PASTURE, FORAGE AND LIVESTOCK PROGRAM

Annual Report for 1989

ICARDA

PASTURE, FORAGE AND LIVESTOCK PROGRAM

ANNUAL REPORT 1989

The International Center for Agricultural
Research in the Dry Areas (ICARDA)
Aleppo, Syria

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RESEARCH HIGHLIGHTS

Neurotoxins in chickling (*Lathyrus* spp). *Lathyrus sativus* has been shown to have a high potential for dry areas. But the seeds contain a neurotoxin, beta-N-oxalyl-amino-L-alanine (BOAA), which is responsible for the paralytic disease called lathyrism in the Indian sub-continent where the grains are used for human consumption. This disease may explain why so little research has been carried out on this genus. With the assistance of the Canadian Grain Commission, seed from 122 selections of three *Lathyrus* species has been screened for BOAA. For example, the lowest content of BOAA in the selections of *L. sativus* and *L. cicera* was 17.6 µg/g seed and 20.0 µg/g seed, respectively. These values are over 100 times below the content of one Indian cultivated line and 10 times below the content of a Canadian variety. The seed yields of these accessions are now being checked. This exciting finding should help feed legume breeders quickly select and develop new lines of chickling with very low contents of BOAA. **A.A. Moneim; P. Williams, Canadian Grain Commission.**

Pastures and feed legumes in cereal-based crop rotations. Research conducted at Tel Hadya, on a station of the Syrian Directorate for Scientific Agricultural Research, and on farmers' fields at different locations in Syria indicates how cereal yields after medic or after feed legumes are higher than after another cereal crop. Even in a growing season of low rainfall, as in 1988/89, nearly 1700 grazing days/ha were achieved from medic pastures and feed legumes grazed by lambs yielded over 100 kg liveweight gain/ha. The seed bank of medic in several farmers' fields at the start of the third regeneration phase was well above the level needed to ensure a large plant population and high herbage yields. This research shows how the Program is closely involved with farmers and successfully transferring new technologies to a national program. **F.A. Bahhady; N. Nersoyan; H. Sawmy; E.F. Thomson; P.S. Cocks and Syrian national scientists.**

Workshop on ley farming in the Mediterranean basin. This workshop, held at the University of Perugia in June 1989, aimed to: 1) discuss research and progress of the ley farming system in the WANA region and elsewhere, 2) formulate a strategy to implement and develop cereal/medic rotations in the Mediterranean region, and 3) define guidelines for the establishment of a network to collect and conserve genetic resources of annual Medicago species. The workshop, financed by the Italian Government and IBPGR, was attended by 19 scientists from WANA and 32 from international research centers and advanced institutes. A list of recommendations for future research on the ley farming system was developed, emphasising the need for more research and extension on the management and social aspects of the system. A strategy for implementing a medic genetic resources network will be initiated. **P.S. Cocks; L.A. Materon; M. Falcinelli, University of Perugia, Italy; IBPGR, Rome.**

Subterranean vetch (Vicia sativa ssp. amphicarpa). Subterranean vetch produces seed pods above and below ground (amphicarp), with the proportions varying depending on the severity of defoliation. For example, severe defoliation simulated by clipping prevented production of aerial pods and plants responded by producing more underground pods. Under this regime the underground seed bank was still 138-185 kg/ha. Under the severe drought conditions of 1988/89 many plants only produced underground pods, indicating how well they are adapted to these conditions. The hardseededness of the seeds is another advantage. Subterranean vetch has the potential to develop into a self-regenerating, feed-producing legume crop grown in rotation with wheat or barley. **A.A. Moneim.**

Marginal lands and edible shrubs. After the signing of the project document between ICARDA, ACSAD, and the Steppe Directorate of the Syrian Ministry of Agriculture and Agrarian Reform, a collaborative study has started on the productivity of marginal lands, edible shrubs, and sheep carrying capacity. The objectives are to determine productivity of marginal lands already improved by planting edible shrubs, measure the economic return from improved marginal lands, and monitor the effects of three stocking rates on the sustainability and productivity of marginal lands. This 5-year study is being carried out at Maraga Station in the steppe of Aleppo Province, 120 km southeast of Aleppo where annual rainfall is about 200 mm. The new study is expected to provide urgently needed information on grazing management of rehabilitated rangelands in Syria. The information should also be useful to other countries of the region where shrubs are being used or considered for rehabilitation work. **A.E. Osman and collaborators from the Syrian Steppe Directorate and Arab Center for Studies of Arid Zones and Dry Areas, Damascus.**

Seed banks in Mediterranean grasslands. Applying phosphate fertilizer to a Mediterranean grassland over a 5 year period increased seed mass from 4.6 to 17.4 mg/m^2 and seed numbers from 3987 to 24129 plants/m^2. During the same period the changes were small when no fertilizer was applied. Since the number of plants is one of the main factors affecting grassland productivity, these results indicate how important it is to reduce grazing pressure in spring when flowering takes place. This is particularly important when grasslands are degraded as is so often the case in WANA. **A.E. Osman.**

Collaboration with pasture and feed legume scientists in Morocco. After 18 months, our outreach scientist in Morocco has developed an effective strategy which emphasises the current research being conducted by scientists in national programs with support, planning, and direction from ICARDA when necessary. The strategy involves: 1) developing locally adapted genotypes of pasture legumes, especially from the local flora, 2) evaluating feed legumes, 3) developing local seed industries which reduce costs and reliance on imports, and 4) establishing the benefits to animal productivity of new systems using self-generating pastures and annual feed legumes. Research activities also started in Algeria in 1988/89. **A. Lahlou, INRA; M. Bounejmate, INRA; B. Boulanouar, INRA/MIAC; P. Beale.**

Collection of rhizobia for pasture (medics) and feed legumes. The collection of rhizobia for pasture and feed legumes is expanding. It now includes 465 strains of _Rhizobium meliloti_ (for medics), 35 antibiotic-resistant strains of _R. meliloti_, 36 strains of _R. leguminosarum_ (for feed legumes), and 45 strains of _R. trifolii_ (for clovers). **L.A. Materon.**

Rhizobium meliloti in West Asian soils. The ley farming system has considerable potential in West Asia and North Africa but research has shown that some soils do not contain strains of _R. meliloti_ that induce effective nodulation on several species of annual _Medicago_. This limits nitrogen fixation in the host plants and ultimately reduces yields. However, highly effective isolates have been identified that perform well under field conditions and they are currently being recommended by ICARDA for the West Asia region. This research is being conducted by a network of researchers in several WANA institutes, one in Spain, and one in France. **L.A. Materon and regional collaborators.**

Unpalatability of peas. Significant progress is being made towards explaining the mystery of the unpalatability of the locally used Syrian landrace of forage peas (Pisum sativum, accession number 205). The rate of ingestion of straw from these peas was lower than straw from some lines taken from the ICARDA germplasm collection. There is also evidence that rates of rumen degradation of the Syrian landrace and a British variety may be lower than some other lines. The rates of degradation of leaf from the Syrian landrace were higher than leaf from palatable Syrian common vetch (Vicia sativa, accession number 2541) but the opposite was the case for the stem. The ratio of leaf to stem will clearly play an important role in determining the amount of these crops ingested by sheep. There were also marked differences in the preference of sheep for the different plant fractions of the Syrian pea, with little discrimination between leaf and stem, a distinct preference for the white flowers, and a clear dislike for the young green pods. It is anticipated that ongoing chemical analysis of the primary and secondary compounds in different plant fractions taken from a range of germplasm will help to explain this unpalatability of peas. **E. Carter (PhD student); E.F. Thomson; A. Stedman, Royal Veterinary College, UK; M. Gill, ODNRI, ODA, UK.**

Helminth parasites and sheep productivity. Once again the Program is conducting pioneering on-farm research, this time on the effects of helminth parasites and management systems on the productivity of Awassi sheep. Samples of ewes treated with fenbendazole in 10 farmers' flocks in Aleppo Province had mortality levels half those in control samples given a placebo. This resulted in survivability of ewes increasing from 82.7 to 90.0%. Similarly, ewe fertility increased from 80 to 85% although this failed to reach statistical significance (P>0.05). However, such an improvement in fertility, together with the reduced mortality, clearly has considerable economic benefits to the farmer. Treated ewes became reinfected because sheep are usually confined during feeding and at night. However, infection levels never reached those of untreated ewes, which indicates that two strategically timed treatments with an anthelmintic effectively controlled the gastrointestinal helminths and Protostrongylid lungworms. This on-farm research indicates that even though sheep appear to be healthy, subclinical infections of helminth parasites can depress performance and therefore prophylactic measures are necessary. These findings have important consequences for the Program's research on improved feeding systems. **E.F. Thomson; G. Orita, JICA consultant; F.A. Bahhady; C. Rhodes, consultant.**

Chapter 1

INTRODUCTION

The major event in 1989 which affected ICARDA as a whole was the completion of the Medium Term Plan and Strategy documents which were a necessary follow-up to the External Program Review held in mid-1988. Both documents were accepted by the Technical Advisory Committee (TAC) at the end of 1989 and are now being given as examples for the other CGIAR Centers to follow.

The strategy document, as its name conveys, emphasises sustainable agriculture and envisages a shift of ICARDA's research focus towards lower rainfall areas. In this respect the Pasture, Forage and Livestock Program plays a central role at ICARDA as the Program is giving particular attention to feed-producing systems where annual rainfall is 200 - 350 mm and soils are particularly susceptible to wind erosion. It is in these areas of WANA that barley is the main crop and livestock products are the most important output of the farming systems.

Livestock account for about 30% of agricultural output in WANA and the Medium Term Plan acknowledges this by outlining the gradual expansion of the Program during the 5-year period starting in 1990. This planned expansion from seven to eleven senior scientists is mainly in the livestock sciences which have hitherto been poorly represented at ICARDA. As well as this change, emphasis will be given to consolidating the existing research, particularly that concerning the constraints to adoption of new pasture and feed legume-based, feed-producing systems and their impact on farm productivity. This research will center around already successful on-farm testing of these systems.

The small ruminants in WANA depend heavily on Mediterranean grasslands, marginal lands, barley grain, cereal straws, irrigated crop residues, and industrial by-products. In addition to these feed resources, the weedy fallows of North Africa are very important and they could be made more productive. The extensive areas of clean fallows in West Asia could be used to produce pasture and feed legumes.

The research on annual feed legumes and annual Medicago (medics) accounts for over half of the Program's activities. This is a reflection of the potential contribution that these legumes could make towards removing the acute and chronic livestock feed deficits in WANA. They are suited for growing on the many million hectares of fallow land, with current research on feed legumes concentrating on areas receiving 250-300 mm annual rainfall, and that on annual medics in areas receiving 300-350 mm. Research on these species is discussed in chapters 2, 3, 4, and 5, with chapter 5 covering the research activities in North Africa. Because of the absence of Dr Cocks on sabbatical leave, research on the ecology of medics is not included in this year's report.

Chapter 6 reports the Program's research aimed at improving both the Mediterranean grasslands in the arable zone, where the land is too steep or too shallow for cultivation, and the marginal lands between the driest zone of cultivation and the deserts. These two categories of permanent grasslands cover 375 million hectares and some authorities consider that they provide 50-60% of the livestock feed. They are particularly fragile and are suffering from severe degradation as an expanding population of small ruminants has been forced to use a declining area due to the steady encroachment of cultivation into the driest areas. The Program is starting to give attention to the use of edible shrubs as drought feed for livestock and a new collaborative project started in 1989 with the Syrian Steppe Directorate and ACSAD. These shrubs are also likely to serve as a form of wind erosion control in areas where barley is being cultivated.

It is essential to have healthy livestock with a high genetic potential to make the most efficient use of the improved feed supply. Both health and genetic aspects of livestock production are discussed in the Medium Term Plan and the former has received attention for the past 3 years. It is hoped that the genetic aspect will be initiated very soon. However, this research will focus on examining feeding strategies that allow improved sheep and goats to reach their genetic potential and not on genetic improvement *per se* which most national programs are successfully doing already. Chapter 7 outlines some pioneering on-farm research investigating the impact of feeding management and helminth parasites on sheep productivity.

The training and workshop activities of the Program are summarized in Chapter 8. The former activities vary from residential courses to degree related research and these are constantly being reviewed to meet the needs of national programs.

No research on cereal straw quality is reported this year since this research was suspended following the death of Francis Herbert in May 1988 and the absence of Dr Thomson on sabbatical.

Collaboration with national scientists and farmers

One aspect worthy of particular mention is the Program's close and successful collaboration with national scientists and farmers. In Syria, our host country, the linkage with the Directorate of Scientific Agricultural Research in Damascus has strengthened and now there is collaboration in projects at El Tah in Idleb Province, El Bab in Aleppo Province, near Kamishly in northeast Syria, and in the Houran area of southern Syria. This research is particularly valued as it allows feedback from farmers on the merits and constraints of new technologies being developed and tested. Similarly, contacts are also being maintained with national scientists and farmers in neighbouring countries. An example is the visit by Jordanian officials and farmers to Tel Hadya, El Tah, and El Bab last April. Whenever possible, the Program endeavours to work through the national scientists and give them guidance when needed. The Program's highly successful work in North Africa is evidence of this strategy (Chapter 5).

One other highly successful collaboration with national scientists is the "need-to-inoculate" research (Chapter 3). This network of national scientists in several WANA countries and two in Europe is allowing rapid progress to be made towards defining the geographic variation in the ecology of Rhizobium meliloti and the effectiveness of nodulation of several species of annual Medicago.

Senior staff

In April Dr Euan Thomson returned from a year's sabbatical at the University of New England, Armidale, Australia where he spent most of his time writing papers and analyzing results from previous research conducted at ICARDA. Dr Phil Cocks left for England in May to start a year's sabbatical at the University of Reading. He also aims to write up previous research.

Also in April, Dr Alan Smith, the Grazing Management Specialist in the Program, returned to England. He joined the Program in September 1985 and initiated a major rotation experiment involving stocking rate studies on medics. The Program appreciates his contributions to its research and to its training, in which he excelled.

The weather in Syria during the 1988/89 season

In Syria and Lebanon the 1988/89 season had two distinct periods. It started with ample, much higher than average rainfall which was followed by a long, very dry second period.

Substantial and early rainfall was received at all stations, starting in the second week of October. Quite heavy rain, in combination with fairly mild temperatures, continued until the end of the year. From the second week of January onward a quite different weather pattern prevailed with very little rainfall (except for a wet spell in March), cold nights, and sunny days, with high evaporative demand in spring. Total seasonal rainfall was far below the long-term average at all sites. There is only approximately a 1 in 10 chance of receiving the same or less rain than during the 1988/89 season, and one has to go back in history until 1954/55 to find a season with a similar intra-seasonal distribution of rainfall in Aleppo.

The heavy rain in October and November fell in distinct spells which made timely planting possible, as there was sufficient time between falls for the field surface to dry. The good rains up to December enabled early sown cereals and legumes to develop good stands which managed to withstand the following frost and drought better than one might have expected, yielding up to half of what is harvested in a normal season. The reduced weed infestation due to the drought also contributed to this effect. Later sown crops, however, suffered severely from drought and frost, often yielding not more than 10% of the average when harvested. In the barley-livestock areas, most fields were grazed off before harvest time. Even in the wetter, wheat growing areas, grazing of the crops was widespread.

Further details of the weather in 1988/89 are provided in Appendix Tables 2.1 - 2.4. W. Goebel (FRMP) kindly provided the meteorological information.

Definitions and abbreviations

Throughout this report we have tried to use the common names of plants, indicating the scientific name when the species is first discussed. However, it may be helpful to readers if some of the more important species are listed here, for easy reference:

vetch - various species of *Vicia*, including common vetch (*V. sativa*), bitter vetch (*V. ervilia*), woollypod vetch (*V. villosa* subsp. *dasycarpa*), hairy vetch (*V. villosa* subsp. *amphicarpa*), and subterranean vetch (*V. sativa* subsp. *amphicarpa*).

chickling - various species of *Lathyrus* including common chickling (*L. sativus*), dwarf chickling (*L.*

cicera), and ochrus chickling (L. ochrus).

forage pea - Pisum sativum.

medics - various species of Medicago; of these only barrel medic (M. truncatula), snail medic (M. scutelata), strand medic (M. littoralis), and gama medic (M. rugosa) have widely accepted common names. M. polymorpha, although often called burr medic, is referred to by its scientific name. At present we do not have a common name for M. rigidula or M. rotata.

clovers - various species of Trifolium, including subterranean clover (T. subterranean) and rose clover (T. hirtum).

We have also defined a number of commonly-used terms:

accession (acc.) - an ecotype as collected in its native habitat and used in a breeding project, or any other sample of material brought into the testing system; normally used in association with an accession number.

cultivar (cv.) - one or a group of similar genotypes, or an ecotype used in commercial agriculture, which has been officially released.

feed - is a general term covering any plant material that can be used for feeding to livestock. It includes annual pasture legumes, feed legumes, cereal and legume grains, cereal and legume straws, irrigated crop residues, industrial by-products, and grasslands.

feed legumes - this term is now preferred to forage legumes. They are monocultures of certain legumes, namely vetch, forage pea, and chickling, or mixtures of these species with cereals. In general, forages are crops sown and harvested in the same year and used for hay, straw, or grazing.

grasslands - refers to non-arable land within the cereal zone with a flora based on Mediterranean annual species. In previous reports we have included this class of land in the term "marginal land".

herbage - plant material used to feed livestock.

herbage yield - the mass of dry material produced. This term replaces "dry-matter yield", which is often used elsewhere. Drying is normally at 80-90°C.

ley farming - in Mediterranean regions the farming system in which self-regenerating pastures are grown in rotation with cereals.

marginal land - land adjacent to the steppe which, because of low and unreliable rainfall, is risky for cultivation and crop production. Also used for all kinds of non-arable land.

pasture - a plant community which is grazed, usually referring to a regenerating population of annual legumes.

residues - herbage which remains on the land after the growing season is finished.

selection (sel.) - resulting from selection within an accession comprising more than one genotype. In its numbering system ICARDA allocates both an accession number and, where applicable, a selection number.

self-regenerating pasture - the annual pastures which establish from dormant seeds after the cereal phase of a pasture/cereal rotation.

steppe - non-irrigated land that receives (in Syria) less than 200 mm of rainfall.

strain - a general term to cover accession, selection, variety, and cultivar. It is used in this report to describe a culture of _Rhizobium_ of different origin to other cultures.

straw - vegetative material (mainly stem plus leaf) obtained from the residues of cereals or legumes which is removed from the field and stored.

stubble - cereal residues remaining in the field after harvest.

variety - we use this term both in its botanical sense, where it is a taxonomic unit beneath species, and to describe a group of genotypes used by farmers in a traditional sense, for example "landraces".

In the sections on ruminant nutrition the following abbreviations are used:

- ADF - acid detergent fibre
- CP - crude protein
- DDMI - intake of digestible dry matter
- DM - dry matter
- DOMI - intake of digestible organic matter
- IVDDM - *in vitro* digestible dry matter
- IVDOM - *in vitro* digestible organic matter
- MBS - metabolic body size = body mass$^{0.75}$
- ME - metabolisable energy
- OM - organic matter
- OMI - intake/kg of metabolic body mass
- NDF - neutral detergent fibre
- VFI - voluntary feed intake

Other abbreviations are as follows:

- ACSAD - Arab Center for Studies of Arid Zones and Dry Areas, Damascus
- CSIRO - Commonwealth Scientific and Industrial Research Organization, Australia
- CIP - Cereal Improvement Program, ICARDA
- FLIP - Food Legume Improvement Program, ICARDA
- GRP - Genetic Resources Program, ICARDA
- JICA - Japanese International Co-operation Agency
- MIRCEN- Microbiology Resources Centres (a network sponsored by UNESCO)
- NARS - National Agricultural Research Systems
- ODNRI - Overseas Development Natural Resources Institute, London
- SMAAR - Syrian Ministry of Agriculture and Agrarian Reform
- SSD - Syrian Steppe Directorate
- UNDP - United Nations Development Program
- WANA - West Asia and North Africa

Preschedules

As in previous years, the report of each experiment refers to a preschedule number. These preschedules are written before the experiment begins and are the basis for discussion and criticism at our planning meetings. Taken together, the Program Annual Report and preschedules provide a reference collection of our work and the thinking which goes into it. A list of preschedules since 1984 is shown in Appendix 3.

Acknowledgements

The scientist responsible for conducting a particular piece of research is acknowledged in the body of this report. As we do not acknowledge the work of the many skilled and dedicated assistants and technicians at the same time, it is appropriate to do so here. They deserve particular tribute since they, and the regular labourers, are responsible for the bulk of the daily work in the Program.

Special mention should be made of several organizations which enable us to conduct some of our most important research. These include the Government of Italy which supports the research on Mediterranean grasslands, JICA which supports the research on helminth parasites, and ODA (UK) which supports the research on pea palatability.

Once again Aida Battikha, with assistance from Zukka Musattat, deserves special thanks for the word processing necessary to prepare this report.

March 1990 **Euan F. Thomson**
Acting Program Leader

Chapter 2

SELECTION OF WIDELY ADAPTED AND PALATABLE FEED LEGUMES

Annual feed crops are one of the alternatives being studied to replace a fallow year in cereal-based rotations in dry areas. They are defined as leguminous species sown and harvested in 1 year for hay, seed, or straw, specifically to feed livestock. They can also be grazed.

The main goal of our breeding program is to produce widely adapted and palatable cultivars of several feed legumes which can be used for different purposes. It is desirable to have widely adapted cultivars that can be recommended for different locations with similar agroecological conditions.

In spite of the diversity of legumes in the Mediterranean basin, few have been used specifically as feed crops, and they have received virtually no attention from plant breeders. Therefore, our goals are to develop improved cultivars of species currently in use by farmers and to examine some of the alternative wild species found in areas receiving 250-600 mm annual rainfall. Because there has been so little feed legume breeding in the past, our emphasis is on selecting from existing landraces and wild ecotypes. About 20% of our available genetic resources are being used for hybridization.

Particular attention is being given to legume crops for dry areas where annual rainfall is 250-300 mm. In these areas, legume crops are not widely grown and farmers grow cereals, usually barley, followed by a fallow year or, increasingly, there is cereal monoculture. In view of ICARDA's overall objective of developing sustainable farming systems, there is a clear need for legume crops adapted to these dry areas.

The two genera being intensively evaluated are vetches (*Vicia* spp.) and chicklings (*Lathyrus* spp.). Of the vetches, we are selecting or hybridizing genotypes from *V. villosa* ssp. *dasycarpa* (woollypod vetch), *V. ervilia* (bitter vetch), *V. sativa* (common vetch), and *V. narbonensis* (narbon vetch) and of the chicklings, *Lathyrus sativus* (common chickling), *L. cicera* (dwarf chickling), and *L. ochrus* (ochrus chickling) are being evaluated. Two of the most exciting species are narbon vetch and dwarf chickling because of their potential in dry areas and tolerance to frost. There has also been exploratory work on *V. hybrida* and *V. palestina*.

The process of developing new crops from wild species involves germplasm evaluation and seed multiplication in nursery rows; evaluation of selected genotypes (selections) in microplot trials; evaluation of promising genotypes in advanced yield trials at two contrasting locations; and multilocation (regional) testing of promising lines in different ecological zones. Hybridization is used to overcome specific weaknesses such as shattering seed pods, lodging, susceptibility to diseases, nematodes, and neurotoxins. The reaction of selected genotypes to major foliar and root diseases under natural and artificial conditions starts in microplot trials. Palatability and nutritive value of the herbage, hay, grain, and straw are also monitored. The process ends with on-farm trials which aim to study the species under farmers' conditions and expose them to the evaluation of farmers.

Evaluation in microplots (Preschedules F71, F75)

The study of variation in agronomic traits helps to establish a suitable breeding program for improved cultivars. Selection for desirable traits such as high herbage production and seed yield, and early flowering and maturity, begins in microplots.

In 1988/89, when the annual rainfall at Tel Hadya was 243 mm and there were over 50 days with temperatures below 0°C, V. sativa, V. ervilia, V. hybrida, and V. palestina were sown in microplot trials at Tel Hadya with 3.5 m^2 plots arranged in a triple lattice design. For all species, seed rate was 100 kg/ha and fertilizer was applied at 40 kg P_2O_5/ha. These microplot experiments, each with three replicates, were duplicated. One trial was harvested at 100% flowering to determine herbage yield and the other was harvested at maturity to measure seed and straw yields and other agronomic traits.

Common vetch (V. sativa). Twenty-five selections were tested at Tel Hadya and the results of the nine most promising lines are shown in Table 2.1. Herbage yield varied from 1474 to 2427 kg/ha, grain yield ranged from 428 to 951 kg/ha, and harvest index ranged from 19 to 32%. Common vetch was slightly affected by frost, but the relatively low seed yields and harvest indexes were mainly due to the low rainfall during the flowering period. Two promising lines, selections 2502 and 2485, are characterized by resistance to lodging at maturity and a high harvest index.

Bitter vetch (V. ervilia). Sixteen selections of bitter vetch derived from nursery evaluation in 1987/88 were tested at Tel Hadya. Table 2.2 shows the yields from the nine best

Table 2.1. Herbage, seed, and straw yields and harvest index for the best lines of *V. sativa* in microplot trials at Tel Hadya.

Selection no.	Herbage yield (kg/ha)	Seed yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
2502	2292	951	2066	32
2485	2013	843	1886	31
2493	1846	823	2228	27
2506	2003	655	1735	27
2497	1474	507	1501	25
2487	2315	737	2087	26
2494	1974	684	1940	26
2483	2241	632	1957	24
2495	1851	696	2077	25
Grand mean[1]	2665	648	2017	24
SE (±)	133	76	144	1.7
LSD (P=0.05)	378	216	410	4.7

[1]Mean for all 25 selections.

Table 2.2. Herbage, seed, and straw yields and harvest index for the best lines of *V. ervilia* in microplot trials at Tel Hadya.

