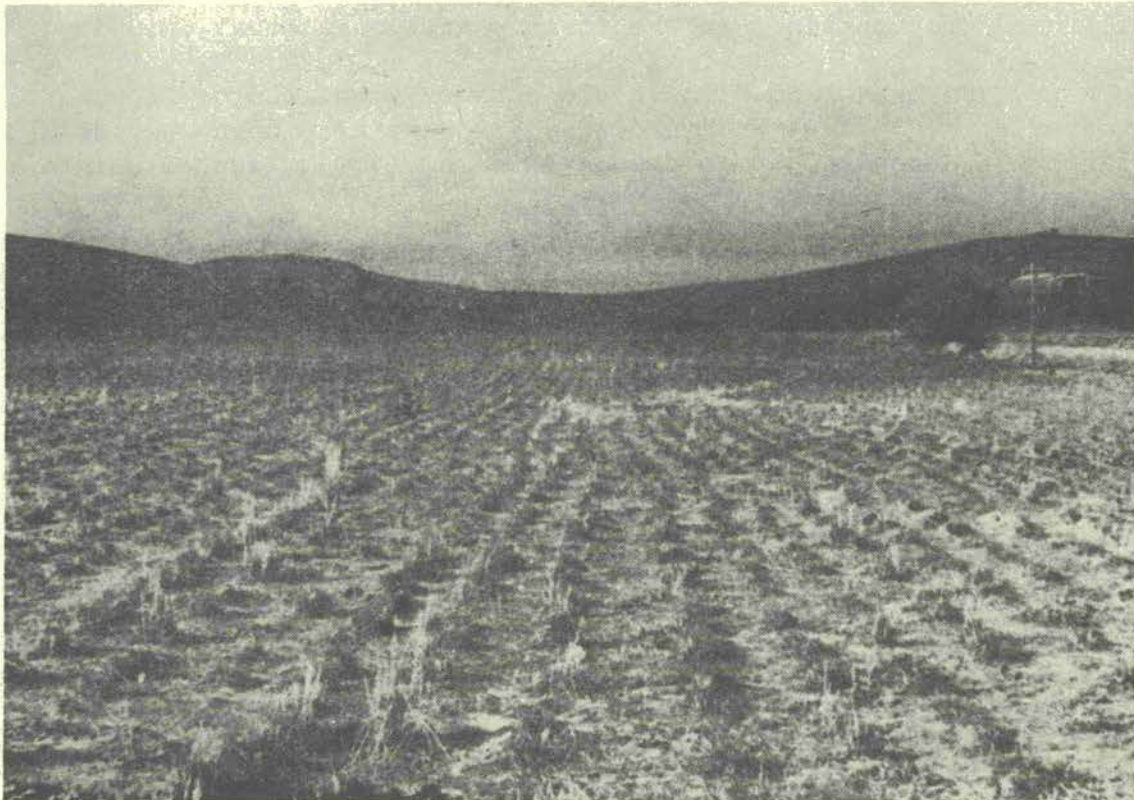


Fig. 7

A dryland stand of *Phalaris truncata*
established for fodder and seed production
in the high plateaux zone

(After Fodder crops and pasture lands, Algeria, 1972, FAO, Rome, p. 51, fig.14)

Vegetative propagation :

P. aquatica, *P. aquatica* var *stenoptera*, *P. arundinacea*, *P. coerulea* and *P. truncata* can also be established vegetatively using cuttings or seedlings. In Morocco transplanting is done early in the autumn at the beginning of the rainy season when the soil is moist at an interrow and within row spacing of 40-60 cm for *P. aquatica*, 50-70 cm for *P. aquatica* var *stenoptera* and 50 cm for *P. coerulea* ; in Cyprus the extra cost of establishing *P. aquatica* and *P. aquatica* var *stenoptera* cuttings is offset by the value of the small seed crop obtained in the first year (Jones et al., 1958).

In Israel four month old nursery seedlings of *P. aquatica*, *P. arundinacea*, *P. coerulea* and *P. truncata* have also been successfully transplanted on a sandy loam in a desert valley (100 mm annual rainfall) under run off farming conditions. (Tadmor et al.).

On a nursery scale *P. aquatica* has also been successfully established by cuttings at a 50 cm interrow and between row spacing in the sub-steppic zone of Iran (1,960 m elevation, 320-350 mm annual rainfall).

Fertilizer application :

Fertilizers have been applied in practice to *P. aquatica* in Cyprus (+450 mm rainfall zone) where 188 kg/ha of single superphosphate (23 % P_2O_5) and 316 kg/ha of sulphate of ammonia (21 % N) have been applied at seeding followed in subsequent years by 375 kg/ha of sulphate of ammonia (21 %) (Jones et al., 1958).

In Tunisia for *P. aquatica* and *P. truncata* and in Morocco for *P. aquatica* the following rates of fertilizer are recommended (Le Houerou, 1965, Le Houérou and Froment, 1969, Ionesco et al., 1969) :

Tunisia

80-100 kg/ha P_2O_5 : 1st and 2nd year (autumn)
5-15 kg/ha N at seeding
20 kg/ha N after seeding
10-20 kg/ha N end of November
15-20 kg/ha N end of February

Morocco

<u>1st year</u>	<u>2nd year</u>
120-180 kg/ha P_2O_5	80-120 kg/ha P_2O_5
80-120 kg/ha K_2O mixed with the soil before sowing	60-80 kg/ha K_2O in the autumn
80-120 kg/ha N (40 kg/ha N before sowing and 20-30 kg/ha N after each cut)	80-100 kg/ha N (40 kg/ha at the beginning of autumn and 20-30 kg/ha after each cut)

13.11. Forage Value

Palatability :

P. aquatica, *P. aquatica* var *stenoptera*, *P. arundinacea*, *P. coerulescens* and *P. truncata* are palatable to all classes of livestock providing they are grazed in the vegetative stage before the stems become too fibrous. In Morocco Giscard (1972) records that *P. aquatica* along with *Ehrharta calycina* were the most palatable to sheep among 15 grass species tested. In the sub-steppic zone of Iran *P. aquatica* in palatability tests with sheep was very well grazed in the vegetative, boot and flowering stages but poorly grazed in the seed production stage (Tech. Rep. No. 1, AGP:IRA10, 1970).

However in the USA lack of palatability is frequently cited (Heath et al., 1973) for *P. arundinacea* and forage intake by sheep has been shown to vary between palatable and unpalatable clones in trials (O'Donovan et al., 1967).

Toxic alkaloids :

Palatability of *P. arundinacea* in the USA has also been linked with the presence of toxic alkaloids in the plant tissues. For instance low intake of *P. arundinacea* forage by grazing steers has been accompanied by rough haircoat and profuse watering of the eyes. (Van Arsdell et al., 1954).

The presence of toxic alkaloids in the plant tissues of *P. aquatica*, which act adversely on the nervous system, can also cause "phalaris" staggers in livestock. Although not yet observed in the Mediterranean region sheep develop "phalaris" staggers in parts of Australia. This condition can be remedied by dosing the sheep with cobalt pellets. The phenomena of "phalaris" staggers even in Australia seems fairly rare, but is more common when grazing fresh summer, autumn or winter re-growth, which has followed a dry spell or has been checked by drought or frost (Meakins, 1974); cattle are more resistant to "Phalaris" poisoning than sheep (Healey, 1967).

Nutritive value :

The forage of *P. aquatica* is nutritious and in India is reported (Narayan and Dabadghao, 1972) to contain 13 percent crude protein on a dry basis.

In Morocco Ionesco et al. (1969) have recorded a forage value for *P. aquatica* of 0.15 forage units, 12 g of digestible protein per kilo of fresh material and 20 % dry matter in the green state and 0.40 forage units, 41 g of digestible protein per kilo of fresh material and 93 % dry matter in the form of hay.

In Tunisia and Morocco the following chemical composition data is also reported (Corriols, 1965, Foury, 1956, Villax, 1963) for *P. aquatica* and *P. aquatica* var *stenoptera* :

Tunisia : *P. aquatica*

Variety	Percentage Digestible Products						
	Date harvest	Protein	Fats	Cellulose	Non-N extract	Metabolizable energy kg/green matter	Forage units kg/green matter
No. 505 from Australia	28.4.56	1.76	0.46	6.21	1.08	480 c	0.13

Morocco : *P. aquatica*

	Percentage composition					Ash
	Water	Protein	Fats	Carbohydrates Soluble	Fibre	
Green forage	80	1.8	0.7	11.3	4.7	1.5
Hay	20	7.4	2.6	45.1	18.9	6.0

	Water	Ash	Protein	Non-N extract	Fats	Cellulose
2.5.50						
Green matter	71.00	2.17	2.67	16.36	0.94	6.86
Dry matter	0	7.50	9.24	56.32	3.27	23.67
6.6.50						
Green matter	63.00	2.33	2.14	21.77	0.80	9.96
Dry matter	0	6.31	5.79	56.62	2.17	26.91
16.1.51						
Green matter	83.51	2.11	2.20	6.51	0.70	4.97
Dry matter	0	12.82	13.04	39.39	4.26	30.49
8.2.51						
Green matter	85.48	1.77	3.53	5.71	0.65	2.86
Dry matter	0	12.19	24.32	39.24	4.50	19.75
3.11.52						
Green matter	58.16	7.32	4.68	18.30	1.19	10.35
Dry matter	0	17.51	11.20	43.72	2.86	24.71
5.3.53						
Green matter	79.97	2.86	2.92	9.05	0.89	4.31
Dry matter	0	14.29	14.62	45.09	4.48	21.52

Percentage Dry Matter					
	CaO	MgO	P ₂ O ₅	K ₂ O	Na ₂ O
3.11.52	0.961	0.010	1.031	3.895	0.003
5.3.53	0.709	0.008	0.764	2.108	0.122
2.4.53	0.608	0.010	0.506	2.997	0.516

P. aquatica var *stenoptera*

Percentage Composition						
	Water	Ash	Protein	Non-N extract	Fats	Cell.
6.2.51						
Green matter	87.87	1.59	3.02	4.64	0.64	2.24
Dry matter	0	13.12	24.95	38.15	5.31	18.47
11.3.51						
Green matter	79.75	3.19	2.73	9.60	0.45	4.28
Dry matter	0	15.73	13.50	47.44	2.22	21.11

Cenchi and Sarti (1971) also report the following chemical composition data and feeding value for *P. truncata* in autumn and spring in Central Italy :

	<u>Spring</u>		<u>Autumn</u>	
	Green matter %	Dry matter %	Green matter %	Dry matter %
Water	82.21	--	79.65	--
Dry matter	17.79	100.00	20.35	100.00
Organic matter	16.21	91.11	17.78	87.35
Crude protein	3.01	16.90	4.11	20.20
Pure protein	2.23	12.54	3.03	14.87
Ether extract	0.57	3.21	0.79	3.90
Non-N extract	7.48	42.05	8.91	43.76
Crude fibre	5.15	28.95	3.97	19.49
Ash	1.58	8.89	2.57	12.65
Lignin	0.62	3.48	0.59	2.89
Calcium	0.08	0.46	0.17	0.86
Phosphorous	0.04	0.24	0.06	0.28
Silica	0.43	2.43	0.87	4.26

Carotene Content			
Spring		Autumn	
Green state mg/kg	Dry state mg/kg	Green state mg/kg	Dry state mg/kg
54	316.81	70	346.48
Forage Units (equivalent to 1 kg of Oat Grain)			
Spring		Autumn	
15.12		17.19	

Giuliani (1974) has noted that *P. coerulescens* in the dry state in south Morocco has on a fresh matter basis a moderate protein level of 4.55 %.

Digestibility :

In the USA a broad-sense variability of 51-80 % of digestibility has been recorded in clones of *P. arundinacea* reserved for autumn grazing indicating the possibility of breeding for improved digestibility in the species (Carlson et al., 1969).

In central Italy Cenchi and Sarti (1971) also report for *P. truncata* the following percentage coefficients of digestibility in the autumn and spring in trials with sheep :

	Average Percentage Coefficient of Digestibility	
	Spring	Autumn
Dry matter	76.42	72.18
Organic matter	78.31	78.31
Crude protein	81.44	81.52
Pure protein	76.49	76.05
Ether extract	69.86	69.22
Non-N extract	78.06	82.37
Crude fibre	77.78	69.69
Ash	57.10	29.88
Lignin	34.20	45.00

13.12. Forage and Seed Production

Forage yields :

In the littoral zone of Tunisia Corriols (1965) reports the following forage units yields/ha for *P. aquatica*, *P. coerulescens* and *P. truncata* in dryland test plantings :

Varieties	First year	Second year	Third year
<i>P. aquatica</i>	3,000	4,000-5,000	4,500
<i>P. coerulescens</i>	2,300	4,000	4,000
<i>P. truncata</i>	--	6,600	--

Corriols (1965) also records the following forage production data for three varieties of *P. aquatica*, two varieties of *P. aquatica* var *stenoptera*, two varieties of *P. coerulescens* and one variety of *P. truncata* :

Varieties	1955-56 (664.7 mm rainfall) Second year				1956-57 (492.2 mm rainfall) Third year			
	Green matter kg/ha	Dry matter kg/ha	Dig. protein kg/ha	Forage units	Green matter kg/ha	Dry matter kg/ha	Dig. protein kg/ha	Forage units
<i>P. aquatica</i> Palestine	38,885	8,943	621	5,055	29,108	6,694	494	3,784
Australia (Victoria)	34,441	7,921	585	4,477	34,107	7,844	579	4,433
Cyprus (ex Australia)	31,552	7,256	536	4,101	20,109	4,625	341	2,614
<i>P. aquatica</i> var <i>stenoptera</i>								
Morocco	31,330	7,205	532	4,072	35,774	8,228	608	4,650
Cyprus (ex USA)	29,997	6,899	509	3,899	18,442	4,241	313	2,397
<i>P. coerulescens</i>								
Tunisia (T1)	31,108	7,154	528	4,044	38,118	8,767	648	4,955
Tunisia (T2)	29,252	6,727	947	3,802	27,197	6,255	462	3,535
<i>P. truncata</i> Tunisia (Beja)	--	--	--	--	51,217	11,779	870	6,658

In the littoral zone of Morocco (500-600 mm annual rainfall) under dryland conditions green forage yields varying from 25,000-50,000 kg/ha and hay yields of 6,000-12,000 kg/ha have been reported for *P. aquatica* (Ionesco et al., 1969, Villax, 1963).

In the high plateaux zone of Algeria (450-600 mm annual rainfall) green forage yields in experimental dryland plantings varying from 14,600-20,600 kg/ha for *P. aquatica*, 26,800-46,300 kg/ha for *P. coerulescens* and 12,500-42,600 kg/ha for *P. truncata* (30,150-46,300 kg/ha for a mixture of *P. truncata* and *Hedysarum coronarium*) have been reported (Maignan, 1970, Gallacher, 1972) ; in one year (seasonal rainfall September-August : 614.8 mm) an application of 90 kg/ha N (ammonium nitrate 33.5 % N) produced a green forage yield of 58,700 kg/ha for *P. truncata* compared to a yield of 35,870 kg/ha when unfertilized.

In the southern desert of Israel (100 mm annual rainfall) under run-off farming conditions in a desert valley transplanted *P. aquatica* averaged 5,000 kg/ha DM over a 6 year period ; corresponding yields for *P. arundinacea* were 3,000 kg/ha DM, for *P. coerulescens* 1,200 kg/ha DM and for *P. truncata* 900 kg/ha DM (Tadmor et al., 1970).

Seed yields :

Seed production of *Phalaris* spp. varies according to climate and soil conditions but in the littoral zone of Morocco seed yields varying from 100-200 kg/ha for *P. aquatica* and 100-300 kg/ha for *P. arundinacea* have been reported (Villax, 1963).

Maignan (1970) reports an experimental seed yield of 138 kg/ha for *P. truncata* in the high plateaux zone of Algeria.

Seed harvesting :

Seed harvesting for most of the above mentioned *Phalaris* spp. requires careful timing and should coincide with the stage when the fertile flowers at the base of the panicle do not detach easily from the glumes.

In Algeria Gallacher (1972) records that seed of *P. truncata* is difficult to harvest by normal methods as the grain ripens in stages. The plants may be cut with a binder then stored in a dry place for threshing when the bulk of the grains are ripe, but there is still a risk of collecting a percentage of green seeds with a very low germination percentage. The most economical and easiest method is to fix a canvas or light iron trough in front of a tractor or Land Rover/pickup, and drive through the crop with sufficient speed so that the ripe seed is shaken into the trough ; several passages can be made at 3-6 day intervals as more seeds ripen.

In the USA most seed of *P. arundinacea* is harvested with combines. About 40-50 % of the seed should be dark grey or brown before direct combining

begins. The seed usually must be dried to prevent heating, which can be accomplished by spreading on the floor of a well-ventilated building with frequent mixing for several days (Heath et al., 1973).

13.13. Utilization

Time of use and establishment :

It is generally preferable not to graze *P. aquatica*, *P. aquatica* var *stenoptera*, *P. arundinacea* and *P. coerulescens* in the first year to allow the young plants to establish a firm root system.

Grazing management :

In Australia Meakins (1974) recommends that cattle should be used to graze newly established stands of *P. aquatica* rather than sheep as they will not graze the pasture so closely. Once established *Phalaris* pastures can be heavily grazed to keep the pasture height down to 60 cm ; in the USA it is recommended to graze *P. arundinacea* pasture when it ranges in height from 15-60 cm (Heath et al., 1973).

Number of fodder cuts and grazings :

Villax (1963) states that in the Mediterranean region it is possible to get one cut from *P. aquatica* and *P. aquatica* var *stenoptera* at the end of February or in March and thereafter to obtain two re-growth cuts. For *P. arundinacea* Villax (1963) recommends cutting at the formation of the panicles in the first and second year for direct feeding, silage or hay ; this can in the second year be followed by several grazings to keep the pasture short and palatable.

In Tunisia Le Houerou (1965) and Le Houérou and Froment (1969) recommend taking 1-2 cuts from *P. truncata* in the first year, and in the second year and succeeding years taking 2-3 cuts or obtaining 4-5 rotational grazings.

Pasture longevity :

Well established pastures of *P. aquatica* and *P. aquatica* var *stenoptera* stand up to grazing and trampling well and in Morocco dryland stands have lasted 10-15 years (Villax, 1963).

Soil conservation :

P. arundinacea is considered to be a valuable species for erosion control because of its vigorous rhizome development. In the USA it is much used for gully control and for the maintenance of grassed waterways, stream channel banks and edges of farm ponds (Heath et al., 1973).

Further evaluation :

More attention needs to be paid to the collection and evaluation of drought resistant ecotypes of *Phalaris* spp. in North Africa and the Near East, particularly for *P. aquatica* and *P. truncata* which show considerable promising for seeding in semi-arid low rainfall areas.

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TECHNICAL DATA

SHEET No 14

GRAMINEAE (= POACEAE)

Poa spp.

14.1. Species

Among the bulbous *Poa* spp. the two most important and widespread in the arid and semi-arid regions of North Africa and the Near and Middle East are *P. bulbosa* L. and *P. sinaica* Steud.

In the Near East Fenibrun (1940) has distinguished four bulbous *Poa* spp. restricted to specific geographical regions : *P. bulbosa* and *P. hackeli* to the Mediterranean part of Palestine, *P. sinaica* to the steppes of Palestine and adjacent countries, and *P. eigii* Fenibr. which is considered endemic to the Judean desert and northern Negev. However Heyn (1962) prefers to regard all four *Poa* spp. as a single agamic complex of *P. bulbosa*.

Two further bulbous *Poa* spp. occur in Iraq, *P. timoleontis* Heldr ex Boiss., recorded by Bor and Guest, which also occurs in Palestine and elsewhere in the Near East, and *P. bulbillifera* recorded by Chrtek and Hadac (1969).

14.2. Common Names

- <i>P. bulbosa</i>	English	Bulbous Meadow Grass (Syria) ; Bulbous Poa, Bluegrass (USA).
	Arabic	El Naw rah El Waloud (Syria) ; Quba (Iraq) ; Nazaa (Jordan).
- <i>P. sinaica</i>	English	Sinai Meadow Grass, Bluegrass (USA).
	Arabic	Quba, Nizza (Iraq) ; Ausay'ah, Quba (Saudi Arabia) ; Anse'a, Sabalz alu el-Hossein (Egypt (UAR) ; Neza, Ansay'ah (Jordan).

14.3. Brief Description

- *P. bulbosa* is a perennial grass with tufted culms reaching a height of 50 cm and having swollen basal sheaths and a bulbil base with also elliptical oblong spikelets almost always exhibiting proliferation or vivipary (Fig. 1) ;

- *P. sinaica* is a tufted perennial grass with numerous leaf shoots surrounded by white, scarious sheaths at the base and having slender, stiff glossy culms reaching a height of 50 cm (Fig. 2) ;

Bor and Guest (1968) mention that *P. sinaica* is extremely similar to *P. bulbosa* and they also point out that the only really reliable differences between the two species are (a) the length of the lemma which is 2-3 mm for

P. bulbosa and 3.5-4 mm for *P. sinaica* and (b) the presence of strands of wool on the culms of *P. bulbosa* before it proliferates which is not present in the case of *P. sinaica* ;

- *P. timoleontis* is a perennial grass with tufted culms attaining a height of 20 cm and more or less pear-shaped bulbils and commonly exhibiting proliferation of the spikelets. In this species the milky-white ligule and margins of the proliferating lemmas are diagnostic features (Fig. 3).

14.4. Varieties

Botanical varieties :

In North Africa Maire (1955) mentions the following subspecies and forms for *P. bulbosa* :

- ssp. *eu-bulbosa* Hayek (= *P. bulbosa* L. sensu stricto)
type species with stems attaining a height of 50 cm ;
present in Cyrenaica, Tunisia, Algeria and Morocco ;
- f. *normalis* Maire et Weiller
with abundant membranous tomentum at the base of the flowers ;
present throughout the region ;
- f. *briziformis* Trabut in B. et T. (= *P. psammophila* Schur,
P. bulbosa var. *psammophila* (Schur) Asch. et Gr.)
with fairly abundant membranous tomentum sometimes naked ;
present in Algeria ;
- f. *vivipara* Koel. (= *P. crispa* Thuill.)
with viviparous spikelets ; present throughout the region
often in mixture with f. *normalis* also recorded in Iran
by Parsa (1950), and in Iraq by Al-Rawi (1964) ;
- ssp. *concinna* (Gaud) Hayek (= *P. concinna* Gaud.)
with very short stems inferior to 15 cm ; present in
Tunisia.

Native ecotypes :

Few, if any, native ecotypes of the *Poa* spp. mentioned have been collected, except in Palestine where the morphological characters of transplants of *P. bulbosa* and *P. sinaica* collected from different habitats in the country and grown at Jerusalem were investigated (Heyn, 1962). *P. sinaica* showed the highest variability in the characters studied, while *P. bulbosa* showed intermediate values.

However in natural populations in situ the degree of existing genetic morphological variation may not be apparent and Greuter (1974) reports that in Crete *P. bulbosa* has a wide altitude range up to 2,100 m elevation without visible differentiation.

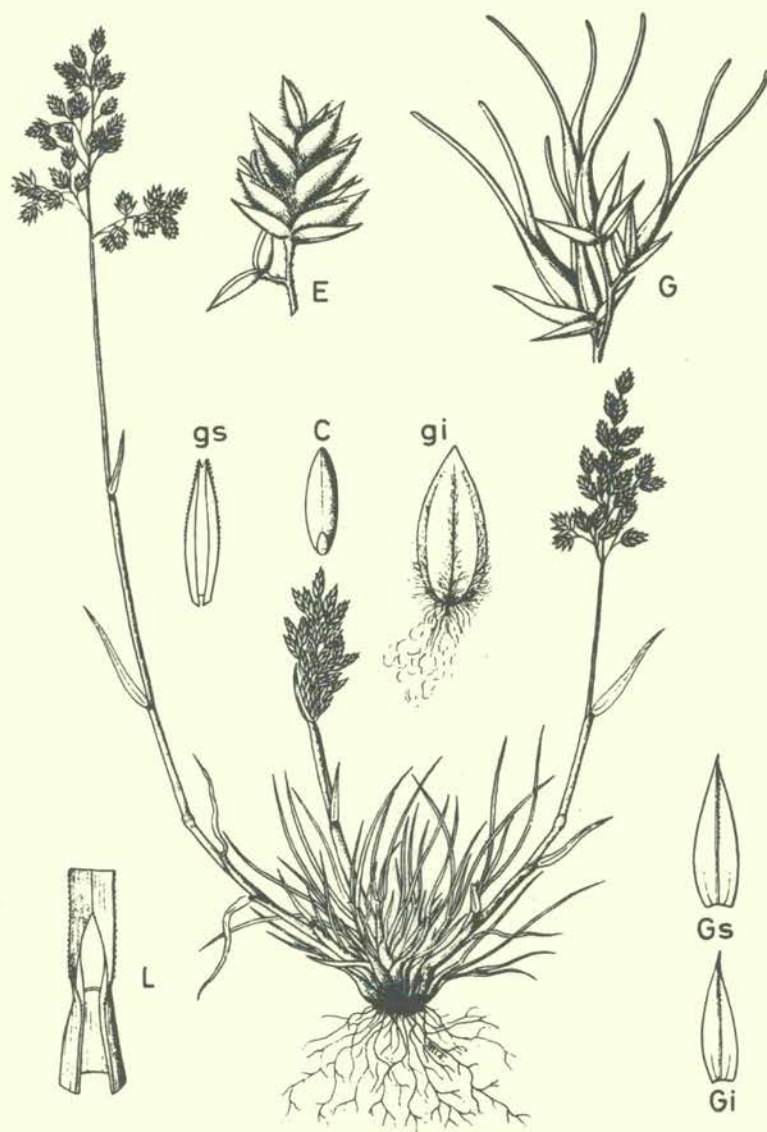


Fig. 1 - *Poa bulbosa*

Plant, x1. E. Spikelets in flower, x5. Gi. Inferior glume, x10. Gs. Superior glume, x10. gi. Inferior glumella, x10. gs. Superior glumella, x10. C. Caryopsis, x10. L. Ligule, x5. G. Group of spikelets of var. *vivipara*, x5.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas, Madrid, 1965, p. 160)

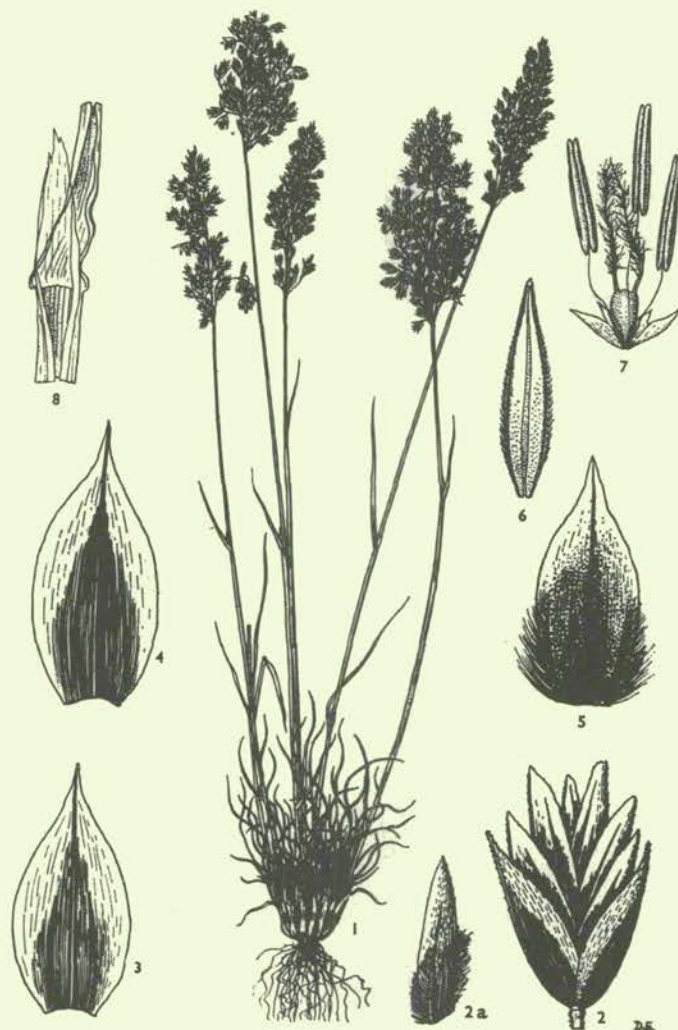


Fig. 2 - *Poa sinaica* L.

1. Habit, $\times \frac{2}{3}$. 2. Spikelet, $\times 8$. 2a. Lemma from the side, $\times 8$. 3. Lower glume, $\times 12$. 4. Upper glume, $\times 12$. 5. Lemma, $\times 12$. 6. Palea, $\times 12$. 7. Flower, $\times 12$. 8. Ligule, $\times 3$.

(After Flora of Iraq, vol. 9, 1968, p. 119, plate 40)

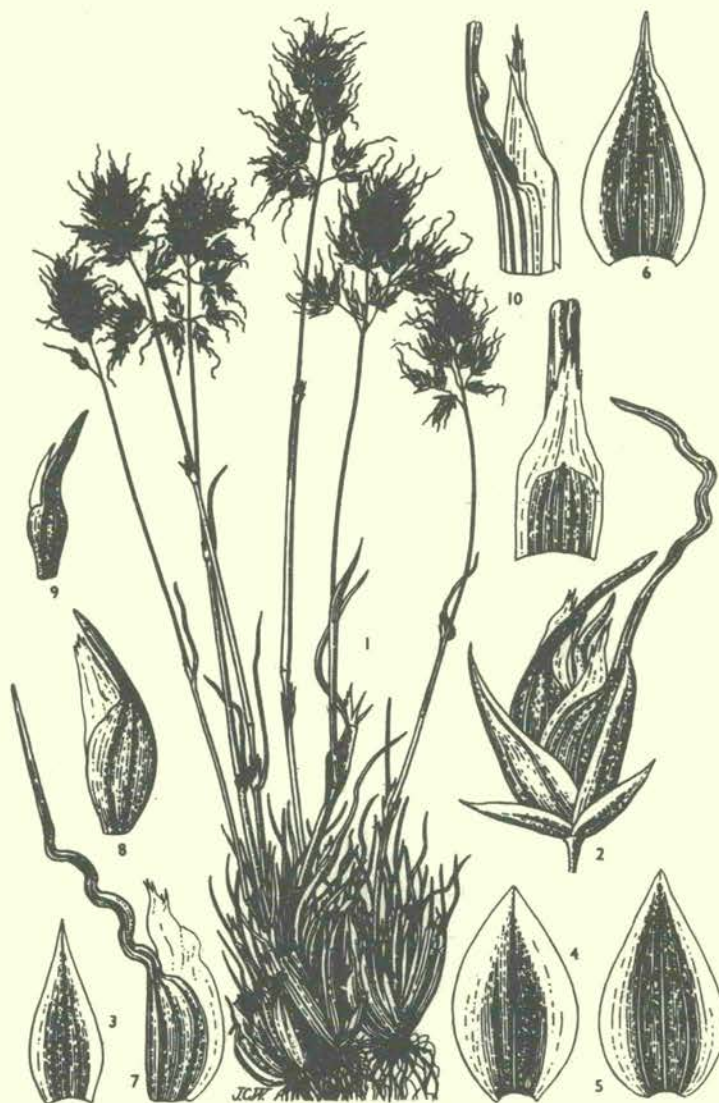


Fig. 3 - *Poa timoleontis* Heldr. ex Boiss.

1. Habit, x1. 2. Proliferating spikelet, x4. 3. Lower glume, x12.
4. Upper glume, x12. 7, 8, 9. Proliferating lemmas, x12. 10. Ligule, x4.

(After Flora of Iraq, vol. 9, 1968, p. 121, plate 41)

Nevertheless the existence of sexual apomictic reproduction that occurs side by side in populations of *P. bulbosa* and *P. sinaica* is considered a highly favourable combination and leads to the production of a pool of genetically differing plants. This pool of forms with differing genotypes is of special importance in the region where the main limiting factor - soil moisture - fluctuates greatly from year to year.

14.5. Number of Chromosomes

P. bulbosa : $2x = 14, 28, 28+1, 35, 39, 40, 42, 42+1, 45, 56, 40-58$, exhibits apomixis. Petrova (1973) also records that tetraploid ($2n = 28$) and hexaploid ($2n = 42$) forms of *P. bulbosa* var *vivipara* have been found in the Kharkov Province in the USSR. For *P. sinaica* the chromosome number is not known but both *P. bulbosa* and *P. sinaica*, according to Rechinger (1964), probably hybridize freely together where they occur in the same habitat.

14.6. Geographical Distribution

P. bulbosa is distributed in C. Europe (up to the USSR including the Crimea) and also in Cyprus, Syria, Lebanon, Palestine, Jordan, Turkey, Caucasus, Iran, Pakistan, N.W. India, C. Asia (Transcaspia to Tian Shan), N. Africa (Morocco, Algeria, Tunisia, Libya) and also introduced into the USA from Europe ;

P. sinaica is distributed in Syria, Lebanon, Palestine, Jordan, Iraq, Sinai, Egypt, Arabia, Turkey, Caucasus, Iran, Pakistan and Afghanistan ;

P. timoleontis is distributed in Syria, Lebanon, Palestine, Turkey, Iran, S. USSR (Astrakhan).

The distribution of the *P. bulbosa* complex as a whole is depicted in Fig. 4 and this distribution accords closely to its range of distribution in regard to rainfall in the cool season (October-June) which varies from less than 100mm at the southern extent of its distribution to more than 1,000 mm at its northern extremity (Fig. 5).

The distribution of both *P. bulbosa* and *P. sinaica* in Palestine and Iraq are also given in Fig. 6 and 7 and show that *P. bulbosa* is common at higher elevation in the moister zones, while *P. sinaica* is largely restricted to the dry steppe and desert to the south.

14.7. Biology and Ecology

P. bulbosa and *P. sinaica* are both cool season species that propagate themselves vegetatively and by seeds.

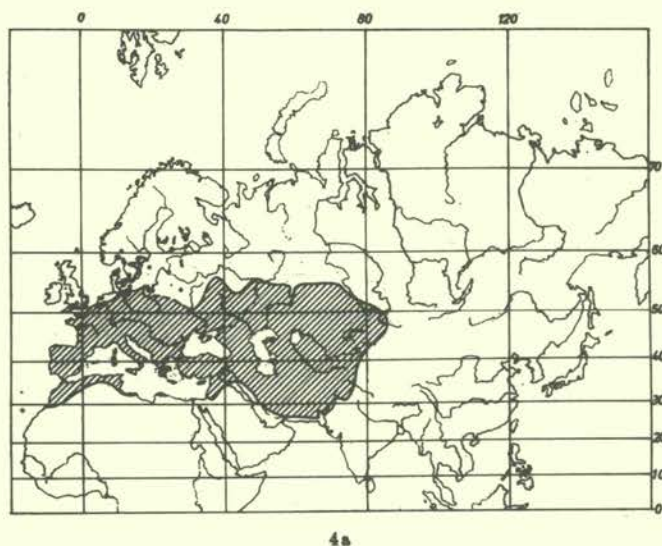


Fig. 4 - Distribution of *P. bulbosa*
(After Flöra, Jena B, 1968, Berlin, No. 4, p. 515)

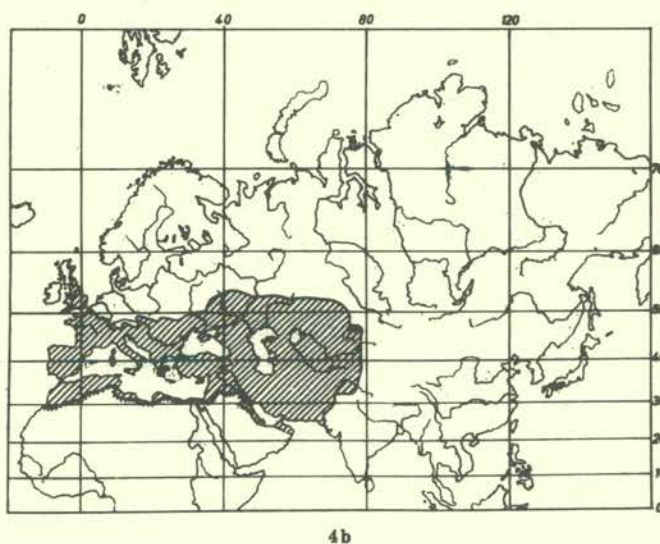


Fig. 5 - Distribution of *P. bulbosa*
in regard to cool season (October-June) rainfall
varying from less than 100 mm to more than 1000 mm
(After Flöra, Jena B, 1968, Berlin, No. 4, p. 515)

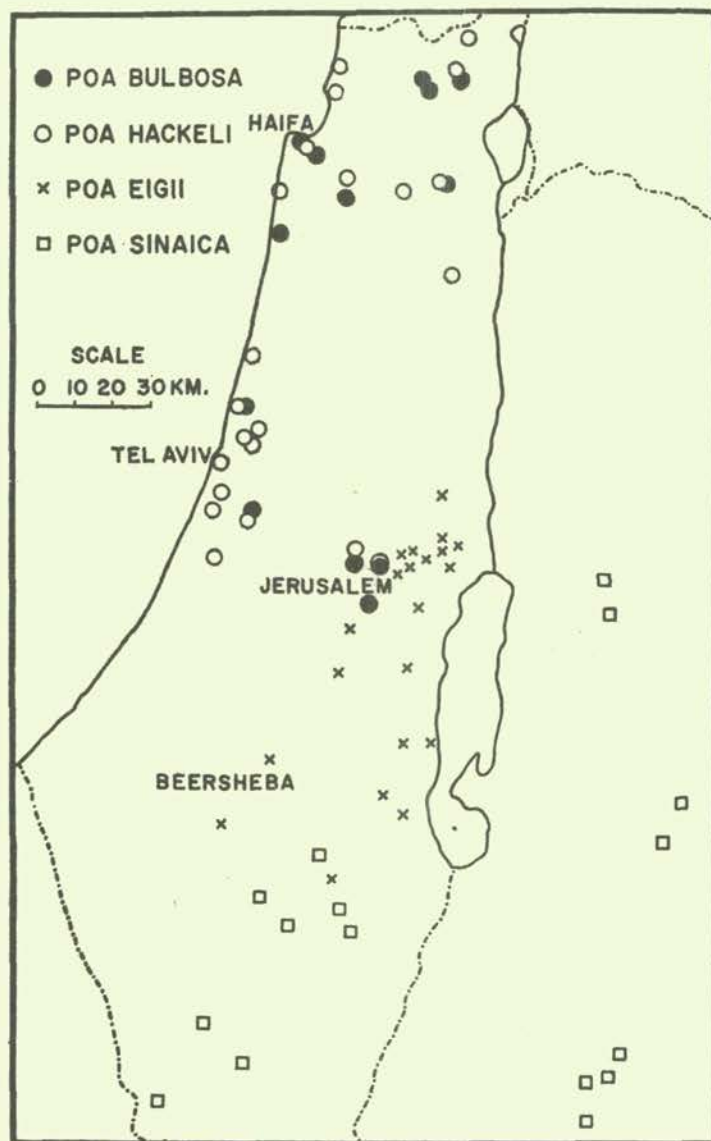


Fig. 6

Distribution of *Poa bulbosa*, *P. hackeli*,
P. eigii and *P. sinaica* in Palestine

(After Bull. Res. Coun. Isr., 11, 1962, p. 118, Fig. 1)

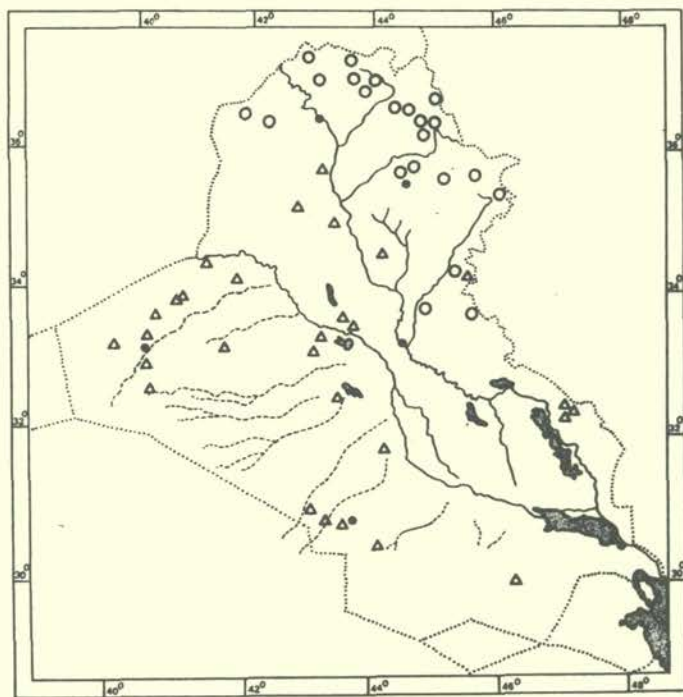


Fig. 7

Distribution of *P. bulbosa* L. (o)
and *P. sinaica* (Δ) in Iraq

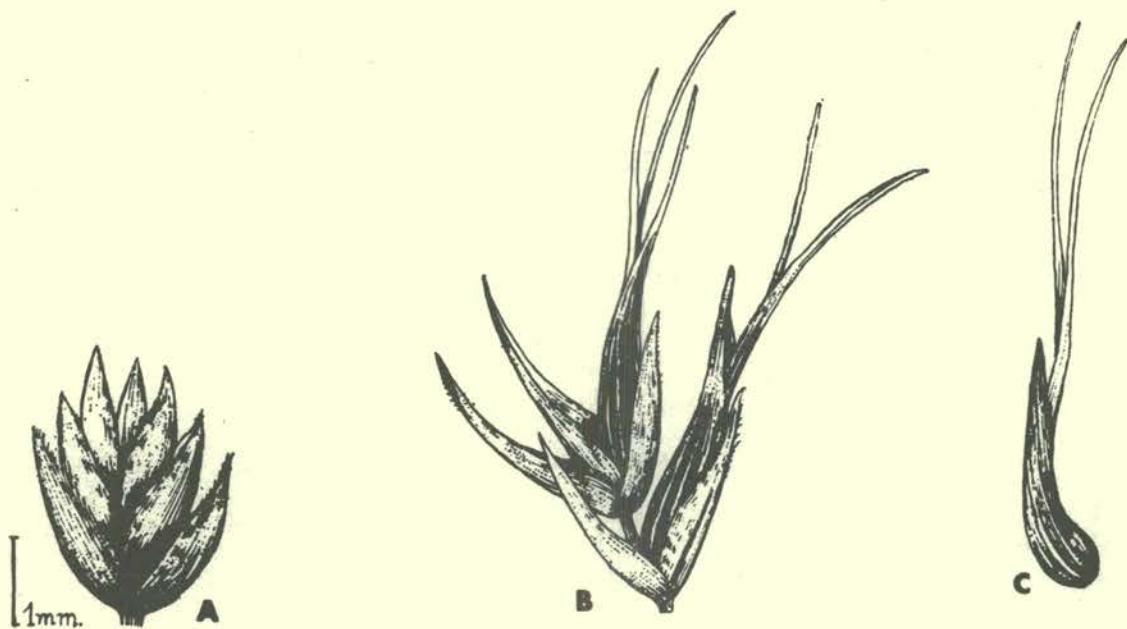
(After Flora of Iraq, vol. 9, Graminae, 1962, p. 117, map 2)

Vegetative propagation :

In Israel Heyn (1971) records that *P. bulbosa* can reproduce itself by above or below ground bulbils ; in the former case they form on the inflorescence and in the latter at the base of the plants where the roots commence.

In viviparous *P. bulbosa* the yield of bulbils is far higher than the seed yield ; 20-100 bulbils in each panicle (at least one bulbil per spikelet) have been observed (Heyn, 1971). Viviparous plants of *P. bulbosa* have inside the glumes small bulbils surrounded by sheaths instead of flowers. These bulbils are released from the mother plant and grow into new plants. This phenomenon is called vivipary or more correctly proliferation, as true vivipary refers to the germination of seeds within fruits, still attached to the mother plant.

In Fig. 8 below is depicted a normal flowering spikelet, a viviparous spikelet and a single detached inflorescence bulbil of *P. bulbosa* :



- Fig. 8 - *Poa bulbosa*

A. Flowering spikelet. B. Viviparous spikelet. C. Single detached inflorescence bulbil.

(After Bull. Res. Council. Isr., 1962, p. 122, Fig. 4)

Underground bulbils of *P. bulbosa* may be formed at different levels depending on moisture conditions. Under desert conditions bulbils of successive years are placed as a rule on the same level, while in more humid regions bulbils from successive years are separated as a rule by a distinct internode (see Fig. 9 below) :

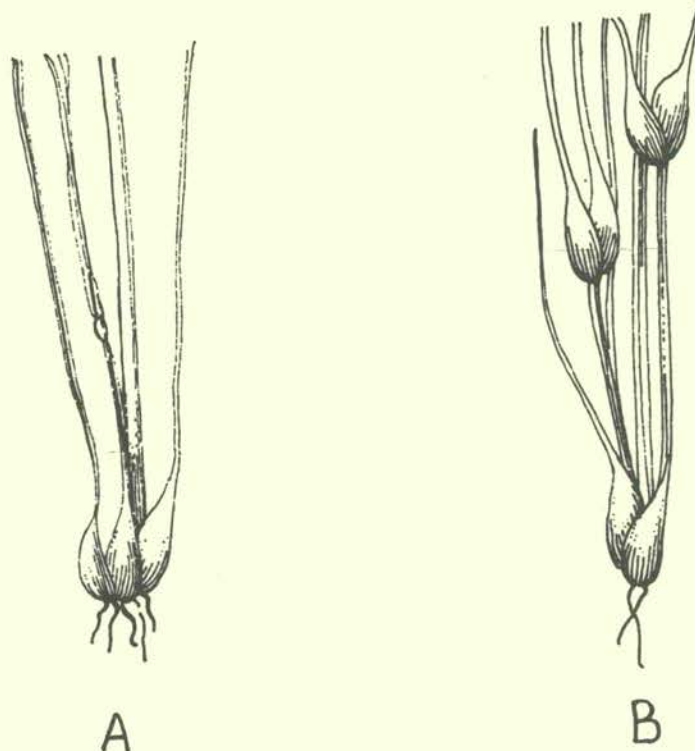


Fig. 9

Underground bulbils of *Poa* from different environments

A. *P. sinaica* (Negev, about 100 mm annual rainfall)

B. *P. bulbosa* (Jerusalem, about 500 mm annual rainfall) nat. size

(After Bull. Res. Counc. Isr., 1962, 11, p. 122, fig. 4)

Both above and below ground bulbils require a period of dormancy before sprouting when ripe. In the Samarkand Desert in southern USSR Khalilov (1966) records that when ripening panicles of *P. bulbosa* var *vivipara* were bent down (as occurs naturally after rainstorms) the bulbils sprouted, rooted, and formed a ground cover ; the ripe bulbils, however, which fall to the ground naturally do not sprout even under favourable conditions for at least 6 weeks and may remain dormant for 7-8 months.

In the USA Laude (1953) also found a period of dormancy obligatory for *P. bulbosa*, and in Israel Heyn (1971) records that above ground bulbils could not be induced by irrigation to sprout before October, while below ground bulbils sprouted in January more or less simultaneously in any single population ; however not all sprouted tufts produced culms in any given year. According to Heyn (1971) above ground bulbils in Israel do not survive for more than a year, but underground bulbils may survive for long periods if properly dessicated.

Flowering and seed characteristics :

P. bulbosa usually occurs in either viviparous or flowering forms.

As a rule in any region only one of the forms (viviparous or flowering) grows (Heyn, 1971). Little information is available on the coexistence of these forms or the possibility of change from one to the other. However in the USA Younger (1960) reports that flower-bearing, viviparous or mixed inflorescences can be obtained by applying different combinations of controlled day length and temperatures.

Heyn (1971) records that the seed yield of flowering plants of *P. bulbosa* is very low and a large number of flowering culms must be threshed to obtain even some seeds ; few field samples yielded more than one seed per panicle and the highest yield was 4.7 seeds per panicle where in most cases the number of flowers per panicle averaged 300.

In *P. bulbosa*, especially, seed-setting would appear to be irregular particularly in viviparous forms and Monokhov and Dmitrieva (1973) report that in the USSR the anthers of *P. bulbosa* var *vivipara* are often degenerate and frequently contain no pollen.

In Israel Heyn (1971) also records that the seeds of *P. bulbosa* ripen in May and that untreated seeds only germinate after a prolonged period of dormancy and in no case before November. Cold treatment of seeds (one week at 2°C) greatly enhanced germination and such seeds in the laboratory germinated in September and in some cases reached about 90 percent of germination. Although no exact data are available Heyn (1971) states that in Israel seeds of *P. bulbosa* remain viable for several years.

Growth and development :

P. bulbosa and *P. sinaica* both exhibit good autumn growth in steppe and desert areas in North Africa, the Near and Middle East after light precipitations of only 10-20 mm. New leaf growth sprouts from the base of the plants and they remain green throughout the winter period ; Gabid-Zashvili (1971) records photosynthesis in winter green *P. bulbosa* var *vivipera* at temperatures of -4 to +4°C.

In dryland introduction plantings in the USA good winter vegetative growth has also been noted for *P. bulbosa*, while in the arid zones of the USSR maximum growth and photosynthesis intensity for *P. bulbosa* occurred at temperatures of 13-22°C.

Both *P. bulbosa* and *P. sinaica* have a short growth period which reaches its maximum in the spring. Spring growth is characterized by rapid stem elongation and flowering which is completed by the onset of hot weather usually in May.

The higher temperatures of summer reduce the physiological activity of both *P. bulbosa* and *P. sinaica* and lead to dormancy. However Prokofiev et al. (1969) report that for *P. bulbosa* this dormancy is not complete and during the months of dormancy some translocation of various components and the growths of buds and their differentiation takes place.

Both *P. bulbosa* and *P. sinaica* exhibit strong resistance to drought and overgrazing due to the fact that they are able to maintain themselves under several different forms of reproduction each with a different selection value under changing conditions.

Climate and soils :

Both *P. bulbosa* and *P. sinaica* are well adapted to seeding in steppe and desert areas with less than 300 mm annual rainfall and are also adapted to cold winter temperatures of 0°C or less. Both *P. bulbosa* and *P. sinaica* are commonly found on sandy-gravelly calcareous soils in desert/steppe regions, while at higher elevation and in moister conditions *P. bulbosa* is found on a wide variety of soils including those that are rocky.

Ecological characteristics :

Maire (1955) records that *P. bulbosa* occurs in forest clearings, pastures and steppes from the littoral up to 2,900 m elevation in the humid, semi-arid and arid regions of N. Africa. Le Houerou (1969) records *P. bulbosa* as forming a major association with *Artemisia herba-alba* in the steppe of Tunisia receiving 300-400 mm annual rainfall ; this vegetation is common elsewhere in the region notably in the steppic areas of Libya, Egypt, Syria, Lebanon, Iraq, Iran and Afghanistan. In Turkey Bakir (1970) mentions *P. bulbosa* var *vivipara* as being dormant in the vegetation cover of Central Anatolia.

P. sinaica on the other hand is found in the drier desert-steppe areas of the region with less than 300 mm annual rainfall. It is common in southern Iraq on rocky calcareous outcrops (Monokhov, 1972) and occurs widely in pure stands on sandy-gravel plains in Saudi Arabia close to Kuwait (Vezey-Fitzgerald, 1955).

Both *P. bulbosa* and *P. sinaica* are also found commonly growing in association with *Carex stenophylla*, and where they constitute the dominant vegetation cover, they often form the last line of defence against soil erosion

14.8. Cultivation Techniques

Time of seeding :

In the Samarkand desert in the southern USSR the best time of seeding *P. bulbosa* var *vivipara* has proved to be from December to mid-February. Autumn seeding of *P. bulbosa* is also the preferred time of planting in Nevada in the USA.

Land preparation :

In the Samarkand desert land preparation has involved ploughing depleted grasslands in 20-50 m wide bands to a depth of 18-20 cm. Ploughing and normal cultivation practices have also been used in preparation for seeding in Nevada in the USA.

Intercultivation with grasses and shrubs :

In the Samarkand desert *P. bulbosa* var *vivipara* has been seeded in mixture with the perennial shrubs *Haloxylon aphyllum* and *Kochia prostrata*, both of which have been seeded successfully in the steppic region of N. Iran. In Nevada (USA) *P. bulbosa* has also been seeded in mixture with the perennial grasses *Agropyron cristatum* and *A. desertorum*.

Seed rate and method of sowing :

In the Samarkand desert (USSR) and in Nevada(USA) the following seed rates have been used in shrub and grass mixtures :

<u>Samarkand desert</u>	<i>P. bulbosa</i> var <i>vivipara</i>	1 kg/ha of seeds	} drilled
	+		
	<i>H. aphyllum</i>	5 kg/ha of seeds	
	+		
	<i>K. prostrata</i>	5 kg/ha of seeds	
<u>Nevada</u>	<i>P. bulbosa</i>	3 kg/ha of seeds	} drilled
	+		
	<i>A. cristatum</i>	3 kg/ha of seeds	
	+		
	<i>A. desertorum</i>	5 kg/ha of seeds	

Seeding success :

Seeding of *P. bulbosa* var *vivipara* in the Samarkand desert has been successful in mixture with shrubs in areas with annual rainfall varying from 110-225 mm and has led to fairly rapid development of productive grasslands in 2-4 years.

14.9. Forage Value

Palatability :

Both *P. bulbosa* and *P. sinaica* are very palatable to livestock particularly sheep and goats. In Morocco Villax (1963) records that livestock greatly appreciate *P. bulbosa* and Allred (1968) records *P. sinaica* as one of the most important and palatable range grasses in Saudi Arabia.

Nutritive value :

In Iraq Kaul et al. (1971) record the following chemical composition for leaves of *P. bulbosa* in the vegetative stage :

Percentage Chemical Composition : Dry Basis					
Date Sampled	Crude Protein	Digestible Crude Protein	Crude Fibre	Fat	Ash
19.11.69	20.63	15.30	19.20	4.4	14.59

In Syria Clemens (1968) also gives the following chemical composition data for *P. bulbosa* at three different stages of growth :

Percentage Chemical Composition : Dry Basis				
Phenological stage of growth	DM content	Crude Protein	Crude Fibre	Non-Fatty extract
Before flowering	34.2	6.2	6.0	13.6
During flowering	40.1	6.3	9.8	22.2
Seed ripeness	86.3	6.7	22.3	49.2

In the Tashkent desert in the USSR Azarova (1969) also reports that winter growing *P. bulbosa* had 20.9 % sucrose in the dry matter and that the starch content declined towards the end of the season to 0.2-0.5 %. In the USSR Tovmaysan (1973) also reports that bulbils of *P. bulbosa* var *vivipara* contain larger amounts of important amino acids than either the stems or leaves.

14.10. Forage and Seed Production :

Forage yields :

Little real data is available on forage yields of native or seeded stands of *P. bulbosa* or *P. sinaica*. In the foothills of the Karakum desert in the USSR Nechaeva (1974) reports average yields of 450 kg/ha DM for native *P. bulbosa*/*Carex pachystylis* grassland.

In Iraq Kernick (1977, loc. cit.) reports average spring forage yields of 100-200 kg/ha DM for *P. bulbosa* and ephemerals at Hatra in the Jezirah desert in a year with 350 mm annual rainfall.

Seed yields :

No data is available on seed yields of either *P. bulbosa* or *P. sinaica*. However seed of *P. bulbosa* var *vivipara* has been multiplied for dryland seeding in the Samarkand desert in the USSR and also for test plantings under dryland conditions in the USA.

14.11. Utilization

Type of use :

Both *P. bulbosa* and *P. sinaica* provide excellent early grazing in the autumn, winter and spring in desert/steppe/foothill regions and experience gained in the USSR and USA with *P. bulbosa* suggests that both *P. bulbosa* and *P. sinaica* can be successfully re-seeded in similar situations in North Africa, the Near and Middle East.

Carrying capacity of pastures :

In Nevada (USA) Robertson et al. (1970) report that re-seeded pasture composed of *P. bulbosa* and *Agropyron* spp. could be stocked with cattle in the spring at close to 1.75 ha/animal unit with a daily gain approaching 1 kg/head.

Soil conservation value :

Because of their fine network of surface roots and strong resistance to overgrazing both *P. bulbosa* and *P. sinaica* are very valuable species for preventing soil erosion in desert/steppe regions.

Further evaluation :

It would be worthwhile giving attention to the collection of native ecotypes of *P. bulbosa* and *P. sinaica* in the region so as to exploit fully the potential of the genetic germplasm that exists. Selection amongst the material collected is likely to prove rewarding and to lead to the development of more productive forms for both species.

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TECHNICAL DATA

SHEET No 15

GRAMINEAE (= POACEAE)

Secale montanum Guss.

15.1. Synonym

Secale montanum (= *Triticum cereale* var. *montanum* Ash.-et Schweinf.)

15.2. Common Name

English

Mountain Rye

15.3. Brief Description

A caespitose perennial with erect or geniculate culms up to 100 cm tall smooth and glabrous ; leaf blades flat, up to 20 cm long shortly, hairy or glabrous ; spike 6-14 cm long, about 1 cm wide (excluding the awns), with a fragile axis densely ciliate on the margins ; spikelets 2-flowered 10-11 cm long, glumes subulate with hyaline margins ; lemmas pectinately ciliate on the keels.

15.4. Varieties

Botanical varieties :

Several botanical varieties occur in the Near and Middle East. In Iran Parsa (1950) mentions two varieties occurring in the Elburz Mountains :

- var *ciliatoglume* Boiss.
with the glume having a ciliated keel and an inferior long bearded glumella ;
- var *anatolicum* Boiss.
(= *S. anatolicum* Boiss.)
with a long inferior ciliated glumella terminated by an awn two times as long as the glumella ; also present in Anatolia in Turkey.

Native ecotypes :

Pabot (1967) records at least two distinct types of *S. montanum* - one with rather erect and strong stems, the other with spreading and less strong stems - and he states that they are both extremely interesting for seeding vast areas of waste lands in sub-steppic climates. Seeds of both these types of *S. montanum* have been collected and multiplied under both dryland and irrigated conditions in the sub-steppic zone of Iran.

Pabot (1967) recommends that it would be valuable to seek other Iranian ecotypes as well as introducing other varieties from Turkey and Lebanon ; eventually this could lead to crossing trials and genetic research with a view to developing more productive hybrid varieties. Recently some 200 ecotypes of *S. montanum* have been collected in E. Turkey and planted under dryland conditions at the Forage Crop Research Institute near Ankara (Kjellqvist, 1977).

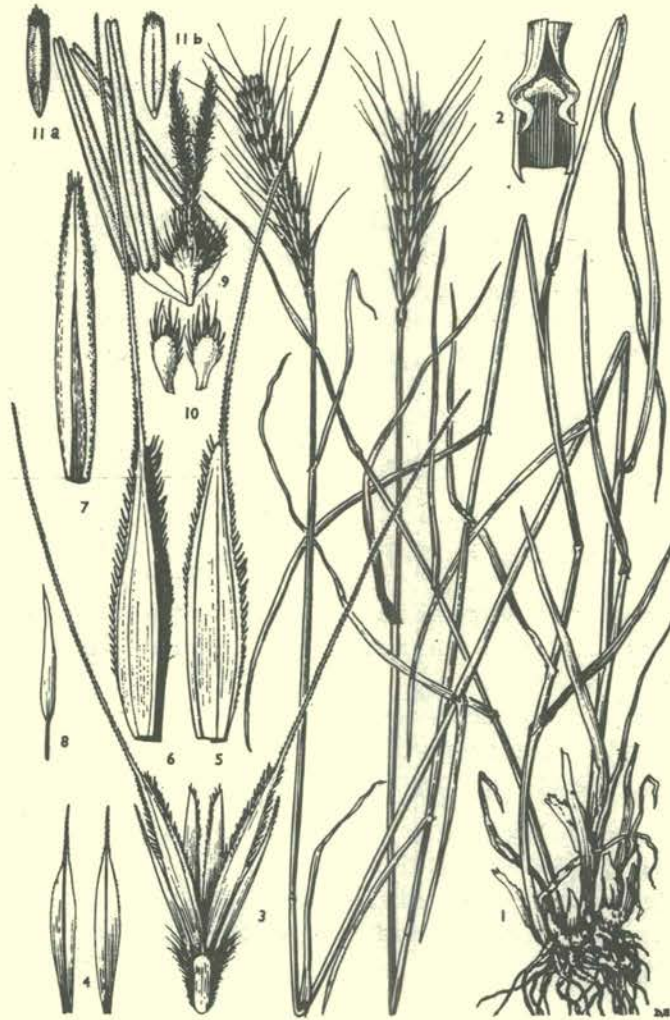


Fig. 1 - *Secale montanum* Guss.

1. Habit, $\times \frac{2}{3}$. 2. Ligule with auricles, $\times 3$. 3. Spikelet, $\times 2.5$.
4. Glumes, $\times 4$. 5, 6. Lemmas, $\times 4$. 7. Palea, $\times 4$. 8. Rhachilla with
rudimentary spikelet, $\times 4$. 9. Flower, $\times 4$. 10. Lodicules, $\times 4$. 11 a,
b. Grain, $\times 2$.

(After Flora of Iraq, vol. 9., Gramineae, 1968, p. 261, plate 90)

Agricultural varieties :

In the USA a hybrid has been developed from a cross between *S. cereale* and *S. montanum* called *S. ceremont* and it has been tested under dryland conditions in Iran.

15.5. Number of Chromosomes

S. montanum : $2x = 14$; 1-2 small B chromosomes ; highly polymorphic cross-fertilizing form.

15.6. Geographical Distribution

S. montanum is native of Central and Southern Europe stretching from Spain to the Balkans and is also found in Turkey, the Caucasus, Lebanon, Iraq, Iran and Morocco.

15.7. Biology and Ecology

Depth of rooting :

S. montanum is a cool season species propagating itself by seed and is deeper rooting than *Hordeum bulbosum* which exhibits a similar type of growth form. In the sub-steppic zone of Iran (1,960 m elevation, 320 mm annual rainfall) on brownish silty-clays, the root system of re-seeded *S. montanum* penetrates to a depth of 120 cm, but lateral rooting is also strong in the surface zone (0-30 cm) in the spring.

Growth and development :

The species, when re-seeded, makes its main growth during the spring (March-June) and vegetative growth starts in early March. Vegetative growth with a preponderance of long basal leaves continues up until early April at which time the booting and heading stages begin. Flowering takes place in early June and the seed production stage at the end of June to beginning of July.

The spring foliage production of *S. montanum* is abundant and the plants remain green but largely dormant in the summer with a small amount of growth occurring in July-August ; in the autumn (end of September-November) a further flush of vegetative growth occurs, its extent depending on the incidence of autumn rains.

In the steppic zone of Iran (1,300 m elevation, 200 mm annual rainfall) the pattern of growth of re-seeded *S. montanum* follows closely that occurring in the sub-steppic zone except that the summer dormancy period is more pronounced and the plants are green for a shorter period in the summer.

Seed germination :

The seeds of *S. montanum* germinate easily and with as little as 20-30 mm of rainfall under dryland conditions. Seed production is generally good but high air temperatures and low atmospheric humidity at or before flowering have adversely affected seed production of re-seeded *S. montanum* in some years in the sub-steppic zone of Iran. This condition referred to as scalding or blasting at flowering has reduced the amount of seed set and produced many empty glumes.

Adaptability in dryland plantings :

In Iran *S. montanum* has proved well adapted to re-seeding in the xerophilous forest (1,300-2,600 m elevation, 400 mm annual rainfall) and sub-steppic (900-2,000 m elevation, 250-350 mm annual rainfall) zones and fairly well adapted to re-seeding in the steppic zone (900-1,200 m elevation, 200-230 mm annual rainfall).

Ecological characteristics :

Pabot (1967) states that *S. montanum* is a very variable bunch-grass found in the mountains of Morocco, Spain, Sicily, Greece, Turkey, Lebanon, Iraq, Iran, but that in the Mediterranean countries the ecotypes are not very vigorous, while the Iranian ecotypes are very hardy and their large tufts can grow for many years.

However the species is not common in Iran being found here and there on eroded slopes or in the vicinity of fields in certain parts of the Zagros Mountains, in Azerbaidjan and in the Elburz Mountains where its altitude range seems to extend from 1,000 to 3,000 m (Parsa, 1950).

In Lebanon Pabot (1959) records *S. montanum* as being locally present in the high Mediterranean zone (1,000-1,500 m elevation) and in the Cedar zone (1,500-2,000 m).

15.8. Cultivation Techniques

Time of seeding :

In N. Iran the best time of seeding for *S. montanum* in both the steppic and sub-steppic zones has proved to be the autumn (November) ; autumn seeding has also proved superior in the sub-steppic zone of Afghanistan.

Seed rate and method of seeding :

In N. Iran seeding has been made with a conventional grain drill (15-20 cm spaced drills) or a pitter seeder under dryland conditions using a seed rate of 5-10 kg/ha ; a 2 row McCormick Orchard drill has also been used to plant *S. montanum* in rows 50 cm apart. Growth in some instances appears

to be enhanced by planting in widely spaced rows (90 cm apart) which permit good lateral root development in the surface soil.

Land preparation :

A firm, weed free seed-bed is required which involves ploughing, discing, harrowing, dragging and rolling. On vesicular soils which occur at various sites in the steppic and sub-steppic zones of northern Iran, and are associated with high calcium carbonate and low organic matter, *S. montanum* has emerged better than other grasses.

Seeding success :

In Libya Soghaier (1961) reports that *S. montanum* var *anatolicum* did well in nursery dryland test seedings at Sidi Mesri over a 3 year period.

In N. Iran nursery and/or adaptability row plantings of *S. montanum* and also *S. ceremont* were successful in test seedings over a 3 year period ; successful field scale seedings of *S. montanum* (Fig. 2) were also made in the steppic and sub-steppic zones of Iran (AGP:SF/IRA 10, Tech. Rep. No 1, 1970).

In Afghanistan Rouffie (1969) also reports that successful small scale seedings of *S. montanum* have been made in the sub-steppic zone near Kabul.



Fig. 2 - A stand of *S. montanum* at Nowdehak at the end of the growing season. Planted autumn 1967. November 1968.
(After Pasture and Fodder Crops Investigation, Iran, Tech. Rep. No 1, 1970, p. 86, Fig. 21)

15.9. Forage Value

Palatability :

S. montanum is a palatable species right up to the time of the formation of the spikes. Palatability tests with native sheep in the sub-steppic zone of northern Iran have shown that it is well grazed in the vegetative (spring and autumn) and boot stages, fairly well grazed in the flowering stage but is not grazed in the seed production stage.

Nutritive value :

The protein content of *S. montanum* is high in the vegetative stage but declines in the flowering and seed production stages in the spring when the plants become fibrous as the following data obtained at Homand in the sub-steppic zone of Iran shows :

Percentage of Dry Matter					
<u>Vegetative Stage</u>		<u>Flowering Stage</u>		<u>Seed Production Stage</u>	
Crude Protein	Crude Fibre	Crude Protein	Crude Fibre	Crude Protein	Crude Fibre
17.6	19.2	7.6	31.3	4.7	32.6

In East Germany *S. montanum* has been found to contain more than double the quantity of crude protein present in *S. cereale* but the percentage of essential amino acids in the crude protein is about the same (Focke, 1956).

Digestibility :

In Canada it was found (Pritchard et al., 1963) that *S. montanum* cut at 9 different dates from late May to late July, in general showed a digestibility decrease of approximately 0.5 percent per day starting from approximately 70 percent digestibility in late May ; the greatest decrease took place after head emergence.

15.10. Forage and Seed Production

Forage yields :

In the sub-steppic zone of northern Iran (1,960 m elevation) the following forage yields of *S. montanum* have been reported from nursery plots harvested in June (Tech. Rep. No. 1, AGP:SF/IRA 10, 1970) :

1966		1967		1968		1969	
Age of stand in years	Forage yield kg/ha DM	Age of stand in years	Forage yield kg/ha DM	Age of stand in years	Forage yield kg/ha DM	Age of stand in years	Forage yield kg/ha DM
4	2,600	5	1,050	6	800	7	1,470
Spring rainfall (March-May) mm :		Spring rainfall (March-May) mm :		Spring rainfall (March-May) mm :		Spring rainfall (March-May) mm :	
175.4		148.6		188.6		282.9	

Seed yields and irrigation :

Seed production of *S. montanum* has varied from 10-120 kg/ha under dryland conditions in the sub-steppic zone of Iran (1,960 m elevation) and in some years seed set has been adversely affected by hot dry winds during flowering ; artificial irrigation and application of nitrogen fertilizer prior to flowering has failed to alleviate this condition.

However, in the steppic zone of northern Iran (1,300 m elevation) where flowering of *S. montanum* takes place 3-4 weeks earlier its seed production under irrigation was greatly increased over that obtained in dryland plantings in the sub-steppic zone (1,960 m elevation).

In the sub-steppic zone of Afghanistan near Kabul, Rouffie (1969) records that light irrigations of field stands of *S. montanum* in the spring were necessary to ensure a good production of seeds.

15.11. Utilization

Time of use and establishment :

To ensure good establishment it is preferable not to graze dryland stands of *S. montanum* during the first year. In the sub-steppic zone of Iran some grazing is possible in the autumn one year after seeding but grazing is best deferred till the spring.

Grazing and conservation for hay :

Because of its early growth *S. montanum* has proved ideal for spring grazing. Alternatively it can be conserved for hay after cutting in the early flowering stage.

Pasture longevity :

Under grazing utilization in the sub-steppic zone of Iran field stands have shown indications of a short-life cycle (2-3 years) but this has yet to be confirmed.

Use in dryland rotations :

Because of its rapid development *S. montanum* could prove useful as part of a 2-3 year forage break in dryland cereal rotations in the sub-steppic zones of the Near and Middle East. *S. montanum* also combines well with the short-lived legumes *Astragalus siliquosus* and *Melilotus officinalis* which could also prove useful for the same purpose.

Further evaluation :

Further studies are needed to evaluate the longevity of *S. montanum* in dryland pastures and to test its potential as a forage break with suitable legumes in dryland cereal rotations.

15.12. Specific References

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16.1. Species

Villax (1963) mentions some eight *Stipa* spp. (Fig. 1, fruits) as having a limited forage value in the Mediterranean region. However, of these species, only *S. barbata* Desf., and to a lesser extent *S. lagascae* Roem. et Schult. and *S. parviflora* Desf. are really widespread throughout North Africa and the Near and Middle East.

16.2 Synonyms

- *S. barbata* (= *S. paleacea* Vahl., *S. szowitsiana* Trin. ex Griseb.)
- *S. lagascae* (= *S. holosericea* Trin. et Rupr., *S. fontanesii* Parl., *S. gigantea* Lag.)

16.3. Common Names

- | | | |
|------------------------|---------|---|
| - <i>S. barbata</i> | English | Feather Grass, Needle Grass, Spear Grass. |
| | Arabic | Sahem (Jordan) ;
Adein rhazel (Libya) ;
Aadame (Tunisia). |
| - <i>S. lagascae</i> | English | Feather Grass. |
| | Arabic | Addam (Libya) ;
Aadame (Tunisia) ;
Gawther, Ghawther (Egypt, UAR). |
| - <i>S. parviflora</i> | English | Small-Flowered Feather Grass (Jordan). |
| | Arabic | Safsoof, Sabal (Sebl) Abu el Mossein (Egypt, UAR) ;
Adden, Bema, Souhai (Morocco). |

16.4. Brief Description

- *S. barbata* is a tough caespitose desert grass with erect culms growing to a height of 60 cm with shining glumes and long awns (Fig. 2) ;
- *S. lagascae* is a caespitose desert grass with stout erect smooth glabrous culms growing to a height of 40-80 cm with silvery glumes and bearded anthers (Fig. 3) ;

- *S. parviflora* is a caespitose desert grass forming though rigid tufts and growing to a height of 40-60 cm with an enlarged inflorescence and spreading awned and silvery spikelets (Fig. 4).

16.5. Varieties

Botanical forms, varieties and subspecies :

A number of forms, varieties and subspecies of *S. barbata*, *S. lagascae* and *S. parviflora* exist under natural conditions in the Mediterranean and the Near and Middle East. In North Africa Maire (1953) mentions the following :

S. barbata :

- var. *eu-barbata* Maire et Weiller n. nom.
type species and present in Cyrenaica, Algeria and the steppes and Atlas Mountains of Morocco ; also recorded in Iraq (Regel, 1954, 1956) ;
- var. *brevipila* Coss. et Dur.
present in Algeria on the high plateaux and in the Atlas Mountains in Morocco.

S. lagascae :

- ssp. *Letourneuxii* Trabut, in B. et T.
rare but present in Tunisia ;
- ssp. *normalis* Maire, in M., C.
rare ; a new variety var. *malvana* also recorded in Morocco (de Brichambaut and Sauvage, 1954) ;
- var. *pubescens* Hackel
present in the littoral zone of Algeria, Tunisia, Cyrenaica and Tripolitania ;
- f. *breviaristata* Maire, C.
present in the littoral zone of Algeria ;
- f. *puberula* Maire, C.
present in Algeria ;
- f. *latifolia* Maire et Weiller in M., C.
present in Tripolitania ;
- var. *Embergeri* Maire, C.
present in the Atlas Mountains in Morocco ;
- var. *Trabutii* Maire, C.
present in the littoral zone of Algeria ;
- var. *australis* Maire in M., C.
present in the littoral zone and Oran Mountains in Algeria and in the Grand Atlas and Saharan Atlas Mountains of Morocco ;
- f. *glabriligulata* Maire in M., C.
present in the Grand Atlas Mountains in Morocco ;
- f. *oropediorum* Maire in M., C.
rare but present in Algeria.

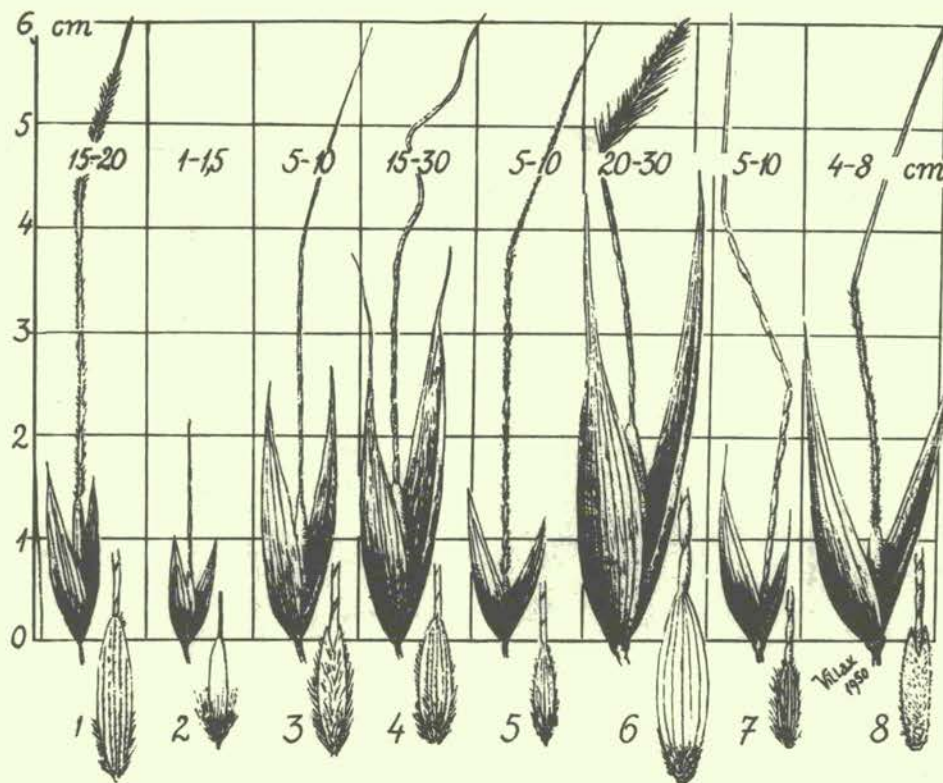


Fig. 1 - The species of *Stipa*

- | | | | |
|---------------------------|--------------------------|-------------------------|--------------------------|
| 1. <i>S. barbata</i> . | 2. <i>S. bromoides</i> . | 3. <i>S. gigantea</i> . | 4. <i>S. lagascae</i> . |
| 5. <i>S. parviflora</i> . | 6. <i>S. pennata</i> . | 7. <i>S. retorta</i> . | 8. <i>S. tenacissima</i> |

(After la Culture des plantes fourragères dans la région méditerranéenne occidentale, 1963, p. 229, fig. 53)



Fig. 2 - *Stipa barbata* Desf.

1. Habit, $\times \frac{2}{3}$. 2. Spikelet, $\times 2$. 3. Floret, $\times 4$. 4. Lower glume, $\times 4$.
5. Upper glume, $\times 4$. 6. Lemma, $\times 4$. 7. Palea, $\times 4$. 8. Flower, $\times 7$.
9. Grain, $\times 4$. 10. Ligule, $\times 2$.

(After Flora of Iraq, vol. 9, Gramineae, 1968, p. 401, plate 150)



Fig. 3 - *Stipa lagascae*

Plant, x1. G : Glumes, x2. C : Caryopsis enclosed by the glumes, x2.
A : Awn, x2. L : Ligule, x4.

(After Introduccion al Estudio de las Especies
Pascicolas Espanolas, Madrid, 1965, p. 164)

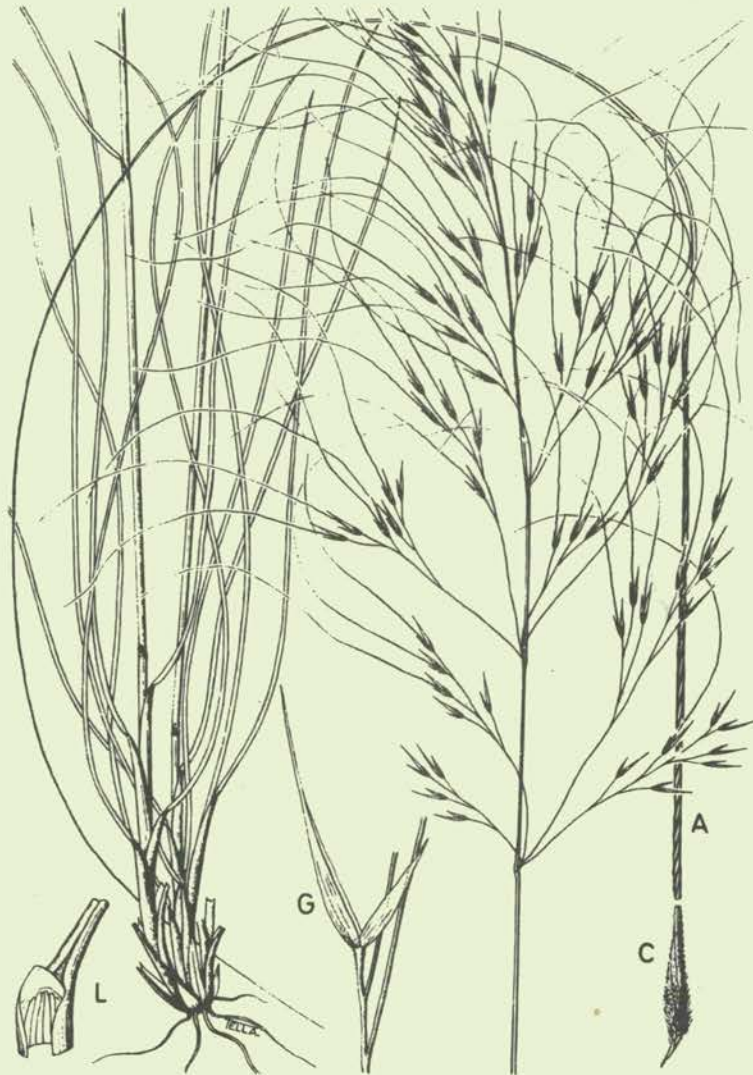


Fig. 4 - *Stipa parviflora*

Plant, x1. G : Glumes, x4. C : Caryopsis enclosed by the glumes, x4.
A : Awn, x4. L : Ligule, x4.