Selection no.	Herbage yield (kg/ha)	Seed yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
2518	2513	1164	1815	39
2516	2336	1082	1749	38
2522	2713	1267	2060	38
2510	2237	976	1814	35
2521	2523	1214	2291	34
2508	2666	1033	1926	34
2513	2565	1109	2196	34
2512	2434	1078	2087	34
2517	2711	1126	2220	33
Grand mean[1]	2417	1017	2082	33
SE (±)	143	102	185	2.1
LSD (P=0.05)	414	295	534	6.1

[1]Mean of all 16 selections

selections. Herbage yield varied from 2019 to 2713 kg/ha, seed yield ranged from 732 to 1267 kg/ha, and harvest index varied from 26 to 39%.

Vicia hybrida. Sixteen selections of V. hybrida derived from nursery evaluation in 1987/88 were tested in microplots at Tel Hadya. Table 2.3 shows the results from the nine best selections. Herbage yield varied from 1625 to 2216 kg/ha, whereas seed yield ranged from 108 to 395 kg/ha and harvest index from 5 to 17%. V. hybrida is characterized by a prostrate, compact growth habit and slow winter growth followed by rapid spring growth. This makes the species suitable for grazing. The low seed yield and harvest index were mainly due to the difficulty of harvesting this prostrate species.

Table 2.3. Herbage, seed, and straw yield and harvest index for the best lines of V. hybrida in microplot trials at Tel Hadya.

Selection no.	Herbage yield (kg/ha)	Seed yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
2539	1625	395	1930	17
2546	1833	345	1931	15
2544	1945	336	1961	14
2547	1993	304	1904	14
2543	2157	334	2217	13
2540	1877	229	1721	12
2550	2080	250	2105	11
2545	2083	213	1954	10
2542	1806	184	1619	10
Grand mean[1]	1968	244	2006	11
SE (±)	97	29	172	0.9
LSD (P=0.05)	282	83	499	2.6

[1]Mean for all 16 selections.

Vicia palestina. Sixteen selections were assessed in microplots at Tel Hadya. The results in Table 2.4 show only the nine best selections. Herbage yield varied from 1304 to 1724 kg/ha, whereas seed yield ranged from 121 to 535 kg/ha and harvest index from 8 to 29%.

Table 2.4. Herbage, seed, and straw yields and harvest index for the best lines of V. palestina in microplot trials at Tel Hadya.

Selection no.	Herbage yield (kg/ha)	Seed yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
2524	1520	535	1333	29
2527	1304	524	1368	28
2523	1457	502	1307	28
2536	1593	519	1387	27
2526	1372	504	1442	26
2525	1651	489	1740	22
2528	1666	416	1743	19
2530	1699	376	1572	19
2529	1342	359	1613	18
Grand mean[1]	1509	373	1569	19
SE (±)	114	41	116	1.1
LSD (P=0.05)	329	119	335	3.3

[1]Mean for all 16 selections.

Table 2.5 is a summary of the microplot trials in 1988/89. Bearing in mind that feed legumes can be used for pasture, hay, straw, and grain production, we can begin to see how the various species will fit into farming systems. The early flowering and maturity and the high grain and straw yields of V. ervilia suggest that it could be used by farmers who want straw and grain. Vicia sativa would be recommended for hay, straw, and grain production, whereas V. hybrida and V. palestina would be suitable for grazing because of their low harvest indexes and grain yields.

Table 2.5. Range in the major attributes of four feed legume species evaluated in microplot trials at Tel Hadya in 1988/89.

Attributes	V. sativa	V. ervilia	V. hybrida	V. palestina
Days to 100% flowering	113-121	105-115	106-120	110-122
Frost effect[1]	1-2	1-2	1-3	2-4
Herbage yield (kg/ha)	1474-2427	2019-2713	1625-2216	1304-1724
Grain yield (kg/ha)	428-951	732-1267	108-395	121-535
Straw yield (kg/ha)	1501-2228	1749-2717	1619-2409	1307-2012
Harvest index (%)	19-32	26-39	5-17	8-29

[1]*On a visual scale where 1 = no damage; 5 = all plants killed by frost.*

Advanced yield trials with chickling and narbon vetch at Tel Hadya and Breda (Preschedules F76, F77)

Promising lines from the microplot studies are tested in advanced yield trials at two locations with very different annual rainfalls, i.e., Breda and Tel Hadya. The low rainfall and temperatures in 1988/89, which followed a high rainfall year, gave us a unique opportunity to assess our promising lines for both frost and drought tolerance.

Promising lines of common chickling, dwarf chickling, ochrus chickling, and narbon vetch were evaluated in advanced yield trials at Tel Hadya and Breda. The four experiments were sown and managed at both locations in the same way as microplot trials except that the plots were 28 m^2. Two lentil lines, ILL 4401 and ILL 5582, were included in each trial to allow comparisons between forage and feed legumes in dry areas.

Common chickling (L. sativus). Sixteen promising lines were tested. Herbage yield varied from 1257 to 1799 kg/ha and from 748 to 1063 kg/ha, at Tel Hadya and Breda, respectively. Yields were greater at Tel Hadya than at Breda, the overall means for total biological and grain yield being 2152 and 446 kg/ha and 1395 and 271 kg/ha at Tel Hadya and Breda, respectively (Table 2.6). Harvest index varied from 18 to 25% and from 14 to 24% at Tel Hadya and Breda, respectively. Selections 347 and 504 produced large biological and grain yields at both sites. Promising lines of common chickling were only slightly affected by frost at both sites.

Table 2.6. Biological and grain yields and harvest index of promising lines of L. sativus grown at Tel Hadya (TH) and Breda in advanced yield trials.

Selection no.	Biological yield (kg/ha)		Grain yield (kg/ha)		Harvest index (%)	
	TH	Breda	TH	Breda	TH	Breda
347	2780	1828	703	443	25	24
504	2220	1480	491	327	22	22
505	2010	1083	389	206	19	19
508	2187	1345	455	190	21	14
510	2070	1327	379	200	18	15
516	2140	1342	457	220	21	16
519	1940	1293	402	268	21	21
520	1853	1221	338	210	18	17
522	2357	1571	464	309	20	20
527	2097	1398	390	260	19	19
526	2000	1333	361	240	18	18
529	2144	1417	483	310	23	22
530	1870	1247	357	238	19	19
531	2293	1467	572	320	25	22
533	1987	1325	421	281	21	21
535	2480	1653	497	319	19	19
Grand mean	2152	1395	446	271	21	19
SE (±)	160	119	62	37	2.6	4.3
LSD (P=0.05)	325	229	126	76	5.3	8.7

Dwarf chickling (*L. cicera*). Ten promising lines of dwarf chickling were tested. At Tel Hadya, herbage yield varied from 1652 kg/ha for selection 536 to 2231 kg/ha for selection 489 and at Breda it varied from 887 kg/ha for selection 536 to 1980 kg/ha for selection 495. In the mature crop at Tel Hadya, grain yield varied from 511 kg/ha for selection 536 to 908 kg/ha for selection 492 and at Breda grain yield ranged from 311 kg/ha for selection 536 to 691 kg/ha for selection 495 (Table 2.7). Generally, dwarf chickling produced more seed and straw than common or ochrus chickling at both Tel Hadya and Breda. The differences between the two sites were less for dwarf chickling than for the other two species, probably because it flowered earlier and was not affected by frost. This small difference between sites may indicate better drought tolerance in dwarf

Table 2.7. Biological and grain yields and harvest index of promising lines of *L. cicera* grown at Tel Hadya (TH) and Breda in advanced yield trials.

Selection no.	Biological yield (kg/ha)		Grain yield (kg/ha)		Harvest index (%)	
	TH	Breda	TH	Breda	TH	Breda
536	2346	1534	511	311	22	20
488	2710	1831	645	454	24	25
489	2636	1814	769	569	29	31
491	2687	1855	790	590	29	32
492	2847	1901	908	608	32	32
493	2677	1824	719	519	27	28
494	2640	1810	748	549	28	30
495	2724	1980	791	691	29	35
496	2617	1817	732	560	28	31
500	2723	1833	739	510	27	28
Grand mean	2660	1820	735	536	27	29.2
SE (±)	158	113	83	36	2.9	2.8
LSD (P=0.05)	328	235	172	74	6.0	5.9

chickling. The most promising line was selection 495 which produced high grain and straw yields at both sites.

Ochrus chickling (L. ochrus). Sixteen selections of ochrus chickling derived from microplot trials in 1987/88 were tested. In the 1988 Program Annual Report we reported that ochrus chickling produced the highest seed and straw yields of the feed legumes due to its earliness and, as far as we could judge, its resistance to broomrape (Orobanche crenata). We also indicated that we had not yet been able to test ochrus chickling in a year of severe frost. The 1988/89 season gave us the perfect opportunity to do this. Unfortunately, all ochrus chickling selections were severely damaged by frost which markedly reduced their total biological yields and subsequent grain and straw yields. At Tel Hadya, the total biological yield varied from 320 to 1193 kg/ha and at Breda from 175 to 383 kg/ha. Grain yield ranged from 5 to 314 kg/ha and from 5 to 92 kg/ha at Tel Hadya and Breda, respectively (Table 2.8). Grain and total biological yields were only 3 and 6% respectively, of those obtained in 1987/1988. The advantages of ochrus chickling are its resistance to Orobanche crenata and its early flowering and maturity.

Narbon vetch (V. narbonensis). Two experiments were carried out to evaluate promising genotypes of narbon vetch. In the first, fourteen selections from microplot trials in 1987/88 were tested in advanced yield trials at Tel Hadya and Breda. In the second, nine selections were evaluated at Tel Hadya and Breda for a second season.

Experiment 1. Herbage yield varied from 1100 to 1428 kg/ha at Tel Hadya and from 570 to 856 kg/ha at Breda, while grain yield varied from 779 to 927 and from 312 to 461 kg/ha at Tel

Table 2.8. Biological and grain yields and harvest index of promising lines of _L_. _ochrus_ grown at Tel Hadya (TH) and Breda in advanced yield trials.

Selection no.	Biological yield (kg/ha)		Grain yield (kg/ha)		Harvest index (%)	
	TH	Breda	TH	Breda	TH	Breda
185	953	235	123	25	13	11
537	1070	352	282	92	26	26
538	1193	309	314	69	26	22
539	927	383	235	64	26	17
540	1183	326	285	81	24	25
541	1043	335	232	46	22	14
542	717	247	145	17	20	7
543	453	237	59	37	12	16
544	320	175	5	5	2	3
545	530	302	89	52	17	17
546	692	251	73	41	10	16
547	510	251	40	26	7	10
548	717	329	72	39	9	12
549	543	256	41	26	8	10
550	453	310	40	31	7	10
Grand mean	749	290	131	43	17	15
SE (±)	167	51	58	18	2.7	2.4
LSD (P=0.05)	340	104	119	36	5.5	5.0

Hadya and Breda, respectively (Table 2.9). The average straw yield was 1411 and 849 kg/ha at Tel Hadya and Breda, respectively.

Experiment 2. Herbage yields varied from 1216 to 1688 kg/ha and from 665 to 864 kg/ha at Tel Hadya and Breda, respectively. Grain yield varied from 836 to 969 kg/ha and from 397 to 556 kg/ha (Table 2.10) and straw yield from 1173 to 1564 kg/ha and from 845 to 673 kg/ha at Tel Hadya and Breda, respectively.

Table 2.9. Biological and grain yields and harvest index of promising lines of V. narbonensis grown at Tel Hadya (TH) and Breda (first year advanced yield trials).

Selection no.	Biological yield (kg/ha)		Grain yield (kg/ha)		Harvest index (%)	
	TH	Breda	TH	Breda	TH	Breda
0067	2237	1395	927	415	41	30
2461	2163	1263	779	389	36	31
2462	2470	990	902	316	37	32
2464	2207	1250	810	385	37	31
2465	2270	1244	874	381	39	31
2466	2413	1123	902	344	37	31
2467	2233	1063	798	312	36	29
2469	2440	1223	915	363	38	30
2473	2210	1057	819	316	37	30
2474	2233	1157	798	331	36	29
2475	2213	1223	840	378	38	31
2476	2160	1410	862	453	40	32
2477	2210	1404	914	461	41	33
2478	2253	1304	812	378	36	29
Grand mean	2265	1222	854	373	38	31
SE (±)	163	160	67	48	1.5	2.6
LSD (P=0.05)	332	326	137	97	3.1	5.4

These results indicate that there were great differences between the 2 years at both sites, attributable to the widely contrasting rainfall.

Table 2.11 is a summary of the advanced yield trials in 1988/89 at Tel Hadya and Breda for three of the chickling species, one narbon vetch, and the two lentil lines. The susceptibility of ochrus chickling to frost is clear and when rainfall is below 250 mm its yield drastically decreases. It also has the lowest seed and straw yields. For these reasons it is recommended only for regions with mild winters.

Table 2.10. Biological and grain yields and harvest index of promising lines of *V. narbonensis* grown at Tel Hadya (TH) and Breda (second year advanced yield trials).

Selection no.	Biological yield (kg/ha)		Grain yield (kg/ha)		Harvest index (%)	
	TH	Breda	TH	Breda	TH	Breda
0067	2533	1250	969	407	38	33
2391	2230	1283	836	474	37	37
2392	2200	1356	902	532	41	39
2387	2110	1325	937	545	44	41
2388	2170	1102	860	433	40	39
2380	2327	1277	968	556	42	44
2390	2327	1070	935	397	40	37
2393	2257	1270	852	425	37	33
2383	2425	1243	925	451	38	36
Grand mean	2286	1242	909	469	39.7	37.7
SE (±)	203	75	82	31	1.8	2.3
LSD (P=0.05)	420	157	172	65	3.7	4.8

Table 2.11. Averages of major attributes of four feed legume species grown at Tel Hadya and Breda in advanced yield trials compared with the average of two promising lines of lentils.

Attributes	Common chickling	Dwarf chickling	Ochrus chickling	Narbon vetch	Lentil
Tel Hadya					
Frost effect[1]	1.5	1.0	4.2	1.0	1.5
Days to maturity	161	155	140	140	157
Grain yield (kg/ha)	446	735	131	909	478
Straw yield (kg/ha)	1706	1925	618	1377	1650
Harvest index (%)	21	28	17	40	22
Breda					
Frost effect[1]	1.5	1.0	4.5	1.0	1.0
Days to maturity	155	148	130	120	150
Grain yield (kg/ha)	271	536	43	469	100
Straw yield (kg/ha)	1124	1284	247	773	616
Harvest index (%)	19	29	15	38	14

[1]On a visual scale where 1 = no damage; 5 = nearly all plants killed by frost.

Dwarf chickling had higher grain yields than lentil at both sites and produced nearly 2t/ha straw at Tel Hadya and 1.3 t/ha at Breda. This species could be of great value in areas receiving less than 300 mm rainfall where lentil is less suitable. Under Tel Hadya conditions, common chickling had nearly the same grain and straw yields as lentils whereas at Breda, where rainfall was 194 mm, its grain and straw yields were twice as high as lentils. Therefore, common chickling is more adapted to drier areas than lentil, and it could be seen as an alternative to lentil for grain and straw production in these areas.

Under Breda conditions, the average seed yield of narbon vetch was 469 kg/ha, although selections 2392 and 2388 produced more than 500 kg/ha. Lentil produced only 100 kg/ha. At Tel Hadya, the grain yield of narbon vetch was twice that of lentil, while the straw yield was slightly less than lentil, which accounts for the higher harvest index of narbon vetch.

Narbon vetch is an ideal legume for producing winter stocks of straw for feeding sheep. It does not lose its leaves following frost, like ochrus chickling, and its seeds look like common chickling. Narbon vetch is also resistant to bird damage at the seedling stage, an attribute which is a major advantage when establishing a good plant population, and is palatable to sheep when fed as hay. It is also easy to establish because its large seeds may be sown deeper, and therefore closer to moisture, than other legume species. Moisture in the surface soil layer often determines seedling viability but the small seedlings of narbon vetch are less affected by drying of the soil surface than other legumes because deeper sowing is possible.

These attributes of narbon vetch illustrate its huge potential in areas receiving 250-300 mm annual rainfall, whereas common vetch is more suited to areas with over 300 mm. More research is needed into the nutritional value for livestock of the grain and straw of narbon vetch.

Woollypod vetch advanced yield trials at Tel Hadya (Preschedule F78)

Fourteen selections of woollypod vetch were tested in advanced yield trials at Tel Hadya. There were large differences in herbage production, seed yield, and harvest index, with herbage yield varying from 838 to 1498 kg/ha, seed yield from 13 to 244 kg/ha, and harvest index from 2 to 21% (Table 2.12). In contrast to narbon vetch, woollypod vetch produced less seed and had a lower harvest index. The low seed production was probably related to the delayed appearance of floral buds since bud development is inhibited by high temperatures and this results in high abortion rates of young pods after fertilization.

Subterranean vetch (Preschedule F80)

The objective of these studies was to make preliminary observations on the response of subterranean vetch (V. sativa ssp. amphicarpa) to grazing. Two experiments were conducted. In the first, four genotypes of subterranean vetch were sown in a replicated split-plot design, the main plots being four genotypes and the sub-plots being clipping treatments (11 April, 25 April, and no clipping). Individual plot size was 9 m^2. The plants were clipped 5cm above the soil surface at each clipping. Herbage was dried at 70°C for 24 h to

Table 2.12. Herbage, seed, and straw yields and harvest index for the promising lines of V. villosa ssp. dasycarpa grown in advanced yield trials at Tel Hadya.

Selection no.	Herbage yield (kg/ha)[1]	Seed yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
683	1149	222	1068	17
2426	838	13	657	2
2431	1200	237	953	20
2437	1219	207	1123	16
2428	1155	182	1074	14
2441	1309	244	1100	18
2442	1323	202	995	17
2445	1498	231	1179	16
2446	1208	214	936	19
2450	1184	198	985	17
2451	1167	205	998	17
2455	1097	193	964	17
2456	1082	169	947	15
2457	1228	241	915	21
Grand mean	1180	224	1014	17
SE (±)	132	44	84	2.2
LSD (P=0.05)	270	91	172	4.5

[1]100% flowering.

determine herbage yield and subterranean seed yield was measured. In the second experiment, the same genotypes were used with the same experimental design but with different treatments applied in the sub-plots: at 50% flowering the plots were clipped to 5, 7.5, and 15 cm above the soil surface compared with no clipping. The subterranean seed yield was measured.

Clipping of aerial shoots stimulated basal branching above and below ground. The plants clipped on 25 April produced more herbage than those clipped on 11 April (Table 2.13) and the plants clipped on 25 April produced more underground seeds than those clipped 2 weeks earlier. Severe clipping to 5cm (Experiment 2) prevented the production of aerial pods and the plants responded by producing more subterranean seeds. The underground seed bank under severe clipping varied from 138 to 185 kg/ha (Table 2.14) and light clipping (15 cm) resulted in more subterranean seeds than moderate clipping (7.5 cm).

Table 2.13. Herbage and underground seed production for four genotypes of subterranean vetch at two clipping dates and without clipping.

Genotypes/origin	Clipping dates		
	11.4.89	25.4.89	No clipping
Herbage production (kg/ha)			
Sel. 2416 Turkey	147	556	972
Sel. 2660 Turkey	195	355	1077
Sel. 2647 Syria	109	231	732
Sel. 2650 Syria	132	316	941
Mean	133	364	931
Underground seed production (kg/ha)			
Sel. 2614 Turkey	157	325	775
Sel. 2660 Turkey	176	386	685
Sel. 2647 Syria	147	218	373
Sel. 2650 Syria	139	301	485
Mean	155	307	579

LSD (P = 0.05):

- herbage production: clipping treatments, 224 kg/ha. genotypes, 140 kg/ha.

- underground seed production: clipping treatments, 140 kg/ha genotypes, 81 kg/ha.

Table 2.14. Effect of clipping height on underground seed production in four genotypes of subterranean vetch (kg/ha).

Genotypes/origin	Clipping height (cm)			
	5	7.5	15	No clip.
2614 Turkey	185	214	291	641
2660 Turkey	155	243	306	675
2647 Syria	161	194	237	690
2650 Syria	138	151	245	501
Mean	160	200	270	627

LSD (P = 0.05) for clipping treatments = 101 kg/ha.
LSD (P = 0.05) for genotypes = 35 kg/ha.

The drier conditions in 1988/89 favoured earlier subterranean flowering and, consequently, the proportion of subterranean pods was greater. Following the prolonged drought in early spring, a large proportion of plants produced only subterranean pods, indicating that the plants were able to persist under prolonged drought and heavy grazing. The 60-80% hardseededness of subterranean vetch reported in last year's Program Annual Report is an added advantage as this vetch could self-regenerate after a cereal crop.

The results are sufficiently promising for the research to be continued under real grazing conditions in 1989/90 using subterranean vetch in rotation with barley.

Screening for resistance to stem and leaf diseases (Preschedule F81)

One of the most important selection criteria for developing productive forage legumes is resistance to major stem and leaf diseases. Plants are screened for disease resistance in microplots and advanced yield trials. Promising genotypes are usually tested in disease nursery plots under artificial conditions.

In 1988/89, 22 promising genotypes of narbon vetch, 16 of common chickling and ochrus chickling, and 10 of dwarf chickling were tested under artificial infection. Artificial epiphytotic infections of downy mildew (Peronospora Vicia sativa Gaum) and powdery mildew (Erisiphe pisi E.sp. sativa) were applied to narbon vetch, and a downy mildew (Peronospora trifolium) and powdery mildew (E. martii F.sp lathyri) were applied to chickling. Ascochyta leaf spot, stem blight and foot rot (Ascochyta pisi and Phoma medicaginis var. pinodella), and botrytis blight (Botrytis cinerea) were applied to both feed legume species. Losses in seed yields were estimated as described in the 1988 Program Annual Report. Lines were evaluated on a scale from 1 (resistant) to 5 (highly susceptible).

One genotype of narbon vetch (selection 67) was resistant and selections 2383, 2387, 2469, and 2465 were tolerant to powdery mildew, Ascochyta leaf spot, and botrytis blight. Crop losses varied from 8 to 46%, 6 to 33%, and 2 to 45% in the three major diseases, respectively. Powdery mildew symptoms did not appear as conditions were unfavourable.

Five genotypes of common chickling, selections 519, 522, 529, 530, and 533, were moderately resistant to powdery mildew, Ascochyta leaf spot and botrytis blight. Crop losses varied from 15 to 65%, 2 to 24%, and 3 to 33% for the three diseases, respectively. Dwarf chickling selection 495 was also resistant to these three major diseases. Crop losses were 12 - 78%, 2 - 31%, and 8 - 41% for the three major diseases, respectively. One genotype of ochrus chickling (selection 539) was moderately resistant to these three major diseases and selections 551, 548, 547, 546, and 185 were tolerant. Crop losses were 3 - 41%, 2 - 37%, and 4 - 46% for the three diseases, respectively.

Screening annual forages for resistance to root nematodes (Preschedule F81)

Surveys carried out over the past 4 years have revealed that root knot nematode (Meloidogyne artiella) and cyst nematode (Heterodera ciceri) attack the roots of both food and feed legumes. Therefore, a new objective in our breeding program is to search for nematode resistance in Vicia spp. and Lathyrus spp. During the past 4 years, most of our vetches, peas, and chicklings have been screened for resistance and sources of resistance have been identified. The screening program is on-going because all new genotypes that are developed are tested for nematode resistance.

In 1988/89, 22 promising genotypes of narbon vetch, 16 of common chickling and ochrus chickling, and 10 of dwarf chickling were screened for resistance to root knot and cyst nematodes under natural conditions. A heavily infested field was used where the average number of second-stage juveniles of root knot nematode was about 6 larvae/g soil and of cyst nematodes was 315/kg soil. These are ideal levels for screening in the field. Under artificial conditions in the greenhouse the infection rate of cyst nematodes was 20 eggs/g soil and of root knot nematode was 20 second-stage larvae/g soil. Seeds were sown in earthen pots with six replicates of each genotype and five plants per pot. At the flowering stage the plants were harvested, the roots carefully washed, and the density of nematodes on the roots determined. Nematodes were extracted and counted as the number of nematodes/g roots.

None of the narbon vetch genotypes were resistant to both nematodes but selections 2461, 2466, 2467, 2476, and 2477 were tolerant to both. Common chickling selections 504, 505, 529, and 535 were tolerant to both nematodes. One genotype of dwarf chickling (selection 356) was tolerant to both nematodes and 11 genotypes of ochrus chickling (selections 185, 537, 544, 548, 550, 539, 540, 543, 545, 546, and 549) were tolerant to both nematodes.

Losses in seed yields, compared with fields treated with carbofuran, were 10 - 50%, 15 - 65%, and 5 - 20% for common, dwarf, and ochrus chicklings, respectively.

Screening _Lathyrus_ species for neurotoxin

Common chickling (_L. sativus_), also known as grass pea, is used in India, Bangladesh, Nepal, Pakistan, China, and West Asia as a food and feed crop. Our studies indicate that it is tolerant to drought and can be grown successfully in areas with an annual rainfall of 200-350 mm. Despite these advantages, relatively little effort has been made to improve this hardy crop. One possible reason is that excessive consumption of the seeds by humans causes a paralytic disease called lathyrism. This is a disorder of the central nervous system that causes weakness and paralysis of the leg muscles and, in extreme cases, death. The seeds contain a neurotoxin, beta-N-oxalyl-amino-L-alanine (BOAA) which is the major component responsible for neurolathyrism produced by _L. sativus_. Animals are also susceptible to the toxin, probably because the barrier between the blood stream and brain cells is permeable to BOAA. Despite this, common chickling continues to be grown as a food crop. Indeed, it may become a major component in the diet during severe drought and famine when its hardiness, drought and frost tolerance, and ability to give fairly good and stable yields under low input conditions gives it an advantage over other legume crops. One major objective of the recent research on Lathyrus spp. at ICARDA is to develop lines which have low contents of BOAA, whilst retaining the high yield.