(After Introduccion al Estudio de las Especies
Pascícolas Espanolas, Madrid, 1965, p. 166)



Fig. 5 - *Stipa parviflora* Desf.

1. Habit, $\times \frac{2}{3}$. 2. Spikelet, $\times 2$. 3. Fruit, $\times 4$. 4. Lower glume, $\times 2$.
 5. Upper glume, $\times 2$. 6. Lemma minus callus, $\times 2$. 7. Palea, $\times 2$.
 8. Flower, $\times 4$. 9. Grain, $\times 4$. 10. Ligule, $\times 3$

(After Flora of Iraq, vol. 9, Gramineae, 1968, p. 409, plate 153)

In North Africa Maire (1953) records that *S. barbata* and its forms are found growing from the littoral zone up to the Saharan Atlas Mountains, while *S. lagascae* and its various forms are found in areas extending from the littoral zone up to the Atlas Mountains and reaching an elevation of 2,800 m.

For North Africa and Sinai Chrtek and Martinovsky (1969) mention the following varieties of *S. parviflora* :

- subsp. *parviflora* var. *mareotica* Chrtek and Martinovsky var. *nova* present in Cyrenaica ;
- subsp. *parviflora* var. *pilosa* Chrtek and Martinovsky var. *nova* present in Almeira, Spain ;
- subsp. *sinaica* Chrtek and Martinovsky subsp. *nova* present in the Sinai ;
- subsp. *sandwithii* Chrtek and Martinovsky subsp. *nova* present in Libya, Cyrenaica and parts of the Orient.

Maire (1953) also records that in North Africa *S. parviflora* presumably incorporating several different forms, occurs in a wide range of habitats extending from the littoral zone up to the steppes and mountains reaching an elevation of 2,300-2,600 m.

For Syria and Lebanon Mouterde (1966) mentions the following varieties of *S. barbata* :

- subsp. *damascena* Boiss. n. comb.
which occurs in both Syria and Lebanon and probably extends also to Interior Asia and to the Sinai ;
- var. *paboti* var. *nov.*
which has no hairs at the base of the awn and occurs only in Syria.

For Iraq Martinovsky (1970) mentions one new variety of *S. barbata*

- var. *longiaristata*

For Iran Parsa (1950) mentions the following variety of *S. barbata*

- var. *seminuda* Hackel
which has an awn that is glabrous from the base up to the middle.

Native ecotypes :

Pabot (1967) states that in Iran there are numerous varieties and ecotypes of *S. barbata* ; some ecotypes can manage with 100 mm of annual rainfall, whilst others will tolerate more than 1,000 mm ; some can grow at nearly sea level (Moghan), while others rise to more than 3,500 m elevation in the Zagros and Elburz Mountains and probably to above 4,000 m elevation in the arid mountains of the south-east.

Pabot (1967) further states that varieties of *S. barbata* in particular could be extremely useful for re-seeding vast steppic and sub-steppic areas with poor soils subject to erosion. Seeds of several ecotypes of *S. barbata* have been collected and seeded in a dryland nursery in the sub-steppic zone of Iran (1,960 m elevation, 320 mm annual rainfall) and it would clearly be valuable to collect seeds of a range of ecotypes of both *S. barbata* and *S. lagascae* and also *S. parviflora* and to evaluate their potential for re-seeding denuded arid and semi-arid rangelands in North Africa as well as the Near and Middle East.

16.6. Number of Chromosomes

S. parviflora : $2x = 28$, other species not known.

16.7. Geographical Distribution

S. barbata is distributed in Spain, Sicily, Cyprus, Syria, Palestine, Jordan, Sinai, Turkey, Caucasus, Iran, Iraq, W. Pakistan, Afghanistan, N.W. India (Kashmir, Chitral), C. Asia, N. Africa (Morocco, Algeria, Tunisia, Libya, Egypt);

S. lagascae is distributed in Mediterranean Europe (Spain, Sicily, Balkans), Cyprus, Lebanon, Syria, Palestine, Jordan, Turkey, Caucasus, Iran, Iraq, C. Asia (Turkmenia), N. Africa (Morocco, Algeria, Tunisia, Libya, Egypt) ;

S. parviflora is distributed in the Mediterranean Europe (Spain, Balkans), Crete, Syria, Palestine, Jordan, Egypt, S. Iran, N. Africa (Morocco, Algeria, Tunisia, Libya, Central Sahara).

16.8. Biology and Ecology

Seed characteristics :

S. barbata, *S. lagascae* and *S. parviflora* are all cool season species propagating themselves by seed.

In Iran Pabot (1976) points out that seeds of *Stipa* spp. in Iran, in general, do not germinate readily and in addition most do not tolerate irrigation.

However germination of *S. barbata*, *S. lagascae* and *S. parviflora* in native stands occurs normally and especially under protection from grazing (Fig. 6).



Fig. 6

Regeneration of the palatable grasses *Stipa parviflora*,
S. lagascae and *S. barbata* after 5 year protection in
the steppe of Algeria (Mergueb area)

(After North Africa : Past, present, future, 1970, p. 271, fig. 32)

Growth and development :

In the sub-steppic zone of Iran at Homand (1,960 m elevation, 320-350 mm annual rainfall) re-seeded *S. barbata* commences its vegetative growth at the end of March in the spring, while the booting stage begins in early April, the flowering stage in mid-June and the seed production stage at the end of June or early July. In the summer the plants are largely dormant but a small amount of vegetative growth occurs in July-August. In the autumn with the onset of cooler temperatures new vegetative growth begins at the end of November and continues until December depending on the incidence of autumn rains.

In the Mediterranean littoral zone in Egypt (UAR) Ibrahim (1968) mentions that both *S. lagascae* and *S. parviflora* provide valuable winter forage although the former species is considered to produce more forage than the latter because it grows taller. While the leaves of *S. lagascae* are somewhat coarser than those of *S. parviflora* the basal leaves remain green over a longer growing period. In Egypt (UAR) *S. parviflora* reaches its peak of growth and vigour in shallow calcareous sandy soils which are believed to be its most favourable habitats ; seeds of *S. lagascae* are difficult to collect and seed production of *S. parviflora* is said to be superior to that of *S. lagascae* (Ibrahim, 1968).

In Lebanon and Syria *S. barbata* and *S. lagascae* are recorded (Mouterde, 1966) as flowering from May-June in mountain pastures and also in arid and semi-arid regions.

Climate and soils :

S. barbata, *S. lagascae* and *S. parviflora* are all strongly drought resistant ; those ecotypes occurring at high elevation all resist cold winter temperatures. All three species are also well adapted to re-seeding in semi-arid areas with as little as 200 mm of annual rainfall.

S. barbata, *S. lagascae* and *S. parviflora* are adapted to a wide range of soils except saline soils and moving sands ; in North Africa they are found on rocky hillsides as well as clay steppes and calcareous sands. In Egypt (UAR) Long (1956) mentions that *S. lagascae* is adapted to sandy calcareous soils of medium depth, while *S. parviflora* is mentioned (Ibrahim, 1968) as being adapted to rocky slopes of shallow soils.

In Iran Pabot (1967) records that *S. lagascae* is less frequent than *S. barbata* and is essentially adapted to sub-steppic and mountain climates.

Ecological characteristics :

Ecologically the three *Stipa* spp. mentioned above are characteristic of denuded steppes in N. Africa and the Near and Middle East where they occur with other perennial grasses and shrubs.

In Tunisia and Libya on sandy soils *S. lagascae* and *S. parviflora* occur on overgrazed steppe in association with *Artemisia campestris*, *Ziziphus lotus* and *Rantherium suaveolens* (0-200 m elevation, 150-250 mm annual rain-fall) (Rattray, 1960) ; Le Hou  rou (1965) states that the plant cover of this association in Libya varies from 20-50 %.

S. parviflora is also round growing in the coastal region of Libya in the forest of the Jebel in association with *Rhaponticum acaule*, *Lygeum spartum* and *Helianthemum ruficomum* and on sandy plains growing in association with *Thymelaea hirsuta* and *Noaea spinosissima* (Le Hou  rou, 1965).

In Egypt Long (1956) mentions that *S. lagascae* is dominant in the N.W. coastal region in the association of *Plantago albicans* and *Echiochilon fruticosum*, and it is also abundant in the association of *Thymelaea hirsuta* and *Gymnocarpus decandrum* ; it is also found in the coastal Mediterranean region growing on inland ridges in the association of *Thymelaea hirsuta*, *Thymus capitatus* and *Asphodelus microcarpus* with also *Dactylis hispanica* (Ayyad and Ammar, 1974).

Ibrahim (1968) mentions that *S. parviflora* is less affected by the aspect of the slope than *S. lagascae* ; *S. lagascae* is much less abundant on southern than northern exposures.

In Jordan in the steppe *S. parviflora* has been recorded (Kasapl  gil, 1956) at 1,500 m elevation, growing in association with *Dactylis glomerata*, *Hordeum bulbosum* and *Ephedra alata*.

In Iran *S. barbata* is commonly found in steppic or sub-steppic regions growing in association with *Artemisia* spp., *Salsola rigida*, herbaceous *Astragalus* and semi-woody species or small shrubs (Pabot, 1967).

16.9. Cultivation Techniques

Time and method of seeding :

S. barbata, *S. lagascae* and *S. parviflora* can all be established by seeds.

In Iran the best time of seeding for *S. barbata* has proved to be the autumn (October-November) and seeds can be broadcast on the surface or in shallow furrows (5-10 cm deep) spaced 50 cm apart ; seeds germinate and seedlings emerge well from depths of seeding ranging from 0.5-4.0 cm.

Delayed seed germination :

Experimental stands of *S. barbata* in northern Iran have often been patchy in the first year because many of the seeds exhibit delayed germination, germinating only in the second or third year after sowing.

Seeding success :

In N. Iran *S. barbata* has been successfully seeded on a nursery scale and in adaptability row plantings in the xerophilous forest (1,300-2,600 m elevation, +400 mm annual rainfall), sub-steppic (900-2,000 m elevation, 250-350 mm annual rainfall) and steppic (900-1,200 m elevation, 200-230 mm annual rainfall) (Tech. Rep. No. 1, AGP:SF/IRA 10, 1970).

Vegetative propagation :

In Egypt (UAR) because seeds of both *S. lagascae* and *S. parviflora* have proved somewhat difficult to collect, Long (1955) recommends transplanting of mother plants of both these species in the autumn in clay pots which are set about 30 cm apart ; alternatively they may be transplanted directly in wet sites. This procedure ensures the success of transplanted mother plants which later on under protection will seed the surrounded areas. In Morocco it has been proved in practice that this procedure is more economical than artificial seeding (Long, 1956).

In the Mediterranean coastal zone of Egypt preliminary studies indicate that transplanted mother plants of *S. lagascae* establish themselves very successfully in the association of *Plantago albicans* and *Echiochilon fruticosum* (Ibrahim, 1968).

16.10. Forage Value

Palatability :

In the sub-steppic zone of Iran *S. barbata* has been found to be a very palatable species much more palatable than a local species of *S. orientalis* (an uncommon mountain species). In palatability tests with native sheep *S. barbata* was very well grazed in the vegetative and boot stages in the spring, fairly well grazed in the flowering stage and poorly grazed in the seed production stage ; in the summer and autumn vegetative stages plants were fairly well grazed.

In Egypt (UAR) the palatability of *S. lagascae* and *S. parviflora* are both considered to be good and in Jordan *S. parviflora* is considered to be a highly palatable grass (Kasapligil, 1956). Plants of *S. lagascae* are rarely left to reach maturity without being grazed, but in studies comparing utilization of *S. lagascae* and *S. parviflora*, plants of the latter were found to be more closely grazed than the former. All the *Stipa* species mentioned above are palatable to goats and probably also to camels.

Nutritive value :

The nutritive value of re-seeded *S. barbata* is also considered to be good with a high protein content in the vegetative and boot stages and a somewhat lower level in the flowering and seed production stages, when the plants become more fibrous, as the following data obtained in the sub-steppic zone of Iran shows :

Vegetative Stage		Boot Stage		Flowering Stage		Seed Production Stage	
Crude Protein	Crude Fibre	Crude Protein	Crude Fibre	Crude Protein	Crude Fibre	Crude Protein	Crude Fibre
16.6	22.5	16.7	22.7	9.8	29.8	7.8	31.6

16.11. Forage and Seed Production

Forage yields :

In the sub-steppic zone of Iran (1,960 m elevation, 320-350 mm annual rainfall) forage yields of well established nursery stands of *S. barbata* have compared favourably with those of other re-seeded grasses and the following yield data for a three year period is given below :

<u>1967</u>		<u>1968</u>		<u>1969</u>	
Age of stands	Forage yield kg/ha DM	Age of stands	Forage yield kg/ha DM	Age of stands	Forage yield kg/ha DM
5th year	1,930	6th year	2,200	7th year	3,280
Spring rainfall (mm) March - May 148.6		Spring rainfall (mm) March - May 188.6		Spring rainfall (mm) March - May 282.9	

Seed yields :

In the sub-steppic zone of Iran seed yields of *S. barbata* have varied from 10-20 kg/ha in nursery plots.

16. 12. Utilization

Time of grazing :

S. barbata, *S. lagascae* and *S. parviflora* are all valuable steppic grasses that can be used for grazing in the spring or the winter. In the spring best grazing utilization is obtained up until heading when the foliage is green and seed heads have not yet been formed.

Hay and fodder conservation :

S. barbata, *S. lagascae* and *S. parviflora* can all be conserved for hay if cut in the early flowering stage and Le Houerou (1962) considers that *S. parviflora* in particular should be tested for providing fodder reserves in steppic areas ; Delbes (1955) also considers *S. parviflora* to be an excellent forage grass.

Injury caused by fruits :

Grazing sheep on *S. barbata*, in particular, from the beginning to the end of fruiting is not recommended since the sharp pointed fruits cling to the animal's body causing irritation or they may get stuck in the animal's throat ; in the USSR serious injury or even death has been reported (Rozhevits and Shishkin, 1934) in the past, but this condition has not been recorded so far in North Africa and the Near and Middle East.

Soil conservation :

S. parviflora which often forms abundant close stands under natural conditions is also mentioned by Ibrahim (1968) as being capable of checking water and wind erosion.

Further evaluation :

More studies are, however, needed on the three *Stipa* species mentioned above in regard to their palatability, seed harvesting, seeding techniques and utilization before these species can receive wider recognition and agronomic use.

16.13. Specific References

- | | |
|--|---|
| CHRTEK, J. & MARTINOVSKY, J.O.
1969 | Intraspecific taxa in <i>Stipa parviflora</i> Desf. and <i>Stipa hoggarensis</i> Chrtek et Martinovsky sp. nova.
<i>Webbia</i> , 24(1): 391-399. |
| MARTINOVSKY, J.O.
1970 | Two new <i>Stipa</i> taxa from Iraq : 21st contribution to the knowledge of the taxonomy of <i>Stipa</i> .
<i>Preslia</i> , 42(4): 373-376. |
| REGEL, C.
1954-56 | <i>S. barbata</i> var <i>eu-barbata</i> in Iraq.
<i>Candollea</i> , 15: 183-191. |

TECHNICAL DATA
SHEET No 17

GRAMINEAE (= POACEAE)

Stipagrostis spp.

17.1. Species

There are seven *Stipagrostis* spp. which are considered to have importance in North Africa and the Near and Middle East. These species are *S. plumosa* (L.) Munro ex T. Anders, *S. ciliata* (Desf.) de Winter, *S. obtusa* (Del.) Nees, *S. raddiana* (Savi) de Winter, *S. pungens* (Desf.) de Winter, *S. lanata* (Forssk.) de Winter and *S. pennata* (Trin.) de Winter.

17.2. Synonyms

- *S. plumosa* (= *Aristida plumosa* L.)
- *S. ciliata* (= *Aristida ciliata* Desf. in Schrad.)
- *S. obtusa* (= *Aristida obtusa* Del.)
- *S. raddiana* (= *Aristida raddiana* Savi, *A. caloptila* non Jaub et Sp., Schwein ex Boiss. (Egyptian records))
- *S. pungens* (= *Aristida pungens* Desf.)
- *S. lanata* (= *Aristida lanata* Forssk., *A. forskahlei* Tausch)
- *S. pennata* (= *Aristida pennata* Trin.).

17.3. Common Names

- | | | |
|---------------------|---------|--|
| - <i>S. plumosa</i> | English | Plumose Three Awned Grass (Saudi Arabia) ;
Triple Awned Grass (Libya) ;
Plumose Triple Awned Grass (Syria, Jordan). |
| | Arabic | Soliane, Ceffar, Bouricha, Dereri, Chaaraïch, Hebil, Neci, Mssil, Caba (Morocco) ;
Russi, Duraya, Shafshurf, Naysi (Saudi Arabia) ;
Sahma, Kicha, N'si (Tunisia) ;
Naussi, Nesa, Nezi, N'sa, N'sha, Nsee (Libya) ;
Nawa haida, Rooq, Qaw, Sha'arq, Sha'eeriya, Sha'araia (Egypt (UAR) ;
Nussi (Iraq). |
| - <i>S. ciliata</i> | Arabic | Nissi (Iraq) ;
Gau Sullayyan, Qaba (Saudi Arabia) ;
Assah, Hmera, Hemlira, Hamareet (Egypt (UAR) ;
Lammati, Morokba, Ressasa (Tunisia) ;
N'say (Libya) ;
Soliane (Morocco) ;
Gharza (Yemen). |

- <i>S. obtusa</i>	English	Triple Awned Grass (Libya).
	Arabic	Sulliyani (Iraq) ; Darayri, Safsuf, Halfa, Sulailah (Saudi Arabia) ; Nicha, N'si (Tunisia) ; N'sa, Silan, Silian (Libya) ; Sabat, Safsuf (Jordan).
- <i>S. raddiana</i>	Arabic	Nussi (Sinai) ; Bechim (Morocco).
- <i>S. pungens</i>	Arabic	Drin (Algeria) ; Drinn, S'bott (Tunisia) ; Es sabat, es Sbat, Lul (seed used as food), Sabot, Sbat, Sbeitt, Shuth, Spat (Libya) ; Haskaneet, Shoak el ghazzal (Egypt (UAR)).
- <i>S. lanata</i>	Arabic	Shafshoof Ain Seela (Egypt (UAR)).

17.4. Brief Description

- *S. plumosa* is broadly caespitose grass (sometimes annual in the Sahara (Villax, 1963) with strong roots attaining a height of up to 40-50 cm with lower sheaths of the stems covered with fugacious wool (in all other species glabrous) (Fig. 1) ;

- *S. ciliata* is a densely caespitose grass and the only species with spreading hairtufts at the nodes (Fig. 2 and 3) ;

- *S. obtusa* is a small compact grass with short capillary curved leaves in dense basal tufts (Fig. 3) ;

- *S. raddiana* is a fine slender often tall grass distinguished by its very long soft plumes (Fig. 4 and 8) ;

- *S. pungens* is tall stiff glabrous desert grass with pungent leaves (Fig. 5 and 6) ;

- *S. lanata* is a rather tall coarse grass with capillary and often curved leaves and woolly internodes ;

- *S. pennata* is a robust erect desert grass with straw coloured spikelets and an awn with a very oblique attachment to the top of the lemma (Fig. 6 and 7).

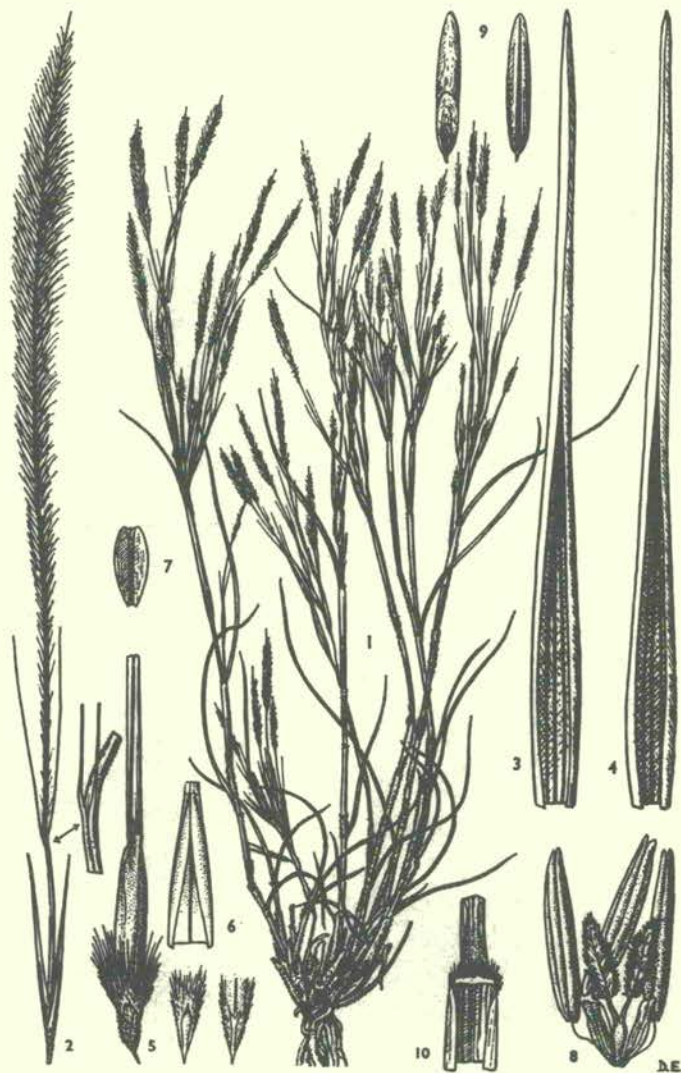


Fig. 1 - *Stipagrostis plumosa* (L.) Munro ex T. Anders.

1. Habit, $\times \frac{2}{3}$. 2. Spikelet, $\times 2$. 3. Lower glume, $\times 8$. 4. Upper glume, $\times 8$.
5. Floret with base of awn, $\times 8$. 6. Lemma, $\times 8$. 7. Palea, $\times 8$.
8. Flower, $\times 8$. 9. Grain, $\times 8$. 10. Ligule, $\times 4$.

(After Flora of Iraq, vol. 9, Gramineae, 1968, p. 390, plate 148)



Fig. 2 - *Stipagrostis ciliata* (Desf.) de Winter

1. Habit, $\times \frac{2}{3}$. 2. Spikelet minus central branch of the awn, $\times 3$.
3. Lower glume, $\times 3$. 4. Upper glume, $\times 3$. 5. Floret, $\times 3$. 6. Lemma, $\times 3$.
7. Palea, $\times 3$. 8. Flower, $\times 6$. 9. Grain, $\times 6$. 10. Ligule, $\times 2$.

(After Flora of Iraq, vol. 9, Gramineae, p. 387, plate 147)

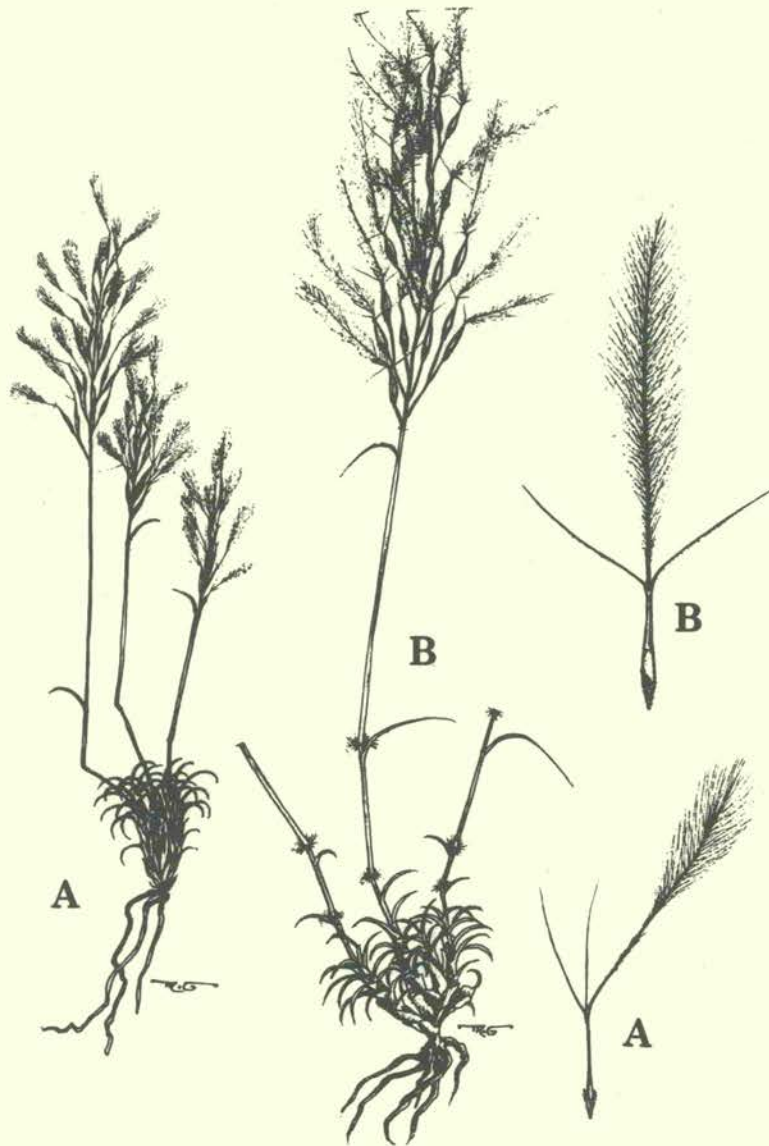


Fig. 3

- A. *Stipagrostis obtusa*
- B. *Stipagrostis ciliata*

(After Students' Flora of Egypt, 1974, p. 723, plate 265)

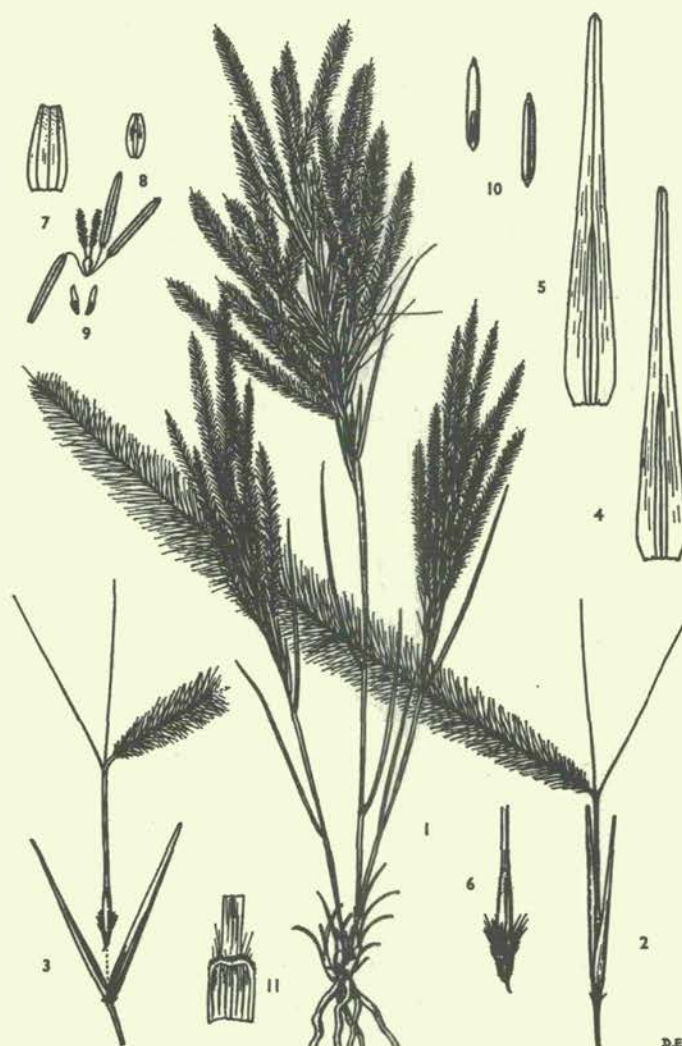


Fig. 4 - *Stipagrostis raddiana* (Savi) de Winter

1. Habit, $\times \frac{2}{3}$. 2. Spikelet, $\times 2$. 3. Glumes and floret, $\times 2$. 4. Upper glume, $\times 4$. 5. Lower glume, $\times 4$. 6. Floret, $\times 4$. 7. Lemma, $\times 4$. 8. Palea, $\times 4$. 9. Flower, $\times 4$. 10. Grain, $\times 4$. 11. Ligule, $\times 2$

(After Flora of Iraq, vol. 9, Gramineae, 1968, p. 393, plate 149)



Fig. 5

Aristida pungens
(= *Stipagrostis pungens*)

(After Flore de l'Iran,
vol. V, 1950, p. 580, fig. 280)

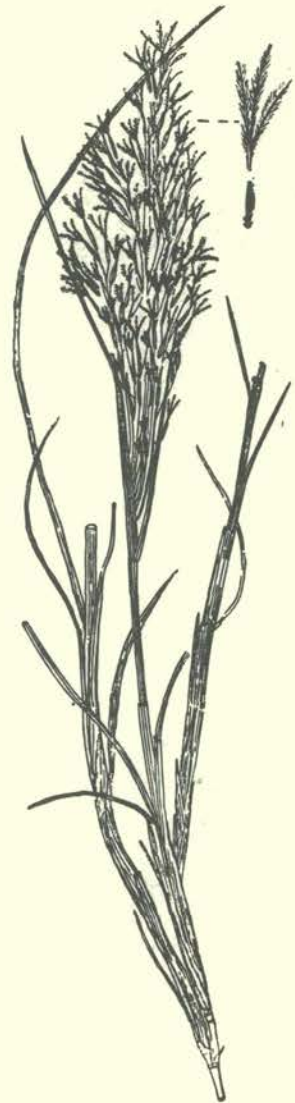


Fig. 6

Aristida pungens
(= *Stipagrostis pungens*)

(After Flore du Sahara
septentrional et central,
1958, p. 165, fig. 31)

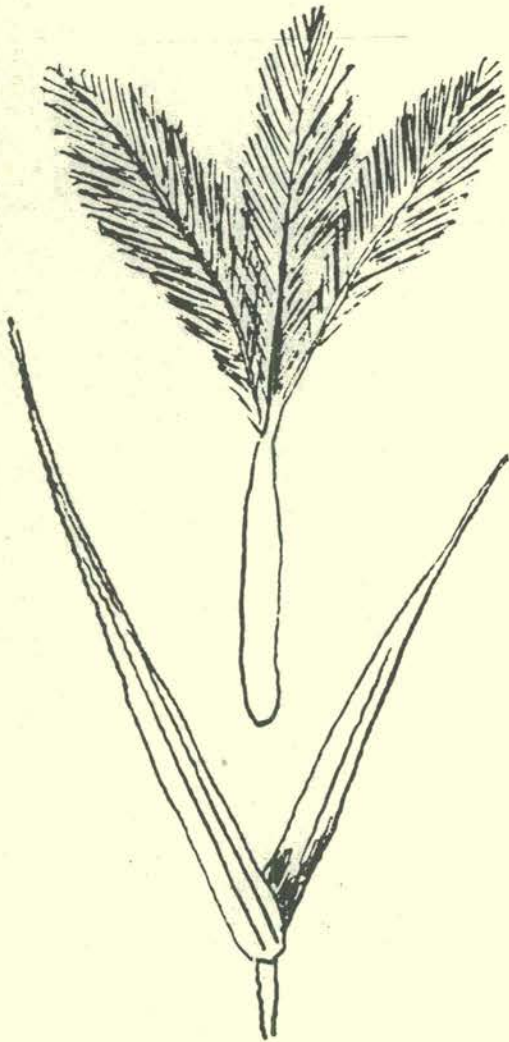


Fig. 7

Aristida pennata Trinus
(= *Stipagrostis pennata* Trin. de Winter)

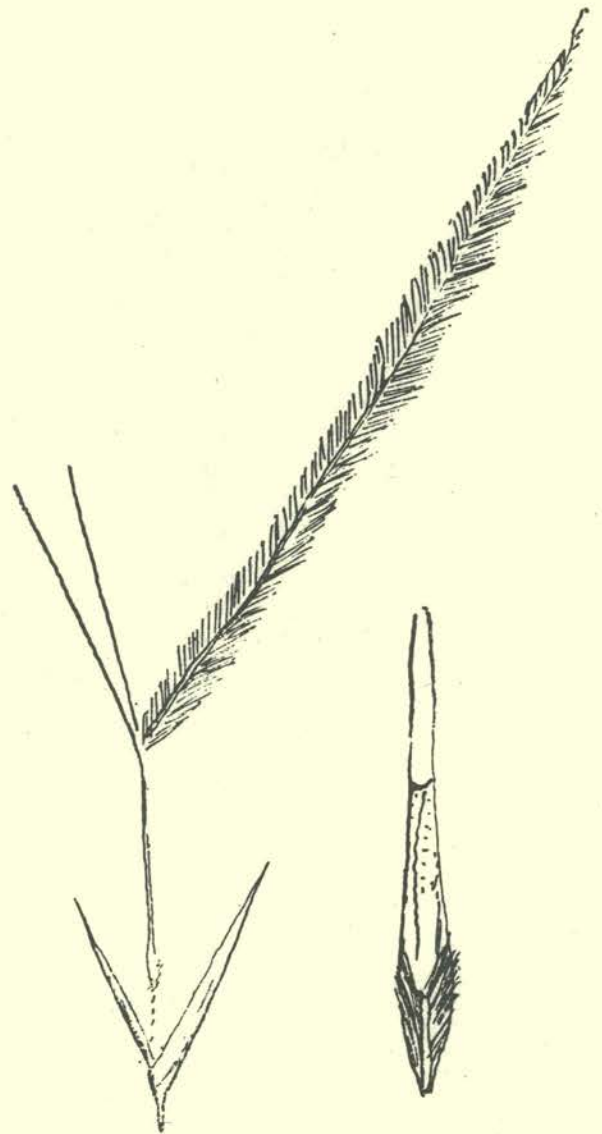


Fig. 8

Aristida raddiana Savi
(= *Stipagrostis raddiana* (Savi) de Winter)

(After Flore de l'Iran, vol. V, 1950, p. 582, Fig. 281 and p. 583, Fig. 282)

17.5. Varieties

Botanical varieties and forms :

A number of botanical forms, varieties and/or sub-species of *S. plumosa*, *S. ciliata*, *S. obtusa* and *S. pungens* exist throughout North Africa and the Near East. In North Africa Maire (1953), Keith (1965) and Tackholm (1974) mention the following :

- *S. plumosa*
 - spp. *eu-plumosa* Maire in M.C.
present in Morocco and Algeria ;
 - var. *typica* Maire in J. et M.
type species ; common from Morocco to Egypt (UAR) ;
 - var. *seminuda* Trin. et Rupr.
common in the Central Sahara also present in Egypt (UAR) ;
 - var. *superciliata* Henrard
common in Egypt (UAR) ;
 - var. *floccosa* (Coss. et Dur.) Durd et Schinz.
present in Libya, Morocco, Algeria, Tunisia ;
 - var. *lanuginosa* (Trabut) Maire in M.C.
present in the littoral zone of Libya ;
 - var. *oranensis* (Henrard) Maire in M.C.
present in the Saharian Atlas ;
 - var. *syrtica* Maire et Weiller in M.C.
present in the littoral zone and Matmarta Mountains in Tunisia ;
 - var. *dubia* Maire in M.C.
present in Algeria ;
 - var. *australis* Maire in M.C.
present in the Western Sahara.
- *S. ciliata*
 - var. *genuina* Trin. et Rupr.
present in Morocco, Algeria, Tunisia, Cyrenaica and Tripolitania ;
 - f. *glutinosa* Trabut in B. et T.
present in Oran district in Algeria ;
 - var. *tricholaena* Hackel
present in the Western Sahara in Morocco.
- *S. obtusa*
 - var. *aruncosa* Corti
present in Libya.

- *S. pungens*
 - var. *genuina* Maire in M., C.
very widespread in littoral, steppes and plateaux ; present in Morocco, Algeria, Tunisia and Cyrenaica also recorded by Keith (1965) in Libya ;
 - f. *normalis* Maire in M., C. ;
 - f. *pseudoscoparia* Maire in M., C.
present in Algeria ;
 - var. *pubescens* Henrard
present in Algeria ;
 - var. *transiens* Maire in M., C.
present in the Central Sahara.

Tackholm (1974), who considers *S. plumosa* to be a multiform species, mentions the following additional botanical varieties in Egypt apart from those already mentioned :

- var. *plumosa* (= *Aristida plumosa* var. *genuina* Henr.)
present in the desert and also mentioned by Bor and Guest (1968) as occurring in the Iraq desert ;
- var. *alexandrina* (Trin. et Rupr.) (= *Aristida plumosa* var. *alexandrina* Trin. et Rupr.)
present in the littoral zone ;
- var. *aethiopica* (Trin. et Rupr.) Täckh (= *Aristida plumosa* var. *aethiopica* Trin. et Rupr.)
present in the south ;
- var. *brachypoda* (Tausch) Bor. (= *S. brachypoda* (Tausch) Trin. et Rupr.)
present throughout the country and also mentioned by Bor and Guest (1968) as occurring in the Iraq desert.

Parsa (1950) also mentions the following two botanical varieties of *S. plumosa* in Iran :

- var. *eichwaldiana* Trin.
present near Teheran and in Azerbaidjan ;
- var. *haussknechtii* Boiss.
present in Khorassan.

Native ecotypes :

In Iran Pabot (1967) states that *S. plumosa* is a collection of sub-species varieties and ecotypes whose study is still very incomplete ; each ecotype seems to be adapted to particular conditions. For example the ecotype from the south-west of Teheran is a very different ecotype from that found at Ahwaz, while the ecotype occurring on the gypsiferous hills of Agha Jari is quite different from the ecotype on the conglomerates north of Dezful ; there even exists a variety of *S. plumosa* which grows between Keshwar and Sefid Dacht (Dez Valley) on calcareous eroded marls (900 m elevation) with an annual rainfall in excess of 400 mm.

17.6. Number of chromosomes

Basic number for the genera *Aristida* (*Stipagrostis*) $x = 11$;
for *S. pennata* $2n = 44$; for other species not known.

17.7. Geographical Distribution

S. plumosa is distributed in Europe (Mediterranean, Balkans), Cyprus, Syria, Palestine, Jordan, Sinai, Egypt (UAR), Arabia, Kuwait, Turkey, Caucasus, Iran, Iraq, Pakistan, Afghanistan, C. Asia (Turkmenia to Pami-Alai), N.W. India, W.-Tibet, N. Africa (Morocco, Algeria, Central Sahara, Tunisia, Libya), Tropical Africa (Mauritania, Nubia) ;

S. ciliata is distributed in Palestine, Jordan, Egypt (UAR), Arabia, Kuwait, Iran, Iraq, Afghanistan, N. Africa (Morocco, Algeria, Central Sahara, Tunisia, Libya), Macaronesia (Canaries, Madeira), Tropical Africa (Sudan, Ethiopia) ;

S. obtusa is distributed in Palestine, Jordan, Sinai, Egypt (UAR) Arabia, Kuwait, W.-Pakistan, N. Africa (Morocco, Algeria, Libya) ;

S. raddiana is distributed in Egypt (UAR), Sinai, Jordan, Arabia, Iraq, S. Iran, Afghanistan ;

S. pungens is distributed in Algeria, Tunisia, Libya, Egypt (UAR), Arabia, Iran, Afghanistan ;

S. lanata is distributed in S. Syria, Palestine, Jordan, Sinai and Egypt (UAR) ;

S. pennata is distributed in Europe (S. USSR), Caucasus, W. Siberia, C. Asia (from Turkmenia to Tian Shan), Iran and Afghanistan.

17.8. Biology and Ecology

Propagation and rooting :

S. plumosa, *S. ciliata*, *S. obtusa*, *S. raddiana*, *S. pungens*, *S. lanata* and *S. pennata* are all thermophilous species propagating themselves by seed ; two species *S. pungens* and *S. pennata* also propagate themselves vegetatively. Naegelé (1956) reports that new tussocks of *S. pungens* develop adventitious roots on buried stems in sand dunes in Mauritania and this process with the help of the prevailing wind can continue for several kilometres. *S. pungens* is also recorded (Rickli, 1943, Guinea, 1944) as having an extensive system of shallow roots spreading up to 15-20 m on sand dunes. In the USSR cuttings of *S. pennata* have produced adventitious roots in 90 % of the cases (Suslova, 1935).

Seed characteristics :

Pabot (1967) states that the seeds of *Stipagrostis* spp. have the special property of boring themselves into the soil due to the action of the wind on their curved and springy plumose awns which assures natural re-seeding. In South Africa *S. ciliata* and *S. obtusa* are reported (Vorster, 1959-60) to produce abundant seed which is readily dispersed.

Growth and development :

In North Africa and the Near East the above mentioned *Stipagrostis* spp. grow vegetatively practically throughout the year in desert and sub-desert regions with mild winters ($+1^{\circ}\text{C}$) and they normally flower in the cool season (spring) ; in Lebanon and Syria *S. lanata* is reported (Mouterde, 1966) to flower throughout the year.

Fruiting generally takes place in early summer (June-July) and at this stage the flowering stems, usually dry, and are yellow-green. However the basal leaves and stems remain green throughout the year and re-growth is strong in the dry season especially on deep sands which retain moisture.

Climate and soils :

All the above mentioned *Stipagrostis* spp. are very drought resistant and also support cold temperatures in winter (0°C) when they remain dormant. Pabot (1967) states that some ecotypes of *S. plumosa* in Iran support very cold winters.

Generally the above mentioned *Stipagrostis* spp. are well adapted to an annual rainfall varying from 50-400 mm and Pabot (1967) records that *S. plumosa* in Iran does not generally succeed in regions with more than 400 mm rainfall.

In the former Spanish Sahara Guinea (1944) considers that *S. pungens* is the hardiest species, while in Palestine, where *S. pungens* is not present, *S. obtusa* is considered (Boyko, 1949) to be the most drought resistant species followed by *S. plumosa* and *S. ciliata*.

In regard to edaphic factors *S. pungens* and *S. pennata* are particularly adapted to colonizing sand dunes and *S. pennata* is also a salt tolerant species ; *S. plumosa* develops essentially on the better drained soils with a sandy or gravelly surface, while *S. ciliata*, *S. obtusa* and *S. raddiana* are all adapted to stony or gravelly soils. In general the above mentioned *Stipagrostis* spp. do not tolerate heavy or saline soils.

Ecological characteristics :

Ecologically *S. plumosa* is the most widespread species in North Africa and the Near East and occurs in a number of plant associations while the other mentioned *Stipagrostis* spp. occur in more specific and sometimes restricted plant associations.

In Tunisia Le Houérou (1969) records in the various steppic associations *S. plumosa* as the major component in the *Artemisia campestris*/*S. plumosa* association (200-300 mm annual rainfall, 500-800 m elevation) on sandy soils and as a scattered component in the *Eragrostis papposa*/*Artemisia campestris*/*Ziziphus lotus* association (200-350 mm annual rainfall, 100-400 m elevation) on deep sands ; *S. pungens* as a major component of the *Rumex tingitanus* var. *lacerus*/*S. pungens* association (200-400 mm annual rainfall, 0-800 m elevation) on sand dunes ; *S. plumosa* and *S. ciliata* as scattered components of the *Launaea angustifolia*/*Erodium glaucophyllum* association (200-300 mm annual rainfall, above 600 m elevation) on gypsiferous soils and *S. ciliata* as a major component of the *Lygeum spartum*/*S. ciliata* association (200-300 mm annual rainfall, 0-300 m elevation).

In Egypt (UAR) Kassas and El Abyad (1962) record *S. ciliata* as occurring in five desert community types, and Ibrahim (1968) mentions that it is a typical component of the *Artemisia herba-alba*/*Asphodelus microcarpus* association in the Mediterranean coastal belt on deep sands which he believes is the northern ecological border of *S. ciliata*.

In southern Palestine Boyko (1949) records a climax vegetation of *S. ciliata* with *Stipa* spp. in the 200-250 mm annual rainfall zone (600 m elevation and above) and of *S. plumosa* and *S. obtusa* in the 150-200 mm annual rainfall zone (below 600 m elevation).

In Jordan Long (1957) records *S. ciliata* as being a component, in the Saharan Mediterranean climate (100-200 mm annual rainfall, +6°C max. temperature of coldest month, 800-1,200 m elevation), of the *Echiochilon fruticosum*/*Helianthemum sessiliflorum*/*Rhantherium garcini* association on coarse sandy slopes and of the *Zilla spinosa*/*Anabasis articulata* association on alluvial sandy terraces where *S. plumosa* and *S. obtusa* are also present.

In Saudi Arabia *S. plumosa* is reported (Kingery, 1972) to occur on reddish-yellow loam sands with *Panicum turgidum*, *Acacia* spp., *Rhantherium epapposum*, *Lasiurus hirsutus*, *Achillea fragrantissima* and *Haloxylon salicornicum* (50-75 mm annual rainfall, 800-1,100 m elevation, north of the 21 st parallel) ; on loose or slightly stabilized sands overlying sandstones and gypsum with *Panicum turgidum* and *Pennisetum dichotomum* (50 mm annual rainfall, 500-800 m elevation) ; in the north on rocky limestone plateaux with wind-blown sand with *Rhantherium epapposum* and *Astragalus spinosus* (50 mm annual rainfall, 175-500 m elevation) ; on ancient alluvia covered with wind blown sand with *Cyperus conglomeratus* and *Tribulus* spp. (less than 50 mm annual rainfall) ; and on cemented sandy plains with *Molukia ciliata* (70 mm annual rainfall).

In Kuwait Kernick (1966) records *S. plumosa* as occurring in association with *Panicum turgidum*, *Lithospermum callosum*, *Cyperus conglomeratus* and *Danthonia forskalii* on coastal sands (50-150 mm annual rainfall) and also in the south as a scattered component of the *Rhantherium epapposum* steppe (50-100 mm annual rainfall) on sandy gravel.

In Iraq Kernick (1976) records *S. plumosa* as occurring in the Jezeira (150-250 mm annual rainfall) in association with *Artemisia scoparia*, *Achillea conferta* and *Haloxylon salicornicum* on dark brown gypsiferous sandy soils and with *Ammothamnus gibbosus*, *Prosopis farcata* and *Cyperus conglomeratus* on localized sand dunes, and in the Kirkuk Plain (200 mm annual rainfall) with *Salsola rigida* on sandy gravel plateaux.

In Iran *S. pennata* is mentioned by Zohary (1963) as covering extensive sand dunes in the Khorassan Province (between Konabad and Torbat Haidarie), while Pabot (1967) records that *S. plumosa* is abundant in the sandy areas of the south up to 2,000 m elevation, and also occurs in association with *Artemisia herba-alba* and other small shrub species in the centre and east up to 1,200 m elevation.

In Afghanistan Pabot (1962) records that *S. plumosa* is abundant on firm sands in the large central plateau area (100 mm annual rainfall, 500-1,000 m elevation).

17.9. Cultivation Techniques

Seeding and seedling survival :

The result of pot and/or nursery sowing trials indicate that *S. plumosa*, *S. ciliata* and *S. pennata* can be successfully seeded in arid regions. Bourreil (1967) reports that 40-50 % of seedlings of *S. plumosa* and *S. ciliata* seeded in August have survived in experiments in Tunisia and southern Africa ; Bourreil (1969) also records that nursery plants of *S. ciliata* originating from North Africa and established by seed survived winter frost in the north west littoral zone of the Mediterranean region near Marseille and flowered in August.

However in the USSR Rudenko (1934) reports that developing seedlings of *S. pennata* seeded at the Repetek Sand Station were killed by rapid soil drying and insulation but survived when irrigated.

Vegetative propagation :

In the USSR Suslova (1935) recommends that vegetative propagation is the most effective method of establishment for *S. pennata*. This is accomplished by digging up plants of *S. pennata* cutting off the tips of the stems, dividing the plants into sections and planting them ; about 90 % of the cuttings produce roots and they can resist shifting sands in the year of planting.

S. pungens can also be propagated vegetatively and farmers in Libya are reported (Keith, 1965) to scatter cuttings of *S. pungens* on the soil when planting *Hordeum vulgare* under shifting cultivation to reduce sand blow.

Seed germination and method of sowing :

Seed germination of *S. pennata* in the USSR is very high (close to 100 %) but if propagation is made by seeds measures must be taken to protect the seedlings from shifting sands especially in the first year. In the case where *S. pennata* is propagated by seeds Gael and Ostanin (1938) recommend surface sowing of seeds.

17.10. Forage Value

Palatability :

In native desert ranges in North Africa and the Near East *S. plumosa*, *S. ciliata*, *S. obtusa*, *S. raddiana*, *S. pungens*, *S. lanata* and *S. pennata* are considered to be palatable to sheep, goats and camels. Dickson (1955) also notes that *S. plumosa* is a favourite food for horses in Kuwait and is harvested for this purpose in the summer, while Naegelé (1977) records that *S. pungens* is especially liked by camels in Mauritania.

In general all the above mentioned *Stipagrostis* spp. become less palatable after heading as they progressively lignify.

Nutritive value :

The nutritive value of the stems and leaves is fair to good as shown by the following data obtained for *S. plumosa* in Kuwait (Kernick, 1966) :

	Date Sampled	Crude Fibre	Crude Protein	Potassium	Phosphorous	Calcium
New leaves and shoots	22.1.62	27.720	14.870	0.009	0.392	0.0667
Dry leaves and shoots	3.11.63	24.750	7.530	0.550	0.010	1.360

17.11. Forage and Seed Production

Forage yields :

No data is available on forage and seed production of the previously mentioned *Stipagrostis* spp. in North Africa and the Near East although Ibrahim (1968) records that *S. ciliata* is less productive than *Stipa* spp. in the coastal belt of Egypt (UAR).

However Naegelé (1977) records forage yields for *S. pungens* in March-April, sampled at nine individual sites in the Mauritanian steppe, varying from 1,300-5,200 kg/ha DM on sands in a region with an annual rainfall varying from 25-150 mm.

In the USSR Kurrochkma et al. (1972) also record a total biomass yield of 2,820 kg/ha DM for *S. pennata* in a psammophytic community in the southern Balkhash area ; 670 kg/ha DM of the total biomass was composed of litter.

17.12. Utilization

Grazing and forage conservation :

All the previously mentioned *Stipagrostis* spp. provide excellent grazing in the spring and summer in arid desert regions often where few other grasses are present. Le Houerou (1962) also recommends that they be reseeded in the dry steppe areas of Tunisia for forage conservation.

Grazing management :

Once *Stipagrostis* spp. are established rotational grazing management will almost certainly be needed since Ibrahim (1968) records that *S. ciliata* in Egypt (UAR) rapidly increases in density and vigour under light grazing use.

Soil conservation :

S. pungens and *S. pennata* and to a lesser extent *S. plumosa* and *S. ciliata* are valuable sand binders and can be used for erosion control on sand dunes areas with 150 mm annual rainfall or less.

Further evaluation :

However more studies are needed on seed production, seeding techniques, palatability and utilization, particularly in regard to the various native ecotypes present, before the valuable *Stipagrostis* spp. previously mentioned can receive wider recognition and agronomic use.

17.13. Specific References

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FAMILY GRAMINEAE (= POACEAE)

ANNUAL SPECIES

18. *Lolium* spp.

TECHNICAL DATA

SHEET No 18

GRAMINEAE (= POACEAE)

Lolium spp.

18.1. Species

There are four *Lolium* of forage importance in North Africa, the Near and Middle East. These species, in order of importance are *L. multiflorum* Lam., *L. rigidum* Gaud., *L. loliaceum* (Bory and Chaub.) Hand.-Mazz. and *L. persicum* Boiss. et Hoh. ex Boiss.

18.2. Synonyms

- *L. multiflorum* (= *L. scabrum* J.S. Presl. ex C.B. Presl.,
L. italicum A. Br.)
- *L. rigidum* (= *L. strictum* Presl.)
- *L. loliaceum* (= *Rottboellia loliacea* Bory et Chaub.,
L. subulatum Vis., *L. rigidum* var.
rottboellioides Heldr. ex Boiss.,
L. rigidum Gaud. var. *loliaceum* (Bory
et Chaub) Hal.)

18.3. Common Names

- | | | |
|-------------------------|---------|--|
| - <i>L. multiflorum</i> | English | Italian Ryegrass. |
| | French | Ray-Grass Italie. |
| | Arabic | Khortane, Maddoun, Mandjour,
Noussel', Zamma (Morocco). |
| - <i>L. rigidum</i> | English | Rigid Ryegrass, Annual Ryegrass,
Swiss Ryegrass (USA) ;
Wimmera Ryegrass (Australia). |
| | Arabic | C'hortam, Samma, Zaywahn (Libya) ;
Sahleh, Zommeir (Egypt, UAR) ;
Sammah, Nusayl (Jordan) ;
El-Shailem (Syria) ;
Ruwaita, Irwaita, Hamaita (Iraq). |
| - <i>L. persicum</i> | English | Persian Ryegrass. |

18.4. Brief Description

- *L. multiflorum* is an annual or biennial grass with solitary or fascicled culms attaining a height of up to 100 cm with slender or rather stout spikes and awned lemmas (Fig. 1) ;

- *L. rigidum* is an annual grass with ascending, spreading smooth and glabrous rather stout stems, attaining a height of up to 80 cm and often branched at the base, and with stiff spikes and long awnless or short awned lemmas (Fig. 2 and 3) ;

- *L. loliaceum* is an annual grass tuftedly branched at the base and attaining a height of up to 35 cm, usually purple below the nodes and with straight or slightly curved spike and uncurved lemmas (Fig. 4) ;

- *L. persicum* is an annual grass with solitary or fascicled erect smooth culms attaining a height of up to 80 cm with dark green leaves and long lemmas awned from the tip (Fig. 5).

18.5. Varieties

Botanical subspecies, varieties and forms :

In North Africa both Maire (1955) and Quezel and Santa (1962) divide *L. multiflorum* into two subspecies, ssp. *italicum* (A. Br.) Schinz et Keller, a fairly constant type with a life cycle of 2-3 years and ssp. *gaudini* (Parl.) Schinz et Keller, a constant annual or biennial type.

Maire (1955) also records the following botanical varieties and forms of *L. multiflorum* and *L. rigidum* in North Africa :

- *L. multiflorum* ssp. *italicum* (A. Br.) Schinz et Keller :
 - var. *aristatum* (Willd.) Maire et Weiller, comb. nov.
(= *L. italicum* A. Br. sensu stricto)
with straight leaves and lemmas with sharp awns ; common in the north and north-west in the mountains up to the Grand Atlas ;
 - f. *longiaristatum* Asch. et Gr.
with long awned superior lemmas, type variety ; here and there throughout the region ;
 - f. *submuticum* Mutel.
with some lemmas briefly curved, others uncurved ; rare but also recorded by Tackholm (1974) in the littoral desert area of Egypt



Fig. 1

A - *Lolium multiflorum*

Plant, $\times \frac{1}{2}$. Spikelet, $\times 3$. Floret, $\times 5$.

B - *Lolium perenne*

Plant, $\times \frac{1}{2}$.

(After Manual of the Grasses of the United States, 1950, p. 276, fig. 370)



Fig. 2 - *Lolium rigidum* Gaud.

1. Habit, $\times \frac{2}{3}$. 2. Terminal spikelet, $\times 3$. 3. Lower glume, $\times 10$. 4. Upper glume, $\times 10$. 5. Lemma, $\times 10$. 6. Palea, $\times 10$. 7. Flower, $\times 10$. 8. Grain, $\times 20$. 9. Ligule, $\times 6$.

(After Flora of Iraq, vol. 9, 1968, p. 97, plate 33)

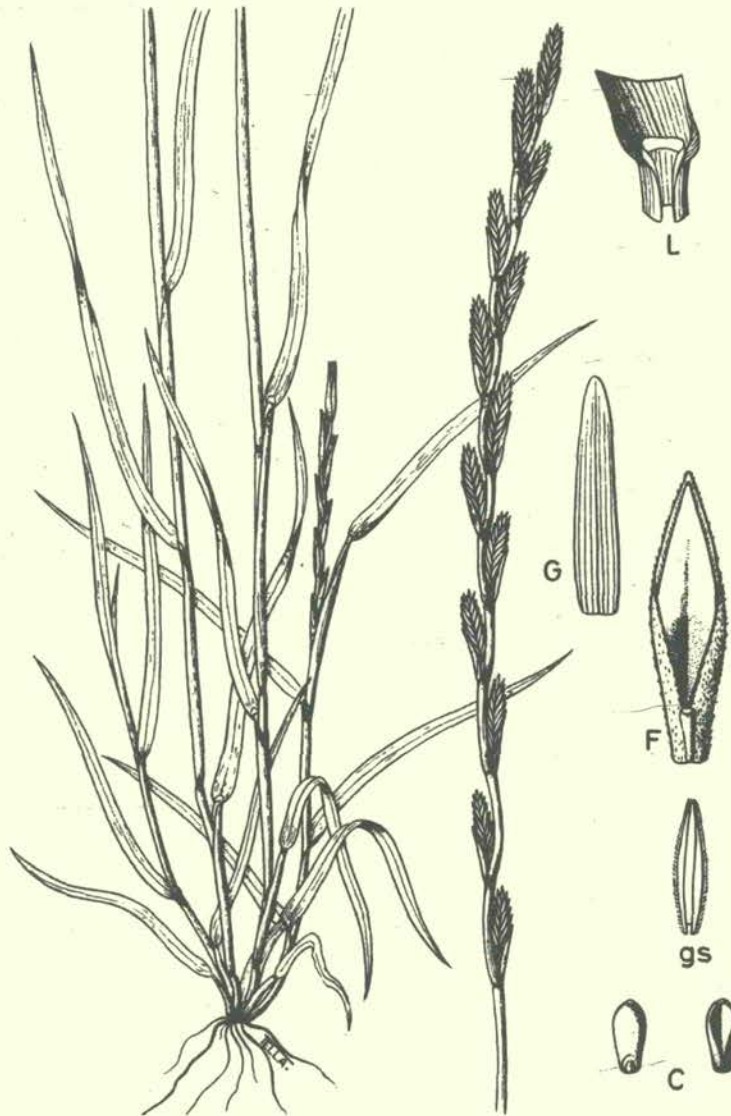


Fig. 3 - *Lolium rigidum*

Plant, x1. F : Fruit enclosed by the glumes, x8. G : Glume, x4. gs : superior glume, x4. C : Caryopsis (dorsal and ventral view), x4. L : Ligule, x2.

(After Introduccion al Estudio de las Especies Pascícolas Espanolas, Madrid, 1965, p. 144)

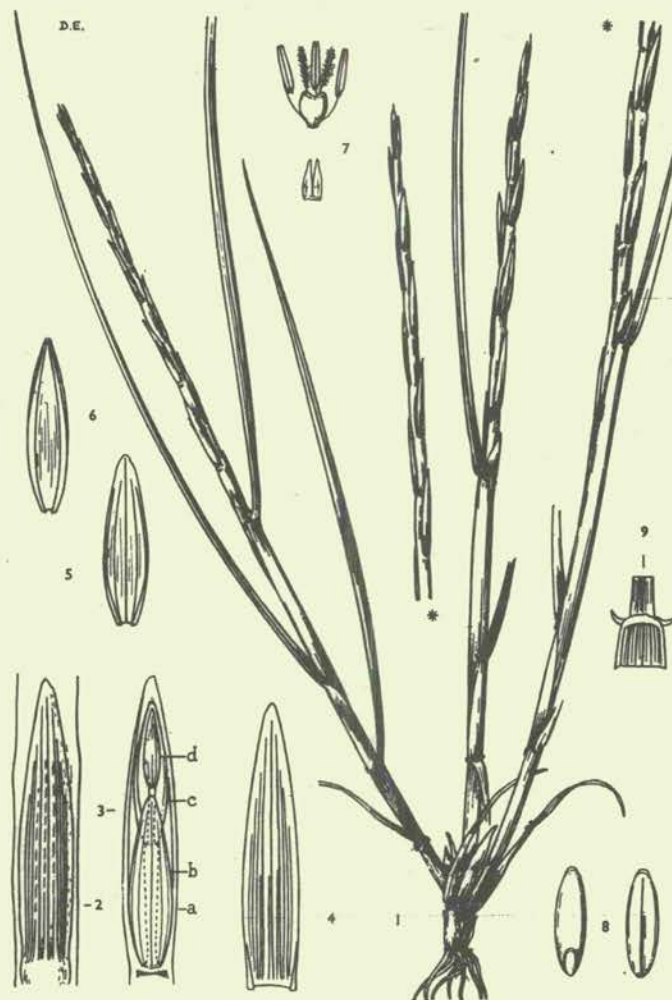


Fig. 4 - *Lolium loliaceum* (Bory et Chaub.) Hand.-Mazz.

1. Habit, $\times \frac{2}{3}$. 2. Spikelet viewed from outside, $\times 3$. 3. Spikelet from inside ; a, upper glume ; b, lowest lemma ; c, second lemma ; d, third lemma, $\times 3$. 4. Upper glume, $\times 3$. 5. Lowest lemma, $\times 3$. 6. its palea, $\times 3$. 7. Flower, $\times 3$. 8. Grain, $\times 3$. 9. Ligule, $\times 1$

(After Flora of Iraq, vol. 9, 1968, p. 9, plate 31)

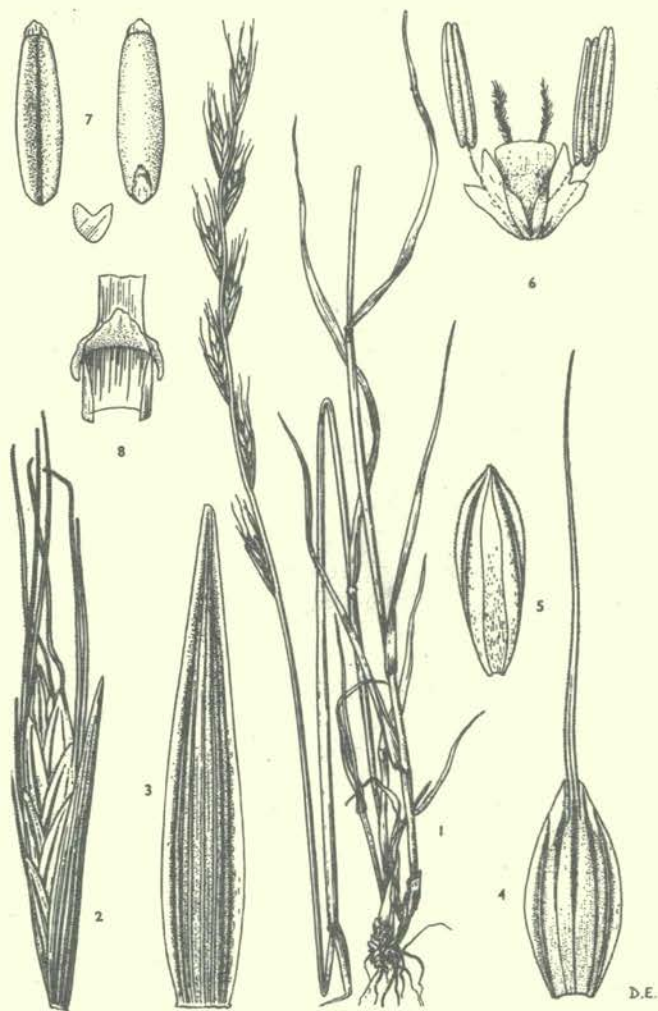


Fig. 5 - *Lolium persicum* Boiss. et Hoh.

1. Habit, $\times \frac{2}{3}$. 2. Lateral spikelet, $\times 4$. 3. Upper glume, $\times 6$. 4. Lemma, $\times 6$.
5. Palea, $\times 6$. 6. Flower, $\times 6$. 7. Grain, $\times 6$. 8. Ligule, $\times 3$ |

(After Flora of Iraq, vol. 9, 1968, p. 95, plate 32)

- *f. muticum* D.C.
with muticated lemmas ; here and there throughout the region ;
- *var. latifolium* Maire in M., C.
with obtuse lemmas even emarginated ; present in the Cedar zone Forest.
- *L. multiflorum* ssp. *Gaudini* (Parl.) Schinz et Keller :
 - *var. siculum* (Parl.) Maire in J. et M. (= *L. siculum* Parl.)
with very obtuse lemmas even emarginated and muticated ;
present in maritime areas in Algeria ;
 - *var. Gaudini* (Parl.) Asch. et Gr.
with scabrous stems under the seed head ; present in Tripolitania and recorded by Tackholm (1974) in the littoral and desert of Egypt
 - *f. macratherum* Maire et Weiller n. nom. (= *L. multiflorum* var. *Gaudini* f. *longiaristatum* Pamp.)
with all or nearly all, lemmas awned ; type variety ;
 - *f. brachyatherum* Maire et Weiller n. nom. (= *L. multiflorum* var. *Gaudini* f. *submuticum* Pamp.)
with one muticated lemma, the others briefly curved ; present here and there with the type variety ;
 - *f. anatherum* Maire et Weiller n. nom. (= *L. multiflorum* f. *muticum* Asch. et Gr.)
with muticated lemmas, present here and there with the type variety ;
 - *f. ramosum* Guss.
with a rainfed seedhead, present here and there but rare ;
 - *var. laeviculme* Maire in M., C.
with loose stems ; common in Morocco.
- *L. rigidum* :
 - *var. genuinum* (G.G.) Briq. (= *L. strictum* var. *genuinum* Godr in G.G.)
with scabrous stems under the inflorescence and angular spike on the rachis ; common throughout Algeria and Morocco ;
 - *var. compressum* (Boiss. et Heldr. in Boiss.)
(= *L. multiflorum* var. *Gaudini* f. *muticum* Pamp.)
with curved spike and very broad spikelets ; present here and there in the littoral of Cyrenaica, also recorded by Tackholm (1974) in the littoral of Egypt ;
 - *var. tenue* (Godr. in G.G.) Durd. et Schinz (= *L. strictum* var. *tenue* Godr. in G.G., *L. rigidum* var. *maritimum* (Godr. in G.G. Briq.)
with slightly sharp lemmas and straight seedheads and more or less protruding spikelets ; common in the littoral of Cyrenaica ;

- *f. maritimum* Godr. (Maire et Weiller) (= *L. strictum* var. *maritimum* Godr. in G.G.)
with glumes nearly equal in length to the spikelet ; present throughout the littoral of North Africa ;
- *f. transiens* (Burolet) Maire et Weiller, comb. nov. (= *L. rigidum* var. *transiens* Burolet)
with short glumes equal to half or one third of the length of the spikelet ; present here and there but rare ;
- *f. macilentum* (Delastre) Maire et Weiller, comb. nov. (= *L. tenue* Guss. non L., *L. macilentum* Delastre)
with 3-5 flowered spikelets ; common in the littoral zone of Cyrenaica ;
- *var. subteres* Maire et Weiller in M.C. (= *L. lepturoides* Boiss. *f. maritimum* Trabut., *L. rigidum* var. *teres* *f. maroccanum* (Sennen) Maire in J. et M. n. *nudum*, *L. rigidum* var. *transiens* *f. latiglume* Burolet)
with obtuse lemmas often a little mucronated ; present on the Atlantic coast but more rare in the Rif of Morocco ;
- *var. corsicum* Briq. (= *L. strictum* Presl. *f. aristatum* Maire in M.C.)
with curved lemmas ; present in the Eastern Sahara ;
- *var. oliganthum* (Godr.) Maire et Weiller, comb. nov. (= *L. temulentum* var. *oliganthum* Godr in G.G., *L. rigidum* var. *rottboellioides* Heldr. in Boiss., *L. subulatum* Vis., *Rottboellia loliacea* Bory et Chaubard, *L. rigidum* var. *lepturoides* (Boiss.) Fiori et Paol., *L. lepturoides* Boiss.)
with loose, sometimes decumbent stems ; present throughout Algeria and Morocco ;
- *var. teres* (Lindb.) Maire in J. et M. (= *L. teres* Lindberg)
with spreading stems scabrous at the summit, present in Morocco ;
- *var. atherophorum* Maire in M., C.
with sharply awned scabrous lemmas ; present in Algeria.

In Egypt (UAR) Tackholm (1974) also records the following botanical varieties not previously mentioned :

- *L. multiflorum* :
- *var. ramosum* Guss.
with a branched spike ; present in the littoral and desert ;
- *var. cristatum* Timon
with approximate spreading spikelets ; present in the littoral and desert.

Native ecotypes :

Villax (1963) mentions that *L. multiflorum* is very rich in ecotypes and a number of indigenous ecotypes have been collected and seeded under dryland conditions in Tunisia (Corriols, 1965).

Several local ecotypes of *L. rigidum* have also been collected in Tunisia (Jaritz and Shulke, 1972), in Israel (Tadmor et al., 1971), in Jordan (Hopkinson, 1975) and in Cyprus (Soteriadou, 1959) ; Soteriadou (1959) also records that *L. rigidum* is a variable species with some later maturing strains which are more drought-resistant than the others.

Agricultural varieties :

The botanical variety *L. multiflorum* Lam. var *westermoldicum* March. is a good example of an annual type developed for agriculture use in Germany and tested in North Africa and Egypt (UAR) which has more rapid development than the biennial type of *L. multiflorum*.

In Tunisia, Ahmim et al. (1975) report that the diploid varieties of Rita and Bernburger, and the tetraploid varieties "Tetrone", "Dilana" and "Pollanum" have been collected and tested under dryland conditions, while Van der Veen (1967) reports that diploid and tetraploid varieties of *L. multiflorum* from Holland have been tested under dryland conditions in Syria ; the tetraploid variety "Tetrone" has also been tested in Egypt (UAR) (Raafat et al., 1974).

Improved agricultural varieties have also been developed by crossing *L. multiflorum* with *L. perenne* to produce H.1 from New Zealand and "Io" and "Regrid" from France ; Soteriadou (1959) considers short rotation ryegrass varieties to be more drought resistant than those of *L. multiflorum* and also adapted to grow on poorer soils.

L. multiflorum has also been crossed with *L. rigidum* and Malik (1967) reports that the results suggest that the two species are phylogenetically related and possibly separated quite recently.

Whyte et al. (1959) also record that *L. rigidum* crosses naturally with *L. loliaceum* and for this reason, the two species have often been confused.

In Australia, three agricultural varieties of *L. rigidum* have been developed from local ecotypes, namely "Commercial", "Wimmera" and "Early Merredin" ; "Early Merredin" is, in fact, an early flowering selection of "Wimmera".

The "Wimmera" variety has performed well in dryland farming areas of Australia with 375 mm annual rainfall and successful dryland test seedings of this variety have been made in the littoral zone of Tunisia and the semi-arid areas of Cyprus, Jordan, Syria, N. Iraq and N. Iran ; the variety "Early Merredin" has also been tested in Cyprus.

Corriols (1965) also reports that a variety No. 504 of *L. loliaceum* has been developed in Australia and tested under dryland conditions in Tunisia ; this variety was presumably developed from material originally collected in the Mediterranean region.

18.6. Number of Chromosomes

L. multiflorum : $2x = 14, 28$;
L. rigidum : $2x = 14$;
L. loliaceum : $2x = 14$;
L. persicum : not known.

18.7. Geographical Distribution

L. multiflorum is distributed in West, Central and Southern Europe (including southwest USSR), Turkey, Transcaucasia, Iraq, Iran, Palestine, Egypt, Macaronesia, North Africa (Morocco, Algeria, Tunisia and Libya) and introduced into most temperate lands such as China, Japan, Australia, South Africa and North America ;

L. rigidum is distributed in Mediterranean Europe (extending to South Central Europe), Syria, Lebanon, Palestine, Jordan, Egypt, Turkey, Caucasus, Iraq, Iran, Kuwait, Afghanistan, Northwest India, Central Asia (Turkmenia), North Africa (Morocco, Algeria, Tunisia, Libya) and introduced into Australia and North and South America ;

L. persicum is distributed in Palestine, Turkey, Caucasus, Iraq, Iran, Pakistan, Afghanistan, Central Asia (Turkmenia to Tien Shan) and introduced into North America ;

L. loliaceum is distributed in Mediterranean Europe (France to Balkans), Crimea, Crete, Turkey, Transcaucasia, Syria, Lebanon, Palestine, Egypt and introduced into Japan, South Africa, Australia and North America (USA).

18.8. Biology and Ecology

Growth and development :

L. multiflorum, *L. rigidum*, *L. persicum* and *L. loliaceum* are all cool season species which propagate themselves by seed.

In the Mediterranean basin, all these *Lolium* spp. grow well after the autumn rains and growth continues in the winter if temperatures are mild.

Villax (1963) records that dryland seeded *L. rigidum* in particular, grows vigorously and rapidly, but that *L. multiflorum* is more at risk during long or cold freezing periods, although it can maintain itself quite well in

a dormant state when conditions are not favourable to growth. Maignan et al. (1975) also record that *L. rigidum* develops well in the winter in Morocco in areas with 250 mm annual rainfall and in the spring development is rapid with a large production of palatable forage.

Corriols (1965) records that a variety of *L. loliaceum* from Australia has grown well after autumn rains in Tunisia and has furnished a fair bulk of forage by the end of April.

In Libya Ketchum et al. (1976) record that dryland autumn (November) seeded *L. rigidum* produced more forage than dryland *Avena sativa* or *Hordeum vulgare* in a below average rainfall year.

In Cyprus, Soteriadou (1959) records that dryland autumn seeded *L. multiflorum* and *L. rigidum* both made quick growth and produced a good bulk of palatable forage in early winter, but plants of *L. rigidum* tended to dry up in the spring.

In North Iraq, Kernick (1976) reports that dryland test plantings of exotic varieties of *L. multiflorum* and *L. rigidum* seeded in November or December have germinated well and produced seedlings in January which resisted well temperatures of -3°C to 4°C for short periods.

In Jordan, Hopkinson (1975) records that in one year, dryland seeded *L. rigidum* made good growth in late winter, but in another year growth started later.

Main growth period :

The main growth of all the above mentioned *Lolium* spp. is in the spring. In the Mediterranean region, Villax (1963) records that *L. rigidum* furnishes a considerable bulk of forage three to four months after autumn seeding and after harvesting a satisfactory regrowth follows if the moisture conditions are favourable.

At Giza, in North Egypt, Rafaat et al. (1967) report that growth of November seeded *L. multiflorum* var *westermolcicum* was slow at the beginning but increased gradually until production of leaves and stems reached a peak after five months growth, which coincided with ear emergence ; production of leaves stopped soon afterwards and stem growth also declined. A single defoliation carried out after three months greatly reduced the subsequent growth rate of leaves and stems.

In North Iraq, Kernick (1976) reports that dryland *L. multiflorum* and *L. rigidum* seeded in November on alluvial soil in one year grew well in February and March, producing a substantial bulk of spring forage even though only 20 mm of rainfall was received in March. Regrowth of both species was negligible but substantial in the following year's seeding when spring rainfall in March-April was sufficient and well distributed.

Rust diseases :

In North Africa, where the winters are more humid, both Villax (1963) and Corriols (1965) report that exotic varieties of *L. multiflorum* have proved very susceptible to rust diseases, but those of *L. rigidum* have remained largely unaffected. However, in Cyprus, Soteriadou (1959) records that most exotic varieties of *L. rigidum* showed poor resistance to rust diseases.

In Tunisia, Corriols (1965) mentions that *L. loliaceum* produces a good quantity of seeds, but if harvesting is delayed beyond maturity, losses from harvester ants can be serious, since the species readily sheds its seeds. Whyte et al. (1959) report that *L. rigidum* is free seeding and will regenerate naturally from fallen seed.

Excellent seed set and seed production is also reported (Kernick, 1976) for dryland seeded *L. multiflorum* and *L. rigidum* during a two-year trial period in Iraq (seasonal (November-May) rainfall 375-474 mm).

Climate and soils :

Le Houerou (1969) indicates that native *L. rigidum* in the Tunisian steppe is very drought resistant, being adapted to a rainfall as low as 100 mm and also supporting cold to warm winters.

Both *L. multiflorum* and *L. rigidum* are well adapted to dryland seeding in semi-arid areas of North Africa and the Near and Middle East with at least 400 mm annual rainfall ; in Morocco, Ionesco et al. (1969) recommend an annual rainfall in excess of 400 mm.

L. multiflorum, which is less drought-resistant, gives superior results in areas with 600 mm annual rainfall and Le Houerou (1969) considers it is an interesting species for areas receiving such a rainfall in Northern Tunisia.

L. multiflorum is best adapted to moist, well drained, fertile soils, while *L. rigidum* does best on the heavier soils but also does quite well on light, even sandy calcareous soils.

Ecological characteristics :

Ecologically, all the previously mentioned *Lolium* spp. can be found as scattered components of the native vegetation or as weeds in abandoned or cultivated fields.

In North Africa, Maire (1955) records that *L. multiflorum* occurs in humid and semi-arid regions in the plain and the mountains up to 2,000 m elevation, while *L. rigidum* occurs in semi-humid/semi-arid regions in the littoral plains and mountains.

In Tunisia, Corriols (1965) records that *L. multiflorum* exists naturally in the littoral region of Tunis at Zarzis and also at Tozeur, and is also a frequent invader of cereal crops in the region of Mateur. He also records *L. rigidum* as occurring naturally at Ben-Gardanne and Gafsa.

In the Tunisian steppe, Le Houerou (1969) records that *L. rigidum* occurs in 12 different steppic plant communities with an annual rainfall range of 180-500 mm and an elevation range of 300-1,200 m .

In Cyprus, Jones et al. (1958) record that *L. rigidum* occurs sparsely throughout most of the grass steppe and barth communities.

In Lebanon and Syria, Mouterde (1966) records that *L. multiflorum*, ssp. *Gaudini* (ssp. *italicum* is not spontaneous) flowers from April to June and occurs on the littoral, plain and mountain ; *L. rigidum* flowers from March to June and occurs in fields and abandoned places ; *L. persicum* flowers from April to June and occurs in moist places ; and *L. loliaceum* flowers from March to May and occurs throughout the littoral.

In Iraq, Bor and Guest (1968) record that *L. multiflorum* flowers and fruits from March to April and occurs as a weed on irrigated land ; *L. rigidum* flowers and fruits in humid places in the steppe mountains and as a weed in fields up to an elevation of 1,900 m ; *L. persicum* flowers and fruits from March to May and occurs in humid places in the mountains and as a weed in the plains up to an elevation of 1,200 m ; and *L. loliaceum* is very rare - found only twice in the moist steppe and lower forest zone.

In Iran, Parsa (1950) records *L. multiflorum* as occurring in Azerbaidjan, near Tabriz, and at Gotvand near the Iran/Iraq border ; *L. rigidum* occurs in Lorestan (800-900 m elevation), Busheir, at Gotvand and Kuhe Sefid (1,800-3,465 m elevation) ; and *L. persicum* in the Elburz mountains (1,400-2,200 m elevation), in the vicinity of Teheran, Rezaiyeh, Lorestan, Baluchestan and at Badghis.

In Afghanistan, Kitamura (1960) records *L. loliaceum* as occurring at Kandahar and *L. persicum* at Gilgit (1,500 m elevation), while in Pakistan Kitamura (1964) records *L. rigidum* as occurring at Quetta and *L. persicum* at Karakoram (1,500 m elevation).

18.9. Cultivation Techniques

Time of seeding :

In North Africa it is recommended (Villax, 1963, Corriols, 1965, Le Houerou, 1969, Ionesco et al., 1969) to seed dryland *L. multiflorum*, *L. rigidum* and *L. loliaceum* at the end of September or after the first autumn rains.

In Cyprus and also in North Iraq, good results have been obtained from seeding *L. multiflorum* and *L. rigidum* in November-December, depending on the incidence of autumn rains (Jones et al., 1958, Kernick, 1976).