In 1988/89, 81 selections of L. sativus, 22 of L. ochrus, and 19 of L. cicera selected from single plants in 1986 and evaluated in microplots in 1987 were analysed for BOAA content in the seeds. In this extensive survey, some lines contained very low concentrations of BOAA. In L. sativus, BOAA content varied from 17.6 (selection 521) to 316.0 µg/g seed (selection 433), while in L. cicera the BOAA content was 20.0 (selection 497) - 266.0 µg/g seed (selection 476). L. ochrus had a higher BOAA content than L. sativus and L. cicera, ranging from 405.4 (selection 549)-559.5 µg/g seed (selection 384) (Table 2.15).

Table 2.15. Beta-N-oxalyl-amino-L-alanine (BOAA) content in seeds of promising lines of three Lathyrus spp.

Species	BOAA content (µg/g seed)			No. of tested lines
	Minimum	Maximum	Mean	
L. sativus	17.6	316.0	196.6	81
L. cicera	20.0	266.0	95.1	19
L. ochrus	405.4	559.5	472.1	22

These concentrations of BOAA are very low in comparison with the 2615 µg/g found in seed of Pusa 24, an Indian cultivated variety, and the 329, 259, and 401 µg/g seed in samples from LS 8246 (a Canadian variety), (Campbell and Briggs 1987).

The seed yields of the selections of L. sativus, L. cicera, and L. ochrus with the lowest BOAA content were 1109, 3360, and 1307 kg/ha, respectively, in the 1987/88 microplot trials.

There is clearly considerable variation in BOAA content so plant breeders could select and develop new chickling varieties that are free from or have a low concentration of BOAA. The establishment of a "safe" level of BOAA in chickling germplasm is an important goal for the improvement program on this genus - **A.A. Moneim.**

The analysis of the samples for BOAA content was kindly arranged by Dr P. Williams, Canadian Grain Commission, Winnipeg, Canada.

Reference

Campbell, C.C. and Briggs, C.J. 1987. Registration of low neurotoxin content lathyrus germplasm, LS 8246. Crop Science 27: 821.

Unpalatability factors in peas (Preschedule L31)

In November 1988, a project was started to identify the factors causing unpalatability of forage peas (Pisum sativum). This followed earlier research which showed that the voluntary intake of immature herbage, hay, and straw of peas was considerably lower than that of common vetch (Vicia sativa) (Thomson et al. 1990) and this would undoubtedly reduce sheep performance. It became necessary to identify the factors causing unpalatability since peas have a high yield potential, fix large amounts of nitrogen (Keatinge et al. 1988) and, when grown on fallow land, could contribute to reducing acute and chronic feed deficits in WANA.

The objectives of the project are to:

- verify the unpalatability of peas using sheep in metabolism trials,
- screen a selection of existing pea germplasm for genetic variation in palatability,
- identify the secondary chemical compounds that contribute to unpalatability,
- develop methods to screen peas for unpalatability factors, and
- verify that peas with low levels of the unpalatability factors have a voluntary intake and sheep production potential similar to common vetch.

The research conducted at ICARDA between March and July 1989 focused on measurements of: 1) rates of ingestion during short periods; 2) rates of degradation using the in-sacco method; 3) proportions of leaf, stem, and pods; 4) content of primary compounds; 5) order of preference of plant fractions; and 6) voluntary feed intake.

Rates of ingestion. Two rate-of-ingestion (RoI) trials were conducted in 1989 using sheep offered material for only 5 min instead of 30 min as in the 1988 trials. A shorter period was considered more appropriate since it would prevent the slower acting gut-fill mechanism controlling voluntary feed intake from confounding the measurement of the short-term effects of the unpalatability factors. Indeed, one would expect a declining RoI as the meal progressed since the gut-fill control mechanism would send increasingly strong feed-back signals leading to termination of the meal. Short periods also reduce the amount of test material needed.

Latin square designs were used, which removed the large sheep-to-sheep variabilities. Partially fasted sheep were offered one test material at a morning meal on each day of the trials, after which they received a maintenance ration of good quality legume hay. Latin squares were used which varied in size from 7 x 7 to 14 x 14 with days equal to periods. Recordings of RoI were made over two consecutive 5 min periods using, in separate trials, chopped hay and straw from several lines of peas. Common vetch and woollypod vetch (V. villosa subsp. dasycarpa) were used as controls.

The RoI of pea and common vetch hays was similar but the RoI of woollypod vetch hay was about two standard deviations below the population mean (Table 2.16). At the straw stage the RoI of Syrian local and Susan peas tended to be lower than the other peas and vetches. However, the RoI of woollypod vetch straw was marginally greater than that of the hay. This is difficult to explain although Thomson et al. (1990) did show this vetch to be unpalatable at the immature stage. There was a general decrease of the RoI from the first 5 min to the second 5 min period with this decrease being greater at the hay stage. The RoI of hays during the first 5 min period was higher than for the straws. During the second 5 min period there was little difference between hays and straws.

Table 2.16. Rate of ingestion (g/min) of two vetches and 18 IFPI pea lines fed to sheep as chopped hay (harvested 21.4.89) and as chopped straw (harvested 18.5.89). (Means and standard deviation.)

IFPI number	No. of sheep	Hay stage Period 1	Hay stage Period 2	No. of sheep	Straw stage Period 1	Straw stage Period 2
V. villosa[1]	12	15.1 ± 3.4	11.4 ± 1.9	14	17.1 ± 2.7	16.4 ± 2.4
V. sativa[2]	12	19.4 ± 4.2	17.7 ± 3.7	14	16.3 ± 1.9	15.8 ± 1.7
424/292	12	20.8 ± 3.3	16.8 ± 4.7	14	17.1 ± 2.8	15.9 ± 2.8
3205/318	7	19.3 ± 1.7	16.3 ± 2.5	14	16.6 ± 1.9	15.6 ± 2.7
44/92	12	17.3 ± 5.3	15.6 ± 5.6	14	19.0 ± 3.4	17.5 ± 3.6
2583/446	12	17.2 ± 3.0	15.7 ± 3.1	14	15.4 ± 2.7	13.1 ± 3.3
86/100	12	19.3 ± 2.9	16.5 ± 4.0	14	17.1 ± 2.9	15.7 ± 3.3
1521/466	7	18.9 ± 4.0	15.2 ± 4.1	7	17.6 ± 3.1	16.0 ± 3.0
3187/541	12	18.1 ± 4.6	15.5 ± 5.0	14	17.9 ± 3.7	15.9 ± 3.6
2382/509	7	18.9 ± 2.4	16.2 ± 2.3	7	14.3 ± 1.7	13.5 ± 2.2
205	12	19.8 ± 5.0	16.0 ± 6.7	14	14.7 ± 3.0	14.1 ± 2.8
Susan	12	19.2 ± 3.7	15.5 ± 4.4	14	14.9 ± 2.2	12.6 ± 4.1
1793/669	12	19.9 ± 4.0	14.0 ± 5.8	14	16.2 ± 3.1	14.4 ± 2.6
88/335	12	19.9 ± 4.2	15.9 ± 5.8	14	18.3 ± 2.7	16.2 ± 3.2
-	-	- -	- -	-	- -	- -
-	-	- -	- -	-	- -	- -
3208/320	-	- -	- -	7	14.9 ± 1.9	13.9 ± 1.8
3085/692	7	19.4 ± 2.9	16.0 ± 3.2	7	16.3 ± 0.7	15.2 ± 2.4
3186/254	-	- -	- -	7	15.3 ± 1.5	14.9 ± 1.3
3211/323	7	19.1 ± 1.9	17.3 ± 2.5	7	16.1 ± 1.7	14.8 ± 2.0
966/324	7	19.5 ± 2.8	16.6 ± 2.6	14	16.3 ± 1.9	14.4 ± 1.9
1597/541	12	19.6 ± 3.2	16.9 ± 3.5	14	16.7 ± 2.8	15.1 ± 2.9
Mean	-	18.8 ± 1.4	15.8 ± 1.4		16.4 ± 1.2	15.0 ± 1.2

[1]Vicia villosa subsp. dasycarpa (woolly pod vetch). [2]V. sativa (common vetch).

The absence of a difference in the RoI between pea lines contrasts with the 1988 findings when they ranged from 7.4 g/min down to 3.8 g/min, with common vetch having a RoI of 8.0 g/min. This large difference between years could be due to several factors such as the amount of rainfall, the method of measurement, and the physical form of the feed.

Amount of rainfall. The low rainfall in 1988/89 most probably reduced the fibre content of the plants at a given phenological stage. This hypothesis will be examined in 1989/90 by investigating the chemical composition of the materials. If confirmed it would agree with findings on cereal straws which are less fibrous in a drought year than a wet year.

Method of determining RoI. Using 5 min periods was better than using longer periods since, as was shown in a separate trial, RoI sometimes decreases by over 50% during six consecutive periods of 5 min (Figure 2.1). The slope of this decrease appeared to vary between lines. For example, IFPI line 88/335 had a regression coefficient of -0.451 (s.e. 0.057, $r = -0.970$) whereas for Susan and Syrian local peas it was -0.121 (s.e. 0.021, $r = -0.943$) and -0.261 (s.e. 0.019, $r = -0.990$), respectively. However, the regression coefficient of local vetch was -0.334 (s.e. 0.013, $r = -0.997$). These differences are hard to explain but the chemical analyses may provide some clues.

Physical form of feed. This is unlikely to have resulted in differences in the RoI between years since the same method of preparing samples was used in both years.

Rates of degradation. Rates of degradation (RoD) were measured using the <u>in</u>-<u>sacco</u> method in which plant material is

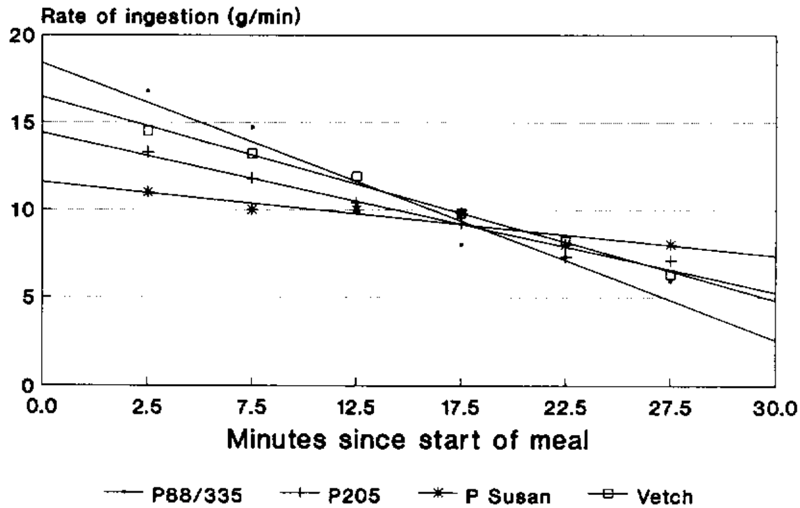

Figure 2.1. Rate of ingestion of chopped pea and vetch straw by sheep during six consecutive periods of 5 min. (—•— = P88/335, a IFPI line of peas; —+— = is P205, the Syrian landrace of pea, —*— = Susan, the British pea, —□— = is the Syrian landrace of vetch. Each point is the mean of seven observations).

incubated in porous nylon bags in the rumen for periods between 6 and 72 h. This is a simple method for identifying large differences in RoD between lines.

The Syrian local and Susan peas were amongst the lines with the lowest RoD at the three stages of maturity, as was the common vetch (Table 2.17). However, these rankings must be interpreted with caution until statistical analyses are completed. They do indicate, however, that there may be lines of peas in the germplasm with higher voluntary feed intake than Syrian local and Susan peas.

Large and consistent differences in potential degradability were apparent between species and between stages of maturity for the leaf and stem fractions (Figure 2.2). The potential degradability of local vetch leaf was always lower than leaf from Syrian local peas but the reverse was found for the stem fractions. The potential degradability of the leaf from the Syrian local pea and Susan pea, which originated from Britain, tended to be similar but Susan stem was less degradable than Syrian local pea stem at all stages of maturity.

Table 2.17. Percentage disappearance in-sacco of two vetches and 18 IFPI pea lines at the immature (2.4.89), hay (21.4.89), and straw (18.5.89) stages of maturity at different incubation times. (Means and standard deviations.)

IFPI line	Immature stage (18h incubation)	Hay stage (18h incubation)	Straw stage (24h incubation)
V. villosa	72.6 ± 1.84	67.4 ± 4.08	54.9 ± 2.56
V. sativa	69.4 ± 4.52	66.4 ± 1.43	55.1 ± 1.70
424/292	78.4 ± 2.82	70.7 ± 4.15	60.5 ± 3.01
3205/318	- -	68.8 ± 1.42	61.6 ± 3.29
44/92	78.2 ± 5.80	72.8 ± 2.07	62.7 ± 3.13
2583/446	77.4 ± 3.82	62.5 ± 2.57	57.6 ± 2.50
86/100	73.7 ± 10.66	78.8 ± 3.84	58.3 ± 2.38
1521/466	81.0 ± 3.48	71.0 ± 2.93	61.8 ± 2.49
3187/541	77.6 ± 1.89	76.7 ± 3.37	65.1 ± 3.80
2382/509	75.7 ± 1.91	70.6 ± 5.29	52.6 ± 2.58
205	- -	70.8 ± 2.41	52.3 ± 2.88
Susan	68.9 ± 2.91	65.4 ± 1.90	52.6 ± 3.40
1793/669	81.4 ± 0.94	71.9 ± 2.15	62.4 ± 2.89
88/335	75.9 ± 2.49	70.7 ± 1.19	62.6 ± 2.28
-	- -	- -	- -
-	- -	- -	- -
3208/320	77.4 ± 1.60	- -	57.5 ± 2.63
3085/692	70.8 ± 4.89	62.6 ± 2.82	60.2 ± 3.80
3186/254	80.3 ± 8.58	- -	59.4 ± 2.90
3211/323	77.7 ± 0.87	67.9 ± 1.45	55.4 ± 4.10
966/324	82.3 ± 2.64	76.4 ± 2.02	57.2 ± 3.00
597/541	73.5 ± 3.99	72.8 ± 2.68	60.4 ± 2.30
Mean	76.2 ± 4.02	70.1 ± 4.58	58.5 ± 3.76

The small leaflets of common vetch have high levels of structural carbohydrates, which would result in the lower potential degradability of this fraction compared with the leaves of peas, which are substantially bigger and contain a larger proportion of lamina. The higher level of structural carbohydrates in pea stems, which are longer and thicker than vetch stems, helps to explain the lower potential degradability of this plant fraction compared with that of common vetch. It is clear from these findings that the proportions of leaf and stem in peas and common vetch should be an important factor in determining the voluntary feed intake of the whole crop material.

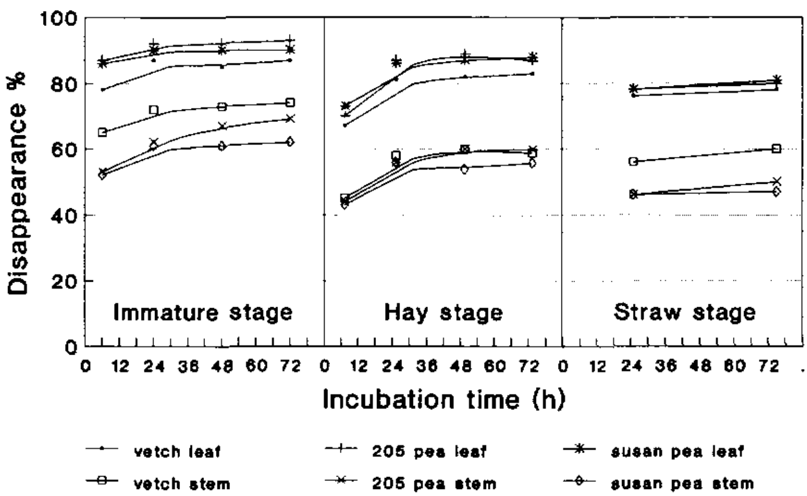

Figure 2.2. Rate of disappearance from porous nylon bags of leaf and stem fractions of the Syrian landrace of pea, British Susan pea, and the Syrian landrace of vetch at three stages of crop maturity.

Proportions of leaf, stem, and pods. Since the proportion of leaf, stem, and pods in a plant species is likely to affect its palatability and voluntary intake, plants from 18 IFPI lines of peas grown in 1989 were sampled at 14-day intervals between the pre-budding and the mature stages, separated into leaves, stems, and pods, dried at 50°C, and weighed.

The means and ranges in leaf, stem, and pod proportions are shown in Table 2.18. Leaf proportion decreased and stem proportion increased as plants matured and pods became a significant proportion of the total plant after flowering. There were also considerable differences in the proportions of these fractions between the 18 lines of peas, with line 44/92 consistently having the greatest leaf proportion at all stages of growth.

Table 2.18. Proportions of leaf, stem, and pods in 18 IFPI pea lines on different sampling dates.

Sampling date	Mean	SD	Minimum	Maximum
Leaf				
19.3.89	0.68	0.04	0.59	0.74
2.4.89	0.58	0.05	0.49	0.67
16.4.89	0.46	0.09	0.36	0.69
30.4.89	0.31	0.11	0.21	0.59
Stem				
19.3.89	0.32	0.04	0.26	0.41
2.4.89	0.41	0.05	0.33	0.51
16.4.89	0.44	0.05	0.31	0.50
30.4.89	0.35	0.07	0.36	0.27
Pods				
16.4.89	0.11	0.07	0.00	0.21
30.4.89	0.34	0.15	0.05	0.52

Contents of primary compounds. An important prerequisite in any plant breeding program is genetic variation in the available germplasm. Variation was found in the primary chemical compounds of the 18 IFPI lines harvested at the hay and straw stages in 1988 (Table 2.19). At the hay stage, the maximum values of crude protein, acid detergent fibre, neutral detergent fibre, and in-vitro DMD were 69%, 39%, 51%, and 50%, respectively, above the minimum values. At the straw stage, the differences were 119%, 85%, 43%, and 34%, respectively.

Table 2.19. Content (%) of primary constituents in 18 IFPI lines at the hay (27.4.88) and straw (2.6.88) stages of crop maturity.

	Mean	SD	Minimum	Maximum
Hay stage				
Ash	9.5	1.88	6.9	13.0
Crude protein	18.0	2.92	14.1	23.8
Acid detergent fibre	25.6	2.37	22.2	30.9
Neutral detergent fibre	37.7	4.35	31.3	47.3
In-vitro DMD[1]	57.7	6.62	46.7	70.0
Straw stage				
Ash	10.4	1.91	8.1	13.6
Crude protein	9.1	1.97	5.9	12.9
Acid detergent fibre	34.4	5.25	24.4	45.2
Neutral detergent fibre	52.4	4.99	43.7	62.3
In-vitro DMD[1]	52.4	4.12	46.3	61.9

Order of preference of plant fractions. It was considered plausible that the taste of the different plant fractions would vary due to variation in the content of secondary compounds and that the content of these compounds would vary between pea lines. A trial was therefore conducted using fresh material from Syrian local pea separated into whole leaf, stipules, pods, flowers, and stems and chopped to 3-4 cm lengths. These five fractions were arranged in pairs to give 10 different combinations and 100 g from each combination were placed in identical containers. Four individually penned sheep were each offered one combination of the fractions during four consecutive periods each lasting 1 min. After each 1 min period, the containers were removed and replaced with another pair of the same combination with the order of the containers being reversed until all four periods were completed. This procedure was repeated for each of the 10 combinations. The residual material in the containers was weighed after each 1 min period.

The preferences of the sheep for the two fractions from the 10 combinations are shown in Table 2.20. Little preference was shown between stipules and leaf and stem and leaf. However, flowers were preferred over leaf and stem and the sheep clearly disliked immature pods. It is noteworthy that the local pea has white flowers and therefore contains none of the anthocyanins associated with flower colour and tannin complexes. It will be important to repeat such preference trials using pea lines with coloured flowers which also display purple tinges in other parts of the plant.

Table 2.20. Preferences of different plant fractions of Syrian local peas offered during four consecutive 1 min periods. (The first and second coefficient for each pair of values refers to the row and column descriptors, respectively.)

	Leaf	Stipule	Stem	Flower	Pod
Leaf	---				
Stipule	0.48/0.52	---			
Stem	0.56/0.44	0.66/0.34	---		
Flower	0.94/0.06	n.a.	0.63/0.37	---	
Pod	0.19/0.81	n.a.	0.22/0.78	0.21/0.79	---

n.a. not available because of insufficient material.

Voluntary feed intake. The voluntary feed intake (VFI) of hay and straw from local common vetch and peas and Susan peas was measured again using material harvested in April and May 1989, respectively. Because of the exceptionally cold period in February and the low rainfall, there was insufficient material to measure the VFI of immature crops.

The results confirmed those from 1988 and previous studies (Thomson et al. 1990) that peas have a lower VFI than common vetch, and whereas the VFI of common vetch marginally decreased from the hay to the mature stage, the VFI of local peas increased marginally (Table 2.21). These changes in VFI

Table 2.21. Voluntary feed intake and in-vivo dry matter digestibility of Syrian local peas, Susan peas, and Syrian local vetch harvested at three stages of maturity in 1988 and 1989 (four sheep per mean).

	Voluntary feed intake ($gDM/M^{0.75}$)		In-vivo digestibility (%)	
	1988	1989	1988	1989
Immature stage				
Syrian local peas[1]	60.1	-[3]	72.7	-[3]
UK Susan peas	-[3]	-[3]	-[3]	-[3]
Syrian common vetch[2]	88.0	-[3]	80.5	-[3]
Hay stage				
Syrian local peas	63.0	78.5	63.4	65.4
UK Susan peas	62.1	77.9	69.0	62.9
Syrian common vetch	90.4	116.2	71.3	72.9
Straw stage				
Syrian local peas	41.6	86.1	57.6	53.6
UK Susan peas	69.9	-[3]	60.1	-[3]
Syrian common vetch	91.2	111.1	61.2	56.8

[1]Accession 205, [2]Accession 2541, [3]Insufficient material for feeding trial.

were accompanied by substantial decreases in the digestibility of both species. Between-sheep variability in the VFI of local and Susan peas was high, indicating again the idiosyncracies of individual sheep. It is hoped that the rate-of-passage measurements conducted during the trials will help to explain the differences in VFI.

Future research. Since July 1989 detailed analyses of the secondary compounds likely to be associated with unpalatability have been in progress in the United Kingdom. The compounds being studied include saponins and phenolics, and a range of techniques are being used including chromatography and near infrared reflectance spectroscopy. Two accessions of peas, and common vetch as a control, are also being grown in growth cabinets to provide fresh material for analysis for volatile compounds.

Volatile compounds will receive particular attention in 1989/90 as they may be responsible for the unpalatability of peas. The same lines of peas will be grown again and intensive sampling and preference tests will be conducted so that by late 1990 the secondary compounds responsible for unpalatability in peas should have been identified. It is also hoped that an explanation will have been found for the low voluntary intake of peas. - **E. Carter, RVC, London; E.F. Thomson, ICARDA; M. Gill, ODNRI, London; A. Stedman, RVC, London.**

Acknowledgement

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Chapter 3

BIOLOGICAL NITROGEN FIXATION AND ANNUAL MEDICS

One of the main advantages of the ley farming system is that it reduces inputs of nitrogen fertilizers. However, a major constraint in the establishment of annual species of *Medicago* is poor or ineffective nodulation. Ineffective populations of *Rhizobium meliloti* cause parasitic nodulation in which the bacteria do not fix enough nitrogen to satisfy the requirements of the plant. Ineffective populations of medic rhizobia in the soil thus pose a considerable barrier to the successful introduction and establishment of inoculant strains, to the exploitation of annual *Medicago* species, and ultimately to the improvement of livestock production.

The Program has identified ecotypes of annual medics able to grow and fix nitrogen without the need for inoculation. But plants and their rhizobial partners respond differently in different environments. This is clearly shown by the range of rhizobial strains that dominate soil microbial populations in a given region. At Tel Hadya, for example, *M. rigidula* and *M. noeana* do not require inoculation as the soils already contain an appropriate strain of *R. meliloti*. However, in the south of Syria or in northern Jordan the same species are not effectively nodulated and this causes a significant reduction in herbage yields. These interactions are expected throughout the region. We are thus conducting research which attempts to understand the relationship between the environment and the need to inoculate annual medics with superior strains of rhizobia.

Symbiotic response of medics to indigenous rhizobia in west Asian soils (Preschedule M18)

It is important to define the distribution and properties of indigenous R. meliloti and to establish whether or not inoculation is required for a particular annual Medicago host in a particular soil. Therefore, a survey was conducted during February, March, and April 1989 in five countries of the region. The aims of this project were to collect R. meliloti from soils of west Asia, isolate the microorganisms as pure cultures, and test their symbiotic characteristics on six different species of annual medics.

Soil samples were collected from arable regions where average annual precipitation was 250 - 350 mm and where wild medic species could potentially be exploited as pasture crops. The number of isolates was 247 (97 from Syria, 40 from Turkey, 58 from Jordan, 36 from Lebanon, and 16 from Cyprus). Medic species for testing the isolates were selected on the basis of their suitability for ley farming in the region; they included M. rigidula, M. rotata, M. noeana, M. orbicularis, and the Australian cultivars Jemalong (M. truncatula) and Circle Valley (M. polymorpha).

The seedlings were aseptically grown in glass tubes containing a vermiculite-gravel mixture moistened with a nitrogen-free solution and were inoculated with suspensions prepared from the soil samples. The shoots of the plants were harvested after 5 weeks of growth, dried, and weighed. The mass of dry shoots from inoculated plants was compared to that of uninoculated plants to measure plant responses to nodulation. Plants were also graded for their response to nodulation on the basis of vigor and color. Effectiveness ratings were graded from 0 to 3, where category 0 equals no nodulation (NN); category 1 is <50% nodulation i.e., ineffective nodulation (I), where nodules in this category were parasitic and non-functional; category 2 equals 50 - 75% nodulation (partially or moderately effective, PE); and category 3 equals 75 - 100% nodulation. An average effectiveness rating was determined for each population of rhizobia from each soil sample, based on the nodulation response of each of the six medic species.