Land preparation :

A good firm weed-free seed-bed is required for seeding, which entails ploughing, discing, harrowing and rolling ; in Cyprus a chain harrow is recommended to obtain a fine seed-bed.

Seeding with legumes :

Both *L. multiflorum* and *L. rigidum* can be seeded with benefit in mixture with an annual legume. In Morocco and Tunisia, Ionesco et al. (1969) and Le Houerou and Froment (1969) recommend seeding *L. multiflorum* in a mixture with either *Trifolium resupinatum* (similar growth rhythm to *L. multiflorum* or *T. alexandrinum*.)

Villax (1963) also mentions that *L. rigidum* can be grown in a mixture with *Vicia sativa*, *V. atropurpurea*, *Trifolium incarnatum*, *T. resupinatum* and *T. subterraneum*.

In Cyprus Jones et al. (1958) report that *L. rigidum* is normally seeded in mixture with *Medicago truncatula* as done in Australia, but low seed rates have been found unsatisfactory because the stand is frequently thinned by harvester ants.

Seed rates and method of seeding :

Recommended seed rates and row spacings vary but the following have been reported from different countries :

Algeria : *L. multiflorum* : 12-15 kg/ha of seeds broadcast
(alone)

L. rigidum : 12-15 kg/ha of seeds broadcast
(alone)

Morocco

and : *L. multiflorum* : 20-25 kg/ha of seeds in lines spaced 15-20 cm
Tunisia : (alone) apart

L. multiflorum 5-7 kg/ha of seeds }
+ } broadcast
T. resupinatum 10-15 kg/ha of seeds }

L. rigidum : 5-15 kg/ha of seeds }
(alone) depth of seeding 2-3 cm } broadcast

<u>Cyprus</u>	: <i>L. rigidum</i>	: 7-11 kg/ha of seeds	} broadcast
	+ <i>M. truncatula</i>	: 9-14 kg/ha of seeds	
<u>Iraq</u>	: <i>L. multiflorum</i>	: 15 kg/ha of seeds broadcast (alone)	
	: <i>L. rigidum</i>	: 15 kg/ha of seeds broadcast (alone)	

Fertilizer application :

The application of fertilizer, particularly nitrogen, is important, especially for *L. multiflorum*. In Tunisia and Algeria, Le Hou  rou (1965) and Le Hou  rou and Froment (1969) recommend an application of 45 kg/ha P_2O_5 to the seed-bed followed by 60-100 kg/ha N split into three equal top dressings. Ionesco et al. (1969) mention that the quantity of nitrogen fertilizer to apply has not yet been determined experimentally, but they recommend 120-160 kg/ha N equivalent to that recommended for *Phalaris truncata*.

In the high plateaux zone of Algeria, Maignan (1970) reports that an application of 45 Kg/ha P_2O_5 has been applied to the seed bed of experimental dryland stands of *L. rigidum* and *L. multiflorum*, with split dressings each of 30 kg/ha N being applied in October, January and March in subsequent years.

In North Iraq, Kernick (1976) records that the application of 100 kg/ha N as a top dressing to dryland *L. multiflorum* in March has given a substantial yield response in a season (November-May) with 475 mm rainfall.

18.10. Forage Value

Palatability :

L. multiflorum, *L. rigidum*, *L. loliaceum* and *L. persicum* are all palatable to livestock especially in the vegetative stage and *L. persicum* is recorded (Bor and Guest, 1968) as making palatable hay ; *L. loliaceum* is, however, considered to be hard stemmed (Whyte et al., 1959).

L. rigidum is most palatable when it is young and succulent, but Bor and Guest (1968) state that there is evidence that it may become tough in the later stages of growth ; after flowering it is recorded (Bor and Guest, 1968) as having cut the mouths of sheep in Iraq.

Nutritive value :

The forage value of *L. multiflorum* is good and in Morocco Ionesco et al. (1969) record that it is of the order of 0.13 forage units and 26 g of

digestible protein per kilo fresh material, and 20 % DM in the green state and 0.55 forage units and 34 g of digestible protein per kilo fresh material and 88 % DM in the hay stage.

The nutritive value of dryland *L. multiflorum*, *L. rigidum* and *L. loliaceum* is also fair to good as the following chemical composition data recorded in different countries shows :

Morocco : (a) Rabat (Villax, 1963)

<i>L. multiflorum</i> : Percentage Composition						
Nature of Forage	Water	Protein	Fats	Carbohydrates Soluble Fibre		Ash
Green	81.5	3.6	0.9	7.4	3.5	3.1
Hay	20.0	15.8	3.8	32.0	15.3	13.1

(b) Mamora (Maignan et al., 1975)

<i>L. rigidum</i> : Percentage Composition Green Matter Basis									
Site	Sample	DM	Fats	Protein	Cellu- lose	Mineral matter	Non-N extract	Dig. Protein	Forage units
A	1	20.43	0.67	2.06	3.79	1.85	-	12.75	0.15
	2	20.84	0.90	2.05	3.80	1.75	12.34	12.70	0.16
B	1	16.53	0.63	2.00	4.11	1.07	8.72	12.39	0.13
	2	20.93	0.77	2.51	4.25	1.85	11.55	15.53	0.16
C	1	18.35	0.84	2.08	3.85	1.46	10.36	12.88	0.15
	2	22.59	0.99	2.49	3.85	1.87	13.39	15.41	0.18

Tunisia : Tunis (Corriols, 1965)

<i>L. loliaceum</i> : Percentage Composition Green Matter Basis (No. 504, Australia)						
Date Sampled	Protein	Fats	Non-N extract	Cellulose	Metabolizable energy/kg green matter	Forage units/kg green matter
11.4.56	1.58	0.82	5.46	4.56	490 c	0.13

Iran : Sang Deh (Dumancic, 1975)

Stage of Growth	DM	Crude Protein	Ca	P
End of Flowering	22.5	17.7	1.6	0.25

18.11. Forage and Seed Production

Forage yields :

In Tunisia Le Houerou and Froment (1969) report that the annual forage yields of *L. multiflorum* in mixture with annual legumes under dryland conditions is of the order of 20,000-50,000 kg/ha green forage and 4,000-9,000 kg/ha DM ; the proportion of the legume increases from the first to the last cut.

In N.W. Tunisia Gachet and Jaritz (1972) record an average forage yield for a dryland mixture of *L. rigidum* and *Trifolium subterraneum* over a 2 year period (average annual rainfall 875 mm) varying from 45,000-54,000 kg/ha green forage and 7,800-8,600 kg/ha DM.

In the littoral zone (500-600 mm annual rainfall) of Morocco Ionesco et al. (1961) and Villax (1963) report average forage yields for dryland *L. multiflorum* varying from 20,000-40,000 kg/ha green forage and 5,000-10,000 kg/ha hay ; with supplementary irrigation forage yields can be increased to 50,000-80,000 kg/ha green forage.

In the high plateaux zone (450-600 mm annual rainfall) of Algeria Maignan (1970) and Gallacher (1972) record average experimental dryland forage yields over a 1-2 year period of 44,000 kg/ha green forage for *L. multiflorum* x *L. perenne* (H 1), 27,000-48,000 kg/ha green forage for *L. rigidum* (variety "Wimmera") and 23,300-42,600 kg/ha green forage for *L. multiflorum* (Australian variety).

In Israel under run off farming conditions in the desert (80-100 mm rainfall) Tadmor et al. (1971) report that two local varieties of *L. rigidum* seeded each year in December in a small valley gave an average forage yield of 3,200-5,000 kg/ha DM over a 9 year period.

In N. Iraq Kernick (1976) reports that in dryland nursery plots on an alluvial soil in a season (November-May) with 375 mm rainfall, and less than 20 mm in March, autumn (November) seeded *L. multiflorum* (USA variety) gave a green forage yield of 22,500 kg/ha and *L. rigidum* ("Wimmera", Australia) a green forage yield of 24,000 kg/ha in early April.

Effect of rainfall and variety :

Forage yields under dryland conditions have varied with rainfall and the performance of the variety sown. The following specific data is given for various varieties of *L. multiflorum*, *L. rigidum* and *L. loliaceum* in various locations and varying annual rainfall conditions in Tunisia and Morocco :

Tunisia : (a) Tunis (Corriols, 1965)

1955-56 (664.7 mm rainfall)				
Species and variety	Green forage kg/ha	Dry matter kg/ha	Digestible Protein kg/ha	Forage Units/ ha
<i>L. multiflorum</i>				
No. 342 (local)	9,554	2,101	150	1,242
No. 643 (local)	6,999	1,539	110	909
No. 672 (local)	7,999	1,759	126	1,039
No. 666 (local)	6,666	1,466	105	866
Westerwolds Bi 419 (New Zealand)	8,110	1,784	128	1,054
<i>L. loliaceum</i>				
No. 504 (Australia)	10,000	2,200	158	1,300

1956 -57 (492.2 mm rainfall)				
Species and variety	Green forage kg/ha	Dry matter kg/ha	Digestible Protein kg/ha	Forage Units kg/ha
<i>L. rigidum</i>				
"Wimmera" <u>1/</u> (Australia)	11,554	2,541	182	1,502
"Wimmera V96" <u>1/</u> (Australia)	14,220	3,128	224	1,848
"Wimmera" <u>2/</u> (Australia)	22,542	4,937	354	2,917
<u>1/</u> Natural sowing (fallen seed) <u>2/</u> Original sowing (planted seed)				

(b) Mitidja (Ahmim et al., 1975)

L. multiflorum : Dry Matter Production (1972-73)									
Variety	Cutting interval 25 days kg/ha			Cutting interval 33 days kg/ha			Cutting interval 45 days kg/ha		
"Rita"	7,200			6,000			5,100		
"Bernburgher"	7,100			6,100			5,000		
"Tetrone"	7,900			6,900			5,700		
"Dilana"	8,300			6,500			5,700		
"Pollanum"	8,300			6,500			6,100		

Rainfall (mm)	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
total : 1042 mm	66	167	3	173	178	325	83	46	0.80
Long term 25 year average annual rainfall						:	658 mm		

At Mitidja the number of cuts had little effect on the yield but the tetraploid varieties yielded 10-12 % more than the diploids in the vegetative period. Increasing the frequency of cutting from 45 days to 25 days increased yield in the vegetative period by 40 % and diminished it by 30 % in the reproductive period.

Effect of fertilizer and soil :

In the Mamora forest area of Morocco Maignan et al. (1975) report the following forage yields under varying soil conditions and fertilizer application :

<i>L. rigidum</i> "Wimmera" (Australia)									
Treatment	Site A (shallow humid sand)			Site B (shallow-deep sandy-clay)			Site C (deep sandy-clay)		
	Green Forage kg/ha	Dry Matter kg/ha	Forage Units/ ha	Green Forage kg/ha	Dry Matter kg/ha	Forage Units/ ha	Green Forage kg/ha	Dry Matter kg/ha	Forage Units ha
Sulphate of Ammonia 46 % N 46 kg/ha N	18,875	3,636	2,278	23,250	4,461	3,117	14,700	2,952	1,695
Ammonium nitrate 33 % N 33 kg/ha N	21,500	4,595	2,801	19,225	3,998	2,311	16,925	3,472	2,370
Control (no fertilizer applied)	10,125	2,514	1,713	9,750	1,889	1,335	10,150	2,261	1,636
Average long term annual rainfall for 20 years (1946-67) : 535.5 mm									

Seed yields :

In regard to seed production, Villax (1963) records average experimental seed yields of 400-800 kg/ha for *L. multiflorum* in Morocco and he mentions also that the seed yield of *L. rigidum* is abundant ; seed production of both these species has also been excellent in N. Iraq.

18.12.. Utilization

Early forage and short rotations :

Both *L. multiflorum* and *L. rigidum* are excellent species for providing early forage production in winter and spring.

In Algeria Gallacher (1973) considers that *L. rigidum* is a very good species for fodder production and that *L. perenne* x *L. multiflorum* (H1) is a good early forage producer, suitable for short rotations since it persists for 3 years.

Number of cuts :

In Morocco Villax (1963) records that *L. multiflorum* furnishes one good cut and two re-growths (3-4 cuts in favourable conditions, (Ionesco et al., 1969), and *L. rigidum* one good cut and one re-growth in favourable moisture and temperature conditions with re-growth occurring without delay after grazing ; if the re-growths are not cut both species can be grazed 2-3 times after the first cutting.

In the high plateaux zone of Algeria Maignan (1970) also records that three cuts (one in March, one in April and one in May) have been taken from dryland seeded *L. multiflorum* and two cuts (one in March and one in April) from *L. rigidum*.

Dual purpose use and soil improvement :

In Morocco Ionesco et al. (1969) also report that *L. multiflorum* can be utilized for green forage (direct fed) grazing or conserved as silage or hay and that it also improves the physical structure of the soil through its well developed root system that provides additional organic matter.

Varieties for hay and silage :

In Tunisia Ahmim et al. (1974) have recommended for *L. multiflorum* the dryland cultivation of the varieties "Dilana" and "Tetrone" for green fodder and the variety "Rita" for hay and silage.

Stage of growth for hay production :

For hay production both *L. multiflorum* and *L. rigidum* should be cut before the formation of the panicles.

Livestock productivity on pasture :

In Cyprus Ramadan (1960, 1961) records that the productivity of a dryland *L. rigidum* pasture, grazed during the spring over a 3 year period by yearling sheep, has varied from 135-255 kg liveweight increase/ha/year ; an average liveweight increase of 215 kg/ha/year during February/April was obtained in one season with yearling sheep which strip grazed dryland pastures of *L. rigidum* with or without *Medicago truncatula*.

Further evaluation :

In the future more attention needs to be paid to the collection and testing of native ecotypes of *L. multiflorum* and *L. rigidum* which show good drought and disease resistance ; opportunities may also exist for crossing these ecotypes with local strains of *L. loliaceum* and *L. persicum*.

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PART TWO

LEGUMES

FAMILY PAPILIONACEAE (= FABACEAE)

PERENNIAL SPECIES

19. *Medicago* spp.
20. *Onobrychis* spp.

TECHNICAL DATA

SHEET No 19

PAPILIONACEAE (=FABACEAE)

Medicago spp.

19.1. Species

The most important species are in order of importance *M. sativa* L., *M. falcata* L. and *M. varia* Martyn. The latter two species are very closely related to *M. sativa* and either hybridize or are derived as a hybrid from it.

19.2. Synonyms

- *M. falcata* (= *M. falcata* subsp. *falcata* (L.) Arcang)
- *M. varia* (= *M. falcata* x *sativa*, *M. silvestris* Fries., *M. medea* Pers.)

19.3. Common Names

- | | | |
|---------------------|---------|---|
| - <i>M. sativa</i> | English | Blue Alfalfa (USSR) ;
Alfalfa (USA)
Lucerne (United Kingdom). |
| | French | Luzerne |
| | Arabic | Alfacah, Amara, Bersim Hadjazi, Fecad,
Fesefca, Kefiz, Mendidjel, Nefel, N'fel,
Rottba, Sefca, Safsafa (Morocco) ;
Sofsafah, Sofsa (Libya) ;
Berseem hegaazi, Gaddooh, Qadaab, Qadb,
Qarad (Egypt (UAR) ;
Bersim hedjazi, Fussa (Syria) ;
Bersim hedjazi, Barsim hijazi, Duhrayjah,
Fussah, Kutat (Saudi Arabia). |
| | Turkish | Winja (Turkey) |
| | Persian | Yunja (Iran). |
| - <i>M. falcata</i> | English | Sickle Medick, Yellow Lucerne (United
Kingdom) ;
Sickle Alfalfa (USA) ;
Blue Alfalfa (USSR). |
| | French | Luzerne jaune
Luzerne sauvage |
| - <i>M. varia</i> | English | Variegated Alfalfa, Variegated Medick |
| | French | Luzerne intermédiaire, Luzerne bigarrée,
Luzerne rustique, Luzerne des sables. |

19.4. Brief description

- *M. sativa* is an erect or ascending much branched, bushy or slender legume attaining a height of from 30-90 cm with a deep much branched tap root and with bluish-purple, yellow flowers carried on a stiff axillary stalk and glabrous pods, coiled spirally upon themselves two to four times, and each containing 6-12 seeds (Fig. 1 and 2) ;

- *M. falcata* is a hardy, much branched perennial with a deep root system, more branching than *M. sativa* with a considerable number of lateral roots spreading in all directions, and with bright yellow flowers and sickle shaped pods bent through one half to a full spiral coil, and containing light to dark brown seeds (Fig. 3) ;

- *M. varia* is a natural hybrid between *M. sativa* and *M. falcata* , growing to an average height of 35-70 cm, with smaller and darker coloured leaflets than *M. sativa*. The flower colour ranges from purple to yellow through bright to dark green or oliveous, often showing great variation in a single plant. The pod is intermediate being formed of a single coil or more.

19.5. Varieties

Botanical varieties :

Villax (1963) distinguishes the following botanical varieties of *M. sativa* L. :

- var. *vulgaris* Alef.
with glabrous plants and non glabrous pods ;
- var. *glandulosa* Urb.
with hairy plants and glandular pods.

There is no doubt that cultivated *M. sativa* in sensu lato throughout the Mediterranean region, and also the Near and Middle East as well as Asia turns wild very easily, as well as forming hybrids between the cultivated types and the various wild ecotypes of the yellow flowered *M. falcata*. Such hybrids are capable of spreading far away from the original growing areas of the cultivated Alfalfa and such escapes or hybrid forms are to be found all over the region.

Wild and cultivated forms :

Even with regard to cultivated forms of *M. sativa* in sensu lato, Sinskaya (1950) has recognized a number of species, subspecies and ecotypes within the major region of diversification. Clearly they are all part of the *M. sativa* complex, but are useful in recognizing the many varieties that have evolved under varying ecological conditions and agricultural use. Sinskaya (1950) has included the following 10 species within the compound species *M. sativa* in sensu lato :



Fig. 1 - *Medicago sativa* (Orig. - Clermont-Ferrand 1949)

(After la Culture des plantes fourragères dans la région méditerranéenne occidentale, 1963, p. 357, fig. 90)

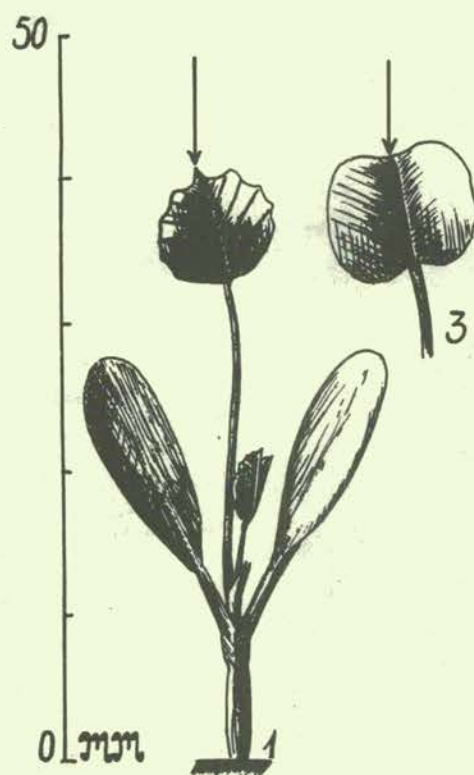


Fig. 2 - *Medicago sativa* 14 days after emergence

(After la Culture des plantes fourragères dans la
région méditerranéenne occidentale, 1963, p. 370,
fig. 93)



Fig. 3 - *Medicago falcata* (Orig. - Clermont-Ferrand 1949)

(After la Culture des plantes fourragères dans la région méditerranéenne occidentale, 1963, p. 361, fig. 92)

- *M. praesativa* (Caucasian Alfalfa),
- *M. jemenensis* (Yemenite Alfalfa),
- *M. polia* (Mediterranean Alfalfa),
- *M. mesopotamica* (Mesopotamian Alfalfa),
- *M. tripolitana* (Tripolitanian Alfalfa),
- *M. syriaco-palestinica* (Syro-Palestinian Alfalfa),
- *M. eu-sativa* (European Alfalfa),
- *M. asiatica* (Asiatic Alfalfa),
- *M. tetrahemicycla* (Afghan wild growing Alfalfa),
- *M. orientalis* (Asia Minor or Near East Alfalfa).

From a grazing point of view under dryland conditions the most interesting ecotypes are the wild growing prostrate forms. The Afghan wild growing form *M. tetrahemicycla* is a case in point. This is a strongly prostrate type and is a tetraploid form which has evolved from the ancient diploid *M. hemicycla*; the cultivated Afghan Alfalfa in turn evolved from the tetraploid *M. tetrahemicycla*.

In the USSR plants of the tetraploid wild growing Afghan Alfalfa have proved to be more winter hardy and long-lived than the cultivated Alfalfas as designated by Sinskaya (1950)

Native ecotypes :

In Iran Pabot (1967) points out that there are interesting prostrate ecotypes of *M. sativa*, often with a very well developed crown, and they resist the drought and cold very well. Unfortunately these ecotypes are seldom abundant and it is often difficult to collect seeds from them because of overgrazing. Nevertheless Pabot (1967) considers they merit collection and evaluation for re-seeding sub-steppic and mountain rangelands because they withstand overgrazing better than cultivated forms, although less productive, and also protect the soil against erosion.

Creeping forms of *M. sativa* have also been collected in Syria and N. Yemen and tested under dryland conditions. Springfield (1957) also reports a wild Alfalfa form growing at 1,700 m elevation in northern Iraq which spreads by a well developed lateral root system and is ideally suited for grazing and recognized as such by the local shepherds; creeping forms of *M. falcata*, namely *M. quasifalcata* Sinsk., also occur in the Caucasus (Sinskaya 1950).

In E. Turkey 120 accessions of native *M. sativa* has been collected for testing under dryland conditions (Hertzsch, 1971).

Agricultural varieties and adaptability :

So far nearly all dryland plantings of *M. sativa* in North Africa and the Near and Middle East have been made with cultivated varieties often introduced from outside the region. Amongst the varieties that have done well under dryland plantings are the following :

<u>Variety</u>	<u>Location</u>
"Kayseri" (Turkey)	Sub-steppic zone of Iran (1,960 m elevation, cold winters -0°C , 320-350 mm annual rainfall)
"St. Louis" (California, USA)	Caspian Forest zone (850 m elevation, cold winters -0°C , +600 mm annual rainfall)
"Kayseri" (Turkey)	
"Indian" (USA)	Littoral zone of Tunisia (mild winters $+1^{\circ}\text{C}$, 400-600 mm annual rainfall)
"African" (USA)	
"Nomad" (USA)	
"Provence" (France)	
"Peruvian" (Peru)	Central zone of Tunisia (400-600 m elevation, cold winters -0°C , 350-400 mm annual rainfall)
"Nomad" (USA)	
"Oklahoma" (USA)	
"Arizona" (USA)	Littoral zone of Algeria (warm winters $6-10^{\circ}\text{C}$, 400-600 mm annual rainfall)
"Du Puits" (USA)	
"Provence" (France)	
"Buffalo" (USA)	
"Sonora" (USA)	High plateaux zone of Algeria (850-1,000 m elevation, cold winters -0°C , 450-600 mm annual rainfall)
"African" (USA)	
"Moapa" (USA)	
"Turkestan" (USA)	

Local cultivars and adaptability in dryland plantings :

A number of local dryland cultivars of *M. sativa* have also been tested under the semi-desert conditions of the W. Kazakhstan in the USSR north of the Caspian Sea (Sydyk-Khodzhaev, 1969), of these the most promising have been Kirgizian (K-6348), Turkmenian (K-8930), Kara-Kalpakian (K-8932) and Chuvashian (K-32792) ; they gave satisfactory yields of forage and seed, and were drought and frost resistant. Sydyk-Khodzhaev (1969) also records that the most winter resistant cultivar under dryland conditions in the semi-desert area of W. Kazakhstan has been a hybrid between *M. trautvetteri* and *M. falcata*.

Cold resistance and growth type :

In regard to resistance to cold and type of growth Villax (1963) has classed the varieties of cultivated Alfalfa into five general groups :

- Group 1 : Non-hardy group

The ecotypes and varieties in this group are not resistant to the cold and have a period of dormancy followed by rapid re-growth. The varieties "African", "Indian", "Peruvian" and "Hunter" (Australia), "Marlborough" (New Zealand) are in this group as well as the local variety "Demnat" from Morocco and "Gabès" from Tunisia. Among the improved Moroccan varieties the variety "Resistante" is the best ;

- Group 2 : Fairly resistant to the cold

In this group are included varieties from Hungary, France, Italy, Roumania, Chile and Argentina. They grow rapidly with a small dormant period and can, in areas with mild winters and less harsh summers, grow over the whole year. The varieties "Bufallo", "de Williamsburg" and "Talent" belong to this group ;

- Group 3 : varieties of Turkestan

The following varieties "Hardistan", "Nemastan", "Orestan" and "Nomad" (a strongly rhizomateous type) are representative of this group. They have a dormancy period after harvest in the autumn and remain for a long time in the rosette stage ;

- Group 4 : Variegated Alfalfas

These varieties have been developed from crosses between *M. sativa* and *M. falcata* and are long day types ; more than 50 % remain in the rosette stage during winter. The varieties "Atlantic", "Baltic", "Cossack", "Viking", "Ferrax" and creeping varieties such as "Hardigan", "Ladak", "Naragansett" and "Ranger" belong to this group ;

- Group 5 : Yellow flowered varieties

All the varieties belong to the species with yellow flowers namely *M. falcata* . They are cultivated in forest regions and usually sown in mixture with other species.

Foury (1950) maintains that following the biology of their autumn growth all the cultivated varieties of *M. sativa* can be divided into three groups :

- (a) prostrate habit with a long period of dormancy and re-growth producing a rosette stage ;
- (b) semi-erect habit with a short dormancy period and re-growth producing a semi-rosette stage ;
- (c) erect habit with no dormancy period and re-growth producing generally a semi-erect rosette stage.

19.6. Number of Chromosomes

M. sativa : $2x = 32$; *M. varia* : $2x = 32$; *M. falcata* : $2x = 16$.

19.7. Geographical Distribution

M. sativa is distributed in C. and S. Europe, Crete, Cyprus, Syria, Lebanon, Palestine, Jordan, Turkey, Caucasus, Iraq, Iran, Pakistan, Afghanistan, C. Asia (Transcaspia, Tian Shan), Manchuria, Korea, N.W. India, China, Japan, Macaronesia (Canaries), N. Africa (Morocco, Algeria, Tunisia, Libya), Egypt (UAR) and introduced and naturalized in S. Africa, Australia, N., C. and S. America, West Indies, Egypt (UAR), Arabia ;

M. falcata is distributed in Europe (except extreme north), Syria, Lebanon, Turkey, Caucasus, N. Iran, N.W. India, Tibet, China, C. Asia, Transcaspia to Tian Shan, E. and W. Siberia ;

M. varia is distributed widely in cultivation in N. France, Germany, N. America and sometimes occurs spontaneously in the Mediterranean basin.

19.8. Biology and Ecology

Conditions for growth :

M. sativa, *M. falcata* and *M. varia* are all cool season species which propagate themselves by seed. Among the many varieties there exists some differences in regard to climate. However nearly all ecotypes and varieties require warm and humid conditions for growth. Although they do not grow in cold winters they generally resist well vigorous winters with frosts supporting temperatures of -10 to 15°C or even lower for very cold resistant varieties ; for instance *M. falcata* has survived temperatures below -27°C in Alaska (Heath et al., 1973).

Seed germination :

Seeds of *M. sativa* start to germinate very slowly at temperatures of $2-3^{\circ}\text{C}$ but the optimum temperature for germination is in the region of 30°C ; Hammouda and Bakr (1969) record $20-25^{\circ}\text{C}$ in Egypt (UAR) and the maximum is around 37°C (Villax, 1963). Above the latter temperature plant development ceases. Monthly average temperatures of $14-16^{\circ}\text{C}$ are satisfactory for growth but the optimum temperature lies between $16-20^{\circ}\text{C}$. *M. sativa* is also strongly drought resistant and can stand a dry period of 6 months in the dormant state.

Growth and development :

In the littoral zone of the Mediterranean basin, Villax (1963) records that under dryland conditions the varieties of *M. sativa* showing only a little autumn dormancy must be utilized ; these varieties develop vigorously from the month of February up to April and even into May and the maturation of the seeds extends over quite a long period. Bouchetata (1969) also states that these varieties have a long duration of growth between 15 March and the autumn in Algeria providing the temperature is equal or superior to 12°C.

In the littoral zone of Tunisia, Corriols (1965) reports that the Turkish variety "Kayseri" seeded on 31 October flowered between the 25 May and 10 June remaining green and producing seeds with a further vigorous re-growth by 30 October ; plants remained green throughout the year except for a limited period during December-January and again in August-September.

In the high plateaux zone of Algeria, Le Houerou (1971) records that plants of dryland *M. sativa* develop well after the first autumn rains and then after a winter dormancy period continue their growth up to at least the middle of July.

In the sub-steppic zone (1,960 m elevation) of Iran, *M. sativa* variety "Kayseri" established under dryland conditions commenced vegetative growth in the spring in the latter half of March, flowering from the beginning of May until the beginning of June and set seed in the latter part of June and early July ; a small amount of vegetative growth occurs in July-August with further vegetative growth occurring in the autumn (October) depending on the incidence of autumn rains. The pattern of growth is similar in the xerophilous forest zone (2,600 m elevation) but spring vegetative growth starts in April and summer re-growth is more pronounced in July-August. In the Caspian Forest zone (850 m elevation with summer rainfall) growth of dryland *M. sativa* is vigorous from March until October.

Climate and soils :

Under dryland conditions *M. sativa* is well adapted to cultivation in semi-arid and sub-humid climates in North Africa and the Near and Middle East with 350-600 mm annual rainfall. Le Hou  rou (1965) and Le Hou  rou and Froment (1969, 1973) considers that the lower rainfall limit for dryland cultivation in Tunisia is 350-400 annual mm, while Ionesco et al. (1969) recommend an annual rainfall of more than 450 mm in Morocco.

In regard to edaphic requirements *M. sativa* requires a well drained soil free of creeping grasses such as *Agropyron repens* and *Cynodon dactylon*, which is deep enough to permit adequate root development and with a certain amount of calcium and humus present ; it also grows satisfactory on poor soils providing they are not too acid or heavy. In Spain Fuentes (1974) reports that the distribution of wild *M. sativa* is strongly influenced by edaphic factors. In soils of moderate acidity (pH 5.5 - 6.0) the acidity reduces nodulation and on more acid soils (pH 5.0 - 5.5) plant development is also strongly inhibited.

Depth of soil and water table :

Soil depth is especially important in dryland culture ; an impermeable or stony layer at shallow depth will adversely affect the vigour and growth of plants especially in dryland cultivation. Similarly a high water table, 150-200 cm from the soil surface can shorten the life of the culture ; plants can also be killed by prolonged flooding of the surface soil for several weeks. However it supports quite well some salinity in the soil up to 0,03 % of Na_2CO_3 (Villax, 1965).

Ecological characteristics :

Ecologically the Anatolian region of Turkey, where both the Mediterranean environment and that of the steppe are present, has been cited (Hausmann, 1954) as containing a wealth of ecotypes of *M. sativa* and *M. falcata* which grow wild on the plateau and up to an elevation of 2,400 m.

19.9. Cultivation Techniques

Time of seeding :

In the littoral zone of North Africa, Villax (1963) and Ionesco et al. (1969) recommend seeding dryland *M. sativa* in the autumn after the first rains providing they arrive in good time ; in this case the plants can become solidly established before winter. In fact both autumn (second half of September) and spring (end of February-beginning of March) seedings can be made in the littoral zone of Tunisia (Le Houerou, 1965, Le Houérou and Froment, 1969) and the high plateaux zone (850-4,000 m elevation) of Algeria (Gallacher, 1972).

However in Tunisia Grainier (1966) prefers spring seeding because of the difficulty of controlling weeds in the developing stand when autumn seeding is made.

In the sub-steppic zone (1,960 m elevation) of Iran the best time of seeding dryland *M. sativa* has proved to be the spring (31 March-15 April) since rising spring temperatures (20-25°C) coinciding with spring rains ensure quicker germination and seedling emergence ; in actual practice spring plantings were successful in 7 years out of 9 (AGP:SF/IRA 10, Tech. Rep. 1, 1970). In the Caspian Forest zone spring (mid-April) seeding has also proved the most favourable time for seeding dryland *M. sativa* (Dumancic, 1975).

In the lower mountain zone (800 m elevation) of Iraq the best time of seeding dryland *M. sativa* has proved to be the spring (last week of February and first week of March), but the performance of *M. sativa* has been below average (Hussein, 1975).

Land preparation :

A well prepared compact, firm, fine seed-bed is required which generally involves ploughing the soil (10-15 cm deep) and then discing, harrowing and rolling it ; Gallacher (1972) has emphasised the need for a well rolled seed-bed.

Grainier (1966) recommends the following land preparation preparatory to spring seeding in Tunisia : 2 passes with the offset disc immediately after harvesting the cereal crop, followed by two further passes in the autumn and from 2-4 supplementary passes in the winter as the weather permits with a final pass just before sowing in February or the beginning of March.

Seed rates, row spacings and method of seeding :

Seed rates and row spacings for dryland *M. sativa* have varied between countries but the following have been reported :

Iran In the sub-steppic zone a seed rate of 10 kg/ha (15 kg/ha broadcast is recommended (Kernick, 1971) in the Caspian Forest zone) is sufficient for obtaining field stands. The seeds have been drilled at a depth of 1-2 cm in nursery rows spaced 50 cm apart (2 row McCormick Orchard Drill) or in field stands 15-20 cm drill spacing (John Deere Grain Drill) (see Fig. 4).

Iraq In the lower mountain zone a seed rate of 10 kg/ha drilled in rows spaced 50-60 cm apart has given the best results ;

Tunisia In the littoral zone Le Houerou (1965) and Le Hou  rou and Froment (1969) recommend a seed rate of 10-20 kg/ha drilled in rows spaced 40-60 cm apart, while Grainier (1966) recommends a seed rate of 10-12 kg/ha drilled in rows spaced 80 cm apart, either with an animal drawn seeder ("Ebra") or with a tractor drawn "Lister" planter that seeds on the ridge ;

Algeria In the high plateaux zone a seed rate of 10 kg/ha is recommended (Gallacher, 1972), and Laumont (1956) has recommended 80-120 cm row spacing to permit interrow cultivation for weed control ;

Morocco In the littoral zone of Morocco Villax (1963) recommends a seed rate of 5-10 kg/ha drilled at a depth of 2 cm in rows spaced 40-70 cm apart, which serves well also the production of seeds, while Ionesco et al. (1969) recommend a seed rate of 10-15 kg/ha drilled in rows spaced 40-60 cm apart and a depth of planting of 2 cm

Intercultivation with grasses :

Although generally sown pure, Villax (1963) also records that a seed rate of 5-10 kg/ha is recommended for dryland *M. sativa* when planting it in mixture with grasses such as *Dactylis glomerata* (seed rate : 8-12 kg/ha), *Ehrharta calycina* (seed rate : 10-15 kg/ha), *Festuca arundinacea* (seed rate : 10-15 kg/ha) or *Phalaris aquatica* (seed rate : 8-12 kg/ha) ; Grainier also records that in Tunisia when included in a cereal rotation it can be seeded at 10 kg/ha in mixture with 60 kg/ha of *Hordeum vulgare*.



Fig. 4

A field of dryland Alfalfa planted in the spring of 1967. In its second year it yielded 1.2 tons of high quality hay per hectare. Kuheen, May 1969 (average rainfall 350 mm)..

(After Pasture and Fodder Crop Investigations, Iran, Tech. Rep. No. 1, 1970, p. 89, fig. 28)

In the Caspian Forest zone dryland *M. sativa* has also been seeded in mixture with *Arrhenatherum elatius* (seed rate : 10 kg/ha) or *Dactylis glomerata* (seed rate : 15 kg/ha) (Dumancic, 1975, Kernick, 1971).

Fertilizer application :

The application of fertilizer to dryland *M. sativa* also varies as between countries but the following have been reported :

Iran No fertilizer has been applied in the sub-steppic zone on calcareous silty clays but on similar soils in the Caspian Forest zone (higher rainfall) 200 kg/ha of superphosphate (46 % P_2O_5) and 150 kg/ha of ammonium nitrate (23 % N) have been applied at seeding, and 80 kg/ha of urea (46 % N) in April in succeeding years ;

Tunisia When seeded in mixture with *Hordeum vulgare* Grainier (1966) recommends an application of 100 kg/ha of superphosphate (16 % P_2O_5) after the harvest of *H. vulgare*, and in the case where *M. sativa* is sown pure, 45-60 kg/ha P_2O_5 at seeding. Le Houérou (1965) and Le Houérou and Froment (1969) also recommend the following for a pure culture of *M. sativa* : 50-100 kg/ha P_2O_5 at soil preparation, 5-10 kg/ha P_2O_5 localized on the seeding rows, and 45 kg/ha P_2O_5 at the commencement of the second year.

Morocco Under conditions where the soil is deficient in phosphorous and potash Ionesco et al. (1969) recommend an application of 120-180 kg/ha P_2O_5 and 80-120 kg/ha K_2O during soil preparation or at seeding, and up to 40 kg/ha N before seeding and lightly covered in the surface soil ; an application of 20-25 kg/ha of borax is also recommended in mixture with phosphorous and potassium fertilizer if the plants of *M. sativa* show signs of borax deficiency ;

Algeria In the high plateaux zone Maignan (1970) records a basic application of 90-150 kg/ha P_2O_5 at soil preparation (July) and 90 kg/ha at seeding (September-October), and also in October in succeeding years.

19.10. Forage Value

Palatability :

It is well known that *M. sativa* is a very palatable forage species for all types of livestock. Under dryland conditions in the sub-steppic zone of Iran grazing palatability trials with native sheep showed that *M. sativa* was very well grazed in the vegetative (spring and autumn), flowering and seed production stages.

Nutritive value :

In the sub-steppic zone of Iran the following chemical composition data is recorded (AGP:SF/IRA 10, Tech. Rep. 1, 1970) for dryland *M. sativa* at four different phenological stages of growth in the spring (April-June) :

Percentage of Dry Matter							
Vegetative Stage		Early Flowering Stage		Late Flowering Stage		Seed Production Stage	
Crude Protein	Crude Fibre	Crude Protein	Crude Fibre	Crude Protein	Crude Fibre	Crude Protein	Crude Fibre
30.5	13.4	20.7	21.3	14.2	22.9	10.8	31.8

In the Caspian Forest zone Dumancic (1975) records the following chemical composition data for dryland *M. sativa* in full flower :

Dry Matter %	Crude Protein %	Ca %	P %
25.0	13.8	2.0	0.27

In Morocco Ionesco et al. (1969) record a forage value for dryland *M. sativa* varying from 0.13-0.16 forage units/kg, 33-39 g of digestible protein/kg and 18-24 % dry matter in the green state, and 0.53 forage units/kg, 109 g of digestible protein/kg and 90.5 % dry matter in the dry state.

In Tunisia Theriez (1966) reports that the O.M. digestibility varied from 70 % at the vegetative stage to 60 % in full flowering and that the energy value was 0.17 FU/kg green material and the average content of digestible nitrogenous substances 4.2 % for the green material.

In Tunisia Corriols (1965) also records the following chemical composition data for dryland *M. sativa* (variety "Kayseri") :

Percentage Digestible Products						
Date Sampled	Protein	Fats	Cellulose	Non-N extract	Metabolizable Energy kg/green matter	Forage Units/kg
9.4.56	3.02	0.69	2.28	6.58	491 c	0.14
7.5.56	3.03	0.59	2.73	4.10	409 c	0.10

Theriez (1968) also records that hay of dryland *M. sativa* harvested at the end of flowering contained 1.6 g of phosphorous, 14.8 g of calcium, 4.4 g of magnesium and 16.2 g of potassium per kilo dry matter.

In Morocco Foury (1950) records the following chemical composition data for *M. sativa*, variety "Provence" harvested in the green state (9 May) at Rabat and in the hay stage at Casablanca which is given below :

	Water %	Ash %	Protein %	Non-N Extract %	Fats %	Cellulose %
Green State						
on wet basis	73.80	2.49	5.83	10.60	0.78	6.50
on dry basis	0	9.50	22.25	40.45	3.00	24.80
Hay Stage						
on wet basis	12.52	8.04	15.05	31.21	1.42	31.76
on dry basis	0	9.20	17.20	35.67	1.63	36.60

Foury (1950) also records the following chemical composition data for hay of *M. falcata* harvested in France :

	Water %	Ash %	Protein %	Non-N Extract %	Fats %	Cellulose %
on wet basis	16.70	6.10	15.20	28.90	3.00	30.10
on dry basis	0	7.50	18.20	34.60	3.60	36.10

19.11. Forage and Seed Production

Forage yields :

In the sub-steppic zone of Iran the following dryland forage yields have been reported (AGP:SF/IRA 10, Tech. Rep. 1, 1970) in nursery and/or field stands of *M. sativa* at Homand (320-350 mm annual rainfall, 1,960 m elevation) :

1966		1967		1968		1969	
Age of stand in years	DM yield kg/ha	Age of stand in years	DM yield kg/ha	Age of stand in years	DM yield kg/ha	Age of stand in years	DM yield kg/ha
3	1,760 <u>1/</u>	4	940	5	1,780 <u>1/</u>	6	3,070
						1 ⁺	480 ⁺
Spring rainfall (March-May) mm:		Spring rainfall (March-May) mm:		Spring rainfall (March-May) mm:		Spring rainfall (March-May) mm:	
175.4		148.6		188.6		282.9	
<u>1/</u> Average yield for 2 varieties							
+ Field stand							

In the Caspian Forest zone (+600 mm annual rainfall with summer rains (July-August) Dumancic (1975) records the following green forage yield data for dryland *M. sativa* alone and in mixture with *Arrhenatherum elatius* or *Dactylis glomerata* in nursery and/or field stands :

Nursery Stands : kg/ha Green Forage			
	1972 3 cuts	1973 3 cuts	1974 1 cut
<i>M. sativa</i>	19,280	32,750	12,600
<i>M. sativa</i> + <i>D. glomerata</i>	24,830	28,150	12,700
Field Stands : kg/ha Green Forage			
	1972 3 cuts	1973 3 cuts	1974 1 cut
<i>M. sativa</i>	37,370	52,400	17,500
<i>M. sativa</i> + <i>A. elatius</i>	39,430	66,100	21,600
<i>M. sativa</i> + <i>D. glomerata</i>	43,590	61,700	23,300

In the littoral zone of Tunisia Corriols (1965) records that dryland *M. sativa* has produced 2,200 forage units/ha from April to July in 3 cuts, and on very fertile soils, with an excellent soil structure receiving 400 mm annual rainfall, 5,000 forage units/ha have been obtained. During the 1955-56 season (664.7 mm rainfall) Corriols (1968) also reports the following forage production data for dryland *M. sativa* (variety "Kayseri") in its second year :

Green Matter kg/ha	Dry Matter kg/ha	Digestible Protein kg/ha	Forage Units/ ha
20,309	4,264	609	2,437

Le Houérou (1965) and Le Houérou and Froment (1969) record that with a rainfall of 400-450 mm at Tunis green forage yields of well established dryland *M. sativa* can reach 20,000 kg/ha per year and he cites also average yields of 5,000-15,000 kg/ha green forage and 750-2,000 forage units/ha in the first year, and 10,000-35,000 kg/ha green forage and 1,500-5,200 forage units/ha in the second and following years.

In the high plateaux zone of Algeria Maignan (1970) and Gallacher (1972) record for dryland *M. sativa* average yields over a 4 year period varying from 16,150-17,700 kg/ha green forage, 9,683-7,361 kg/ha DM and 5,436-4,080 forage units/ha for the best varieties ("Provence", "Sonora", "Buffalo", "Moapa", "African" and "Turkestan") ; rainfall over the 4 years varied from 409 mm to 615 mm.

In Morocco Ionesco et al. (1969) record average yields of 10,000-20,000 kg/ha green forage, 5,000-6,000 kg/ha of hay and 3,000-5,000 forage units/ha for dryland *M. sativa* receiving 450 mm annual rainfall and average green forage yields of 30,000-40,000 kg/ha in the region of Meknès-Fès with more than 450 mm annual rainfall ; Villax (1963) cites average yields of 20,000-40,000 kg/ha green forage and 5,000-10,000 kg/ha hay in the littoral zone (400-600 mm annual rainfall).

Effect of row spacing :

Foury (1950) reports the results of early trials on the effect of spacing on the forage yield of dryland *M. sativa* in Morocco. In general there is little difference in yield at spacings varying from 10 cm up to 80 cm but spacings of 25-40 cm generally gave superior yields.

Seed yields and harvesting :

According to Villax (1963) in Morocco seed yields of dryland *M. sativa* utilized only for seed production vary from 100-300 kg/ha and similar yields varying from 100-360 kg/ha have been recorded (Maignan, 1970) for dryland *M. sativa* (varieties "Sonora", "African" and "Moapa") in the high plateaux zone of Algeria.

In the sub-steppic zone of Iran at Homand seed yields of dryland *M. sativa* have varied from 30-350 kg/ha ; in some years high air temperatures and low soil and atmospheric humidity at or before flowering have adversely affected the seed set ; seed yields have also been lowered in Morocco even under irrigation when excessive heat and dryness occurs during flowering (Villax, 1963).

In regard to seed production of dryland *M. sativa* in Morocco Villax (1963) states that the first growth is in general not suitable because the density of the crop does not favour the formation of seeds. At the time of flowering he recommends the placement of bee hives to aid pollination and increase seed set. Because seed maturation extends over a long period (3-6 weeks) it is necessary to cut the crop before all the pods are mature to avoid losses. Gallacher (1972) states that the seed may be harvested and threshed with a combine harvester, but it should be left spread out in a dry place to dry as the green material mixed in the seed causes overheating and spoiling if left in bags.

19.12. Utilization

Type of use and number of harvests :

Dryland *M. sativa* can be utilized for grazing or for hay. In Tunisia Le Houérou (1965) and Le Houérou and Froment (1969) recommend a mixed system of cutting and grazing. In the first year 1-2 cuts for hay are recommended, while the second and following years 2-4 cuts for hay or 3-5 grazings can be taken or a mixture of both forms of utilization can be achieved. In Morocco Ionesco et al. (1969) recommend 1-2 cuts in the first year and 3-5 cuts from the beginning of the second year for dryland *M. sativa*.

In the sub-steppic zone of Iran, at Homand, good grazing utilization of dryland *M. sativa* on a field scale has been obtained with native sheep (Fig. 5) during the period May-June.

Management for hay production :

Grainier (1966) emphasises the need to cut dryland *M. sativa* for hay when 25 % of the crop is in flower and to harvest it rapidly because temperatures can approach 42°C for short periods in May and June in Tunisia leading to rapid dessication. This has necessitated cutting the crop in the morning and baling it in the late afternoon of the same day to avoid serious loss of leaf.

Supplementary ration for dairy cattle :

In the region of Medjezel Bab in Tunisia Grainier (1966) records that 6 ha of dryland *M. sativa* has proved sufficient to provide a supplementary ration for 30 dairy cattle for two months in the spring (May-June) and one month in the autumn (October).



Fig. 5

Experimental sheep grazing a stand of *Medicago sativa* planted at Homand in the spring of 1968.

(After Pasture and Fodder Crop Investigations, Iran, Iran, Tech. Rep. No. 1, 1970, p. 92, Fig. 33)

Maintenance of stands :

For maintenance of dryland stands of *M. sativa* both Grainier (1966) and Villax (1963) emphasize the need for weeding between the rows several times in the first year up to the time of the first harvest. At the end of the autumn and during the winter cultivating between the rows is recommended, but the last cut of dryland *M. sativa* should be effected to ensure a re-growth of 10-20 cm before the onset of the cold winter period.

Value in crop rotations :

Dryland *M. sativa* is also useful for inclusion in crop rotations because it enriches the soil with nitrogen. Villax (1963) states that a culture over a period of 5 years will add in the region of 300 kg/ha N from its root system.

Pasture longevity :

The longevity of dryland *M. sativa* depends greatly on the average amount of annual rainfall, and the drainage of the soil (Le Houérou, 1965, Le Houérou and Froment, 1969). Under favourable conditions stands can remain for 8-10 years. However Villax (1963) states that in general forage yields diminish gradually from the fourth year in North Africa. Grainier (1966) nevertheless reports dryland 7-8 year old stands of *M. sativa* in full production in Tunisia (Medjez el Bab region).

Further evaluation :

In the future more attention needs to be paid to the collection and testing of native ecotypes of *M. sativa* in the region, especially the creeping rhizomatous forms, which are long lived and are well adapted to grazing use.

19.13. Specific References

- | | |
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TECHNICAL DATA

SHEET No 20

PAPILIONACEAE (=FABACEAE)

Onobrychis spp.

20.1. Species

In the region as a whole the most important *Onobrychis* species for forage is *O. viciifolia* Scop., but Pabot (1967) also mentions five other species of good forage value in N. Iran, namely *O. gaubae* Bornm., *O. melanotricha* Boiss., *O. persica* Sir. et Rech., *O. scrobiculata* Boiss. and *O. ptolemaica* (Del.) D.C. ; the last species is also found in the Near East.

20.2. Synonyms

- *O. viciifolia* (= *O. sativa* Lamk.)
- *O. scrobiculata* (= *O. marginata* Beck.)
- *O. ptolemaica* (= *Hedysarum ptolemaica* Del., *Onobrychis lanata* Boiss., *O. pinnata* (Bertol.) Hand.-Mazz.)

20.3. Common Names

- | | | |
|------------------------|---------|---|
| - <i>O. viciifolia</i> | English | Sainfoin,
Holy Clover (Syria) ;
Korunga (Turkey). |
| | French | Sainfoin,
Esparcette,
Espères (Iran). |
| | Arabic | El Birsim Al Mukaddes (Syria). |
| - <i>O. ptolemaica</i> | Arabic | Widaan el hardeeb,
Kanaasir el aroos (Egypt, UAR). |

20.4. Brief Description

- *O. viciifolia* is a perennial legume with a strong well developed tap root system growing to a height of 40-80 cm with 5-7 or more pairs of opposite leaves, with pink rarely white flowers, and indeluscent one seeded pods covered with a dense network of veins (Fig. 1, 2, 3, 4) ;

- *O. gaubae* is a perennial plant with upright stems growing to a height of 20-30 cm with 4-5 pairs of leaflets and large leaves and spiny pods shaped like goads ;

- *O. melanotricha* is a perennial plant with a ligneous base with 4-5 pairs of leaflets and round pods covered with soft hairs ;

- *O. persica* is a perennial plant with erect or spreading hairy stems growing to a height of 20-50 cm with 5-9 pairs of leaflets hairy underneath and with hairy pods with a denticular disk ; it resembles *O. viciifolia*, but usually has spreading or prostrate stems and thinner leaves ;

- *O. scrobiculata* is a perennial hairy or glabrous plant with semi-erect stems growing to a height of 30-40 cm with 3-5 pairs of leaflets and stalked pods covered with hairs and shaped like goads ;

- *O. ptolemaica* is a perennial ligneous plant with lined hairy stems growing to a height of 50 cm and having 5-7 pairs of leaflets and densely woolly or suborbicular pods with a goad-like disk and margin with minute prickles (Fig. 5).

20.5. Varieties

Botanical subspecies, varieties and forms in nature :

In Iran Parsa (1950) mentions the following botanical varieties and forms of *O. gaubae* and *O. melanotricha* :

- *O. gaubae* :
 - f. *obscura* Sirj.
with nearly violet corolla and present at Pitch Kuh (1,600-2,200 m elevation) in N. Iran ;
- *O. melanotricha* :
 - var. *minor* Boiss.
with 3 pairs of petioles and peduncles (4 cm long); present near Isfahan in C. Iran ;
 - f. *villosa* Boiss.
with hairy stems and present between Kermanshah and Kerenden in N. Iran.

In Iraq Townsend and Guest (1974) record the following botanical subspecies for *O. ptolemaica* :

- subsp. *ptolemaica*
with wings of corolla short and present in S. Iraq ;
- subsp. *macroptera*
with wings of corolla long and present in N. Iraq.

However Davis (1966) considers that *O. ptolemaica* is one species in Turkey with intermediate types certainly occurring, although he mentions that the main centre of variation is in Iraq.



Fig. 1 - *Onobrychis viciifolia* (Orig. - Elvas 1953)

(After la Culture des plantes fourragères dans la
région méditerranéenne occidentale, 1963, p. 479, Fig. 132.)

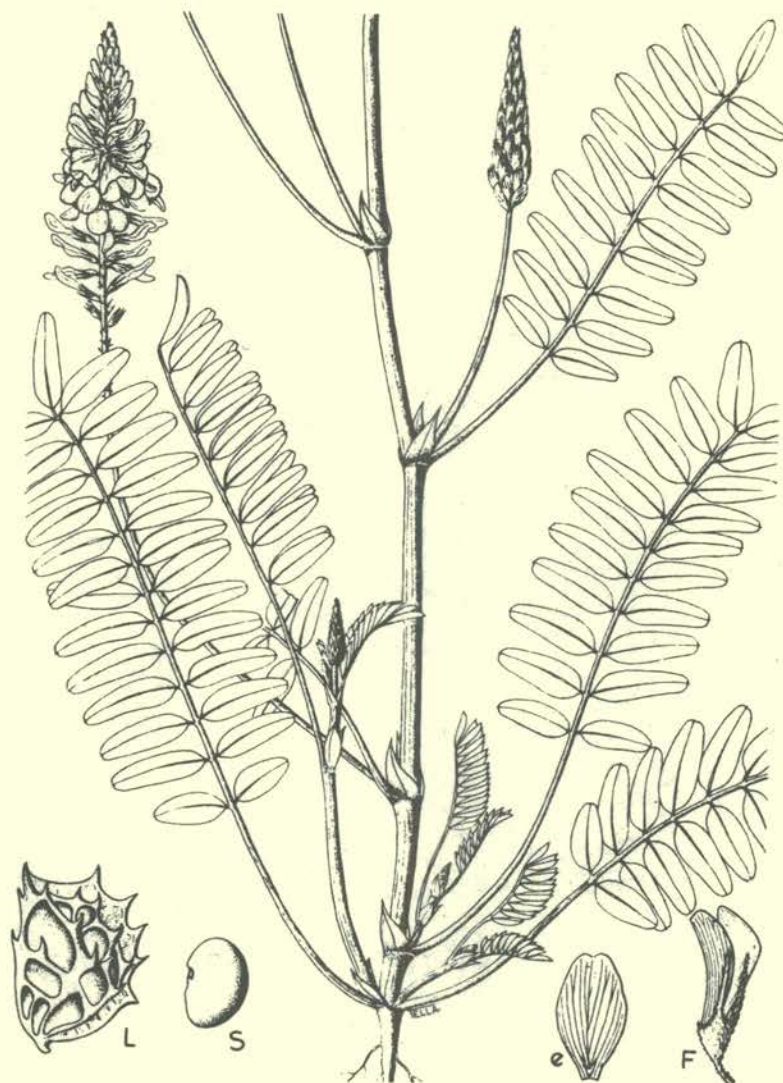


Fig. 2 - *Onobrychis sativa* (= *O. viciifolia*)

Plant, x1. F : Flower, x3. e : Standard, x3. L : Fruit, x5. S : Seed, x5.

(After Introduccion al Estudio de las Especies
Pascícolas Espanolas, Madrid, 1965, p. 251)

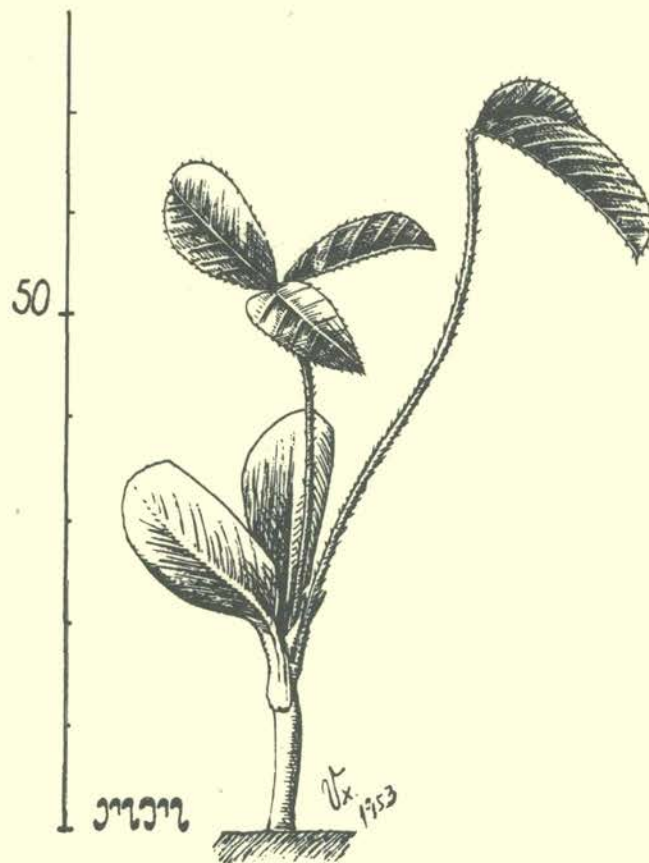


Fig. 3 - Seedling of *Onobrychis sativa* after 21 days of emergence

(After la Culture des plantes fourragères dans la région Méditerranéenne occidentale, 1963, p. 478, fig. 131)

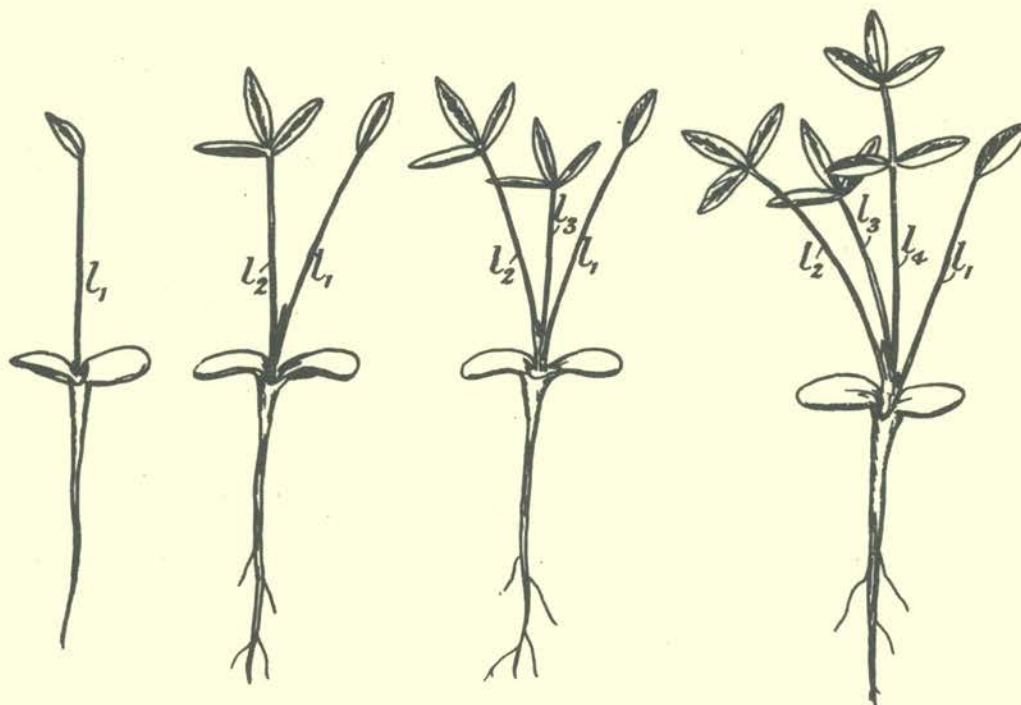


Fig. 4 - Successive stages in the development of a seedling of Sainfoin
l₁, l₂, l₃, l₄, first, second, third and fourth leaves

(After Leguminous forage plants, 1949, p.76, fig. 21)

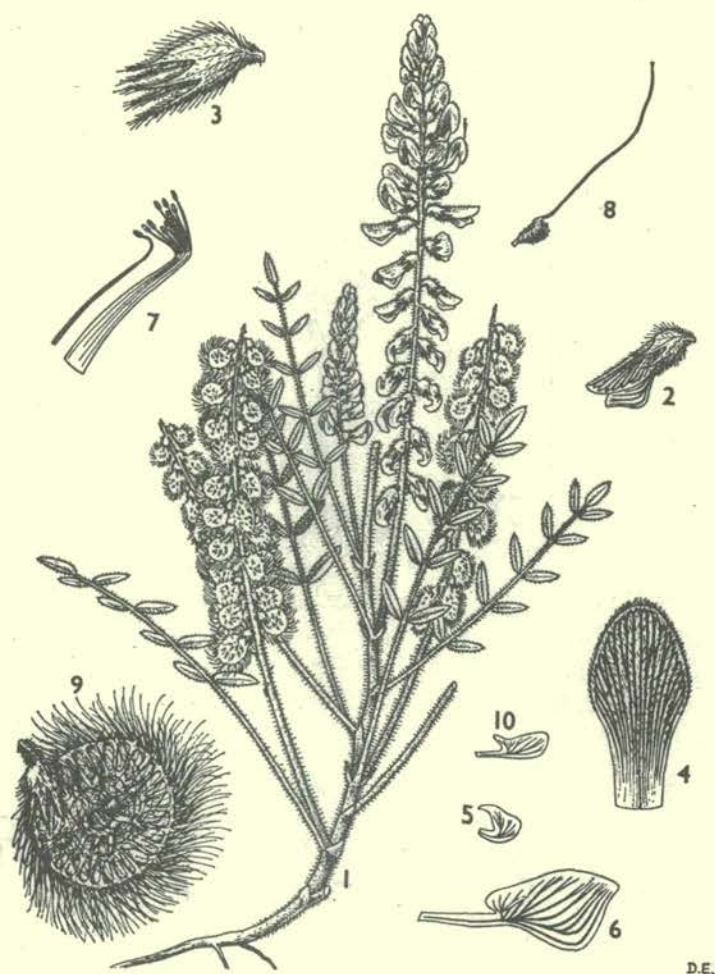


Fig. 5 - *Onobrychis ptolemaica* (Del.) D.C.

Habit, $\times \frac{1}{2}$. 2. Flower, $\times 1$. 3. Calyx, $\times 2$. 4. Standard, $\times 2$. 5. Wing, $\times 2$.
6. Keel, $\times 2$. 7. Androecium, $\times 2$. 8. Gynoecium, $\times 2$. 9. Pod, $\times 2$. *Onobrychis*
ptolemaica (Del.) D.C. subsp. *macroptera* Townsend. 10. Wing, $\times 2$.

(After Flora of Iraq, Leguminales, vol. 3, 1974, p. 488, plate 94)

Botanical varieties and species in cultivation :

Villax (1963) states that the following botanical varieties of *O. viciifolia* occur in agricultural use :

- var *communis* Alef.
the most widespread in cultivation and exacting in its ecological requirements ; it furnishes one forage cut and is recognized as Common Sainfoin in Europe (Robinson, 1947) ;
- var *bifera* Alef.
produces generally two forage cuts and is known as Giant or Double Cut Sainfoin in Europe ; Robinson (1947) states that seeds of *bifera* and *communis* are not distinguishable ;
- var *maxima*
which has the best development and yield but has the most exacting ecological requirements ;
- var *persica* Sir. (= *O. subinermis* Boiss.)
which grows rapidly and is the least ecologically exacting variety ; recorded by Parsa (1950) in Azerbaidjan (Mt. Sivik) and Kerman in Iran and also present in south-east USSR.

Hincuk (1938) has recorded three species of sainfoin in cultivation namely European (*O. viciifolia* Scop.), Near Asian (*O. antasiatica* (Chin.) and Sandy (*O. arenaria* (Kit.) D.C. *O. antasiatica* is represented in cultivation by two types-Iran-Azerbaidjan, flowering early in the first year , and Armenian-Anatolian, flowering late or not flowering in the first year . For *O. arenaria* only two types are known ; of these Ukrainian, late flowering in the first year, is much more widely used than the late Siberian plain ecotype. Landolt (1970) postulates that *O. viciifolia* in Switzerland has evolved out of hybridization between *O. arenaria* and *O. montana*.

Native ecotypes :

A number of ecotypes of *O. viciifolia* have been collected in E. Turkey in recent years with some 40 different collections being made in 1976 and planted under dryland conditions at the Forage Crop Research Institute near Ankara (Kjellqvist, 1977).

Seeds of several ecotypes of *O. gaubae*, *O. melanotricha*, *O. persica* and *O. scrobiculata* have also been collected in N. Iran along with some other native ecotypes of perennial *Onobrychis* spp., which Pabot (1967) has tentatively named *O. "jajerudi"*, *O. "takestani"* and *O. "zanjani"* after the place of collection ; all these ecotypes have been planted in a dryland nursery in the sub-steppic zone (1,960 m elevation, 320-350 mm annual rainfall) at Homand (N. Iran).

Pabot (1967) also states that *O. pinnata* is an interesting species for dryland re-seeding at low elevation in the south of Iran.

Varieties used in dryland plantings :

Dryland plantings of *O. viciifolia* in Algeria, Tunisia and Iran have largely been made with seeds multiplied from original introductions made from Turkey.

A number of varieties (cultivars) of *O. viciifolia* have also been developed in Montana (USA) for dryland planting in semi-arid areas with 330 mm annual rainfall which are recorded by Heath et al. (1974) and are the following :

- "Eski" is a late maturing cultivar released in 1964,
- "Rement" is an earlier maturing cultivar than "Eski" and recovers more rapidly after harvest ; released in 1971,
- "Melrose" is a cultivar phenologically similar to "Eski" but earlier in maturity and more rapid in recovery growth after harvest ; licensed in Canada in 1969.

20.6. Number of Chromosomes

O. viciifolia $2x = 14, 28$; for the other *Onobrychis* spp. mentioned not known.

20.7. Geographical Distribution

O. viciifolia is distributed in most of Southern Europe and eastward to Lake Baykal in Siberia and also in North Africa ; the Armenian Plateaux covering a large part of Turkey is considered to be an important centre of diversity ;

O. ptolemaica is distributed in Syria, Iran, Iraq (see distribution map, Fig. 6), Jordan, Sinai and Saudi Arabia ;

O. gaubae, *O. melanotricha*, *O. persica* and *O. scrobiculata* appear to be restricted to N. Iran. The general distribution for the genus *Onobrychis* is given in the distribution map in Fig. 7.

20.8. Biology and Ecology

Seed characteristics :

O. viciifolia, *O. gaubae*, *O. melanotricha*, *O. persica*, *O. pinnata* and *O. scrobiculata* are all cool season species which propagate themselves by seed.

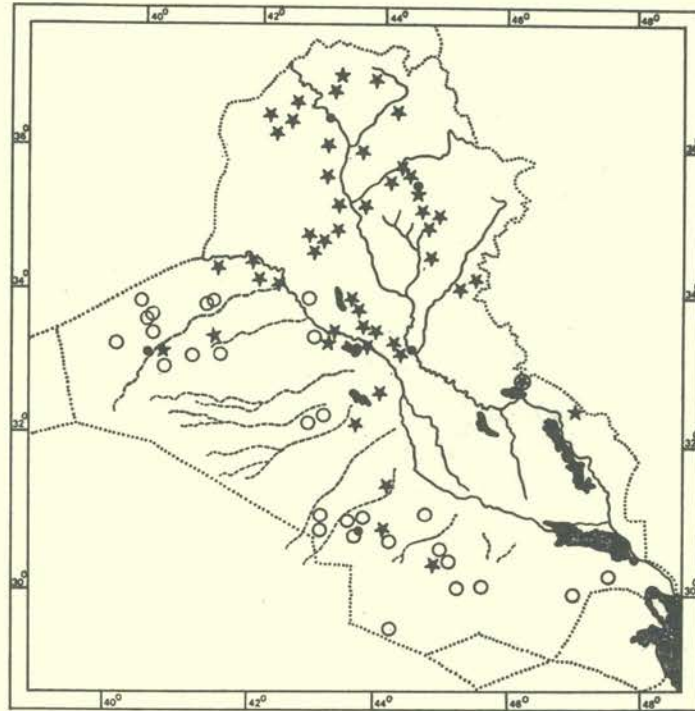


Fig. 6

Distribution in Iraq of *Onobrychis ptolemaica* (Del.) D.C.
subsp. *ptolemaica* (O), subsp. *macroptera* Townsend (★) and
intermediate ⊙

(After Flora of Iraq, Leguminales, vol. 3, 1964, p. 489, map 6)

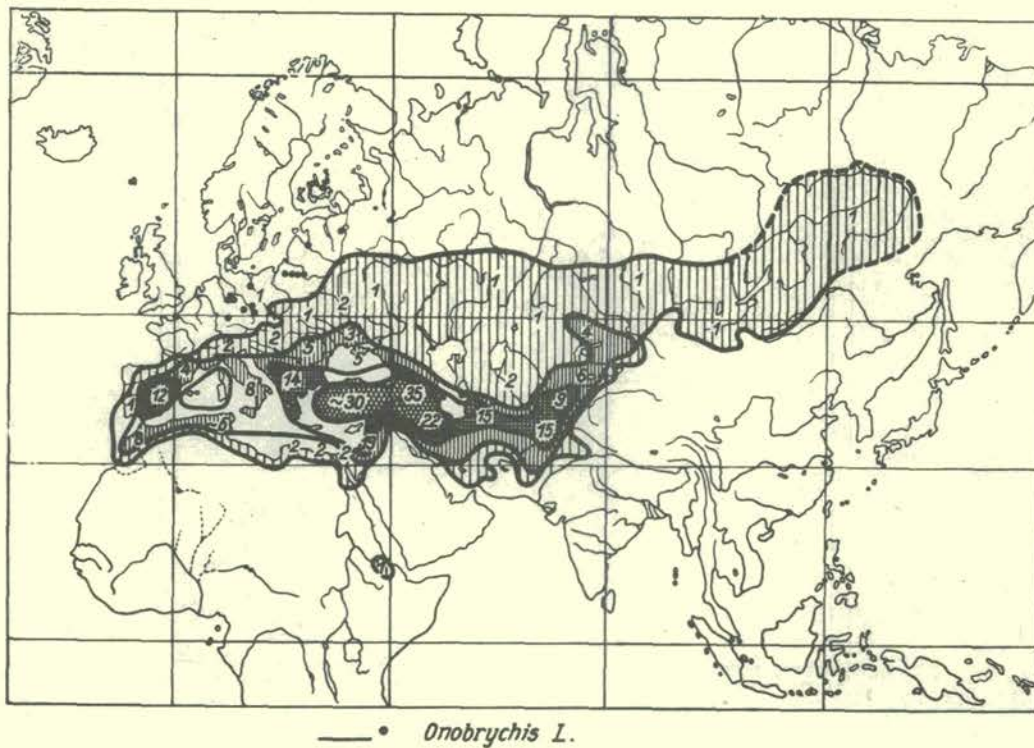


Fig. 7

Area of distribution of the genus *Onobrychis* L.
(numerals refer to the number of species present
in each region)

(After Die Kulturpflanze, Beiheft, 1962, p. 252, Fig. 2)

In the sub-steppic zone (1,960 m elevation, 320-350 mm annual rainfall) *O. viciifolia* germinates best in the spring (March) and satisfactory emergence is obtained with 20-30 mm rainfall. *O. gaubae*, *O. melanotricha*, *O. pinnata*, *O. persica* and *O. scrobiculata* all exhibit delayed germination due to the impermeable seed coat of the pods which gradually breaks down permitting most germination of the seed in the second and third year after pod dispersal. Best germination for both *O. viciifolia* and native *Onobrychis* spp. occurs in the spring when soil temperatures reach 20 to 25°C. Germination tests showed that 3-6 months old pods with seeds of all these native *Onobrychis* spp. gave only a 5 % germination, while seeds removed from the pods gave 70-90 % germination after 10 days ; for *O. viciifolia* some benefit also occurred from removal (hulled) of seed from the pods (92 % germination) compared to non-removal (unhulled) of seeds from the pods (65 % germination) (Bailey, 1966).

In Morocco Villax (1963) recommends the use of hulled seed of *O. viciifolia* to obtain rapid germination and establishment.

However in the USA Carleton et al. (1968) report that there is no difference in field emergence of dryland seeded *O. viciifolia* using hulled or unhulled seed because of rapid removal of germination inhibitors in the seed pods by rain ; this also accords with field planting experience in the sub-steppic zone of Iran except in dry years when the use of hulled seed has an advantage.

Growth and development :

In North Africa *O. viciifolia* under dryland conditions grows well in the littoral zone with mild winters and in Morocco Villax (1963) records that growth is rapid after autumn rains and the plants can be grazed at the end of March ; in the littoral zone of Tunisia Corriols (1965) reports that dryland plantings of *O. viciifolia* also remain green throughout the year.

O. viciifolia also grows well in the high plateaux zone (850-1,000 m elevation) of Algeria (Maignan, 1970) and in the Midelt region (1,700 m elevation) of Morocco (Otmene, 1974).

In Iran *O. viciifolia* spp. grows well in the spring and summer in the Caspian Forest zone (1,200 m elevation, +600 mm annual rainfall with summer rains, July-August, and in the spring in the sub-steppic zone (1,960-2,050 m elevation, 320-350 mm annual rainfall) ; *O. viciifolia* and *O. gaubae* also show promise in the steppic-zone (200-400 mm annual rainfall) of Jordan (Bailey, 1967).

In Iran in the sub-steppic zone (1,960 m elevation) vegetative growth of *O. viciifolia* starts at the end of March, flowering at the beginning of May and seed production in early June ; the other native *Onobrychis* spp. previously mentioned show the same pattern of phenology in the spring. Some

vegetative growth for all these native *Onobrychis* spp. and *O. viciifolia* occurs in July with further vegetative growth occurring in the autumn (October) depending on the incidence of autumn rains (AGP:SF/IRA 10, Tech. Rep. 1, 1970).

Climate and soils :

All the previously mentioned *Onobrychis* spp. are resistant to cold temperatures (below 0°C) and are also drought resistant.

O. viciifolia is well adapted to cultivation in the littoral zone and mountain region of the Mediterranean and also to the interior sub-steppic zones of the Irano-Turanian region with 350-600 mm annual rainfall ; in Morocco an annual rainfall of more than 500 mm is recommended for dryland cultivation (Ionesco et al., 1969).

O. gaubae, *O. melanotricha*, *O. persica* and *O. scrobiculata* have also proved well adapted to dryland cultivation in the sub-steppic zone of Iran and other native types such as *O. "jajerudi"*, *O. "takestani"* and *O. "zanjani"* look promising ; multiplication of all these native *Onobrychis* has not proved successful under irrigated conditions (Pabot, 1967).

In regard to edaphic factors *O. viciifolia* is well adapted to light, well drained, calcareous soils and also to marls ; Corriols (1965) mentions that it is a plant well adapted to calcareous soils in the littoral zone of Tunisia, while Gallacher (1972) reports that it thrives on marls in the high plateaux zone of Algeria.

All the native *Onobrychis* spp. mentioned for Iran are well adapted to calcareous soils and *O. pinnata* also occurs on marls and gypsiferous sands in Khuzistan (Iran), and on sandy gravel and conglomerate soils in the lower mountain steppe and desert zones of Iraq (Townsend and Guest, 1974).

Ecological characteristics :

Ecologically in Iran Pabot (1967) mentions that *O. gaubae* occurs on formerly cultivated lands near Homand in the sub-steppic zone and is also recorded at Karadj (Parsa, 1950) ; *O. melanotricha* is common to natural sub-steppic ranges in the E. Zagros Mts., is very resistant to overgrazing and is also recorded in the south-west at Kohrud, Razwand, Borodjerd, Oshtorankuh, Arak, Marzedjara (Parsa, 1950) ; *O. persica* is quite a rare species and is found on the edge of fields in the Bachtari and near Soltaniyeh and is also recorded at Borseh à Nourabad (Parsa, 1950) ; *O. scrobiculata* is a species of the wasteland of north-west Zagros (Hamadan, Khorramabad) and is also recorded at Kemanshah and west of Tabriz (Parsa, 1950) and *O. pinnata* is fairly common on the hills of Khuzistan between Masjid-Soleiman and Behbahan, and is also recorded at Suz (Parsa, 1950) ; it is also found in the Syrian desert under annual rainfall conditions of less than 150 mm (Pabot, 1967).

In Iraq Townsend and Guest (1974) record *O. ptolemaica* subsp. *macroptera* (= *O. pinnata*) as occurring on lower mountain slopes and valleys and steppic and desert plains, while Tackholm (1974) records *O. ptolemaica* as occurring occasionally on the desert plain in Libya and the Sinai.

In Iran *O. viciifolia* has been recorded (Parsa, 1950) as occurring in the Elburz and Zagros Mountains at Shatrestanak, Azerbaidjan, Rezaiyeh, Deylaman, Gerlosa, Tchahrik and Lorestan.

20.9. Cultivation Techniques

Method of propagation :

The cultivation of all the previously mentioned *Onobrychis* spp. is normally done through the planting of seeds, but Chasneaux (1966) also reports that plants of *O. viciifolia* can be multiplied by cutting consisting of one or more stems and part of the main root.

Time of seeding :

In the sub-steppic zone of Iran (1,960 m elevation) the best time of seeding *O. viciifolia* in dryland field stands has proved to be the spring (31 March-15 April) ; in the Caspian Forest zone (1,200 m elevation) both early autumn (preferred) and spring sowings of dryland *O. viciifolia* have succeeded, but late sowings in these periods are not advised (Dumancic, 1975).

In the littoral zone of North Africa seeding after the first autumn rains is recommended (Villax, 1963) for dryland *O. viciifolia*, and in Tunisia Le Houerou (1965) and Le Houérou and Froment (1969) advise seeding in October (littoral zone) and Maignan (1970) recommends September in the high plateaux zone of Algeria.

Land preparation :

A well prepared, compact and fine seed-bed is required which involves ploughing the soil to a depth of 10-15 cm and then discing and rolling it.

Seed rate and method of seeding :

In Iran 10 kg/ha of hulled or unhulled seed has proved sufficient for establishing field stands of *O. viciifolia* in the sub-steppic zone in drills 15-20 cm apart (John Deere Grain Drill), (30 kg/ha is recommended (Kernick, 1971) in the Caspian Forest zone). Germination and emergence of native *Onobrychis* spp. in the sub-steppic zone has been improved by sowing hulled seed and scarification of seeds of *O. persica* has also improved germination and emergence in some years. However *O. gaubae* and *O. melanotricha* have shown the most regular germination and have proved easy to multiply.

In Tunisia Le Houérou (1965) and Le Houérou and Froment (1969) recommend sowing 20-40 kg/ha of unhulled seed and 10-20 kg/ha of hulled seed for the establishment of dryland *O. viciifolia* in the littoral zone, and Maignan (1970) records a hulled seed rate of 15 kg/ha in the high plateaux zone of Algeria, while Villax (1963) recommends a higher seed rate of 60-100 kg/ha (hulled seed) in the littoral zone of Morocco to ensure a dense stand. In Tunisia drilling dryland *O. viciifolia* in lines spaced 40-50 cm apart on the contour is also recommended.

Fertilizer application :

In both the sub-steppic and the Caspian Forest zones of Iran no fertilizer has been applied to the seed-bed or later for dryland *O. viciifolia* although soils are fertile in the Caspian Forest zone the low (6-8 ppm) phosphorous status of the soil would appear to merit the application of some phosphate fertilizer.

In the littoral zone of Tunisia Le Houérou (1965) and Le Houérou and Froment (1969) recommend an application of 45 kg/ha P_2O_5 to the seed-bed, 10-20 kg/ha P_2O_5 and 10 kg/ha N to the lines at seeding and 45 kg/ha P_2O_5 at the beginning of October in the second year for the establishment of dryland stands of *O. viciifolia*.

In the high plateaux zone of Algeria Maignan (1970) records an application of 45 kg/ha P_2O_5 at the time of soil preparation (July) and 22 kg/ha N before seeding, and in succeeding years (October), for establishing and maintaining dryland stands of *O. viciifolia*.

Weed control :

Weeds have hindered establishment on cultivated land in the sub-steppic zone of Iran, particularly *Hulthemia persica*, a deep rooted weed belonging to the Rosaceae family ; deep cultivation combined with spraying of 2,4 D ester before seeding of *O. viciifolia* has proved successful in controlling the infestation of *H. persica*.

In Tunisia Le Houérou (1965) and Le Houérou and Froment (1969) recommend that interrow weeding be carried out in the first year after the seeding of *O. viciifolia* has emerged and to repeat this in the second and following years at the end of September.

20.10. Forage Value

Palatability :

O. viciifolia, *O. gaubae*, *O. melanotricha*, *O. persica* and *O. scrobiculata* have all proved very palatable to native sheep in the sub-steppic zone of Iran ; in grazing palatability tests at Homand they have been well grazed by sheep (Fig. 8) in the vegetative, flowering and seed production stages in the spring, and also in the vegetative stage in summer and autumn (AGP:SF/IRA 10, Tech. Rep. 1, 1970).

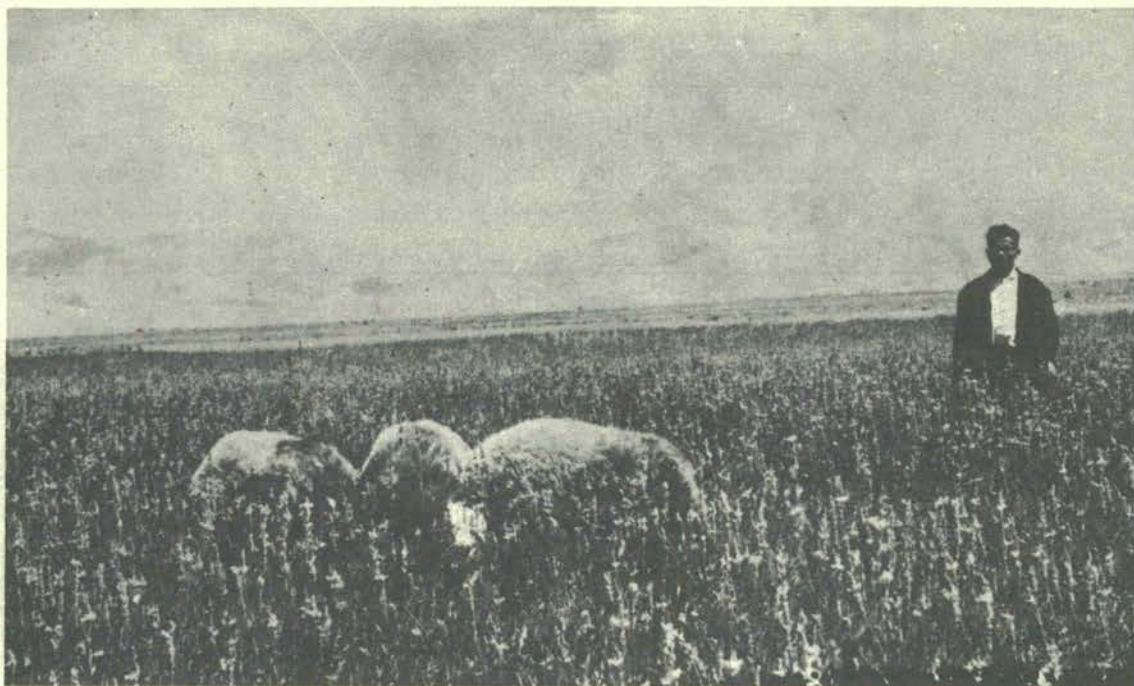


Fig. 8

Experimental sheep grazing a dryland stand of *Onobrychis sativa* planted at Homand in the spring of 1968. Above photo taken in June 1969.
(After Pasture and Fodder Crops Investigations, Iran, Tech. Rep. No 1, 1970, p. 92, Fig. 34)

Nutritive value :

In the Caspian Forest zone of Iran a chemical analysis of the forage of dryland *O. viciifolia* before flowering gave the following data :

Dry Matter %	Crude Protein %	Ca %	P %
22.0	14.0	0.73	0.25

In the littoral zone of Tunisia Corriols (1965) records the following chemical composition for an introduced variety (Turkish/Italian type) of *O. viciifolia* under dryland conditions :

Percentage Digestibility Products						
Date of Sampling	Protein	Fats	Cellulose	Non-N Extract	Metabolizable Energy kg/green matter	Forage Units kg green matter
12.4.56	1.97	0.86	2.55	3.90	375 c	0.10

In the littoral zone of Morocco Foury (1954) also records the following chemical composition data for dryland *O. viciifolia* at Rabat :

Percentage Composition						
Date Sampled	Water	Ash	Protein	Non-N Extract	Fats	Cellulose
3.6.49						
Green matter	70.00	2.15	2.92	15.04	0.60	9.29
Dry matter	0	7.16	9.74	50.11	2.00	30.99
18.4.51						
Green matter	76.01	1.84	4.18	13.56	1.08	3.33
Dry matter	0	7.70	17.46	56.56	4.39	13.89

Robinson (1947) reports some chemical composition data for dryland *O. viciifolia* (common Sainfoin) when cut at the hay stage just as the flowers are opening, which is given below :

	Ether Extract	Crude Protein	Fibre	Ash	Soluble carbo- hydrates	P	Ca
Stem	2.00	9.88	37.50	4.00	46.62	0.376	0.686
Leaf	4.60	21.62	17.20	6.00	50.58	0.516	1.988
Flower head	3.10	28.67	18.50	6.50	43.23	1.110	1.400
Whole plant	2.61	17.00	28.00	6.25	46.14	0.526	1.260

20.11. Forage and Seed Production

Forage yields :

In the sub-steppic zone (1,960 m elevation, 320-350 mm annual rainfall) of Iran at Homand the following forage yields have been obtained for dryland *O. viciifolia* and *O. scrobiculata* in nursery or field stands :

Nursery stands								
Species	1966		1967		1968		1969	
	Age of stand in years	kg/ha dry matter	Age of stand in years	kg/ha dry matter	Age of stand in years	kg/ha dry matter	Age of stand in years	kg/ha dry matter
<i>O.viciifolia</i>	4	2,380	5	200	6	520	1 1/	1,270 1/
<i>O.scrobiculata</i>	--	--	--	--	5	1,880	--	--
1/ Figure obtained from a field stand								

In the Caspian Forest zone (1,200 m elevation, +600 mm annual rainfall) Dumancic (1975) records that dryland *O. viciifolia* has yielded 30,000-36,000 kg/ha of green forage in three to four cuttings during the spring and summer.

In the littoral zone of Tunisia (400-600 mm annual rainfall) Corriols (1965) records a modest production of 1,800-3,000 forage units/ha in the second year and 1,300-1,800 forage units/ha in the third year for dryland *O. viciifolia* and reports the following production data for two introduced varieties in experimental dryland plantings :

	1955-56 (664.7 mm rainfall) Second year				1956-57 (492.2 mm rainfall) Third year			
	Green matter kg/ha	Dry matter kg/ha	Dig. protein kg/ha	Forage units/ ha	Green matter kg/ha	Dry matter kg/ha	Dig. protein kg/ha	Forage units/ ha
Giant Type (Libya)	18,998	3,419	360	1,899	13,776	2,479	261	1,377
Turkish Italian Type	29,885	5,379	567	2,988	18,887	3,399	358	1,888

For dryland field stands of *O. viciifolia* in the littoral zone of Tunisia Le Houérou (1965) and Le Houérou and Froment (1969) record green forage yields varying from 10,000-20,000 kg/ha in the first year, and 15,000-40,000 kg/ha in the second and following years.

In the littoral zone (400-600 mm annual rainfall) of Morocco Villax (1963) reports green forage yields varying from 16,000-32,000 kg/ha and hay yields from 4,000-8,000 kg/ha for experimental dryland plantings of *O. viciifolia*, while Gallacher (1977) records green forage yields varying from 8,000-16,000 kg/ha for introduced Iranian varieties (originally from Turkey) in experimental dryland plantings in the high plateaux zone (450-600 mm annual rainfall) of Algeria.

Seed yields :

In the sub-steppic zone of Iran, at Homand (1,960 m elevation) *O. viciifolia* has given a maximum unhulled seed yield of 350 kg/ha, but in some years the seed yield has been as low as 50 kg/ha due to poor seed set ; *O. gaubae* has proved the most reliable seed producer of the native *Onobrychis* spp. and gave an unhulled seed yield of 60 kg/ha in one year.

In the littoral zone of Morocco Villax (1963) records an unhulled seed yield for dryland *O. viciifolia* varying from 400-800 kg/ha and Maignan (1970) records a seed yield of 264 kg/ha in one year in June in the high plateaux zone of Algeria.

Effect of climate on seed set :

High air temperature and low atmosphere in some years at or before flowering have adversely affected the amount of seed set of both native *Onobrychis* spp. and *O. viciifolia*. However, at Karadj, in the steppic zone (1,300 m elevation), where flowering takes place 3-4 weeks earlier, the seed production of *O. viciifolia* has been greatly increased under irrigation where yields of unhulled seed have reached 500-1,000 kg/ha.

20.12. Utilization

Type of use :

O. viciifolia can be used either for grazing or hay, while the previously mentioned native *Onobrychis* spp. of Iran are ideally suited to grazing use, since most of them produce short growing, prostrate or semi-erect plants.

Grazing utilization :

In the littoral zone of North Africa Villax (1963) mentions that October-seeded *O. viciifolia* can be grazed from the end of March to May in the following spring and supports well grazing and trampling by livestock.

In Turkey *O. viciifolia* has been grazed over a 6 month period when seeded in double or alternative rows with *Medicago sativa* and *Bromus inermis* under dryland conditions (Bakir, 1969). The sheep grazed the forage species more uniformly in double rows than in alternative rows. However, *O. viciifolia* was not suitable for long term pastures because of its susceptibility to pest damage.

Alternate use for hay, green cut forage and grazing :

In Morocco Villax (1963) mentions that *O. viciifolia* can be cut for hay in April, and may then give sufficient re-growth for a further grazing. If seed production is required the first growth should not be utilized.

In the littoral zone of Tunisia Le Houérou (1965) and Le Houérou and Froment (1969) recommend one cut in March-April in the first year, and one cut in December-January, one cut at the beginning of March, and one cut at the end of April in the second and following years.

In the Caspian forest zone of Iran three cuts have been possible each year in the spring and summer, while in the sub-steppic zone of Iran one or two grazing or one hay crop has been possible in the period from March to end May.

Pasture longevity :

Under dryland conditions *O. viciifolia* is generally considered to be short lived and to give its maximum forage production in the first 3-4 years ; thereafter its forage production tends to diminish considerably.

Use in dryland crop rotations :

For this reason *O. viciifolia* can be considered as useful for inclusion in dryland crop rotations. In the Caspian Forest zone of Iran Dumancic (1975) has recommended the inclusion of dryland *O. viciifolia* in a four course rotation as follows : first year cereal (wheat), second year sainfoin, third year sainfoin, fourth year soya bean, maize.

In Turkey dryland *O. viciifolia* has been included on an experimental basis in a three year legume (sainfoin) followed by four year cereal (wheat) rotation ; the inclusion of *O. viciifolia* substantially raised wheat yields compared to various combinations of wheat and fallow over a seven year rotation period, and also produced an annual average hay yield of 5,000 kg/ha over a 10 year period (Alinoglu, 1974).

Further evaluation :

All the previously mentioned native *Onobrychis* spp. of Iran are long lived species, but further development work is required to evaluate their real potential for dryland seeding in the sub-steppic zone of Iran and elsewhere in the Near and Middle East and also North Africa.

20.13. Specific References

- | | |
|--------------------------------------|---|
| CARLETON, A.E. <u>et al.</u>
1968 | Effect of seed pod and temperature on speed of germination and seedling elongation of Sainfoin (<i>Onobrychis viciifolia</i> Scop.).
<i>Agron. J.</i> , 60(1): 81-84. |
| CHESNEAUX, M.T.
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FAMILY PAPILIONACEAE (= FABACEAE)

ANNUAL SPECIES

- 21. *Lathyrus* spp.
- 22. *Medicago* spp.
- 23. *Vicia* spp.

TECHNICAL DATA

SHEET No 21

PAPILIONACEAE (=FABACEAE)

Lathyrus spp.

21.1. Species

There are three useful *Lathyrus* spp. for forage in North Africa and the Near and Middle East, which are in order of importance *L. sativus* L., *L. cicera* L. and *L. ochrus* (L.) D.C.

21.2. Synonyms

- *L. sativus* (= *L. sativus* var *stenophylla* Boiss.)
- *L. ochrus* (= *Pisum ochrus* L.)

21.3. Common Names

- | | | |
|---------------------|---------|---|
| - <i>L. sativus</i> | English | Chickling Vetch,
Blue Chickling,
Blue Vetchling,
Grass Pea (USA) ;
Khessary Pea (India). |
| | French | Gesse commune,
Pois carré. |
| | Arabic | Djilben, Djiben el-biod, Ajilbane,
Beiqa, Baqia, Hamikou, Kerfala
(Morocco, Algeria) ;
Quarfala (Algeria, Tunisia) ;
Sa'eyda, Gilbaan (Egypt (UAR) ;
Gilbane, Julban (Palestine, Syria) ;
Hurtumann (Iraq). |
| - <i>L. cicera</i> | English | Flat-podded Vetchling,
Flat-podded Pea or Vetch,
Dwarf Chickling. |
| | French | Gesse chiche, Jarosse. |
| | Arabic | Djilban bangeru, Djelban banqueran,
Djelben bouqroun (Morocco) ;
Sesa, Saysa (Jordan). |
| - <i>L. ochrus</i> | English | Ochrus Vetch, Cyprus Vetch, Yellow
Pea. |
| | French | Gesse ocre. |
| | Arabic | Latila (Morocco). |

21.4. Brief Description

- *L. sativus* is an erect or ascending much branched bushy or slender legume reaching a height of 30-90 cm with a deep much branch tap root with numerous bluish-purple, yellow flowers carried on a stiff axillary stalk with glabrous spiral pods each containing 6-12 seeds (Fig. 1) ;

- *L. cicera* is a robust legume reaching a height of 20-100 cm with copper coloured flowers and canicular pods not winged at the corners, with angular brown or grey seeds with black markings ; seeds and flowers are smaller than those of *L. sativus* (Fig. 3) ;

- *L. ochrus* is a scrambling legume with winged stems reaching a height of 20-70 cm with solitary or pairs of yellow flowers and glabrous pods, fawn coloured at maturity with longitudinal laminae adpressed to the wings on the back, each pod containing 4-8 round black seeds lightly covered with a bloom (Fig. 4).

21.5. Varieties

Botanical varieties :

Several botanical varieties of *L. sativus* and *L. cicera* have been noted in N. Africa and the Near and Middle East. In Morocco Foury (1954) mentions the following :

- *L. sativus* :
 - var *albus*
with white flowers ;
 - var *roseus*
with pink or red flowers ;
 - var *cyaneus*
with blue flowers.
- *L. cicera* :
 - var *genuinus* Rouy
present throughout Morocco ;
 - var *angustifolius* Rouy
present in the Rif and Haouz ;
 - var *longistipulatus* Sennen
present in the Rif.

In Iran Parsa (1950) mentions also the following botanical variety of *L. cicera* :

- var *ciliatus* Lipsky
with ciliated leaflets, present at Marand.

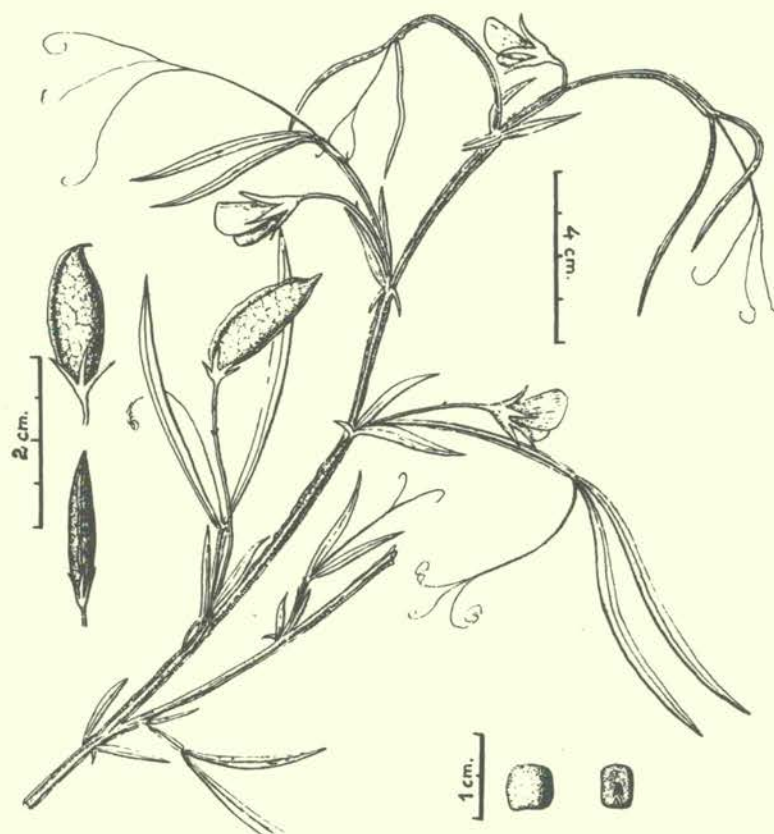


Fig. 1 - *Lathyrus sativus* (L.) (Orig. - Paris)

(After Recueil iconographique des espèces comestibles
de légumineuses africaines, 1960-61, p. 17, fig. 16)

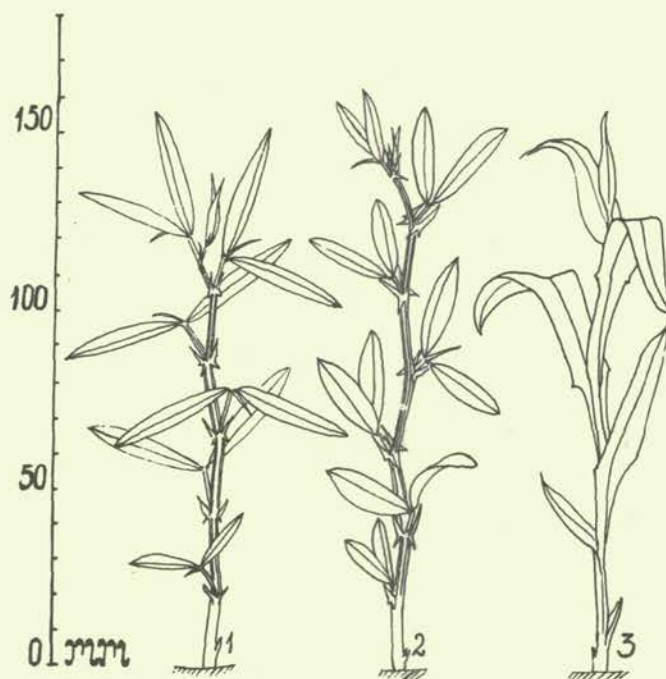


Fig. 2

Seedlings of several species of the genus
Lathyrus 21 days after emergence

1. *L. sativus* 2. *L. cicera* 3. *L. ochrus*

(After la Culture des plantes fourragères dans la région
méditerranéenne occidentale, 1963, p. 495, fig. 141)

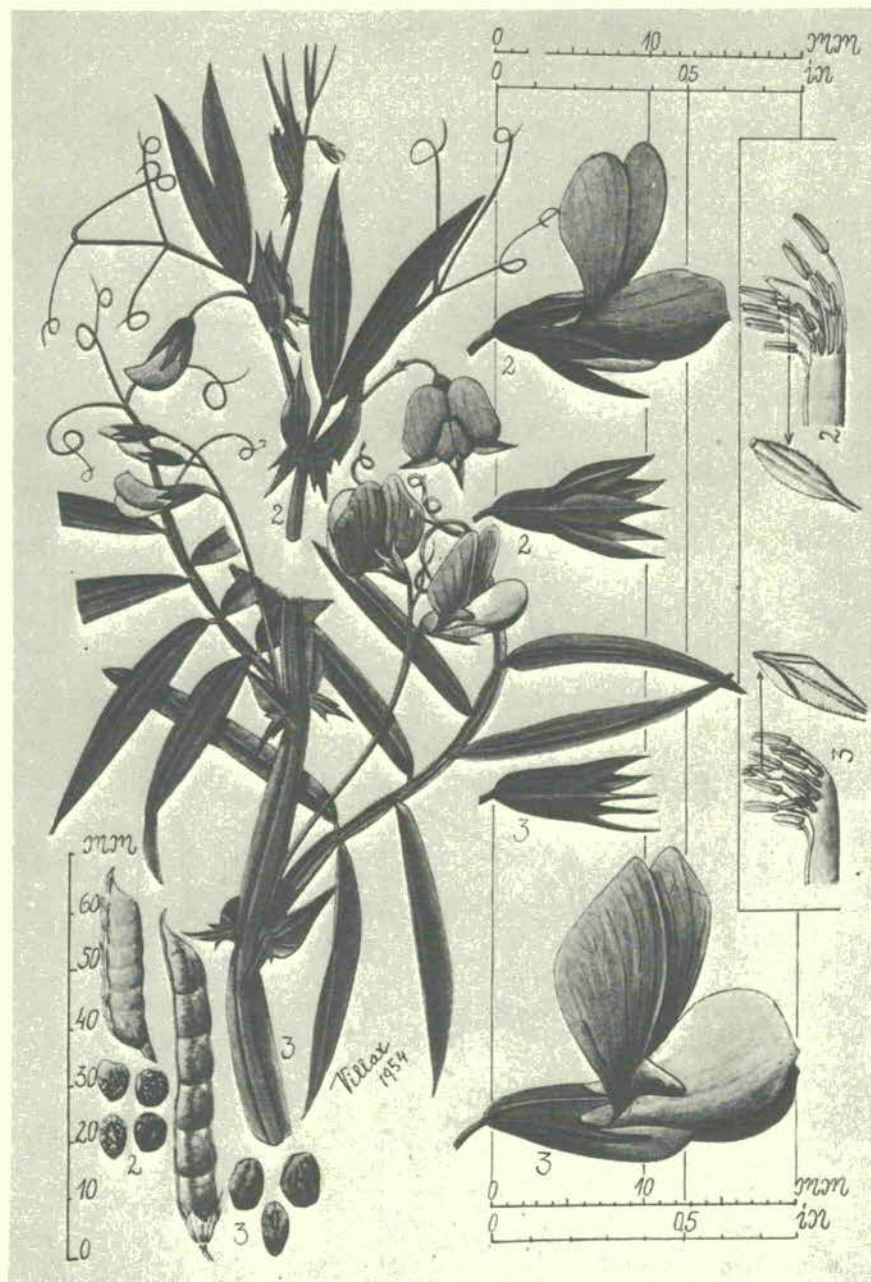


Fig. 3

Lathyrus cicera (2) and *L. clymenum* (3)

(Orig. - Elvas 1954)

(After la Culture des plantes fourragères dans la région méditerranéenne occidentale, 1963, p. 492, fig. 140)

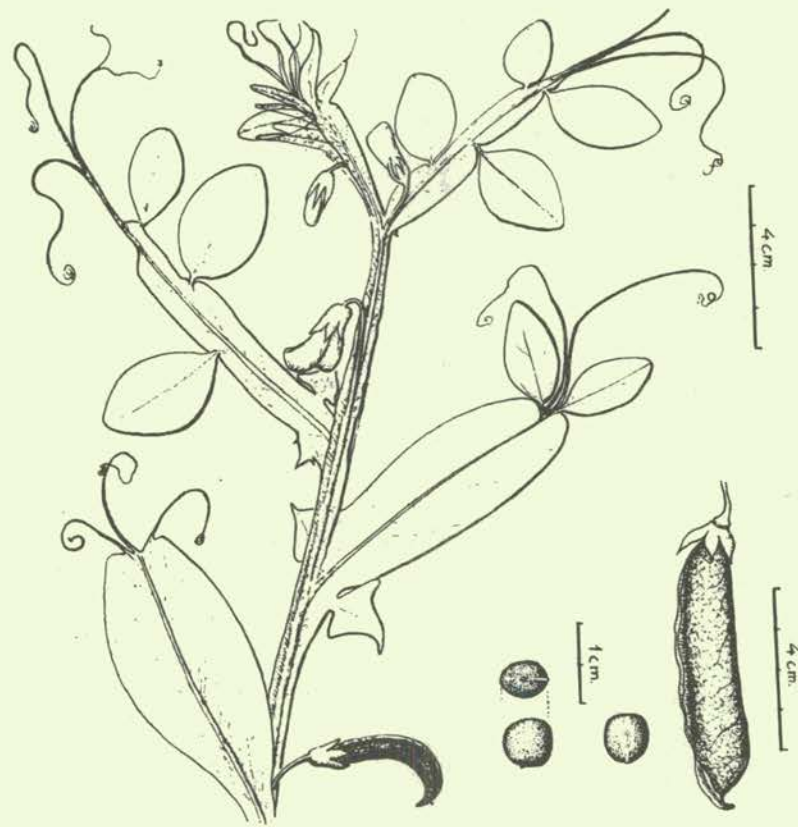


Fig. 4

Lathyrus ochrus L. D.C. (= *Pisum ochrus* L.) (Orig. - Paris)

(After Recueil iconographique des espèces comestibles
de légumineuses africaines, 1960-61, p. 16, fig. 15)

Although *L. sativus* var *stenophyllus* Boiss. is recognized as being the synonym for *L. sativus*, Mouterde (1966) in Syria and Lebanon, Parsa (1950) in Iran, and Kitamura (1960, 1964) in Afghanistan record *L. sativus* var *stenophyllus* as occurring in a naturalized spontaneous form, which is different from the typically cultivated form of *L. sativus*.

Native ecotypes :

In Turkey Hertzsch (1970) records that 9 ecotypes of *L. sativus*, 2 ecotypes of *L. cicera* and 61 ecotypes of an unspecified species of *Lathyrus* have been collected in the different regions of Turkey during the period 1965-69 and assembled on the west coast at Izmir.

Varieties and adaptability :

A number of native cultivars or varieties of *L. sativus*, *L. cicera* and *L. ochrus* have been introduced and tested in dryland plantings in N. Africa and the Near East.

In the littoral zone of Morocco Villax (1963) records that the variety "Grao da Gramicha" of *L. cicera* from Portugal and a variety of *L. ochrus* from Israel have performed well among others, while in the littoral zone of Tunisia Corriols (1965) records that the variety "Grao da Gramicha" and the variety "Favetta" of *L. sativus* and the variety "Louvana" of *L. ochrus*, both from Cyprus, have performed well among varieties introduced from Greece, Libya and Portugal.

In Cyprus Soteriadou (1959) reports that among 4 local varieties and 23 introductions from Algeria, Australia, Egypt, Greece, Libya, Portugal and Turkey of *L. sativus*, *L. cicera* and *L. ochrus*, a variety of *L. sativus* from Greece has outyielded other introductions and was more leafy, while a variety of *L. cicera* from Libya and a local variety of *L. ochrus* proved superior to other introductions ; several varieties including a local one of *L. sativus*, and all the varieties of *L. ochrus*, were susceptible to *Perenospora viciae*. Duration of growth averaged 178-185 days for varieties of *L. sativus*, 165-172 days for varieties of *L. cicera* and 164-172 days for varieties of *L. ochrus*.

In Jordan Hopkinson (1975) records that a variety of *L. sativus* from Cyprus has performed well, while in Syria Van der Veen (1967) records that two varieties of *L. sativus* from Cyprus and one variety of *L. ochrus* from Cyprus and one from Portugal have proved well adapted.

In N. Iraq a local variety of *L. sativus* is cultivated extensively in some areas, while a variety introduced from Turkey in small adaptability row tests at Mosul has proved to be more productive and cold tolerant than the local variety (Kernick, 1976).

21.6. Number of Chromosomes

L. sativus : $2x = 14$; *L. cicera* : $2x = 14$; *L. ochrus* : $2x = 14$.

21.7. Geographical Distribution

L. sativus is cultivated and extensively naturalized in C., S. and E. Europe (from Germany south to Portugal and Spain and east to the Balkans and S. Russia), also in Crete, Rhodes, Cyprus, Syria, Lebanon, Palestine, Egypt, Caucasus, Iraq, Iran, Afghanistan, N. India, C. Asia (Balkhash to Palmir-Alai), Macaronesia (Madeira, Canaries, Teneriffe, Azores), also cultivated in N. Africa (Morocco, Algeria), tropical Africa (Sudan, Ethiopia), S. Africa and Australia ;

L. cicera is distributed in S. and Mediterranean Europe (from Portugal to Italy to the Balkans and the Crimea), Crete, Aegean Isles, Cyprus, Syria, Lebanon, Palestine, Jordan, Egypt, Turkey, Caucasus, Iraq, Iran, C. Asia (Turkmenia to Palmir-Alai), Macaronesia (Madeira, Canaries, Teneriffe), N. Africa (Morocco, Algeria, Tunisia, Libya) and introduced into S. Africa ; Davis (1966) also records the distribution of *L. cicera* in Turkey which is shown in the distribution map in Fig. 5 ;

L. ochrus is distributed in Mediterranean Europe (Portugal, Spain, S. France, Corsica, Sardinia, Italy, Sicily, Malta, Yugoslavia, Greece), Crimea, Aegean Isles, Cyprus, Syria, Lebanon, Palestine, Turkey, N. Africa (Morocco, Algeria, Tunisia, Libya).

21.8. Biology and Ecology

Growth and development :

L. sativus, *L. cicera* and *L. ochrus* are all cool season species propagating themselves by seed.

Villax (1963) records that all three *Lathyrus* spp. grow well in the Mediterranean region when seeded in the autumn supporting well mild winters but also resisting mild frosts and also dry periods during the winter and spring.

In the littoral zone of Tunisia Corriols (1965) mentions that dryland *L. sativus*, *L. cicera* and *L. ochrus* seeded in the first week of November gave a 100 % germination by the last week of November, flowered in March-April and produced seeds at the end of June-beginning of July ; plants of *L. sativus* and *L. cicera* were dry by mid-June but those of *L. cicera* did not dry until mid-July.

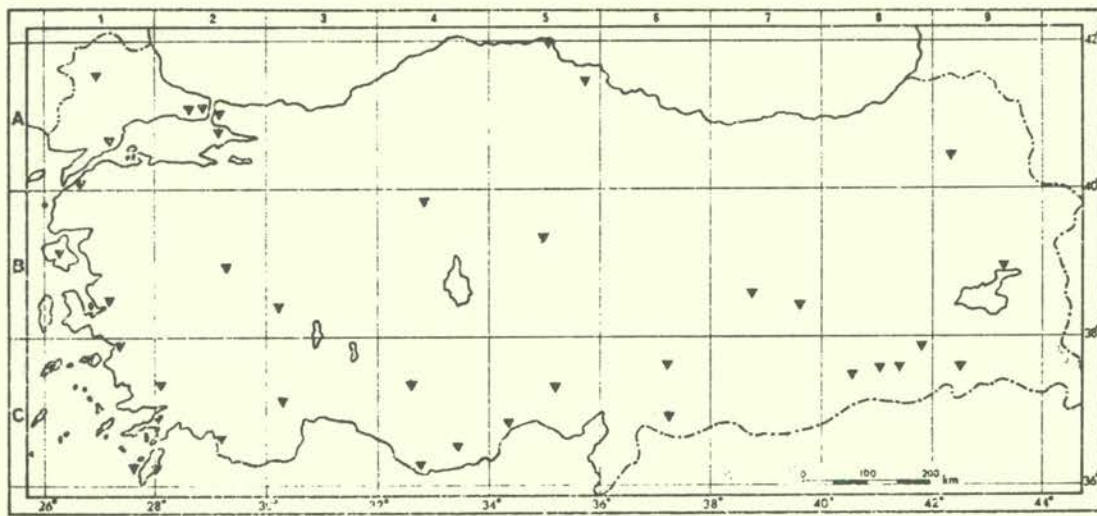


Fig. 5

Distribution of *Lathyrus cicera* in Turkey

(After Flora of Turkey and the Aegean Islands,
1966, p. 363, map 78)

In Jordan Hopkinson (1975) records that dryland *L. sativus* and *L. ochrus* at Kerak grew fairly well during the spring period and *L. sativus* was less sensitive to late sowing than *Vicia* spp. ; *L. ochrus* also matured earlier than *L. sativus* but both species flowered in early April. Although *L. sativus* matured more slowly it proved more resistant to shattering than the other *Lathyrus* spp. and also *Vicia* spp., while *L. ochrus* suffered less bird damage than the other *Lathyrus* spp.

In N. Iraq Kernick (1976) records that over two seasons *L. sativus* has grown well on calcareous alluvial soil in the region of Mosul but developed poorly on sandy soil at Hatra to the south even though rainfall conditions were similar in both regions. Germination and establishment of *L. sativus* occurred by the end of December in the Mosul and Hatra regions where maximum vegetative growth and flowering occurred in April and seed production in May ; in one year in February at Mosul seedlings of *L. sativus* resisted well temperatures of -4 to 5°C for a week.

Although the growth period of *L. sativus* is a little longer than for *L. cicera* and *L. ochrus* the growth of all these species ceases with the onset of the hot dry summer period in the littoral and interior steppe zones of N. Africa and the Near East.

Climate and soils :

In regard to annual rainfall *L. sativus*, *L. cicera* and *L. ochrus* require 300-500 mm for dryland cultivation and superior results are obtained with +400 mm rainfall ; winter temperatures also influence performance and cold tolerant varieties give superior results in areas with minimum winter temperatures at or below 0°C.

In regard to edaphic conditions the above mentioned *Lathyrus* spp. are adapted to a wide range of soils as long as they are not very wet at the surface or flooded. Villax (1963) also mentions that *L. cicera* prefers calcareous clays and that *L. ochrus* prefers fertile land.

Ecological characteristics :

Ecologically *L. sativus*, *L. cicera* and *L. ochrus* occur spontaneously in forest clearings, pastures, fallows and by roadsides in the littoral, interior steppes and plains and mountains of N. Africa and the Near and Middle East. In general these *Lathyrus* spp. are found up to 1,000 m elevation, in the lower mountains of N. Africa and the Near East, but in the Middle East *L. sativus* has been recorded by Parsa (1950) in N. Iran at 2,350 m elevation at Kuhe Nasr and by Kitamura (1964) in Afghanistan at 2,700 m elevation in the Hindukush and at 3,500 m elevation at Nagil.

21.9. Cultivation Techniques

Time of seeding :

In the Mediterranean region *L. sativus*, *L. cicera* and *L. ochrus* are normally seeded after the first autumn rains.

In Tunisia Corriols (1965) reports that seeding has been carried out in November for dryland *Lathyrus* spp. in the littoral zone and Soteriadou (1959) records the same time of sowing in Cyprus.

In Syria, Jordan and N. Iraq the best time of seeding for *Lathyrus* spp. has also proved to be November, although Hopkinson (1975) records that later sowing has also proved successful in Jordan at Karak.

Land preparation :

A firm, fine, weed-free seed-bed is required for planting which normally entails ploughing the soil, 10-15 cm deep, followed by a discing, harrowing and rolling.

Supporting crop :

It is preferable to plant the *Lathyrus* spp., especially *L. cicera* and *L. ochrus* which have more straggling stems, with a supporting crop such as *Avena sativa* or *Hordeum vulgare* and sometimes *Vicia narbonensis* ; however, *L. sativus* is quite often seeded alone.

Seed rates, row spacing and method of seeding :

Seed rates and spacings for seeding of *Lathyrus* spp., alone or in mixture, varies between countries but the following have been reported :

<u>Morocco</u>	<i>L. sativus</i> (alone)	120-160 kg/ha of seeds broadcast
	<i>L. cicera</i> (alone)	100-130 kg/ha of seeds broadcast or 80-100 kg/ha of seed drilled in lines spaced 20-40 cm apart
	<i>L. ochrus</i> (alone)	100-140 kg/ha of seeds broadcast or drilled in lines spaced 30-50 cm apart
<u>Cyprus</u>	<i>L. sativus</i> +	} broadcast
	<i>H. vulgare</i>	
<u>Syria</u>	<i>L. sativus</i> +	} broadcast
	<i>H. vulgare</i>	

<u>Iraq</u>	<i>L. sativus</i> (alone)	60 kg/ha of seeds drilled in lines spaced 15-20 cm apart	
	<i>L. sativus</i> + <i>V. narbonensis</i> + <i>H. vulgare</i>	40 kg/ha of seeds 32 kg/ha of seeds 24 kg/ha of seeds	} broadcast
	<i>L. sativus</i> + <i>H. vulgare</i> or <i>A. sativa</i>	60 kg/ha of seeds 75 kg/ha of seeds 75 kg/ha of seeds	} <i>L. sativus</i> seed drilled in one direction and the cereal cross-drilled in the other direction ; drill spacing 15-20 cm

Fertilizer application :

In regard to fertilization both Van der Veen (1967) and Kernick (1976) record that a basic application of 60 kg/ha P_2O_5 has been applied to the seed-bed for experimental and field scale plantings of *L. sativus*, *L. cicera* and *L. ochrus* alone or in mixture with *A. sativa* or *H. vulgare* in Syria and N. Iraq.

21.10. Forage Value

Palatability :

L. sativus, *L. cicera* and *L. ochrus* are all very palatable to livestock and Villax (1963) records that the seeds of *L. cicera* are rich in albumin (20-25 %) and can be fed to animals.

Seed toxicity :

Villax (1963) considers that the seeds of *L. ochrus* can be fed safely to animals, but Foury (1954) considers that they are dangerous and some cases of toxicity has been reported when feeding the seeds of both *L. cicera* and *L. ochrus* to sheep in Morocco.

Nutritive value :

The nutritive value of *L. sativus*, *L. cicera* and *L. ochrus* is good as the following data record from various countries shows :

Portugal : Elvas (Villax, 1963)

Percentage Chemical Composition						
Species	Nature of Feed	Water	Protein	Fats	Carbohydrates Soluble	Fibre Ash
<i>L. sativus</i>	seed	13	25	1	50	7 4
<i>L. cicera</i>	green	80	4.5	0.5	8	5 2
	hay	14	14	2	40	25 5
	straw	14	12	2	31	35 6
	seed	13	27	1	50	6 3
<i>L. ochrus</i>	seed	13	26	1	49	7 4

Morocco : Rabat (Foury, 1954)

Percentage Chemical Composition							
Species	Nature of Forage	Water	Ash	Protein	Non-N Extract	Fats	Cellulose
<i>L. sativus</i>	Dry plant						
	(on wet basis)	9.44	12.48	13.50	22.50	0.64	41.40
	(on dry basis)	0	13.79	14.41	24.85	0.71	45.74
<i>L. sativus</i>	Green plant						
	(on wet basis)	55.00	3.24	6.68	18.01	1.11	15.96
	(on dry basis)	0	7.22	14.86	39.97	2.47	35.48

Cyprus : Nicosia (Soteriadou, 1959)

Percentage Composition in May			
Species	Nature of Forage	Dry Matter	Crude Protein
<i>L. sativus</i> (average for 7 varieties)	Green plant (on dry basis)	19.9	28.7
<i>L. cicera</i> (average for 6 varieties)	Green plant (on dry basis)	20.1	27.0

In N. Iraq Kernick (1976) records that the crude protein content on a dry matter basis for *L. sativus* sampled from dryland field stands varied from 12 to 15 % in April.

21.11. Forage and Seed Production

Forage yields :

In the littoral zone (500-600 mm annual rainfall) of Morocco Villax (1963) reports that average experimental dryland forage yields have varied from 6,000-12,000 kg/ha green forage (1,500-3,000 kg/ha hay) for *L. cicera* and 10,000-20,000 kg/ha green forage (2,500-5,000 kg/ha hay) for *L. ochrus* with average forage yield of *L. sativus* being noted as a little higher than those of *L. cicera*.

In Libya, at Tarhuna (Tripolitania), Soghaier (1961) reports very low dryland forage yields in a dry year, with less than 200 mm annual rainfall amounting to only 800 kg/ha green forage for *L. sativus* and 350 kg/ha for *L. cicera*.

In Syria Van der Veen (1967) records over two years at Kamishli (300-400 mm annual rainfall) average experimental forage yields for dryland *L. sativus* varying from 6,500-11,500 kg/ha green forage, unfertilized, and from 12,800-16,400 kg/ha green forage fertilized with 60 kg/ha P_2O_5 ; however, in a dry below average rainfall year, average forage yields dropped to 1,700-3,400 kg/ha green forage unfertilized, and to 1,900-4,000 kg/ha green forage fertilized with 60 kg/ha P_2O_5 .

In N. Iraq Al Maiuf (1966) reports that over a three year trial period autumn (November) seeded dryland *L. sativus* at Bakrajo (+500 mm annual av. rainfall) gave an average green forage yield of 10,000 kg/ha in May. Kernick (1976) also records at Mosul in N. Iraq, in a year with 475 mm of well distributed rainfall, average green forage yields varying from 10,000-14,000 kg/ha for autumn (November) seeded *L. sativus* planted alone or in mixture with *A. sativa* and fertilized with 60 kg/ha P_2O_5 , while in a year with 327 mm rainfall, not well distributed and less than 20 mm falling in March, the average green forage yield was only 5,000 kg/ha.

Seed yields and harvesting :

In regard to seed production Villax (1963) records in the littoral zone of Morocco dryland seed yields averaging 150-250 kg/ha for *L. cicera* and 100-200 kg/ha for *L. ochrus*, with seed yields of *L. sativus* being noted as somewhat lower than those cited for *L. cicera*. Villax (1963) also mentions that the seed harvesting of all three *Lathyrus* spp. should not be delayed since the seeds shatter from the mature pods readily.

21.12. Utilization

Multipurpose use :

L. sativus, *L. cicera* and *L. ochrus* can be grazed, cut directly for green feed or conserved as silage or hay or the seeds may be fed directly to livestock ; Villax (1963) also considers that *L. sativus* is a useful green manure crop.

Seed varieties :

In Morocco Villax (1963) recommends the cultivation of the small grey-seeded varieties of *L. sativus* for providing a concentrate for feeding livestock since the seeds are not toxic.

Stage of growth for grazing :

For grazing use Villax (1963) recommends pasturing both *L. cicera* and *L. ochrus* at the beginning of flowering which occurs generally in February or March in the littoral zone of N. Africa.

Conservation as hay and silage :

In N. Iraq on a field scale a mixture of dryland *L. sativus* and *A. sativa* has been successfully harvested for hay and baled in May after drying in the windrow (Kernick et al., 1976). In North Africa Villax (1963) also mentions that *L. ochrus* can be ensiled in the seed formation stage.

Liveweight gains of lambs on pasture :

In regard to livestock production Kernick et al. (1976) also report that 3-4 month old Awassi male lambs made average liveweight gains of 200 g /head/day when grazing a dryland mixture of *L. sativus* and *L. vulgare* during March-April in N. Iraq.

Crop rotations :

L. sativus, in particular, shows considerable promise for use on fallow land for forage production in the Near East, where it could present a practical alternative to the use of *Vicia* spp. either grown alone or in mixture with *A. sativa* and *H. vulgare*.

Further evaluation :

In the future more attention needs to be given to the collection and evaluation of native ecotypes of *L. sativus*, *L. cicera* and *L. ochrus* which show desirable attributes of cold and drought tolerance, early maturity and disease resistance.

TECHNICAL DATA

SHEET No 22

PAPILIONACEAE (=FABACEAE)

Medicago spp.

22.1. Species

Amongst the many annual and related *Medicago* spp. present in North Africa and the Near and Middle East, Gachet and Elmir (1972) consider the following belonging to the *Spirocarpos* section to be both widespread and of agronomic importance : *M. truncatula* Gaertn, *M. scutellata* (L.) Mill., *M. laciniata* (L.) Mill., *M. rugosa* Desr., *M. minima* (L.) Bart., *M. polymorpha* (L.), *M. tornata* (L.) Mill. Gard., *M. littoralis* Rhode ex Loisel, *M. rigidula* (L.) All., *M. turbinata* (L.) All., *M. murex* Willd. and *M. intertexta* (L.) Mill. Gard. ; to this list must also be added *M. orbicularis* (L.) Bartal from the *Orbiculares* section, *M. lupulina* L. and *M. arabica* (L.) Huds.

22.2. Synonyms

- *M. truncatula* (= *M. tribuloides* Desr.)
- *M. scutellata* (= *M. polymorpha* var. *scutellata* L., *M. inermis* L.)
- *M. laciniata* (= *M. polymorpha* var. *laciniata* L.)
- *M. rugosa* (= *M. elegans* Jaqu. ex Willd.)
- *M. minima* (= *M. polymorpha* L. var. *minima* L., *M. polymorpha* var. *recta* Desf., *M. recta* (Desf.) Willd.)
- *M. polymorpha* (= *M. hispida* Gaertn.)
- *M. tornata* (= *M. obscura* Retz emend. Urb., *M. italica* (Mill.) Steud.)
- *M. rigidula* (= *M. gerardi* Waldst. et Kit. ex Willd.)
- *M. turbinata* (= *M. polymorpha* L. var. *turbinata* L., *M. tuberculata* Willd.)
- *M. murex* (= *M. muriculata* St. Lag., *M. sphaerocarpus* Bertol.)
- *M. intertexta* (= *M. polymorpha* L. var. *intertexta* L.)
- *M. orbicularis* (= *M. polymorpha* L. var. *orbicularis* L., *M. applaudata* Willd.)
- *M. lupulina* (= *M. willdenowii* (Mérat) Urb., *M. lupulina* var. *willdenowii* (Mérat) Urb.)
- *M. arabica* (= *M. polymorpha* L. var. *arabica* L., *M. maculata* Sibth.)

22.3.

Common Names

- | | | |
|------------------------|---------|--|
| - <i>M. truncatula</i> | English | Aleppo Clover (Palestine) ;
Barrel Clover (Morocco) ;
Barrel Medick (USA) ;
Barrel Medic (Australia) ; |
| | French | Luzerne tronquée (Morocco) ; |
| | Arabic | Nafala Halabiya (Palestine). |
| - <i>M. scutellata</i> | English | Snail Medic (Australia) ; |
| | French | Luzerne à écussons,
Luzerne attrape (France, Morocco). |
| - <i>M. laciniata</i> | English | Cut Leaf Medic (Australia) ; |
| | French | Luzerne laciniée ; |
| | Arabic | N'fel (Morocco) ;
Aouinet el hanech (Tunisia) ;
Hasak (Saudi Arabia). |
| - <i>M. rugosa</i> | English | Snail Clover (USA) ; |
| | French | Luzerne élégante,
Luzerne rugueuse (France, Morocco). |
| - <i>M. minima</i> | English | Goldfields Medic, Small Bur Medic,
Kalgoorlie Medic (Australia) ;
Little Medick, Bur Medick (USA) ;
Least Medik (Libya) ; |
| | French | Luzerne nâne, Petite Luzerne
(France, Morocco) ; |
| | Arabic | Lissaij, Qunjierka (Iraq) ;
Korchet el Arnab (Tunisia). |
| - <i>M. polymorpha</i> | English | Burr Medic, Burr Clover, Bur
Trefoil (Australia) ;
Denticulate Medick (United Kingdom) |
| | French | Luzerne hérissée ; |
| | Arabic | Qurt, Nafal, Nifil, Qatt, Barri,
Qaraina (Iraq) ;
El Nafil, El Shawki, (Syria) ;
Gerrad, Oqqeil' (Egypt (UAR)). |

- <i>M. tornata</i>	French	Luzerne escargot, Luzerne italienne, Luzerne obscure, Luzerne limaçon (France, Morocco).
- <i>M. littoralis</i>	English	Strand Medic, Harbinger Medic (Australia) ; Coast Medik (Libya) ;
	French	Luzerne des rivages, Luzerne littorale.
- <i>M. rigidula</i>	English	Tifton Medick (USA) ;
	French	Luzerne rigide, Luzerne de Gérard, Lampourdette (France, Morocco).
- <i>M. turbinata</i>	English	Cogwheel Medick, Tubercled Medick, Snail Clover (USA) ;
	French	Luzerne turbinée, Luzerne entoupie (France, Morocco).
- <i>M. murex</i>	French	Luzerne hérissée, Luzerne à fruits sphériques (France, Morocco).
- <i>M. intertexta</i>	English	Calvary Medic (Australia) ;
	French	Luzerne à épines enchevêtrées, Luzerne hérisson (Morocco).
	Arabic	Khaasag (Egypt (UAR)).
- <i>M. orbiculatis</i>	English	Flat-podded Medick, Button Medick, Button Clover (USA) ;
	French	Luzerne orbiculaire, Luzerne marginée, Luzerne ronde, Herbe au limaçon, Limaçon, Escargot (France, Morocco) ;
	Arabic	Khobz El Ra'i (Syria) ; Hubzu rayi (Jordan).
- <i>M. lupulina</i>	English	Black Medick, Hop Clover, Hop Medick, Nonesuch, Yellow Trefoil ;
	French	Minette, Lupuline.
- <i>M. arabica</i>	English	Spotted Bur Clover, Spotted Medic, Heart Medic, Heart Trefoil, southern Bur Clover (USA)
	French	Luzerne d'Arabie, Luzerne hongroise, Luzerne maculée.

22.4. Brief Description

- *M. truncatula* is an annual legume ascending or procumbent, branching from the base, with yellow flowers growing to a height of 15-30 cm, having leaflets with rounded tips and with short or long cylindrical spiny often pubescent pods, hardening at maturity and containing yellow seeds (Fig. 1 and 2) ;

- *M. scutellata* is an annual hairy, semi-erect legume with yellow-orange flowers growing to a height of 15-30 cm and pods with 5-6 cup shaped coils and containing 6-8 large kidney shaped seeds ; 1-2 seeds in each coil (Fig. 3) ;

- *M. laciniata* is an annual glabrous legume with yellow flowers, angular stems and irregular leaf margins and with pods in the form of barrel shaped burrs covered with long spines ; 1-2 seeds in each coil (Fig. 4) ;

- *M. rugosais* a procumbent densely hairy annual legume with light to dark yellow flowers growing to a height of 10-30 cm with many seeded pods having a dorsal suture without spines ; 1 seed in each coil (Fig. 5, fruits) ;

- *M. minima* is a small very hairy prostrate annual legume with light to dark yellow flowers growing 5-30 cm high and with spirally coiled pods with slender hooked spines ; each coil containing 1-2 seeds (Fig. 6) ;

- *M. polymorpha* is a glabrous procumbent or ascending annual legume with small bright yellow flowers growing to a height of 15-40 cm, with no hairs on the upper surfaces of the leaflets, and spiny pods with 3-6 yellow seeds in each coil (Fig. 7 and 8) ;

- *M. tornata* is a more or less pubescent usually procumbent annual legume with bright yellow flowers, growing 15-40 cm long, sometimes exceeding 100 cm, with spineless pods, each coil containing 1-2 seeds (Fig. 9)

- *M. littoralis* is a hairy annual (sometimes biennial, Foury, 1950) legume with small yellow flowers and small spineless pods each containing 3 seeds (Fig. 10) ;

- *M. rigidula* is a usually procumbent hairy annual (sometimes biennial, Foury, 1950) legume with small yellow flowers and growing 10-50 cm long with pods having hooked spines and pin point slits between the coils at maturity ; 1-2 seeds in each coil (Fig. 11) ;

- *M. turbinata* is a hairy procumbent or ascending annual legume with small yellow flowers reaching a height of 15-40 cm with glabrous pods generally without spines ; 1-2 seeds in each coil (Fig. 12) ;

- *M. murex* is a generally glabrous annual legume with yellow-orange flowers, growing to a height of 10-50 cm and with spiny or spineless pods, having coils with a distinct veinless border ; 1-2 seeds in each coil (Fig. 13) ;

- *M. arabica* is a procumbent or ascending annual legume growing to a height of 10-60 cm with a purplish black central spot on the leaves, yellow flowers and discoid glabrous pods (Fig.

- *M. intertexta* is a stout procumbent or ascending annual legume with yellow flowers growing to a height of 20-50 cm with distinct pods characterised by the long curved sharp spines flattened to the pods ; 1-2 seeds in each coil (Fig. 14) ;

- *M. orbicularis* is an annual legume usually procumbent with stems attaining a length of 25-75 cm with small yellow flowers and pods without spines and 3-6 seeds in each coil (Fig. 15 and 16) ;

- *M. lupulina* is an annual or short-lived pubescent perennial legume attaining a height of from 10-50 cm with numerous small yellow flowers in long peduncled cylindrical heads and having small kidney shaped pods with spirally twisted tips which are black when ripe and have a single brownish-black seed in each pod (Fig. 17).

22.5. Varieties :

Botanical varieties :

In North Africa and the Near and Middle East a number of botanical varieties of *M. truncatula*, *M. laciniata*, *M. rugosa*, *M. minima*, *M. polymorpha*, *M. tornata*, *M. littoralis*, *M. rigidula*, *M. turbinata*, *M. murex*, *M. intertexta* and *M. lupulina* occur in the native flora.

In North Africa Foury (1950) mentions the following, recorded by Maire, the greater part of which occur in the littoral zone of Morocco, Algeria, Tunisia and Libya ; Negre (1956, 1959) has also made a more detailed revision of the varieties mentioned below :

- *M. truncatula* :

- var. *genuina* (Koch.) Briq. (= *M. tribuloides* Desr. s. Str.),
- var. *narbonensis* Str. (= *breviaculeata* (Moris) Urb.,
M. truncatula G.G.),
- var. *laciniata* Batt (= *M. hornemmaniana* Ser.).

- *M. laciniata* :

- var. *prochyasantha* Boiss.,
- var. *longispina* Benth.

- *M. minima* :

- var. *vulgaris* Urb.,
- var. *recta* (Desf.) Burnat.,
- var. *pulchella* Lowe.

- *M. murex* :

- var. *sphaerocarpa* (Bert.) Urb.,
- var. *ovata* (Carmign.) Urb. subvar. *brevisetata* Rouy et Foue.)

- *M. orbicularis* :

- var. *typica* and subvar. *applanata* (Willd.) Asch. et Gr.,
- var. *marginata* (Willd.) Beuth.

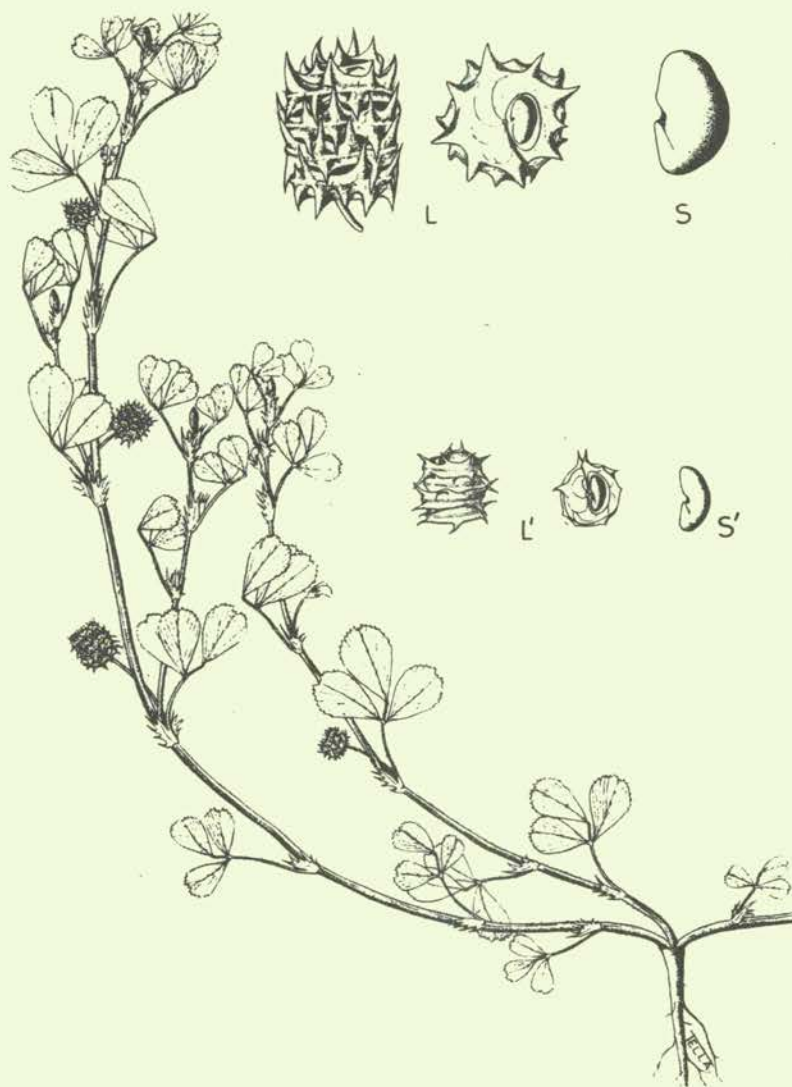


Fig. 1 - *Medicago truncatula*

Plant, x1. L : Ligule and upper surface of a coil, x3. S : Seed, x6.
Medicago littoralis - L' : Ligule and upper surface of a coil, x3. S' : Seed, x

(After Introduccion al Estudio de las Especies Pascicolas Espanolas,
 Madrid, 1965, p. 236.)



Fig. 2 - *Medicago truncatula*

A, var *longispina* - habit (slightly reduced)

B, var *longispina* - pod (x2)

C, var *truncatula* - pod (x2) from plant

(After Scripta hierosolymitana, 1963, vol. 12, p. 97, fig. 24)

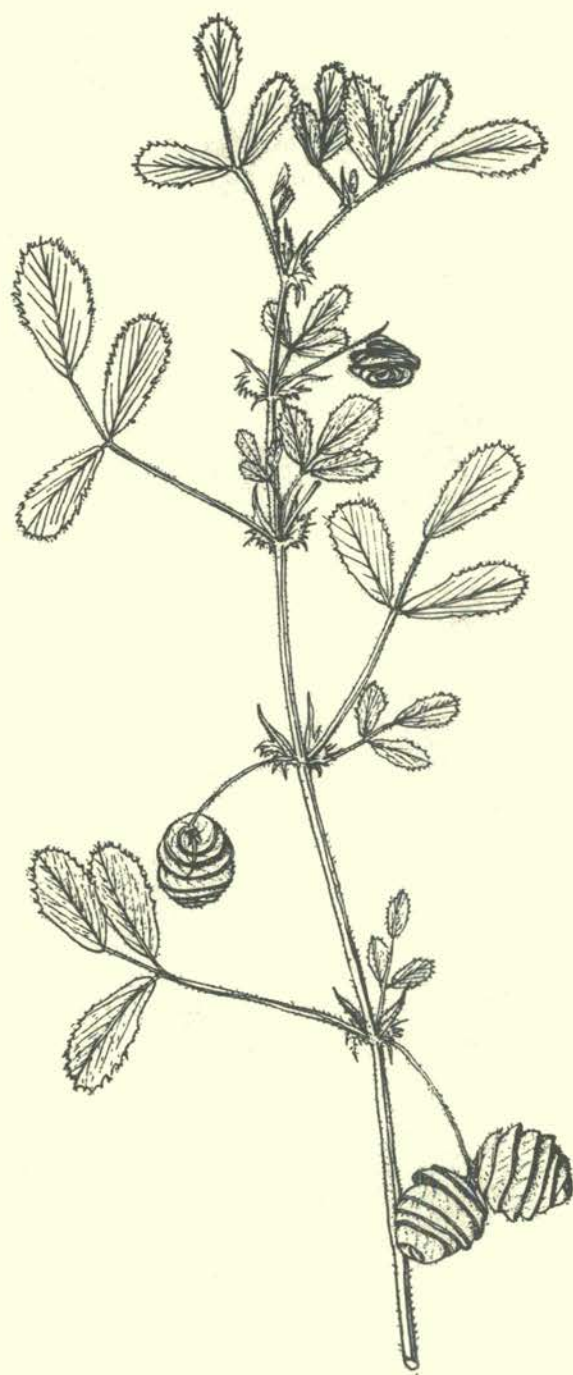


Fig. 3

Medicago scutellata - habit (about natural size - from plant)
(After Scripta hierosolymitana, 1963, vol. 12, p. 40, fig. 9)



Fig. 4 - *Medicago laciniata*

A-C var *laciniata*

D-E var *aschersoniana*

A, habit (natural size)

D, branch (natural size)

B, pod from above (x4 $\frac{1}{2}$)

E, surface of a middle coil (x5)

C, pod from below (x3)

(After Scripta hierosolymitana, 1963, vol. 12, p. 56, fig. 15)

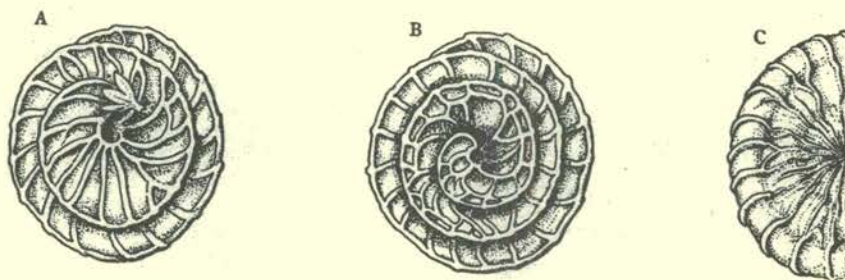


Fig. 5 - *Medicago rugosa*

pod (x5)

A, from above

B, from below

C, surface of a middle coil (from plant)

(After Scripta hierosolymitana, 1963, vol. 12, p. 42, fig. 10)



Fig. 6 - *Medicago minima* var *minima*

A, habit (about natural size)

B, pod from above (x3)

C, pod from below (x3)

D, surface of a middle coil (x6)

all from plant

(After Scripta hierosolymitana, 1963, vol. 12, p. 62, fig. 16)



Fig. 7 - *Medicago hispida* (= *M. polymorpha*)

Plant, x1. L : Upper surfaces of two coils with large and short spirals, x3.
S : Seed., x6. *Medicago hispida* ssp. *polymorpha* - A : fragment of the plant,
x1. L' : Upper surface of a coil, x3. S' : Seed, x6.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas,
Madrid, 1965, p.239)

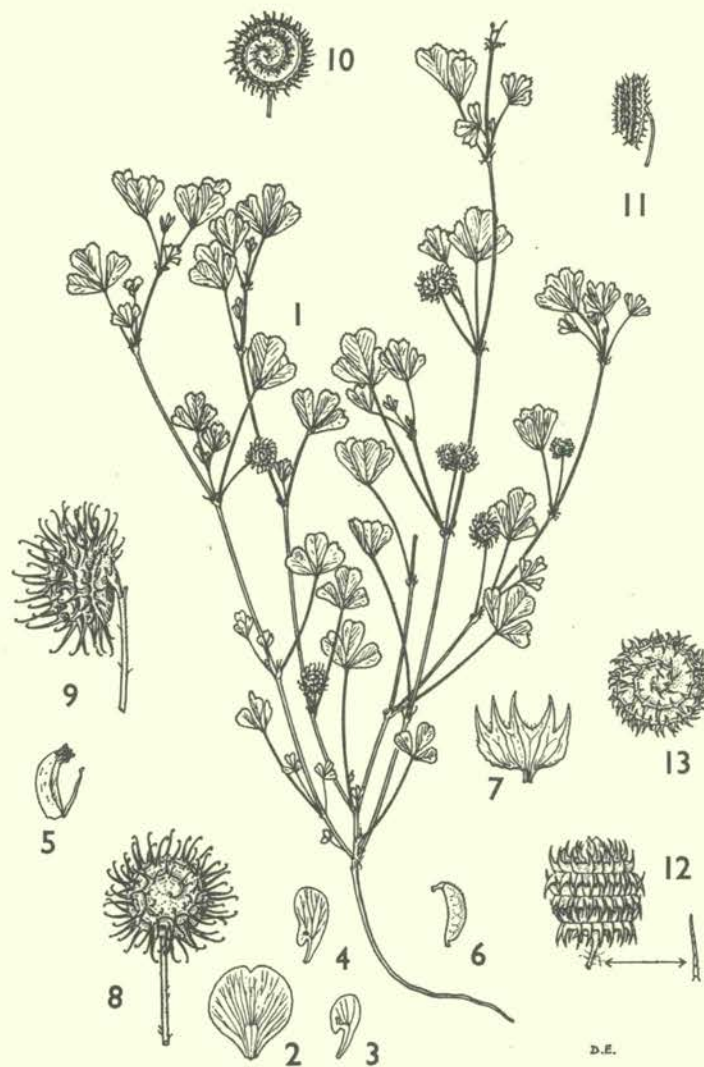


Fig. 8

Medicago polymorpha L. emend. Shinn. var *vulgaris* (Benth.) Shinn.

1. Habit, $\times \frac{2}{3}$. 2. Standard, $\times 4$. 3. Wing, $\times 4$. 4. Keel, $\times 4$. 5. Androecium, $\times 4$. 6. Gynoecium, $\times 4$. 7. Calyx opened out, outer surface, $\times 4$. 8. Fruit, $\times 2$. 9. Fruit, lateral view, $\times 2$.

Medicago polymorpha L. var *brevispina* (Benth. emend. Heyn) Heyn

10. Fruit, $\times 2$. 11. Fruit, lateral view, $\times 2$.

Medicago arabica (L.) Huds.

12. Fruit, lateral view with enlarged multicellular hair, $\times 2$. 13. Fruit, $\times 2$.

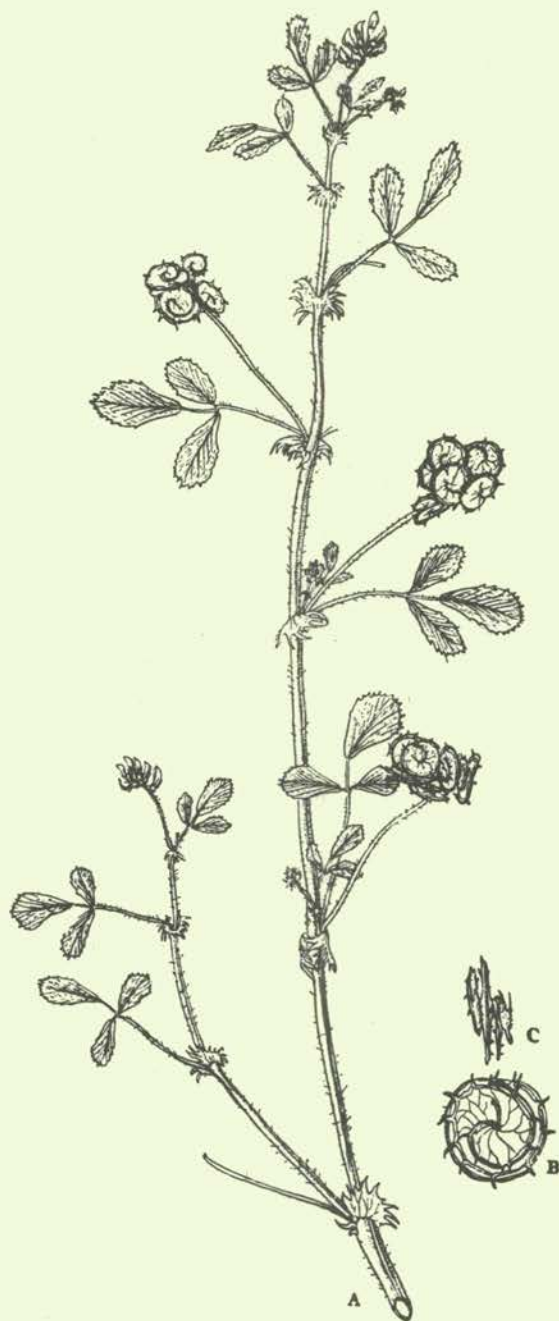


Fig. 9 - *Medicago tornata* var *aculeata*

A, branch (about natural size)

B, pod from above (x2)

C, pod side view (x2)
from plant

(After Scripta hierosolymitana, 1963, vol. 12, p. 86, fig. 22)



Fig. 10 - *Medicago littoralis* var *littoralis*
habit (about natural size) - from plant
(After Scripta hierosolymitana, 1963, vol. 12, p. 92, fig. 23)

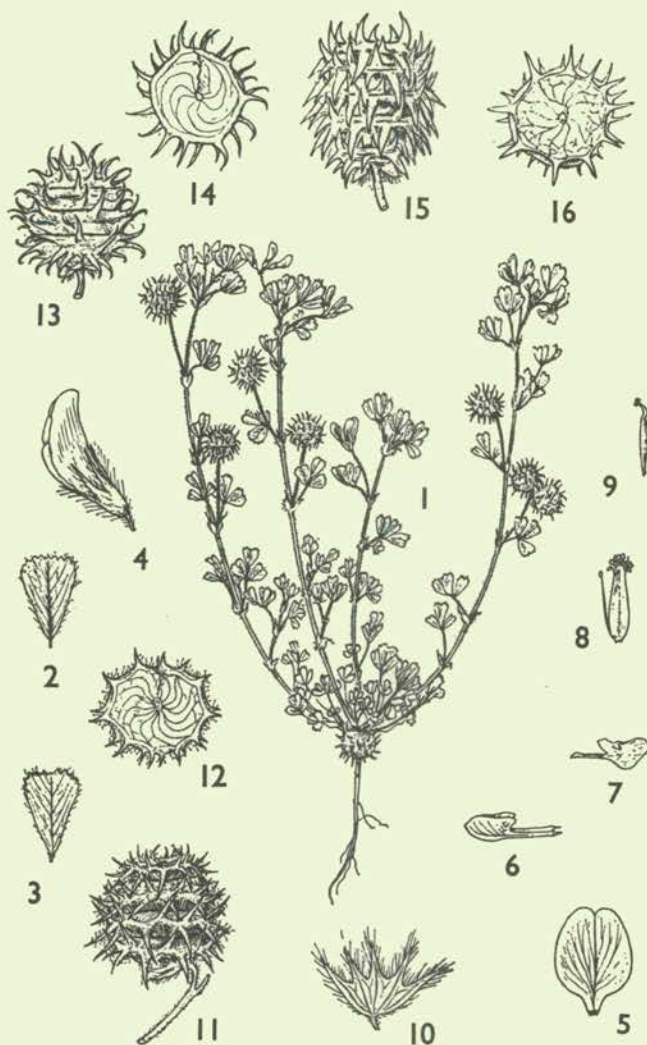


Fig. 11

Medicago rigidula (L.) All.

1. Habit, $\times \frac{2}{3}$. 2. Leaflet, lower surface, $\times 2$. 3. Leaflet, upper surface, $\times 2$.
4. Flower, $\times 4$. 5. Standard, $\times 4$. 6. Keel, $\times 4$. 7. Wing, $\times 4$. 8. Androecium, $\times 4$.
9. Gynocium, $\times 4$. 10. Calyx opened out, inner surface, $\times 4$. 11. Fruit, $\times 2$.
12. Surface of one coil of fruit, $\times 2$.

Medicago constricta Dur.

13. Fruit, $\times 2$. 14. Surface of one coil of fruit, $\times 2$.

Medicago truncatula Gaertn.

15. Fruit, $\times 2$. 16. Surface of one coil of fruit, $\times 2$.

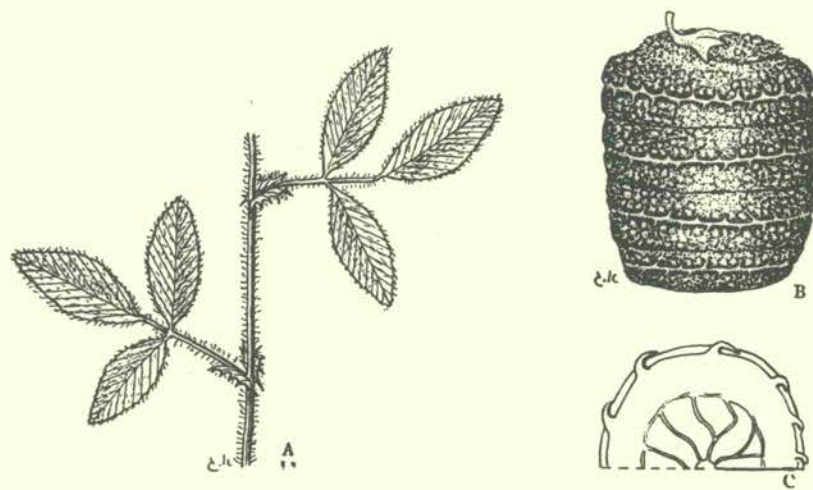


Fig. 12 - *Medicago turbinata* var *turbinata*

A, part of branch ($\times 1\frac{1}{2}$)

B, pod ($\times 5$)

C, surface of middle coil ($\times 5$)
from plant

(After Scripta hierosolymitana, 1963, vol. 12, p. 117, fig. 29)

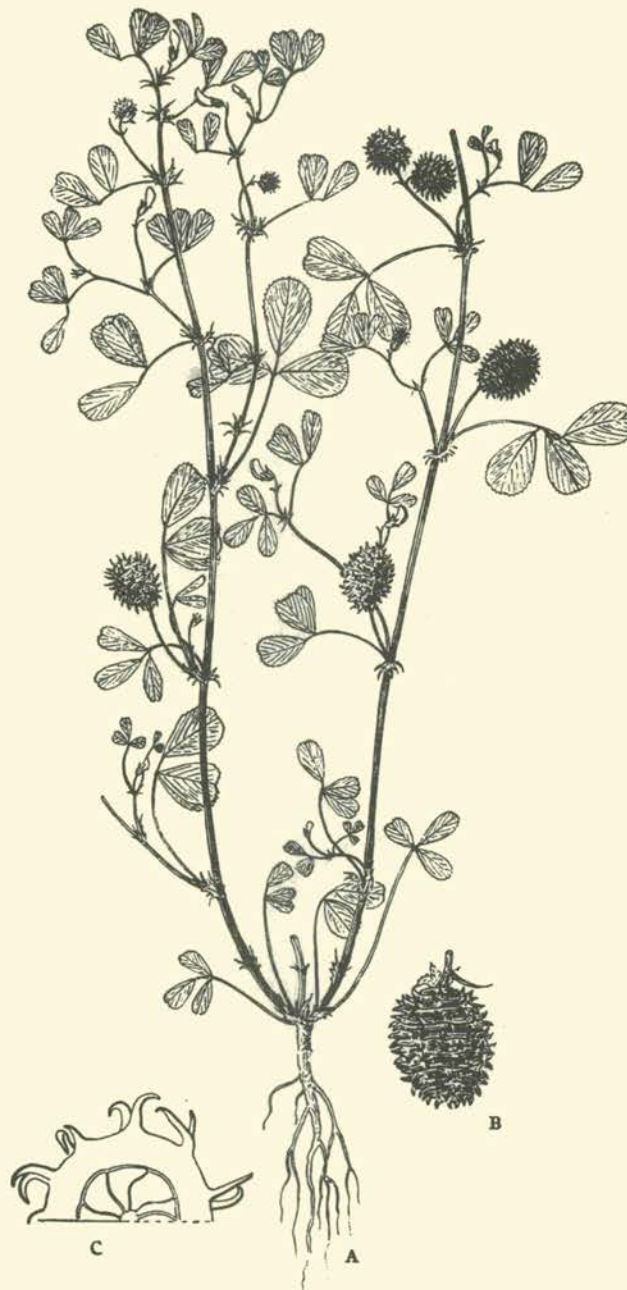


Fig. 13 - *Medicago murex* var *murex*

A, habit (slightly reduced)

B, pod (x2)

C, surface of a middle coil (x3)
from plant

(After Scripta hierosolymitana, 1963, vol. 12, p. 123, fig. 31)



Fig. 14 - *Medicago intertexta* var *ciliaris*
habit (slightly reduced) - from plant
(After Scripta hierosolymitana, 1963, vol. 12, p. 126, fig. 32)

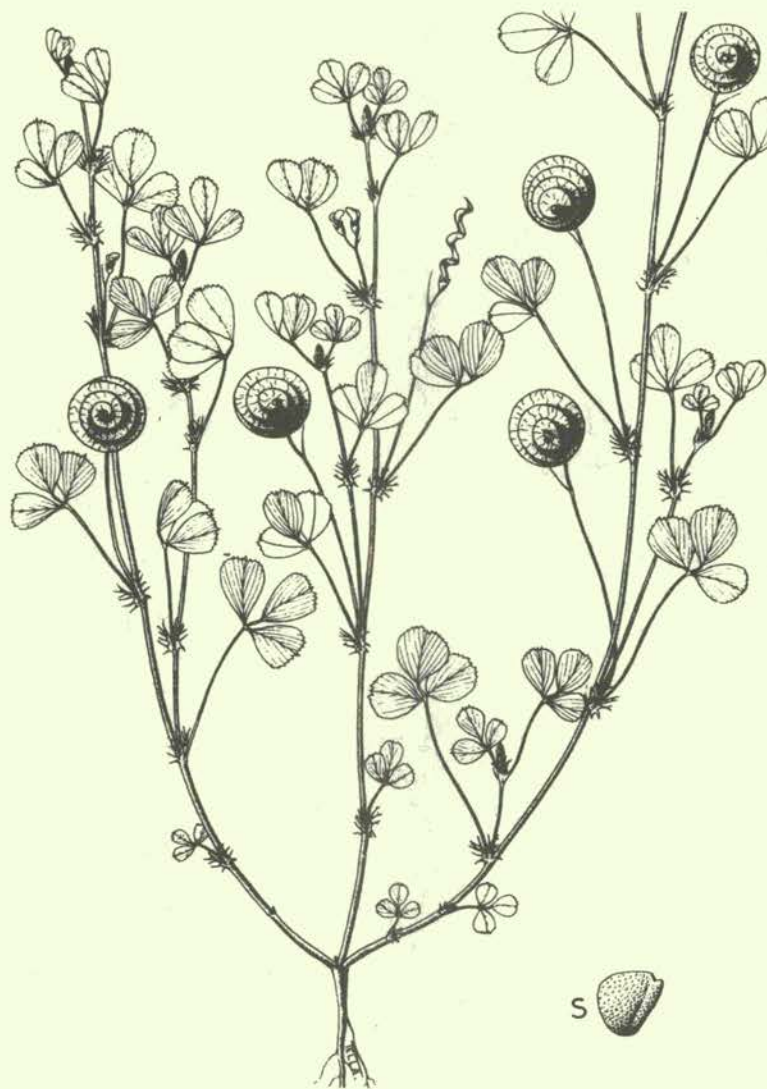


Fig. 15 - *Medicago orbicularis*

Plant, x1. Seed, x5.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas,
Madrid, 1965, p. 230)

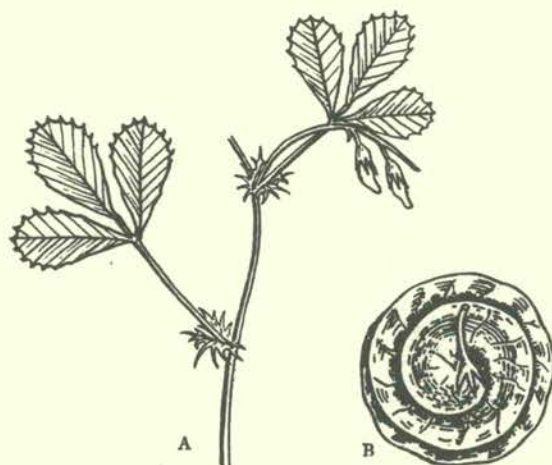


Fig. 16 - *Medicago orbicularis*

A, branch (slightly enlarged)

B, pod (x2)

from plant

(After Scripta hierosolymitana, 1963, vol. 12, p. 137, fig. 36)

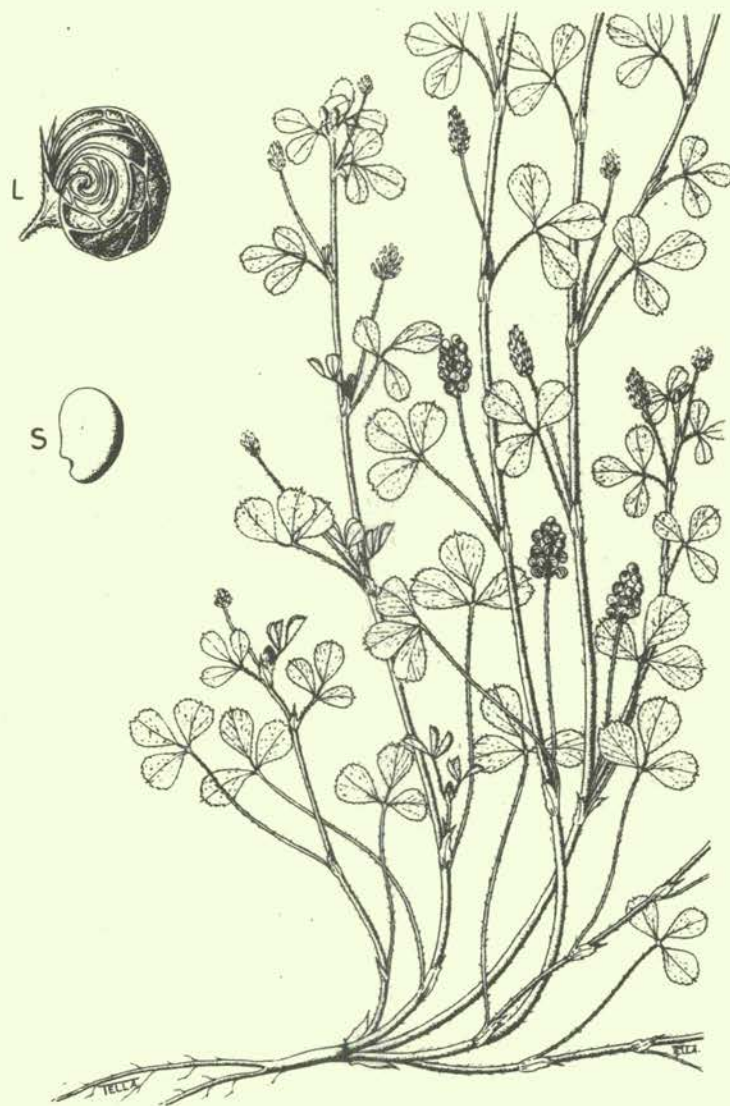


Fig. 17 - *Medicago lupulina*

Plant, x1. L : Ligule, x10. S : Seed, x10.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas,
Madrid, 1965, p. 224)

- *M. polymorpha* :
 - var. *lappacea* Burnat (= *M. tricycla* D.C.),
 - var. *microdon* (Desr.) Batt. (= var. *apiculata* (Willd.) Burnat),
 - var. *denticulata* (Willd.) Burnat),
 - var. *brachyacantha* (Lowe) Brig (= var. *Terebellum* (Willd.) Urb.),
 - var. *macrocantha* (Lowe) Brig (= var. *nigra* (Willd.) Burnat),
 - var. *confinis* (Koch.) Burnat).
- *M. tornata* :
 - 1) ssp. *Helix* (Willd.) Emb. et Maire (= *M. obscura* ssp. *Helix* Batt.)
 - var. *inermis* (Urb.) Emb. et Maire
 - var. *spinosa* (Guss) Fiori (= *Medicago obscura* ssp. *aculeata* (Guss.) Urban)
 - 2) ssp. *tornata* (Willd.) Emb. et Maire (= *Medicago obscura* var. *tornata*)
 - var. *laevis* Emb. et Maire (= *M. obscura* var. *tornata* f. *inermis* Urban).
 - var. *muricata* (All.) Fiori.
- *M. littoralis* :
 - var. *inermis* Moris et subvar. *tricycla* (D.C.) Urban (= *M. striata* Balb.),
 - var. *brevisetata* D.C., (subvar. *cyindracea* (D.C.) Urban (= *M. rugulosa* Batt. subvar. *depressa* Urban (= *M. arabica* var. *Faurei* Maire)
 - var. *longesita* (= *M. Braunii* G.G.).
- *M. rigidula* :
 - var. *germana* (Jord.) Rouy.,
 - var. *minor* Ser. (= *M. cinerascens* Jord.).
- *M. turbinata* :
 - var. *aculeata* (Gaertn.) Fiori (= *M. muricata* Guss.),
 - var. *oliviformis* (Guss.) Batt.,
 - var. *inermis* Asch.
- *M. lupulina* :
 - var. *glandulosa* Neiler.,
 - var. *canescens* Moris.,
 - var. *cinerea* d'All.