Plants showing positive responses to inoculation were selected, the _Rhizobium_ strain occupying their nodules isolated, and cultures of these bacteria tested to confirm their ability to fix nitrogen. To avoid genetic variation these cultures were lyophilized and kept in small vials at 4°C. Many of them were then utilized to prepare peat-based inoculants for evaluation under field conditions (Preschedule M26, page 54).

Moderately effective populations of _R_. _meliloti_ were common in eastern Cyprus (Fig. 3.1), with all soils sampled containing infective rhizobia. The proportions of highly and moderately effective populations suggest a high probability of successful medic establishment. Inoculation of medic seed is thus not as essential as it is in other areas of west Asia, although herbage yield increases have recently been obtained for _M_. _rotata_ and _M_. _rigidula_ using elite strains of rhizobia (ICARDA M3, M15, M54, and M254) isolated outside Cyprus.

In soil from the dry Jordanian environments, the indigenous populations of _R_. _meliloti_ were smaller than those in other soils of the region. Numbers of _R_. _meliloti_ averaged less than 750 per gram of dry soil. Most of the samples contained a very large proportion of ineffective bacteria (Fig. 3.1). Approximately 40% of arable soils contained nitrogen fixing bacteria suitable for M. rotata and M. orbicularis, but less than 10% of the soil samples contained rhizobia infective for the other species tested.

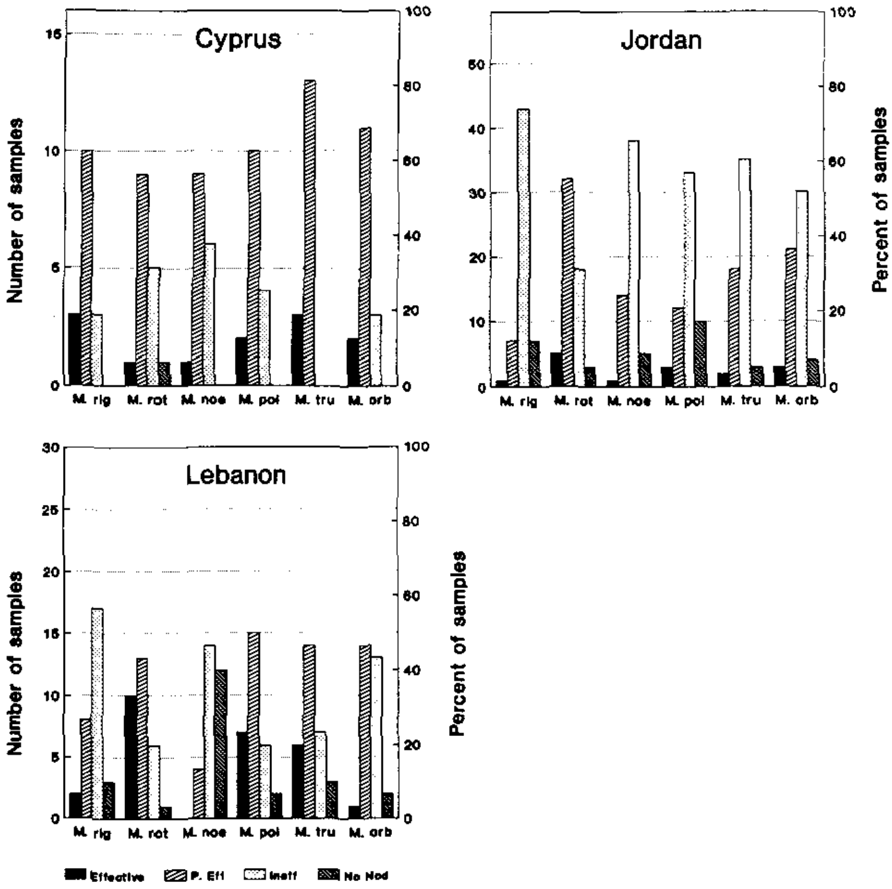

Figure 3.1. Symbiotic responses of six annual species of Medicago to inoculation with indigenous populations of R. meliloti collected in Cyprus, Jordan, and Lebanon.

Attempts to introduce M. rigidula have failed in Jordan due to the overwhelming presence of incompatible bacteria. In fact, approximately 93% of the soil samples tested contained bacteria not suitable for M. rigidula. Results strongly suggest that inoculation is necessary for successful establishment of pastures in Jordanian soils. Introduced strains selected elsewhere in the region have produced functional nodulation in this host with a significant increase in herbage yields (ICARDA 1989 page 108).

In populations of R. meliloti in Lebanese soils from the Beqaa Valley, predominantly ineffective bacteria nodulated M. rigidula and M. noeana. The latter failed to nodulate when inoculated with dilutions of 41% of the soil samples tested. In more than half of the cases, nodules of M. noeana contained ineffective bacteria which produced parasitic nodulation in this host (Fig. 3.1).

M. rotata formed normal and healthy symbioses with the indigenous rhizobia from Lebanese soils; less than 20% of the samples contained R. meliloti which produced non-functional nodulation in this host (Fig. 3.1). The Australian cultivars M. polymorpha and M. truncatula had a better chance of being effectively nodulated by the indigenous bacteria in both Lebanon and Cyprus compared to any other country of the region. The presence of high numbers of effective and partially-effective bacteria in the Beqaa Valley may be due to environmental conditions, soil fertility, and previous history of cultivation.

Less than 7% of the populations in the soil samples from Syria were highly effective, regardless of the host species. Ineffective nodulation of Medicago hosts was common, as was the presence of partially-effective R. meliloti able to nodulate all the hosts (Fig. 3.2). In contrast to Lebanese and Cypriot soils, Syrian soils do not contain suitable R. meliloti to effectively nodulate the Australian cultivars M. truncatula and M. polymorpha. An inoculation program must be followed for these popular cultivars to ensure nodulation otherwise their use should be avoided. Effective nodulation of M. rigidula occurs with the indigenous rhizobial populations in soils of northern Syria but functional nodules are not produced with rhizobia from southern soils. Therefore, M. rigidula does not require inoculation in northern Syria whereas in the south inoculation is imperative.

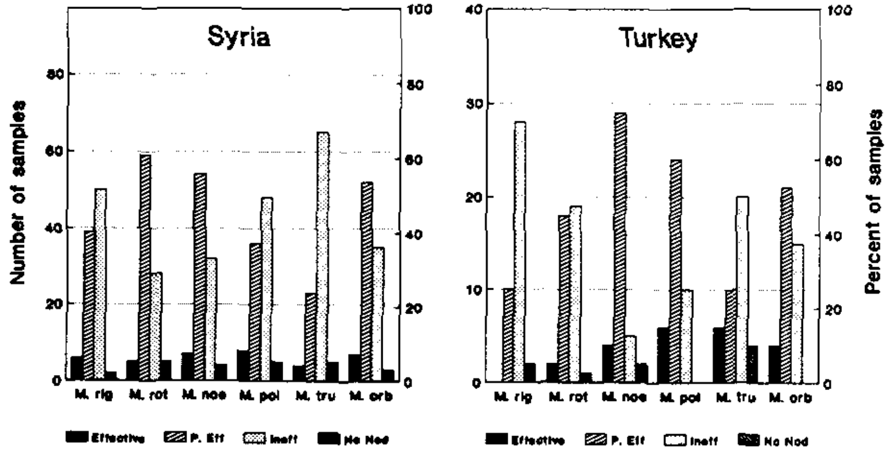

Figure 3.2. Symbiotic responses of six annual species of Medicago to inoculation with indigenous populations of R. meliloti collected in Syria and Turkey.

The soil samples from Turkey contained large proportions of R. meliloti which normally nodulated M. noeana, M. polymorpha, and M. orbicularis. No suitable indigenous R. meliloti was found for M. rigidula (Fig. 3.2), but recent trials in some areas with elite strains of R. meliloti selected at ICARDA have shown significant responses of M. rigidula to inoculation. Previous research with local strains has shown that this species requires specific rhizobia for effective symbiosis (Brockwell et al. 1988). In addition, this species appears to grow better in calcareous soils than in the basaltic soils of southeastern Turkey.

Populations of R. meliloti from each of the five countries under study varied markedly in their symbiotic response with each of the medic hosts. Numbers of viable saprophytic R. meliloti ranged from 4.5×10^2 to 7.2×10^3 in areas where medics have not previously been cropped as components of ley farming systems. Because of these low numbers and the type of rhizobia encountered in most soils, it is advantageous to sow inoculated seed to ensure effective nodulation and successful pasture establishment. A number of highly efficient strains of R. meliloti isolated during these studies are being recommended to national institutions and research groups in west Asia. - **L.A. Materon and cooperators.**

Selection of more effective strains of medic rhizobia (Preschedule M26)

The selection of elite strains of rhizobia is essential for the production of peat-based seed inoculants. Identification of these strains involves testing which starts in the plastic-house using in-vitro techniques and ends with a rigorous field testing program. The main criteria for strain selection are the quality of nodulation and production of herbage biomass by the host plant at different times during the growing season.

This series of experiments aims to identify strains of R. meliloti able to achieve the most copious and functional nodulation in their corresponding Medicago hosts. Selected strains of R. meliloti were tested against three species of annual medics (M. rigidula sel. 716, M. rotata sel. 2123, and M. polymorpha (cv Circle Valley). The experiment had a split-plot design with strains as main plots, thus minimizing the risk of contamination, and medic species as subplots. There were three replicates. The medics were sown on 22 November 1988.

In the 1988/89 season, 27 strains of R. meliloti were tested at Tel Hadya and compared with uninoculated controls with and without nitrogen in fields which, as far as was known, have not previously been cropped to annual medics. Several of these strains had already been evaluated for three consecutive seasons. Herbage cuts were taken on 9 and 30 April 1989 and oven dried for determination of mass. The response to inoculation is based on plant growth prior to flowering when nitrogen fixation is greatest. Measurements were also taken at the pod stage.

Table 3.1 shows the response of the medic hosts to inoculation at Tel Hadya. Unfortunately, climatic conditions were not favorable to the growth of medics during 1988/89 and M. polymorpha was totally killed by continuous frost.

Table 3.1. Statistical significance of herbage yield responses to inoculation at flowering and at pod maturity, and magnitude of increase in herbage yield expressed as a ratio of the yields of plots sown with inoculated seed to those with uninoculated seed. The table only shows the most responsive strains. (ns = P>0.05; * = P<0.05).

Harvest stage	*Rhizobium* strain	*M. rigidula* sel. 716	*M. rotata*	Increase in herbage
Flowering	M254	ns	*	1.94x
Pod	NA39	ns	*	1.77x

Note: The unresponsive strains tested were: ICARDA M 3, 15, 28, 29, 38, 53, 208, 219, 234, 239, 243, 244, 254, 257, 277, 282, 291, 296, 300, 301, 302, 306, 307, 309, and 315 and strain U45 from Uruguay via Australia.

R. meliloti strains ICARDA M254 and NA39 increased herbage production of *M. rotata* sel. 2123 almost twofold. As expected, *M. rigidula* sel. 716 did not respond to any of the 27 strains of rhizobia tested, indicating that the soil at Tel Hadya contains an effective population of its specific rhizobia. The experiment will be repeated in 1989/90. - **L.A. Materon and M. Zaklouta**

Inoculation techniques for medic seed (Preschedules M21 and M22)

In west Asia it is often necessary to sow medics before the onset of the first autumn rains, so rhizobia must be able to survive on the seed coat in dry soils, sometimes for several weeks. Treating the peat medium containing the inoculum with a sticking solution is one way to ensure adhesion of the inoculant to the seed. Certain sticking agents also protect the rhizobia and thus lengthen their survival. In addition, covering the inoculated seed with a protective coat or layer containing a very finely ground inorganic or organic material has extended the survival of rhizobia by providing extra protection against environmental factors.

Experiments were started in 1985 to identify the best materials to protect the inoculant bacteria. The experiments were conducted at Tel Hadya and Seyade, 90 km south of Tel Hadya (Syria). Six species of medics (M. rigidula, M. noeana, M. orbicularis, M. rotata, M. polymorpha, and M. truncatula) were tested with the adhesives gum cellulose, beet molasses, and water. The inoculated seeds were treated with various coating agents such as calcium carbonate (lime) and rock phosphate. The controls were not inoculated and uncoated. As in the strain selection experiment (page 54), these experiments suffered from moisture stress and unusually low temperatures which affected normal plant growth. Two of the species tested, the Australian cultivars of barrel medic M. truncatula and Circle Valley M. polymorpha, were totally killed by frosts. M. orbicularis responded to inoculation at both sites with 2.2 fold increases ($P<0.05$) in herbage yields over those of the uninoculated controls, regardless of sticking or coating treatment. Herbage production of M. rigidula and M. noeana did not indicate significant responses to inoculation, as had been seen in previous seasons.

Plants grown in Seyade did not grow normally because of the moisture and temperature stresses; nodulation of both inoculated and uninoculated plants was very sparse, with fewer than eight nodules per plant. This indicated that the plants did not invest any energy in producing and maintaining nodulation under these particular circumstances. These experiments will be repeated because the abnormally wet year affected the results. - **L.A. Materon and M. Zaklouta**

Persistence of introduced strains of rhizobia (Preschedule M20)

In this experiment the survival of inoculant strain WSM244 was monitored following inoculation of three medics in 1985. The experiment had a split-plot design with M. rigidula sel. 716, M. truncatula cv Jemalong, and M. polymorpha cv Circle Valley as main plots and three inoculation rates (1x, 5x, and 10x the recommended rate of peat inoculant) as the subplots. Results of the first year were reported in the 1986 Program Annual Report (page 111). Since then, the plots have been left uncultivated, allowing self-regeneration of the medics.

Samples of nodules are taken every growing season to determine the proportion of nodules containing WSM244. The technique distinguishes the inoculant strain from the indigenous soil rhizobia and is based on the resistance of WSM244 to an antibiotic. In this case, we used a mutant of WSM244 able to grow on yeast mannitol agar containing 150 micrograms of streptomycin sulfate. The mutant's symbiotic characteristics when associated with medics were the same as the parental strain. The contents of disinfected nodules were grown on yeast mannitol agar with and without streptomycin.

Mutant WSM244, a strain which originated in Iraq and was previously recommended for M. rigidula, failed to form nodules with that species (Table 3.2). The introduced strain formed most nodules with M. polymorpha, from which the strain was originally isolated, and M. truncatula.

Table 3.2. Nodules produced by an introduced strain of _R. meliloti_ (WSM244) in self-regenerating species of _Medicago_ during the fourth year of establishment at Tel Hadya (1988/89).

Medic species	% nodules produced by		Mean number of nodules per plant	Dry herbage yield[1] (t/ha)
	WSM244	Native rhizobia		
M. rigidula	0	100	11.2	3.6
M. polymorpha	89	11	4.6	--
M. truncatula	92	8	5.4	--

[1]Herbage collected at flowering. Both Australian cultivars were killed by frosts at early stages of growth.

The persistence of WSM224 is rather surprising as it has successfully competed with the indigenous population and nodulated two compatible species of medics. The native soil strains were able to form most nodules on _M. rigidula_, not because they are more competitive but because this species does not nodulate with WSM244. This highlights the importance of host-strain relationships in the genus _Medicago_. - **L.A. Materon**

Collection of rhizobia for pasture and feed legumes (Preschedule M19)

The Program aims to establish an international collection of rhizobia for annual _Medicago_, _Trifolium_ (clovers), and feed legumes (_Lathyrus_, _Astragalus_, _Vicia_, and other indigenous species). The rhizobia for these legume species are _Rhizobium meliloti_, _R. trifolii_, and _R. leguminosarum_, respectively.

The objectives of the project are to:

- have a bank of effective strains suitable for legumes with potential in the region,
- promote and encourage research in strain selection in WANA, and
- preserve the microbial resources of the region.

Most of the strains are isolated from soil samples collected during spring in the WANA countries. Dilutions from a particular soil sample collected from a specific area are used to inoculate legume seedlings. Rhizobia are then isolated from the nodules and preserved in a lyophilized (freeze-dried) state to minimize genetic variation and prolong storage life. Purified strains of rhizobia for pasture and feed legumes are available upon request for interested scientists (Table 3.3).

Table 3.3. Lyophilized cultures requested by research institutions in 1988/89.

Country	Type of culture	Number of ampoules
Australia	*R. meliloti*	2
France	*R. meliloti*	2
Iraq	*R. meliloti*	6
England	*R. meliloti*	4
England	*R. trifolii*	1
Morocco	*R. meliloti*	3
Spain	*R. meliloti*	3
United States	*R. meliloti*	11

At present, the rhizobial collection consists of 465 purified strains of *R. meliloti* for inoculation of medics, 35 of which are spontaneous antibiotic resistant mutants, 45 are *strains of R. trifolii for clover inoculation,* and 36 are strains of R. leguminosarum for feed legumes. The collection is continuously expanding with the assistance of cooperators from national institutions, including IBPGR, MIRCENs, and ICARDA's Genetic Resources Unit. Our laboratory also produces peat-based inoculants utilizing gamma irradiated peat imported from Australia. Quality of the inoculant is maintained by counting the number of rhizobia/g of peat. The standard set is 10^9 rhizobia/g. In 1988/89 the laboratory distributed 773 inoculant bags to cooperators throughout the region, mostly from countries of the Mediterranean basin (Table 3.4).

Table 3.4. International requests for peat-based inoculants for pasture and feed legumes in 1988/89.

Type of legume	Amount of seed inoculated (kg)	Number of inoculant bags[1]	Country[2]
Medics	245.0	70	Algeria
Medics	10.5	3	Chile
Medics	21.0	7	Cyprus
Medics	648.5	471	Jordan
Medics	50.0	14	Morocco
Medics	360.5	103	Syria
Medics	59.5	20	Turkey
Clovers	10.5	3	Syria
Clovers	87.5	25	Turkey
Vetches	39.0	13	Cyprus
Vetches	40.0	14	Jordan
Lathyrus	48.0	16	Cyprus
Lathyrus	40.0	14	Jordan

[1]Each bag of peat-based inoculant weighs 90 g and inoculates approximately 3.5 kg of medic seed or 3.0 kg of the other species listed regardless of the type of bacterial inoculum.

[2]Includes cooperative projects between ICARDA and Ministries of Agriculture.

Inoculation network experiments (Preschedule M47)

Closer links have already been established among cooperators in west Asia and north Africa after the recommendations of a workshop organized by ICARDA/UNDP on biological nitrogen fixation in 1986 (Beck and Materon 1988). Because each country of the region has different environmental and soil microbial characteristics it is necessary to conduct an international series of experiments with regional cooperators from national institutions. Without such research, the recommendations emanating from Tel Hadya are likely to be misleading when applied elsewhere.

Table 3.5 lists the institutes of the network in 1988/89. Most of the research was targeted to annual medics and their rhizobia. Some of the highlights of the results so far reported by members of the network are reported here.

Table 3.5. International network for inoculation of pasture and feed legumes: activities during 1988/89.

Legume type	Collaborative institution	Country	Number of sites
Medic	Ministry of Agriculture	Jordan	3
Medic	Ministry of Agriculture	Syria	3
Medic	Ministry of Agriculture	Iraq	1
Medic	Ministry of Agriculture	Iran	1
Medic	INRA Montpellier	France	2
Medic	Ministry of Agriculture	Algeria	3
Medic	Ministry of Agriculture	Chile	1
Medic	University of Cukurova	Turkey	1
Medic	University M. Ben Abdallah	Morocco	3
Medic	CSIRO (Canberra)	Australia	1
Medic	Agric. Res. Institute	Cyprus	1
Medic	University of Granada	Spain	1
Medic	University of Pennsylvania	USA	1

I. Within ICARDA region. A series of experiments has been conducted in cooperation with the Jordanian National Center for Agricultural Research and Technology Transfer (NCARTT) at three research stations (Ramtha, Mushaqar, and Rabba). The experiments aimed to evaluate 17 strains of R. meliloti for symbiotic performance. Some strains performed better on M. rigidula sel. 716, M. polymorpha sel. 1035, and M. rotata sel. 2123, and results varied with the region under study. In contrast to previous investigations, M. rigidula did not respond to inoculation with the treatment strains. For M. polymorpha, rhizobial strains ICARDA M3, M15, M38, M53, M208, M243, and M254 produced herbage yields comparable to those of the uninoculated nitrogen controls (100 kg N/ha). Due to the unusually dry season at Mushaqar and Rabba experiment stations, herbage yields were markedly affected by moisture stress. Experiments will continue in 1989/90.

In an attempt to increase the number of R. meliloti on inoculated seed, the peat-based inoculant was treated with various sticking agents (adhesives). The adhesives were solutions of gum cellulose, gum arabic, beet molasses, and water and the coating materials were rock phosphate and calcium carbonate (lime). An inoculated, non-coated control was included, and uninoculated controls were included for both adhesives and coating experiments. Strains ICARDA M3 and M29 failed to effectively nodulate M. rigidula whereas both strains effectively nodulated the other two hosts at the three sites. No significant differences were detected among adhesives and coating treatments. However, caution must be exercised in the interpretation of the results due to moisture stress throughout the growing season. These experiments will continue next season. - **A. Turk (NCARTT)** and **L.A. Materon**

In Cyprus four species of medics (M. rigidula, M. rotata, M. polymorpha, and M. truncatula) and five strains of R. meliloti (ICARDA M3, M15, M29, M53, and M254) were tested at an experiment station in Nicosia. The objective was to determine if there were responses to inoculation as well as host-strain interactions under Cypriot conditions. There were no significant differences between strains within each of the species tested. However, M. truncatula produced significantly more dry herbage (7262 kg/ha) than M. polymorpha (6428 kg/ha). Differences in yields of M. rigidula (5390 kg/ha) and M. rotata (5177 kg/ha) were not statistically significant but they were different to M. polymorpha and M. truncatula. - I. Papastylianou and L.A. Materon

The objective of the experiments in Turkey was to determine whether or not inoculation of medics is required in the central south. The experiments were conducted at Cukurova University Research Farm and involved three medic species (M. rigidula sel. 716, M. polymorpha sel. Tah, and M. truncatula cv Jemalong) and R. meliloti strains ICARDA M28, M29, and M38. Phosphate treatments were 0 and 18 kg P/ha and uninoculated controls with and without nitrogen (90 kg N/ha) were included. Results indicated that plants responded to phosphorus fertilization by a factor of 2.3 ($P<0.05$). Nodules in the phosphorus-treated plants were generally longer than 4 mm whereas nodules were smaller in plants lacking phosphorus and the introduced inoculant rhizobia. All plants responded to inoculation and plant masses were significantly ($P<0.05$) heavier than for those plants from uninoculated plots with no nitrogen fertilizer. M. noeana, previously tested at this site, does not require inoculation as the soil rhizobia are highly effective in this host.

In addition to strain-host-environment relationships, a project is currently being conducted on the effect of residual aldicarb (Temik) on numbers of R. meliloti. - **M. Engin and L.A. Materon**

In Morocco, a series of need-to-inoculate trials has been conducted at the University of Sidi Mohammed Ben Abdallah at Meknes. The species selected for this purpose were M. polymorpha, M. truncatula, and M. rigidula and the inoculants were ICARDA M29, M28, M34, and M38 and WSM244, U45, CC169, and W118 from Australian collections. Response to inoculation was assessed by comparing the dry herbage yields of the inoculated and uninoculated treatments. Nitrogen content of the herbage was also measured.

All three species tested responded significantly to inoculation and the response was strain dependent. For example, M. polymorpha produced 4990 kg dry herbage/ha when inoculated with strain U45 whereas the uninoculated treatment mean was 1608 kg dry herbage/ha. A 2.8 times increase in herbage yield over the control was obtained for M. rigidula with strain CC169 and a 2.1 times increase for M. truncatula with ICARDA strain M38. Nitrogen contents of the herbage were also increased with inoculation.

Fractional distribution of biologically fixed nitrogen by annual Medicago species to the following wheat crop is of major interest in Morocco. The objectives of our future experiments are to measure the direct transfer of nitrogen to the soil and its effect on the subsequent cereal crop. Isotopic nitrogen (^{15}N) techniques are being applied in this investigation. - **M. Ismaili and L.A. Materon**

II. Outside the ICARDA region. One of the constraints to nitrogen fixation by pasture legumes is the inhibition of nodulation at low temperatures. A strain of R. meliloti able to induce nodulation of M. rigidula at low temperatures has been patented by INRA-Montpellier (France) and is labelled BZI. Antibiotic resistant mutants have already been developed and they will be tested as inoculants on medic seed in the coming season. Herbage yield increases of various Medicago species have been observed. Our local ecotype M. rigidula sel. 716 and recommended strains ICARDA M28, M29, M44, and CC169 did not perform well. In contrast, local French ecotypes of M. rigidula produced almost four times more herbage when associated with strain BZI. **- J.C. Cleyet-Marel, G. Gintzburger, and L.A. Materon**

Projects on innovative microbiology with advanced institutions

***Phylogenetic studies on medic rhizobia (University of* Pennsylvania, USA).** The genetic structure of populations of R. meliloti collected from soils of west Asia (Preschedule M18, page 49) was examined by multilocus enzyme electrophoresis (MLEE). This technique has been widely used to study chromosomal genetic diversity and population structure in species of human pathogenic bacteria and has recently been applied to the analysis of the population genetics of soil bacteria (Eardley et al. 1990). Restriction fragment length polymorphism (RFLP) has also been used to analyze operons to determine the genetic structure of medic rhizobia. A total of 232 isolates of R. meliloti were analyzed; 115 isolates from the ICARDA collection and 117 isolates which were collected by a USDA-ARS team in Nepal and Pakistan. Chromosomal genotypic characterization has revealed two highly differentiated evolutionary lineages, one of which appears to be adapted to annual medic species of the Mediterranean basin.