In Libya Keith (1965) records the following botanical varieties :

- *M. truncatula* :
 - var. *breviaculeata* Urb. f. *sinistrorsa* Urb. present in Tripolitania ;

- var. *breviaculeata* Urb. f. *dextrorsa* Urb. (= *M. truncatula* Gaertn. var. *tenaculata* (Willd.) Aschers et Graebn. f. *dextrorsa* Urb. Aschers et Graebn.)
present at Kussabat and Tarhuna in Tripolitania and at Benghazi Fueihat, Giok Kebir, Bardia in Cyrenaica ;
- var. *breviaculeata* Urb. f. *sinistrorsa* Urb. (= *M. truncatula* Gaertn. var. *tentaculata* Willd. Aschers et Graebn. f. *sinistrorsa* Urb. Aschers et Graebn.)
present at Tarhuna in Tripolitania and Benghazi and Raaba in Cyrenaica ;
- var. *coryrensis* (Somm.) Fiori
present at El Abiar in Cyrenaica ;
- var. *rugosissima* Maire et Weill.
present at Giotto of Lethe east of Benghazi in Cyrenaica ;
- var. *tentaculata* (Willd.) Aschers. et Graebn. f. *dextrorsa* (Urb.) Aschers. et Graebn.) ;
- var. *tentaculata* (Willd.) Aschers. et Graebn. f. *sinistrorsa* (Urb.) Aschers. et Graebn.).
- *M. littoralis* :
 - var. *brevisetata* Lam.
present in the Garian Hills in Tripolitania and at Benghazi, Giuliana Raaba, between Raaba and Benma , Dema and Wadi Dema in Cyrenaica ;
 - var. *brevisetata* Lam. f. *dextrorsa* Urb.
present at Tripoli, Kussabat and Tarhuna in Tripolitania ;
 - var. *brevisetata* Lam. f. *sinistrorsa* Urb.
present at Tripoli and Tarhuna in Tripolitania ;
 - var. *inermis* Moris
present at Demal in Cyrenaica ;
 - var. *inermis* Moris f. *dextrorsa* Urb.
present at Tarhuna in Tripolitania ;
 - var. *inermis* Moris f. *sinistrorsa* Urb.
present at Tripoli, Tarhuna and Zanzur in Tripolitania ;
 - var. *inermis* Moris f. *tricycla* (D.C.) Urb.
present at Benghazi in Cyrenaica ;
 - var. *rugulosa* Batt.
- *M. minima* :
 - var. *longisetata* D.C.
present at Kussabat, Tarhuna and Garian in Tripolitania ;
 - var. *recta* (Willd.) Burn.
present at Benghazi in Cyrenaica.

- *M. murex* :
 - var. *aculeata* Urb. f. *ovata* Urb.
present at Kussabat and Garian in Tripolitania ;
 - f. *ovata* (Carmign) Urb.
present at Benghazi and Raaba in Cyrenaica.
- *M. lupulina* :
 - ssp. *cupaniana* (Fuss.) Batt. var. *glandulosa* Rouy

varieties : In Egypt (UAR) Tackholm (1974) records the following botanical

- *M. truncatula* :
 - var. *longiaculeata* Urb.
common in the western littoral zone.
- *M. littoralis* :
 - var. *subinermis* Boiss.
rare but present in the Nile region.
- *M. intertexta* :
 - var. *ciliaris* (L.) Heyn (= *M. ciliaris* (L.))
present in the littoral N.W. coastal zone and the Nile region.
- *M. lupulina* :
 - var. *glandulosa* Koch. in Rohting (= var. *willdenowii* Ashc.).

varieties : In Lebanon and Syria Mousterde (1966) mentions the following

- *M. truncatula*
 - var. *truncatula* (= *M. truncatula* Gaertn., *M. truncatula* Willd., *M. tribuloides* Desr. var. *breviaculeata* Check)
 - var. *tribuloides* (Desr.) Halacsy
both the above varieties common in rocky maritime areas and dry regions and flower from March to April.
- *M. minima* :
 - var. *sessilis* (Peyron) n. comb. (= *M. sessilis* Peyron)
present in fields and pastures in dry regions, flowers from February to April.

- *M. polymorpha* :
 - var. *apiculata* Willd. (= *M. denticulata* Willd. var. *apiculata*),
 - var. *denticulata* (= *M. denticulata* Willd.),
 - var. *lappacea* (= *M. denticulata* Willd. var. *lappacea* D.C.),
 - var. *nigra* (= *M. polymorpha* var. *nigra* L., *M. denticulata* var. *pentacycla* D.C., Boiss., *M. hispida* Gaertn. var. *macrocarpa* Urban, *M. hystrix* Ten.)
all found on borders of fields and roadsides and flower February-May ;
 - var. *lappacea* also recorded (Parsa, 1950) in Gilan between Pahlavi and Rasht (Iran).
- *M. littoralis* :
 - var. *subinermis* Boiss.
found in sandy, rocky places and flowers from February-April.

In Israel Heyn (1963) records the following varieties :

- *M. truncatula* :
 - var. *longispina* Urb.
which is the most widespread variety of the species,
 - var. *tricycla* (Negre) stat. nov.
found in the Negev and also recorded by Negre (1959) in Morocco in the marginal belt on the edge of arid zones.
- *M. laciniata* :
 - var. *laciniata*
found in the Negev and Sinai deserts also recorded (Townsend and Guest, 1974) in the S.E. sector of the dry steppe zone and desert in Iraq, and also present in Saudi Arabia, Bahrain, Algeria and Morocco,
 - var. *brachycantha* Boiss.
found in the Negev and Sinai deserts and also recorded (Townsend and Guest, 1974) in the Southern desert of Iraq, and present also in the desert of Baluchistan, Morocco and Tunisia ; appears to be more prevalent in more arid localities than var. *laciniata*.
- *M. minima* :
 - var. *minima*
very widespread and grows throughout the range of species and present also in the arid zone of Algeria and Morocco,
 - var. *brevispina* Benth
much less frequent than var. *minima*.

- *M. polymorpha* :

- var *polymorpha*
present at Sharon and also recorded (Townsend and Guest, 1974) on the alluvial plain in the desert region of Iraq, and present also in the desert region of Morocco and Libya,
- var *vulgaris* (Benth) Shin.
present in the Jordan valley and also recorded (Townsend and Guest, 1974) in the lower forest zone and steppe, and on the alluvial plain in the desert region of Iraq,
- var *brevispina* (Benth emend) comb. nov.
present at Tiberias, and also recorded (Townsend and Guest, 1974) as an occasional in the lower forest and steppe, but rare in the desert region; also present in the littoral zone of Algeria.

- *M. tornata* :

- var *aculeata* Guss. comb. nov.
present at Sharon on sandy soils and also present in Algeria,
- var *rugulosa* (Ser.) comb. nov.
present at Caesarea and also present in the littoral zone of Morocco, Algeria, Tunisia and Libya.

- *M. littoralis* :

- var *littoralis*
the most widespread variety of the whole species,
- var *inermis* Moris
present at Sharon and also at Larnaca in Cyprus.

- *M. rigidula* :

- var *rigidula*
present in Galilee and also recorded (Townsend and Guest, 1974) on stony and rocky hillsides and gravelly foothills, gypseous hills and sandy gravel plains in Iraq,
- var *submitis* Boiss.
present at Ammon and also recorded (Townsend and Guest, 1974) on dry mountain slopes (700-900 m elevation) in Iraq; present also in Kerman (Mt. Djamal) in Iran (Parsa, 1950),
- var *agrestis* (L.) All.
present in Upper Galilee and also recorded (Townsend and Guest, 1974) on grassy steppe and mountain slopes (700-1,200 m elevation) in Iraq; present also at Badghis in Afghanistan.

- *M. turbinata* :
 - var *turbinata*
present in Upper Galilee and Mt. Carmel,
 - var *apiculata* (Urb.) comb. nov.
present in Upper Galilee and also at Tripoli in Lebanon,
 - var *aculeata* (Moris in Moris ex De Not emend.) comb. nov.
present in Upper Galilee and Mt. Carmel.
- *M. murex* :
 - var *murex*
present at Sharon and also at Reghaia in Algeria,
 - var *inermis* (Guss.) Urb.
present at Arsuf and at Constantine in Algeria.
- *M. intertexta* :
 - var *ciliaris* (L.) comb. nov.
present in the Esdraelon Plain and at Sharon, also recorded (Townsend and Guest, 1974) as an occasional on the alluvial plain in the sub-desert zone (Iraq) ; also recorded in the littoral zone of Algeria, Morocco, Tunisia and Libya.

Although Heyn (1963) assumed that *M. ciliaris* should be considered a variety of *M. intertexta* Mill. both Negre (1959) and Lesins and Gillies (1972) consider *M. ciliaris* as being a separate species.

In Afghanistan Kitamura (1960) records the following botanical varieties of *M. hispida* and *M. lupulina* :

- *M. hispida* :
 - var *apiculata* Willd.,
 - var *denticulata*.
- *M. lupulina* :
 - var *glandulosa* Mertens et Koch.,
 - var *perannans* Hal ex Hegi.

Native ecotypes :

In N. Africa and the Near and Middle East renewed interest has recently been shown in the collection and evaluation of native *Medicago* spp. having agronomic importance. In Algeria a collection of 850 native ecotypes of annual *Medicago* spp. is presently being evaluated at Tessala and Saida (600-800 m elevation) (Jefferies, 1977) ; ecotypes of annual native *Medicago* spp. have also recently been collected in N. Iraq (Radwan et al., 1974) and Libya (Roberts and Halse, 1976), and in 1977 1,100 ecotypes of annual *Medicago* spp. were collected by the Waite Institute, S. Australia, in the Near East and duplicates deposited at Aleppo, Syria (Blazing, 1978).

In Israel Katznelson and Putviesky (1974) report that out of hundreds of lines and strains of annual *Medicago* spp. collected in various parts of the country only two or three lines of *M. polymorpha* persisted and re-seeded themselves over several years in evaluation trials.

In Turkey Hertzsch (1970) reports that during the period 1965-69 some 56 ecotypes of 17 different annual *Medicago* spp. have been collected in various parts of the country and assembled at Izmir (W. Turkey).

Gachet and Elmir (1972) also stress the importance of a systematic study of the annual *Medicago* spp. in Tunisia with a view to selecting and developing the types most suited to the different environmental conditions.

Agricultural varieties :

In Australia *M. laciniata*, *M. rugosa*, *M. minima*, *M. polymorpha*, *M. tornata* and *M. orbicularis* have been accidentally introduced and become naturalized in native pastures, while a number of selected varieties of *M. truncatula*, *M. scutellata*, *M. rugosa*, *M. littoralis* and *M. tornata* have been developed for agricultural use which are the following :

- M. truncatula* : "Cyprus", "Woodside", "Jemalong", "Cyfield", "Hannaford", "Borung", "Akbar" and "Ghor" ;
- M. scutellata* : "Commercial" ;
- M. rugosa* : "Paragosa" ;
- M. littoralis* : "Harbinger" ;
- M. tornata* : "Tornafield". Also developed in the USA :
- M. rigidula* : "Tifton".

The above varieties have been developed largely from comprehensive introductions made from the Mediterranean region (Donald, 1970) and maintained by the C.S.I.R.O. at Canberra. The classification of 2266 genotypes for 20 annual *Medicago* spp. has also been carried out at Canberra, in Australia, and their agronomic and seed permeability characteristics stored in a data bank (Crawford, 1975).

22.6. Number of Chromosomes

M. truncatula : $2x = 16$; *M. scutellata* : $2x = 32$; *M. laciniata* : $2x = 16$; *M. rugosa* : $2x = 32$; *M. minima* : $2x = 16$; *M. polymorpha* : $2x = 14$; *M. tornata* : $2x = 16$; *M. littoralis* : $2x = 16$; *M. rigidula* : $2x = 14$; *M. turbinata* : $2x = 16$; *M. murex* : $2x = 16, 14$; *M. ciliaris* : $2x = 16$, *M. intertexta* : $2x = 16$; *M. lupulina* : $2x = 16$; *M. arabica* : $2x = 16$.

22.7. Geographical Distribution

M. truncatula is distributed in Mediterranean Europe, Crete, Aegean Isles, Cyprus, Syria, Lebanon, Palestine, Jordan, Egypt (UAR), Turkey, Caucasus, Iran, Iraq, Macaronesia (Canary, Teneriffe, Madeira), North Africa (Morocco, Algeria, Tunisia, Libya). Introduced in Australia, N. America ;

M. scutellata is distributed in the S. Mediterranean (Spain to Greece and the Archipelago), USSR (Crimea and southern shore of the Black Sea), Turkey, Cyprus, Syria, Lebanon, Palestine, N. Africa (Morocco, Algeria, Tunisia) ;

M. laciniata is distributed in Syria, Palestine, Jordan, Sinai, Egypt (UAR), Arabia, Kuwait, Bahrain, Iraq, Iran, Pakistan (to Punjab), Afghanistan, Macaronesia (Canary, Teneriffe), N. Africa (Morocco, Algeria, Tunisia, Libya) ;

M. rugosa is distributed in the S. Mediterranean (Portugal to Greece and the Archipelago), Lebanon, Palestine, Algeria, Morocco, Tunisia ;

M. minima is distributed throughout most of C. and S. Europe (from Britain, Spain, Portugal north to Sweden and east to the Balkans and S. USSR), Cyprus, Syria, Lebanon, Palestine, Sinai, N. Egypt (UAR), Turkey, Caucasus, Iran, Iraq, Afghanistan, C. Asia (Turkmenia to Tian Shan), N.W. India, China, Japan, Macaronesia (Canary, Teneriffe), N. Africa (Morocco, Algeria, Libya, Tunisia) ;

M. polymorpha is distributed throughout Southern Europe, Malta, Lebanon, Palestine, Jordan, Iraq, Iran, Egypt, Arabia, Turkey, Caucasus, Afghanistan, C. Asia (Turkmenia, Syr Danja), N.W. India, China, Japan, Macaronesia (Azores, Madeira, Canary), N. Africa (Morocco, Algeria, Tunisia, Libya), tropical Africa (Ethiopia) ; introduced into N. Europe, Australia, N., C. and S. America ;

M. tornata is distributed in Portugal, Spain, France, Corsica, Sardinia, Italy, Sicily, Turkey, Palestine, Macaronesia (Madeira, Canary), N. Africa (Morocco, Algeria, Tunisia, Libya). Introduced into Australia ;

M. littoralis is distributed along the coasts of Portugal, Spain, Corsica, Sardinia, Italy and Isles, Yugoslavia, Greece and Archipelago, Turkey, Cyprus, Syria, Lebanon, Palestine, Madeira and Canary Isles, Morocco, Algeria, Tunisia, Libya, Egypt (UAR) and Black Sea ;

M. rigidula is distributed in W. and S. Europe, Crete, Cyprus, Turkey, Syria, Lebanon, Palestine, Jordan, N. Egypt (UAR), Iraq, Iran, Afghanistan, C. Asia (Turkmenia to Pamir Alai), N. Africa (Morocco, Algeria) ;

M. turbinata is distributed in Mediterranean Europe, Aegean Isles, Crete, Cyprus, Turkey, Syria, Lebanon, Palestine, Jordan, N. Egypt (UAR), Iraq, Iran, N. Africa (Morocco, Algeria) ;

M. murex is distributed in Portugal, Spain, France, Corsica, Sardinia, Italy, Greece, Crete, Turkey, Syria, Lebanon, Palestine, Morocco, Algeria, Tunisia ;

M. intertexta is distributed in Mediterranean Europe, Aegean Isles, Cyprus, Turkey, Syria, Lebanon, Palestine, Egypt (UAR), Iraq, Iran, Macaronesia (Canary, Teneriffe, Madeira), N. Africa (Morocco, Algeria, Tunisia, Libya) ;

M. orbicularis is distributed in S. Europe (from Portugal to the Crimea), Aegean Isles, Sicily, Lebanon, Palestine, Jordan, N. Egypt (UAR), Turkey, Caucasus, Iraq, Iran, Macaronesia (Canary, Teneriffe, Madeira), N. Africa (Morocco, Tunisia, Algeria, Libya) and tropical Africa (Ethiopia) ;

M. lupulina is distributed in S. and C. Europe, Aegean Isles, Cyprus, Syria, Lebanon, Palestine, Egypt (UAR), Arabia, Turkey, Caucasus, Iran, Pakistan, Afghanistan, N.W. India, Tibet, China, Japan, Macaronesia (Canary, Azores), N. Africa (Morocco, Algeria, Tunisia, Libya), tropical Africa (Ethiopia), C. Asia (Transcaspia, Tian Shan Mongolia, Manchuria) ; also introduced into N., C. and S. America, Australia and elsewhere ;

M. arabica is distributed in C. and S. Europe, Aegean Isles, Cyprus, Syria, Lebanon, Palestine, Turkey, Transcaucasia, Iran, N. Africa (Morocco, Algeria, Tunisia, Libya), Egypt and introduced in Australia , N. and S. America ;

The distribution map (Fig. 18) shows the general distribution of annual and perennial species of *Medicago* in the Europe Mediterranean, Near and Middle East, and Central Asia regions.

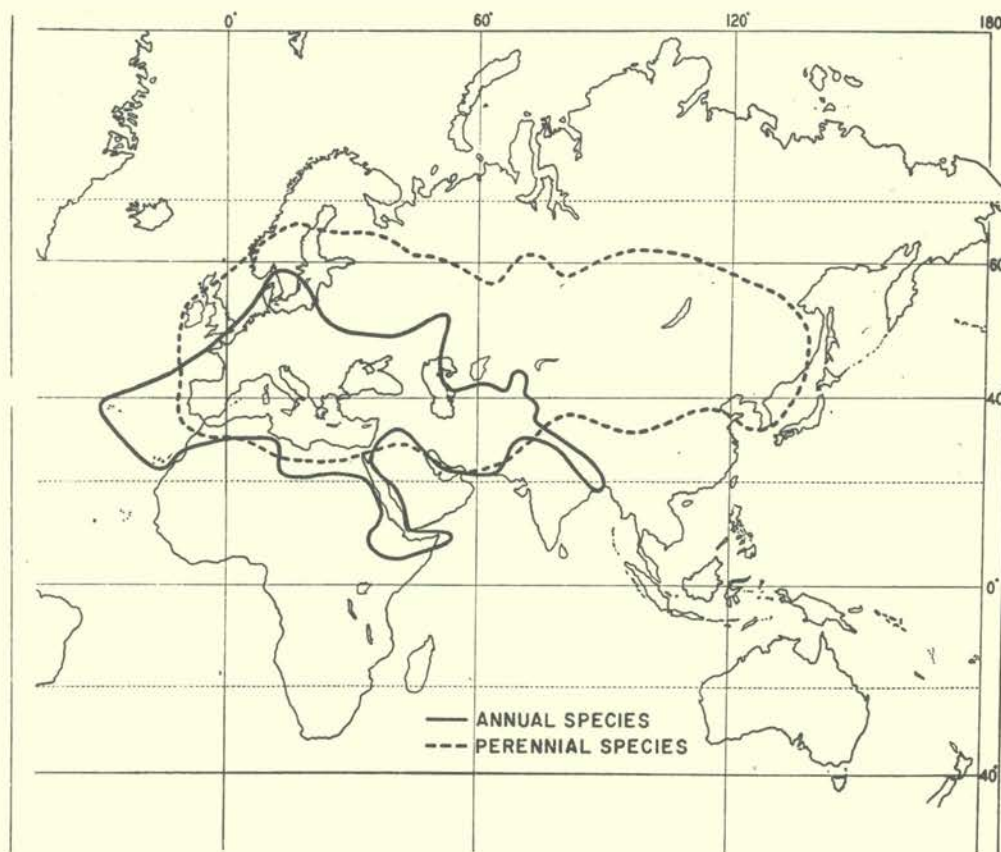
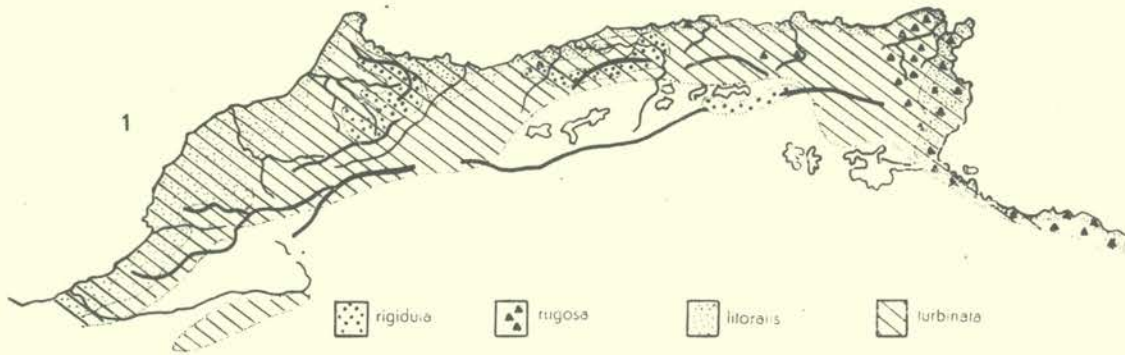


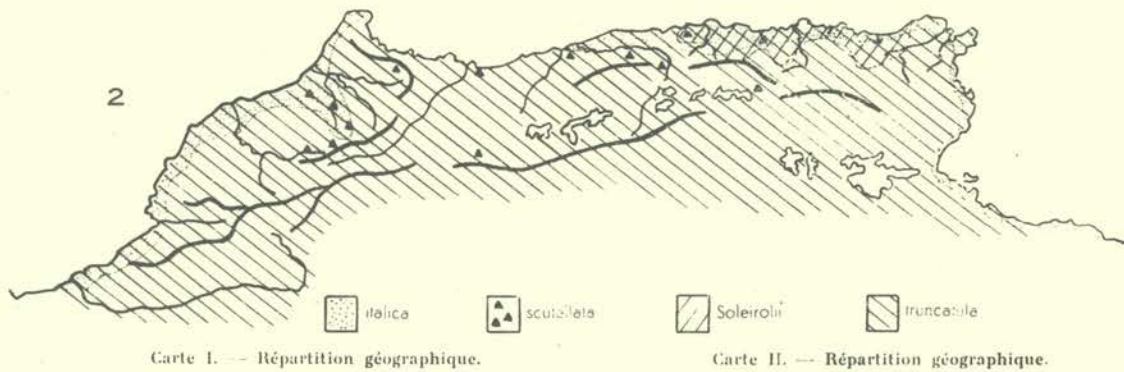
Fig. 18

Distribution area of the annual and the perennial species of *Medicago* (partly after Kousnetzoff, 1926)
(After Scripta hierosolymitana, 1963, vol. 12, p. 13, Fig. 3)

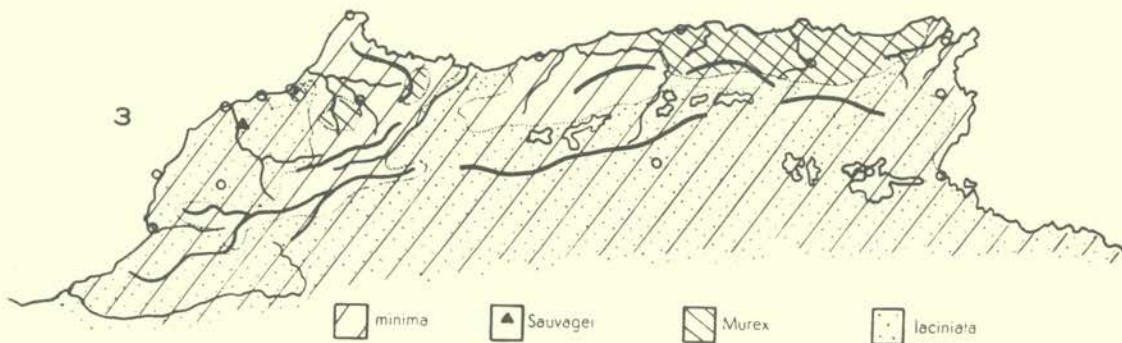
Negre (1959) has also produced distribution maps of the most important annual and perennial *Medicago* spp. occurring in the Mediterranean littoral zone of North Africa (see maps 1-6 below) :



Map 1 - Geographical distribution

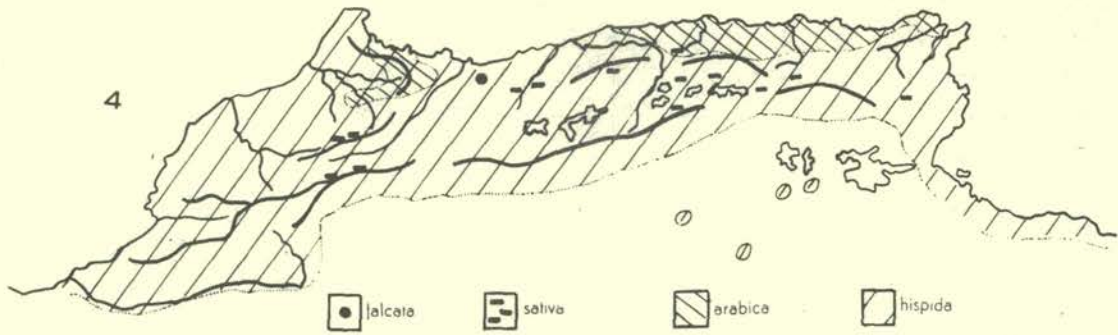


Map 2 - Geographical distribution



Map 3 - Geographical distribution

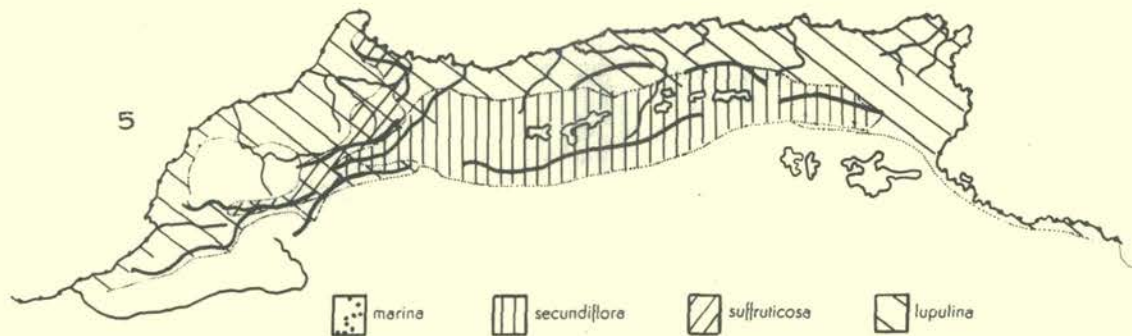
(After Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord, No 7-8, 1959)



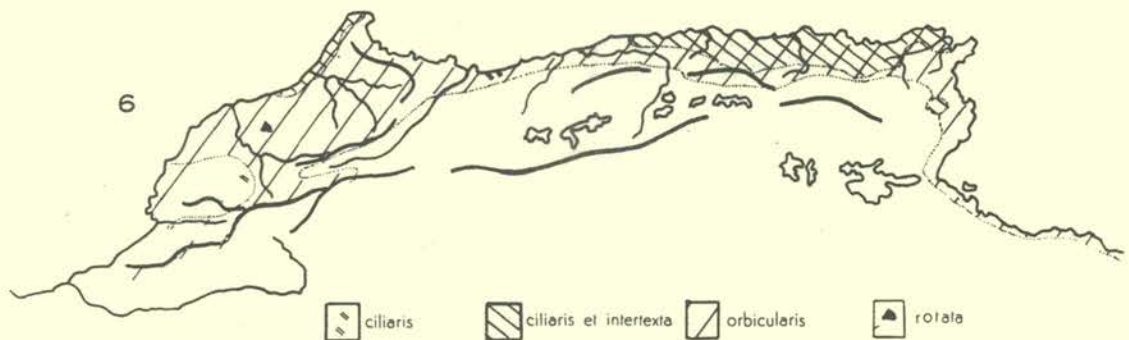
Carte III. — Répartition géographique.

Carte IV. — Répartition géographique.

Map 4 - Geographical distribution



Map 5 - Geographical distribution



Map 6 - Geographical distribution

(After Bulletin de la Société d'Histoire
Naturelle de l'Afrique du Nord, No. 7-8, 1959)

22.8. Biology and Ecology

M. truncatula, *M. scutellata*, *M. laciniata*, *M. rugosa*, *M. minima*, *M. polymorpha*, *M. tornata*, *M. littoralis*, *M. rigidula*, *M. turbinata*, *M. murex*, *M. intertexta* and *M. orbicularis* are all self regenerating annual legumes that propagate themselves by seeds and are self-pollinated (5-8 % cut crossing).

Seed characteristics :

Germination of seeds takes place over a wide range of temperatures from 4 to 25°C, the optimum being situated between 15-20°C. In Israel Tadmor et al. (1968) report that *M. truncatula* is more sensitive to lower temperatures than *M. polymorpha* and that its optimum temperature for germination lies between 20-25°C.

The seeds of all the above mentioned *Medicago* spp. have a dormancy period of one year or more so that when planted only 5-10 percent of the seeds produced in the first year germinate in the second year, while the remaining seeds germinate in the subsequent years.

Hard seeds in annual *Medicago* spp. result from an impermeable seed coat ; embryo dormancy does not play an important role. Layers of suberin deposited as the seed coat ripens and loses moisture to the air make the seed coat impermeable. The proportion of the hard seed depends on the stage of seed development when drying starts. Seeds that mature quickly because of the dry weather have less hard-seededness (Breth, 1975).

Growth and development :

In the littoral zone of North Africa seedlings of *M. truncatula* and *M. littoralis* seeded in October-November have reached a height of 10-15 cm, 40-60 days after germination if the winter is not too cold ; at this time they will cover the soil completely (Bakhtri, 1976). However Roberts and Halse (1976) record in the Jefara Plain in Libya that young seedlings of *M. truncatula* and *M. littoralis* have in some areas been seriously damaged by wind erosion, especially on light sandy soils.

In March-April the plants start flowering ; Bouglé (1974) reports that both seeded *M. truncatula* ("Jemalong") and *M. littoralis* ("Harbinger") flower in the first days of April along with the spontaneous species *M. ciliaris* and *M. turbinata* in the littoral zone of Algeria. From the time of sowing (10 October) until flowering (4 April) the average temperature was not inferior to 5°C. *M. littoralis* ("Harbinger") which flowers 7-14 days earlier than *M. truncatula* ("Jemalong") was in full flower on 4 April. Later in April the plants of *M. truncatula* ("Jemalong") and *M. littoralis* ("Harbinger") start to form seed pods which dry up and fall to the ground in late June. Webber (1974) mentions that *M. littoralis* ("Harbinger") is a prolific seed producer, which is an advantage in the drier seasons.

Muckle (1977) records that pods of both *M. truncatula* ("Jemalong") and *M. littoralis* ("Harbinger") fall to the ground at the onset of high temperatures +35°C at the end of the vegetative cycle in the littoral zone of Algeria. If the temperature rise is sudden, as in the case of the Sirocco in Algeria, the pods may ripen prematurely and fall before the seed has been able to form inside them.

In the steppic region (400 m elevation, 350-400 mm annual rainfall) of N. Iraq Kernick (1976) reports that seedlings of *M. truncatula* ("Jemalong") and *M. scutellata* ("Commercial") seeded on light calcareous soils in November reach a height of 5 cm by late December and a height of 10-15 cm by the end of March ; flowering occurs in April-May and the pods ripen and fall to the ground in mid-June.

In N. Iraq (steppic zone) late winter (January) and spring (March) seedlings of *M. truncatula* ("Jemalong", "Borung"), *M. scutellata* ("Commercial"), *M. polymorpha* (native ecotypes) and *M. orbicularis* (native ecotypes) on light calcareous and heavy soils also produced seedlings 10-20 cm tall in April followed by flowering in mid-May and vigorous pod formation and seed setting in June.

In the Mediterranean basin Villax (1963) records that *M. lupulina* develops well at the end of the winter and in the spring under dryland conditions but grows practically all the year when irrigated.

Effect of soil conditions :

Edaphic conditions have markedly affected growth, particularly in years with a dry spring. In N. Iraq, on alluvial soil (50 % clay fraction) soil moisture was retained to a high degree allowing plants of *M. truncatula* ("Jemalong") and *M. scutellata* ("Commercial") to reach a height of 30 cm by the beginning of April, even though only 20 mm of rainfall was received in March ; in contrast, on a sandy soil (50 % sand fraction) plants only reached a height of 5-10 cm in May under similar rainfall conditions.

Root growth :

In Israel Tadmor et al. (1968) record that root growth of *M. truncatula* and *M. polymorpha* is much influenced by the level of soil moisture as the following data shows :

Root Development (cm/day)				
Species	Initial Humidity in % of Soil Weight			
	12 %		18 %	
	Soil horizon 0-12 cm 12-24 cm		Soil horizon 0-12 cm 12-24 cm	
<i>M. truncatula</i>	1	1.2	1.1	3.0
<i>M. polymorpha</i>	1	1.2	1.1	3.0

Effect of rhizobium and seed supply :

Tadmor et al. (1971) have also reported that the growth of seeded annual *Medicago* spp. (fertilized with P_2O_5 and N but uninoculated) under run off farming conditions (100 mm annual rainfall) in Israel was not completely satisfactory until the 4th year regeneration, when natural inoculation of the ecologically adapted Rhizobium had spread sufficiently in the soil and an adequate seed supply had been built up.

Effect of low temperatures :

In some years in northern Iraq freezing temperatures (-2° to $-5^{\circ}C$) for a week in January have caused winter killing of *M. truncatula* ("Jemalong") seedlings especially on exposed sites, but seedlings of *M. scutellata* ("Commercial") were not affected. Winter killing or poor development of autumn seeded plants of *M. truncatula* ("Jemalong"), *M. scutellata* ("Commercial") and *M. littoralis* ("Harbinger") due to the effect of cold temperatures has also been reported in the steppe zones of Iran (AGP:SF/IRA 10, Tech. Rep. 1, 1970), Syria (Van der Veen, 1967) and in Jordan (Bailey, 1967). In the Yemen, at Taiz, Tamimi (1976) also records that *M. truncatula* ("Jemalong") is sensitive to low winter temperatures when seeded in October, but has given excellent growth when planted in the spring, while *M. scutellata* ("Commercial") seeded in the spring grew well and set seeds within 40 days.

Leeuwrik (1974) has discussed the limitations low winter temperatures may impose on the cultivation of Australian varieties of annual *Medicago* spp. in the Near and Middle East and records that in Iran only the Gorgan, Khoramabad and Qombat regions have a temperature and rainfall regime that is suitable.

In North Africa Bakhtri (1976) considers an elevation of 600 m as maximum for the cultivation of *M. truncatula* ("Jemalong") and *M. littoralis* ("Harbinger") when the temperature falls to $0^{\circ}C$. However recent work in Algeria suggests that *M. truncatula* ("Borong") may succeed at higher elevations (Jefferies, 1977).

Climate and soils :

All the previously mentioned annual *Medicago* spp. are adapted to growing in semi-arid regions with 250-500 mm annual rainfall and are strongly drought resistant surviving the hot summer as dormant seeds. For various annual *Medicago* spp. under water stress, Cornish (1974) records that seedling drought resistance decreased in the order *M. minima*, *M. laciniata*, *M. truncatula* and *M. polymorpha*.

Pate (1962) has also demonstrated that species with hairy leaves and stems such as *M. minima*, *M. scutellata*, *M. truncatula* and *M. turbinata* are more resistant to drought than *M. orbicularis* and *M. polymorpha* which are non-hairy (glabrous).

In North Africa Bakhtri (1976) reports that *Medicago truncatula* ("Jemalong") is well suited to medium textured soils and zones with more than 300 mm annual rainfall, and that *M. littoralis* ("Harbinger") is also suited to alkaline sandy soils and lower rainfall where the former species does not perform well.

Dillon (1976) records that in Libya (Benghazi plain) *M. truncatula* ("Jemalong", "Borong"), *M. littoralis* ("Harbinger"), *M. rugosa* ("Paragosa") and *M. scutellata* have all proved successful on alkaline soils.

In general annual *Medicago* spp. are well adapted to neutral and alkaline soils.

Ecological characteristics :

In regard to their specific habitat and ecology, the following examples are recorded for individual *Medicago* spp. under natural conditions :

M. truncatula : occurs on terra rossa, basaltic and alluvial soils in Israel where it is common in dwarf shrub associations ; also found on maritime sands and in scrub, pastures and irrigated cereal fields in Algeria ;

M. scutellata : occurs on heavy soils and in cultivated or fallow fields in Turkey and Israel, and on terra rossa soils in the maquis forest in Jordan (200-350 m elevation) ;

M. laciniata : occurs on dry light soils in steppes and hammadas (stony deserts) in Israel, in sandy deserts (also saline) in Jordan (380 m elevation), and on sandy gravel, gypsum or conglomerate desert soils up to an elevation of 250 m in Iraq ;

M. rugosa : occurs on heavy soils and in fallow fields or on road-sides in Israel and Lebanon, on terra rossa soils at 700 m elevation in Jordan, and in pastures in Algeria ;

M. minima : occurs on hillsides, in steppe, fields and forests in Israel and on dry barren foothills in Iraq from 100-950 m elevation ;

M. polymorpha occurs on rocky limestone slopes, fallow fields, waste places, ditches and irrigation channels in Turkey from sea level up to 900 m elevation ;

M. tornata : occurs on light soils and in cultivated fields in Israel, and on rocky volcanic soil in Turkey ;

M. littoralis : occurs on sandy seashores in Israel, and in Algeria on flooded low-land ;

M. rigidula : occurs on heavy soils in Israel where it is common in dwarf shrub associations also on dry rocky slopes and by roadsides in Jordan (1,600 m elevation) and in fields, lower mountain slopes and valleys, dry foothills and steppic plains in Iraq (200-1,200 m elevation) ;

M. turbinata : occurs on terra rossa and alluvial soils in Israel, in the forest zone in N. Iraq and in sandy pine-woods, limestone phrygana, waste places usually near sea level in Turkey ;

M. intertexta : occurs on heavy moist soils in Israel and Turkey, and in the irrigated alluvial plain in the sub-desert zone of Iraq (50-100 m elevation), and in forest pastures in Algeria ;

M. orbicularis : occurs on heavy soils, rocky slopes, cultivated and fallow fields from sea level up to 900 m elevation in Turkey ;

M. murex : occurs in scrub and pastures in Algeria and Israel ;

M. lupulina : occurs in moist situations in scrub, meadows, irrigated fields, waste places from sea level up to 2,000 m elevation in Turkey and Iraq ;

M. arabica : occurs in littoral zone of Libya and in woodlands from sea level up to 850 m elevation in Turkey.

22.9. Cultivation Techniques

Time of seeding :

In N. Africa and the Near and Middle East the previously mentioned annual *Medicago* spp. have generally been sown in the autumn (October-November) ; early seeding is considered important to maximize forage production and seed set especially in the first year (Bakhtri, 1976).

Land preparation :

The seed-bed preparation must be adequate but shallow cultivation (8-10 cm) is preferred and has not lowered cereal yields in Algeria (Bakhtri, 1976). Shallow cultivation assists in obtaining a more even and compact seed-bed and prevents the pods of native annual *Medicago* spp. already present being buried too deeply. In Algeria a high incidence of native *Medicago* spp. is recorded (Webber, 1974) in native fallows, but in contrast Radwan et al. (1975) record a low incidence in native fallows in N. Iraq.

Seed rate and method of seeding :

In Algeria, Libya and Tunisia a seed rate of 10-20 kg/ha is recommended for *M. truncatula* ("Jemalong") and *M. littoralis* ("Harbinger") when broadcast or drilled ; increasing the seed rate to 24 kg/ha has not produced an increase in the seed yield.

Bouglé (1974) however recommends a higher seed rate (18 kg/ha) for *M. littoralis* ("Harbinger") when drilling because the seed is smaller and rounder and runs more easily in the drill.

In Libya culti-trash seeders have been used for seeding medics in cereal crop stubbles in the Gefara Plain (Roberts and Halse, 1976) and aerial seeding has also been carried out successfully in the Benghazi Plain (Dillon, 1976).

In Morocco Foury (1950) and Villax (1963) recommend a seed rate of 15-30 kg/ha for *M. lupulina* when broadcast seeded alone, or a seed rate of 4-8 kg/ha when seeded in mixture with *Lolium italicum*.

In Israel under run off farming conditions in the desert, various annual *Medicago* spp. were seeded at a rate of 10-20 kg/ha broadcast on nursery plots but this seed rate was considered inadequate to give a complete ground cover in the first year (Tadmor et al., 1971).

In N. Iraq a seed rate of 5-10 kg/ha has proved sufficient for seeding *M. truncatula* ("Jemalong") and *M. scutellata* ("Commercial") using a grain drill (Nardi) with a drill spacing of 15 cm ; in general 10 kg/ha gave the best results (Kernick, 1976).

In the USA a seed rate of 15 kg/ha has been used for drilling *M. arabica* and *M. hispida* (McKee, 1949).

Seed inoculation :

Although there always exists a certain quantity of rhizobium on the pods of annual *Medicago* spp. Gachet and Elmir (1972) consider that they are insufficient to assure good nodulation and inoculation is therefore indispensable. Under dry conditions Brockwell and Whalley (1962) recommend the use of pelleted seeds incorporating a peat inoculant.

On the light calcareous soils in N. Iraq nodulation of seeded *M. truncatula* ("Jemalong") and *M. scutellata* ("Commercial"), where the seed was not inoculated, has been weak leading to the appearance of yellow seedlings in early spring ; an application of 42 kg/ha of N has assisted their growth and restored the normal green colour. This has not occurred to seedlings produced in the second year regeneration presumably because adequate numbers of adapted rhizobium were present (Kernick, 1976).

Depth of sowing :

Bakhtri (1976) states that the optimum depth of sowing for *M. truncatula* ("Jemalong") and *M. littoralis* ("Harbinger") is 1.5 cm and for *M. scutellata* with larger seeds the optimum varies between 1-4 cm. In N. Iraq shallow (1 cm) and surface seeding has given the best results for *M. truncatula* ("Jemalong") leading to quick and vigorous seedling establishment.

Fertilizer application :

The application of phosphate fertilizer is normally required although in North Africa, where there is often high residual levels of

phosphate in the soil, there is no response to phosphate. Nevertheless an application of 45 kg/ha of P_2O_5 at or before seeding is usually recommended on phosphate deficient soils, and 50 kg/ha of superphosphate has been applied in Libya on soils with 10 ppm of phosphorous or less.

In N. Iraq where soil phosphate levels are also very low (8-10 ppm) the application of phosphate at a rate of 60-120 kg/ha is recommended and has greatly increased the first year forage yields of *M. truncatula* ("Jemalong", "Borong"), *M. littoralis* ("Harbinger"), *M. scutellata* ("Commercial"), *M. polymorpha* (native ecotypes) and *M. orbicularis* (native ecotypes).

Weed control :

Weeds also affect the growth and establishment of annual *Medicago* spp. In Algeria Bouglé (1974) recommends a cross-harrowing soon after seeding *Medicago* spp. to kill emerging weeds. The control of weeds by spraying herbicides in the preceding cereal crop is also under investigation and shows promise in Algeria (Jefferies, 1977).

22.10. Forage Value

Palatability :

All the previously mentioned annual *Medicago* spp. are palatable to livestock but there is some evidence from N. Iraq that the native *Medicago* spp. are much more palatable to native sheep and goats than varieties introduced from Australia (Kernick, 1976).

Nutritive value :

Little data is available on their forage value in North Africa and the Near and Middle East, but Foury (1950) mentions the following data for *M. polymorpha* and *M. lupulina* in Morocco :

Species	Water %	Ash %	Protein %	Non-N Extract	Fats %	Cellulose %
<i>M. polymorpha</i> (hay)						
on wet basis	13.22	9.12	15.22	33.44	1.34	27.66
on dry basis	0	10.51	17.54	38.52	1.54	31.89
<i>M. lupulina</i> (green forage)						
on wet basis	72.00	1.50	5.77	13.61	0.56	6.55
on dry basis	0	5.40	20.60	48.60	2.00	23.40

Similar data is also recorded from Australia for hay of *M. polymorpha* and *M. truncatula* which is given below :

Species	Water %	Crude Protein %	Crude Fibre %	Ash %	Non-N Extract %	Fats %
<i>M. polymorpha</i>	10.1	12.6	26.3	7.2	41.1	3.1
<i>M. truncatula</i>	14.7	19.8	20.6	10.3	32.4	1.6

In N. Iraq the crude protein of seeded *M. truncatula* ("Jemalong") and *M. scutellata* ("Commercial") was found to vary from 15-17 % on a dry basis when sampled in flower in April ; data from Australia (Radcliffe and Cochrane, 1970) indicates that the crude protein of these two varieties can be as high as 21-23 % before and at the beginning of flowering.

Digestibility and consumption of pods :

Further data on digestibility of *M. truncatula* and *M. scutellata* and the digestibility and consumption of seeds and pods of *M. truncatula* is also available from Australia (Vercoe and Pearce (1969) and is given below :

Percentage Digestibility of Dry Matter				
<i>M. truncatula</i>		<i>M. scutellata</i>		
Phenological Stage of Growth	Dry Matter Digestibility %	Phenological Stage of Growth	Dry Matter Digestibility 1st year % 2nd year	
Before flowering	72	Before flowering	--	--
15 days later	65	20 days later	--	81.1
Beginning of flowering	57	Beginning of flowering	--	79.7
15 days later	54	Mid-flowering	78.9	77.3
Beginning of pods dispersal	47	Beginning of maturation	73.2	74.5
15 days later	45	Beginning of pods dispersal	64.1	61.7
30 days later	27	Majority of pods dispersal	55.3	54.4
		Nearly all the stems dry	50.4	49.3

Chemical Composition of the seeds and pods of <i>M. truncatula</i> on a dry matter basis			
	Crude Protein	Crude Fibre	Ash
Seeds	45.4	6.1	3.0
Pods	6.1	56.4	3.7

Digestibility of pods of <i>M. truncatula</i> and quantity consumed/day by sheep				
Quantity consumed DM g/day	Percentage Digestibility			
	Dry Matter	Organic Matter	Crude Protein	Crude Fibre
940	30	32	67.5	17.9

22.11. Forage and Seed Production

Forage yields :

In the littoral zone of Algeria in a season with 770 mm rainfall (September-May) a fallow pasture comprising seeded *M. truncatula* ("Jemalong") and volunteer annual legumes and grasses yielded on 21 May a green forage yield of 24,400 kg/ha and 7,000 kg/ha DM ; of this total *M. truncatula* yielded 7,000 kg/ha green forage and 2,000 kg/ha DM (Bouglé, 1974).

In the littoral zone of Tunisia Le Houerou and Froment (1973) report green forage yields of the order of 20,000 kg/ha in dryland cultivation for *M. denticulata*, *M. hispida*, *M. scutellata* and *M. tribuloides*.

In the steppic zone (220 m elevation) of N. Iraq in two seasons with a rainfall varying from 330 to 475 mm (November-May) fallow fields on light calcareous soil seeded separately with *M. truncatula* ("Jemalong") and *M. scutellata* ("Commercial") and fertilized with 60 kg/ha P_2O_5 gave an average yield varying from 2,000-3,300 kg/ha green forage for *M. truncatula* and 5,700-6,000 kg/ha green forage for *M. scutellata*.

In nursery plots on alluvial soil in the steppic zone (220 m elevation) of N. Iraq in a season with 475 mm rainfall (November-May) the following forage yields have been recorded from various annual *Medicago* spp. seeded in late January :

Forage Yield kg/ha in June				
Species	Fertilized (60 kg/ha P_2O_5)		Unfertilized	
	Green Matter	Dry Matter	Green Matter	Dry Matter
<i>M. truncatula</i> ("Jemalong")	9,200	4,200	7,600	2,700
<i>M. truncatula</i> ("Borong")	8,000	3,200	5,800	2,000
<i>M. truncatula</i> ("Cyprus")	4,000	1,600	3,000	1,200
<i>M. scutellata</i> ("Commercial")	7,400	3,000	5,000	2,200
<i>M. littoralis</i> ("Harbinger")	2,600	5,000	1,200	400
<i>M. polymorpha</i> (native)	4,500	1,900	3,400	1,400
<i>M. orbicularis</i> (native)	4,200	1,600	3,200	1,100

Much lower yields, 300 kg/ha green forage for *M. truncatula* ("Jemalong") and 400 kg/ha green forage for *M. scutellata* ("Commercial"), were recorded further south in the steppic zone of Iraq at Hatra on sandy soils, in a season with 340 mm rainfall (November-May) ; 30 kg/ha P_2O_5 was applied at seeding but the seeds were not inoculated and the resultant yellow plants may have developed through poor nodulation.

In a semi-arid region (170-413 mm annual rainfall) of Israel Eyal et al. (1975) report an annual forage yield of 3,000-6,000 kg/ha DM over a 5-6 year period for *M. polymorpha* and *M. truncatula*. Promising forage yields have also been recorded (Tadmor et al., 1971) in the desert (80-100 mm annual rainfall) under run off farming conditions, where ecotypes of *M. polymorpha*, *M. orbicularis*, *M. tornata*, *M. scutellata*, *M. truncatula* and *M. turbinata* planted in nursery plots re-seeded themselves each year and fertilized annually with 72 kg/ha P_2O_5 and 42 kg/ha N averaged from 20,000-30,000 kg/ha green forage or 4,000-6,000 kg/ha dry matter over a 9 year period.

Seed yields :

In the littoral zone of Algeria seed yields in June of seeded field stands of *M. truncatula* ("Jemalong") have varied from 545-1,070 kg/ha when previously grazed and up to 1,330 kg/ha when cut for hay ; corresponding figures for *M. littoralis* ("Harbinger") were 430 kg/ha when previously grazed and 1,250 kg/ha when cut for hay (Bouglé, 1974). Naturally occurring *M. ciliaris*

in the same field stands gave a seed yield of 717 kg/ha when previously grazed. Yields varying from 2,700-3,200 kg/ha have also been recorded for pods produced by seeded annual *Medicago* spp. in Algeria (Breth, 1975).

On a field scale a combine harvester, forage harvester and sheep-skin roller have been used on an experimental basis to harvest pods of *M. polymorpha* (native) and *M. truncatula* ("Jemalong") in Algeria with considerable success ; the recovery of the pods with the forage harvester reached almost 100 % (Muckle, 1977).

22.12. Utilization

Use in dryland cereal rotations :

Experience in N. Africa shows that both *M. truncatula* ("Jemalong") and *M. littoralis* ("Harbinger") can be seeded and maintained in rotation with cereal crops (1 year cereal, 1 year medic) and utilized for grazing or hay.

Grazing management :

Grazing management is very important especially in the first year to build up a reservoir of seeds. Bakhtri (1974) points out that it is very important to allow young *Medicago* plants to become well established before they are heavily grazed. But when weeds are in competition with the *Medicago* the pasture must be grazed quickly with a large number of sheep to reduce early competition ; this is recommended when the weeds are 10-15 cm high and the plants of *Medicago* have reached the 6-8 leaf stage.

Topping of pasture and conservation for hay :

Topping of the pasture is also recommended to prevent seed set of annual grass weeds. When utilizing *Medicago* spp. for hay Webber (1974) recommends cutting the crop higher than normal to encourage seed set and to do this only in second and third year pastures after sufficient seed reserves have been built up.

Liveweight gain and stocking rate on pasture :

In Algeria Bouglé (1974) reports daily weight gains of 200 g/day for native lambs grazing mixed seeded *M. truncatula* and *M. littoralis* pastures over a 35 day period in April and early May ; grazing was not extended beyond this period to allow the pastures to set adequate seed.

In Libya Dillon (1976) reports stocking rates of 3 sheep/ha on re-seeded medic pastures in the Benghazi Plain from mid-January onwards and sufficient growth also for an adequate seed set.

In Israel seeded pastures of *M. polymorpha* and *M. truncatula* have been stocked at a rate of 1.5/2.5 ewes/ha each year for 5-6 years but fertility disorders apparently due to oestrogenic activity occurred in a year of high legume growth (Eyal et al., 1975).

Benefits of including legume in cereal rotations :

In North Africa it is also reported (Breth, 1975) that wheat following seeded medics (*M. truncatula* ("Jemalong") or *M. littoralis* ("Harbinger") produced grain yields equal to those of wheat fertilized with 60 kg/ha of nitrogen following a wheat fallow ; in Libya (Benghazi Plain) Dillon (1976) also reports an increase of 33 % in the wheat yield following medic pasture compared to continuous wheat cultivation. In Libya, too, preliminary work suggests that the net increment in soil nitrogen from growing medics in dryland cereal rotations is of the order of 40 kg N/ha/annum (Roberts and Halse, 1976).

Further evaluation :

More attention in the future needs to be paid to the collection and testing of native ecotypes of the annual *Medicago* spp. mentioned which are better adapted to low temperatures as is now underway in Algeria, N. Iraq and Libya.

Collection now needs to be concentrated on the wealth of local adapted plant material present which shows good cold and drought tolerance as well as early autumn or spring growth, and which has a high percentage of hard-seededness. Such material will be of immense value for developing cultivars for large-scale cultivation in dryland farming in the region where there is now wide interest in replacing part of the fallow in the predominantly cereal-fallow rotation by a productive self-regenerating annual forage legume.

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TECHNICAL DATA

SHEET No 23

PAPILIONACEAE (= FABACEAE)

Vicia spp.

23.1. Species

Among the many annual and related *Vicia* spp. present in North Africa, the Near and Middle East, the following are considered to be important forage species : *V. atropurpurea* Desf., *V. ervilia* Willd., *V. fulgens* Batt., *V. monantha* Retz., *V. narbonensis* L., *V. pannonica* Cr., *V. peregrina* L., *V. sativa* L., *V. sativa* L. subsp. *amphicarpa* (Dorth.) Aschers. et Graebn., *V. villosa* Roth., *V. villosa* Roth. subsp. *dasycarpa* (Ten.) Cav. A comprehensive monograph covering the genus *Vicia* and pertaining to the Mediterranean region has also been assembled by Guinea (1953).

23.2. Synonyms

- *V. atropurpurea* (= *V. benghalensis* L.)
- *V. ervilia* (= *Ervum ervilia* L.)
- *V. fulgens* (= *V. cruenta* Cosson.)
- *V. monantha* (= *V. calcarata* Desf.)
- *V. narbonensis* (= *V. galilaea* Plitm. et Zoh., *Faba narbonensis* (L.) Schur)
- *V. pannonica* (= *V. striata* M. B.)
- *V. sativa* (= *V. communis* Rouy)
- *V. sativa* subsp. *amphicarpa* (= *V. subterranea* Gér. ex Dorthes, *V. amphicarpa* Dorth., *V. angustifolia* L. var. *amphicarpa* (Dorth.) Alef.)
- *V. villosa* (= *Ervum villosum* Tranutv.)
- *V. villosa* subsp. *dasycarpa* (= *V. dasycarpa* Ten., *V. varia* Host., *V. villosa* Roth. var. *glabrescens* Koch.)

23.3. Common Names

- | | | |
|--------------------------|---------|--|
| - <i>V. atropurpurea</i> | English | Purple Vetch ; |
| | French | Vesce de Bengale, Vesce Purple ; |
| - <i>V. ervilia</i> | English | Bitter Vetch, Black Bitter Vetch, Pigeon's Pea ; |
| | French | Ers, Erse, Ervilière, Pois de Pigeon ; |
| | Arabic | Kersana, Kersanna, Kersenna, Kersannah, Garfallah (Morocco) ; Kersenne (Syria, Lebanon, Palestine) ; |

- | | | |
|-------------------------|---------|--|
| - <i>V. fulgens</i> | French | Vesce écarlate ; |
| - <i>V. monantha</i> | English | Bard Vetch, Syrian Vetch ; |
| | French | Vesce éperonnée ; Vesce à éperon ; |
| | Arabic | Foulia, Dokhreg, Djelbant el
aâcheb, Chariq, Khariq, Sella
(Morocco) ;
Jilbana, Udays (Jordan) ;
Halb Adh -Dharait (Iraq) ; |
| - <i>V. narbonensis</i> | English | Narbonne Vetch, French Vetch,
Broad-leaved Vetch ; |
| | French | Vesce de Narbonne, Fève des
chevaux ; |
| | Arabic | Bakker, Foul ibliss (Morocco) ;
Biqla harastaniye (Syria) ;
Habb Adh-Dharat, Habb Adh-Dharant
(Iraq) ; |
| - <i>V. pannonica</i> | English | Hungarian Vetch ; |
| | French | Vesce de Hongrie, Vesce de
Pannonée ; |
| - <i>V. peregrina</i> | English | Broad Podded Vetch ; |
| - <i>V. sativa</i> | English | Common Vetch, Common Tare,
Wild Vetch ; |
| | French | Vesce commune, Vesce cultivée ; |
| | Arabic | Djelbana, Djilbana, Djoulban,
Garfala, Rharfala, Hacheb en niml,
N'fel, Nefel (Morocco) ;
Eddeis Besillet-iblees, Fool
roomi, Dehorag, Bakhr, Bakhran
(Egypt (UAR) ;
Bakiyah, Ful Rumi (Jordan) ;
Biql'a harastaniye (Syria) ;
Habb Adh-Dharait, Habb Adh-Dharat
(Iraq) ; |
| - <i>V. villosa</i> | English | Hairy Vetch, Sand Vetch, Russian
Vetch, Siberian Vetch, Winter
Vetch ; |
| | French | Vesce velue, Vesce des sables,
Vesce de Russie, Vesce de Sibérie ; |
| | Arabic | Jilbana (Iraq) ; |

- | | | |
|---|---------|---|
| - <i>V. villosa</i> ssp. <i>dasycarpa</i> | English | Cardyne Vetch, Woolly Pod Vetch, Winter Vetch ; |
| | French | Vesce de cerdage, Vesce variée. |

23.4. Brief Description

- *V. atropurpurea* is an annual or biennial with robust stems and long lasting roots and having leaves with 5-8 pairs of petioles, dark reddish purple flowers grouped in clusters and pods covered with non-rigid hairs ; the species is also very closely related to *V. villosa* (Fig. 1) ;

- *V. ervilia* is an annual with much branched angular stems growing to a height of 20-50 cm with small red-violet flowers and having leaves with 16-24 petioles and hanging glabrous fruits with pods having small raised edges on the surface and containing 3-4 seeds (Fig. 2) ;

- *V. fulgens* is an annual with very long stems (100-200 cm), finely pubescent or completely glabrous and with dense clusters of red flowers, glabrous pods and black seeds ;

- *V. monantha* is a much branched annual growing to a height of 30-70 cm with pale violet flowers often in groups of 2, sometimes 3 to 6 with oblong pods containing 2-4 seeds (Fig. 3) ;

- *V. narbonensis* is a vigorous growing annual with angular straight stems growing to a height of 30-60 cm and strongly pigmented at the base of the axillary buds and having violet flowers and linear oblong pods ; aspect of growth is similar to *V. faba* L. but the pods and grains are smaller (Fig. 4) ;

- *V. pannonica* is a hairy annual with climbing stems growing to a height of 40-60 cm with 5-8 pairs of leaflets, white flowers and hairy pods containing spherical seeds (Fig. 5) ;

- *V. peregrina* is a procumbent, decumbent or erect annual, growing to a height of 10-100 cm, with purplish flowers, sometimes whitish with blue veins, and narrowly oblong shortly beaked legume with numerous, sub-globose, chestnut-brown shining seeds (Fig. 6) ;

- *V. sativa* is a weak decumbent or scrambling annual with a much branched slender root system growing to a height of 10-50 cm with purplish-blue solitary or paired flowers on very short stalks and a more or less hairy legume with 4-8 smooth dark-brown mottled seeds (Fig. 7) ;

- *V. sativa* subsp. *amphicarpa* is a small erect annual often with very narrow-leaved basal shoots, dimorphic flowers and fruits, and aerial and subterranean stems, the latter bearing rudimentary flowers producing 1-2 seeded fruits below ground (Fig. 8) ;

- *V. villosa* is a strongly hairy annual or biennial with strong tap roots and growing to a height of 30-45 cm or 100-200 cm, if supported by a cereal crop, and having 3-12 pairs of leaflets, violet flowers hanging in long groups and glabrous or pubescent pods containing 1-5 seeds (Fig. 9) ;

- *V. villosa* ssp. *dasycarpa* is an annual growing to a height of 30-50 cm and less hairy than *V. villosa* with erect and not hanging violet flowers with pale or even white flowers (Fig. 10).

23.5. Varieties

Botanical varieties and subspecies :

A number of botanical varieties and subspecies have been recorded for *V. atropurpurea*, *V. monantha*, *V. narbonensis*, *V. pannonica*, *V. sativa* and *V. villosa* in North Africa, the Near and Middle East. In North Africa Foury (1950) and Villax (1963) record the following :

V. atropurpurea :

- var. *atropurpurea* Desf. Maire
present throughout Morocco ;
- var. *heterocalyx* Maire et Weiller
present in north and eastern Morocco ;
- var. *perennis* (D.C.) Fiori
present at Tétouan, Morocco ;

V. monantha :

- ssp. *eu-biflora* Maire
- ssp. *cinerea* (M.B.) Maire

V. narbonensis :

- var. *serratifolia* Koch (= *V. serratifolia* Jacq.)
also recorded in Iraq by Townsend and Guest (1974) and in Turkey by Davis (1966) ;
- var. *heterophylla* Rouy (= *V. heterophylla* Rohb.)

V. pannonica :

- var. *typica* Nob.
the cultivated form ;

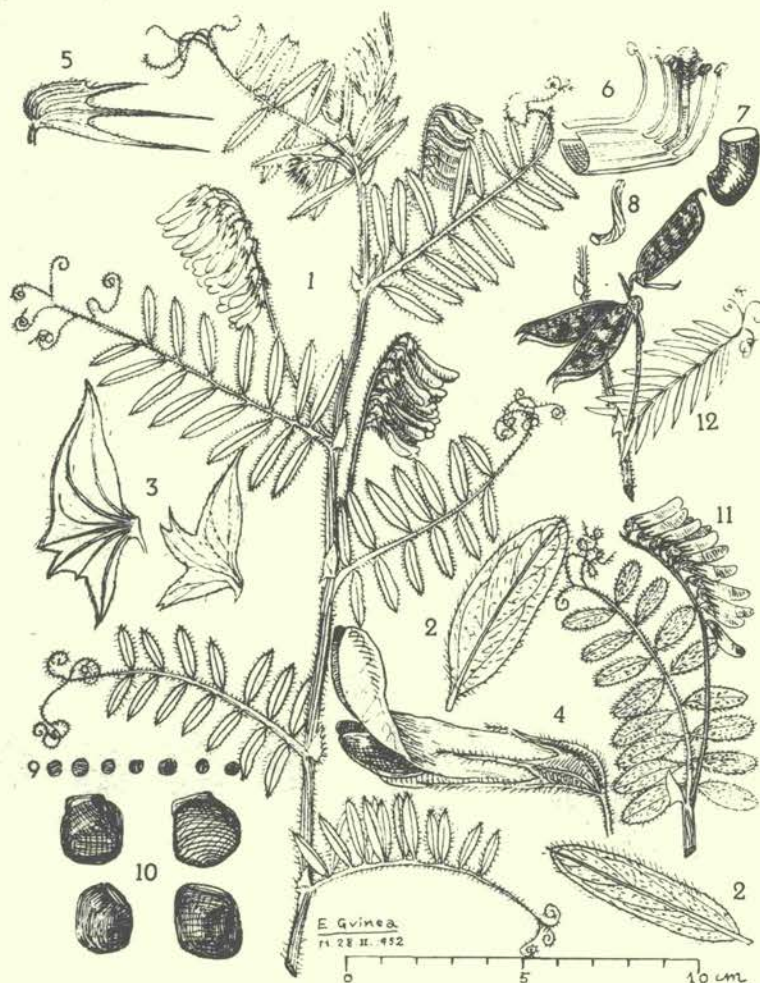


Fig. 1

Vicia benghalensis L. (= *V. atropurpurea* Desf.)

1. Specimen. 2. Enlarged leaflet. 3. Enlarged stipule. 4. Enlarged flower. 5. Enlarged calyx. 6. Androecium. 7. Enlarged section of the stile. 8. Enlarged curvature of stile. 9. Seeds. 10. Enlarged seeds. 11. Branch with leaflets and flowers. 12. *Vicia perennis* Pau.

(After Estudio Botanico de las Vezas Y Arvejas Espanolas,
1953, p. 131)

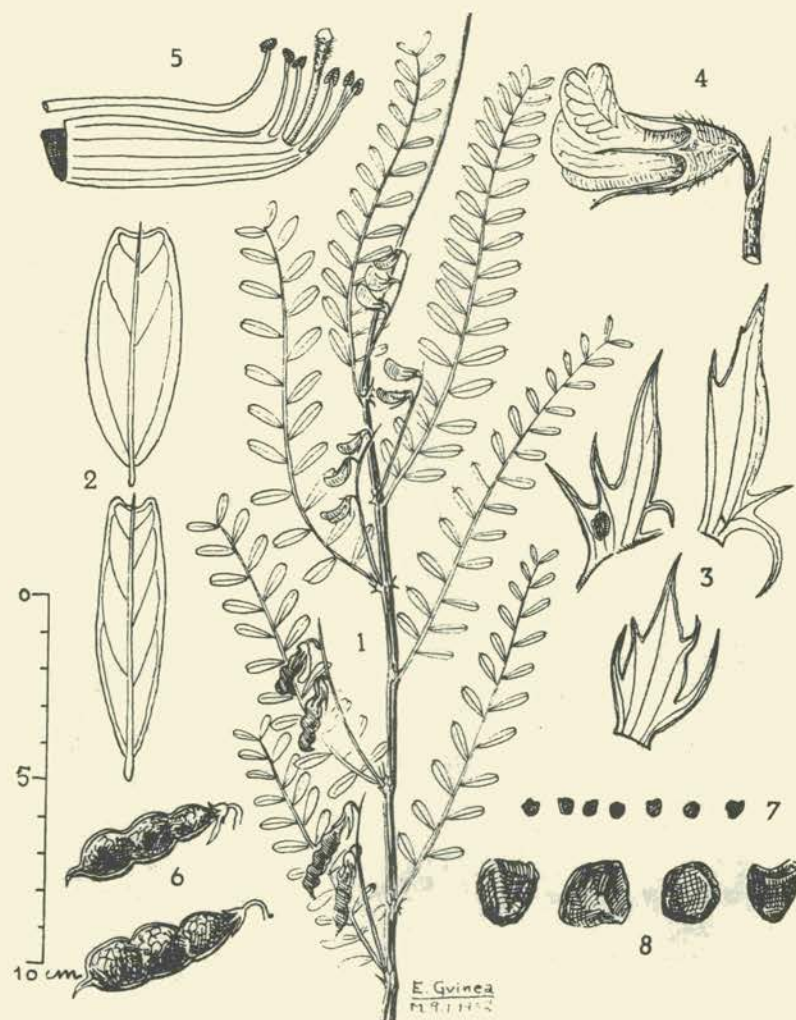


Fig. 2 - *Vicia ervilia* (L.) Willd.

1. Specimen. 2. Enlarged leaflets. 3. Enlarged stipules. 4. Enlarged flower. 5. Androecium. 6. Enlarged pods. 7. Seeds. 8. Enlarged seeds.

(After Estudio Botanico de las Vezas Y Arvejas Espanolas,
1953, p. 173)

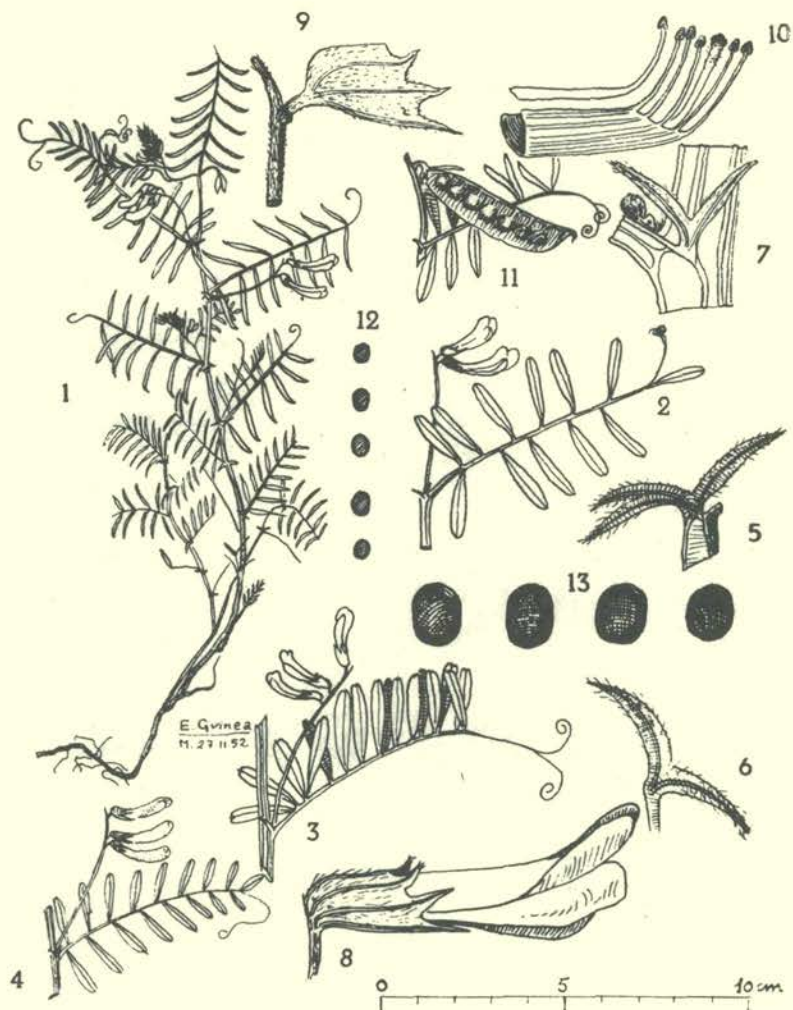


Fig. 3 - *Vicia monantha* Retz.

1. Specimen. 2. Branch with leaflets and flowers. 3. *Vicia carthaginensis* Pau. 4. Branch with leaflets and flowers. 5. Stipule. 6. Stipule. 7. Stipule. 8. Flower. 9. Calyx. 10. Androecium. 11. Branch with leaflets and legume (pod). 12. Seeds. 13. Enlarged seeds.

(After Estudio Botanico de las Vezas Y Arvejas Espanolas,
1953, p. 134)



Fig. 4 - *Vicia narbonensis* L.

1. Specimen. 2. Branch with stipules, leaflets and pod. 3. Inflorescence. 4. Androecium. 5. Pod. 6. Enlarged detail of surface of pod. 7. var. *serratifolia* Jacq. 8. Seeds. 9. Enlarged seeds. 10. Leaflets of var. *serratifolia*.

(After Estudio Botanico de las Vezas Y Arvejas Espanolas, 1953, p. 69)

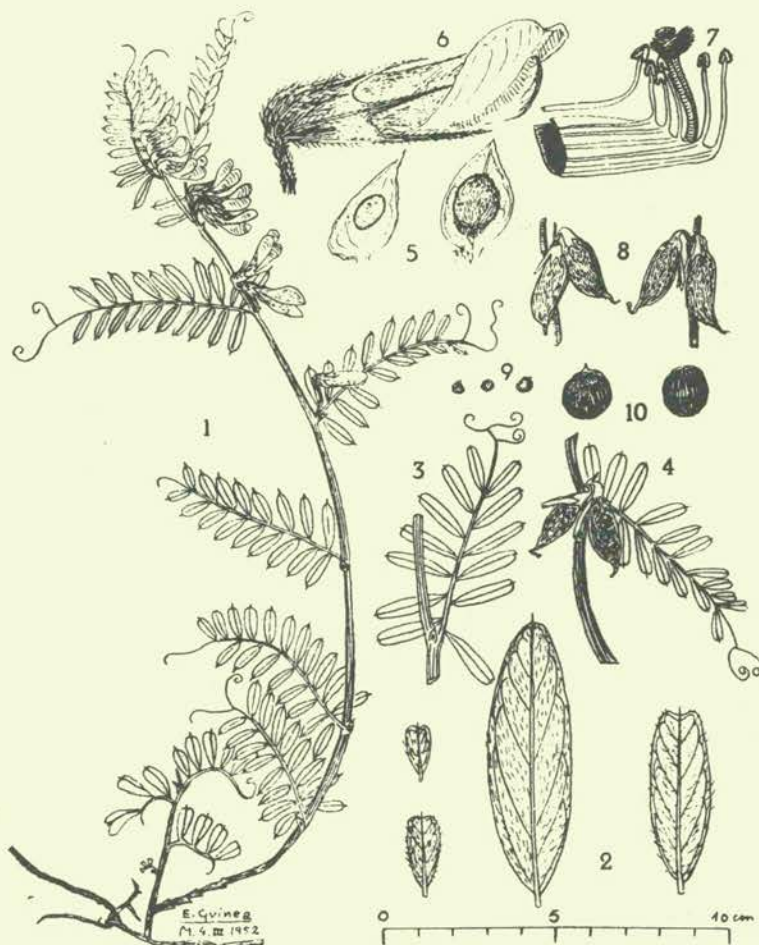


Fig. 5 - *Vicia pannonica*

1. Specimen. 2. Enlarged leaflets. 3. Branch with leaflets. 4. Branch with pods. 5. Enlarged stipule. 6. Enlarged flower. 7. Androecium. 8. Pods. 9. Seeds. 10. Enlarged seeds.

(After Estudio Botanico de las Vezas Y Arvejas Espanolas, 1953, p. 82)

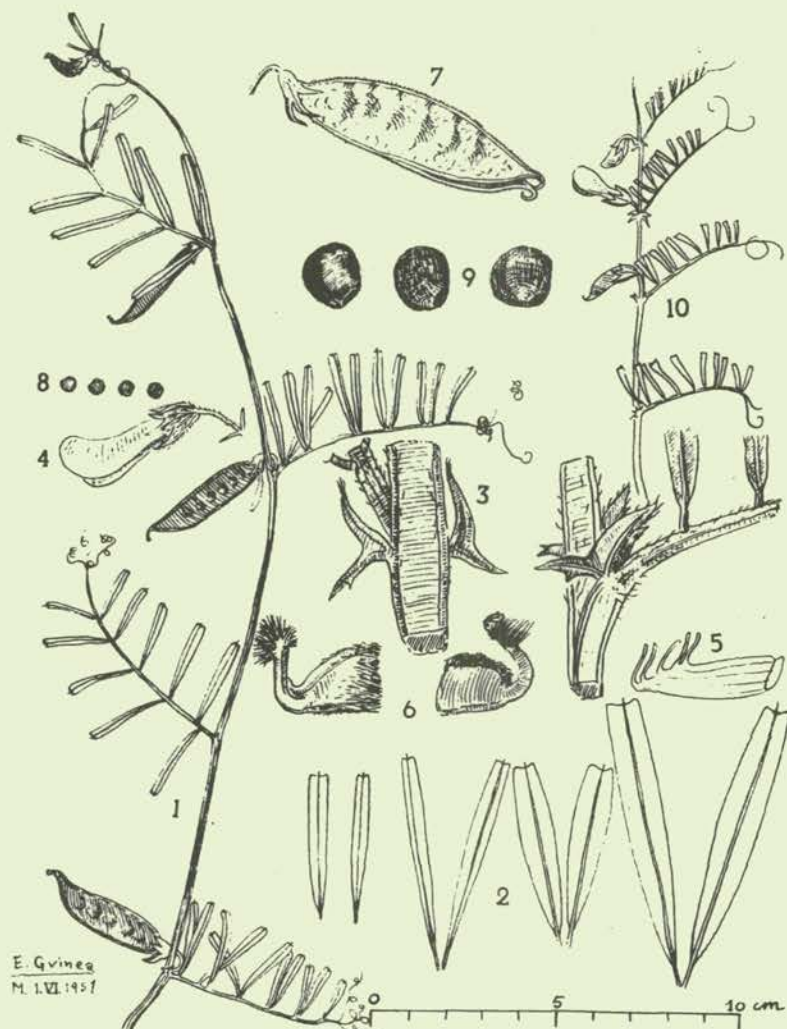


Fig. 6 - *Vicia peregrina* L.

1. Specimen. 2. Enlarged leaflets. 3. Enlarged stipule. 5. Androecium.
 6. End of the gynoecium. 7. Enlarged pod. 8. Seeds. 9. Enlarged seeds.
 10 Specimen from small plant.

(After Estudio Botanico de las Vezas Y Arvejas Espanolas,
 1953, p. 50)

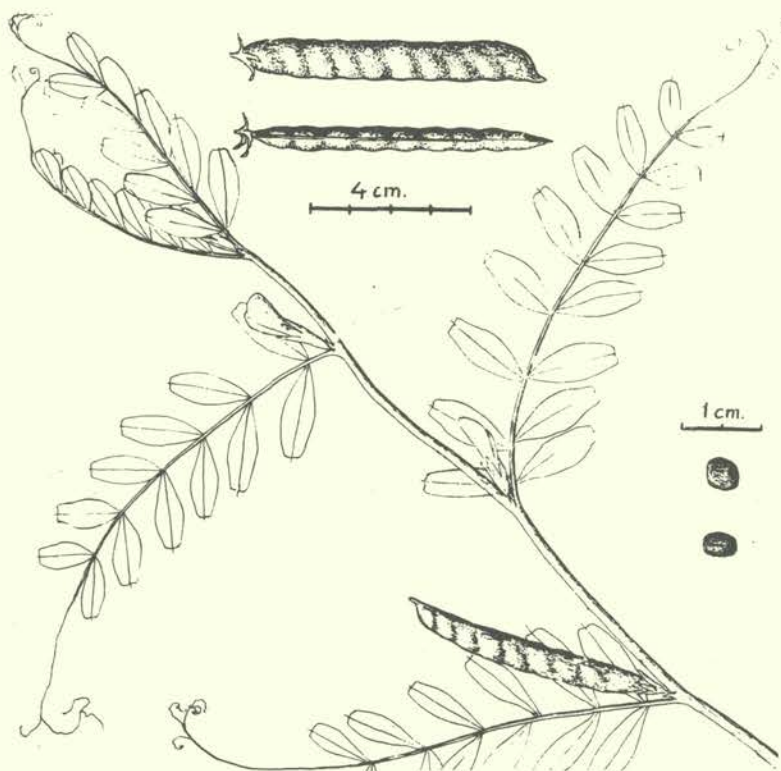


Fig. 7

Vicia sativa L. (Orig. - Paris)

(After Recueil iconographique des espèces comestibles de légumineuses
africaines, 1960-61, p. 48, fig. 47)

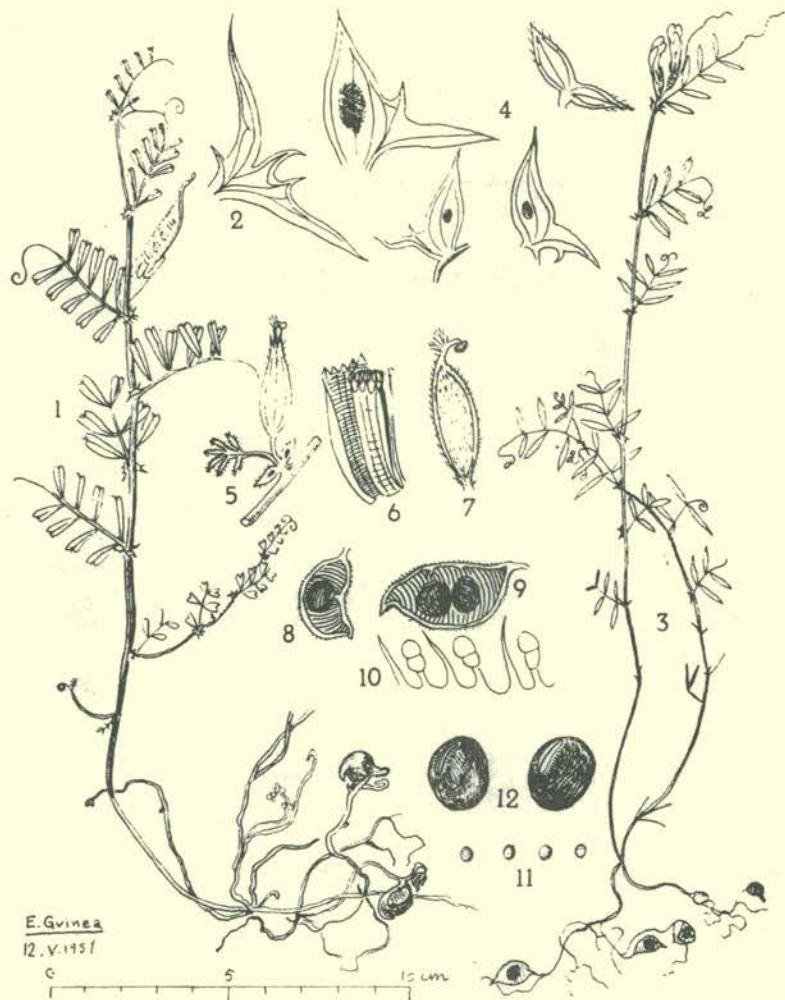


Fig. 8

Vicia sativa subsp. *amphicarpa* Dorothés

1. Specimen. 2. Enlarged stipule. 3. *Vicia amphicarpa* var *linearifolia* Senne. 4. Enlarged stipule. 5. Branch with withered flower and calyx. 6. Androecium. 7. Pod. 8. 1-Seeded pod. 9. 2-Seeded pod. 10. Detail of hairs of indumentum. 11. Seeds. 12. Enlarged seeds.

(After Estudio Botanico de las Vezas Y Arvejas Espanolas,
1953, p. 27)

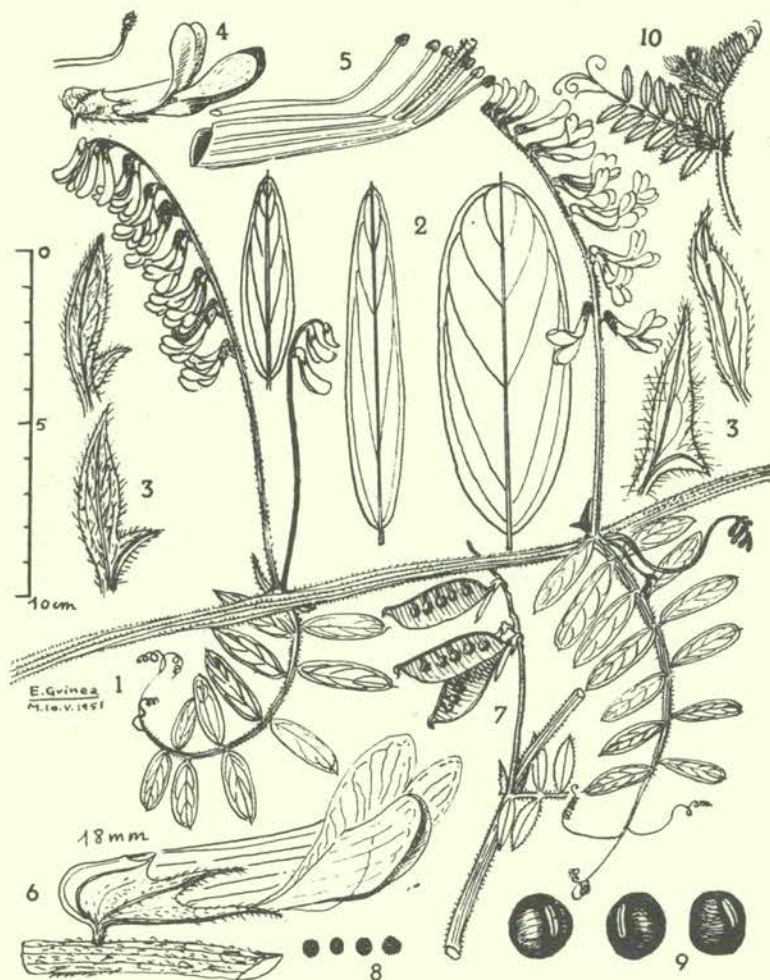


Fig. 9

Vicia villosa subsp. *villosa*

1. Specimen. 2. Enlarged leaflets. 3. Enlarged stipules. 4. Enlarged flower. 5. Androecium. 6. Enlarged flower. 7. Pods. 8. Seeds. 9. Enlarged seeds. 10. Hairy extremities of young branch and leaflets.

(After Estudio Botánico de las Vezas Y Arvejas Españolas,
1953, p. 119)

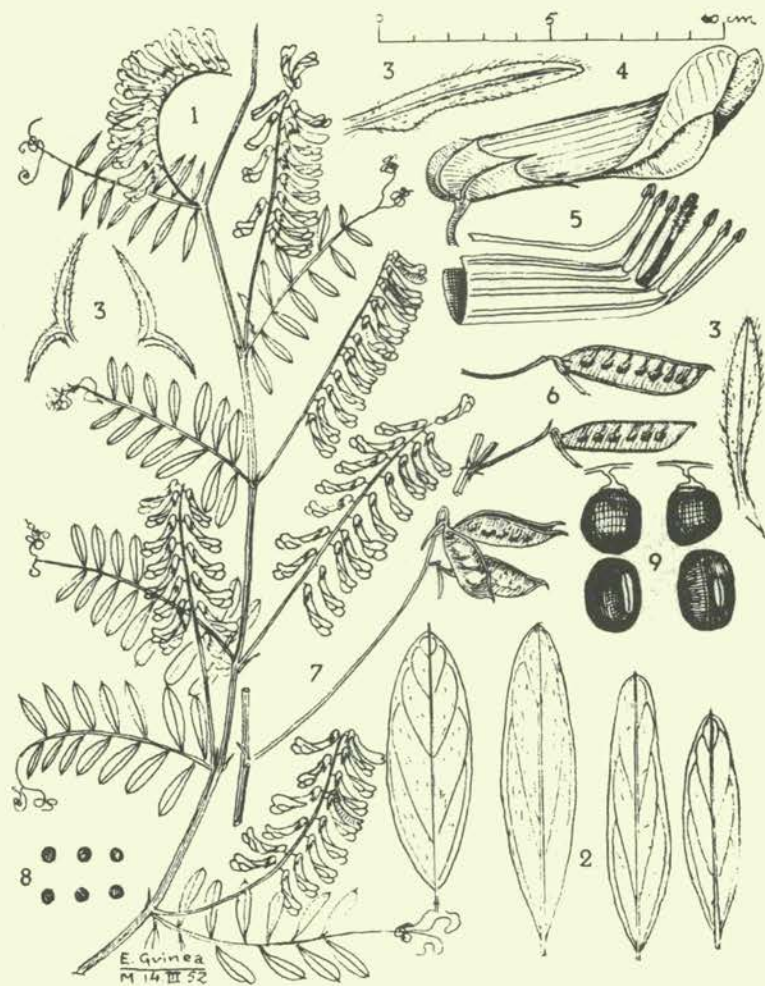


Fig. 10

Vicia villosa ssp. *dasycarpa*

1. Specimen. 2. Enlarged leaflets. 3. Enlarged stipules. 4. Enlarged flower. 5. Androecium. 6. Pods. 7. Branch with pods. 8. Seeds. 9. Enlarged seeds.

(After Estudio Botanico de las Vezas Y Arvejas Espanolas,
1953, p. 123)

- var. *purpurascens* Ser. in D.C.
occurs spontaneously in Morocco near Rabat and also recorded in Libya by Keith (1965) and in Turkey by Davis (1966) ;

V. sativa :

- ssp. *obovata* (Ser.) Gaud.
with many botanical and several agricultural varieties ;
- ssp. *angustifolia* (L.) Gaud.
occurs spontaneously throughout the Mediterranean basin and also recorded in Lebanon and Syria (Mouterde, 1966) ; this subspecies (English name : Narrow Leaf Vetch) has now been classified by Ball (1968) in the USA as subsp. *nigra* L. (Ehrh.) ; it has black pods which are not constricted between the seeds, and narrow leaflets ;
- ssp. *cordata* (Wulfen) Asch. et Gr.
with several botanical varieties ; occurs spontaneously throughout the Mediterranean basin and in the littoral zone and high plateaux regions of Morocco, and also recorded in Libya (Keith, 1965), Egypt (UAR) (Tackholm, 1974), and in Syria and Lebanon (Mouterde, 1966) ;
- ssp. *amphicarpa* (Dorthes) Asch. et Gr.
occurs spontaneously throughout the Mediterranean region, also recorded in Tunisia by Le Houerou (1969), in Egypt (UAR) by Tackholm (1974) and in Turkey by Davis (1966) ;
- var. *heterophylla* (= var. *heterophylla* Rchb.)
occurs spontaneously in Morocco ;

V. villosa :

- ssp. *eu-villosa* Cavill.
which exists nearly exclusively in cultivation and recorded as such as ssp. *villosa* with occasional naturalized relics also in Iraq by Townsend and Guest (1974) ;
- ssp. *dasycarpa* (Ten.) Cavill.
occurs spontaneously throughout the Mediterranean basin and also recorded in Egypt (UAR) by Tackholm (1974), in Iraq by Townsend and Guest (1974) and in Turkey by Davis (1966) ;
- ssp. *dasycarpa* var. *glabrescens* Koch
corresponds to the cultivated Cardyne Vetch ;
- ssp. *dasycarpa* var. *leisolens* Faure et Maire
occurs spontaneously in Morocco and Tripolitania ;
- ssp. *pseudocracca* (Bert.) Rouy
(= *Cracca Bertolonii* G.G.)
occurs spontaneously throughout North Africa ;

- ssp. *pseudocracca* var. *brevipes* Nillk. (= *V. pseudocracca* Bert. var. *subbiflora* Pau., *V. subbiflora* Salzm, *V. elegantissima* Schuttl.) ;
- ssp. *pseudocracca* var. *Wilezeski* Maire
both the above varieties occur spontaneously in Morocco ;
- ssp. *garbiensis* F.Q. et Pau
occurs spontaneously throughout the Mediterranean basin ;
- ssp. *simulans* Maire
occurs spontaneously throughout the Mediterranean basin.

In Libya Keith (1965) records the following not already mentioned :

V. monantha :

- ssp. *calcarata* Desf. Maire
present in the Garian Hills in Tripolitania ;

V. peregrina :

- var. *cyrenaea* Maire et Weill.
present near Cyrene in Cyrenaica ;

V. sativa :

- var. *angustifolia* L. (= *V. angustifolia* L.)
present near Tobruk in Cyrenaica ;
- var. *amphicarpa* Boiss.
present near Benghazi, Sciallabi El Bebas in Cyrenaica and near Tripoli, Suani ben Adem and Wadi Megemin in Tripolitania ;
- var. *cuneata* Guss.
cultivated in the Fezzan ;
- var. *segetalis* (Ser.)
present near Tobruk in Cyrenaica.

In Egypt (UAR) Tackholm (1974) records also the following not already mentioned :

V. narbonensis :

- var. *aegyptiaca* Kcke. ;
- var. *affinis* Kcke. ;
- var. *pilosa* Post
the above varieties together with var *serratifolia* already mentioned occur spontaneously in the littoral western region, Nile Valley and the Isthmic desert ;

V. sativa :

- var. *albiflora* Boiss. ;

- ssp. *nigra* (L.) Ehrh. (= *V. angustifolia* L., *V. cuneata* Boiss., *V. heterophylla* C. Presl., *V. pilosa* Bieb.)
both the above occur spontaneously in the littoral western region, Nile Valley and the Isthmic desert ;

V. villosa :

- ssp. *microphylla* (d'Urv.) P.W. Ball (= *V. microphylla* d'Urv., *V. salaminia* Heldr. et Sart. in Boiss., *V. microphylla* ssp. *salaminia* (Heldr. et Sart.) Hayek).

In Lebanon and Syria Mousterde (1966) records the following not previously mentioned :

V. narbonensis :

- var. *pilosa* Post.
with pods covered with dense tubercular hairs ; occurs in Transjordan and probably elsewhere ;
- var. *laodicena* nov. var.
occurs in the forest in Syria.

In Iraq Townsend and Guest (1974) record the following varieties not previously mentioned :

V. narbonensis :

- var. *narbonensis*
occurs spontaneously in the mountains and also recorded in Turkey by Davis (1969) ;

V. sativa :

- var. *sativa*
occurring spontaneously in the desert, steppe and mountains ;
- var. *angustifolia* L.
occurs spontaneously in the steppes and mountains.

In Turkey Davis (1966) records the following not already mentioned :

V. monantha :

- subsp. *monantha* (= *V. gracilis* Banks et Sol. in Russel
V. monantha subsp. *cinerea* (Bieb.) Maire)

V. narbonensis :

- var. *narbonensis* (= *V. latifolia* Moench., *V. narbonensis* L.
var *genuina* Gren. et Godr., *V. narbonensis* var *integrifolia* Ser. in DC.

V. pannonica :

- var. *pannonica*
with standard green or purple veined flowers ;

V. sativa :

- subsp. *macrocarpa* (Moris) Arc. ;
- subsp. *sativa* ;
- subsp. *incisa* (Bieb.) Arc. ;
- var. *incisa* (Bieb.) Boiss. ;
- var. *nigra* L. ;
- var. *segetalis* (Thuill.) Ser. ex DC.

Burt and Lewis (1949) have taxonomically revised *V. monantha* using the old synonym *Orbus viciiformis* Lagascei and dividing it into two subspecies : ssp. *triflora* Ten. Burt et Lewis comb. nov. and ssp. *cinerea* (M. Bieb.) Maire, which they consider interlace in the area between Morocco and Egypt ; Davis (1969) also reports an overlap for these two subspecies of *V. monantha*, in Palestine, where small flowered populations occupy drier habitats than large flowered ones.

Davis (1969) also mentions that *V. sativa* is one of the most variable (genetically and phenotically) in the genus with five main taxa at subspecific rank being distinguished in the complex in Turkey.

Native ecotypes :

In Turkey Hertzsch (1971) records that a large collection of native ecotypes of *Vicia* spp. including 43 accessions of *V. ervilia*, 35 of *V. narbonensis*, 57 of *V. pannonica*, 71 of *V. peregrina*, 234 of *V. sativa*, 20 of *V. villosa* and 75 of *V. villosa* subsp. *dasycarpa* have been assembled at Izmir (W. Turkey) and is being evaluated under dryland conditions. Breeding work with some selections of *V. sativa* is also underway. A number of accessions of native *V. sativa* subsp. *amphicarpa* have also been collected in E. Turkey and agronomic studies have been carried out at the Grassland Research Institute near Ankara (Kjellqvist, 1977).

In Jordan Hopkinson (1975) mentions a native ecotype of *V. ervilia* (No. 110) that has been collected locally and in N. Iraq Van der Veen (1959) notes that the local native ecotype of *V. narbonensis* growing in the mountains in the Sulemaniya region is a prostrate (spreading) to half erect type.

Vetch varieties :

A number of varieties of *V. atropurpurea*, *V. ervilia*, *V. narbonensis*, *V. pannonica*, *V. sativa*, *V. villosa* and *V. villosa* ssp. *dasycarpa* have been selected in the Mediterranean region particularly in Portugal, Spain, Greece, Turkey, Algeria, Morocco and Cyprus.

In Morocco Villax (1963) records that the most interesting local varieties of *V. sativa* developed at Rabat have been the "A" lines : INRA 6303/1963 (late), INRA 6307/1963 and INRA 6316/1963, all of which are resistant to the fungus disease anthracnose. Villax (1963) also records that both *V. sativa* ssp. *obovata* and *V. sativa* ssp. *macrocarpa* are resistant to the fungus diseases anthracnose and oidium.

Ionesco et al. (1969) mention that the varieties of *Vicia* spp. actually multiplied in Morocco are Nos. 6235, 6238, 6241 and 4242 for *V. sativa*, 6194 for *V. villosa* and 6229 for *V. atropurpurea*. Foury (1954) also records that some 10 native selections of *V. ervilia* from Sles, Tafraente, Beni Oulid, Tabanda Rharb and Rhafsai have been multiplied in Morocco.

Villax (1963) mentions that the following agricultural varieties of *V. sativa* grow well in the Mediterranean region : "Kabylie", "Tangier" (with very small seeds), "Evilhaca der Caia" (Portugal), 8263 (Spain), INIA 149 (Madrid), "Languedoc", "Provence", "Toulouse", "Bulgaria", "Roumania", "Hungary". The last six are spring varieties in Europe, but seeded in autumn they furnish a satisfactory and regular forage yield in the Mediterranean basin including Morocco, Algeria and Tunisia.

In Algeria the varieties of *Vicia* spp. that have been developed include *V. atropurpurea* 178, *V. fulgens* 202, *V. ervilia* 3978, and *V. narbonensis* 229 (Barbut, 1955).

In Cyprus Soteriadou (1960) records the local variety of C-52-70 of *V. sativa*, which has outyielded 9 other local varieties, and 63 introduced varieties from Algeria, Australia, France, Greece, Israel, Italy, Portugal, Turkey and the USA in dryland nursery tests, but the majority of these varieties including the local types were susceptible to the fungus diseases *Asochyta pisi* and *Botrytis fabae* which are prevalent in humid winters and springs.

However in dryland field plantings in Cyprus Hadjichristodoulou (1974) records that the varieties Bi64, Bi65 and M6900 of *V. sativa*, all from Greece, have proved superior to the best local variety available.

In Syria Van der Veen (1967) reports that the development of two local cultivars, namely "Harastani" (*V. sativa*) and "Aleppo" (*V. narbonensis*), which have been seeded successfully in dryland plantings, are in agricultural use.

In the USA for *V. sativa* the varieties "Williamette", developed in Oregon, and "Warrior", released in Alabama in 1968, give high forage and seed production and for *V. villosa* ssp. *dasycarpa* the varieties "Auburn", "Oregon" and "Lana" have been developed by the experiment stations of Alabama, Oregon and California respectively ; "Lana", the most popular variety, is grown in California and Texas and has been successfully seeded in dryland plantings in Jordan, Syria and N. Iraq (Van der Veen, 1967, Hopkinson, 1975, Kernick, 1976).

In Australia commercial varieties have been developed for *V. atropurpurea*, *V. sativa* and *V. villosa* ssp. *dasycarpa* from original collections made in the Mediterranean region.

Le Houérou (1965) and Le Houérou and Froment (1969) record that the most productive and suitable varieties of *V. sativa* in dryland cultivation in Algeria and Tunisia have proved to be "Languedoc 225" and "159", "Kabylie 130", "Bulgaria 836" and "Roumania 3-226-1" and 3-232-111".

Cereal and vetch varieties in mixture :

Laumont (1959) has cited the following varietal mixtures for *V. sativa*, *V. atropurpurea*, *V. villosa* ssp. *dasycarpa* and *V. fulgens* grown in combination with *Avena sativa*, *Hordeum vulgare* or *Secale cereale* depending on whether they are early, medium or late maturing varieties :

<u>Maturity phase</u>	<u>Vetch</u> (Variety)	<u>Cereal</u> (Variety)
Very early	<i>V. sativa</i> (Languedoc 225)	{ <i>A. sativa</i> (Cowra 1917) <i>H. vulgare</i> (M 38) <i>S. cereale</i> (244)
Early	<i>V. sativa</i> (Languedoc 159)	{ <i>A. sativa</i> (Cowra 977) <i>H. vulgare</i> (Saida 183)
Medium late	<i>V. sativa</i> (Kabylie 130 Bulgaria 837)	{ <i>A. sativa</i> (Cowra 977 Bouteille 1163) <i>H. vulgare</i> (Mahouna 3445)
Late	<i>V. sativa</i> (Roumania 3-226-II-2 Roumania 3-232-III)	{ <i>A. bysantina</i> (8, 31 or 61) <i>A. sativa</i> (912) <i>H. vulgare</i> (Bordier)
Very late	<i>V. atropurpurea</i> (178) <i>V. villosa</i> ssp. <i>dasycarpa</i> (294) <i>V. fulgens</i> (202)	{ <i>A. sativa</i> (912) }

Le Houérou (1965) and Le Houérou and Froment (1969) record that there is a difference of 20 days in the time of heading between the early and late maturing above mentioned varieties of *Vicia* spp.

In the Mediterranean region varieties of *H. vulgare* have been selected which mature later than the local varieties. These varieties have longer straw and are leafier than the shorter strawed local varieties and more suited to growing in mixture with *Vicia* spp., especially to support the climbing types.

In Cyprus the best fodder varieties of *H. vulgare* has proved to be "Athenais", "48 Alger" and "628" ; "48 Alger" matures about 10 days later than "Athenais" the check variety (Hadjichristodoulou, 1974).

In Libya for *H. vulgare* the larger strawed varieties "Club Mariout", "Atlas" and "Jordan 6 row" have also been found to produce more fodder under dryland conditions than the short strawed types such as "California Mariout", "Esperance" and "Beladi 16" (Oran, 1959).

In Libya under dryland conditions the varieties "Dale", "Ballido", "Albinia" and "Nemaha" have proved to be the best and most productive fodder varieties of *A. sativa*, while "Palestine" was the most productive fodder variety of *A. byzantina* (Soghaier, 1961).

In N. Iraq a Canadian variety of *A. sativa* has proved a superior fodder producer alone and in mixture with *V. sativa*, *V. villosa* ssp. *dasycarpa* and *V. narbonensis* (Kernick, 1976).

In Cyprus the most productive dryland fodder varieties of *A. sativa* have proved to be "Sierra" and "Montezuma" which have given higher fodder production than the *A. byzantina* variety "Palestine"; the variety "Sierra" matures about 10-12 days later than the other two varieties (Hadjichristodoulou, 1974).

In general the late maturing varieties of *A. sativa* and *A. byzantina* have proved most suitable for grazing in mixture with *Vicia* spp.

23.6. Number of Chromosomes

- V. atropurpurea* : $2x = 14$;
- V. ervilia* : $2x = 14$;
- V. fulgens* : not known ;
- V. monantha* : $2x = 14$;
- V. narbonensis* : $2x = 14$;
- V. sativa* : $2x = 12$;
- V. sativa* subsp. *amphicarpa* : not known ;
- V. villosa* : $2x = 14$;
- V. villosa* subsp. *dasycarpa* : $2x = 14$.

23.7. Geographical Distribution

V. atropurpurea originates in the Mediterranean basin and is distributed in North Africa (Morocco, Algeria and Tunisia) ;

V. ervilia is distributed (Fig. 11) in Mediterranean Europe (Spain to Greece) and in Crete, Cyprus, Syria, Lebanon, Palestine, Jordan, Egypt (UAR) (N.W. littoral), Turkey, Iraq, Iran, Transcaucasia, Afghanistan, Macaronesia (Canary Isles) ;

V. fulgens is distributed in N. Africa (Algeria, Morocco) ;

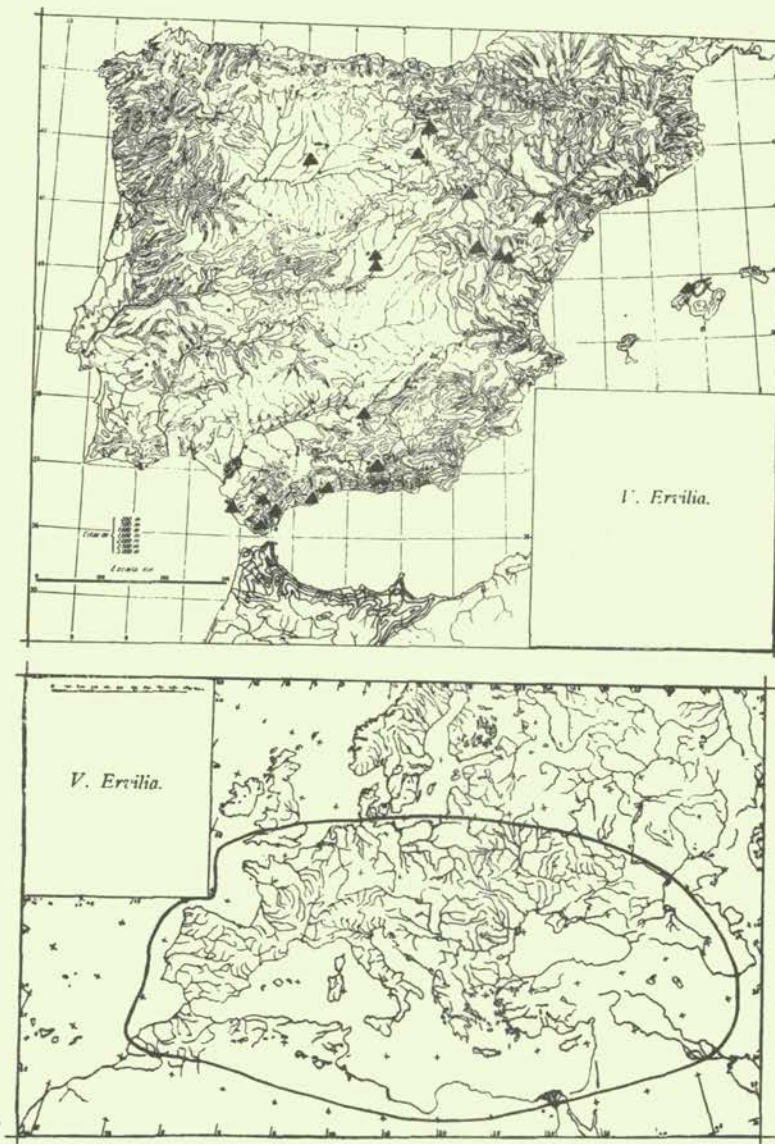


Fig. 11 - Distribution map of *Vicia ervilia*
(After Estudio Botanico de las Vezas Y Arvejas Espanolas,
1953)

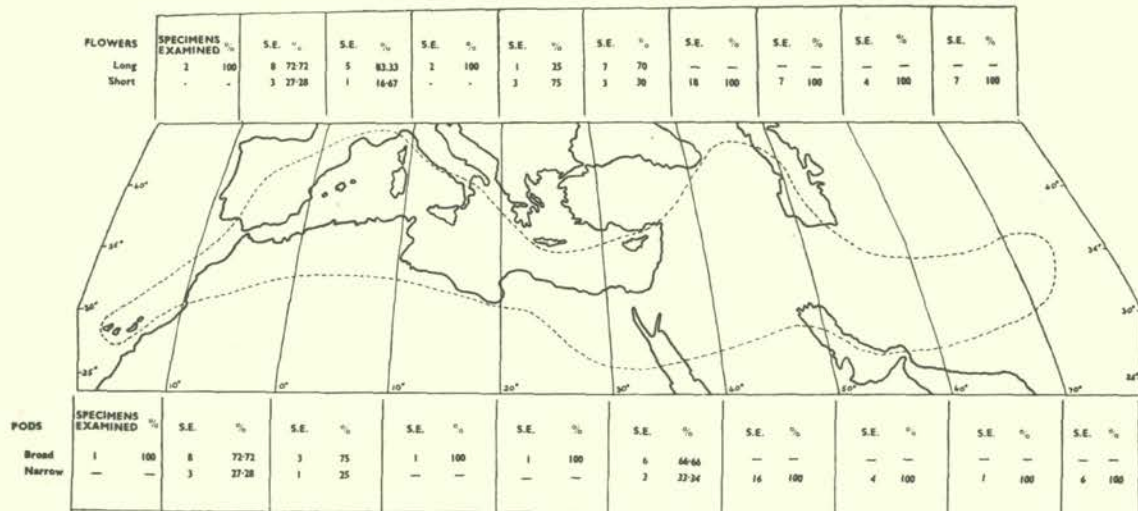


Fig. 12

Range of *Vicia monantha* Retz. and longitudinal distribution of variation in terms of flower length and pod width

(After Kew Bulletin No. 1, 1949, p. 498, fig. 1)

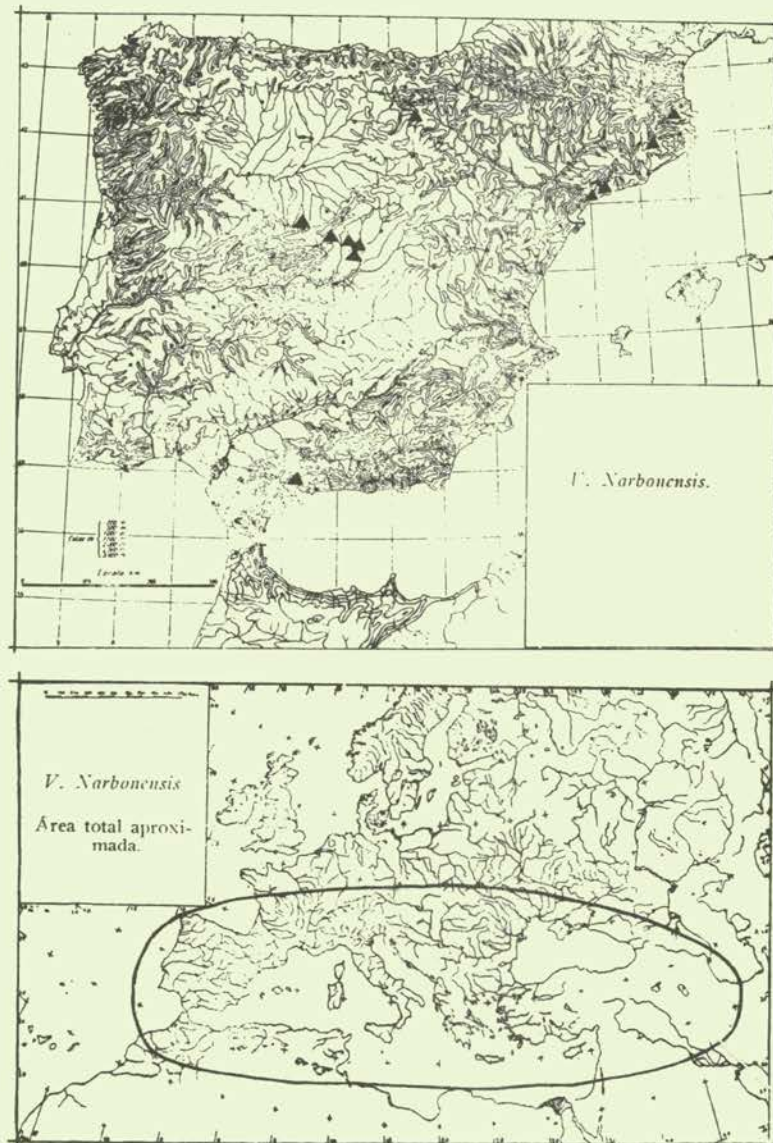


Fig. 13

Distribution map of *Vicia narbonensis*
(After Estudios Botanico de las Vezas Y Arvejas Espanolas,
1953)



Fig. 14

Distribution map of *Vicia pannonica*

(After Estudio Botanico de las Vezas Y Arvejas Espanolas,
1953)



Fig. 15

Distribution map of *Vicia peregrina*

(After Estudio Botanico de las Vezas Y Arvejas Espanolas,
1953)

V. monantha is distributed (Fig. 12) in W. and S. Europe (Spain to Greece) and in Cyprus, Syria, Lebanon, Palestine, Jordan, Egypt (UAR), Arabia, Kuwait, Bahrain, Turkey, Caucasus, Iraq, Iran, Pakistan, Afghanistan, C. Asia (Turkemenia to Pamir-Alai) ;

V. narbonensis is distributed (Fig. 13) in C. and S. Europe (Spain to the Crimea) and in Cyprus, Syria, Lebanon, Palestine, Jordan, Sinai, Egypt (UAR), Turkey, Caucasus, Iraq, Iran, N.W. India, C. Asia (Turkemenia to Tian Shan), N. Africa (Morocco, Algeria, Tunisia, Libya) ;

V. pannonica is distributed (Fig. 14) in S., C. and E. Europe, N.W. Africa, Cyprus, Lebanon, Turkey, Caucasus and Iran ;

V. peregrina is distributed (Fig. 15) in Mediterranean Europe (from Spain to S. USSR) and in Crete, Aegean Isles, Rhodes, Cyprus, Syria, Lebanon, Palestine, Jordan, Sinai, Egypt (N.W. littoral), Turkey, Caucasus, Iran, Afghanistan, Pakistan, C. Asia (Turkemenia to Tian Shan), N. Africa (Morocco, Algeria, Libya) ;

V. sativa is distributed in Europe, Crete, Aegean Isles, Cyprus, Syria, Lebanon, Palestine, Jordan, Sinai, Egypt, Arabia, Turkey, Caucasus, Iran, Pakistan, Afghanistan, India, Java, Siberia to Kamchatka, China, Japan, C. Asia (Turkemenia to Tian Shan), N. Africa (Morocco to Libya) ;

V. sativa subsp. *amphicarpa* is distributed in S. Europe, Crete, Palestine, Egypt (UAR), Turkey, Caucasus, N. Africa (Morocco to Libya) and Macaronesia ;

V. villosa is distributed in C., S. and E. Europe, Aegean Isles, Cyprus, Syria, Lebanon, Palestine, Turkey, Caucasus, Iraq, Iran, Afghanistan, C. Asia (Kara Kum and Syr Darya), and N. Africa (Morocco, Algeria, Tunisia, Libya, Egypt (UAR) ;

V. villosa subsp. *dasycarpa* is distributed in S. Europe (Sicily, Greece, Aegean Isles), Turkey, Cyprus, Egypt (UAR), Iraq and Iran.

23.8. Biology and Ecology

V. atropurpurea, *V. ervilia*, *V. fulgens*, *V. monantha*, *V. narbonensi*, *V. pannonica*, *V. peregrina*, *V. villosa*, *V. villosa* ssp. *dasycarpa*, *V. sativa* and *V. sativa* ssp. *amphicarpa* are all cool season species propagating themselves by seed and are commonly self-pollinated except for *V. atropurpurea* and *V. villosa* which are cross-pollinated.

Adaptability and cold tolerance :

Villax (1963) considers that both *V. villosa* and *V. villosa* ssp. *dasycarpa* are better adapted to cultivation in the mountains of North Africa where their later growth cycle and greater cold tolerance make them more suited to the prevailing climate conditions than *V. sativa* which is much more sensitiv

to damage from cold and freezing temperatures. Villax (1963) also records that *V. villosa* can suffer from shortage of soil moisture in the spring although it is not as vulnerable as *V. atropurpurea* which can disappear completely if the weather is very dry at the end of the winter or beginning of the spring.

V. ervilia is mentioned by Villax (1963) as being the most resistant of the *Vicia* spp. to cold and freezing temperatures and also to dry periods which do not markedly affect its growth cycle.

Foury (1954) also mentions that autumn seeded *V. pannonica* is as resistant to cold as *V. villosa* and shows greater cold tolerance than *V. sativa* in Morocco, while Heath et al. (1973) report that *V. atropurpurea* is the least winter hardy of the cultivated *Vicia* spp. in the USA.

In the mountains of N. Iraq Van der Veen (1959) reports that both *V. ervilia* and *V. narbonensis* are well adapted to the cold temperatures and produce early vegetative growth when seeded in the autumn. In addition *V. narbonensis* also shows strong resistance to bird damage in the early stages of growth and it appears to be one of the most resistant of the *Vicia* spp. in this respect.

Growth and development :

In N. Africa growth of seeded *Vicia* spp. starts after the first autumn rains, but Foury (1954) reports that *V. villosa* ssp. *dasycarpa* has a long dormant winter phase in Morocco which puts it at a disadvantage with competing weeds in the littoral zone with mild winters ; it also shows poor re-growth after cutting and has proved to be the latest maturing of all the *Vicia* spp. tested in dryland plantings at Rabat.

Growth of *Vicia* spp. is generally excellent in the spring, especially for autumn seedings of *V. atropurpurea*, *V. villosa*, *V. villosa* ssp. *dasycarpa*, *V. ervilia*, which can develop later particularly in the mountains of North Africa and the Near and Middle East.

In the steppe zone (300-400 mm annual rainfall) of Jordan, Syria and N. Iraq autumn (November) seeded plants of *V. ervilia*, *V. narbonensis*, *V. sativa*, *V. villosa* and *V. villosa* ssp. *dasycarpa* make their main vegetative growth in March-April. Flowering generally occurs in early May and seed production is normally completed by mid to end June.

Laumont (1959) points out that a general drawback of *Vicia* spp., except for *V. narbonensis* and *V. faba*, is that they produce numerous weak straggling or prostrate stems, which make their forage and seed difficult to harvest unless they are seeded with a supporting crop such as a cereal or grass.

In Jordan Hopkinson (1975) reports that *V. villosa* ssp. *dasycarpa* seeded alone could be harvested fairly easily in dryland plantings, but other shorter, less erect species such as *V. ervilia* and *V. sativa* proved difficult to harvest cleanly.

In N. Iraq Kernick (1976) reports that the foliage of *V. narbonensis* tends to dry up quickly in the spring turning brown and shedding its leaves unlike *V. villosa*, *V. villosa* ssp. *dasycarpa* and *V. sativa* which remained green right up to the formation of seeds.

With the onset of the dry hot summer period growth of *Vicia* spp. ceases in the littoral and interior steppe zones of North Africa and the Near and Middle East, but may continue a little longer in the mountains depending on the elevation, temperature and moisture conditions.

Susceptibility to fungus diseases :

In North Africa Villax (1963) records that *V. sativa*, especially, can be severely attacked by fungus diseases such as anthracnose and oidium which diminishes its yield considerably. The prevalence of fungal diseases attacking *Vicia* spp. has not in general been reported from the interior region of the Near and Middle East where the atmospheric humidity is generally much lower.

Seed characteristics :

In Algeria Laumont (1959) points out that the germination of the seeds of some *Vicia* spp. can be capricious under dryland planting conditions depending on the moisture conditions at the time of sowing.

Foury (1954) reports that the seeds of *V. monantha* and *V. villosa* in Morocco exhibit irregular and often poor germination. *V. monantha* in culture has given only 5-6 percent germination with 2-3 percent germination after the winter. Foury (1954) also mentions that *V. villosa* ssp. *dasycarpa* produces few seeds in dryland culture in North Africa.

V. villosa also exhibits poor or difficult germination according to Foury (1954), who states that this is caused by lack of seed coat permeability. The degree of permeability appears to be associated with differences in coloration when the seed changes from green to chestnut to black. The seeds are capable of germinating more readily when they come into contact with a ready supply of moisture.

The percentage of hard seeds varies considerably depending on the locality from which the selection originates ("Provenance") and on the moisture holding capacity of the soil. High humidity which favours a strong vegetative growth also increases the percentage of hard seeds. *V. villosa* generally has a higher percentage of hard seeds than *V. sativa*.

In N. Iraq Radwan et al. (1974) report that light scarification for 3 minutes or treatment with sulphuric acid of the seeds of native *Vicia* spp. (*V. calcarata*, *V. sativa* and *V. villosa*) increased the mean seed germination to 92 % compared to only 14.2 % for unscarified seeds. In Algeria Laumont (1959) also recommends immersion of hard seeds of *Vicia* spp. in a weak solution of sulphuric acid for 20-25 minutes to improve their germination capacity.

Climate and soils :

In general the above mentioned *Vicia* spp. are well adapted to dryland cultivation in the littoral interior steppe and mountain regions of North Africa, the Near and Middle East with 300-500 mm annual rainfall.

In Morocco Ionesco et al. (1969) consider that more than 400 mm annual rainfall is required for *V. sativa* with a mean winter temperature superior to 0°C.

In Algeria Laumont (1954) considers that the cultivation of *Vicia* spp. can be accomplished without great risk in regions where the annual rainfall is superior to 500 mm ; in the semi-arid regions (300-500 mm annual rainfall) the dryland culture of *Vicia* spp. is more dependent on the variations of rainfall from year to year, but this factor can be partly compensated for by proper attention to working the soil correctly.

In regard to edaphic conditions the following represents the preferences of specific *Vicia* spp. :

V. sativa prefers calcareous clay soils with good fertility and does not do well on sandy soils ;

V. villosa and *V. villosa* ssp. *dasycarpa* are both adapted to a wide range of soils, but prefer those that are sandy, and in dry conditions the soil should contain enough humus to retain sufficient moisture for the growth of *V. villosa* ; *V. villosa* has also supported some salinity in the soil in Morocco when lightly flooded for a short period ;

V. monantha has proved adapted to poor, thin, calcareous soils in N. Africa ;

V. narbonensis has proved well adapted to poor, dry, siliceous soils in France, and does well on light calcareous soils in Syria as long as they are not too dry or humid ;

V. atropurpurea is adapted to a wide range of soils, but prefers heavy fertile soils that retain moisture ;

V. ervilia is adapted to a wide range of soils.

Ecological characteristics :

Ecologically *Vicia* spp. occur spontaneously in humid and dry places in the littoral, steppe and mountain regions of N. Africa and the Near and Middle East.

In Tunisia Le Houerou (1969) records *V. monantha* ssp. *cinerea* in the steppe in arid areas with less than 100 mm annual rainfall.

In Egypt Tackholm (1974) records *V. narbonensis* and *V. monantha* as a weed in cultivated fields in the Nile Libyan Oasis, Mediterranean coastal region and in the Isthmic desert, while *V. sativa* and *V. ervilia* are also recorded in the western Mediterranean region.

In Lebanon Mousterde (1966) records *V. sativa* and *V. narbonensis* as occurring in grassy places and in forest areas, while *V. ervilia*, *V. villosa* and *V. villosa* ssp. *dasycarpa* are found on abandoned and cultivated fields ; all these species are recorded as flowering between March and May.

In Jordan Kasapligil (1956) records *V. monantha* as occurring in the Kerak district as a weed on sandy places at about 350 m elevation, while *V. narbonensis* is recorded in the Jordan Valley as a weed in fields at about 200 m elevation, and *V. sativa* is recorded at Irbid Ajlun and Soos Ummul Melebiye at an elevation of 900 m in *Quercus infectoria* forest on terra rossa soil.

In Iraq Townsend and Guest (1974) records *V. monantha* on eroded hills, rolling plains, valleys and wadis on sandy clay and loam often in segetal or ruderal habitats up to 600 m elevation ; *V. ervilia* on mountain slopes on limestone in coppiced oak and fields at an elevation of 800-1,100 m (flowering and fruiting April-June) ; *V. sativa* on mountain sides and upland steppe, desert wadis, depressions and often as a weed in fields up to 1,300 m elevation (flowering and fruiting March-May) ; *V. villosa* on grassy mountain slopes from 1,050-2,200 m elevation (flowering and fruiting July-October).

In Turkey Davis (1969) records *V. villosa* as occurring in *Quercus* forests and on the edges of fields from sea level up to 1,900 m elevation ; *V. sativa* on rocky, calcareous hillsides, in corn and fallow fields and waste places from sea level up to 1,600 m elevation ; *V. pannonica* on cultivated and fallow fields and roadsides from sea level up to 1,300 m elevation, and *V. peregrina* in *Quercus* scrub, phygana , rocky limestone slopes, corn and fallow fields from sea level up to 1,400 m elevation.

23.9. Cultivation Techniques

Time of seeding :

In North Africa and the Near East it is generally recommended to seed *Vicia* spp. after the first autumn rains. In Algeria Laumont (1950) recommends early seeding before 15 September for dryland *V. sativa* to ensure early establishment of the plants permitting flowering and seed production to occur before the onset of high summer temperatures at the end of June.

Later maturing *Vicia* spp. such as *V. villosa*, *V. villosa* ssp. *dasycarpa* and *V. ervilia* can be seeded later in October-November.

Land preparation :

The preparation of the seed-bed is important for *Vicia* spp. A well prepared, firm and weed-free seed-bed is required ; eradication of competing weeds is particularly important, and the best results according to Laumont (1959) are obtained if the same procedure is followed as preparing the seed-bed for dryland cereal crops, which is a stubble ploughing (15-20 cm) in the early autumn followed by a discing, harrowing and then rolling.

Intercultivation with a supporting crop :

Vicia spp. are normally seeded with a supporting crop such as *A. sativa* (Fig. 16), *H. vulgare* or *Triticum vulgare* which are particularly useful for climbing forms of *Vicia* spp. with tendrils such as *V. ervilia* and *V. villosa* ssp. *dasycarpa*.



Fig. 16 - Mixture of *Vicia sativa* and *Avena sativa* (Rabat, 1961)
(After la Culture des plantes fourragères dans la région Méditerranéenne
occidentale, 1963, p. 519, fig. 150)

In Syria and N. Iraq experimental mixtures of *Vicia* spp. with *Lolium multiflorum* or *L. rigidum* have also been tested under dryland conditions (Van der Veen, 1967, Kernick, 1976).

Seed rates and methods of seeding for cereal-vetch mixtures :

For mixtures the seed rates, drill spacings and methods of planting used vary from country but the following have been reported :

<u>Tunisia</u>	<i>V. sativa</i>	40 kg/ha of seeds	}	in drills spaced 15-30 cm apart
	+			
	<i>A. sativa</i> or <i>H. vulgare</i>	40 kg/ha of seeds		
<u>Morocco</u>	<i>V. sativa</i>	60 kg/ha of seeds	}	in drills spaced 15-20 cm or 20-40 cm apart or broadcast
	+			
	<i>A. sativa</i> or <i>H. vulgare</i>	25 kg/ha of seeds		
<u>Algeria</u>	<i>V. sativa</i>	30-40 kg/ha of seeds	}	broadcast
	+			
	<i>A. sativa</i>	60-70 kg/ha of seeds		
<u>Libya</u>	<i>A. sativa</i>	60 kg/ha of seeds	}	broadcast
	+			
	<i>A. byzantina</i>	40 kg/ha of seeds		
<u>Cyprus</u>	<i>V. sativa</i>	60 kg/ha of seeds	}	broadcast
	or			
	<i>V. villosa</i> ssp. <i>dasycarpa</i>	60 kg/ha of seeds		
	+			
	<i>A. sativa</i> or <i>H. vulgare</i>	40 kg/ha of seeds		
<u>Syria</u>	<i>V. sativa</i>	30 kg/ha of seeds	}	broadcast
	or			
	<i>V. narbonensis</i>	50 kg/ha of seeds		
	or			
	<i>V. villosa</i> ssp. <i>dasycarpa</i>	60 kg/ha of seeds		
	+			
<u>Iraq</u>	<i>A. sativa</i> or <i>H. vulgare</i>	30 kg/ha of seeds	}	Cross drilling : <i>A. sativa</i> in one direction, <i>Vicia</i> spp. in the other direction
	<i>V. sativa</i>	60 kg/ha of seeds		
	or			
	<i>V. villosa</i> ssp. <i>dasycarpa</i>	60 kg/ha of seeds	}	
	or			
	<i>V. narbonensis</i>	50 kg/ha of seeds		
	+			
	<i>A. sativa</i>	75 kg/ha of seeds		

In some countries the amount of seed of *A. sativa* and *H. vulgare* is reduced in order to obtain a better balanced mixture since the vigorous growth of the cereals can often reduce the forage contribution of the vetch in the mixture. For instance in Morocco Foury (1954) has recommended a seed rate of 100-150 kg/ha of *V. atropurpurea*, *V. narbonensis* or *V. sativa* in mixture with only 25-50 kg/ha of *A. sativa*, *H. vulgare* or *S. cereale*.

Particularly with *H. vulgare* and also to a considerable extent with *A. sativa* and *A. byzantina* a well balanced mixture is difficult to obtain and the *Vicia* species in the mixture rarely produces more than 20-30 percent of the total forage yield. However in N. Iraq Kernick (1976) reports that in a cross-drilled mixture of *V. villosa* ssp. *dasycarpa* and *A. sativa* 50 percent of the total forage yield was provided by the vetch.

In Algeria Laumont (1959) also reports variations in the seed rates of mixtures depending on the type of utilization envisaged. If the forage is to be fed green or conserved as hay a seed rate of 60-80 kg/ha for *V. sativa* and 60 kg/ha for *A. sativa* is recommended with a seed rate of 40-60 kg/ha for *V. sativa* and 60 kg/ha for *A. sativa* being recommended if the mixture is to be ensiled.

Seed rates and methods of seeding for vetches :

In Morocco Foury (1954) and Villax (1963) recommend a seed rate of 50-120 kg/ha for dryland *V. ervilia* seeded in lines spaced 30-50 cm apart or broadcast. Villax (1963) also recommends the following for other *Vicia* spp. in Morocco :

<i>V. monantha</i> :	60-100 kg/ha of seeds broadcast or drilled in lines spaced 30-40 cm apart
<i>V. narbonensis</i> :	80-140 kg/ha of seeds broadcast
<i>V. pannonica</i> :	80-130 kg/ha of seeds drilled in lines spaced 20-40 cm apart
<i>V. villosa</i> :	80-130 kg/ha of seeds drilled in lines spaced 20-40 cm apart
<i>V. sativa</i> :	90-140 kg/ha of seeds drilled in lines spaced 20-40 cm apart

In N. Iraq Kernick (1976) reports that optimum seed rates in dryland plantings in the moist steppe zone (300-400 mm annual rainfall) were 60 kg/ha for *V. villosa*, *V. villosa* ssp. *dasycarpa* and *V. sativa*, and 90 kg/ha for *V. narbonensis*.

In Cyprus in semi-arid areas with 300-400 mm annual rainfall Hadjichristodoulou (1974) reports that optimum seed rates for *V. sativa* and *V. villosa* ssp. *dasycarpa* were 100-130 kg/ha.

Fertilizer application :

In regard to fertilizer application the following has been reported as being used in practice in various countries for dryland cereal-vetch mixtures :

Tunisia For a mixture of *A. sativa* and *V. sativa*
45 kg/ha P_2O_5 before planting
20 kg/ha N^2 at planting
20 kg/ha at the end of winter ;

Morocco For a mixture of *H. vulgare* and *Vicia* spp.

- (a) with less than 400 mm annual rainfall :
20-40 kg/ha P_2O_5 and
20-40 kg/ha K_2O mixed with the soil before sowing,
minimal quantities of N applied ;
- (b) with more than 400 mm annual rainfall :
40-60 kg/ha P_2O_5 and
40 kg/ha K_2O mixed with the soil before sowing,
minimal quantities of N applied ;

For a mixture of *A. sativa* and *V. sativa*
20-40 kg/ha N (three weeks before sowing) and
40-60 kg/ha P_2O_5 and
40-60 kg/ha K_2O mixed with the soil before sowing ;

Syria For mixture of *A. sativa* and *Vicia* spp.
60 kg/ha P_2O_5 ;

Iraq For mixture of *A. sativa* and *Vicia* spp.
60 kg/ha P_2O_5 before planting
nil N application.

Kernick (1976) also reports substantial yield increases for dryland *V. villosa* ssp. *dasycarpa* when the application of phosphorous fertilizer has been increased from 60 kg/ha up to 120 kg/ha P_2O_5 on dry calcareous soils with a low phosphorous content (6-8 ppm) in N. Iraq (moist steppe zone 300-400 mm annual rainfall).

In Syria Van der Veen (1967) also records substantial yield increases for dryland seedings of *V. atropurpurea*, *V. narbonensis*, *V. villosa*, *V. villosa* ssp. *dasycarpa* and *V. sativa* in the steppe region (400 mm annual rainfall) with an application of 60 kg/ha P_2O_5 compared to a nil application.

23.10. Forage Value

Palatability :

All the *Vicia* spp. are very palatable to livestock and the seeds and pods are particularly relished. *V. ervilia* in North Africa is reported by Villax (1963) and Foury (1954) to be especially cultivated for its seeds which are fed to cattle, especially draft animals.

Seed toxicity :

Foury (1954) states that the grain of *V. ervilia* is about twice as nutritive as cereal grains but overfeeding of *V. ervilia* grain can cause a type of intoxication in animals, which can be very serious in some cases if too much is fed over a long period ; not more than 10-15 % should be incorporated in the feed ration and it should not be fed constantly.

Nutritive value of vetches :

The nutritive value of *Vicia* spp. is in general good as the following data recorded in Morocco by Villax (1963) indicates :

Percentage Chemical Composition						
Species	Nature of Product	Water	Protein	Fats	Carbohydrates Soluble Fibre	Ash
<i>V. atropurpurea</i> origin CRA Rabat (Morocco)	Green	80	4	0.5	7.5 6	1
<i>V. ervilia</i> origin Elvas (Portugal)	Green	80	5	1	7 5	2
	Hay	16	10	2	34 30	8
	Seed	13	21	2	55 6	3
<i>V. monantha</i> origin CRA Rabat (Morocco)	Green	80	3	0.5	9 6	1.5
<i>V. sativa</i> origin Hungary	Green	80	4	0.5	5.5 8	2
	Hay	16	20	2	36 19	7
	Seed	13	25	2	50 7	3
<i>V. villosa</i> origin Hungary	Green	80	5	0.5	6.5 6.5	1.5
	Hay	16	23	2	2.5 26	8
	Straw	14	7	1	33 41	4
	Seed	13	24	2	51 7	3

Foury (1954) also records the following nutritive data for several *Vicia* spp. in Morocco :

Percentage Chemical Composition							
Species	Date Sampled	Water	Protein	Fats	Non-N Extract	Cellulose	Ash
<i>V. atropurpurea</i> origin CRA Rabat (Morocco)	27.5.49						
A	green matter	59.00	4.71	0.44	19.50	13.81	2.54
	dry matter	0	11.50	1.09	47.50	33.71	6.20
B	green matter	71.00	5.48	0.48	12.06	8.98	2.00
	dry matter	0	18.90	1.66	41.26	30.98	7.20
<i>V. monantha</i>	23.5.49						
	green matter	72.00	4.17	0.75	12.40	8.33	2.35
	dry matter	0	14.95	2.68	44.27	29.70	8.40

In N. Iraq Kernick (1976) reports crude protein contents ranging from 14 to 16 percent for dryland *V. villosa* ssp. *dasycarpa* with pods and seeds present in May while Hadjichristodoulou (1974) reports the following crude protein contents for dryland *V. sativa* and *V. villosa* ssp. *dasycarpa* in Cyprus :

Stage of cutting	Crude Protein in dry matter basis %
<i>V. sativa</i>	
Beginning of flowering	24.6
Pod formation	22.0
Full pod formation	20.1
<i>V. villosa</i> ssp. <i>dasycarpa</i>	
Pre-flowering	25.6
Beginning of flowering	23.8
Pod formation	22.9

Nutritive value of cereal-vetch mixtures :

In Morocco Ionesco et al. (1969) record a forage value for a dryland mixture of *V. sativa* and *A. sativa* of 0.09-0.10 forage units per kg fresh forage in the green state, and from 0.30-0.35, 85 % dry matter, and 60 g of digestible protein per kg fresh forage for hay.

The following nutritive and digestibility data have also been recorded by Theriez et al. (1966) in Tunisia for hay harvested from a dryland mixture of *V. sativa* and *A. sativa* containing different proportions of vetch :

% Chemical Composition on a dry matter basis				
Hay Type	Dry Matter %	Ash	Protein	Crude Fibre
A	80.8 (78.0-86.5) ^{1/}	9.9 (5.5-13.4)	15.0 (11.0-20.0)	29.7 (26.8-32.0)
B	81.8 (69.1-87.7)	10.6 (5.5-17.0)	10.4 (6.4-16.3)	28.0 (20.4-34.7)
C	86.4 (77.8-91.3)	8.2 (6.7-9.3)	5.2 (2.0-7.0)	37.4 (35.1-39.0)
% Digestibility				
	Organic matter	Protein	Crude Fibre	
A	66.7 (61.0-73.4)	69.2 (11.0-73.4)	63.0 (51.8-70.4)	
B	66.5 (58.1-73.9)	58.5 (40.3-72.8)	63.9 (58.6-76.7)	
C	56.4 (56.5-64.9)	35.4 (20.0-44.5)	56.2 (47.7-62.0)	
A : harvested early with high (1) content of vetch B : harvested early with poor content of vetch C : harvested late (2) with poor content of vetch (1) the proportion of vetch is always equal or superior to 45% (2) cut when the oats is in the soft dough ^{1/} Figures without brackets are average, within brackets extremes				

Content of digestible protein			
Hay Type	Digestible Protein % Dry matter	Digestible Protein % Organic matter	Digestible Protein % hay
cut early high content of vetch	10.4 (6.7-13.8)	11.5 (7.0-15.3)	8.2 (5.3-10.7)
cut early poor content of vetch	6.2 (5.7-11.8)	6.9 (4.2-14.1)	4.9 (3.1-10.1)
cut late poor content of vetch	2.2 (0-4.4)	2.3 (0-4.7)	1.9 (0-4.4)
figures without brackets are average, within brackets extremes			

Net Energy Value			
Hay Type	Forage Units/kg dry matter	Forage Units/kg Organic matter	Forage Units/kg hay
cut early high content of vetch	0.64 (0.56-0.74)	0.71 (0.64-0.85)	0.52 (0.49-0.62)
cut early poor content of vetch	60.63 (0.45-0.76)	0.70 (0.52-0.91)	0.51 (0.38-0.66)
cut late poor content of vetch	0.45 (0.34-0.61)	0.55 (0.41-0.66)	0.39 (0.30-0.47)
figures without brackets are average, within brackets extremes			

Average total nutritive value per 100 kg green weight when fed to livestock					
Hay Type	Energy value/ kg dry matter	Digestible protein content	Quantity consumed per 100 kg green weight	Forage Units in the ration	Quantity of digestible protein
cut early high content of vetch	0.64	104 g	2990 g dry matter	1.46	238 g
cut early poor content of vetch	0.63	62 g	2060 g dry matter	1.30	127 g
cut late poor content of vetch	0.45	22 g	1440 g dry matter	0.64	31 g

Thierez (1968) also gives the following average mineral composition data for a mixture of *V. sativa* and *A. sativa* in Tunisia :

Grains per kilo dry matter			
Phosphorous	Calcium	Magnesium	Potassium
1.7	4.8-12.6	1.7	18.9

23.11. Forage and Seed Production

Forage yields of cereal-vetch mixtures :

The following experimental forage yields have been reported in various countries for cereal-vetch mixtures under dryland conditions :

Algeria

littoral zone : *V. sativa* { - 15,000-60,000 kg/ha green forage
400-600 mm +
annual rainfall *A. sativa* { - 3,500-15,000 kg/ha hay
(Le Houérou & Froment, 1969,
1973; Laumont, 1959)

high plateaux zone : *V. sativa* {
seasonal rainfall +
(Sept-April) 381 mm *A. sativa* { - 3,000-4,000 kg/ha hay
1 year or
H. vulgare {
(Maignan, 1970)

steppic zone : *V. sativa* { - 20,400 - 26,500 kg/ha green forage
seasonal rainfall +
(Sept-May) 364 mm *A. sativa* { (nil (50 kg/ha P_2O_5)
fertilizer) (50 kg/ha K_2O)
(1st year) (30 kg/ha N)

seasonal rainfall *V. sativa* {
(Sept-May) 164 mm +
(2nd year) *A. sativa* { - 600-1,000 kg/ha green forage
(Delhay et al.,
1974)

Tunisia

littoral zone : *V. sativa* { -15,000-60,000 kg/ha green forage
400-600 mm +
annual rainfall *A. sativa* { - 3,500-15,000 kg/ha hay

littoral zone (Tunis) : *V. sativa* { -25,000-47,300 kg/ha green forage
400-600 mm +
annual rainfall *A. sativa* { - 5,000-12,000 kg/ha hay
(Gachet and
Jaritz, 1972)

Morocco

average seasonal rainfall (Sept-May) 400 mm	<i>V. sativa</i> + <i>A. sativa</i>	{ - 15,000-25,000 kg/ha green forage - 4,000- 7,000 kg/ha hay - 3,000- 4,000 forage units/ha
more than 500 mm	<i>V. sativa</i> + <i>A. sativa</i>	{ - 25,000-40,000 kg/ha green forage - 8,000-12,000 kg/ha hay - 5,000- 7,000 forage units/ha

(Ionesco et al., 1969)

Cyprus

steppic zone : 400 mm annual rainfall 4 year period	<i>V. sativa</i> or <i>V. villosa</i> ssp. <i>dasycarpa</i> + <i>H. vulgare</i>	{ - 7,480 kg/ha DM - 4720 kg/ha TDN - 930 kg/ha Protein
---	--	--

(varieties Athenais and 48 Alger)
(Hadjichristodoulou, 1974)

Syria

steppic zone : seasonal rainfall 658 mm (1 year)	<i>V. sativa</i> + <i>H. vulgare</i>	{ - 37,500 kg/ha green forage
	<i>V. villosa</i> <i>dasycarpa</i> + <i>H. vulgare</i>	{ - 38,000 kg/ha green forage

Iraq

moist steppe zone : seasonal rainfall (Nov-May) 327 mm (only 20 mm in March) (1st year)	<i>V. narbonensis</i> + <i>H. vulgare</i>	{ - 5,200 kg/ha green forage
475 mm well distributed (2nd year)	<i>V. villosa</i> ssp. <i>dasycarpa</i> (variety Lana)	{ - 16,200 kg/ha green forage (60 kg/ha P_2O_5) - 5,900 kg/ha hay (60 kg/ha P_2O_5) - 19,900 kg/ha green forage (60 kg/ha P_2O_5 , 42 kg/ha N) - 7,100 kg/ha hay (60 kg/ha P_2O_5 , 42 kg/ha N)

(Kernick, 1976)

Rainfall distribution and forage yield :

In Tunisia adequate rainfall in January and at seeding in September-October has been shown (Gachet and Jaritz, 1972) to be necessary for obtaining high forage yields of cereal-vetch mixtures, while in Iraq low rainfall in March has seriously depressed cereal-vetch forage yields (Kernick, 1976).

Forage yields of vetches :

The following experimental forage yields have been reported in various countries for different *Vicia* spp. seeded alone under dryland conditions :

Morocco

littoral zone : 400-600 mm annual rainfall	<i>V. villosa</i> (Villax, 1963)	- 25,000-30,000 kg/ha green forage - 5,000- 7,000 kg/ha hay
	<i>V. sativa</i> (Villax, 1963)	- 16,000-18,000 kg/ha green forage - 4,000- 7,000 kg/ga hay
	<i>V. ervilia</i> (Foury, 1954)	- 8,000-12,000 kg/ha green forage

Tunisia

northern interior : 600-650 mm annual rainfall	<i>V. sativa</i> (one season)	- 52,400 kg/ha green forage
	<i>V. villosa</i> ssp. <i>dasycarpa</i> (one season)	- 51,800 kg/ha green forage
	<i>V. atropurpurea</i> (one season) (Bethoux et al., 1973)	- 49,000 kg/ha green forage

Cyprus

300-400 mm annual rainfall	<i>V. villosa</i> ssp. <i>dasycarpa</i> (variety "Lana")	Average for 2 years and 6 locations	
		DM kg/ha	Protein kg/ha
Pre-flowering		2683	687
Beginning of flowering		3415	813
Pod formation		4359	998
Beginning of flowering Pod formation Full pod formation	<i>V. sativa</i> (local variety)		
		2248	553
		2731	601
		3878	779
	(Hadjichristodoulou, 1974)		

Syria

300-400 mm annual
rainfall

V. sativa
("Harastani" cultivar)
V. narbonensis
("Aleppo" cultivar)
V. villosa
V. villosa ssp.
dasycarpa
(variety "Lana")
(Van der Veen, 1967)

Kamishili (1964/65)

60 kg/ha P_2O_5	Nil fertilizer
Green forage	Green forage
6,400	2,200

4,500	1,600
-------	-------

12,800	2,500
--------	-------

16,300	2,400
--------	-------

N. Iraq

moist steppe zone

V. narbonensis
(local cultivar)
V. villosa
(Turkish variety)
V. villosa ssp.
dasycarpa
(variety "Lana")
V. sativa
(Turkish variety)

Rashidia nursery plots
(alluvial soil, 327 mm
annual rainfall)

60 kg/ha P_2O_5 in seed-bed

Green forage kg/ha	Dry matter kg/ha
--------------------------	------------------------

11,000	2,800
--------	-------

17,000	4,300
--------	-------

19,000	3,800
--------	-------

10,000	4,300
--------	-------

Darnajoukh field plots
(calcareous soil, 475 mm
seasonal rainfall)

V. narbonensis

10,000	3,500
--------	-------

V. villosa ssp.
dasycarpa

15,700	6,400
--------	-------

22,700 $\frac{1}{2}$	6,800 $\frac{1}{2}$
----------------------	---------------------

$\frac{1}{2}$ 120 kg/ha P_2O_5 in seed-bed (Kernick, 1976)

Bakrajo field plots

(400-600 annual rainfall)

V. narbonensis

10,000	2,000
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(Al Maiuf, 1966)

In Iran dryland *V. ervilia* is reported to give good hay yields on cereal fallows (Fig. 18) in Khuzistan and around Kamanshah but no yield data are available.



Fig. 18

A field of harvested bitter vetch showing good forage yield.
(Borujerd, Iran, June 1969)

(After Pasture and Fodder Crop Investigations,
Iran (UNDP/FAO), 1970, p. 89, fig. 27)

Seed yields and row spacing for seed production :

In regard to seed production Villax (1963) records at Rabat, in Morocco, average seed yields of 100-300 kg/ha for *V. villosa*, and 600-1,200 kg/ha for *V. sativa* ; *V. villosa* is a poor seed producer and the harvesting of the seeds is a delicate operation. Better seed production for *V. villosa* according to Villax (1963) is obtained under irrigation which permits flowering and seed formation to take place before the onset of dry hot period in the late spring.

In Algeria Laumont (1959) recommends the seeding of *Vicia* spp. in pure culture for seed production in rows spaced 60-80 cm apart in normal culture, and 120-150 cm apart on cultivated fallows. For *V. sativa* he recommends the following seed rates according to the variation in weight of 1,000 seeds and the row spacing chosen :

Row Spacing	Weight of 1,000 seeds (g)		
	60	70	80
	Seed rate kg/ha		
60 cm	60	70	80
80 cm	46	53	60
100 cm	36	42	48
125 cm	30	35	40
150 cm	34	28	32

Laumont (1959) also reports average dryland seed yields for *V. sativa* varying from 600-800 kg/ha. The seed yield is variable according to the variety, place and year ; "Languedoc 159" and "Kabylie 130" have given average seed yields as high as 1,200-1,600 kg/ha at an 80 cm row spacing in some years. Early varieties tend to give higher seed yields than late varieties, and *V. villosa* ssp. *dasycarpa* has given notably lower seed yields than varieties of *V. sativa* ; harvesting the seeds of *V. villosa* is difficult and should commence when the first pods are mature.

23.12. Utilization

Type of use :

Vicia spp. can be utilized in dryland culture for providing fodder for grazing, ensilage, direct green feed, hay production and for some species, such as *V. ervilia* and *V. narbonensis*, also grain for livestock feeding.

Number of forage cuts :

In Morocco Villax (1963) states that early seeded (September-October) dryland *V. sativa* can first be exploited for fodder production in March when it normally flowers, but if later autumn seeding (November) was effected then it can be cut for hay at the end of March or during the course of April.

In Algeria Laumont (1959) considers that a mixture of *V. sativa* and *A. sativa* may provide two cuts in favourable rainfall years, with the first cut being harvested in February and the second cut at the end of April or beginning of May. The number of cuts, often reduced to one cut in many years, depends on the winter rainfall ; if the winter is dry the yield is often poor. Conversely if spring rains are abundant the crop can be adversely affected by lodging and rotting.

Time of cutting for green feed :

For direct green feeding of *Vicia* spp., Laumont (1959) considers that the best time of cutting is at the moment of flowering when it is greatly appreciated by livestock.

In Morocco Ionesco et al. (1969) recommend cutting a mixture of *V. sativa* and *A. sativa* for direct green feed when the oats are still green, that is to say one week before flowering on condition that the vetch is well developed.

Time of cutting for silage :

For ensilage Laumont (1959) recommends utilizing a mixture of *V. sativa* and *A. sativa*, where the cereal constitutes at least 50 percent of the yield of the mixture, in order to ensure satisfactory lactic acid fermentation in the silo. In Algeria the best time for cutting a mixture of *V. sativa* and *A. sativa* for silage appears to be when the vetch has passed the flowering stage and commenced seed formation, and when the seeds of oats are in the milk stage. This is in agreement with studies in Cyprus (Hadjichristodoulou, 1974) where the optimum harvesting stage for maximum DM and protein yield has proved to be the 50 % heading to milk stage for cereals and the pod formation stage for vetches.

Time of cutting for hay :

For hay production both Laumont (1959) and Le Houerou (1971) emphasise the importance of not cutting a mixture of *V. sativa* and *A. sativa* too late if quality is not to be sacrificed to quantity in the harvested crop ; in addition *V. sativa* sheds its leaves more easily than other *Vicia* spp. and the making of hay is a delicate operation.

In certain cases Laumont (1959) states that cutting for hay can be retarded until the moment the vetch has passed the flowering stage and especially for an early maturing variety such as "Kabylie", but late cutting should generally be avoided because the vetch lignifies quickly after flowering.

Cutting and baling hay :

In Morocco Ionesco et al. (1969) recommend leaving the cut crop of *V. sativa* and *A. sativa* on the field for several days to reduce the moisture content from 85 to 20 % ; careful turning of the crop with a side-delivery rake is needed to ensure homogeneous drying and in wet springs it is prudent to use tripods (20-25 per hectare) to dry the crop.

In N. Iraq Kernick (1976) reports that a mixture of *V. villosa* ssp. *dasycarpa* and *A. sativa* has been successfully cut and baled in May even though intermittent rain interfered with harvesting. The crop was cut leaving a stubble height of 10 cm which permitted effective drying of the crop in the windrow and reduced the loss of vetch leaves to a minimum. At the same time the harvesting of a pure seeding of *V. villosa* ssp. *dasycarpa* in the same situation for hay was less successful ; clean cutting was difficult and some loss of leaf occurred due to mold development in the lodged crop.

Liveweight gain of lambs on pastures :

In Syria Van der Veen (1967) records that Awassi lambs weighing an average initial liveweight of 26.3 kg made average gains of 100 g/head/day grazing a mixture of *V. villosa* ssp. *dasycarpa* and *A. sativa* from late April to early June, while Awassi lambs weighing an average initial liveweight of 27.4 kg made average gains of 294 g/head/day when grazing a mixture of *V. sativa* and *A. sativa* from late April to the end of May.

In N. Iraq Kernick (1976) reports that Awassi lambs weighing an average initial liveweight of 26 kg made average gains of 250 g/head/day when grazing a pure seeding of *V. villosa* ssp. *dasycarpa* during late April to the end of May ; at this time the crop was largely in the pod and seed formation stage when the protein yield of the crop is considered to be at its optimum.

Late spring grazing of cereal-vetch mixture :

In Algeria Jefferies (1977) considers that a mixture of *Vicia* spp. with *A. sativa* could also prove profitable and valuable for providing late grazing in May and June when annual *Medicago* pastures need to be rested in order to ensure good seed production.

Value in dryland crop rotations :

In Syria Van der Veen (1967) reports encouraging results in the steppe zone at Kamshili (+400 mm annual rainfall) where wheat yields in the third and fourth year following *V. narbonensis* or *V. villosa* ssp. *dasycarpa*, which had been fertilized with phosphate, showed an increase over wheat yields after fallow.

In Morocco Ionesco et al. (1959) recommend a dryland rotation of wheat-vetch/oats or wheat-vetch/oats-grain legume in the region of Meknès-Fès (300-400 mm annual rainfall).

Further evaluation :

More attention in the future needs to be paid to the testing and utilization of *Vicia* spp., particularly native varieties in dryland farming rotations in North Africa and the Near and Middle East, since they clearly offer scope for increasing supplementary forage for livestock as well as improving soil conditions.

Among the native varieties *V. sativa* ssp. *amphicarpa* would appear to merit special attention since it buries its seeds below the ground and may offer considerable scope for developing a self-regenerating type of *Vicia* species similar to *Trifolium subterraneum*.

23.13. Specific References

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FAMILY PAPILIONACEAE (= FABACEAE)

ANNUAL AND PERENNIAL SPECIES

- 24. *Lotus* spp.
- 25. *Hedysarum* spp.
- 26. *Trifolium* spp.

TECHNICAL DATA

SHEET No 24

PAPILIONACEAE (= FABACEAE)

Lotus spp.

24.1. Species

Among the many annual and perennial *Lotus* spp. that are widespread in the region the most important for forage purposes are considered to be *L. corniculatus* L., *L. creticus* L., *L. edulis* L., *L. halophilus* Boiss. et Sprun. and *L. pedunculatus* Cav.

24.2. Synonyms

- *L. creticus* (= *L. commutatus* Guss.,
L. salsamanni Boiss. et Reuter)
- *L. halophilus* (= *L. villosus* Forssk.,
L. pusillus Viv.,
L. aucheri Boiss. et Sprun.,
L. pusillus Viv. var. *majus* Boiss.)
- *L. pedunculatus* (= *L. uliginosus* Schk.,
L. major Sm.)

24.3. Common Names

- | | | |
|--------------------------|---------|---|
| - <i>L. corniculatus</i> | English | Birds foot Trefoil,
Common Birds foot,
Birds foot Deer-Vetch (USA). |
| | French | Lotier cornicule,
Lotier de prés. |
| | Arabic | Bou gueru, Bou kheris, Haialem,
Medjeru (Morocco) ;
Quoon el ghazaal, Rigl-el-asfoor,
Zeita, Zeiti (Egypt (UAR) ;
Qutaihah (Syria). |
| - <i>L. creticus</i> | English | Silvery Bird's Foot Trefoil (Libya). |
| | French | Lotier de Crète,
Lotier maritime (Morocco). |
| | Arabic | Esshb Oshb (Egypt (UAR) ;
Grain, Hueta, Zghiga (Libya). |
| - <i>L. edulis</i> | English | Esculent Bird's Foot Trefoil (Libya). |
| | French | Lotier comestible (Morocco). |
| | Arabic | Guernel feru (Morocco). |

- <i>L. halophilus</i>	English	Pretty Bird's Foot Trefoil (Libya, Iraq).
	Arabic	Qurn-al-Ghazzal (Syria, Palestine, Iraq).
- <i>L. pedunculatus</i>	English	Greater Bird's Foot Trefoil, Big Trefoil, Marsh Bird's Foot Trefoil.
	French	Lotier de Marens, Lotier velu, Grand Lotier, Pied de poule, Pied de pigeon.
	Arabic	Bon Gueru (Morocco).

24.4. Brief Description

- *L. corniculatus* is a glabrous to pubescent perennial legume, ascending or erect, not stoloniferous but with stems up to 50 cm long and reaching a height of from 8-80 cm with a terminal leaflet and a pair of opposite leaflets at the apex of the common footstalk, and having bright yellow flowers sometimes tinged red, which turn grey when dry, and also long narrow cylindrical pods each containing about 20 globular brown or yellow seeds (Fig. 1, 2, 3 and 5) ;

- *L. creticus* is a silvery or golden silvery prostrate perennial legume reaching a height of 20-40 cm with golden yellow flowers and glabrous cylindrically compressed pods 2-4 cm long with globose seeds (Fig. 4) ;

- *L. edulis* is a pubescent prostrate annual legume reaching a height of 10-40 cm with golden yellow solitary flowers, rarely in groups of two, with seeds that when young are edible (Fig. 5) ;

- *L. halophilus* is a small silvery-pubescent annual legume reaching a height of 6-12 cm with narrow elliptical leaflets, lemon-yellow flowers, on a slender peduncle longer than the leaf, with a broad legume slightly flattened and torulose with small globose dull seeds (Fig. 5) ;

- *L. pedunculatus* is a tall glabrous creeping stoloniferous , perennial with vigorous underground rhizomes and fine stems reaching a height of 30-80 cm, with also relatively large leaves, dark yellow flowers and small globose green seeds.