Inoculant strains of R. meliloti for agricultural use have traditionally been selected by an arduous trial-and-error method (as Preschedule M26, page 54) in which isolates of undefined genetic background are evaluated. Identifying a variety of phylogenetic lineages that may be expected to vary in phenotypic traits helps to increase the efficiency of the selection process. The results may also help to further define the host-R. meliloti affinity groups suggested by our genotypic analysis. - **B. Eardly and L.A. Materon**

Mycorrhizae for medics (University of Granada, Spain). This project aims to develop techniques to inoculate soil and seed with selected mycorrhizae. In many semi-arid soils of the ICARDA region, the scarcity of available phosphorus is important in determining the growth of legumes as an adequate phosphorus supply is necessary for satisfactory nodulation and nitrogen fixation. Nodules often contain two to three times more phosphorus per unit of dry matter than the roots on which they are formed. The rate of fixation per gram of nodule can therefore be increased by applying fertilizer phosphorus. Various micro trace elements such as molybdenum, boron, zinc, iron, copper, and sulphur are also required for satisfactory growth and nitrogen fixation.

Mycorrhizae can greatly improve phosphorus and micro trace element uptake by making use of the absorbing capacity of the extensive network of external hyphae associated with the infected root. This network extends for several centimeters from the root surface and provides an effective uptake system from soil beyond the root hairs, particularly for ions which diffuse slowly in the soil, such as phosphate, zinc, and molybdate.

A research team from the University of Granada is cooperating with ICARDA in isolating suitable strains of mycorrhizae for M. rigidula, M. rotata, and M. polymorpha and is currently looking for the most productive medic-fungus combinations. The second phase will include evaluating techniques to infect roots with the selected mycorrhizae and R. meliloti, thus making plants self-sufficient for P and N. This approach will be particularly desirable at sites where the soil contains a low concentration of phosphorus and ineffective rhizobia. - **J.M. Barea and L.A. Materon**

Improvement of the energetic efficiency of medic rhizobia (Polytechnical University, Madrid, Spain). In the process of nitrogen fixation, hydrogen is lost as a gas diffusing out of the nodules of medic plants. However, some groups of rhizobia able to nodulate legume plants other than medics are able to recycle hydrogen using the enzyme hydrogenase. If R. meliloti were able to recycle its lost protons (H^+), the nitrogen fixing process in Medicago would be energetically more efficient.

Because medic rhizobia do not possess the genes coding for hydrogenase, we are trying to incorporate the hydrogenase gene from R. leguminosarum into the genome of R. meliloti. The strains being engineered are compatible with some of the medic species of interest to ICARDA.

The aim is to transfer the genes P Sym-hup, which code for nitrogen fixation and hydrogen uptake, respectively, and are located on a plasmid carried by R. leguminosarum strain 128C53, into the genome of R. meliloti strains ICARDA M29 and

M34. The plasmid has been marked by the transposon system (Tn-mob) and transferred by bacterial conjugation into the recipient rhizobial strains. The organisms so produced are still being tested for genetic stability and possible alterations due to the presence of the genes coding for nitrogen fixation and hydrogen recycling. Once these parameters are defined, we will evaluate their symbiotic performance in association with the annual medics of interest to the Program. - **L. Ruiz-Argueso and L.A. Materon**

Freeze-dried, oil-based inoculants (Boyce Thompson Institute at the University of Cornell, USA). Lyophilization or freeze drying of rhizobial cells ensures long viability and lack of genetic variability during long-term storage. Freeze-dried inoculants have the advantage that they can be applied at higher rates (cells per seed) than peat-based inoculants. This is especially important for small-seeded legumes and where populations of ineffective rhizobia are large. In addition, mortality of rhizobia by desiccation is common in the small seeds of *Medicago* which have to be sown at a shallow depth. Some researchers have reported that oil-based inoculants extend the survival of rhizobia in dry soil.

Current work with the Boyce Thompson Institute includes the lyophilization of *R. meliloti* strains selected at ICARDA. Viability and selection of appropriate oils to prepare the final slurry with peat are currently being investigated. Research at ICARDA has shown that dextran and peptone (DPM) and dextran, sucrose, and sodium glutamate (DSG) are better materials in which to suspend medic rhizobia for lyophilization than yeast mannitol broth (YMB) or distilled water. A high density of rhizobial cells (5.0×10^8/ml) was observed after 5 months using DPM or DSG but there were fewer than 100 cells in the YMB or water treatments.

Once high numbers of lyophilized rhizobia can be assured after reconstitution or rehydration, a series of trials will be conducted in the field. - **J. Ellis and L.A. Materon**

Projects on non-symbiotic nitrogen fixation

Effect of Azospirillum brasiliense and mycorrhizae on the growth of barley. It has been reported that the bacterium Azospirillum brasiliense fixes atmospheric nitrogen in association with the roots of several crops including cereals. Some researchers conclude that the plant growth responses to A. brasiliense may not be entirely due to nitrogen fixation. Associations of A. brasiliense with cereal roots may also increase permeability of the host roots to nitrogen, phosphorus, and potassium ions, alter plant root growth due to bacterially produced, growth-regulating substances, and alter enzyme activities of root bacteria. Plant growth regulators produced by A. brasiliense include auxins, gibberellin-like substances, cytokinins, and other unidentified substances.

Another bacterium reputed to have associative nitrogen fixing abilities is the unidentified Bacillus strain C-11-25. It has been shown that this bacterium supplied more nitrogen to wheat plants under temperate conditions than A. brasiliense and that the amount of associative nitrogen fixation was dependent on the host plant genome. It has not yet been determined whether the plant growth-altering activities of associative nitrogen fixing bacteria are also affected by the host plant genome.

As cereals are of interest to ICARDA, we undertook preliminary investigations on this subject. The studies aimed to test two hypotheses: a) inoculation of barley with A. brasiliense increases yields due to increased nitrogen inputs and b) inoculation of barley with mycorrhizae increases the phosphorus content of the plant and increases nitrogen uptake.

A plastic-house and a field experiment were started in November 1987 at Tel Hadya and Breda, respectively. The treatments consisted of inoculating two barley genotypes, Arabi Abiad and Rihane-3, with A. brasiliense strain 39 and mycorrhizae. The mycorrhizal treatment was only included in the plastic-house experiment. The mycorrhizal inocula were indigenous Glomus, Enterophora, and Acaulospora in highly infected roots of the grasses Agropyrum cristatum and A. elongatum. Two methods of inoculating Azospirillum were tested: a) growing the bacteria in peat and using this carrier in a slurry mixture with a sticker and b) liquid inoculation of the seed onto the seedbed. Uninoculated controls with and without nitrogen (90 kg N/ha) and phosphorus (18 kg P/ha) were included. The masses of roots and shoots were monitored at various intervals during the growing season.

Results obtained from the field experiment at Breda showed no significant differences ($P>0.05$) for the parameters tested. In contrast, in the absence of water stress both barley genotypes responded to the treatments. Table 3.6 shows the positive effect of Azospirillum on the shoot and root dry masses of Arabi Abiad and Rihane-3 in the presence or absence of adequate amounts of soil phosphate.

Studies on non-symbiotic nitrogen fixing bacteria and their effect on the growth of barley and wheat are, at this stage, of low priority in the Program. But as no research on

Table 3.6. Effect of Azospirillum brasiliense and mycorrhizae on the growth of two barley genotypes under controlled environmental conditions at Tel Hadya (1987/88).

	Barley genotypes	
Treatment	Arabi Abiad	Rihani-3
Effect on roots (mg/4 plants)		
Azospirillum	629	778
Mycorrhiza	425	191
Azospirillum + mycorrhiza	476	746
Azospirillum + phosphate	703	833
Phosphate only	444	405
Nitrogen only	354	208
Phosphate + nitrogen	461	302
Untreated	268	154
LSD (P=0.05) Treatment 293		
Genotype 322		
Effect on shoots (mg/4 plants)		
Azospirillum	242	429
Mycorrhiza	48	67
Azospirillum + mycorrhiza	212	331
Azospirillum + phosphate	132	391
Phosphate only	102	221
Nitrogen only	193	67
Phosphate + nitrogen	71	81
Untreated	50	82
LSD (P=0.05) Treatment 127		
Genotype 128		

this topic has ever been conducted in the ICARDA region, we will continue evaluating various methods of inoculation with Azospirillum and its interaction with the host in the coming seasons. - **M. Zaklouta and L.A. Materon**

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Chapter 4

EVALUATING ANNUAL PASTURES AND FEED LEGUMES IN CEREAL-BASED CROP ROTATIONS

This chapter presents research on annual pastures (medics) and feed legumes being examined in rotations based on cereals. The trials are large enough to allow the inclusion of the grazing animal. This inclusion of the animal in the pasture and feed legume research is an essential element of the Program's strategy. Another element is the need to conduct our research at the farm level as well as on the research station. This not only exposes new technologies to the scrutiny of farmers and brings farmers and scientists into close contact, but the on-farm trials involve scientists from National Programs or are conducted on the stations of National Programs with only back-up support from ICARDA.

Also included in this chapter is our more applied pasture and feed legume research. We wish to show that both these feed-producing systems could be found on the same farm because the pastures provide feed between late winter and late summer, and the legumes provide conserved feed during the rest of the cycle. The third feed resource being examined by the Program is the Mediterranean grasslands and marginal lands which are examined in Chapter 6.

Stocking rate and grazing management of medics (Preschedule L13)

The objectives of this project are to:

Acknowledgement

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Stocking rate and grazing management of medics (Preschedule L13)

The objectives of this project are to:

- assess the productivity of a medic/wheat rotation, with three stocking rates (4, 7, and 10 ewes/ha) being applied to the medic, and
- compare this rotation with the biological yields and economic benefits from wheat/fallow, wheat/watermelon, wheat/lentil, and wheat/vetch rotations.

At the end of 1988/89 the project finished its fourth year. It is expected to continue until 1994.

Grazing management. The very low rainfall in 1988/89 resulted in early flowering of the medic, a short growing period, and low feed availability compared with the previous season which had a high rainfall. All these factors affected our grazing management decisions. At the beginning of the season pastures were grazed for short periods to control cereal volunteers and other weeds. After grazing for only 8 days in January, further defoliation was delayed until March to avoid overgrazing of young medic plants and to maintain enough growth to allow pod formation. Sheep stopped grazing for 3 weeks in April at flowering and then continued until the end of May.

Wheat crops were grazed instead of harvested because expected returns from grain would have been much less than the costs of harvesting. Grazing of wheat after medic started on 26 May for all three treatments, continuing until 2 August for the high, 21 August for the medium, and mid-October for the low stocking rates, respectively.

A comparison between the number of grazing days for the "wet" 1987/88 and "dry" 1988/89 seasons showed a reduction in grazing days for the latter, averaged across all stocking rates.

The plant-animal interface. The quantity of pasture available was measured throughout the year and estimates were made of the quantity grazed. There were distinct differences among the three stocking rates in herbage available during the grazing period and after grazing ended in May, with less herbage remaining at the high stocking rate. Herbage production, especially in this low rainfall season, was clearly highest at the low stocking rate (Fig. 4.1).

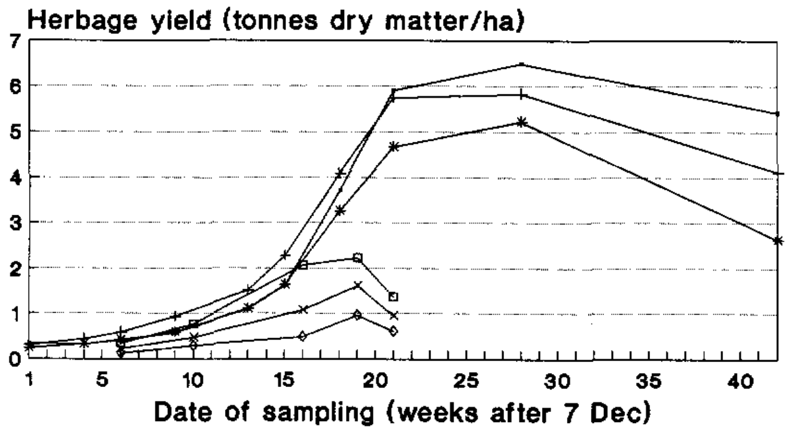

Figure 4.1. Herbage yields of pastures grazed at three stocking rates in 1987/88 and 1988/89. (= low 87/88, = low 88/89, = medium 87/88, = medium 88/89, = high 87/88, = high 88/89).

Early winter grazing is an important practice for controlling competition to medics from cereal volunteers. In addition, weeds in pastures are a very good source of feed, especially in early winter when volunteer cereals and weeds are palatable. Sheep preferentially graze volunteer cereals and weeds at this stage, thus allowing medic plants to continue to grow. Although weeds were less of a problem this season, grazing pressure during winter was high enough to eliminate volunteer cereals and most remaining weeds from all medic plots (Table 4.1).

Table 4.1. Changes in the botanical composition of grazed medic pastures from January to May 1989. (Percentages of medic, volunteer cereal, and weeds are averages across the high, medium, and low *stocking* rates.)

Date	Medic	Cereal	Weed
Jan 15	80	7	12
Feb 27	92	2	7
Mar 27	90	1	9
Apr 18	88	-	12
May 01	95	-	5
May 30	98	-	2

Monitoring the seed bank in pasture residues. The quantity of medic pasture in a particular year depends on the numbers of seed pods left on the ground at the end of the previous pasture phase, the minimum quantity of seed for continuation of a productive medic pasture being about 200 kg/ha. To maintain an adequate seed bank, seed in the pasture residues was monitored during the summer so that grazing would be stopped at the proper time. An estimation in September showed that the seed bank in all medic plots after 4 years was satisfactory. The amount of seed present in and above the soil level was 241, 224, and 175 kg/ha for the low, medium, and high stocking rate plots, respectively (Table 4.2). Drought, cold, and the short growing period caused very low seed production, resulting in a 30% reduction in number of mature seeds per pod due to incomplete filling.

Animal performance, feeding levels, and productivity. Sheep weights were recorded weekly, a record was made of the date of mating and predicted date of lambing, and milk yield was measured every day after lambs were weaned at 90 days of age. A supplementary feeding strategy was practiced based on two premises: first, to give sufficient feed to maintain animal health, and second, to use the minimum amount of supplement so that pastures and stubbles would be utilized to the fullest extent.

Table 4.2. Medic seed bank at the end of the fourth year (kg/ha).

<table>
<tr><th>Stocking rate</th><th>Location</th><th>Old seeds</th><th>New seeds</th><th>Total</th></tr>
<tr><td rowspan="2">Low</td><td>Soil surface</td><td>61</td><td>47</td><td rowspan="2">241</td></tr>
<tr><td>Below surface</td><td colspan="2">133</td></tr>
<tr><td rowspan="2">Medium</td><td>Soil surface</td><td>67</td><td>51</td><td rowspan="2">224</td></tr>
<tr><td>Below surface</td><td colspan="2">106</td></tr>
<tr><td rowspan="2">High</td><td>Soil surface</td><td>63</td><td>32</td><td rowspan="2">175</td></tr>
<tr><td>Below surface</td><td colspan="2">80</td></tr>
</table>

The shorter grazing period in 1988/89 caused a considerable increase in the quantity and costs of supplementary feeds consumed compared with the previous year (Table 4.3). Table 4.3 also shows the outputs of animal products for the three stocking rates. Because of the greater number of animals, the high stocking rate produced the highest revenues and highest margin-over-feed costs. However, this simple economic analysis should be treated with caution until a complete biological and economic analysis has been made.

Crop productivity. The yields of vetch and lentil for hay, seed, and straw were very low (Table 4.4), so the vetch and lentil plots were grazed instead of harvested, after yields had been estimated. The very low moisture content of the soil prevented watermelons from reaching a marketable size.

Table 4.3. Outputs and value of animal products, feed costs, and margin-over-feed costs from medic pastures grazed at three stocking rates using 1989 prices.

	Stocking rate		
	Low	Medium	High
Outputs of animal products (kg/ha)			
- Meat[1]	127	188	274
- Milk	43	108	85
- Wool	8	15	21
Value of animal products (SL/ha)			
- Meat	6350	9400	13700
- Milk	688	1728	1360
- Wool	220	413	578
- Total	7258	11541	15638
Feed costs (SL/ha)[2]			
- Concentrates	1358	2254	3360
- Cottonseed cake	280	686	1120
- Cereal straw	777	1960	3185
- Total	2415	4900	7665
Margin-over-feed costs (SL/ha) (Value of outputs - feed costs)	4843	6641	7973

[1]Lamb sales.
[2]Feed prices: concentrate SL3.5/kg; cottonseed cake SL4.67/kg; cereal straw SL1.75/kg.

Table 4.4. Hay, seed, and straw yields of lentil and vetch (kg/ha).

	Hay	Seed	Straw
Lentil	-	451	768
Vetch	410	181	400

In previous years, yield of wheat following a medic pasture was lower than after fallow. Wheat yields following vetch and lentil were also lower than after fallow but to a lesser extent. Table 4.5 shows the wheat yields from the various rotations. This year, wheat grain yield after medic was particularly low compared to previous years and other rotations, although straw yields were similar to those after vetch and lentil.

Table 4.5. Yields of wheat grain and straw following fallow and four alternative crops grown in the previous year.

Previous crop	Grain yields (kg/ha)	Relative to fallow (=100%)	Straw yields (kg/ha)	Relative to fallow (=100%)
Fallow	1217	100	2264	100
Water melon	1506	124	2812	124
Vetch	896	74	1797	79
Medic	294[1]	23	1387[1]	61
Lentil	828	68	1453	64
LSD (P=0.05)	282	-	381	-

[1]Averaged across three stocking rates.

In the coming years further detailed work will be conducted to identify the factors responsible for depressing the yield of wheat after medic. - **N. Nersoyan**

On-farm testing of the ley farming system - the Tah Project (Preschedule M6)

The Tah project is conducted in close collaboration with the Syrian Directorate of Scientific Agricultural Research and it aims to evaluate the ley farming system in on-farm trials. The project involves both researcher-managed and farmer-managed on-farm trials. In the former category researchers make recommendations concerning the agronomic and grazing management of the medic pastures but farmers are the ultimate decision makers. In the latter category the farmers make all the management decisions but they are given advice when this is requested.

The project has now completed five seasons. The 22 farmers participating in the researcher-managed trials included 16 in or north and east of Tah village (Maara Mantika, Idlib Province), 4 in the Jezira area of northeast Syria, and 2 in the Houran area of southern Syria. Of the 22 farmers, 2, 4, 4, 8, and 4 of them have been involved in the project for 1, 2, 3, 4, and 5 years, respectively. Thus there were farmers with first and second cycle regenerating medic pastures, some with first year medics, and others with cereals and other crops growing after medics. There are 50.8 ha of trials on these 22 farms.

There were 63 farmer-managed trials in 1988/89 with 31 in Idlib Province, 23 in the Jezira, 6 in Houran, 2 in Hama Province, and 1 near Lattakia. These farmers were included because they had seen and heard from others about medics and had requested seed. They were given simple instructions about land preparation and seeding rate but were otherwise totally responsible for establishing and managing their pastures. A total of 2.25 t of seed from a mixture of medic species were distributed to these farmers, enough for 114 ha. However, because the growing season was so cold and dry only about three-quarters of this area was sown. Furthermore, of the sown pastures, the cold caused high mortality of *M. truncatula* (Circle Valley) and the Tah medic (*M. polymorpha*) and, because the host farmers and migrating Bedouins were desperately in need of feed for their flocks, pastures were unavoidably overgrazed.

Herbicides, pod numbers, and medic seed yields. On eight farms growing wheat after medic, herbicide (brominal plus) was applied to half the wheat area and the rest left unsprayed (control), the aim being to remove the competitive effect of medic volunteers on wheat growth. After the wheat harvest in June 1989, soil cores were taken, residual medic pod numbers counted, and seed yield estimated. The pod numbers in the control and treated wheat stubbles were 2832 (S.D. 1229)/m^2 and 2862 (1677)/m^2, respectively, and the seed yields were 245 (161.7) and 242 (151.1) kg/ha, respectively. These results suggest that very few medic seeds germinated during the wheat phase. On the other 11 farms where fields were sampled for medic pods after the 1989 wheat crop had been harvested, there were 2120 (2928.5) pods/m^2 and seed yield was 258.6 (256.4) kg/ha. This indicates that these fields still have an adequate seed bank.

Pod production on the medic pastures in the 19 out of 22 farms sampled in 1988/89 was 1022 (595)/m^2 and seed yield was 121 (81) kg/ha. This is below the 200 kg/ha threshold needed to ensure the establishment of an optimal plant population in the next regeneration year.

Pasture yields and grazing days. The dry, cool season severely reduced herbage yields but on the 19 farms where grazing took place, average herbage dry matter yield from inside cages was 1233 (804) kg/ha. Similarly, the duration of grazing was reduced to 31.6 days because flocks of 97.6 head were grazed on medic pastures averaging 1.89 ha. It is worth noting that in this situation an estimated stocking rate has little meaning. A more useful expression of pasture productivity is grazing days/ha, which reached 1633. This value can easily be related to the performance of other pastures in other areas and years where the duration of grazing may be longer at a lower stocking rate.

These results indicate one of the major problems facing the ley farming system in West Asia - an imbalance between flock size and pasture area. However, in reality the imbalance might not be so great since farmers would probably allocate more of their land to pastures. But with flocks averaging 100 head and 7 head/ha being an estimated sustainable stocking rate, at least 14 ha of pasture would be needed and this is larger than the size of many farms in northwest Syria.

Crop yields after medics. One benefit of growing legume crops is the residual nitrogen they leave for the following crop which is usually cereals. In previous seasons at Tah, beneficial effects of medics on subsequent cereal crops were observed (Program Annual Report 1988, pages 24-26). To investigate this aspect further in 1988/89, on several farms half the area of cereal crops growing after medics and other crops received phosphate and nitrogen before sowing, and in some cases a spring dressing of nitrogen. The grain yields of the cereal crops are shown in Tables 4.6 and 4.7.

As would be expected after the abundant rainfall in 1987/88, wheat yields after fallow were higher than after medic (Table 4.6). Conversely, wheat yields after sesame were lower than wheat after medic and wheat after barley yielded less than after medic. Wheat yields after medic and after lentil were similar. The clear benefit of fallowing is seen in Table 4.7 were barley yields after fallow were higher than after medic. However, as was the case with sesame as a previous crop, barley yields after cumin, a summer crop, were lower than after medic. Little difference was observed between the effects of medic and chickpea on the next barley crop.

Table 4.6. Grain yields (kg/ha) of wheat grown after medic, fallow, cereals, and sesame. Half the area of the wheat crop was fertilized (see text for details).

Farm number (rainfall)	Wheat variety	After medic		After other crops	
		N_0P_0[1]	$N_{25}P_{65}$	N_0P_0	$N_{25}P_{65}$
7	Sham 3[2]	604	584	512(F)[4]	680(F)
(242 mm)	Hourani[3]	544	468	640(F)	720(F)
10	Sham 4[2]	1300	1088	830(S)[5]	711(S)
(207 mm)	Mexipack[2]	1096	980	711(S)	622(S)
11-12	Sham 3[2]	880	684	650(B)[6]	310(B)
(171 mm)	Hourani[3]	852	744	340(B)	490(B)
13	Sham 4[2]	-	482[8]	-	484(L)[7,8]
(242 mm)	Mexipack[2]	-	468[8]	-	464(L)[7]
Average (excluding farm 13)		879	758	614	589

[1]N = nitrogen, P = phosphate; 0, 25, and 65 show kg/ha.
[2]Improved variety. [3]Local variety.
[4]F = fallow. [5]S = sesame. [6]B = barley. [7]L = lentil.
[8]No nitrogen applied and only 40 kg/ha of phosphate.

Note: Generally a 0.25 ha contiguous area of wheat after medic and a 0.03 - 0.125 ha contiguous area of wheat after other crops or fallow were harvested for the yield estimation. This was made by measuring the number of bags of grain collected from a commercial combine. However, on farm 13 the area of wheat after medic sampled was 1.25 ha and wheat after lentils was 0.5 ha.

Interpretation of these results is difficult because the effect of medics is being compared with several other preceding crops. However, they confirm other research reported in this document (pages 79-80 and 88) that cereal yields after fallow are higher than after another cereal crop and that wheat yields after medic are intermediate.

Table 4.7. Grain yields (kg/ha) of barley grown after medic, fallow, cumin, and chickpea. (Half the area of barley received 25 kg N/ha and 40 kg P_2O_5/ha at sowing. No spring dressing of nitrogen was applied because of drought.)

Farm number (rainfall)	Barley variety	After medic		After other crops	
		N_0P_0	$N_{25}P_{40}$	N_0P_0	$N_{25}P_{40}$
20[1]	Rihane[4]	202	110	760(F)	692(F)
(192 mm)	ACSAD[4]	195	181	368(F)	435(F)
21[2]	Arabi Abiad[5]	227	779	449(Cu)	579(Cu)[7]
(241 mm)	WI[4]	429	388	293(Cu)	265(Cu)[7]
23[3]	Arabi Abiad[5]	-	108[6]	-	102(Ch)[6,8]
(162 mm)	WI[4]	-	148[6]	-	186(Ch)[6,8]

[1,2,3]Sampling areas of 50 m^2 (x 2 quadrats), 50 m^2 (x 2 quadrats), and 15 m^2 (x 4 quadrats), respectively.
[4]Improved variety. [5]Local variety. [6]No nitrogen applied.
[7]Cumin. [8]Chickpea.

The drought conditions, indicated by an annual rainfall ranging from 162 to 242 mm at these sites, were clearly responsible for the low cereal yields. The frequent lack of a response to fertilizer is symptomatic of the inability of the plants to respond when moisture is severely limiting.

The Tah project has now entered its sixth year and there is every indication that the 22 farmers are happy to continue growing medics with very little outside technical input and advice. However, continuation of the ley farming system on these farms and elsewhere is heavily dependent on the availability of seed, especially when reseeding is necessary, as can happen following a drought year. Availability of seed, probably at subsidized prices, and backed up by experienced extension officers, is arguably one of the most important factors that will enable these farmers and others to adopt *and continue* using the ley farming system. Hopefully national programs will acknowledge this important fact and develop their own medic seed-producing industry, as seems to be occurring in an increasing number of countries of the WANA region. - **H. Sawmy; B. Mallawi, DSAR, SMAAR; E.F. Thomson; P.S. Cocks**

On-farm feed legume and grazing trials at El Bab (Preschedule L24)

The on-farm feed legume and grazing trials project at El Bab is now entering its fourth season. The aims of the project are to:

- measure the effect of using fallow land to grow common vetch and chickling on whole-farm productivity and subsequent barley grain and straw yields,
- introduce both feed and pasture legumes (medics) to farmers,
- measure the yields of seed and straw of feed legumes harvested at the mature stage,
- measure the growth rate of lambs grazing feed legumes in spring,
- assess farmers' reactions to feed and pasture legumes and fertilizer use, and
- obtain feedback from farmers as to the most appropriate use of these crops.

The researcher-managed on-farm trials are replicated on eight farms representing different soil types in two villages east of El Bab in northeast Aleppo Province. Before sowing in November 1988, soils were analysed for phosphorus and nitrogen content. Triple superphosphate was applied to areas where barley would be the next crop according to the phosphate status of the soil. Ammonium nitrate was applied to half of the barley crop area to measure carry-over effects of the feed legumes. Several farmers also sowed their own feed legumes using seed supplied by ICARDA. Such seed was only provided to farmers growing the crops for the first time.

The trials on each farm cover 4 ha divided between the legume and barley phase of the rotation. The feed legume treatments are common vetch (*Vicia sativa*, V) and chickling (*Lathyrus sativus*, C). Located between the two large plots of the two feed legume species is a strip of land divided into one 10 x 10 m plot of annual *Medicago* (M), two 10 x 10 m plots of barley (B), and four larger plots of land left fallow (F). This gives the rotations BpV, BpC, BpM, BpB, and BpF, where p is phosphate application. However, phosphate is only applied when necessary. Additionally, since half the barley area receives ammonium nitrate, there are also the rotations BpnV, BpnC, BpnM, BpnB, and BpnF. Applying all the fertilizer to the barley phase is intentional since we wish feed legumes to be seen as a low input technology. Indeed, many farmers in the area add fertilizer to barley crops already.

In 1988/89 the Syrian Ministry of Agriculture and Agrarian Reform (SMAAR) became more involved in the trials through their team based at El Bab. In addition, a trainee from SMAAR spent 7 months working with the ICARDA group. The SMAAR officials, visitors from Jordan, and students from Aleppo University also participated in the field days held for farmers from the area.

Small areas of feed legumes were sampled at the hay stage. Other areas were sampled at the mature stage to estimate grain and straw yields. At three farms, the crops were harvested by farmers for grain and straw and on five farms, starting in early April, lambs grazed the crops. On these five farms the crops were growing on shallow soils.

At the start of grazing there was more dry matter from vetch (836 kg/ha) than from chickling (771 kg/ha) and barley (651 kg/ha). The grazing season was only 23 days compared with last year's 48 days, mainly due to the low rainfall (201 mm).

The growth rates of lambs on the five fields used for grazing are shown in Table 4.8. Performance was below last year's levels when lambs gained 260-360 g daily. This is mainly attributed to the poor plant stands compared with 1987/88 when the rainfall was 465 mm.

Table 4.8. Performance of lambs[1] grazing vetch and chickling grown on five farms at El Bab.

Farm number	1	2	3	4	5	Mean
Grazing days	22	22	26	22	30	24
Stocking rate (lambs/ha)	27	34	32	29	23	29
Daily gain (g/lamb)	140	189	102	105	158	139
Liveweight gain (kg/ha)	105	137	88	79	112	104

[1]For ease of management lambs grazed vetch and chickling together.

The yields of mature crops after barley were also low (Table 4.9). The grain yield of chickling was non-significantly (P>0.05) higher than that of common vetch. A similar result was found last year at El Bab and in the previous project at Breda.

Table 4.9. Yields (kg/ha) of mature feed legumes after barley (n=8).

	Vetch	Chickl.	Barley	Medic	SEM[1]	Sign.[2]
Grain	177	369	397	106	81	ns
Straw	1047	1052	762	594	115	ns
Total	1224	1421	1159	700	167	*

[1]Standard error of mean.
[2]Significance: *=$P<0.05$; ns=non-significant ($P>0.05$).

Most of the farmers growing their own feed legumes chose to harvest them for grain and straw because they wanted to use the straw as winter feed and the grain as seed for sowing a larger area in 1989/90. Table 4.10 shows the number of farmers and area sown to feed legumes for the past 3 years at El Bab.

Table 4.10. Area (ha) of feed legumes sown in the project area.

Year	No. of farmers	Vetch	Chickling	Medic
1986/87	6	6	6	7
1987/88	7	11	10	13
1988/89	11	22	18	17

In the barley phase, yields of barley following fallow where higher ($P<0.05$) than barley after all the other crops (Table 4.11), and barley after barley consistently gave the lowest yields. Yields of barley after vetch and chickling tended to be higher than after medic. The higher yields of barley after chickling than after vetch, even though they were not statistically significant ($P>0.05$), confirm previous studies made at Breda.

Table 4.11. Yields (kg/ha) of barley after feed legumes, fallow, and barley (n=8).

	BpV[1]	BpC	BpB	BpF	BpM	SEM	Sign.
Grain	994	1109	722	1313	840	112	*
Straw	1534	1794	1048	1946	1242	108	**[2]
Total	2528	2903	1770	3259	2082	201	**

[1]See text for explanation of rotations.
[2]** = P<0.01.

Barley crops responded to nitrogen application and the response was statistically significant (P<0.05) in the case of straw (Table 4.12). In the previous year, the barley crops responded to nitrogen fertilizer application by producing more grain (P<0.05) and straw (P<0.05), probably because more moisture was available.

Table 4.12. Yields (kg/ha) of barley with (+N) and without (-N) ammonium nitrate as a spring dressing (El Bab).

	-N	+N	SEM	Sig.
Grain	795	830	27	ns
Straw	1282	1406	31	*
Total	2077	2236	55	ns

The yields of barley crops on the trial areas compared with the adjacent barley crops in farmers' fields were higher for both straw and grain (Table 4.13). These differences were clear to participating farmers since many of them could harvest barley from the trial plots, but they considered it to be uneconomic to harvest their own crops for grain. These differences are a clear illustration of a Type II yield gap. (A Type I yield gap is the one between research station trials and researcher-managed on-farm trials.)

Table 4.13. Yields (kg/ha) of barley grown in on-farm trials compared with farmers' fields (El Bab).

	On-farm trials	Farmers' fields	SEM	Sig.
Grain	1047	708	65	*
Straw	1640	1151	154	ns
Total	2687	1859	211	*

As well as the information reported here, a comprehensive questionnaire is being used to get a detailed picture of the farmers' attitudes towards the feed legumes. Other aspects of their farms are also monitored, such as farm size, crop types and areas, management practices, and crop yields, as well as information on the vetch and chickling that many of them have started growing. The results of the questionnaire are currently being summarized. They should provide a unique data set for further analysis concerning farmers' attitudes towards these feed legumes, the possibilities of adoption, and the impact they will have on the farm economy. The project is being continued in 1989/90 with more involvement of the Directorate of Scientific Agricultural Research (Douma) and the Aleppo Department of Agriculture, both of which are part of the SMAAR. - **F.A. Bahhady; E.F. Thomson; and SMAAR collaborators.**

Productivity of medic-wheat and other wheat-based rotations (Preschedule L34)

In October 1986 a trial was initiated in collaboration with the Syrian Ministry of Agriculture and Agrarian Reform at Himo Research Station, near Kamishly in northeast Syria.

The main objectives of the trial are to:

- compare the productivity of a wheat-medic rotation with wheat-vetch, wheat-wheat, and wheat-fallow rotations,
- monitor the effect of three different stocking rates on medic and sheep productivity, and
- compare the economic returns and biological yields of the different rotations.

The trial has three replicates with plots that are large enough to be grazed by flocks containing 12 sheep. The three stocking rates applied to the medic pastures are 5 sheep/ha (low), 9 sheep/ha (medium), and 12 sheep/ha (high). The season's rainfall at the station was 245 mm.

The yields of wheat after different crops in 1987/88 and 1988/89 are shown in Table 4.14. Wheat yields in 1987/88 were little affected by the crop grown in the previous year. However, the low rainfall in 1988/89 markedly depressed yields except for crops grown after fallow ($P<0.05$), probably because substantial amounts of water were stored in the soil at the start of the season following the high rainfall in 1987/88 (699 mm). Wheat after wheat gave the lowest yields in both years, particularly in 1988/89. The yields of wheat after vetch tended ($P>0.05$) to be higher than after medic, which was also seen in other research at Tel Hadya (see pages 79-80), and El Bab (page 88).

In this dry season, medic pastures yielded more dry matter (1726 kg/ha) than common vetch (1180 kg/ha) and wheat (503 kg/ha), and the common vetch failed to produce any seed. Seed set of medics was satisfactory in the year of establishment and 500 - 600 kg/ha were produced in 1987/88

Table 4.14. Yields (kg/ha) of wheat after medic, vetch, fallow, and wheat at Himo Research Station (Kamishly).

	Grain		Straw		Total	
	1987/88	1988/89	1987/88	1988/89	1987/88	1988/89
Medics[1]:						
- Low	1486	105	2975	1274	4461	1379
- Medium	1328	114	3498	1012	4826	1126
- High	1267	258	3338	1393	4605	1651
Vetch	1496	225	4007	1694	5503	1919
Fallow	1381	1515	3136	3150	4517	4665
Wheat	1402	52	2777	1079	4179	1131
LSD (P=0.05)	639	339	1085	723	1982	1549
Sign.	ns	*	ns	*	ns	*

[1]At three stocking rates.

(Table 4.15). However, seed set was low in 1988/89.

A new flock of sheep was established in March 1989 following a severe disease outbreak in 1988 and was introduced to medic pastures on 13.3.89. Table 4.16 shows the number of grazing days on medic pasture and wheat stubble, with and without supplementary feeding. The duration of grazing on medic pastures was very short, mainly because of low rainfall and the poor stand of medic pasture. As stocking rate increased, the number of days of

Table 4.15. Seed set of medics for the three stocking rates at Himo Research Station (Kamishly) in the establishment years (kg/ha).

	Low	Medium	High
1986/87	494	517	429
1987/88	575	505	603

Table 4.16. Number of days that sheep were grazing or supplemented (Himo Station, Kamishly).

	Low	Medium	High
Grazing green medic pasture	28	28	28
Supplementary feeding alone	35	42	49
Grazing dry medic pasture	37	30	23
Grazing wheat stubble	35	21	21
Grazing wheat stubble plus suppl.	21	35	35

supplementary feeding increased and the duration of grazing on dry medic residues decreased. Other differences between stocking rates were small.

Liveweight of sheep was recorded each week. The average liveweights at the start of grazing the low, medium, and high stocking rates were 41.6, 41.2, and 39.2 kg, respectively. At the end of the season all sheep had gained weight, reaching 50.5, 47.1, and 45.2 kg, respectively. Thus, daily liveweight gain of ewes was 58 g, 38 g, and 40 g, respectively. The high stocking rate still produced the highest output of animal products (Table 4.17).

This trial is very valuable because the results come from a geographical area of Syria where rainfall is higher than at

Table 4.17. Output of animal products from sheep grazing medics at three stocking rates (kg/ha) (Himo Station, Kamishly).

	Low	Medium	High
Milk	75	135	235
Lamb production	58	111	151
Wool	10	16	23

Tel Hadya and wheat is the dominant crop. It is entirely managed by national scientists who spent 9 months as long-term trainees in the Program when they learnt all the procedures for managing such trials. The value of this type of training can be judged from the success of the trial and the valuable results that are being generated. - **G. Malki, DSAR, SMAAR; M. Kewan, DSAR, SMAAR; M. Hussein, DSAR, SMAAR;, F.A. Bahhady; E.F. Thomson.**

Chapter 5

RESEARCH IN NORTH AFRICA

The research strategy

The Program has had a scientist stationed in Rabat since January 1988 and a research strategy is being implemented which aims to encompass the needs of National Programs, the priorities of the Pasture, Forage and Livestock Program and, latterly, the *recommendations of the Perugia workshop on* the Introduction of the Ley Farming System into the Mediterranean Basin (see page 152). The strategy has the following components:

- developing locally adapted genotypes of pasture legumes, especially from the local flora,
- evaluating feed legumes,
- developing local seed production industries to supply seed of feed and pasture legumes and so reduce costs and reliance on imports,
- establishing the effect on animal productivity of new systems using ley farming and feed legumes, and
- studying methods of improving weedy fallows.

In all phases the emphasis is on the work being undertaken by local scientists within the National Programs with support in planning and direction of research from ICARDA. Where necessary the initiative is taken by ICARDA and responsibility passed to the national scientists when and where appropriate. This chapter shows how our strategy is being applied in North Africa.

An ecogeographic survey of wild legumes in Morocco (Preschedule M39)

As part of the Program's strategy to develop locally adapted genotypes of pasture legumes using local flora, an ecogeographic survey of wild legumes in Morocco was conducted in 1988. The 161 sites sampled provided 1194 accessions belonging to 18 genera and at least 50 species. Soil samples and climatic data were collected at each site. The Medicago part of the collection is being used by an INRA scientist, Mr M. Bounejmate, as the basis for his PhD studies at the University of Western Australia.

Species identification. Analysis of the results continued during 1988/89 with the growing out of all Trifolium species at Rabat so that species could be verified and seed multiplied. Only the following changes were necessary to the list of Trifolium species in the 1988 Program Annual Report:

- All lines listed as bullatum were regrouped with tomentosum to make a total of 44 lines of tomentosum.
- Four lines were identified as striatum.
- One species of cherleri was changed to bocconei.
- The number of lines not positively identified has been reduced to two.

A wide range of soil types was encountered (Table 5.1) with sand content ranging from 2% to 95% and clay and loam percentages as high as 65% and 58%, respectively. Soil pH ranged from 5.5 (KCl) to 8.7, averaging slightly over 7. Site altitudes ranged from sea level to over 2000 m (Table 5.2) with rainfall varying from 210 mm to over 900 mm.

Table 5.1. Physical and chemical properties of soil from the ecogeographic survey.

	Number of sites	Min	Max	Mean	Standard deviation
Physical properties					
Clay (%)	159	2.4	65.3	27.0	14.1
Sand (%)	159	1.7	95.5	45.6	20.6
Loam (%)	157	2.7	58.2	27.7	11.3
Fine loam (%)	155	2.5	36.1	12.5	7.7
Coarse loam (%)	154	0.6	33.9	15.6	6.5
Fine sand (%)	159	1.3	80.8	25.9	15.6
Coarse sand (%)	159	0.4	73.5	19.8	13.9
Chemical properties					
pH H_2O	160	6.3	8.7	7.8	0.52
pH KCl	160	5.5	8.7	7.1	0.54
Carbon (%)	159	0.3	4.6	1.7	0.88
Nitrogen (%)	160	0.05	1.03	0.18	0.11
C/N ratio	159	5.8	13.2	9.5	0.80
Organic matter (%)	159	0.5	7.9	2.9	1.50
P_2O_5 (ppm)	156	2.0	166	44.2	37.00
K_2O (ppm)	155	106	1406	486	273
Salt m.semens/m^3	156	0.3	16.5	1.0	1.30
$CaCO_3$ (%)	157	0.01	58.0	11.9	13.00

Table 5.2. Climatic data and altitude for 161 sites in the ecogeographic survey.

	Min	Max	Mean	Standard deviation
Minimum temperature (°C)	1.7	8.2	4.6	1.7
Maximum temperature (°C)	27.0	39.8	34.0	3.7
Rainfall (mm)	210	930	470	207
Altitude (m)	0	2100	519	407

Minimum temperature = average of coldest month.
Maximum temperature = average of hottest month.

Further evaluation of annual *Medicago*. During the ecogeographic survey a field was found at Kasbah Tadla near Beni Mellal which had a high density of *Medicago* pods. Seed was harvested from this field in two ways: firstly, by hand to obtain pure lines of *M. aculeata*, *M. orbicularis*, and *M. truncatula*, and secondly, by suction harvester to obtain a mixture of species for field trials.

The seed mixture was sown at nine locations; four in the Rommani area and five in the Settat region. Widespread drought resulted in poor establishment at all the sites in the Rommani area and two of the sites in the Settat region. One site in the Settat region was inundated with spontaneous medic, mainly *M. aculeata*, *M. truncatula*, and *M. polymorpha*, and was therefore not of value as a trial site. It did, however, become a site for gathering local ecotypes of medics to suit that particular area. At the remaining two sites the medics established well.

Some data from the original collection site and from Had Soulem are shown in Table 5.3. *M. aculeata* maintained the largest seed bank at the original site of collection and also had the greatest amount of seed at Had Soulem at the end of the summer.

As far as is known, *M. aculeata* has not been used commercially, but it could be a very useful species in Morocco. The pods of *M. aculeata* are particularly hard and also tend to become partially buried in the soil. This may provide some protection from grazing animals and could be very useful in a ley farming system. - **M. Bounejmate, INRA; A. Lahlou, INRA; P. Beale**

Table 5.3. Seed yield, plant density, and pasture composition of the Beni Mellal mixture at Beni Mellal, and seed yield at Had Soulem.

	Beni Mellal (original collection site)				Had Soulem
	Seed (kg/ha) May 1988	Plants (m^2) Dec 1988	Pasture compos-ition(%) Apr 89	Seed (kg/ha) July 1989	Seed (kg/ha) August 1989
M. aculeata	93	93	22	117	59
M. truncatula	31	58	28	48	31
M. orbicularis	14	0	0	2	1
M. polymorpha	21	100	6	16	45
M. minima	0	0	0	2	0
Weeds	-	-	38	-	-
Bare ground	-	-	6	-	-

Improving weedy fallows using balansa clover (Preschedule M39)

The term "weedy" fallows is used in North Africa since they produce substantial quantities of biomass, much of which is an important source of feed to livestock. These fallows usually contain many legume species which would respond to phosphate fertilizer. Balansa clover, sown annually, could enrich the legume component even more.

Eight sites were sown with balansa clover at 10 kg/ha. At each site 1 ha of cereal stubble was divided in two and half of the area sown dry with balansa clover and the other half left as normal weedy fallow. The balansa clover was hand broadcast on the surface and the farmer requested to cover it lightly with whatever implement was readily available to him. In each case the method to be used was discussed and agreed upon and the farmer left to carry out the operation. A second split was made and phosphate applied to half of the area sown to clover, with the other half left as normal weedy fallow. It was also agreed that the farmer would graze his livestock on the area in the traditional way but with the proviso that if extra feed were available in the spring due to the balansa clover, he would not add extra stock above what he would normally use, to allow the clover to express its spring potential.

Problems were encountered with insufficient coverage of the seed, but the greatest problems were drought and weeds. All four sites in the Rommani area were abandoned following poor establishment, attributable to some extent to not covering the seed and to drought and frost. Two sites in the Settat region suffered the same fate and at another site balansa clover established well but was overwhelmed by volunteer medic, producing an excellent legume dominant pasture but of medic not clover. The eighth site at Had Soulem was successful. Here the agreed stocking rate was 12 sheep/ha but it was actually grazed by 14 cows as well although only for half of each day. Although this meant the grazing pressure was very high it was in a way fortuitous since it helped to control a severe infestation of Emex, and balansa clover is able to withstand heavy grazing. However, a trial with the Beni Mellal medic mixture adjacent to the clover plot gave superior results and was judged by the farmer to be better.

Dry matter production at the two sites is summarized in Figure 5.1. Balansa clover proved to be well adapted at Had Soulem. Total annual dry matter production of balansa clover receiving phosphate was 6000 kg/ha compared with under 4000 kg/ha from unimproved fallow. However, the increased production was largely attributable to the addition of phosphate. Additional yield from balansa clover without phosphate was around 600 kg/ha whereas the simple addition of 45 kg/ha of P_2O_5 as superphosphate increased the production of the fallow by over 2000 kg/ha. At Khmis Gdana, balansa clover had no effect on overall dry matter production whereas superphosphate again increased production.

Although balansa clover grew well at Had Soulem it was inferior to medic with the grazing regime used. The Moroccan Ministry, however, has been sufficiently impressed by this and other trials with balansa clover to wish to sow a larger area in 1989 in the higher rainfall areas. ICARDA will supply 250 kg of seed of PARADANA balansa clover for Ministry trials in 1989.

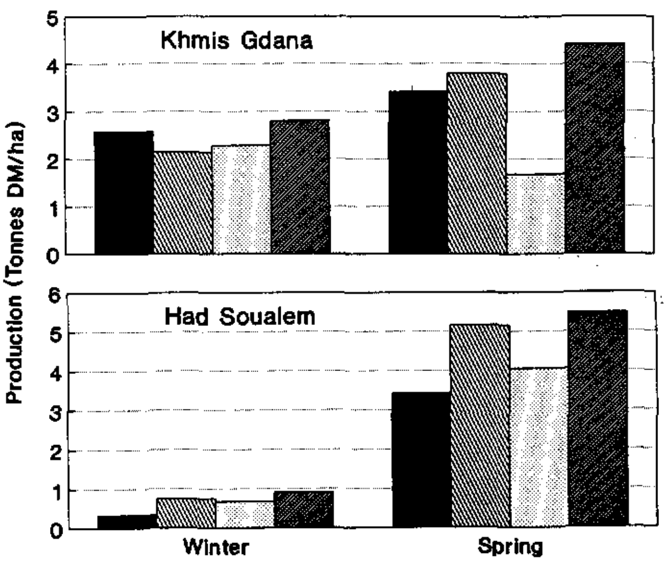

Figure 5.1. Production of weedy fallow and balansa clover, with and without application of phosphate fertilizer in winter and spring at Khmis Gdana and Had Soualem, Morocco. (= fallow, = fallow/balansa, = fallow/P_2O_5, = fallow/balansa/P_2O_5).

The study has been useful in highlighting the possible role of balansa clover and stimulating the Ministry to try some larger experimental sowings. The results, however, do not warrant a continuation of the research program in the light of the much better results with medics which need to be given priority. The value of adding phosphate to increase productivity of fallow was confirmed in this trial and perhaps merits further studies. - **H. El Mzouri, INRA, Settat; A. Lahlou, INRA; P. Beale**

Evaluating annual feed legumes

Trials with improved lines of vetches (V. sativa) from ICARDA and local selections were conducted near Fes (451 mm) and near Tangiers (750 mm). The trial at Fes established well and survived a period of around 6 weeks of very cold weather with little rainfall during the winter. This was followed by excellent spring rainfall resulting in good growth. In contrast, the trial at Tangiers suffered from waterlogging soon after sowing and then extreme cold which virtually annihilated many plots.

Observations on crop development are shown in Table 5.4 and yields of fresh and dry matter and seed yield in Table 5.5. Growth of most lines was similar during the early part of winter but by the end of February there were big differences. This is reflected in the large and significant yield differences that were found between lines. By mid-April, for example, the yields of fresh matter ranged from 5 t/ha to over 27 t/ha and dry matter yields varied from 1 to 3.5 t. Maximum dry matter yields were recorded in May for all varieties with nearly 6 t/ha for acc. 1812. This accession was consistently good from early winter until the end of the season and also had good resistance to Orobanche

Table 5.4. Date of emergence, growth scores, and <u>Orobanche</u> rating of vetches at several stages of growth.

Variety	Date of emer- gence	Growth stage[1]	Growth score[2] 19 Jan	1 Feb	16 Mar	Growth stage on 13 May	Orobanche rating[3] (1 May)
Acc 638	7/12	4F	5.0	6.9	6.0	Late flower	0
Acc 2542	3/12	SB	5.0	6.0	4.2	Pod	+
Acc 715	7/12	SB	5.0	6.3	4.5	Full flower	0
Acc 708 sel 2037	5/12	SB	4.0	5.9	4.2	Full flower	+
Acc 534 sel 2165	6/12	3F	4.5	6.1	4.0	Early flower	+
Acc 1458	5/12	SB	4.0	5.5	3.0	Pod	+++
Acc 1416 sel 1448	8/12	4F	3.5	4.9	2.0	Flower buds	+++
Acc 1361 sel 1448	9/12	SB	4.0	4.9	2.2	Flower buds	+
Acc 1812	5/12	SB	6.0	7.5	7.0	Full flower	+
Acc 384 sel 2062	2/12	SB	5.0	5.3	5.0	Pod	0
Acc 384 sel 2108	1/12	SB	6.0	8.1	5.0	Pod	+++
Acc 2 sel 1334	1/12	SB	6.0	7.6	5.2	Flower buds	+++
Acc 709	2/12	SB	5.5	6.4	5.0	Pod	0
Namoi	7/12	BS	5.5	7.5	6.0	Full flower	+
104537	5/12	SB	4.0	6.0	6.0	Full flower	+
6194[4]	4/12	SB	5.5	6.3	6.5	Early flower	+
6235[4]	6/12	SB	5.0	6.1	5.0	Pod	++

[1]3F=heavy stage, 4F=4 leaf stage, SB=start of branching.
[2]Growth score, 0-10 (10=very good).
[3]<u>Orobanche</u>, 0=nil to +++ (heavy infestation). [4]Control.

which was very severe in some plots. This line was therefore selected for catalogue trials with a view to commercial release. Although the seed yield is relatively low with a high percentage of shattering, it was considered that the seed yield of this line would be satisfactory if the seed was harvested before most of the shattering had occurred. A number of other lines also look promising and will be further evaluated in 1989/90. - **C. Al Faiz, INRA; P. Beale**

Table 5.5. Yield (t/ha) of fresh matter, dry matter, and grain of vetches harvested on four dates.