24.5. Varieties

Botanical sub-species and varieties :

A number of botanical subspecies and/or varieties of *L. corniculatus*, *L. creticus* and *L. halophilus* have been noted in N. Africa and the Near and Middle East.

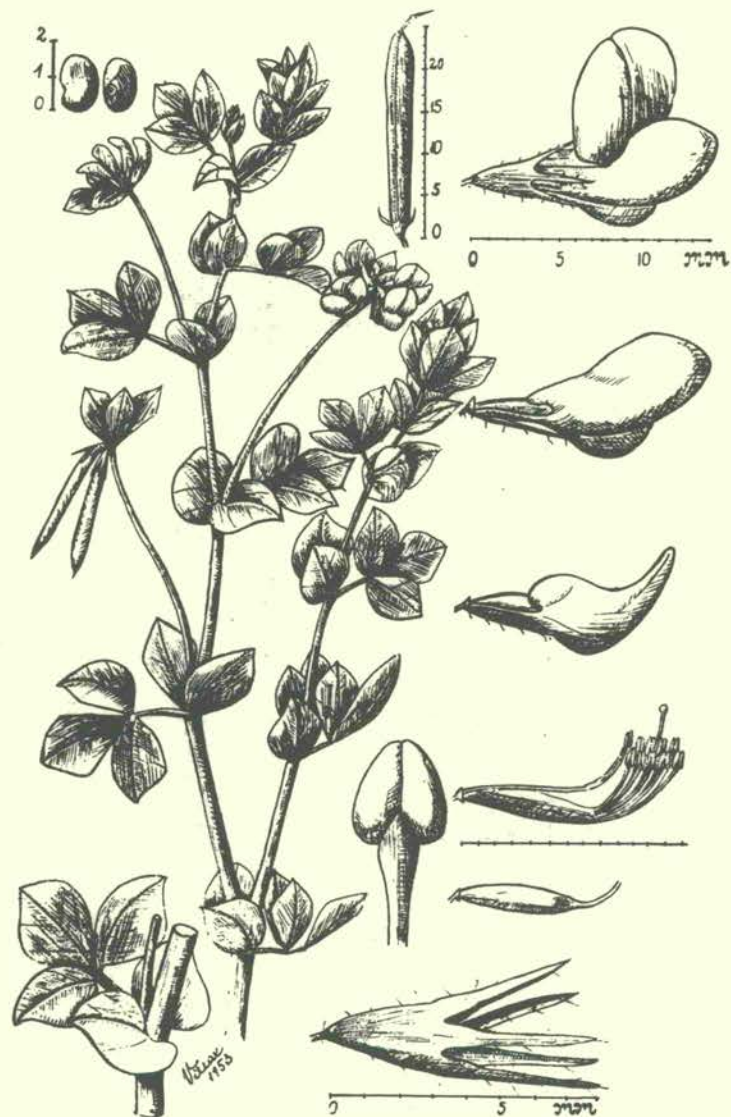


Fig. 1

L. corniculatus L. (Orig. - Elvas 1953)

(After la Culture des plantes fourragères dans la région Méditerranéenne occidentale, 1963, p. 453, fig. 120)

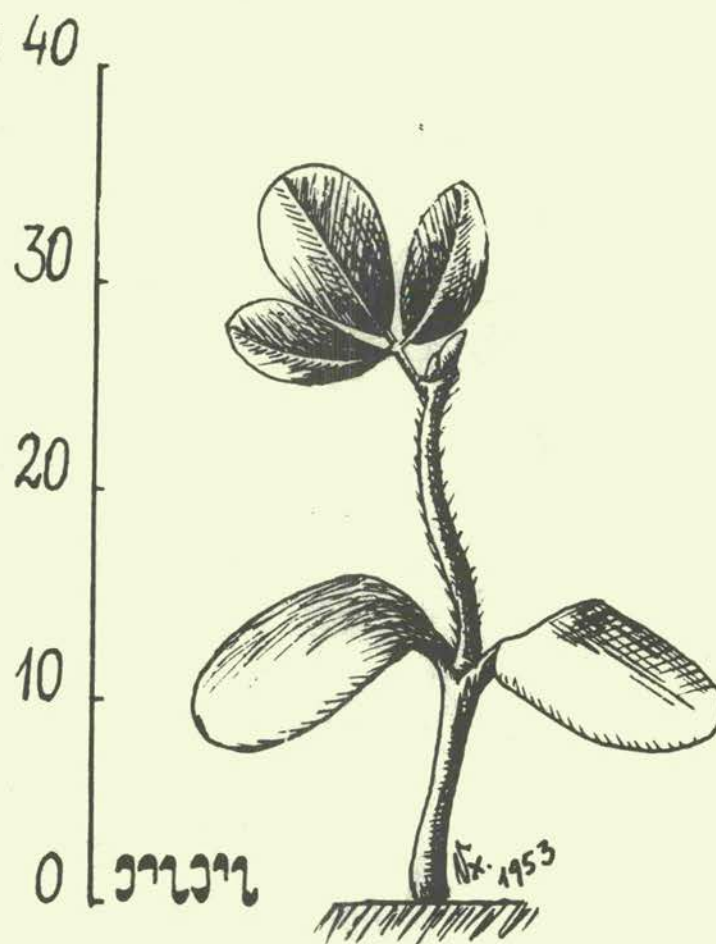


Fig. 2

Seedling of *Lotus corniculatus* L. 14 days after emergence
(Orig. - Elvas)

(After la Culture des plantes fourragères dans la région
Méditerranéenne occidentale, 1963, p. 451, fig. 119)

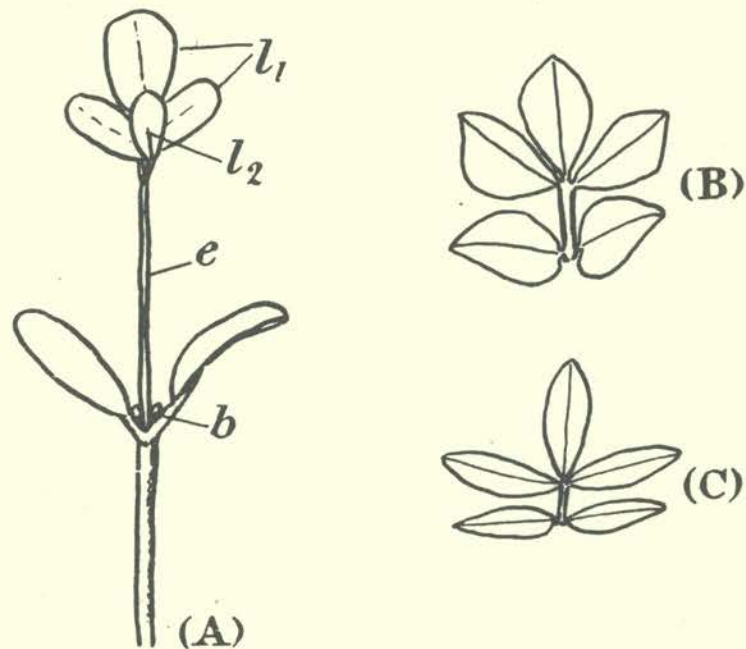


Fig. 3

A, seedling of birdsfoot trefoil ; b, buds in axils of cotyledons ; e, epicotyl ; l_1 , l_2 , first and second leaves.
B, leaf of common type ;
C, leaf of narrow-leaved type.

(After Leguminous Forage Plants, 1947, p. 66, fig. 18)

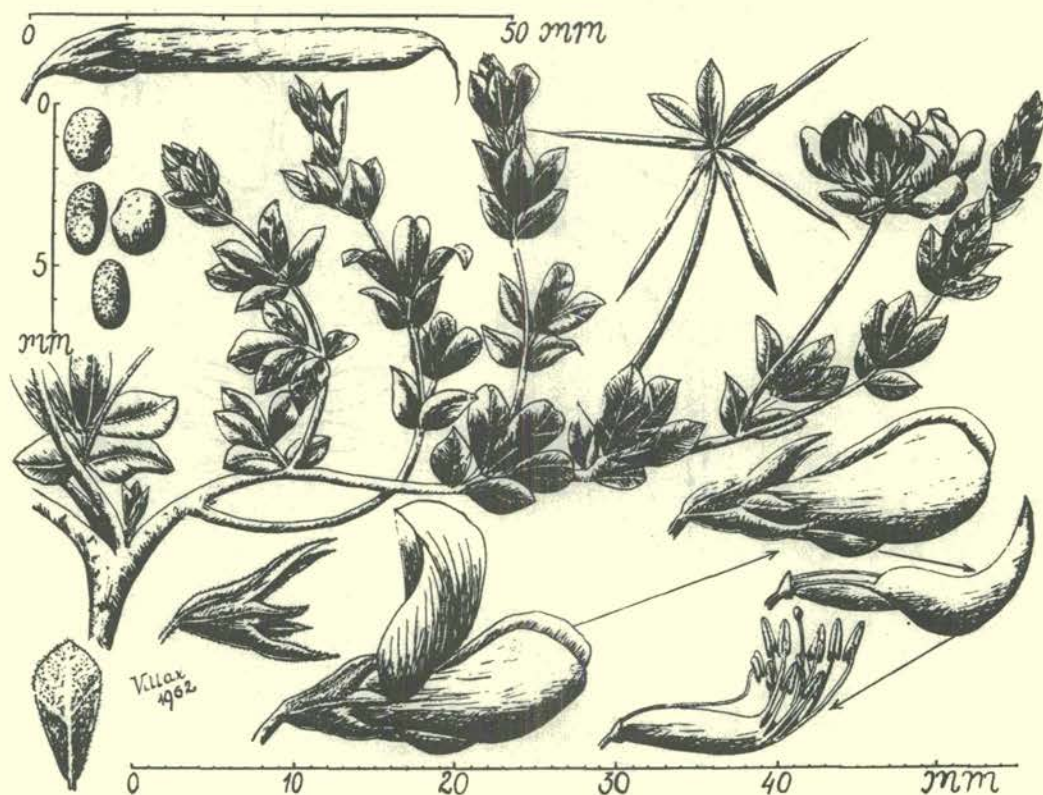


Fig. 4

Lotus creticus (Orig. - Rabat 1962)

(After la Culture des plantes fourragères dans la région Méditerranéenne occidentale, 1963, p. 457, fig. 121)

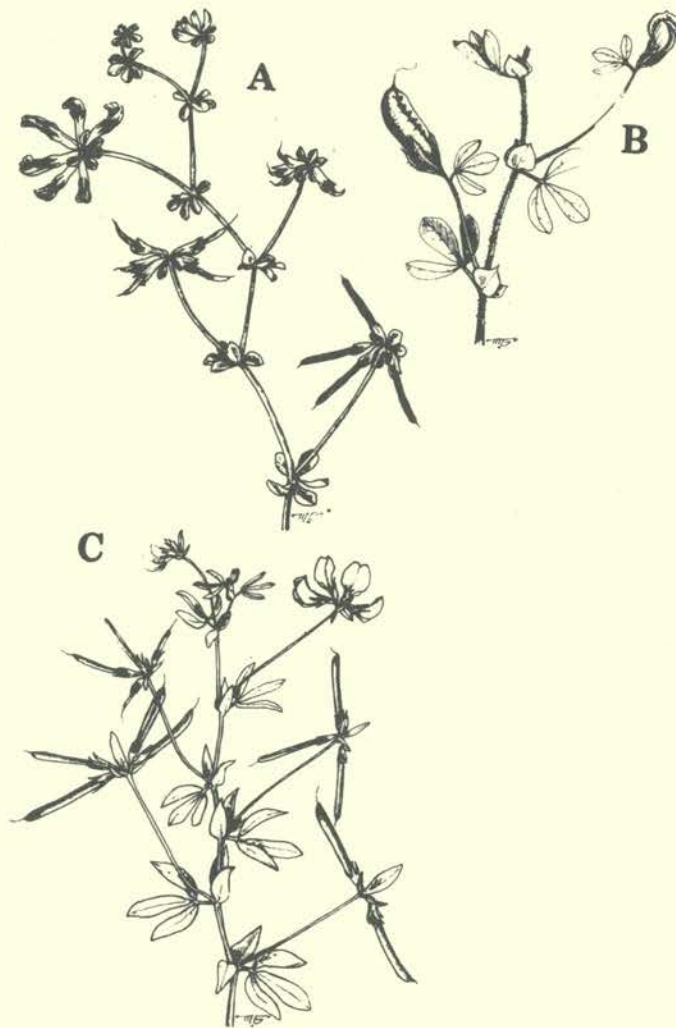


Fig. 5

A, *Lotus creticus* B, *Lotus edulis* C, *Lotus corniculatus*

(After Student's Flora of Egypt, 1974, p. 244, plate 77)

In North Africa Foury (1954), Quezel and Santa (1962) and Villax (1963) mention the following :

- *L. corniculatus* :

- ssp. *eu-corniculatus* Syme (n = 12)
with lanceolate petioles and more or less erect stems ;
present in Spain, Algeria, Morocco and is the main type in cultivation ;
- ssp. *tenuifolius* L. Rchb. (= *L. decumbens* Forst., *L. tenuis* Wald. et Kit.), common name : english : Narrow Foot Trefoil, n = 6)
with lanceolate leaves and grows on saline soils ; present in Morocco ;
- ssp. *decumbens* (Poirot) Briq.
with lanceolate or linear-lanceolate leaves ; present in Algeria.

- *L. creticus* :

- ssp. *eu-creticus* (Maire) Briq.
with sessile silky whitish leaves ; present in the littoral zone of Morocco, Algeria and Tunisia ;
- ssp. *commutatus* (Guss.) Batt. (= *L. salzamanni* Boiss. et Reut.)
with pubescent silky white plants and aspect of the preceding subspecies ; present in the Atlantic littoral of Morocco and Portugal and also the littoral of Algeria ;
- ssp. *collinus* Boiss. (Briq) (= *L. prostrata* Batt.)
with lively yellow flowers ; present in the interior mountains of Algeria and also recorded by Kasapligil (1956) in the maquis forest of Jordan ;
- ssp. *cytisoides* (L.) Asch. (= *L. prostratus* Desf., *L. Allionii* Desv.) (n= 7)
with clear yellow flowers ; present in the lower mountains of Algeria ;

Heyn and Hernstadt (1967-68) also state that *L. creticus* comprises three mediterranean varieties :

- var *creticus*
the typically hairy type widely present in the western part but rare in the east ;
- var *glabrescens*
the non-silky type present in the western part ;
- var *collinus*
a non-silky type with long petioles and peduncles present in the eastern part.

Heyn and Hemstadt (1967-68) also consider that the *L. creticus* group comprises four species namely *L. polyphyllus*, *L. cytisoides*, *L. creticus* and *L. collinus*.

In Egypt (UAR) Tackholm (1974) also mentions the following botanical varieties of *L. corniculatus* :

- var. *tenuifolius* L. (= *L. tenuis* Kit.ex Willd., *L. tenuifolius* (L.)Reichb.)
with tall slender richly branched plants ; present in the littoral and desert zone and also recorded by Townsend and Guest (1974) in the desert region of Iraq and by Davis (1966) in the Anatolian region of Turkey ;
- var. *brachyodon* Boiss. (var. *alpinus* Schleich)
with small hairy short leaflets and few flowered umbels ; present in the Nile Delta and also recorded by Mouterde (1966) in the mountains of Syria and Lebanon and by Davis (1966) in the mountains of Turkey ;
- var. *rothianus* Brand
an annual type (all preceding varieties perennial) with 1-2 flowered peduncles ; present in the oasis of the Libyan desert.

In the mountains of N. Iraq and Turkey, Townsend and Guest (1974) and Davis (1966) also record the following varieties of *L. corniculatus* :

- var. *corniculatus*
with glabrous to moderately hairy plants ;
- var. *tenuifolius*
with glabrous plants or plants only slightly hairy on the upper portions.

In Iran Parsa (1950) also mentions the following botanical varieties of *L. corniculatus* :

- var. *ciliatus* Koch
with ciliated leaves ; present in Khorassan (between Kuch and Meshed) and at Gotvind in the west ;
- var. *oceanus*
with plants that are glabrous at the base with large curved wings to the fruits ; present in the south-west around Khowanshar.

In Afghanistan and Pakistan Kitamura (1960, 1964) also records the following variety of *L. corniculatus* :

- var. *japanicus* Regel
present at Karakoraun, Hindukush, and Swat Himalaya from 2,170-2,500 m elevation.

Finally in Libya Keith (1965) and in Israel Heyn (1966) mention the following botanical varieties of *L. halophilus* :

- var *macrocanthus* (Boiss.) Heyn
with large flowers ; occurs in the E. Mediterranean ;
- var *vivianii* Pamp.
occurs at Ain Mara in Cyrenaica.

Native ecotypes :

In regard to native ecotypes Le Houerou (1965) and le Houerou and Froment (1969) record that a local strain of *L. creticus* from Djebel Serz in Tunisia has been collected and multiplied and dryland test plantings have been made at Sidi Thabet.

In Turkey Hertzsch (1970) also records that 53 native ecotypes of *L. corniculatus* have been collected in the various regions of the country during the period 1965-69 and assembled at Izmir on the west coast.

In N. Iran Pabot (1961) records also the occurrence of a very interesting probably annual native *Lotus* sp. which he tentatively calls *L. "khuzistanicus"* ; this species occurs on conglomerates and marls north of Maggid-i-Suleiman, resists overgrazing well and remains green all the year in a semi-arid area with around 300 mm annual rainfall.

Agricultural varieties :

A number of agricultural varieties of *L. corniculatus* have been developed in the USA and Canada, and some of these varieties have been tested under dryland conditions in N. Africa and the Near and Middle East.

Corriols (1965) reports that the varieties "Empire", and "Granger" seeded in dryland test plantings in the littoral zone (400-600 mm annual rainfall) of Tunisia, at Tunis, have grown fairly well and persisted over three years.

Hussein (1975) reports that the variety "Cascade" has been successful in dryland plantings in the lower mountain zone (500 mm annual rainfall) on N. Iraq, and Kernick (1971) records that the varieties "Viking" and "Mansfield" grow well in dryland test plantings in the Caspian Forest zone (+600 mm annual rainfall) of N. Iran.

In the USA Heath et al. (1972) record that the varieties "Cascade", "Granger", "Maitland", "Mansfield", "Tana" and "Viking" are all European types having an early spring semi-erect to erect growth habit and more rapid seedling recovery growth than "Empire" and they also report on the characteristics of some other important varieties of *L. corniculatus* developed in N. America :

- "Dawn", an erect earlier flowering type than "Empire", resistant to root rots ; developed in Missouri (USA) ;
- "Leo", more winter hardy than "Empire" or "Viking" with excellent spring vigour ; developed in Canada ;
- "Carroll", a winter hardy pasture type but less prostrate and slightly earlier in maturity than "Empire" ; developed in Iowa (USA).

Two varieties of *L. pedunculatus* have also been developed at the Oregon Experiment Station in the USA, which are "Beaver" with glabrous leaves, and "Colombia", which has pubescent stems ; both have similar growth habits to varieties of *L. corniculatus* (Heath et al., 1973).

24.6. Number of Chromosomes

L. corniculatus : $2x = 24$; *L. creticus* : $2x = 28$; *L. edulis* : $2x = 14$; *L. pedunculatus* : $2x = 12$, (24) ; *L. halophilus* : $2x = 14$.

Grant (1965) also records that the following crosses have been successfully effected :

L. corniculatus x *japonicus* ; *L. corniculatus* x *alpinus* ;
L. corniculatus x *tenuis* ; *L. pedunculatus* x *corniculatus* and *L. pedunculatus* x *tenuis*.

24.7. Geographical Distribution

L. corniculatus is distributed almost throughout Europe, the Aegean Isles, Turkey, Caucasus, Iran, Iraq, Syria, Lebanon, Palestine, Lower Egypt, S.W. Arabia, Bangladesh, Afghanistan, N. and C. Asia (Siberia, Pamir, Tianshan, Altai to Manchuria), India, China, Korea, Japan, Australia, Tasmania, tropical Africa (Sudan, Ethiopia, Kenya, Uganda, Tanzania) and introduced into the USA and elsewhere ;

L. creticus is distributed in S. Europe (very rare), the Mediterranean basin including Spain, Portugal, Azores, Sicily, Jordan, Turkey, Egypt (UAR), Algeria, Morocco, Tunisia ;

Meusel and Jäger (1962) have also indicated the main geographical distribution of *L. corniculatus* in the region which is shown in the distribution map in Fig. 6 and Heyn and Hemstadt (1967-68) have indicated the geographical distribution of *L. creticus* and also *L. polyphyllus* and *L. cytisoides*, both belonging to the *L. creticus* group, which is shown in the distribution map in Fig. 7, 8 and 9 ;

L. edulis is distributed in S. Europe and Asia Minor and Cyprus, Lebanon, Syria, Turkey, Algeria, Morocco, Tunisia and Egypt (UAR) ;

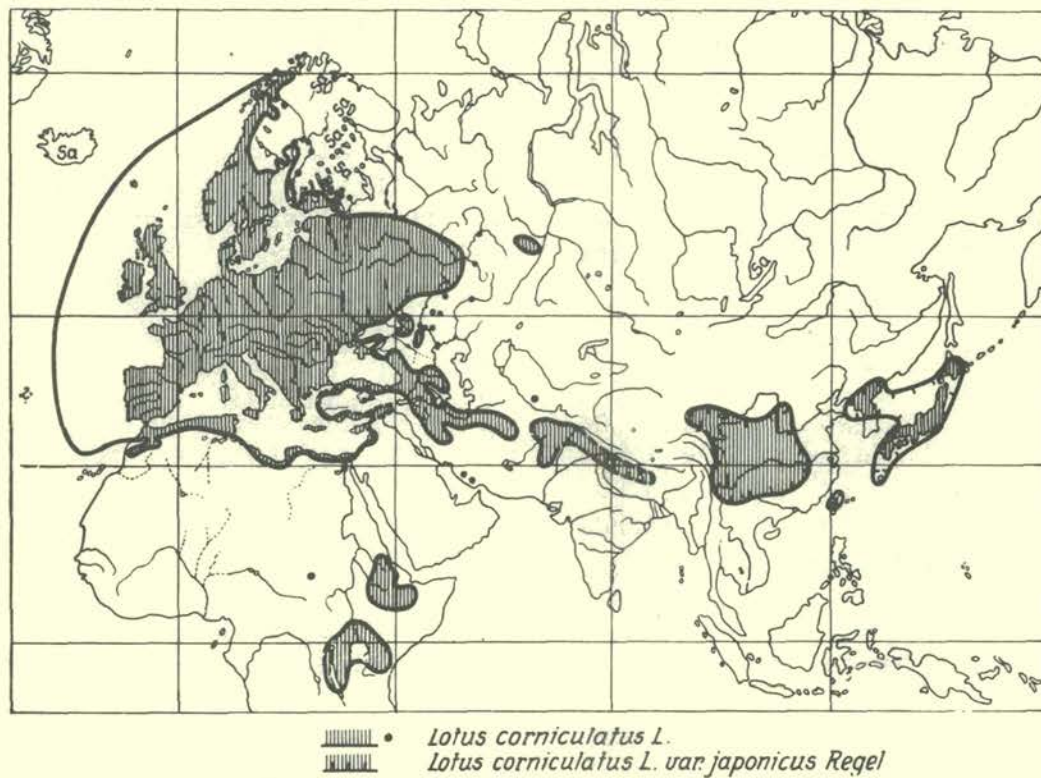


Fig. 6

Area of distribution of the
Lotus corniculatus L. complex

(After Die Kulturpflanze, Beiheft, 1962, p. 259, Fig. 8)



Fig. 7 - Distribution of *L. polyphyllus* (x) and *L. collinus* (●) based on observed specimens
(After Kew Bulletin, 21, 1967-68, p. 299, map 1)

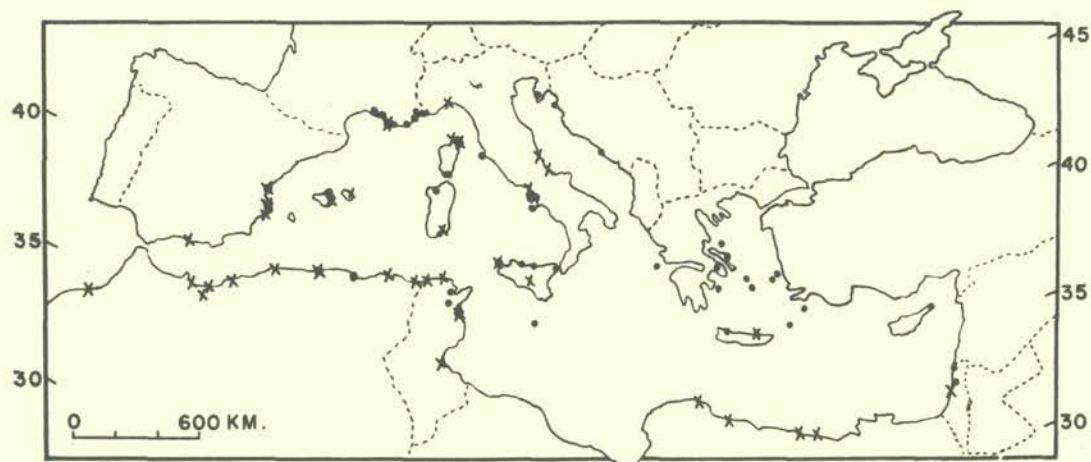


Fig. 8 - Distribution of *L. cytoides* : sericeus form (x) and non-sericeus form (●) based on observed specimens
(After Kew Bulletin, 21, 1967-68, p. 301, map 2)

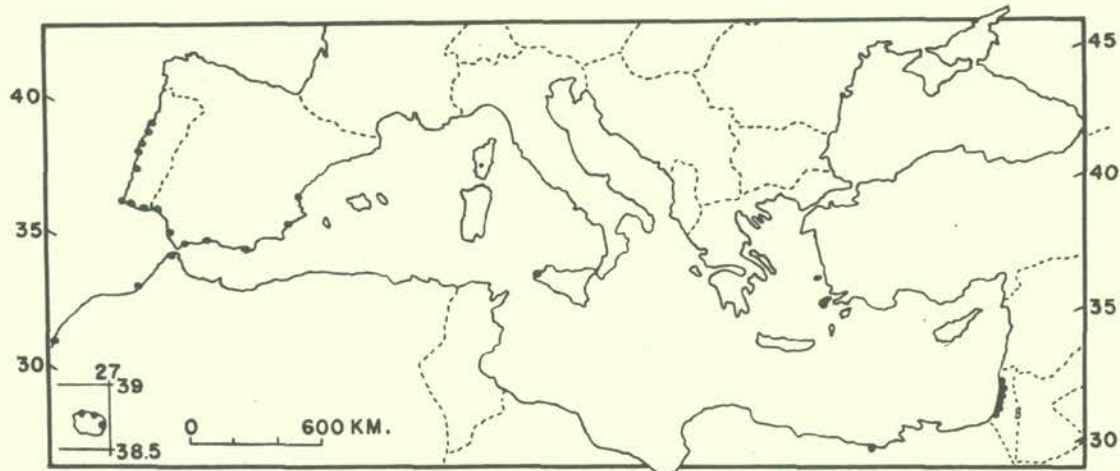


Fig. 9 - Distribution of *L. creticus* based on observed specimens
(After Kew Bulletin, 21, 1967-68, p. 302, map 3)

L. halophilus is distributed in S.E. Mediterranean Europe (Malta, Sicily, Greece) and in Crete, Rhodes, Cyprus, Turkey, Syria, Lebanon, Palestine, Sinai, Egypt, Arabia, Kuwait, Bahrain, Iraq, Iran, N. Africa (Morocco, Algeria, Tunisia, Libya) ;

L. pedunculatus is distributed throughout Europe (eastward to W. USSR) and also S.W. Asia and N. Africa (Morocco, Algeria, Tunisia, Egypt (UAR)).

24.8. Biology and Ecology

Growth and development :

L. corniculatus, *L. creticus*, *L. halophilus* and *L. pedunculatus* are all cool season species that propagate themselves by seed.

L. corniculatus grows well in the humid littoral and mountain regions of N. Africa and the Near and Middle East, and resists well cold temperatures and even frosts, but is susceptible to high summer temperatures although showing considerable drought resistance.

In Morocco Villax (1963) records that *L. corniculatus* seeded in the autumn is in full flower in April or May, and under dryland cultivation in the high plateaux zone (800-1,200 m elevation) of Algeria, Maignan (1970) records that substantial vegetative growth occurs by the beginning of April.

In Tunisia Corriols (1965) records that *L. corniculatus* seeded at the end of November germinated only at the beginning of April, flowered at the end of May, but was still green at the end of July ; in summer growth ceased with the onset of high temperatures and was not resumed until cool temperatures prevailed at the end of September.

In Morocco Foury (1954) also mentions that *L. corniculatus* has proved more resistant to pests and diseases in humid areas than *Trifolium* spp. or *Medicago sativa*.

In the lower mountain zone of Iraq Hussein (1975) records that dryland seeded *L. corniculatus* has given 80-100 % germination in the spring, while dryland *L. corniculatus* seeded in the sub-steppic and Caspian Forest zones of Iran in the spring has given a substantial vegetative growth in May-June ; in the Caspian Forest zone, with summer rainfall, growth continued during July-September and Dumancic (1975) reports that *L. corniculatus* was also self-seeding.

In one dryland field planting in the sub-steppic zone of Iran at Homand (1,960 m elevation, 320-350 mm annual rainfall) *L. corniculatus* in the spring of the second year produced more forage than a second year dryland field stand of *Medicago sativa* (AGP:SF/IRA 10, Tech. Rep. 1, 1970).

Villax (1963) records that *L. pedunculatus* can be cultivated under dryland conditions in the littoral zone and mountains of the Mediterranean basin, but likes mild temperatures and humid conditions and supports to some extent the heat. However Corriols (1965) records that *L. pedunculatus* did not succeed well in dryland test plantings at Tunis and the few plants which grew eventually died during the hot summer period.

Both Foury (1954) and Villax (1963) consider that *L. pedunculatus* is best adapted to semi-humid forest areas where it can replace *L. corniculatus* more effectively in shady situations.

L. creticus develops well under dryland conditions in the Mediterranean region and Villax (1963) records that it grows nearly all the year round but especially in the winter and spring period.

L. creticus prefers a humid climate with mild winter temperatures but supports well cold and drought in the littoral zone of N. Africa.

L. edulis and *L. halophilus* are both naturally occurring self-seeding annual species widespread in semi-arid areas of N. Africa and the Near and Middle East, which make their main vegetative growth in the spring and are well adapted to dry conditions ; in Kuwait in the desert Kernick (1966) records that *L. halophilus* produced significant growth of forage in March on sandy soil with only 21.5 mm of rainfall in one year.

L. edulis also resists cold temperatures and in the mild littoral areas of N. Africa can produce substantial growth in the winter.

With the onset of high summer temperatures both *L. edulis* and *L. halophilus* dry up and set seeds generally at the end of June.

Seed characteristics :

Unsatisfactory germination of the seeds of *L. creticus* sometimes occurs because of their naturally hard seed-coat. Tsurieil (1974) nevertheless reports good self-seeding of *L. creticus* in the littoral zone of Israel.

Heath et al. (1973) also record that in the USA seed coats of mature seed of *L. corniculatus* are often impermeable to water and hard harvested seed can contain up to 90 % hard seed, which is reduced to 40 % when the seed is harvested with a combine ; hard seed is also of little value for carry over and production of new seedlings.

Climate and soils :

In regard to rainfall and edaphic conditions the following is a summary of the requirements of the previously mentioned *Lotus* spp. :

- *L. corniculatus* : + 500 mm annual rainfall and stands cold winters and frost ; adapted to a wide range of soils from calys to sandy loams ; supports flooding and small quantities of salt in the soil ;

- *L. pedunculatus* : + 500 mm annual rainfall and stands cold winters and frost ; well adapted to poorly drained soils that are acid or alkaline ;

- *L. creticus* : + 300 mm annual rainfall ; prefers mild winters but stands some cold ; very resistant to aridity, and Le Houerou (1969) records it as being adapted under natural conditions in the Tunisian steppe to 100 mm annual rainfall ; adapted to poor soils but prefers sandy soils and does not tolerate flooding ;

- *L. edulis* : + 300 mm annual rainfall and stands cold and drought ; prefers sandy soils ;

- *L. halophilus* : + 100 mm annual rainfall and mild winters ; very resistant to aridity ; prefers sandy soils.

Ecological characteristics :

Ecologically *L. corniculatus* and *L. pedunculatus* occur in humid places chiefly in the mountains of N. Africa and the Near and Middle East. In Iraq Townsend and Guest (1974) record that *L. corniculatus* is quite common in the desert region on the alluvial plain as well as in the mountains up to 2,400 m elevation, but *L. pedunculatus* has not so far been recorded. In Turkey Davis (1966) records *L. corniculatus* as occurring from sea level up to 2,750 m elevation, and var *tennifolius* as occurring on damp, heavy soils, river banks and marshes.

L. creticus is recorded by Foury (1954) and Quezel and Santa (1962) as being common in maritime sands in the littoral zone of Algeria and Morocco, by Tackholm (1974) on maritime sand in the N. W. coastal zone of Egypt (UAR), and by Davis (1966) on fixed sand dunes in W. Turkey. At Burg El-Arab in N. Egypt Ayyad and Ammar (1973) also record that *L. creticus* prefers N. facing slopes.

L. edulis is also found growing in the littoral zone of Morocco and Algeria (Foury, 1954), and also occurs in association with *L. creticus* and *Cynodon dactylon* on poor brown calcareous soils in Central Tunisia (Naegelé, 1977), while Davis (1966) records *L. edulis* as occurring on stony ground in waste places and dunes from sea level to 50 m elevation in N.W. Turkey, W. and C. Anatolia and Islands.

L. halophilus is very common on sandy soils and dunes throughout the littoral, steppe and desert areas of N. Africa and the Near and Middle East. In Iraq Townsend and Guest (1974) record *L. halophilus* as occurring in sandy desert places, dunes, wadis, sandy pockets in sandstone or conglomerate up to an elevation of 300 m, where it flowers from March to early May.

9. Cultivation Techniques

Time of seeding :

In N. Africa *L. corniculatus* and *L. creticus* are normally seeded after the first autumn rains. Le Houerou (1965) and Le Houerou and Froment (1969, 1973) recommend seeding *L. creticus* in Tunisia at the end of September beginning of October and Maignan (1970) reports seeding dryland *L. corniculatus* at the end of September in the high plateaux zone of Algeria.

In the lower mountain zone of Iraq, Hussein (1975) records that the spring (last week of February and first week of March) has proved the best time of seeding for dryland *L. corniculatus* and spring seeding has proved superior to autumn seeding.

In the sub-steppic zone of Iran spring seeding of dryland *L. corniculatus* at the end of March was the most successful, and spring seeding is also preferred (Dumancic, 1975) in the Caspian Forestry zone.

Land preparation :

Seeds of both *L. corniculatus* and *L. creticus* require a well prepared, compact, firm, fine, weed-free seed-bed similar to that required for *Medicago sativa* and *Onobrychis viciifolia*. This normally entails ploughing the soil 10-15 cm deep, followed by a disking, harrowing and rolling.

Seeding in mixture with grasses :

Lotus spp. can be seeded in mixture with other grasses such as *Dactylis glomerata*, *Ehrharta calycina*, *Festuca arundinacea* or *Phalaris aquatica* (= *P. tuberosa*) with *L. corniculatus* and *L. pedunculatus* (Villax, 1963), and *Agropyron elongatum*, *Brachypodium phoenicoides*, *Ehrharta calycina* or *Oryzopsis miliacea* with *L. creticus* (Le Houérou, 1965) ; in the Balearic Isles Montserrat (1959) recommends seeding *L. creticus* in mixture with *Dactylis glomerata*.

Seed treatment :

Heath et al. (1973) recommend scarification of the seeds of *L. corniculatus*, before seeding in seed lots that contain a significant amount of hard seeds, and in the Balearic Isles the planting of cuttings has been recommended (Montserrat, 1959) for *L. creticus* because the hard seed do not germinate well.

Seeds of *L. corniculatus* should also be inoculated before sowing with a suitable strain of *rhizobium* bacteria.

Seed rates, row spacing and method of seeding :

Seed rates and spacings for dryland *L. corniculatus*, *L. creticus* and *L. pedunculatus* vary between countries but the following have been reported :

<u>Morocco</u>	<i>L. corniculatus</i> (alone)	10-20 kg/ha of seeds broadcast <u>or</u> seeded in lines spaced 20-40 cm apart
	<i>L. creticus</i> (alone)	15-30 kg/ha of seeds broadcast <u>or</u> seeded in lines spaced 20-30 cm apart
	<i>L. corniculatus</i> or <i>L. creticus</i> + Grass	3-6 kg/ha of seeds } 12-24 kg/ha of seeds } broadcast
	<i>L. pedunculatus</i> (alone)	5-10 kg/ha of seeds broadcast
	<i>L. pedunculatus</i> + Grass	3-5 kg/ha of seeds } 15-25 kg/ha of seeds } broadcast
	<i>L. edulis</i> (alone)	25-50 kg/ha of seeds broadcast
<u>Tunisia</u>	<i>L. creticus</i> (alone)	15 kg/ha of seeds drilled in lines spaced 40-50 cm apart
	<i>L. creticus</i> + Grass	10 kg/ha of seeds } 10 kg/ha of seeds } drilled in lines spaced 40-50 cm apart
<u>Algeria</u>	<i>L. corniculatus</i> (alone)	10 kg/ha of seeds broadcast
<u>Iraq</u>	<i>L. corniculatus</i> (alone)	5 kg/ha of seeds drilled in lines spaced 50-60 cm apart on level land or 3-5 kg/ha of seeds sown in the bottom of contour furrows spaced 1-2 m apart, or on the berm of contour trenches spaced 4 m apart on steep or sloping land
<u>Iran</u>	<i>L. corniculatus</i> (alone)	10 kg/ha of seeds drilled in lines spaced 15-20 cm apart

Fertilizer application :

Little information is available on the fertilizer needs of the previously mentioned *Lotus* spp., but Maignan (1970) reports the application of 45 kg/ha P_2O_5 to the seed-bed followed by 22 kg/ha N after seeding for experimental dryland plantings of *L. corniculatus*.

24.10. Forage Value

Palatability :

All the previously mentioned *Lotus* spp. are palatable to livestock. In Morocco Villax (1963) reports that hay of *L. corniculatus* is very readily eaten by livestock but he mentions that in the green state the forage is slightly bitter especially in dry weather and is then less appreciated.

Non-bloat characteristic :

An advantage of *L. corniculatus*, especially when grazed, is its non-bloat characteristic ; in the USA it has been grazed in pure stands and also cut and fed green with no apparent bloat problem (Heath et al., 1973).

Nutritive value :

The nutritive value of *L. corniculatus*, *L. creticus*, *L. edulis* and *L. halophilus* is good as the following chemical composition data from various countries shows :

Morocco : (a) at Rabat (Villax, 1963)

Percentage Chemical Composition						
Species	Nature of Forage	Water	Protein	Fats	Carbohydrates Soluble	Fibre Ash
<i>L. corniculatus</i>	Green	80.0	3.2	0.4	9.7	4.8 1.9
	Dry	12.4	16.1	4.0	35.3	24.5 7.7
<i>L. creticus</i>	Green	80.5	2.6	0.6	11.5	3.1 1.7

(b) at Rabat (Foury, 1954)

Percentage Chemical Composition						
Species	Water	Ash	Protein	Non-N Extract	Fats	Cellulose
<i>L. corniculatus</i>						
(i) <u>green, 12.5.49</u>						
on wet basis	80.00	1.88	3.16	9.72	0.43	4.81
on dry basis	0	9.42	15.83	48.46	2.19	24.10
(ii) <u>green, 9.8.49</u>						
on wet basis	72.00	2.39	4.10	12.88	0.64	7.99
on dry basis	0	8.56	14.66	45.93	2.30	28.55
<i>L. creticus</i>						
(i) <u>green, 9.8.49</u>						
Sample A on wet basis	67.00	2.29	4.05	14.72	0.67	11.27
on dry basis	0	6.94	12.26	44.59	2.05	34.16
Sample B on wet basis	71.00	1.83	3.40	11.52	0.53	11.72
on dry basis	0	6.32	11.75	39.64	1.86	40.43
(ii) <u>green, 20.3.51</u>						
Sample A on wet basis	86.27	1.29	2.60	6.95	0.56	2.33
on dry basis	0	9.44	18.92	50.57	4.15	16.92
Sample B on wet basis	85.15	1.47	2.99	7.48	0.60	2.31
on dry basis	0	9.93	20.17	50.24	4.05	15.61
(iii) <u>green, 24.4.51</u>						
on wet basis	80.50	1.65	2.59	11.53	0.62	3.07
on dry basis	0	8.51	13.32	59.16	3.22	15.79
<i>L. edulis</i>						
<u>green, 26.5.52</u>						
on wet basis	79.28	2.85	2.46	11.18	1.47	3.77
on dry basis	0	13.77	11.79	53.94	2.31	18.19

Kuwait : at Kuwait City (Kernick, 1966)

<i>L. halophilus</i> : Chemical Composition - Percentage of Dry Matter							
Nature of Forage	Date Sampled	Ash	Crude Fibre	Crude Protein	Potassium	Phosphorous	Calcium
Green stems	10.1.62	13.380	16.140	24.670	0.010	0.060	1.252
leaves	28.2.62	9.900	25.490	17.680	0.786	0.414	1.959

Iran : at Sangh Deh (Dumancic, 1975)

Percentage Chemical Composition					
Species	Phenological stage of growth	Dry Matter	Crude Protein	Ca	P
<i>L. corniculatus</i> (self-seeded)	Full flower	25.0	20.9	0.98	0.27
<i>L. corniculatus</i> (direct seeded)	Full flower	29.0	15.0	0.97	0.25

24.11. Forage and Seed Production

Forage yields :

In the littoral zone of Morocco Villax (1963) records average dryland forage yields varying from 12,000-24,000 kg/ha/year green forage (2,000-6,000 kg/ha hay) for *L. corniculatus* and 8,000-16,000 kg/ha/year green forage (2,000-4,000 kg/ha hay) for *L. creticus* and *L. pedunculatus*.

In the littoral zone of Tunisia Le Houerou (1965) and Le Houerou and Froment (1969, 1973) record average green forage yields varying from 5,000-15,000 kg/ha/year in the first year for dryland *L. creticus* and from 20,000-40,000 kg/ha/year in the second and subsequent years.

In the high plateaux zone of Algeria Maignan (1970) records for dryland *L. corniculatus* a green forage yield of 44,200 kg/ha in a year with a seasonal rainfall of 511.3 mm in two cuts during the period April-May.

In the sub-steppic zone of Iran in a year with a spring (March-May) rainfall of 282.9 mm a second year field stand of dryland *L. corniculatus* gave a yield of 500 kg/ha DM in June on a brown vesicular calcareous soil (AGP:SF/IRA 10, Tech. Rep. No. 1, 1970).

In Kuwait Kernick (1966) records that *L. halophilus* in association with *Plantago albicans* and *P. ovata* gave in March a dry matter yield of 80 kg/ha in the desert littoral on a sandy soil in a year with only 21.6 mm seasonal rainfall ; the application of supplementary irrigation equivalent to 25.4 mm rainfall increased the yield to 260 kg/ha DM and that equivalent to 50.8 mm rainfall increased it to 530 kg/ha DM.

Seed yields and harvesting :

In regard to seed production Villax (1963) records average seed yields varying from 100-300 kg/ha for *L. creticus* and *L. pedunculatus* under dryland conditions in the littoral zone of Morocco and Foury (1954) reports that at Rabat in Morocco seed yields of *L. corniculatus* can be raised to 500 kg/ha under irrigation.

Seed harvesting can be difficult for *L. corniculatus* since the long seed pods set seed over an extended period. Heath et al. (1973) report that in the USA pod shattering and seed loss can be high when relative humidity drops below 40 % and they recommend cutting before all the pods are mature and when a significant proportion of the pods are still light green ; the commonest and safest method of harvesting is to cut, windrow and then combine directly from the partially dried windrow.

In Morocco Villax (1963) recommends cutting *L. corniculatus* for seed production always at an early hour in the morning when the plants are wet with dew.

24.12. Utilization

Type of use :

All the previously mentioned *Lotus* spp. provide excellent grazing for sheep and cattle and some such as *L. corniculatus* and *L. creticus* provide excellent forage for conservation as hay, with *L. creticus* also being useful for soil conservation plantings.

First and second year management :

In both Morocco and Tunisia dryland *L. creticus* is not generally utilized in the first year but is cut for hay or grazed in subsequent years ; in Morocco Villax (1963) mentions that it can be grazed 3-4 times during the second and subsequent years, while Le Houerou (1965) and Le Houerou and Froment (1969, 1973) recommend in Tunisia 2-3 weedings, and a final cut to control weeds at the beginning of the summer in the first year, followed by 3-5 grazings from November to June in the second and subsequent years.

In Morocco Villax (1963) mentions that dryland *L. corniculatus* seeded in the autumn in the littoral zone can be cut in full flower for hay in April or May and the aftermath growth can then be grazed ; in subsequent years 1-2 cuts or 1-2 grazings can be taken during the period November-June.

Pasture longevity :

In Morocco Villax (1963) records that *L. creticus* can persist 3-4 years in dryland culture in the littoral zone, but only 1-2 years in the interior.

The longevity of *L. corniculatus* in North Africa and the Near and Middle East is not known since no long term field stands exist. However experience in the USA indicates that if dryland *L. corniculatus* is cut repeatedly for hay and not allowed to re-seed itself, stands will not persist over long periods. Natural re-seeding is a definite advantage too in maintaining stands and cutting heights should not be below 7-8 cm to prevent loss of axillary ends, which are needed to produce carbohydrates for re-growth (Heath et al., 1963).

Soil conservation value :

L. creticus has proved useful for soil conservation when seeded on sand dunes. In Israel Tsuriehl (1974) mentions that direct-sowing of *L. creticus* in rows parallel to the prevailing winds has proved very effective in combination with chemical sprays for fixing sand dunes. Similar conservation success has also been reported (Soil Conservation Authority, Victoria, 1968) in S. Australia, where *L. creticus* has grown well when seeded on coastal sands.

Further evaluation :

In the future more attention needs to be paid to the collection, multiplication and evaluation of native ecotypes of *Lotus* spp. in the region, since a wealth of material clearly exists that could have economic potential for ground cover, soil erosion control and pasture use under both arid and saline conditions.

24.13. Specific References

- | | |
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TECHNICAL DATA
SHEET No 25

PAPILIONACEAE (= FABACEAE)

Hedysarum spp.

25.1. Species

Among the large number of native *Hedysarum* spp. in the region *H. coronarium* L., *H. humile* L., *H. pallidum* Desf. non Biv., *H. spinosissimum* L., *H. carnosum* Desf. and *H. flexuosum* L., which occur chiefly in the Mediterranean and in N. Africa, are known to have a good forage value in semi-arid or arid areas.

25.2. Synonyms

- *H. humile* (= *H. confertum* Desf.)
- *H. flexuosum* (= *H. algeriense* Pomel.)
- *H. spinosissimum* (= *H. pallens* (Moris) Halacsy.)

25.3. Common Names

- | | | |
|---------------------------|---------|---|
| - <i>H. coronarium</i> | English | French Honeysuckle, Garland Cook's Head, Spanish Sulla, Sulla ; |
| | French | Sainfoin d'Espagne, Sainfoin à bouquets, Sainfoin des jardiniers, Sulla ; |
| | Arabic | Silla, Sella, Solla, Fudela (Morocco). |
| - <i>H. humile</i> | French | Hedysarum humble, Petit Sulla (Morocco). |
| - <i>H. pallidum</i> | French | Sulla pâle, Hedysarum pâle (Morocco). |
| - <i>H. carnosum</i> | French | Sulla rose, Hedysarum carné ; |
| | Arabic | Hazelaf (Morocco). |
| - <i>H. flexuosum</i> | French | Sulla annuel, Hedysarum flexueux (Morocco) ; |
| | Arabic | Solla, Serd, Fouila (Morocco). |
| - <i>H. spinosissimum</i> | French | Sulla épineux, Hedysarum en tête (Morocco) ; |
| | Arabic | Kheniget adjaiz (Morocco). |

25.4. Brief Description

- *H. coronarium* is a biennial, sometimes perennial legume with a strong taproot and numerous secondary roots and growing to a height of 80-150 cm with red, sometimes white or pink, flowers on long peduncles and brown strongly articulated pods with a spiny surface (Fig. 1 and 2) ;

- *H. humile* is a perennial plant growing to a height of 20-30 cm with a whitish colour; flowers purplish grouped in long bunches (6-10), the stipules adhere together opposite the leaves ; the fruits have pods divided into hairy joints covered with little tubercles or little spines, and containing 2-3 seeds (Fig. 3) ;

- *H. pallidum* is a distinctly perennial plant with a large rootstock attaining a diameter of 200-300 cm with also extremely powerful roots penetrating deeply in the soil ;

- *H. carnosum* is an annual erect growing species with red flowers and nearly straight hanging spiny or rough pods containing 2-5 seeds ;

- *H. flexuosum* is a robust erect growing annual reaching a height of 120 cm and forming a thick tuft ; the leaves have nearly round leaflets, the flowers are red or violet, 10-12 mm in length, forming thick bunches ; the fruits have a number of pods, forming rounded joints in a zigzag form, one on top of the other ;

- *H. spinosissimum* is an annual hairy plant growing from 10-45 cm high, with red or purple flowers grouped in pseudo-flower heads, leaves carrying 11-17 straight leaflets nearly glabrous on the upper surface, hairy and white on the lower surface, the fruits have flat pods divided into rounded hairy joints covered with small hooked spines (Fig. 4).

25.5. Varieties

Botanical subspecies and varieties :

In Morocco Foury (1954) records the following botanical sub-species and/or varieties of *H. humile*, *H. pallidum* and *H. spinosissimum* :

- *H. humile* :

- var. *Brivesii* Maire,
 - var. *speciosum* Emb. et Maire,
 - var. *subspeciosum* Emb. et Maire,
- present in littoral zones, plains and lower mountains.

- *H. pallidum* :

- var. *eu-pallidum* Maire
- present in the Rif, eastern steppe and littoral (Oran) zones ;



Fig. 1

Hedysarum coronarium (Orig. - Elvas 1953)

(After la Culture des plantes fourragères dans la région
Méditerranéenne occidentale, Rabat, 1963, p. 473, fig. 130)

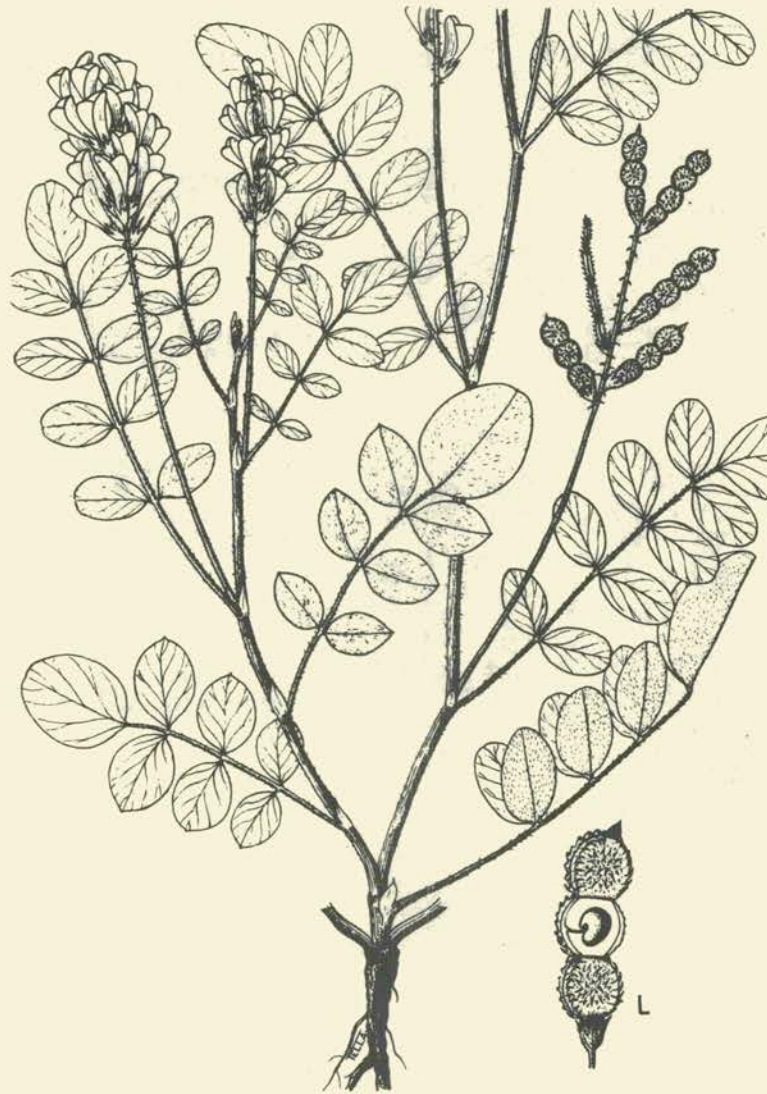


Fig. 2 - *Hedysarum coronarium*

Plant, x1. L : a cross section of a legume showing a seed.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas,
Madrid, 1965, p. 198)

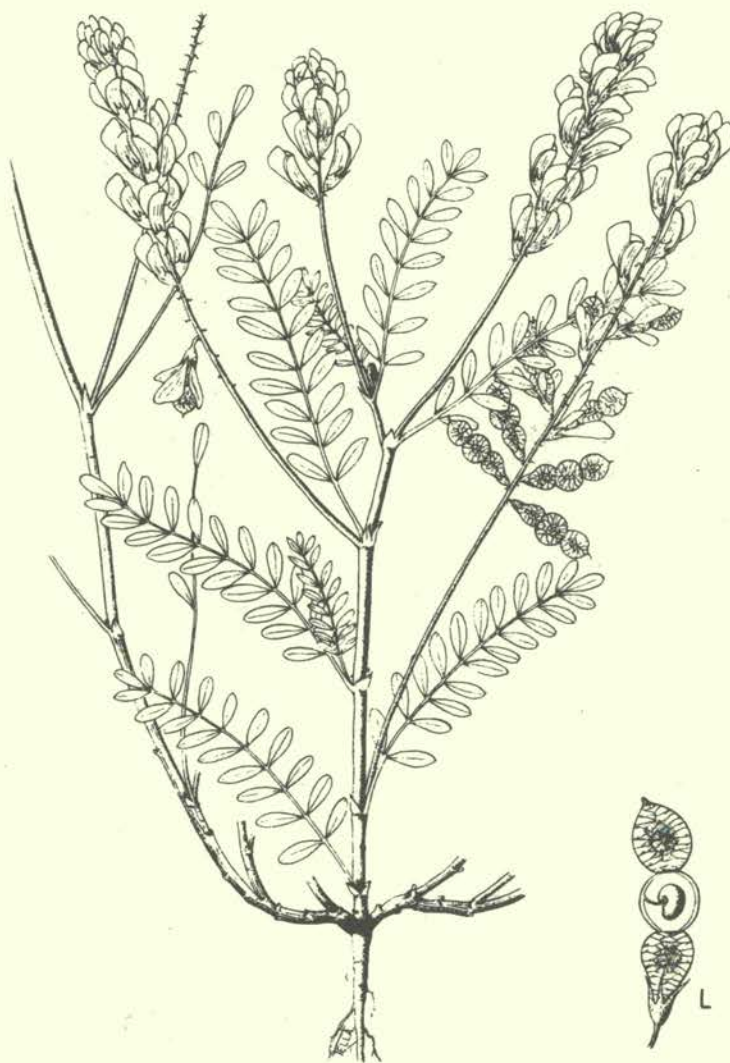


Fig. 3 - *Hedysarum humile*

Plant, x1. L : a cross section of a legume showing a seed.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas,
Madrid, 1965, p. 200)



Fig. 4 - *Hedysarum spinosissimum*

Plant, x1. L : a cross section of a legume showing a seed.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas,
Madrid, 1965, p. 202)

- var *atlanticum* Pomel. Batt.
present in the littoral (Oran) zone.
- *H. spinosissimum* :
 - ssp. *eu-spinosissimum* Briq. (= *H. spinosissimum* D.C.)
present in the Rif, Central region and Grand Atlas Mountains ;
 - ssp. *capitatum* (Desf.) Asch. et Graebn.
present in the west, central and eastern regions ;
 - ssp. *capitellatum* Pau et F.Q.
present in the Rif (Mt. Malmus).

In Libya Keith (1965) also records the following botanical subspecies and varieties of *H. spinosissimum* :

- ssp. *eu-spinosissimum* Briq. var *genuinum* Rouy
present at Leptis Magna in Cyrenaica ;
- var *genuinum* Rouy
present at Kussabat in Cyrenaica ;
- var *lanatum* Maire et Weill.
present in the marly hills west of Homs (200 m elevation)
near Tripoli ;
- var *pallens* (Moris) Rouy
present near Benghazi, Rahba, Tolmetta and Tobruk in
Cyrenaica, and near Tripoli, Kussabat, Tarhuna, Garian and
Bugheilan in Tripolitania.

Native ecotypes :

Many indigenous ecotypes of *H. coronarium* exist in the native vegetation in North Africa, Spain and particularly Italy. In general the Spanish and Italian ecotypes are more sensitive to the cold than those from North Africa. In Italy ecotypes from Northern Italy exhibit greater cold tolerance than those from Southern Italy and Sicily. Among the ecotypes tested from Northern Italy "Grimaldi", "Fabricano", "Force Ombrone" and "Iesi" show the best forage yield per plant (Monotti, 1975), while in Sicily the variety "Sparacia 1" selected from a local population has proved suitable for haymaking and grazing in autumn and spring (Ballatore, 1969). A new variety No. 564 from Italy has also produced a green forage yield of 13,000 kg/ha in one cut under dryland conditions in Sicily (Conti, 1956).

In Tunisia several local ecotypes of *H. coronarium* have been collected, multiplied and tested (Corriols, 1965), but the main ecotype multiplied for agronomic use is actually an erect ecotype ("Sgaravatti" 1187) selected in Italy showing superior productivity compared to the local ecotypes, which are generally prostrate in growth habit and not adapted to cutting for hay (Le Houerou, 1965) ; hard-seediness is only 10-30 % in the case of "Sgaravatti 1187" compared to 30-70 % for the local ecotypes.

In Algeria eight local varieties of *H. coronarium* and one local variety of *H. flexuosum* have been tested under dryland conditions (Barbut, 1955).

A number of ecotypes of *H. flexuosum*, *H. pallidum* and *H. spinosissimum* have also been collected in Morocco and tested under dryland conditions (Foury, 1950).

25.6. Number of Chromosomes

H. coronarium : $2x = 18$; *H. spinosissimum* : $2x = 16$;
for the other species not known.

25.7. Geographical Distribution

H. coronarium is distributed in Mediterranean Europe, Egypt (UAR), North Africa (Algeria, Morocco, Tunisia) and cultivated in Greece, Spain, Portugal and North Africa (Morocco) ;

H. flexuosum is distributed in Portugal, Southern Spain, North Africa (Morocco and eastern Algeria) ;

H. spinosissimum is distributed in S. Europe, Cyprus, W. Syria, N. Egypt, North Africa (Morocco, Algeria, Tunisia) and Turkey ;

H. humile is distributed in Spain, southern France and North Africa (Morocco) ;

H. carnosum and *H. pallidum* are distributed in North Africa (Morocco, Algeria, Tunisia).

25.8. Biology and Ecology

Growth and development :

All the species of *Hedysarum* previously mentioned propagate themselves by seed and grow well in the Mediterranean basin.

In the Mediterranean region *H. coronarium* grows best in areas where the winters are mild, but in Morocco Villax (1963) states that it also supports more rigorous winter temperatures, although it will not stand frequent temperatures below -4°C (Foury, 1954).

In the first winter *H. coronarium* develops rather slowly depending on the incidence of the autumn rains which influence the timing of seed germination ; in Malta active growth begins about November. Growth is accelerated in the spring in the Mediterranean region and continues up till the onset of the dry summer.

In the littoral zone of Tunisia *H. coronarium* remains green up to mid-June, but becomes dry thereafter only becoming green again at the onset of new growth in the autumn (beginning of October) (Corriols, 1965). At this time re-growth is vigorous after the first rains and in the littoral zone of Tunisia flowering is early taking place from the end of November up to the beginning of January.

H. flexuosum, closely related to *H. coronarium*, and also *H. carnosum* and *H. spinosissimum* exhibit the same pattern of growth, but being annual species, they die with the onset of the dry summer period.

Seed characteristics :

Seeds of certain native ecotypes of *Hedysarum* spp., particularly *H. coronarium* and *H. flexuosum*, exhibit a hard-seediness which causes delayed germination and is a survival mechanism which operates successfully in dry seasons.

Climate and soils :

H. coronarium is specific in regard to its climate requirements, which are an annual rainfall of at least 400 mm with a range of 400-1,000 mm and mild winters with the minimum temperature in January superior to 3°C. Evidence for the rather precise rainfall requirement of *H. coronarium* is shown by the fact that it grows well in Malta but has failed completely in Cyprus (Whyte, 1949) where the amount and duration of the rainfall is insufficient.

Both *H. carnosum* and *H. spinosissimum* are more drought resistant than the other *Hedysarum* spp. and are well adapted to steppe and desert areas with 100-400 mm annual rainfall.

In regard to edaphic conditions the following are the requirements for individual *Hedysarum* spp. :

H. carnosum : adapted to calcareous clay and gypsiferous soils ;

H. coronarium : prefers fertile calcareous clay soils ;

H. flexuosum : prefers fertile calcareous clay soils ;

Both *H. coronarium* and *H. flexuosum* do not grow well on poor, sandy or marshy soils ;

H. pallidum : adapted to calcareous sandy and also saline and gypsiferous soils ;

H. spinosissimum : adapted to calcareous clay and sandy soils, and also to alluvial river soils.

Ecological characteristics :

In the littoral zone of North Africa natural pastures of *H. carnosum*, *H. coronarium*, *H. flexuosum* and *H. spinosissimum* are found on clay (marl) soils especially in Morocco and Tunisia. In the Tunisian steppe Le Houerou (1969) records *H. carnosum* growing on clay soils in association with *Moricandia arvensis* ssp. *suffruticosa* and *Atriplex glauca* (300-350 mm annual rainfall).

Le Houerou (1969) also mentions *H. spinosissimum* as being present in the following plant association in the Tunisian steppe : *Artemisia campestris* and *Minuartia geniculata* (300-400 mm annual rainfall, 800-1,200 m elevation) ; *Artemisia campestris* and *Aristida plumosa* (200-300 mm annual rainfall, 500-800 m elevation) ; *Eragrostis papposa*, *Ziziphus lotus* and *Artemisia campestris* (200-350 mm annual rainfall, 100-1,000 m elevation) ; *Echiochilon fruticosum*, *Cutandia divaricata* and *Lavandula multifida* (300-400 mm annual rainfall, 300-400 m elevation) ; *Launaea resedifolia*, *Diploaxis simplex* and *Cutandia dichotoma* (180-300 mm annual rainfall, less than 300 m elevation), and *Chrysanthemum coronarium* and *Peganum harmala* (200-300 mm annual rainfall, 100-600 m elevation).

In Turkey Davis (1969) records that *H. spinosissimum* is present on rocky slopes from sea level to 100 m elevation.

In Morocco *H. humile* occurs in forest clearings and rocky clay pastures of the lower mountains, while *H. pallidum* is found in the brush vegetation of the plains and lower mountains. In the Tunisian steppe Le Houerou (1969) records *H. pallidum* as occurring in association with *Phalaris truncata*, *Cynara cardunculus* and *Medicago tunetana* (400-500 mm annual rainfall, 800-1,200 m elevation).

25.9. Cultivation Techniques

Time of seeding :

In the littoral zone of North Africa (500-600 mm annual rainfall) all the above mentioned *Hedysarum* spp. are normally planted at the end of September under dryland conditions, but planting can continue till December although it is hazardous if unhulled seeds are sown (Foury, 1954, Granier, 1966) ; in Malta *H. coronarium* is seeded in August (O'Donovan, 1972).

Land preparation :

Before planting the soil should be well worked because the seeds require a fine seed-bed ; at least 2-3 cultivations are required after ploughing using a tine cultivator (Granier, 1966).

Seed treatment :

Corriols (1965) mentions that because seeds of native ecotypes of *H. coronarium* in Tunisia exhibit a high percentage of hard-seediness this necessitates removal of the seeds from the pods before planting. In contrast, improved varieties of *H. coronarium* from Italy and Spain have proved to have a low percentage of hard seeds when cultivated in Tunisia and their removal from the pods has proved unnecessary.

For *H. coronarium* the treatment giving the best results has proved to be soaking the seeds in hot water (65-75°C) for one minute ; water at higher temperatures has impaired germination (Cavazza, 1950). This method has also proved effective in Algeria where scarification of seeds of *H. coronarium* has also given good results (Gallacher, 1972). Alternatively seeds can be immersed in a solution of CaCO_3 (50°C) ; pricking of the seeds with a pin has also assisted the germination of the seeds of *H. flexuosum* as the following data (Foury, 1954) shows :

	Daily Germination % Seeds													Final Germination % Seeds
Nature of Seeds harvested 1950	1	2	3	4	5	6	7	8	9	10	15	30		
Unhulled seeds sown 23 Dec. 1950	0	0	0	0	0	1	0	0	0	0	0	0	1	
Hulled seeds sown 5 Jan. 1950	0	0	0	4	12	6	0	0	0	2	1	0	25	
Hulled seeds pricked with a pin sown 22 Jan. 1950	0	27	28	4	0	0	0	0	2	0	0	0	67	

Germination of the seeds of *H. flexuosum* has also been affected by the length of time elapsing between harvesting and sowing the seed as well as sowing hulled or unhulled seed as the following data (Foury, 1954) shows :

Nature of Seeds harvested in 1951 and 1952	Germination Percentage after 7 days	Germination Percentage after 15 days
Hulled seeds harvested 1951 sown 8 Aug. 1952	69	78
Hulled seeds harvested 1952 sown 8 Aug. 1952	37	51
Unhulled seeds harvested 1952 sown 12 Aug. 1952	0	1

Seed rate, spacing and method of seeding :

In North Africa the seeds are planted usually on the contour in rows spaced 30-50 cm apart for *H. coronarium* and 20-40 cm apart for *H. flexuosum* ; in Tunisia an 80 cm row spacing has also been used for *H. coronarium* (Granier, 1966).

The seed rate depends on whether hulled or unhulled seeds are sown and also on the desirability of obtaining a dense stand.

In Tunisia hulled seeds are preferred because they germinate more rapidly (5-10 days for *H. coronarium*) and are easier to clean and multiply. Unhulled seeds germinate less rapidly (15-30 days for *H. coronarium*) and germination is more affected by the irregularities of the rainfall. In Morocco higher seeds rates are preferred because a denser sowing is considered to ensure the development of fine stems. In Tunisia and Morocco the following seed rates are recommended for *Hedysarum* spp. :

Tunisia

H. coronarium :

25-30 kg/ha unhulled seeds,
10-20 kg/ha hulled seeds (Le Houerou (1965) and Le Hou  rou and Fro-
35 kg/ha unhulled seeds, ment (1969, 1973);
15 kg/ha hulled seeds (Foury, 1954) ;
30 kg/ha unhulled seeds,
10 kg/ha hulled seeds (Granier, 1966) ;

Morocco

H. coronarium :

30-50 kg/ha hulled seeds (Villax, 1963) ;
20-30 kg/ha hulled seeds (Foury, 1954) ;
25-50 kg/ha unhulled seeds,
10-20 kg/ha hulled seeds (Ionesco et al., 1969) ;

H. flexuosum :

25-30 kg/ha hulled seeds (Villax, 1963) ;
20-30 kg/ha hulled seeds,
75-100 kg/ha unhulled seeds (Foury, 1954) ;

H. pallidum and *H. spinosissimum* :

20-30 kg/ha hulled seeds,
75-100 kg/ha unhulled seeds (Foury, 1954).

If unhulled seeds of *Hedysarum* spp. are planted, they must be broadcast by hand, but hulled seeds can also be seeded mechanically. In Tunisia Granier (1966) records excellent establishment for *H. coronarium* when seeded with a Lister planter and also an Ebra seeder. Fig. 5 shows a dryland stand of *H. coronarium* planted near Tunis in its second year :



Fig. 5

H. coronarium planted near Tunis (second year)
(After Bull. Ecol. Nat. Sup., Tunis, No 10, 1966, p. 32)

Fertilizer application :

In Tunisia Le Houérou (1965) and Le Houérou and Froment (1969, 1973) recommend fertilizing the soil before seeding with 50-100 kg/ha of P_2O_5 , which is well mixed with the surface soil, and to follow this by a surface application of 5 kg/ha N and 5 kg/ha P_2O_5 applied locally to the rows at seeding, while Granier (1966) recommends applying 50-60 kg/ha P_2O_5 locally to the rows at seeding. In Algeria Maignan (1970) records an application of 90 kg/ha P_2O_5 in the autumn of the first and succeeding years. In Morocco Bouzoubaa et Michel (1969) recommend the following fertilizer application :

first year : 60-80 kg/ha P_2O_5 ; 40-60 kg/ha K_2O mixed with the soil before sowing then 20 kg/ha N at sowing ;

second year : 40-60 kg/ha P_2 ; 40 kg/ha K_2O in the autumn.

25.10. Forage Value

Palatability and non-bloat characteristics :

The forage value of *H. coronarium* is good, and it does not cause bloat being appreciated by all livestock up to the appearance of the first flowers ; four days later the leaves become hard and it is avoided by livestock (Corriols, 1965).

Nutritive value :

H. coronarium is considered to be nearly as nutritious as *Medicago sativa* but is less appreciated by both cattle and sheep in the dry state when the leaves are very fibrous and it can readily lose its leaves. Nevertheless its roughage value in the dry state is considered of value by farmers in Malta who feed it along with cereals (straw and grain) to their livestock (O'Donovan, 1972).

The nutritive value of both *H. coronarium* and *H. flexuosum* is good as the following chemical composition data from Tunisia and Morocco show :

Tunisia

<i>H. coronarium</i> (variety 1834 from Sicily)						
Percentage Digestible Products						
Date Sampled	Protein	Fats	Cellulose	Non-N Extract	Metabolizable Energy kg/Green Matter	Forage Units/kg
13.3.56	2.04	0.69	3.20	3.50	374 c	0.10
7.5.56	1.94	0.85	5.05	5.05	421 c	0.12

Morocco

<i>H. coronarium</i> : Percentage Composition						
	Water	Ash	Protein	Fats	Non-N Extract	Cellulose
2.6.49						
Green Matter	79.00	2.00	3.20	0.31	11.10	4.34
Dry Matter	0	9.84	15.28	1.48	52.47	20.93
19.11.49						
Green Matter	76.12	3.20	4.02	0.61	11.61	4.44
Dry Matter	0	13.44	16.77	2.55	48.64	18.60
11.3.49						
Green Matter	88.39	1.27	2.92	0.53	5.75	1.14
Dry Matter	0	10.94	25.20	4.63	49.38	9.85
28.4.49						
Green Matter	78.22	3.07	3.55	0.61	10.83	3.72
Dry Matter	0	14.09	16.32	2.81	49.70	17.08

<i>H. flexuosum</i> : Percentage Composition						
	Water	Ash	Protein	Fats	Non-N Extract	Cellulose
22.6.51						
Green Matter	74.94	2.76	3.12	0.79	12.58	5.81
Dry Matter	0	11.02	12.47	3.16	50.13	23.22
Silage						
Green Matter	79.70	2.70	3.30	0.88	7.14	6.28
Dry Matter	0	13.33	16.25	4.35	35.16	30.91

In Morocco Ionesco (1969) reports a forage value of 0.11 forage units, 25 g digestible protein per kilogramme green forage and 21 percent dry matter for *H. coronarium*.

In Malta a chemical analysis of *H. coronarium* in the green state has shown a crude protein content of 15.7 % and a fibre content of 19.9 % for the upper leafy portion, and a crude protein content of 9.8 % and a fibre content of 30.8 % for the lower stemmy portion of the plant (O'Donovan, 1972).

In Italy Maymone et al. (1951) have given the following chemical composition data for *H. coronarium* (see tables 1-4 below) :

Table 1 Chemical Composition of stem, leaves and inflorescence of *H. coronarium* L. (referred to dry matters)

Parts of the plants	Crude Protein %	Crude Fats %	Crude Fibre %	Ash %	N-free Extract %
Stems at the beginning of the blooming	19.37	2.40	43.83	7.82	26.58
Stalks, leaves and flowers of the same plant	20.25	3.20	22.27	12.32	41.96
Stems in full bloom	7.87	1.31	42.50	7.59	40.73
Stalks, leaves and flowers of the same plant	18.81	2.79	21.22	12.19	44.99
Stems in advanced bloom	7.50	0.94	46.50	8.42	36.64
Stalks, leaves and flowers of the same plant	20.44	2.97	18.35	13.74	44.50

Table 2 Mineral Composition of *H. coronarium* L. in 100 gr of ash

Vegetative stage	Na %	K %	Ca %	Mg %	P %	S %	Cl %	Fe %	Si %
At the beginning of the blooming	10,89	26,40	9,02	1,96	2,74	5,93	3,39	0,60	1,57
In full bloom	10,32	23,64	9,27	2,32	4,93	4,19	3,31	0,70	2,03
Hay	11,38	17,68	13,10	2,47	2,68	3,14	3,16	0,67	2,77

Table 3 Vitamin contents of *H. coronarium* L. in pre-florescent stage

	In 100 gr green matter	In 100 gr dry matter
1- b-Carotene	gamma 2.820	gamma 18.200
2- Thyamin. (Vit. B ₁)	gamma 300	gamma 1.935
3- Riboflavine (Vit. B ₂)	gamma 230	gamma 1.485
4- Tocopherol (Vit. E) ²	mg. 2,86	mg. 18,45
5- 1-ascorbic acid (Vit. C)	mg. 47,0	mg. 310,0

Table 4 Total digestible nutrients of *H. coronarium* L. in a moisture-free basis

Vegetative stage	Digestible crude protein %	T.N.D. (total digestible nutrients)%
At the beginning of the blooming	13,69	68,3
In full bloom	8,02	57,3
Hay	7,65	47,1

25.11. Forage and Seed Production

Forage yields :

In the littoral zone of Tunisia *H. coronarium* has provided forage under dryland conditions over a three year period. Corriols (1965) states that the most interesting varieties are the following :

- Sgaravatti (Italy) No. 1.887 giving 10,200 forage units/ha in the second year and 9,500 forage units/ha in the third year ;
- Sicily No. 1.834 giving 8,200 forage units/ha in the second year and 9,700 forage units/ha in the third year ;
- Italy No. 2.645 giving 8,300 forage units/ha in the first year.

These three varieties are clearly superior to the local ecotype Beja that gives 4,160 forage units/ha in the second year and 4,750 forage units/ha in the third year, and the following forage production data is recorded for this ecotype and variety Nos. 1.887, 1.834 and 2.645 :

1955-56 (664.7 mm rainfall) <u>second year</u>					1956-57 (492.2 mm rainfall) <u>Third year</u>			
Variety	kg/ha Green Matter	kg/ha Dry Matter	kg/ha dig. Protein	Forage Units/ ha	kg/ha Green Matter	kg/ha Dry Matter	kg/ha dig. Matter	Forage Units/ ha
No. 1887	92,879	15,789	1,857	10,212	85,991	14,618	1,719	9,459
No. 1834	75,325	12,805	1,506	8,285	88,324	15,015	1,766	9,715
Beja T3	53,872	9,158	1,077	5,925	49,439	8,404	988	5,438
No. 2645	--	--	--	--	76,325	<u>First year</u>		8,395
						12,975	1,526	

Le Houerou (1965) and Le Houerou and Froment (1969, 1973) record that green forage yields of *H. coronarium* in Tunisia average 20,000-30,000 kg/ha in the first year, and 30,000-50,000 kg/ha in the second year, but in certain years yields can reach 70,000-90,000 kg/ha. In the littoral zone of Morocco Villax (1963) records average green forage yields of 25,000-50,000 kg/ha and hay yields of 6,000-12,500 kg/ha for *H. coronarium*, and average green forage yields of 14,000-28,000 kg/ha and average hay yields of 3,500-7,000 kg/ha for *H. flexuosum*.

In the high plateaux zone (450-600 mm annual rainfall) of Algeria Maignan (1970) and Gallacher (1972) report green forage yields for various varieties of *H. coronarium* varying from 16,000-65,000 kg/ha green forage in two cuts in the period February-May.

In Morocco Ionesco et al. (1969) also report green forage yields of 20,000-30,000 kg/ha in the first year, and 30,000-50,000 kg/ha in the second year ; with irrigation (4,000-5,000 m² of water per ha) yields can be more than 60,000 kg/ha.

Seed yields :

In Morocco Villax (1963) reports average seed yields of 300-600 kg/ha for *H. coronarium* and 200-300 kg/ha for *H. flexuosum*, but Foury (1954) records an average seed yield of only 20-50 kg/ha for *H. coronarium* under dryland conditions at Rabat (Morocco).

In Tunisia Granier (1966) mentions that a row spacing of 80 cm permits a good seed yield in the first year ; in Italy the highest seed yield under dryland conditions, about 300 kg/ha, has been obtained from a 35 cm row spacing (Prima, 1972).

25.12. Utilization

Type of use :

H. humile, *H. pallidum*, *H. carnosum* and *H. flexuosum* are most useful for grazing, while the utilization of *H. coronarium* is sometimes not easy on account of the large amount of forage produced per unit area over a relatively short period. For *H. coronarium* it is therefore necessary to use a combination of grazing, zerograzing (soiling) and conservation as hay or silage to make proper use of the large amount of forage produced.

Time of cutting for hay and silage :

For *H. coronarium* in the littoral zone of North Africa (500-600 mm annual rainfall) both silage and hay making may have to be delayed until April on account of heavy rains in the period January-March. A silage cut is preferable where possible in January-February, since the first cut gives the largest forage yield and the maximum yield of protein is also obtained at the beginning of flowering. In practice the cutting of *H. coronarium* for hay or silage is only possible when it is in full flower.

Conservation of silage :

The conservation of good silage from *H. coronarium* is possible if certain precautions are taken. The crop should have a dry matter content of 30 % for ensiling. Preferably the crop should be chopped before placing in the silo (Fig. 6) and chopped straw can also be added in layers (5 cm deep) alternatively with layers of *H. coronarium* (20-30 cm deep). The addition of a preservative preferably sodium metabisulphite (3-5 parts per 1000) is also recommended as well as good consolidation in the silo preferably using a caterpillar tractor (Le Houerou, 1965, and Le Houerou and Froment, 1969, 1973).