Variety	21.3.89		13.4.89		9.5.89		Grain yield (kg/ha) (29.6)	Level[1] of shatt-ering
	Fresh matter	Dry matter	Fresh matter	Dry matter	Fresh matter	Dry matter		
Acc 638	8.72	1.53	19.89	3.33	20.60	5.36	707	2
Acc 2542	3.57	0.87	9.22	2.36	14.20	4.39	1018	3
Acc 715	4.11	0.92	10.33	2.17	19.96	5.22	1208	2
Acc 708 sel 2037	3.51	0.77	8.11	1.73	18.23	4.75	735	6
Acc 534 sel 2165	4.07	0.86	11.18	1.90	15.41	4.00	270	6
Acc 1458 sel 2106	2.11	0.49	4.98	1.14	9.30	3.01	481	4
Acc 1416	1.03	0.23	6.72	1.12	13.58	3.38	224	3
Acc 1361 sel 1448	1.07	0.24	5.94	1.10	11.60	3.00	218	1
Acc 1812	9.93	1.82	27.48	3.39	26.62	5.80	391	7
Acc 384 sel 2062	5.02	1.05	10.72	2.12	19.72	4.93	739	3
Acc 384 sel 2108	6.07	1.24	10.00	2.14	9.93	2.59	143	4
Acc 2 sel 1134	5.16	1.12	9.50	2.20	10.02	2.73	57	7
Acc 709	5.14	1.17	9.53	2.37	16.81	5.03	1010	8
Namoi	9.32	1.68	20.72	3.27	20.54	5.57	557	1
104537	9.58	1.70	27.05	3.80	22.95	5.45	291	3
6194	7.98	1.48	26.33	3.47	27.18	5.95	311	5
6235	5.22	1.07	11.05	2.16	17.50	5.12	887	5
Average	5.39	1.07	13.46	2.34	17.30	4.49	545	
Signif.[2]	**	**	***	**	**	*	**	
CV (%)	27.7	26.5	21.6	22.1	20.1	23.6	405	
SD	1.49	0.28	2.96	0.52	3.47	1.06	220	

[1]0 = no shattering, 9 = high level of shattering.
[2]* = P<0.05, ** = P<0.01, *** = P 0.001.

Animal productivity from weedy fallow improved with medic

A trial was established in October 1988 to compare animal production from weedy fallow improved with medic versus normal weedy fallow. This INRA/MIAC/USAID project was managed by Mr B. Boulanaouar and Dr Scott Christiansen. The fallow was improved by cultivation (disc-harrowing) followed by hand spreading a 50:50 mixture of Medicago polymorpha cv Serena and M. truncatula cv Jemalong at a seeding rate of 22 kg/ha, and then rolling with a cultipacker roller. The weedy fallow treatment was also cultivated but not sown. The medic established well and by February represented around 50% of the total dry matter of approximately 2000 kg/ha.

Grazing commenced at the beginning of February with 13 lambs of just over 15 kg liveweight. Maximum available dry matter yield occurred in late April (almost 4000 kg/ha) by which time medic represented 60% of the pasture. The sheep gained weight steadily until June when they averaged around 37 kg liveweight. Up to June there was no difference in liveweight gain between the sheep on medic and those on weedy fallow. During June the sheep were transferred to the cereal stubbles as this is the local farming practice. The sheep were transferred back to the medic and weedy fallow dry residues during the latter half of August 1989.

In the future this trial will indicate whether: 1) medic pastures regenerate with satisfactory plant densities, 2) sheep production is increased on regenerating medic pastures, 3) soil fertility is improved by the use of medics, and 4) what effect medic will have on wheat yields. - **B. Boulanour, INRA/MIAC, Settat, Morocco; S. Christiansen, INRA/MIAC; P. Beale**

In-country seed production

Seed of the pure lines of the local genotypes of Medicago orbicularis, M. aculeata, and M. truncatula found during the ecogeographic survey was multiplied during 1988/89. Seed of each line will be available for further multiplication and evaluation in 1989/90 as shown below.

	Seed (kg)	1000-grain weight (g)
M. orbicularis	57	3.9
M. aculeata	20	8.5
M. truncatula	8	4.4

A. Lahlou, INRA; M. Bounejmate, INRA; P. Beale

Activities in Algeria

No cooperative projects were carried out in Algeria during the 1988/89 season since the first season in North Africa was used to establish work in Morocco. However, Dr Beale visited Sidi Bel Abbes and Algiers during the year to establish links, discuss the current work in Algeria, and discuss a program for the future.

A brief summary of these discussions is given below.

- A major collection of annual legumes was made across Algeria in 1988 by ITGC and INRA, France. In addition, some improved lines of *Medicago* species have been selected from earlier collections and several kilograms of seed of some lines are available for further evaluation and seed production.

- Evaluation of feed legumes is in progress. Particular emphasis is being given to pea/triticale mixtures which have proved to be reliable yielders in the Sidi Bel Abbes region. ICARDA will cooperate with this project, particularly by supplying improved lines of feed legumes developed by ICARDA.

- An area of 15-30 ha will be selected in eastern Algeria for medic seed production, with the aim of establishing local seed production and providing training in seed production methods. Locally selected genotypes will be multiplied along with imported cultivars for which there is a demand.

A major experiment was proposed to commence as soon as possible, possibly in 1990/91, to compare animal production from feed legume-cereal mixtures (vetch/oats or peas/triticale, for example) with animal production from weedy fallow improved with medic. The initial experiment would be established on a government station in western Algeria, but hopefully at a later date the work will expand into farmers' fields making similar comparisons. - **P. Beale**

Chapter 6

IMPROVEMENT AND ECOLOGY OF MEDITERRANEAN GRASSLAND AND MARGINAL LANDS

Mediterranean grassland is the new term we have decided to use when describing the non-arable land within the cereal zone. In our previous reports this type of land, together with the arable land adjacent to the steppe, was collectively called 'marginal land'. Within the cereal zone, non-arable lands are steep and stony with shallow soils and farmers have no choice but to use them for grazing. In the case of land adjacent to the steppe, cultivation is possible but the risk of crop failure is high. The term 'marginal land' will still be applied to the latter while 'Mediterranean grasslands' will be used for the non-arable land within the cereal zone. This report will deal mainly with Mediterranean grassland research in the 1988/89 season.

Productivity of Mediterranean grasslands (Preschedule ML2)

This long-term study, in which the effect of phosphate fertilizer on Mediterranean grassland and on stocking rate is being monitored, is now entering its sixth season. Three rates of triple superphosphate (0, 25, and 60 kg P_2O_5/ha) and two stocking rates, low (1.2 ha/sheep) and high (0.65 ha/sheep), are applied across three replications. The fertilizer is broadcast every year in November.

Initially, 90 Awassi ewes were divided into groups of five, each containing 2 - 6 year old ewes, and each group was permanently assigned to large (6.0 ha) or small (3.2 ha) plots representing low and high stocking rates, respectively, in each of the fertilizer treatments. During the 1988/89 season, two more ewes were added to each flock, making 0.86 and 0.46 ha/sheep in the low and high stocking treatments, respectively. Each year the oldest ewe in each flock is replaced by a 2 year old ewe.

Every year soil phosphorus content and herbage and seed yields are measured and botanical composition of the pasture is recorded. Herbage is sampled every 3 - 4 weeks from December to May to estimate yields of legumes, grasses, and other species. Seed yield is assessed at the end of the season in June. In 1988/89 sheep were supplemented with barley grain during late pregnancy (October-December) and with barley-vetch hay during early lactation (January-March). Since the unusually low rainfall resulted in a shortage of pasture, additional barley grain, cottonseed cake, and barley straw were provided when necessary from June to November for ewes with a mass falling below 43 kg.

Figure 6.1 shows herbage yields on the pasture during the season. There were significant yield differences due to phosphate application for the legume (Fig. 6.1a) and the legume and grass components combined (Fig. 6.1b) in comparison with the control treatment. These differences were recorded as early as December and continued throughout the year. The differences between the two phosphate treatments (P_{25} and P_{60}) were not significant ($P>0.05$) except at the end of the season and for legumes only. These results show that phosphate application can benefit the pasture even in dry years with rainfall less than 250 mm.

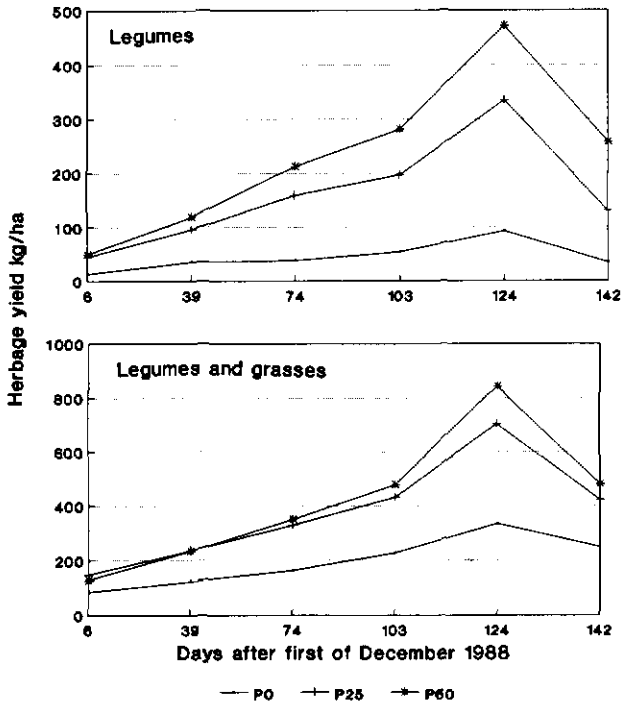

Figure 6.1. Herbage yields of pasture during the 1988/89 season.

Table 6.1 shows the pasture composition in April. Legumes were dominant in the phosphate treated plots while grasses and other species were dominant in the control treatment. Both legume and grass components accounted for a larger proportion of the pasture under low stocking than with high stocking, although the differences are not statistically significant. Other species formed a significantly larger proportion of the pasture under the high stocking rate.

Table 6.1. The percentage of legumes, grasses, and other species (on a dry matter basis) in grassland[1] in relation to the level of phosphate and stocking rate[2] (1989 at Tel Hadya).

	Legumes	Grasses	Other species
Phosphate level[2]			
P_0	17	60	23
P_{25}	34	59	9
P_{60}	46	40	14
LSD (P=0.01)	9	9	6
Stocking rate[2]			
Low	35	53	12
High	30	51	18
LSD (P=0.05)	ns	ns	5[3]

[1]Based on mass of hand separated samples taken in April.
[2]Means in each phosphate level are the average of two stocking rates and those of the stocking rates are the average of three phosphate treatments.
[3]LSD (P=0.01).

Table 6.2 shows that legume plant numbers and mass were significantly larger with phosphate application. This is important since plant numbers correlate highly with pasture productivity. Studies with medic pastures under Mediterranean conditions in Australia and in north Syria have shown that plant numbers of 1000 and more are necessary for maximum pasture productivity. In this study, where legumes were not sown, their numbers fluctuate each season, and both rainfall and phosphate application seem to exert a marked effect on plant numbers (see Program Annual Report 1988, page 202). In 1988/89 with 234 mm rainfall, the effect seems to have been due to phosphate application, with plant numbers increasing by 108 and 169% and plant mass by 84 and 126% under P_{25} and P_{60}, respectively, compared with P_0.

Table 6.2. Legume plant numbers and plant mass in grassland at three levels of phosphate (1989 at Tel Hadya, April sampling).

Phosphate level[1]	Plant numbers (plants/m^2)	Plant mass (mg/plant)
P_0	326	26
P_{25}	679	48
P_{60}	879	59
LSD (P=0.01)	211	11

[1]Each value is an average of two stocking rate treatments.

Plant numbers in the pasture are also a reflection of the build-up of seeds and the seed dormancy characteristics of the different species. Table 6.3 shows the seed mass and seed number in 1985, 1 year after the experiment started, and in 1989. There is more than a threefold build-up of seed mass and a sixfold increase in seed number as a result of phosphate application. The control treatment showed a slight change in seed number over the 5 years.

The treatment effect on the grazing animals is shown in Figure 6.2 where the mass of ewes is compared 22 weeks before lambing and 13 weeks after lambing. Differences over the control treatment (P_0) were highly significant for P_{25} and P_{60}, but the differences between P_{25} and P_{60} were not statistically significant. Similarly, Figure 6.3 shows better animal performance under the low stocking rate than under the high stocking rate. The treatment effects are also shown in Table 6.4 for lamb growth rate and wool production of ewes. In both cases phosphate application resulted in significantly larger yields over the control. Lamb growth rate and wool production were significantly better at the low stocking rate. The fast growth rates of the lambs are noteworthy as they indicate the ability of the ewe to buffer the effects of reduced pasture availability in a season with below average rainfall.

Table 6.3. Seed mass and seed number of legumes in grassland as affected by phosphate level (Tel Hadya, 1985 and 1989).

Phosphate level[1]	Seed mass (mg/m^2)		Seed number ($plants/m^2$)	
	1985	1989	1985	1989
P_0	2.9	2.7	2108	4327
P_{25}	3.7	12.1	3112	18637
P_{60}	4.6	17.4	3987	24129
LSD (P=0.05)	1.3	3.2[2]	879	4811[2]

[1]Each value is the average of the two stocking rate treatments.
[2]LSD (P=0.01)

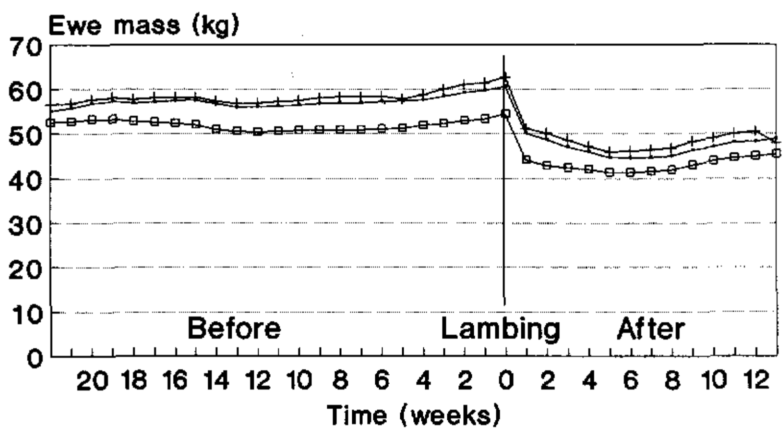

Figure 6.2. Mass of individual ewes grazing pastures receiving no phosphate (—▫—), 25 kg P_2O_5/ha (——) and 60 kg P_2O_5/ha (—+—), 22 weeks before lambing and 13 weeks after lambing.

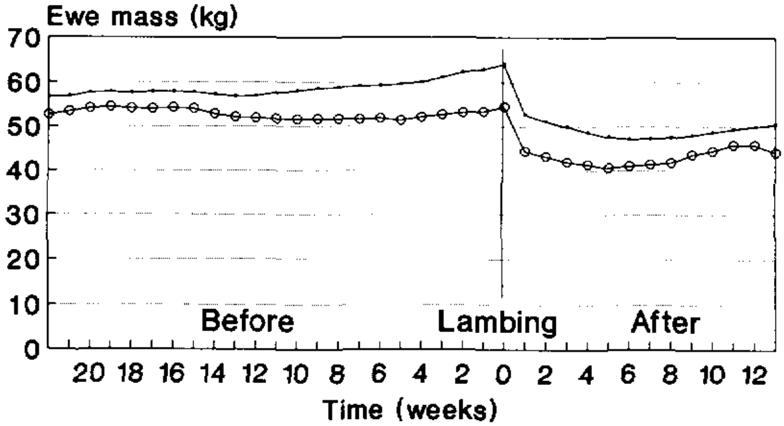

Figure 6.3. Mass of individual ewes grazing pastures at a low (—·—) and a high (—o—) stocking rate, 22 weeks before lambing and 13 weeks after lambing.

Table 6.4. Lamb growth rate and ewe wool production as affected by phosphate level and stocking rate (1988/89 season).

	Lamb growth rate[2] (g/day)	Wool production (kg/ewe)
Phosphate level[1]		
P_0	275	1.99
P_{25}	308	2.36
P_{60}	322	2.38
LSD (P=0.01)	23	0.32
Stocking rate[1]		
Low	329	2.40
High	275	2.08
LSD (P=0.01)	18	0.26

[1]Values of phosphate treatments are averages of the two stocking rates and those of the stocking rates are averages of the three phosphate levels.
[2]From birth to weaning at 56 days.

Table 6.5 shows the amounts and costs of hay and barley grain used in winter, while Table 6.6 shows the amounts and costs of feeds used during the summer. Slightly more feed was used in the winter than in the summer and significantly more feed was consumed by flocks grazing the P_0 pastures than those grazing the P_{60} pastures. These levels of feeding are considered necessary to avoid increased mortality due to undernutrition and to maximize conception rate, which is known to decrease when ewes are in poor condition.

Table 6.5. Total amount and cost of hay and barley grain used to supplement sheep grazing at two stocking rates on pastures receiving different levels of phosphate fertilizer from October 1988 to March 1989 (Tel Hadya).

Phosphate level[1]	Amount[1] (kg)		Cost[2] (SL)		Totals	
	Hay	Barley	Hay	Barley	Cost	Saving
Phosphate level						
P_0	124.5	85.3	273.9	402.6	676.5	-
P_{25}	55.8	46.9	122.8	221.4	344.2	332.3
P_{60}	26.0	32.2	57.2	152.0	209.2	467.1
LSD (P=0.05)	48.6	31.4	106.9	148.2	-	-
Stocking rate						
Low	23.3	25.4	51.2	120.0	171.2	477.6
High	114.3	84.2	251.5	397.3	648.8	-
LSD (P=0.01)	56.4	36.5	124.1	172.1	-	-

[1]Based on a flock of seven ewes per plot.
[2]Based on a market price of SL2.20/kg and SL4.72/kg for hay and barley grain, respectively. (Winter 1988/89 prices.)

The cost of feed was calculated using prevailing market prices during the winter and summer periods. The saving as a result of using phosphate is clear (Tables 6.5 and 6.6). No attempt will be made at this stage to talk about profits, but rather to indicate how additional costs resulting from a drought could be reduced by applying phosphate fertilizer to pastures. Decisions on stocking rates will be based on the additional feed cost and on their implications for sustainable pasture productivity.

Table 6.6. Total amount and cost of supplementary feed used for sheep grazing at two stocking rates on pastures receiving different levels of phosphate fertilizer from June to November 1989 (Tel Hadya).

	Barley grain	Cottonseed cake	Barley straw	Total	Saving
		Feed amounts (kg/7 ewes)			
Phosphate level					
P_0	360.2	73.0	161.8	595.0	-
P_{25}	224.0	43.0	101.5	368.5	226.5
P_{60}	128.2	23.8	53.5	205.5	389.5
LSD (P=0.05)	117.5	24.1	51.2	-	-
Stocking rate					
Low	57.1	11.2	27.3	95.6	588.1
High	417.8	82.0	183.9	683.7	-
LSD (P=0.01)	136.5	28.0	89.4	-	-
		Feed costs[1] (SL/7 ewes)			
Phosphate level					
P_0	1836.7	656.5	485.2	2978.4	-
P_{25}	1141.8	386.2	304.3	1832.3	1146.1
P_{60}	653.2	213.4	160.4	1027.0	1951.4
LSD (P=0.05)	599.2	217.3	153.5	-	-
Stocking rate					
Low	290.7	100.4	81.8	472.9	2945.9
High	2130.4	737.0	551.4	3418.8	-
LSD (P=0.01)	695.9	252.4	178.3	-	-

[1]The market prices (summer 1989) are: barley grain SL5.1/kg; cottonseed cake SL9.0/kg; barley straw SL3.0/kg.

Edible shrubs, the steppe, and sheep production (Preschedule ML12)

A new experiment has been started in collaboration with the Syrian Steppe Directorate and ACSAD on the evaluation and management of marginal land in which edible shrubs have been sown. The experiment is laid out in the steppe 120 km southeast of Aleppo where annual rainfall is 150-250 mm. Much of the area is now used for continuous barley cultivation although traditionally it was grazed. For the past 10 - 15 years the grazing pressure has been excessive and the area is now heavily degraded and typical of land under threat of desertification, as in many countries of North Africa and West Asia.

The objectives of the experiment were to:

- determine the productivity of marginal lands improved by seeding with edible shrubs, including Atriplex spp.,
- measure the economic return from improved marginal lands, and
- monitor the effects of three stocking rates on biomass production and sustainability, and sheep production and productivity.

The study is expected to generate much needed information on the grazing management of rehabilitated marginal lands in Syria that should also be useful to other countries of the region. Sheep are expected to enter the experimental plots in February 1990. - **A.E. Osman**

Environmental factors and growth of Mediterranean grasslands (Preschedule ML13)

As well as investigating the effects of phosphate application and stocking rate on the productivity of Mediterranean grasslands, the Program is conducting two experiments to study some of the interactions between environmental factors and plant growth and composition. An understanding of these interactions will help in making decisions about appropriate methods to improve these grasslands, such as the choice of species for reseeding. Results from two on-going experiments are reported in the following section.

Experiment 1. This experiment monitors the environmental and vegetative variation between adjacent quadrats and investigates relationships between vegetation and environmental characteristics within quadrats. It forms part of the experiment on phosphate application and stocking rate of Mediterranean grasslands described in the previous section.

Transects of 100 m were laid down in four plots which were being grazed at the low or the high stocking rates, and had received 0 or 25 kg/ha of phosphate since 1984. In October 1987, 50 quadrats (1 x 0.25 m) were spaced at 2 m intervals along the transect and they were all left open to grazing. In October 1988 the quadrats were moved to an adjacent position. Detailed recordings were made of the vegetation, environment, slope, and soil physical and chemical characteristics. Further details of the methods and analyses are reported by Pagnotta (1989).

There was marked environmental variability within and among plots (Tables 6.7 and 6.8). The most variable attribute was available (Olsen) phosphorus which in 1987/88 varied from 7 ppm to 99 ppm in plots receiving phosphorus and from 3ppm to 9 ppm in plots not receiving phosphorus.

Table 6.7. Variations in environmental factors in the four plots (1987/88).

Plot number[1]	Mean	SE[2]	CV[3]	Min	Max
Depth (cm)					
1	16	8.3	51	0	47
2	17	7.4	43	5	34
7	24	8.9	37	7	53
8	16	4.7	30	4	24
Organic matter (%)					
1	5.86	1.08	18	4.21	9.00
2	6.05	1.45	24	4.26	11.00
7	3.28	0.36	11	2.65	3.89
8	4.18	0.53	13	3.04	6.69
Total nitrogen (%)					
1	0.34	0.060	18	0.26	0.57
2	0.37	0.081	22	0.25	0.61
7	0.20	0.018	9	0.17	0.24
8	0.26	0.025	10	0.21	0.31
Olsen P (ppm)					
1	17.1	8.81	52	6.7	59.1
2	22.5	15.31	68	8.7	98.6
7	4.5	0.86	19	2.9	6.7
8	5.7	1.19	21	4.1	9.3
Volume of stone (%)					
1	2.77	1.415	51	0.7	7.52
2	5.07	3.504	69	1.46	18.96
7	3.83	1.683	44	1.32	9.10
8	4.55	2.325	51	0.66	13.49
Weight of soil (g)					
1	390.5	112.9	29	52.60	591.0
2	325.6	117.0	36	42.20	681.0
7	413.2	74.3	18	228.4	555.2
8	382.0	87.3	23	170.4	569.1

[1]1 = P_{25} + low stocking rate; 2 = P_{25} + high stocking rate; 7 = P_0 + high stocking rate; 8 = P_0 + low stocking rate.
[2]Standard error.
[3]Coefficient of variation.

Table 6.8. Variations in environmental factors in the four plots (1988/89).

Plot number	Mean	SE[1]	CV[2]	Min	Max
Depth (cm)					
1	16	8.3	53	0	32
2	19	10.0	54	4	51
7	27	9.8	36	6	51
8	17	6.3	37	2	31
pH					
1	7.9	0.09	1	7.7	8.1
2	7.9	0.10	1	7.6	8.1
7	8.1	0.06	1	7.9	8.2
8	8.0	0.05	1	7.9	8.1
$CaCO_3$ (ppm)					
1	17	5.79	33	6.2	29.7
2	11	2.86	26	5.7	16.2
7	17	4.99	30	10.8	24.8
8	11	1.66	15	8.7	17.9
Organic matter (%)					
1	5.83	2.06	35	4.10	17.20
2	5.56	1.33	24	3.80	9.80
7	3.30	0.48	14	2.40	4.50
8	3.73	0.39	10	3.00	4.80
Total nitrogen (%)					
1	0.36	0.093	26	0.26	0.82
2	0.35	0.078	22	0.25	0.60
7	0.21	0.028	14	0.16	0.29
8	0.26	0.029	11	0.19	0.33
Olsen P (ppm)					
1	15.4	7.70	50	7.6	46.7
2	19.2	8.69	45	4.6	60.3
7	5.1	1.24	24	3.5	9.5
8	6.4	2.55	40	4.5	17.1
Volume of stone (%)					
1	7.86	3.655	46	3.00	23.67
2	11.64	5.286	45	3.47	34.40
7	10.51	2.583	25	5.96	16.90
8	11.57	5.859	51	5.44	40.00
Density of soil (g/cm)					
1	891.9	212.4	24	351.0	1256.8
2	954.8	427.3	45	541.8	3497.7
7	793.6	103.0	13	547.6	1023.9
8	940.8	153.0	16	741.7	1471.6

[1]Standard error
[2]Coefficient of variation

The experimental data for 1987/88 and 1988/89 were analyzed using K-means clustering (Engelman and Hartigan 1983). Nine clusters were identified. Figure 6.4 shows the statistical distance between and within clusters and how the variables are associated. Two points are pertinent here: firstly, quadrats falling into the same cluster are not necessarily adjacent, illustrating once again the variability of the site and secondly, shallow soils tend to have a higher organic matter content than soils of about 50 cm depth. This may compensate for what would otherwise be a soil with a low water-holding capacity and explain why the percentages of plant cover and amount of herbage are both negatively related to soil depth.