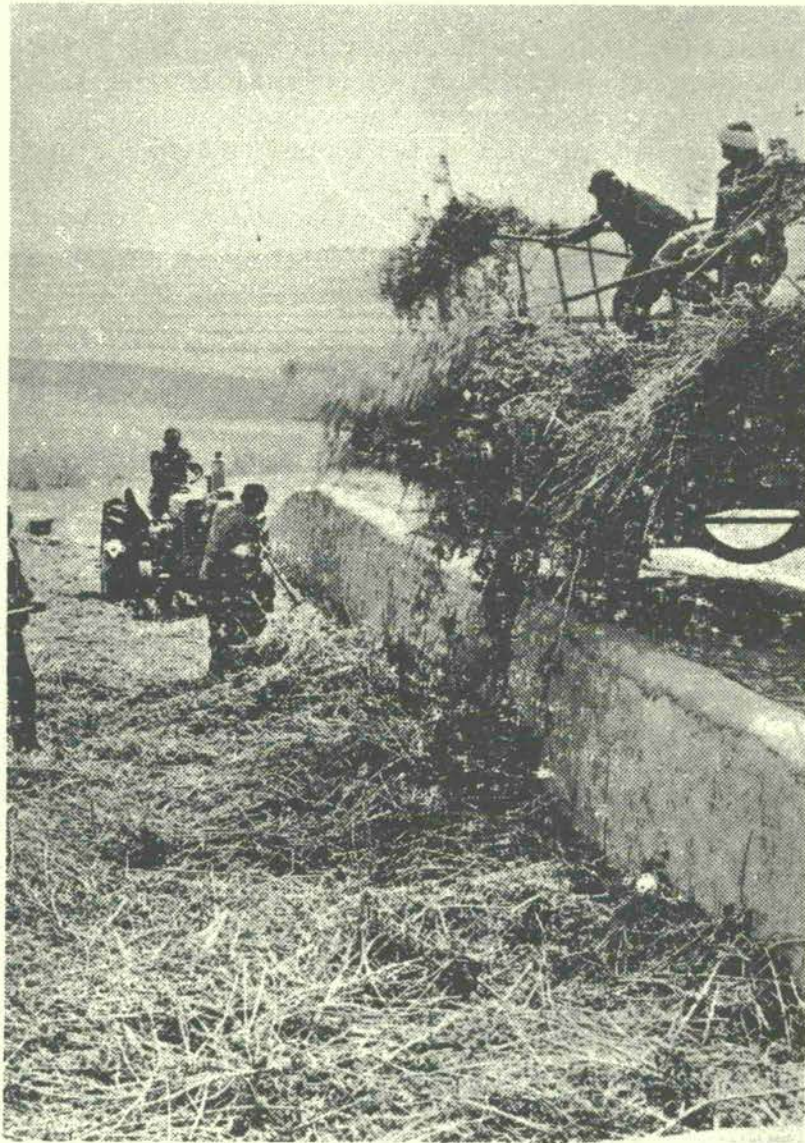


Fig. 6 - *H. coronarium* being unloaded into a concrete silo in Tunisia
(After Bull. Ecol. Nat. Sup., Tunis, No 10, 1962, p. 32)

Management for permanent pasture :

In Tunisia on clay soils with steep slopes, it is recommended to maintain permanent pastures of *H. coronarium*. This can be effected by leaving the last cut of the second year for seed production. After seed maturity and in the course of the harvest sufficient seeds fall to the ground to maintain the pasture in succeeding years ; under these conditions the original row planting lines disappear and the pasture becomes a dense stand.

H. pallidum, which is a perennial species, can of course be left as a permanent pasture for several years, but if left for a longer period the root stock becomes very strong and fibrous, which hinders the further exploitation of the pasture.

Soil fertility and use in rotations :

H. coronarium, in particular, greatly aids the build up of soil organic matter. Pantanelli (1950) estimates that a 2 year pasture produces about 20 tons/ha of dry roots equivalent to about 100 kg of nitrogen or the equivalent of 60 tons of cow manure. Because *H. coronarium* enriches the soil Le Hou  rou (1965) and Le Hou  rou and Froment (1969) recommend that it be grown in rotation with wheat in both the 400-500 mm and 500-1,000 mm annual rainfall zones in Tunisia.

Carrying capacity :

In regard to carrying capacity Granier (1966) has estimated that 2-2.5 ha of *H. coronarium* provides sufficient forage under grazing utilization to feed 30 dairy cows for three months ; this entails an output of 6,000 forage units/ha which is a normal yield for *H. coronarium* in the littoral zone of Tunisia.

Further evaluation :

More attention needs to be given to the collection of native ecotypes of the *Hedysarum* spp. mentioned other than *H. coronarium*, since they show excellent adaptation to dry areas and some also to saline and gypsiferous soils.

25.13. Specific References

- | | |
|--------------------------|--|
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TECHNICAL DATA

SHEET No 26

PAPILIONACEAE (= FABACEAE)

Trifolium spp.

26.1. Species

Among the numerous native *Trifolium* spp. occurring in the region there are some nine species including *T. subterraneum* L., *T. alexandrinum* L., *T. ambiguum* M.B., *T. cherlei* L., *T. fragiferum* L., *T. hirtum* All., *T. pilulare* Boiss., *T. resupinatum* and *T. tomentosum* which are all widespread and have a good forage value in dryland plantings.

26.2. Synonyms

- *T. alexandrinum* (= *T. maritimum* (non Huds.), *T. panormitanum* (non Presl Anth.)
- *T. ambiguum* (= *T. ambiguum* var *majus* Hossain)
- *T. fragiferum* (= *T. fragiferum* var *pulchellum* Lange.)
- *T. resupinatum* (= *T. resupinatum* var *majus* Boiss., *T. resupinatum* var *microcephalum* Zoh.)

26.3. Common Names

- | | | |
|--------------------------|---------|--|
| - <i>T. subterraneum</i> | English | Subterranean Clover,
Subterranean Trefoil. |
| | French | Trèfle souterrain,
Trèfle semeur. |
| | Arabic | Beid-diez-Zouch (Morocco) ;
El-Nefel, El Ardhi (Syria). |
| - <i>T. alexandrinum</i> | English | Alexandrian Clover,
Egyptian Clover,
Berseem. |
| | French | Bersim,
Trèfle d'Alexandrie,
Trèfle alexandrin. |
| | Arabic | Bersim, Berseem, Bersyn (Morocco) ;
Berseem, Berzoon (Egypt (UAR) ;
Barsim Masri', Barsim (Saudi
Arabia) ;
Bersim (Libya). |
| - <i>T. ambiguum</i> | English | Kura Clover (USA). |

- <i>T. cherlei</i>	English	Cupped Clover (Australia).
- <i>T. fragiferum</i>	English	Strawberry Clover, Strawberry headed Clover, Strawberry Trefoil, Strawberry headed Trefoil.
	French	Trèfle fraise, Trèfle porte-fraise, Trèfle capiton.
	Arabic	Nifil el Fraiz (Syria) ; Nifil (Iraq).
- <i>T. hirtum</i>	English	Rose Clover (Australia).
- <i>T. resupinatum</i>	English	Persian Clover, Reversed Clover, Reversed Trefoil, Shaftal Clover (USA) ; Peshawar Clover (India).
	French	Trèfle de Perse, Trèfle renversé.
	Arabic	Qort, Goreida, Loeyna, Khaneyshe, (Egypt (UAR) ; Naflah (Jordan) ; El Nefel El Farsi (Syria) ; Nafal, Nifil, Nafal Ahmar, Qurt (Iraq).
- <i>T. tomentosum</i>	English	Woolly Trefoil (Libya) ;
	Arabic	Nefel (Libya).

26.4. Brief Description

- *T. subterraneum* is a prostrate annual legume branching from the base with a relatively strong tap root and reaching a height of 15-30 cm with white flowers on axillary stalks and having pods composed of a network of fibres each containing one seed ; after fertilization the flower stalk turns downwards and the fruit and seed is buried (Fig. 1 and 2) ;

- *T. alexandrinum* is an erect growing annual legume reaching a height of 30-90 cm with yellowish-white flowers and egg-shaped seeds (Fig. 2 and 3) ;

- *T. ambiguum* is a procumbent to ascending rhizomatous perennial legume reaching a height of 10-30 cm, with pinkish-white flowers and a beaked pod containing two seeds ;

- *T. cherlei* is an annual legume reaching a height of 6-30 cm with globular white flowers and ovoid yellow seeds (Fig. 4 and 7 (10-11) ;

- *T. fragiferum* is a creeping stoloniferous perennial legume rooting at the nodes and reaching a height of 15-40 cm with pale-pink flower-heads and ovate pods each containing two light brown seeds (Fig. 5 and 6) ;

- *T. hirtum* is an annual legume branching at the base with decumbent and prostrate branches and a deeper root system than *T. subterraneum* and reaching a height of 8-40 cm with globular pubescent flowerheads and crimson flowers and ovoid yellow seeds (Fig. 7 (1-9) and 8) ;

- *T. pilulare* is an erect or decumbent annual legume with densely hairy stems branching from the base and reaching a height of 6-25 cm with creamy-white flowers, ovoid pods and rounded black smooth seeds (Fig. 9) ;

- *T. resupinatum* is an erect decumbent or prostrate annual legume, branching from the base and reaching a height of 15-30 cm, with prostrate stems attaining a length of 50-100 cm, and with pink-mauve very sweet-smelling flowers and ovoid pods and pale brown seeds (Fig. 10 and 11) ;

- *T. tomentosum* is an erect decumbent or prostrate annual legume, branching from the base and reaching a height of from 5-20 cm and having yellow flowers and woolly fruits (Fig. 12).

26.5. Varieties

Botanical subspecies and varieties :

A number of botanical subspecies and varieties of *T. subterraneum*, a polytypic group with a wide geographical and ecological range, have been recorded by Katznelson and Morley (1965) in Europe, the Mediterranean and the Near East which are the following :

- subsp. *subterraneum*
with plants usually pubescent and calyx longitudinally veined ;
- var. *subterraneum*
with compact plants ;
- var. *majureculum* (Andamovic)
with more loose and robust branches ;
- var. *brachycladum* Gib. et Bell.
with peduncles much shorter than the petioles ; also recorded by Madueno (1954) in Spain ;

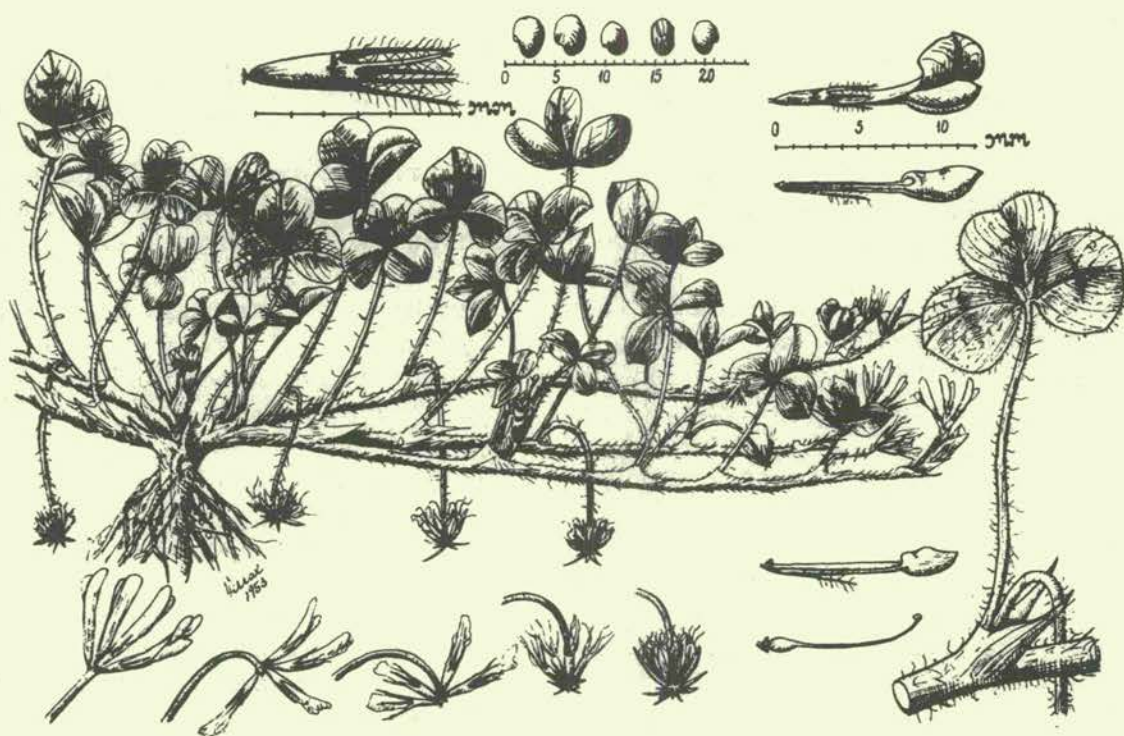


Fig. 1

Trifolium subterraneum L.
(Orig. - Elvas 1953)

(After La Culture des plantes fourragères dans la région
Méditerranéenne occidentale, 1963, p. 443, fig. 117)

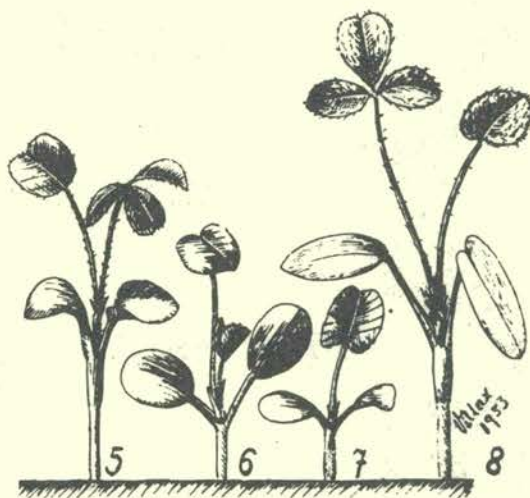


Fig. 2

Seedlings of the genus *Trifolium* 14 days after emergence

- 5. *T. alexandrinum*
- 6. *T. resupinatum*
- 7. *T. fragiferum*
- 8. *T. subterraneum*

(After la Culture des plantes fourragères dans la région Méditerranéenne occidentale, 1963, p. 441, fig. 116)

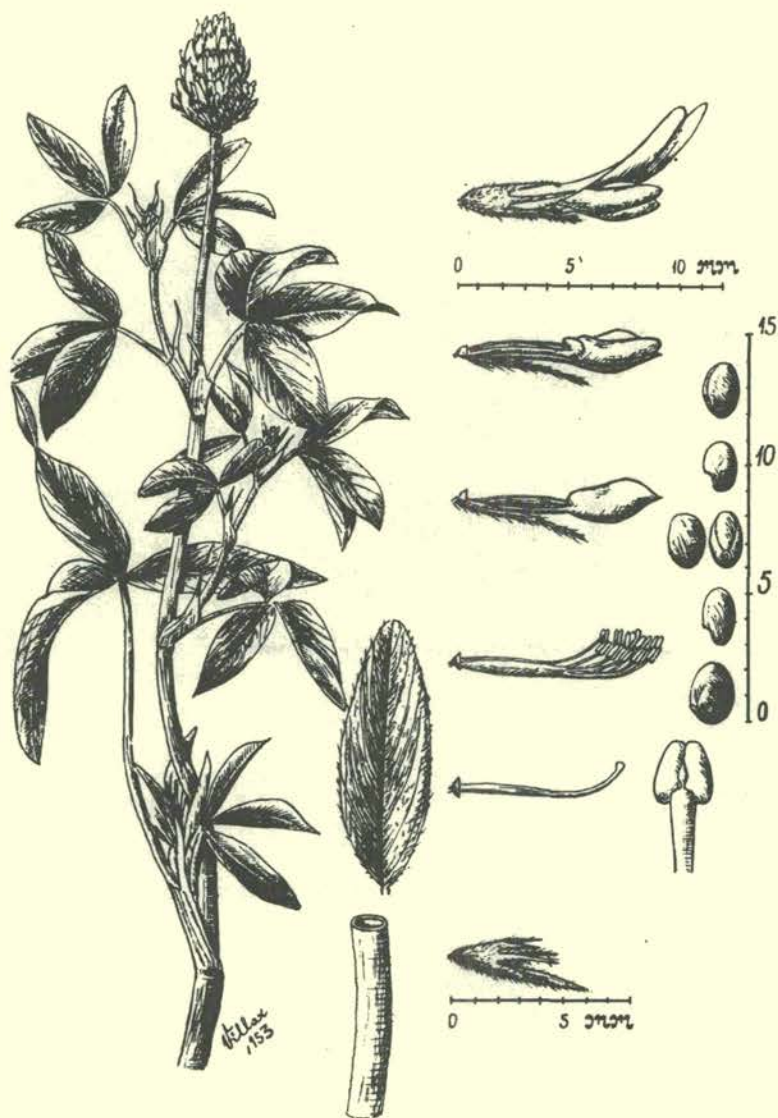


Fig. 3

Trifolium alexandrinum L.
(Orig. - Elvas 1953)

(After la Culture des plantes fourragères dans la région
Méditerranéenne occidentale, 1963, p. 1609, fig. 105)

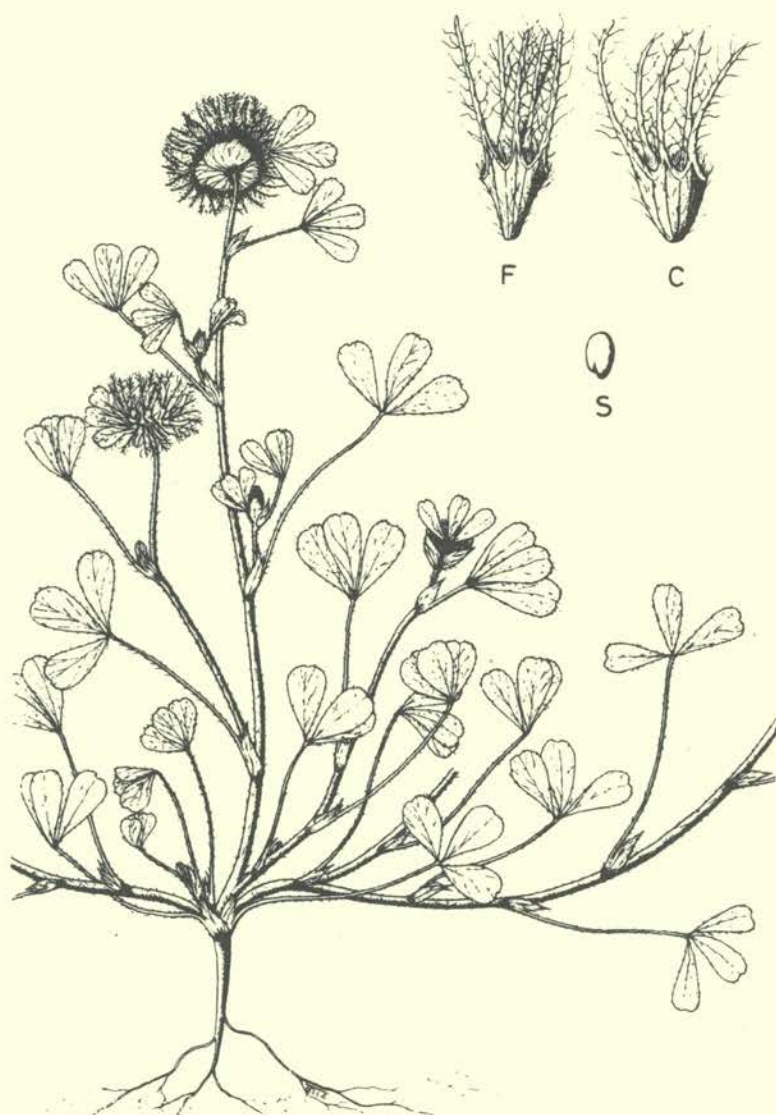


Fig. 4 - *Trifolium cherlei*

Plant, x1. F : Flower, x4. C : Fruit bearing calyx, x4. S : seed, x4.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas,
Madrid, 1965, p. 297)

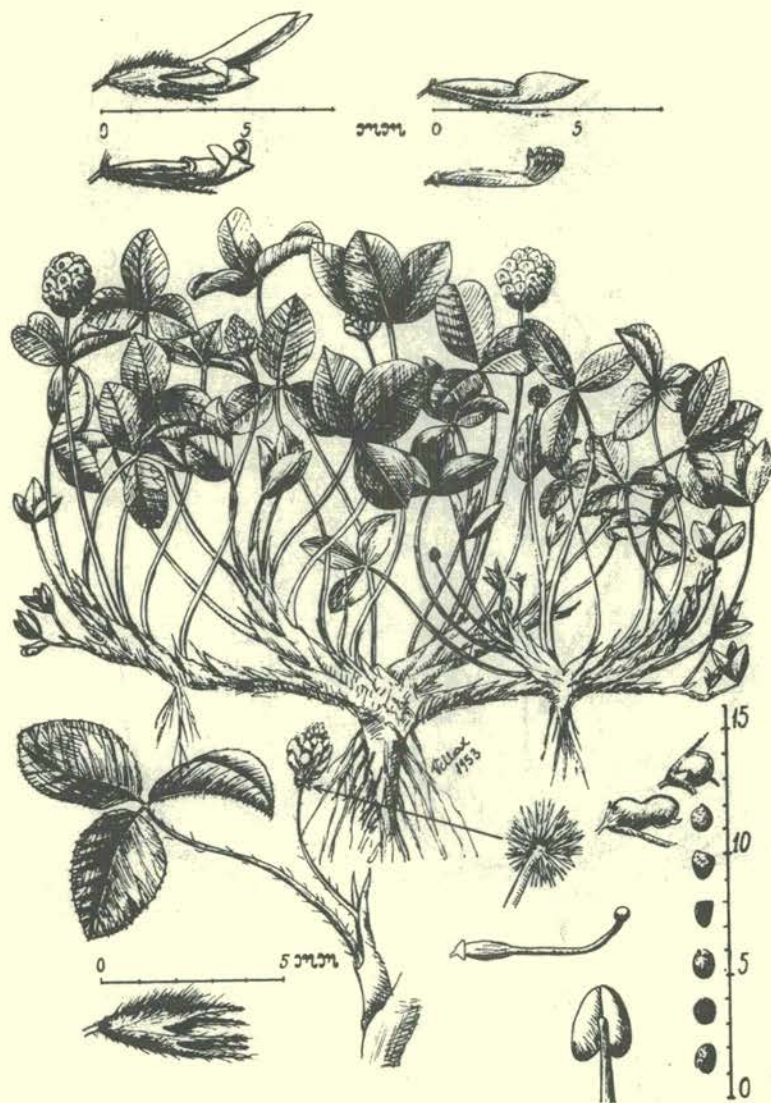


Fig. 5

Trifolium fragiferum L.
(Orig. - Elvas 1953)

(After la Culture des plantes fourragères dans la région
Méditerranéenne occidentale, 1963, p. 417, fig. 107)

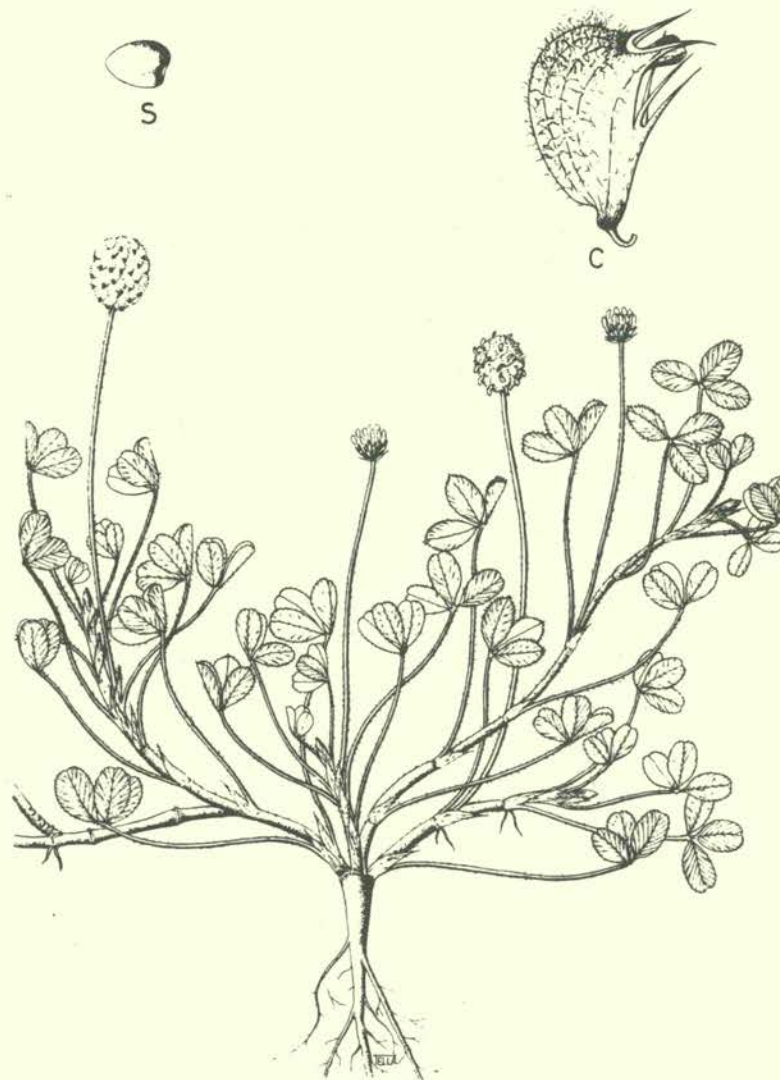


Fig. 6 - *Trifolium fragiferum*

Plant, x1. C : Fruit bearing calyx, x8. S : Seed, x8.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas,
Madrid, 1965, p. 301)

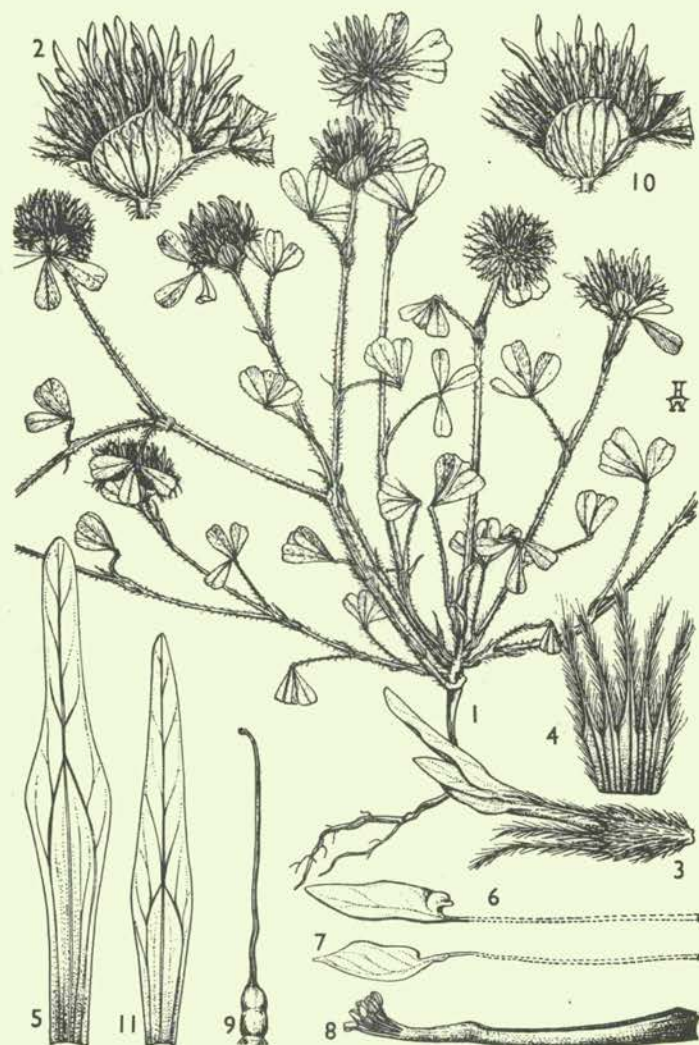


Fig. 7

Trifolium hirtum : 1. Habit, $\times \frac{2}{3}$. 2. Inflorescence showing involucre stipules, $\times 2$. 3. Flower, $\times 5$. 4. Calyx opened out, inner surface, $\times 4$. 5. Standard, $\times 6$. 6. Wing, $\times 6$. 7. Keel, $\times 6$. 8. Androecium, $\times 6$. 9. Gynoecium, $\times 6$.
Trifolium cherlei : 10. Inflorescence showing involucre stipules, $\times 2$. 11. Standard, $\times 6$.

(After Flora of Iraq, vol. 3, Leguminales, 1974, p. 170, plate 23)

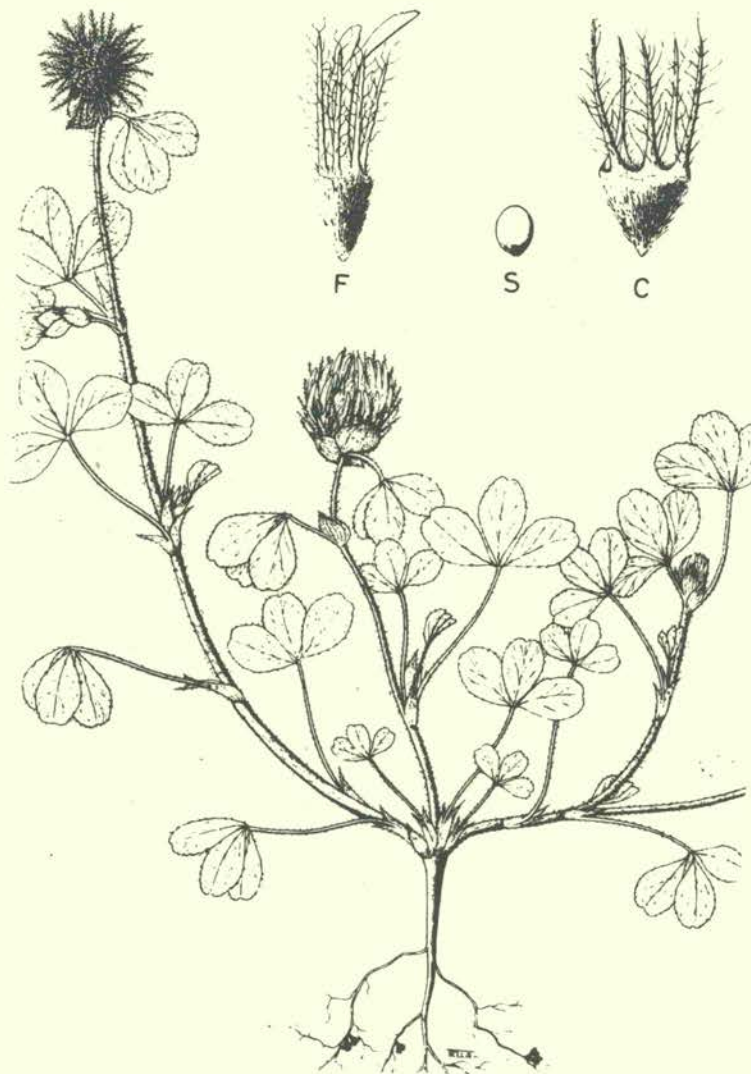


Fig. 8 - *Trifolium hirtum*

Plant, x1. F : Flower, x1. C : Fruit bearing calyx, x5. S : Seed, x5.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas,
Madrid, 1965, p. 293)



Fig. 9 - *Trifolium pilulare* Boiss.

1. Habit, $\times \frac{2}{3}$. 2. Fertile flower, $\times 8$. 3. Calyx of sterile flower, $\times 8$. 4. Petals and vexillary stamen, $\times 8$. 5, 6 & 7. Standard, wing and keel petals - free portions only, $\times 8$. 8. Androecium, $\times 8$. 9. Gynoecium, $\times 8$.

(After Flora of Iraq, vol. 3, Leguminales, 1974, p. 175, plate 24)

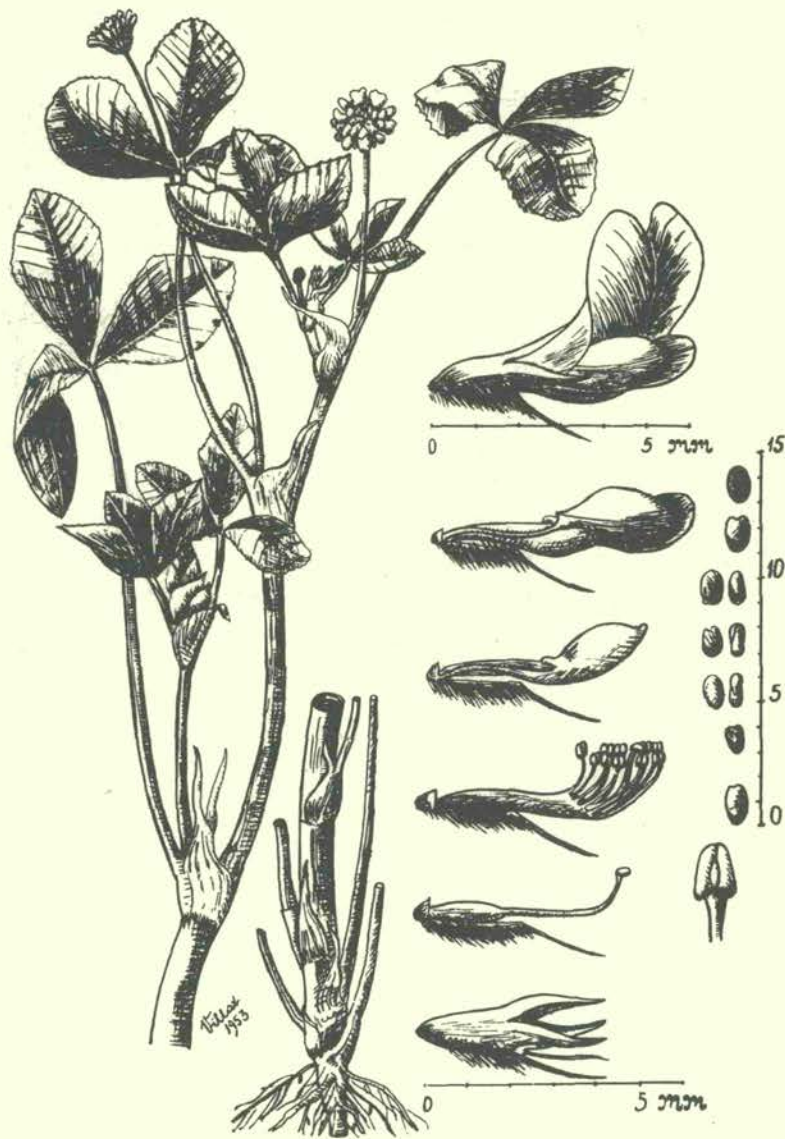


Fig. 10

Trifolium resupinatum
(Orig. - Elvas 1953)

(After la Culture des plantes fourragères dans la région
Méditerranéenne occidentale, 1963, p. 47, fig. 107)

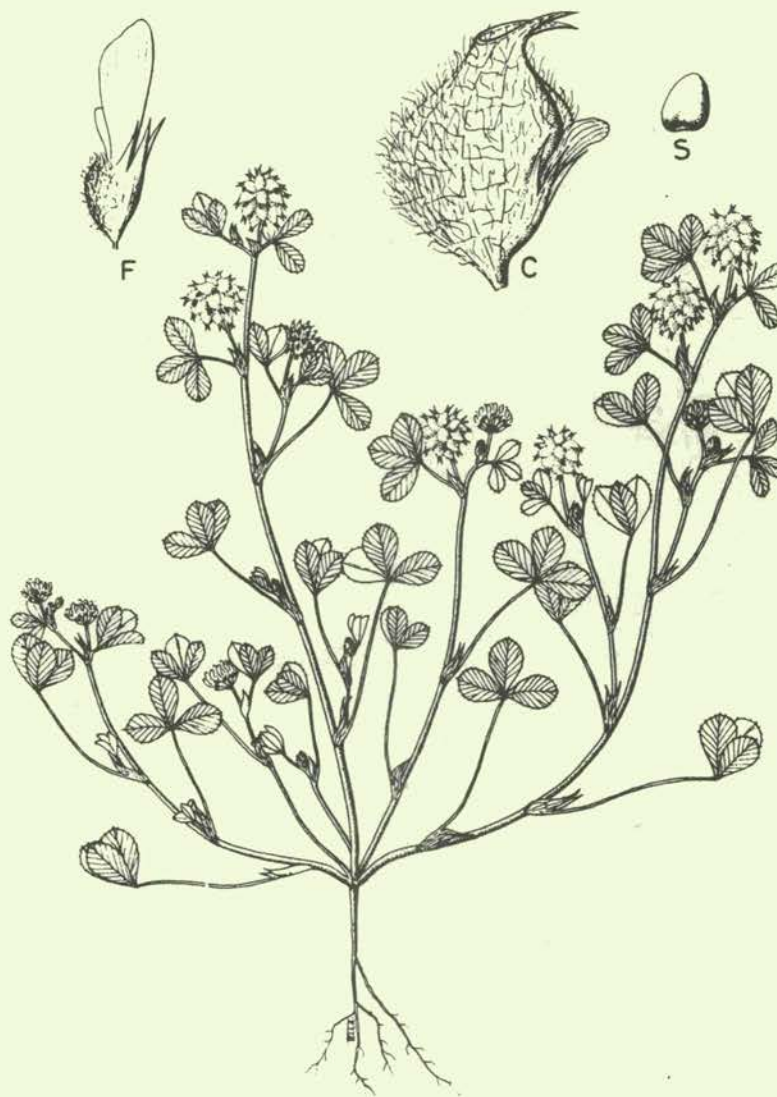


Fig. 11 - *Trifolium resupinatum*

Plant, x1. F : Flower, x8. C : Fruit bearing calyx, x8. S : Seed, x8.

(After Introduccion al Estudio de las Especies Pascicolas Espanolas,
Madrid, 1965, p. 306)

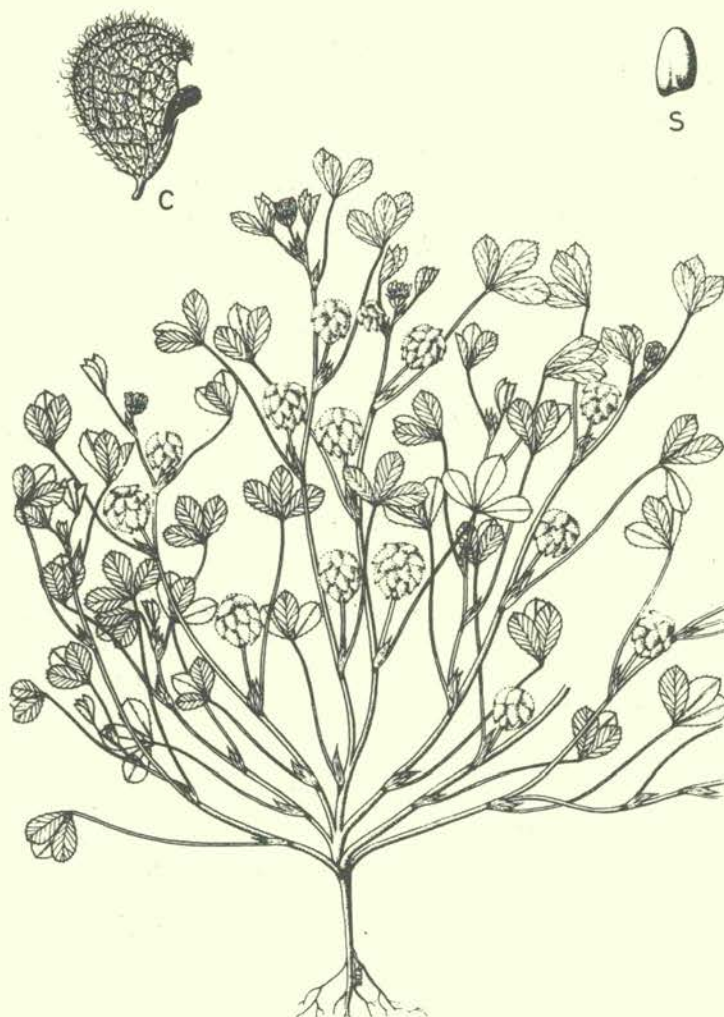


Fig. 12 - *Trifolium tomentosum*

Plant, x1. C : Fruit bearing calyx, x8. S : Seed, x8.

(After introduccion al Estudio de las Especies Pascicolas Espanolas,
Madrid, 1965, p. 303)

- subsp. *yanninicum* Katzn. et Morley
with glabrous plants, seldom glabrescent ;
- subsp. *brachycalycinum* Katzn. et Morley
with thick strongly bent peduncles ;
- var. *graecum* Katzn. et Morley
with delicate plants ; present in the Balkan Peninsula ;
- var. *oxaloides* (Bunge) Katzn. et Morley
with robust long internoded plants ; present around the Black Sea, also recorded by Madueno (1954) in Spain ;
- var. *brachycalycinum* Katzn. et Morley
with short broad stipules ;
- var. *flagelliforme* Guss.
with thicker stems and long stipules ; present in the W. Mediterranean, Greece and W. Turkey.

In Spain Madueno (1954) also records an additional botanical variety of *T. subterraneum* :

- var. *longipes* with a large flora peduncle.

In Egypt (UAR) Tackholm (1974) mentions the following botanical varieties for *T. resupinatum* and *T. tomentosum* :

T. resupinatum :

- var. *majus* Boiss. (= *T. suaveolens* Boiss.)
tall with large leaves and infleeted stems ;
- var. *minus* Boiss. (= *T. elusii* Godr et Green with v. *Kahiricum* Zoh.)
small and slender.

T. tomentosum :

- var. *ihthonocephalum* Bornm.
fruiting heads all crowded at base of plant ;
- var. *orientale* Bornm.
heads all sessile, the upper ones often in pairs ;
- var. *curvisepalum* Tackh. (= *T. curvisepalum* Tackh.)
with globular small lobulate heads.

A number of botanical varieties of *I. fragiferum* and *I. resupinatum* have also been noted in the Near and Middle East. In Turkey Davis (1966) records the following :

T. fragiferum :

- var. *fragiferum* (= *T. bonanni* Presl., *T. congestum* Link non Guss., *T. neglectum*)

present also in Eurasia and extending to W. Pakistan, to Arabia and N. Africa ;

- var *pulchellum* Lange.

present also in Spain and also recorded by Parsa (1950) in Kerman (S.E. Iran).

T. resupinatum :

- var *resupinatum*
also recorded and described in England and Belgium ;
- var *microcephalus* Zoh.
present also in Israel, N. Iraq and Syria ;
- var *majus* Boiss. (= *T. suaveolens*)
widely cultivated in Europe and Asia.

In Iran Parsa (1950) also mentions for *T. resupinatum* :

- var *minus* Boiss.
with a small reduced growth form ; present in the north littoral (Caspian zone) up 1,400 m elevation.

Native ecotypes :

In Iran Pabot (1967) considers that the native ecotypes of *T. fragiferum* although less productive than the improved exotic varieties are probably better adapted to the very cold winters and long dry periods.

In Turkey Hertzsch (1970) records that 78 native ecotypes of *T. fragiferum* as well as 8 of *T. subterraneum*, 15 of *T. resupinatum*, 24 of *T. hirtum*, 7 of *T. pilulare*, 11 of *T. cherlei* and 3 of *T. alexandrinum* have been collected during the period 1965-69 in various parts of the country and assembled at Izmir in the west coast. Kjellqvist (1977) also reports that more than 50 native ecotypes of *T. ambiguum* have also been collected in E. Turkey together with inoculum strains and some of the material is under study in the United Kingdom and Australia.

Two ecotypes of *T. ambiguum* originating from the Caucasus - a diploid ("Summit") and a hexaploid (C.P.I. 150329) together with another introduction C.P. 16884 from Georgia, USSR, and released as "Treeline" - have all shown good adaptation in the Snowy Mountains of Australia (CSIRO, 1970, Spencer et al., 1975).

Somaroo (1977) considers that *T. ambiguum* is of special interest as a forage species in the Near and Middle East since it is winter hardy, drought tolerant, very persistent and resistant to a wide range of pests and diseases.

In Israel Tadmor et al. (1971) report that six native ecotypes (Nos. 908, 917, 918, 945, 953, 1004) of *T. subterraneum* and one ecotype (56-51) of *T. pilulare* have been collected and tested under dryland conditions.

In Algeria Barbut (1955) records that five native ecotypes (Nos. 707, 717, 718, 719, 720) of *T. resupinatum* and one ecotype (No. 218) of *T. hirtum* have been collected and tested under dryland conditions while in Tunisia Le Houerou and Froment (1973) record that a local ecotype ("Oued Bersik") of *T. subterraneum* has been collected and multiplied.

Agricultural varieties :

A number of agricultural varieties of *T. subterraneum* developed in Australia, where more than 500 strains of *T. subterraneum* have been assembled and 11 out of 15 of the agricultural varieties in use are naturally occurring biotypes (Quinvilan et al., 1968), have been tested under dryland conditions in N. Africa and the Near East. However Le Houerou (1971), Le Houerou and Froment (1973) and Van der Veen (1967) report that only the variety "Clare" and to a lesser extent "Mt. Barker" and "Woogenellup" have given good results on alkaline calcareous soils together with the variety 1-54-22 from Cyprus, tested in Syria.

The variety "Clare" belongs to the subsp. *brachycalycinum* which develops well on strongly alkaline calcareous soils present in much of N. Africa and the Near East ; the subsp. *subterraneum* develops well on neutral or acid soils and is a little tolerant to calcareous soils, while subsp. *yanninicum* develops well on humid and waterlogged soils.

Le Houerou and Froment (1973) list the following varieties as belonging to the three subspecies of *T. subterraneum* :

- subsp. *subterraneum* : "Mt. Barker", "Woogenellup", "Bacchus Marsh" (= "Marrar"), "Geraldton", "Dwalganup", "Tallarook", "Dinninup", "Daliak", "Seaton Park", "Uniwager", "Howard" and "Carnamak" from Australia and "Oued Bersik" from Tunisia ;
- subsp. *brachycalycinum* : "Clare" and "Wenijup" from Australia and "Victor" from Portugal/Spain ;
- subsp. *yanninicum* : "Yarloop" and "Yabba" from Australia and also "Larisa" and "Trikkala", two recent varieties from Australia (Mackay, 1975 (a), (b)).

The varieties "Geraldton", "Seaton Park", "Dwalganup" and "Yarloop" are reported by Maignan et al., (1975) to have been successfully established under dryland conditions on humid acid soils in N. Tunisia.

The varieties "Kaliak", "Seaton Park", "Trikkala" and "Uniwager" are also reported (Donald, 1970, Mackay, 1975) to exhibit low oestrogenetic activity which is a desirable attribute when they are to be grazed by sheep.

In Israel Katznelson (1974) reports the development of the variety "Revital" derived from the interspecific cross *T. brachycalycinum* x *T. riosphaecum* which has proved superior to the variety "Clare" in dryland test plantings.

In Australia some 200 different selections of material of *T. cherlei* and *T. hirtum* collected originally in Spain, Portugal, Turkey and Cyprus has been used to develop the agricultural varieties "Kondinin", "Hykron", "Troodos", "Olympus" and "Sirint" for *T. hirtum*, and "Beenong" and "Yamina" for *T. cherlei*, which contain only negligible amounts of oestrogens (Bailey, 1968). Some of these varieties have shown limited promise in dryland test plantings in Syria and Jordan (Bailey, 1967, Van der Veen, 1967).

In Morocco Villax (1963) records that the diploid variety "Persia Maral" and the tetraploid variety "Giant Persia Feral" of *T. resupinatum* performed well, while Bryssine (1968) mentions that two selections of *T. resupinatum*, INRA 6205 and 6209, were superior to other selections at six experimental stations.

In the high plateaux zone of Algeria Maignan (1970) reports that one variety of *T. fragiferum* and one variety of *T. resupinatum* both from France have performed well in dryland test plantings.

Villax (1963) also mentions that the following varieties of *T. alexandrinum* are adapted to dryland cultivation in N. Africa :

- "Baali" originating from Palestine and furnishing 2-3 cuts ;
- "Fahl" originating from Upper Egypt and furnishing a single cut ;
- "Saidi" originating from Upper Egypt and furnishing 2-3 cuts.

Kernick (1971) also mentions that two multicut varieties of *T. alexandrinum*, "Mt Carmel" and "Tabor" from Israel and two varieties of *T. fragiferum*, "Salina" and "Palestine" from the USA, have performed well in dryland test plantings in the Caspian Forest zone of N. Iran.

26.6. Number of Chromosomes

T. subterraneum : $2x = 12, 16$; *T. alexandrinum* : $2x = 16$;
T. cherlei : $2x = 10$; *T. fragiferum* : $2x = 16$; *T. hirtum* : $2x = 10$;
T. ambiguum : $2x = 16, 32, 48$; other species not known.

Angulo and Sanchez (1974) also report that the haploid chromosome number was in all cases $x=8$ for 4 Spanish ecotypes (Ba5, Ba7, Ba8, cc2) and 6 Australian varieties ("Tallarook", "Dwalganup", "Bacchus Marsh", "Geraldton", "Clare" and "Yarloop" of *T. subterraneum*.

T. subterraneum has also been shown to consist of groups of in bred lines, which when crossed produce FI's with high levels of pollen sterility and poor seed setting (Katznelson and Morley, 1965) ; cytogenetic studies are also underway in Israel on the *T. alexandrinum* group (Katznelson and Putviesky, 1974).

26.7. Geographical Distribution

T. subterraneum is distributed in S. and W. Europe (Spain, Portugal and Balearic Isles), N. to Britain and Holland, E to Hungary, the Balkans, Roumania and S. USSR, Malta, Italy (including Sardinia and Sicily), Crete, Aegean Isles, Cyprus, Syria, Lebanon, Palestine, Turkey, Caucasus, Iraq, N. Iran, Macaronesia (Azores, Madeira, Canary Isles), N. Africa (Morocco, Algeria, Tunisia) and introduced into Australia, tropical Africa (Kenya), S. Africa, N. and S. America; Katznelson and Morley (1965) have also depicted the regional distribution of the *T. subterraneum* taxa in Europe, the Mediterranean and Near East (see Fig. 13 distribution map);

T. ambiguum is distributed in E. Europe (Roumania, S.W. USSR) Turkey, Caucasus, N. Iraq, N. Iran;

T. alexandrinum is distributed in Greece, Turkey, Syria, Lebanon, Palestine and Egypt and introduced into Australia, tropical Africa (Kenya, Rhodesia) and the USA;

T. cherlei is distributed in Mediterranean Europe, Portugal, Spain, Balearic Isles, S. France, Corsica, Sardinia, Sicily, Italy, Yugoslavia, Albania, Bulgaria, Greece, Crete, Rhodes, Cyprus, Syria, Lebanon, Palestine, Jordan, Turkey, Iraq, W. Iran, Macaronesia (Madeira, Canary Isles), N. Africa (Morocco, Algeria, Tunisia) and introduced in Australia and tropical Africa (Kenya);

T. hirtum is distributed in S. Europe (Spain, Portugal, S. France, Corsica, Italy, Yugoslavia, Albania, Bulgaria, Greece, Crimea), Aegean Isles, Cyprus, Syria, Lebanon, Turkey, Iraq, Caucasus and introduced into Australia, tropical Africa and elsewhere;

T. fragiferum is distributed practically throughout Europe except in the extreme north and also in the Aegean Isles, Cyprus, Syria, Lebanon, Palestine, Jordan, N. (coastal) Egypt, S. Arabia (Aden), Turkey, Caucasus, Iraq, Iran, Afghanistan, Pakistan, N. W. India, C. Asia (Transcaspia to Tian Shan), Macaronesia (Madeira, Teneriffe, Canary Isles), N. Africa (Morocco, Algeria), tropical Africa (Ethiopia) and introduced into tropical Africa and elsewhere;

T. pilulare is distributed in the Aegean Isles, Rhodes, Cyprus, Syria, Lebanon, Palestine, Jordan, Turkey, Iran and occasionally introduced as a casual in Britain, Australia and the USA;

T. resupinatum is distributed in Mediterranean Europe (Spain, Portugal, France, Corsica, Sardinia, Italy, Malta, Switzerland, Hungary, Yugoslavia, Albania, Bulgaria, Roumania, Greece, S.W. Russia), Aegean Isles, Cyprus, Syria, Lebanon, Palestine, Jordan, Sinai, Turkey, Caucasus, Iraq, Iran, Afghanistan, Pakistan, N.W. India, Macaronesia (Azores, Canary Isles), N. Africa (Morocco, Algeria) and introduced into Europe, Australia, tropical Africa, S. Africa, N. and S. America;

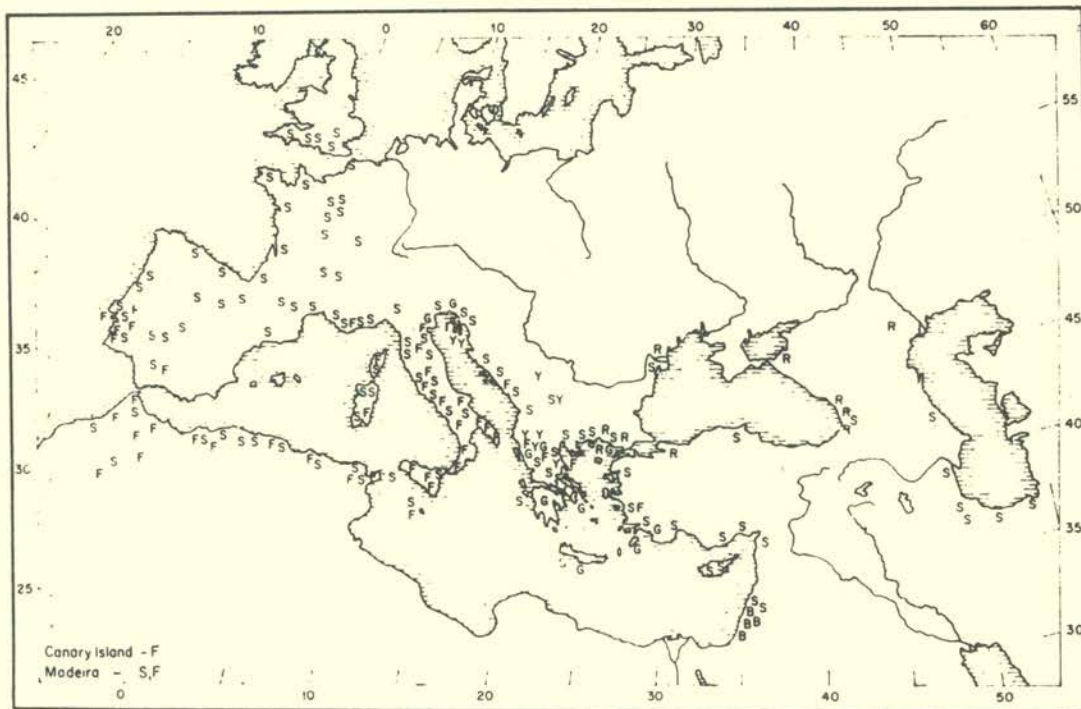


Fig. 13

Distribution of the intraspecific taxa of *T. subterraneum*

- S - ssp. *subterraneum* Y - *yanninicum*
B - ssp. *brachycalycinum* var *brachycalycinum*
F - ssp. *brachycalycinum* var *flagelliforme*
R - ssp. *brachycalycinum* var *oxaloides*
G - ssp. *brachycalycinum* var *graecum*

(After Israel J. Bot., 1965, 14, No. 3, p. 118, Map 1)

T. tomentosum is distributed in Mediterranean Europe, Crete, Aegean Isles, Cyprus, Syria, Lebanon, Palestine, Jordan, Sinai, N. Egypt, Turkey, Iran, N. Africa (Morocco, Algeria, Libya), Macaronesia (Azores, Madeira, Canary), tropical and S. Africa.

26.8. Biology and Ecology

T. subterraneum, *T. alexandrinum*, *T. ambiguum*, *T. cherlei*, *T. fragiferum*, *T. hirtum* and *T. resupinatum* are all cool season species which propagate themselves by seed and are cross-pollinated by insects.

Growth and development :

In N. Africa Villax (1963) records that seedlings of dryland seeded *T. subterraneum*, *T. alexandrinum*, *T. fragiferum* and *T. resupinatum* establish themselves rapidly and grow well in the winter and spring in the littoral zone and support cold periods and even frosts providing they are not too long.

In the littoral zone of Tunisia, at Tunis, Corriols (1965) reports that Australian varieties of *T. subterraneum* when seeded in late November gave 80-90 % germination by the end of December, a soil cover of 30-100 % by mid-March and flowered during April.

Laumont (1951) also states that *T. alexandrinum* can grow satisfactorily over a temperature range of 0-35°C ; below 0°C and above 35°C growth is stopped, while plants cannot resist temperatures below -5 to -8°C or above 40°C.

Villax (1963) also mentions that growth of *T. alexandrinum* can be prolonged in late spring and early summer by supplementary irrigation but that all growth ceases with onset of high summer temperatures ; plants can also be attacked by anthracnose in humid weather.

T. fragiferum and *T. resupinatum* are also reported to resist dry periods in the Mediterranean region and *T. resupinatum* is considered to resist unfavourable conditions better than *T. alexandrinum* (Villax, 1963).

In N.W. Tunisia Jaritz and Shulke (1972) report that dryland *T. subterraneum* seeded in mixture with *Lolium rigidum* made its main growth from February to March and became dominant in the pasture from mid-March onwards ; flowering occurred around mid-May.

In the Near East Bailey (1957) reports promising growth of dryland *T. cherlei*, *T. hirtum* and *T. pilulare* seeded in December in the steppe zone (300-400 mm annual rainfall) in Jordan. Hopkinson (1975) also records promising growth of *T. hirtum* in a dryland pasture at Rabba (400 mm annual rainfall) in the steppic zone of Jordan, but around Karak (300-400 mm annual rainfall) dryland seedlings of *T. alexandrinum* and *T. resupinatum* gave a superior growth performance to that of *T. subterraneum* and *T. hirtum* which was poor.

In the steppe zone of Jordan Hopkinson (1975) records that *T. hirtum* flowered in mid-April and *T. alexandrinum* and *T. resupinatum* in May. Most of the *Trifolium* spp. dried up in June, but *T. resupinatum*, *T. alexandrinum* and *T. subterraneum* were not completely dry until early July.

In the Mediterranean region of N. Africa and the Near East seed setting of the previously mentioned *Trifolium* spp. is generally good but hot dry periods in the spring can interfere with flowering and seed set ; *T. resupinatum* is also reported (Villax, 1963) to shatter its seed readily.

Seed characteristics :

Germination of the seeds takes place over a wide range of temperatures from 0.5-30°C for *T. subterraneum* and *T. cherlei*, and from 5-30°C for *T. hirtum* according to Young et al. (1970).

However Katznelson and Morley (1965) report that germination of seeds of *T. subterraneum* is very poor at 30°C and even scarified seeds germinated more slowly at 30°C than at 15°C ; optimum germination took place between 15-20°C.

T. subterraneum, *T. cherlei*, *T. hirtum* and *T. resupinatum* all exhibit hard-seededness and Hammouda and Bakr (1969) report that seeds of *T. resupinatum* germinated well if the seeds were heated to 70°C for 2 hr/day ; 10-20 mm of rainfall was sufficient to produce germination but 5 mm of rainfall was insufficient.

Hard seeds in *T. subterraneum*, *T. cherlei* and *T. hirtum* have a dormancy period of one year or more so that when planted only 5-10 percent of the seeds produced in the first year germinate in the second year, while the remaining seeds germinate in subsequent years.

Non-germination of seeds is governed by a combination of hard-seededness and physiological dormancy. Under natural conditions dormancy of *T. subterraneum* is relatively transitory, while long term conservation is dependent more on hard-seededness (Morley, 1958). High temperature dependent physiological dormancy is also important in regions where summer rainfall is common (Katznelson and Carpenter, 1975).

Climate and soils :

All the above *Trifolium* spp., except for *T. ambiguum* which is adapted to the high plateaux zone of the Middle East, are well adapted to dryland cultivation in the Mediterranean region in areas with mild and humid winters.

The following is a summary of the climatic and edaphic requirements for the various *Trifolium* spp. :

T. subterraneum : +500 mm annual rainfall, winter temperature +3°C, prefers acid or neutral soil pH 5-7 except for varieties belonging to ssp. *brachycalycinum* which tolerate soils with pH 7-8 ;

T. alexandrinum : +450 mm annual rainfall, minimum January temperature +3°C ; prefers fertile but not too heavy soils that are compact or poor in lime or acid ; supports some soil salinity 0.01-0.03 % NaCl ;

T. cherlei, *T. hirtum*, *T. pilulare*, *T. tomentosum* : 300-450 mm annual rainfall ; mild winters ; prefer light textured calcareous alkaline soils but not adapted to poorly drained soils ;

T. fragiferum : +500 mm annual rainfall ; stands cold winters ; prefers clay soils ; supports slight soil salinity and very well flooding ;

T. resupinatum : +450 mm annual rainfall ; stands cold winters ; preference for deep well drained calcareous clay marls or loams ; supports slight soil salinity and to some extent flooding.

Ecological characteristics :

Ecologically all the above mentioned *Trifolium* spp. occur spontaneously in specific habitats in N. Africa and/or the Near and Middle East and summarized information on their habitat or location in a number of countries in the region is given below :

T. ambiguum : occurs on steep screes, slopes, edges of forests and fields from 1,700-2,750 m elevation in Turkey, N. Iraq and N.W. Iran ;

T. cherlei : occurs in grassy places, forest clearings, fixed dunes and gravel slopes from sea level up to 1,750 m elevation in Algeria, Morocco, Lebanon, Syria, Turkey ;

T. fragiferum occurs in humid and moist shady places, river sands, damp open plains and in mountain habitats from sea level up to 1,750 m elevation in Algeria, Morocco, Lebanon, Syria, Turkey, N. Iraq and Iran ;

T. hirtum occurs in grassy places, forest cleanings, scrub, rock places, roadsides and humid places in the lower mountains from 50 to 1,700 m elevation in Algeria, Morocco, Lebanon, Syria, Turkey, N. Iraq and N. Iran ;

T. pilulare : occurs on borders of road, fields grassy places, rock slopes, lower mountain slopes, stony clay soils from sea level up to 1,450 m elevation in Syria, Lebanon, Turkey, N. Iraq and W. Iran ;

T. resupinatum : occurs in borders of roads, fields, waste places, humid grassy plains and lower mountains from sea level up to 1,500 m elevation in Algeria, Morocco, Syria, Lebanon, Turkey, N. Iraq and W. Iran ;

T. subterraneum : occurs on humid non-calcareous soils open littoral plains and mountains from sea level up to 1,800 m elevation in Algeria, Morocco, Syria, Lebanon, Turkey and N. Iran ;

T. tomentosum : occurs in grassy places, roadsides, forests, maquis and open ground in Algeria, Morocco, Libya, Cyprus, Egypt, Lebanon and N. Iran.

26.9. Cultivation Techniques

Time of seeding :

In North Africa and the Near East it is generally recommended to seed *Trifolium* spp. after the first autumn rains, usually in October but sometimes in November.

However Le Houerou (1965) and Le Houerou and Froment (1969, 1973) recommend seeding dryland *T. alexandrinum* in mid-September and state that *T. resupinatum* which is more resistant to the cold can be seeded later in October ; Ionesco et al. (1969) also recommend October seeding for dryland *T. resupinatum* in Morocco.

Early seeding of *T. alexandrinum* has also proved beneficial in N. Iraq where seeding in September with one light supplementary irrigation in the moist steppe zone (400 mm annual rainfall) proved superior to seeding later in October-November (Kernick, 1976, loc. cit.).

In Jordan Hopkinson (1975) also reports good results from early seeding of *T. resupinatum*, but *T. hirtum* grew slightly better when seeded at the end of February.

Land preparation :

For the seeding of *Trifolium* spp. a good firm, weed-free seed-bed is required, and in Algeria Laumont (1951) recommends ploughing to a depth of 20-25 cm after the first autumn rains followed by a discing and then cross-harrowing to eliminate any newly germinated weed seedlings.

Intercultivation with grasses :

T. subterraneum, *T. fragiferum* and *T. resupinatum* can also be seeded in mixture with grasses in dryland cultivation. In Morocco Villax (1963) mentions that *T. subterraneum* can be seeded in mixture with *Phalaris aquatica* (= *P. tuberosa*), *Lolium perenne* or *L. italicum* in the higher annual rainfall areas (+600 mm), or with *Dactylis glomerata*, *Ehrharta calycina*, *Festuca arundinacea* or *Oryzopsis miliacea* in the lower annual rainfall areas (400-600 mm), while in Algeria Maignan et al. (1976) and Le Houerou (1969) suggests seeding *T. subterraneum* in mixture with *Lolium rigidum* or undersowing it in an autumn sown cereal crop.

In Morocco Villax (1963) also mentions that *T. fragiferum* can be seeded in mixture with *Lolium perenne*, *Phalaris aquatica* (= *P. tuberosa*) or *P. arundinacea* while Ionesco et al. (1969) state that *T. resupinatum* can be seeded in mixture with *Lolium italicum*.

Seed inoculation :

Seeds of *T. subterraneum*, *T. cherlei* and *T. hirtum* should be inoculated before sowing with a suitable inoculum strain.

In Algeria Gallacher (1972) has recommended that the seeds of *T. subterraneum* be inoculated with a bacterial culture either in a peat or agar solution applied to the seeds on the day of sowing.

Gallacher (1972) states that for the dry peat culture the best method is to moisten the seeds, dissolve 2 tablespoons of sugar for each litre of water and prepare a peat slurry. Each litre of solution is sufficient to treat 30 kg of seed. It is preferable to sow the inoculated seed in a damp seed-bed or immediately after rain followed by a light harrowing ; the inoculated seed should not be mixed with superphosphate in a seed drill.

Seed rates and spacing :

Seed rates and spacings for the previously mentioned *Trifolium* spp. seeded pure or in mixture with grasses under dryland cultivation vary but the following have been reported from various countries :

<u>Morocco</u>	<i>T. subterraneum</i> (alone)	10 kg/ha of seeds broadcast
	<i>T. subterraneum</i> (alone)	7 kg/ha of seeds {
	undersown with <i>Hordeum vulgare</i>	50 kg/ha of seeds { broadcast
	or <i>Triticum vulgare</i>	50 kg/ha of seeds {
	<i>T. resupinatum</i> (alone)	10-15 kg/ha of seeds in lines spaced 20-40 cm apart ; depth of sowing 1-3 cm
	<i>T. resupinatum</i> +	15 kg/ha of seeds { in lines spaces 20-
	<i>L. italicum</i>	10 kg/ha of seeds { 40 cm apart ; depth of sowing 1-3 cm
	<i>T. alexandrinum</i> (alone)	25 kg/ha of seeds broadcast <u>or</u> seeded in lines spaced 20-40 cm apart
	<i>T. fragiferum</i> +	3-6 kg/ha of seeds {
	Perennial Grass	7-24 kg/ha of seeds { broadcast

<i>T. fragiferum</i> (for seed production)	10-15 kg/ha of seeds in lines spaced 15-30 cm apart
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<u>Algeria</u>	<i>T. resupinatum</i> (alone)	10-15 kg/ha of seeds broadcast
	<i>T. resupinatum</i> + <i>L. italicum</i>	10-15 kg/ha of seeds { broadcast 5-10 kg/ha of seeds }
	<i>T. subterraneum</i> (alone)	5-6 kg/ha of seeds broadcast
	<i>T. subterraneum</i> + <i>L. rigidum</i>	10 kg/ha of seeds { broadcast 10-20 kg/ha of seeds }
	<i>T. fragiferum</i> (alone)	1 kg/ha of seeds broadcast

<u>Tunisia</u>	<i>T. subterraneum</i> (alone)	10 kg/ha of seeds broadcast
	<i>T. subterraneum</i> + <i>L. rigidum</i>	5 kg/ha of seeds { broadcast 5 kg/ha of seeds }
	<i>T. resupinatum</i> (alone)	15-20 kg/ha of seeds broadcast
	<i>T. alexandrinum</i> (alone)	25 kg/ha of seeds broadcast

For *T. cherlei* and *T. hirtum* a seed rate of 1-5 kg/ha is recommended for direct dryland seeding in W. Australia and 1-2 kg/ha when undersowing it in a cereal crop (Bailey, 1966). However limited experience in the Near East suggests that higher seed rates of 10-15 kg/ha may initially be required to obtain satisfactory stands in dryland cultivation.

Vegetative propagation :

In Tunisia Le Houerou and Froment (1969) have also recommended planting cuttings of *T. fragiferum* in October-November after the passage of a cultivator between lines of second year dryland *Festuca arundinacea*.

Fertilizer application :

The application of phosphate fertilizer to the seed-bed and later after seeding and establishment is generally recommended for all the previously mentioned *Trifolium* spp. and is essential on phosphorous deficient soils.

Fertilizer application has varied between countries but the following have been reported :

- Morocco for *T. alexandrinum* and *T. subterraneum* :
60-80 kg/ha P_2O_5 and 40-60 kg/ha K_2O to the seed-bed, 0-20 kg/ha N some days after seeding (Ionesco² et al., 1969) ;
- Algeria for *T. subterraneum*, *T. fragiferum* and *T. resupinatum* :
150 kg/ha P_2O_5 to the seed-bed followed by 90 kg/ha P_2O_5 in subsequent years in July and in October (Maignan, 1970) ;
- Tunisia for *T. alexandrinum* :
45 kg/ha P_2O_5 in the seed-bed followed by 5-10 kg/ha N at sowing (Le Houerou, 1965, Le Houérou and Froment, 1969) ;
- Syria for *T. subterraneum*, *T. hirtum* and *T. resupinatum* :
60 kg/ha P_2O_5 in the seed-bed (Van der Veen, 1967).

In Cyrenaica, Libya (250 mm annual rainfall), El Bargati (1978) reports that forage production of native dryland stands of *T. tomentosum* is greatly increased by the application of phosphate fertilizer.

26.10. Forage Value

Palatability and intake :

All the previously mentioned *Trifolium* spp. are palatable to livestock particularly sheep and cattle. Bailey (1966) also mentions that in W. Australia *T. hirtum* is palatable at all stages of growth, in spite of its stemmy appearance when dry, and is especially palatable at about flowering time.

In Germany Simon (1974) also reports that in tests under grazing conditions with native sheep *T. resupinatum* had a higher palatability and voluntary intake than either *T. alexandrinum* or *T. pratense* during the summer period.

Nutritive value :

The forage value of all the *Trifolium* spp. previously mentioned is also high as the following chemical composition data reported from various countries shows :

Morocco : (a) Littoral zone, Rabat (Villax, 1963)

Percentage Chemical Composition							
Species	Nature of Forage	Water	Protein	Fats	Carbohydrates Soluble	Fibre	Ash
<i>T. alexandrinum</i>	Green	81.5	2.9	0.6	8.6	3.8	2.5 ^{1/}
	Hay	9.5	13.5	0.6	41.4	22.5	12.5 ^{1/}
<i>T. resupinatum</i>	Green	78.0	2.6	0.5	10.6	6.3	2.0
	Hay	15.8	14.1	2.2	40.0	13.8	14.1
<i>T. subterraneum</i>	Green	69.0	4.2	0.8	10.0	11.3	4.7
1/ The ash was composed of phosphoric acid and lime							

(b) Littoral zone, Rabat (Foury, 1950)

Species	Date of Sampling	Water	Ash	Protein	Non-N Extract	Fats	Cellulose
<i>T. resupinatum</i> (green)	3.5.49						
green matter basis		78.00	2.05	2.57	10.60	0.50	6.28
dry matter basis		0	9.34	11.62	48.12	2.31	28.61
<i>T. subterraneum</i> (green)	29.4.49						
green matter basis		68.00	3.97	4.03	17.40	0.75	10.80
dry matter basis		0	9.88	11.32	48.20	2.00	30.00

Tunisia : Littoral zone, Tunis (Corriols, 1965)

Percentage Digestible Products : Green Matter Basis						
Species	Protein	Fats	Cellulose	Non-N Extract	Metabolizable Energy/kg green matter	Forage Units/kg green matter
<i>T. subterraneum</i>	2.52	0.96	3.22	5.69	494 c	0.14

In Cyprus, at Nicosia (400 mm annual rainfall) it is reported (Cyprus Agricultural Research Institute, 1964) that *T. subterraneum* grown in rotation with wheat and harvested twice at the pre-flowering and pod-formation stage has yielded in the 2nd year 39,000 kg/ha green forage and in the 3rd year 36,000 kg/ha green forage.

In the littoral zone of Tunisia (400-600 mm annual rainfall), at Tunis, Le Houérou and Froment (1973) record that dryland experimental forage yields of *T. cherlei*, *T. hirtum* and *T. clypeatum* have varied from 1,000-3,000 kg/ha DM over a 4 year period.

In S. Africa, in a low winter rainfall region, Wasserman and Wicht (1972) also mention the valuable ability of *T. hirtum* to recover well after cutting, and that in this respect it was superior to both *T. cherlei* and *T. subterraneum*.

Yield of varieties and ecotypes :

In the littoral zone of Tunisia, at Tunis, Corriols (1965) also reports the following experimental forage production data for four Australian varieties of *T. subterraneum* during one season (1955-56) :

1955-56 (664.7 mm rainfall)				
Species and Variety	Green Matter kg/ha	Dry Matter kg/ha	Digestible Protein kg/ha	Forage Units/ha
<i>T. subterraneum</i>				
"Bacchus Marsh"	13,109	2,752	327	1,835
"Dwalganup"	20,831	4,374	520	2,916
"Mt. Barker"	6,666	1,399	166	933
"Tallarook"	11,110	2,333	277	1,555

However Le Houerou and Froment (1973) report that the variety "Clare" has given 6,000-8,000 kg/ha DM on calcareous-clay soils (pH 8.0, 35 % CaCO₃) at Tunis.

In the high plateaux zone of Algeria Maignan (1970) also reports good dryland experimental forage yields for the varieties "Clare" and "Woogenellup" of *T. subterraneum* and for French varieties of *T. fragiferum* and *T. resupinatum* which are given below :

Species and Variety	1967-68	1968-69	1969-70	
	1st cut	1st cut	1st cut	2nd cut
	Green Matter kg/ha	Green Matter kg/ha	Green Matter kg/ha	Green Matter kg/ha
<i>T. subterraneum</i>	seasonal rainfall 437.7 mm	seasonal rainfall 489.2 mm	seasonal rainfall 257.6 mm	seasonal rainfall 252.9 mm
"Woogenellup"	13,300 (18.4.68)	10,500 (7.5.69)	--	--
"Clare"	20,000 (18.4.68)	50,000 (7.5.69)	18,250 (18.12.69)	21,200 (2.4.70)
<i>T. fragiferum</i> (variety from France)	--	--	seasonal rainfall 374.4 mm 17,800 (21.3.70)	seasonal rainfall 205.0 mm 16,800 (16.5.70)
<i>T. resupinatum</i> (variety from France)	--	--	seasonal not 15,000 (2.4.70)	rainfall given 17,000 (6.5.70)

In the littoral zone of Tunisia (400-600 mm annual rainfall), at Tunis, Le Houerou and Froment (1973) record that dryland experimental forage yields of *T. cherlei*, *T. hirtum* and *T. clypeatum* have varied from 1,000-3,000 kg/ha DM over a 4 year period.

Effect of spacing on forage yields :

In extensive spacing trials under dryland cultivation Foury (1950) reports that *T. alexandrinum* in the littoral zone of Morocco has given highest forage yields when broadcast seeded or drilled in lines 10-25 cm apart.

Seed yields :

In regard to seed production Villax (1963) and Foury (1950) record in the littoral zone of Morocco average seed yields of 300-600 kg/ha for *T. alexandrinum* and 100-200 kg/ha for *T. fragiferum*.

In the high plateaux zone of Algeria Maignan (1970) reports a seed yield of 276 kg/ha for an experimental stand of *T. resupinatum* in a year with 579.4 mm rainfall.

Data on dryland seed yields of *T. cherlei* and *T. hirtum* in N. Africa and the Near East is not available, but Bailey (1965) reports that for Australian varieties of both these species in W. Australia experimental seed yields have varied from 180-800 kg/ha depending on rainfall conditions.

Seed harvesting :

Harvesting of *T. subterraneum* seeds present certain difficulties. Gallacher (1972) states that early or mid-season varieties can be direct headed from the swath with an all crop harvester, or header with pick up attachment ; this often leaves a lot of seed on the ground which can be windrowed with a side delivery rake and broom hitched together for the next passage of the harvester. After the top growth of *T. subterraneum* is removed a sheepskin roller with the wool facing outwards can be used to pick up the seed burrs from the ground, which are then scraped into boxes as the roller moves along ; light harrowing of the soil may be necessary to "float" the burrs to the surface and several passages of the sheepskin roller may be required. For later varieties vacuum type harvesters may be used after similar preparation and harrowing already mentioned has been carried out.

Gallacher (1972) also mentions that in Algeria harvesting of seeds *T. fragiferum* and *T. resupinatum* is best achieved by first cutting the crop to allow the plants to dry in the windrow, and then either directly harvesting the crop in the windrow using a combine harvester with a pick up attachment, or utilizing an ordinary combine and forking the dry material into the comb of the machine.

26.12. Utilization

Use in rotation :

T. subterraneum, *T. cherlei* and *T. hirtum* could prove of special value for replacing the fallow in the cereal/fallow rotation in which sometimes cereals crops are grown several years in succession especially in the higher annual rainfall (400-500 mm) areas of N. Africa and the Near East.

Pasture management :

As for annual medic pastures, grazing management of *T. subterraneum*, *T. cherlei*, *T. hirtum* and *T. tomentosum*, which are also self-seeding annual legumes, is very important especially in the first year to build up a reservoir of seeds. Plants of all these four species must be allowed to become well established before grazing, but when weeds are in competition heavy grazing for a short period or cutting is required.

In N. W. Tunisia Jaritz and Shulke (1972) report that 1-2 cuts have been necessary for the upkeep of *T. subterraneum* pasture - the first to control *Raphanus raphanistrum*, and the second made at the end of the vegetative period to eliminate annual grasses. For seed production of *T. subterraneum* in Algeria Gallacher (1972) recommends cutting the crop before flowering so that 10-15 cm of top growth remains for flowering and seed formation.

In N. Africa both *T. alexandrinum* and *T. resupinatum* are generally harvested for direct green feed or hay ; in Tunisia and Morocco dryland *T. alexandrinum* furnishes 2 cuts and *T. resupinatum* 1 cut (Le Houerou, 1965, Le Houerou and Froment, 1969, 1973, Ionesco et al., 1969).

In Morocco the first cut of dryland *T. alexandrinum* is normally taken at the end of December or in January ; the second cut in the spring is used for direct green feed or sometimes pastured but hay is seldom made. For hay production great care needs to be exercised to minimize leaf losses. Villax (1963) states that the last cut of the season can equally be taken for seed production.

In Tunisia Le Houerou and Froment (1969, 1973) state that *T. fragiferum* is normally grown in mixture with *Festuca arundinacea* and cut for hay in the first year and then cut for hay, pastured or a mixture of both in subsequent years.

In the high plateaux zone of Algeria Gallacher (1972) mentions that *T. subterraneum* and *T. resupinatum* are useful in mixtures for crop rotations, fodder, intensive grazing and soil restoration, while *T. fragiferum* in mixture with *Festuca arundinacea* is valuable for seeding on drainage lines and heavy marls to provide early and late season fodder for intensive grazing ; under good management *T. fragiferum* will persist in pastures for many years.

Liveweight gain and stocking rate :

Jaritz and Shulke (1972) report that native and Brown Swiss cattle when grazing a mixed pasture of *T. subterraneum* and *Lolium rigidum* in N. W. Tunisia for 188 days made liveweight gains of 627 g/head/day from the end December to end February, 862 g/head/day from March to the end of May and 333 g/head/day from the beginning of June to early March.

Data on animal performance for livestock grazing *T. cherlei* and *T. hirtum* in N. Africa and the Near East is not available but Emrick (1968) reports that dryland *T. hirtum* pasture in California (300 mm annual rainfall) has been stocked at a rate of 2.1 beef cattle/ha over a 253 day grazing period from 12 February to 25 October, and cattle made an average daily gain over the period of 700 g/head.

Further evaluation :

In the future more attention needs to be given to the collection, selection and evaluation of native ecotypes of the previously mentioned *Trifolium* spp. in N. Africa and the Near and Middle East since previous studies indicate that a wealth of material exists.

Particularly in the Near East and the high plateaux zone of the Middle East cold tolerant as well as drought tolerant varieties are needed that are adapted to the wide extremes of temperature occurring in both winter and summer.

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