The analysis reveals some interesting relationships confirmed by the correlation matrix (Table 6.9). For example, in 1987/88 the correlation between plant density of _T. stellatum_ and available phosphorus and between plant density of _T. tomentosum_ and the quantity of stones is significant. Stoniness appears to influence species distribution by creating a micro-environment in which evaporation is reduced and seedlings are protected from the wind and grazing. The latter is known to encourage _T. tomentosum_. Contrary to the high rainfall year 1987/88, there was a negative relationship between stoniness and _T. tomentosum_ in the dry and cold season of 1988/89. Possibly the beneficial effects of stones are offset during periods of frost because the stones in the experimental site have a light colour and so absorb less heat.

The principal factor analysis (Frane _et al_. 1983) of the environmental data in the 2 years identified two factors which explained 42% and 28% of total variance in 1987/88 and 45% and 19% in 1988/89, respectively. In both years, Factor

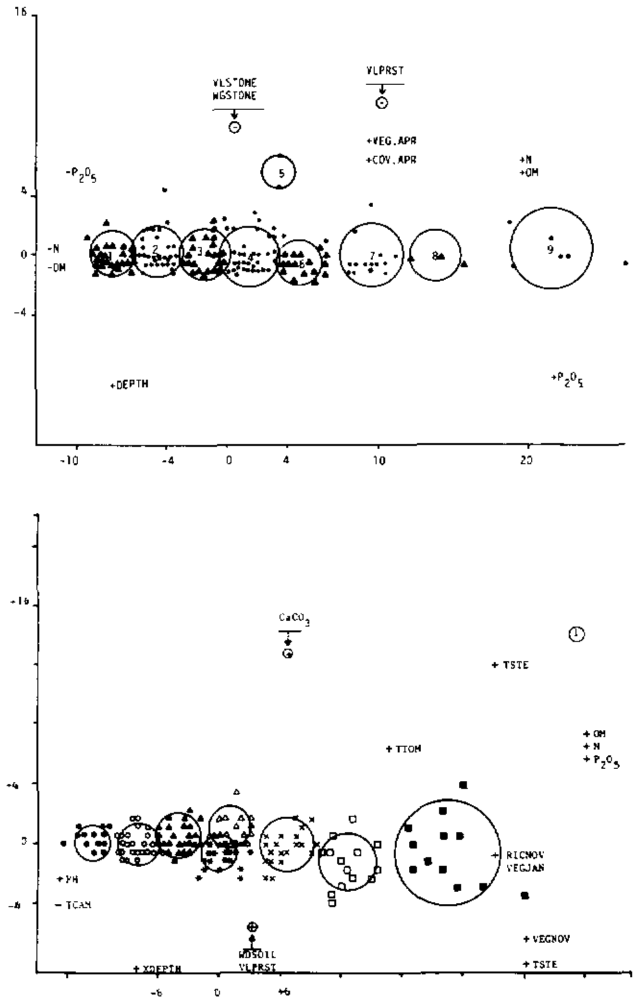

Figure 6.4. The statistical distance between nine clusters formed by K-means clustering in 1987/88 (a) and in 1988/89 (b). The position of the parameters (soil depth=DEPTH, available P=P_2O_5, nitrogen=N, organic matter=OM, volume of stone=VLSTONE, volume of stone in percent of soil+stone volume=VLPRST, total vegetation in April=VEG.APR, percent of cover in April=COV.APR, calcium carbonate=$CaCO_3$, pH) relative to the clusters gives an indication of which cluster has the highest value of any parameter (for example cluster 1 in 1987/88 has the highest values for phosphate and depth of soil).

Table 6.9. Correlation matrix between the most common genera and species, measured as plant density, and environmental variables (P=0.05).

Genus/ species (year)	Soil depth	Vol. of stone	Soil density	Org. matter	Olsen P	Total N	$CaCO_3$	pH
Avena sp. (88)	0.26	ns	0.24	ns	ns	ns	–[1]	–[1]
Avena sp. (89)	0.52	ns	–0.20	ns	ns	ns	ns	ns
Bromus sp. (88)	–0.22	0.23	ns	0.23	0.19	0.23	–	–[1]
Bromus sp. (89)	–0.29	0.22	ns	0.20	0.20	0.20	ns	ns
T. stellatum (88)	–0.22	ns	–0.25	0.68	0.49	0.69	–[1]	–[1]
T. stellatum (89)	–0.31	ns	–0.20	0.61	0.59	0.63	–0.19	–0.61
T. tomentosum (88)	–0.19	0.22	ns	ns	ns	ns	–[1]	–[1]
T. tomentosum (89)	–0.23	–0.18	0.27	0.24	0.21	0.24	ns	–0.31
T. campestre (88)	ns	ns	0.21	–0.19	–0.29	–0.19	–[1]	–[1]
T. campestre (89)	–0.20	0.20	ns	–0.23	–0.27	–0.21	ns	–0.21

[1]Not measured.

1 is positively associated with the soil content of organic matter, nitrogen, and phosphorus, and negatively with soil depth and in 1989 also with pH (Figure 6.5). In both years Factor 2 is associated positively with stoniness (VLPRST and WESTONE, Figure 6.5) and in 1989 negatively associated with $CaCO_3$.

Figure 6.6 shows how the quadrats for each of the four plots are distributed in relation to Factors 1 and 2 of the principal factor analysis. Comparing the 1987/88 data from plots 1 and 2, which both received phosphorus, shows that plot 2 (the high stocking rate) has higher soil fertility and is stonier than plot 1. Plots 7 and 8 are similar, although the low stocking rate plot (plot 8) appears to be a little more fertile. There was a similar distribution in 1988/89. The $CaCO_3$ content of the soil was higher in plots 1 and 7 (Figure 6.6b).

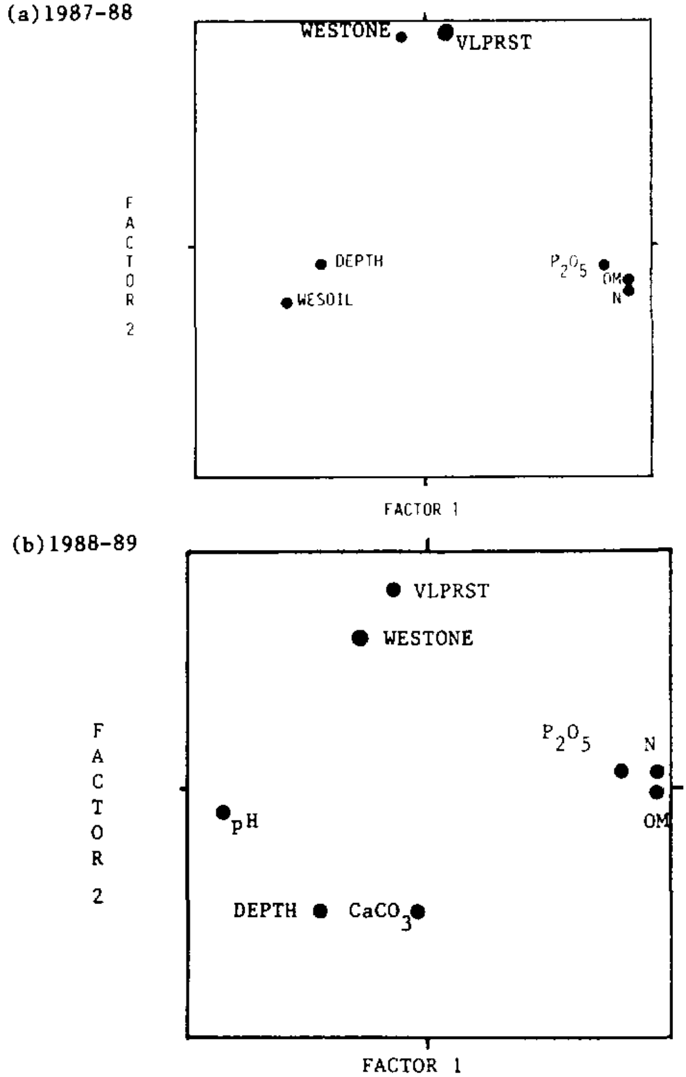

Figure 6.5. Distribution of the seven parameters used in the principal factor analysis of environmental variables relative to factor 1 and factor 2 (soil depth=DEPTH, available p=P_2O_5, nitrogen=N, organic matter=OM, volume of stone in percent of soil+stone volume=VLPRST, calcium carbonate=$CaCO_3$, pH, weight of soil=WESOIL, weight of stone=WESTONE).

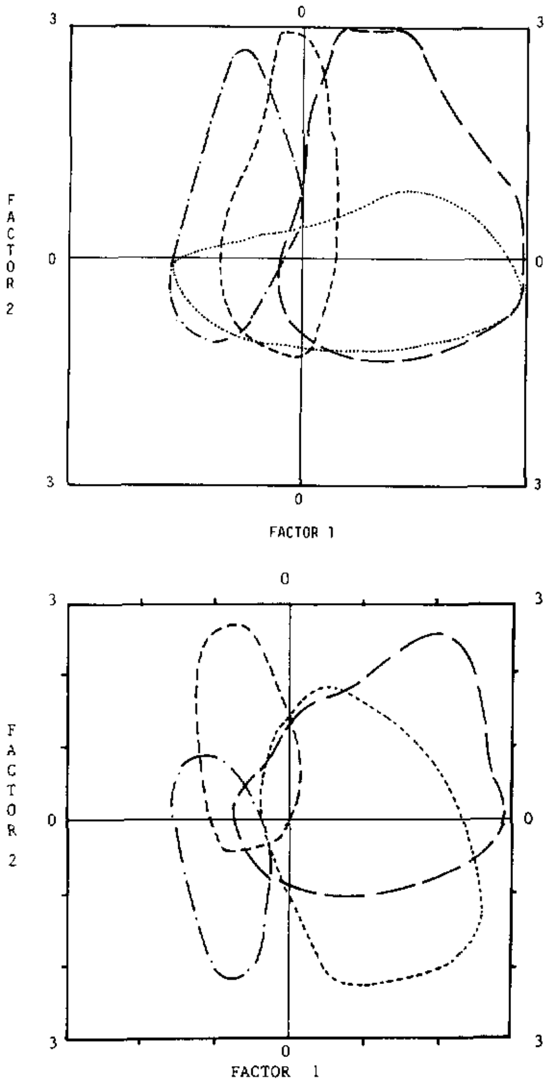

Figure 6.6. Distribution of quadrats in plot 1 (enclosed by dotted lines), plot 2 (enclosed by long dashes), plot 8 (enclosed by small dashes), and plot 7 (enclosed by alternate dots and dashes) relative to factors 1 and 2 of a factor analysis of seven environmental variables principal (see text).

Even after two seasons the results already show how some plant species react to their environment and illustrate the extreme variability of these grassland ecosystems.

Experiment 2. This experiment examines the effect of four treatments - stone cover, grazing pressure, plant density, and phosphate application - on the ecology of Mediterranean grasses and legumes. A short description of the treatments follows.

Stone-cover: the results from 1987/88, discussed in the previous section, suggest that the presence of stones is positively correlated with some legume species, including _T. tomentosum_.

Grazing pressure: grazing pressure, mediated through defoliation by large and small herbivores, affects the productivity and composition of grassland. Its impact on botanical composition reflects differences in growth habit and palatability between plant species. In general, grazing increases the annual legume content of Mediterranean grasslands although the content of tall legumes may be reduced.

Plant density: the selection of areas with low and high initial vegetation levels was used to assess the importance of the initial conditions and interactions with the other treatments.

Phosphate application: phosphorus fertilizer increases the yields of total biomass and the percentage ground cover and increases the content of legume species (ICARDA 1988).

In October 1988, 16 areas were chosen in the 0 and 25 kg P_2O_5/ha and low and high stocking rate treatments discussed in the previous experiment. These were the main plots. Each of these areas was a sub-plot (50 x 50 cm) in a split-plot factorial experiment with the following sub-treatments:

1) initial stone, 2) initial vegetation, 3) final stone, and 4) grazing protection. Each of the four sub-treatments had two levels: **initial stone** (IS), with either high (ISH) or low (ISL) initial stone representing over 80% or less than 20% of the surface covered by stone, respectively; **initial vegetation** (IV), with either low (IVL) or high (IVH) initial vegetation. After ranking each sub-plot from 1 to 9, low initial vegetation scored around 2 and high initial vegetation scored around 8. In the **final stone** (FS) sub-treatment the ISL sub-plots either had stones added (FSH) or they were left unchanged (UL) and to ISH sub-plots stones were either removed (FSL) or they were left unchanged (UH). For **grazing protection** the two sub-treatments were grazed (G), the sub-plot being left open and grazed at the same stocking rate as the main plot, or protected (P) by 60 x 60 x 40 cm cages. (Originally it was intended to cut the protected sub-plots infrequently, but this was not necessary due to the low rainfall.) For each sub-plot the same characteristics were recorded as in the previous experiment.

At the March sampling, phosphorus application had increased ground cover from 50.2 to 64.4% with the legumes showing the greatest response. But the response was not the same for all species. Indeed, Colopodium residues were 16 kg/ha and 8 kg/ha at the low and the high phosphate levels, respectively.

Several significant interactions were observed between treatments. For example, initial vegetation cover at the low level of phosphorus was not the factor limiting the flower number of T. stellatum (Table 6.10). But at a high level of initial vegetation, associated with more competition between plants, phosphorus application increased the number of flowers more than with a low level of initial vegetation.

For <u>Avena</u> spp., which are grasses, the situation is different. They produced a large amount of biomass, as indicated by the yield of residue, when initial vegetation cover was high and phosphate application low (Table 6.10). Phosphate application did not increase production of <u>Avena</u> spp. but the initial vegetation had a big effect in the first season of the measurements. Application of 25 kg P_2O_5/ha advanced flowering from 5 April 1989 to 27 March.

Table 6.10. Number of <u>T. stellatum</u> flowers and <u>Avena</u> residue yield at two levels of initial vegetation and phosphorus (kg/ha).

	Initial vegetation	Phosphorus level	
		P_0	P_{25}
<u>T. stellatum</u> (flower no./m^2)	Low	21.9^b	44.1^b
	High	19.8^b	241.4^a
<u>Avena</u> residue yield (g/m^2)	Low	7.2^b	11.2^b
	High	38.8^a	14.4^a

In each group of four values, means followed by different letters are statistically different ($P<0.05$).

Because the growing season in 1988/89 was dry and cold the plants were unable to spread to the newly exposed soil in the treatment where 50% of the soil surface that had had a high initial stone cover (ISH) was cleared of stones. Hence, ground cover was greater for the soil with a low initial stone cover (Table 6.11).

Table 6.11. Percent of soil free for colonization in early February and percentage of ground cover in March, at two levels of initial stone.

	Initial stone		LSD
	Low	High	
Soil free for colonization in early February (%)	40.6	51.6	10.5 (P=0.01)
Ground cover in March (%)	63.8	50.8	8.4 (P=0.05)

Changing the level of stone cover was generally detrimental to individual species, including T. tomentosum which is usually found mainly in stony areas (see Exp. 1). Removing stones, which can disturb the soil surface (as happens during cultivation), decreases vegetation establishment. This effect is another of the difficulties in improving productivity of grasslands. The real effects of moving stones will be clearer in the future.

Generally, the presence of stones encouraged pasture growth, a finding that agrees with the hypothesis mentioned previously. In fact, the amount of vegetation tended to be associated with stoniness whether the final stone cover was initially high (UH) or was increased to a high level by adding stones (FSH). Moreover, within species there was better flower production where the level of stone was unchanged, whether high (UH) or low (UL) (Table 6.12). This positive effect on flower production is perhaps more pronounced in a dry year such as 1988/89 when the effect of decreasing the total area of soil available for colonization by plants is less important than the effect of stones in protecting the plants from grazing.

Table 6.12. Numbers of flowers (per m^2) of *T. tomentosum* and *T. stellatum* at two levels of final stone cover.

	Final stone cover		LSD (P=0.05)
	Low UH	High FSH	
T. tomentosum	17.9	8.1	8.5
T. stellatum	146.4	32.7	16.2

In 1988/89 stone cover was beneficial, especially under the high stocking rate. This was true even for *Avena* spp. which are usually poorly adapted to stony fields. For these species the interaction between initial stone and stocking rate (Table 6.13) shows that if the grazing pressure is severe the presence of stones can be advantageous since they protect the plants from grazing. Conversely, if the stocking rate is low, *Avena* spp. are more common where the stone cover is less.

Table 6.13. Number of *Avena* plants at two levels of initial stone and two stocking rates.

	Initial stone	Stocking rate: Low	Stocking rate: High
Avena plants (no./m^2)	Low	178.8^{a}	72.7^{ab}
	High	32.7^{b}	119.9^{a}

Means followed by different letters are significantly different ($P<0.05$).

Not surprisingly, grazing protection increased the amount of vegetation and the plant residue and seed yields (Table 6.14). However, since this was the first year of protection there were no changes in plant density. The flowering time of Bromus spp. was delayed by grazing protection. The interaction between stocking rate and grazing protection showed that the latter has a greater effect on the amount of vegetation and ground cover at the high than at the low stocking rate (Table 6.15). This is illustrated by the flower numbers of T. tomentosum. Furthermore, grazing at the low stocking rate advanced flowering of T. tomentosum whereas at the high stocking rate the opposite was true.

Table 6.14. Amount of vegetation (score 1-9), plant residue and seed yields, and Bromus flowering time at two levels of grazing protection.

		Grazing protection		
		Low	High	LSD
Amount of vegetation	Late February	3.4	4.4	0.8[2]
	March	4.1	5.1	0.8[2]
Plant residue yield (g/m^2)	Low initial stone	7.3	14.7	6.6[3]
	High initial stone	7.9	18.1	8.0[3]
Seed yield (g/m^2)		0.7	1.8	1.0[3]
Bromus spp. flowering time[1]		23.0	30.1	6.3[2]

[1]Number of days from 1.3.89. [2]$P = 0.05$ [3]$P = 0.01$

To improve communal land, grazing pressure should be eased for several years, at least during seed set. This allows recovery of the seed bank, an increase in the amount of vegetation (Table 6.15), and a decrease in plant residue yields (Table 6.16). This would result in an improvement of the pasture quality.

Table 6.15. Amount of vegetation (score 1-9) in early and late February, ground cover in March, number of flowers of *T. tomentosum*, and flowering time for different combinations of grazing protection and stocking rate.

		Grazing protection	Stocking rate Low	High
Amount of vegetation	Early Feb.	Grazed	4.4^{ab}	3.5^{b}
		Protected	4.1^{ab}	5.1^{a}
Amount of vegetation	Late Feb.	Grazed	4.0^{a}	2.9^{b}
		Protected	3.9^{ab}	4.9^{a}
Ground cover in March (%)		Grazed	53.8^{ab}	44.0^{b}
		Protected	45.0^{ab}	60.6^{b}
T. tomentosum (number/m^2)	Flower numbers	Grazed	19.8^{a}	6.0^{b}
		Protected	14.7^{ab}	17.9^{a}
T. tomentosum	Flowering time[1]	Grazed	30.2^{b}	35.0^{a}
		Protected	36.5^{a}	31.3^{ab}

In each group of four values, means followed by different letters are statistically different (P<0.05).

[1]Number of days from 1.3.89.

Table 6.16. Plant residue yields for combinations of initial stone and stocking rate.

	Initial stone	Stocking rate Low	High
Weed residue yields (g/m^2)	Low	4.8^{c}	11.2^{a}
	High	6.0^{bc}	8.4^{ab}

Means followed by different letters are statistically different (P<0.05).

Table 6.17. Amount of vegetation (score 1-9) and percent of soil free for colonization on three sampling dates at two levels of initial vegetation cover.

	Initial vegetation	Early February	Late February	March
Amount of vegetation	Low	2.5	2.3	2.8
	High	6.5	6.1	6.8
	LSD (P=0.01)	1.4	1.4	1.6
Soil free for colonization (%)	Low	70.8	48.4	36.5
	High	21.3	61.0	78.1
	LSD (P=0.01)	12.0	15.9	15.0

The level of initial vegetation markedly affected the amount of vegetation produced during the first growing season (Table 6.17). Conversely, seed production (not shown in Table 6.17) was highest where the level of initial vegetation was low (1628 seeds/m^2 at IVH versus 6872 seeds/m^2 at IVL), possibly because of competition for moisture. This may be a mechanism for restoring the seed bank which serves as a buffer to compensate for yearly variations in climate, and guarantees that some plants will be present in pastures even in the driest and coldest years. - **M.A. Pagnotta, PhD student, University of Reading; P.S. Cocks, ICARDA; R.W. Snaydon, University of Reading, UK**

Acknowledgement

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Chapter 7

PRODUCTIVITY OF SHEEP AND THE INFLUENCE OF HELMINTH PARASITES
(Preschedule L33)

From 1985 to 1987 valuable knowledge was gained concerning the main genera of lungworms and gastrointestinal parasites infecting sheep at ICARDA's main station, Tel Hadya (ICARDA 1986). These parasites have a marked seasonal pattern of activity (Thomson and Orita 1988) which maximizes the chances that the parasites, after passing through the larval stages, reinfect the host and thereby complete their life cycle.

What still remains an important question is whether the levels of helminth infection encountered are a threat to productivity. This question arises because sheep seldom show clinical signs of helminthiasis. Low levels might be expected in semi-arid areas where small ruminants graze sparse pastures at low grazing pressures, thus reducing the risks of transmission of the parasites. The research reported here shows that subclinical infection was responsible for reduced fertility and increased mortality of ewes.

The 4-year project started in May 1987 and initial results are reported elsewhere (Rink 1989). The second year of the project involved monthly monitoring of 10 flocks in Aleppo Province, northwest Syria. In each flock, about 20 ewes were treated with fenbendazole (Panacur) and another 20 were given a placebo. Sheep were treated in autumn to remove adult helminths which become active at that time of the year, and in late spring so that ewes would start the dry, hot summer period with low parasite loads. On each occasion ewes were treated twice, with 20 days between treatments. Every month, except during November - February, ewes were weighed and their body condition scores recorded by manually assessing the amount of body tissue covering the transverse processes of the lumbar vertebrae. Farmers were interviewed every month to gain detailed information on feeding and management practices and changes to the flock inventory. Eggs and larvae of the common helminth species were extracted from faecal samples collected every month <u>per rectum</u> and counted using standard procedures. Results were statistically analysed using Chi-squared tests.

Ewe survival and mortality. Treatment resulted in a substantial reduction in ewe mortality ($P<0.05$) and slaughterings ($P>0.05$) and together these two changes improved ewe survivability by 8.8% ($P<0.05$, Table 7.1). Ewe mortality in all age categories, except those over 8 years, was lower for treated than for control ewes ($P<0.05$) and only in 1 flock out of the 10 in the sample was mortality of treated ewes higher than in controls. It was not possible to conduct autopsies on dead ewes because of the low frequency of visits so the causes of death are unknown. Mortality levels could not be attributed to management levels on the different farms.

It is surprising that deworming of ewes had such a clear effect on mortality considering that the parasite burden was subclinical. This indicates that control of sub-clinical infections should be part of a management package aiming to improve sheep productivity. It is also important to prevent such effects from influencing the results of research on improved forage- and pasture-based feeding systems.

Table 7.1. Inventory of control and treated ewes expressed as percentages (from 1 June 1988 to 31 May 1989, n = 455).

Category	Control	Treated
Surviving	82.7	90.0
Slaughtered	4.9	2.5
Sales	0.5	2.0
Mortality	10.3	4.5
Unknown	2.6	1.0

Body condition score. Body condition score is a valuable tool for assessing the health and nutritional status of a ewe since it is largely independent of body frame size (Meat and Livestock Commission 1981). This is not the case with body mass which can be a misleading term since a small framed ewe with a low mass can be in good condition (fat) and conversely a large framed ewe with a large mass can be in poor condition (thin).

It was expected that treatment would improve both ewe mass and body condition score and, since both positively affect fertility (Thomson and Bahhady 1988), treatment should have also benefited fertility. There was an effect on fertility. Increasing body condition score, averaged over the mating season from June to August, was associated with both ewe fertility ($P>0.05$) and survival ($P<0.05$, Table 7.2). These results encourage us to investigate more closely the use of body condition scoring as a simple method to predict ewe performance. It has the advantage of being easier to measure than ewe mass since it requires no equipment, staff appear to learn the technique quickly, and repeatability between assessors is good.

Table 7.2. Ewe body condition score during the mating season and ewe fertility[1] and survival, expressed as percentages.

Body condition score	Ewe fertility	Ewe survival
1.0 (thin)	80.0	80.0
1.5	81.0	70.0
2.0	80.0	87.0
2.5	83.0	88.0
3.0	98.0	97.0
3.5 (fat)	100.0	94.0

[1]Ewes lambing per 100 ewes put to ram.

Ewe fertility. An effect of anthelmintic treatment on ewe fertility has been shown in Morocco (Dakkak and Ouhelli 1988). In our research, treatment also enhanced ewe fertility, defined as ewes lambing per 100 ewes put to the ram, but the 80 - 85% improvement was not statistically significant ($P>0.05$). However, this improvement would markedly increase flock profits. It should be possible in the coming year to verify the effect of parasite burdens on ewe fertility, especially since a very dry cropping season (1988/89) followed a very wet season (1987/88) which should amplify differences in sheep performance.

Seasonal patterns in parasite burdens. The gastrointestinal egg counts and lungworm larval counts followed the classic seasonal patterns seen in farm animals (Figure 7.1). High counts occur from October to April when temperatures are low and humidity is high, whereas low counts are seen during the hot, dry summer when the helminths pass into the resting stage (hypobiosis). Eggs and larvae were being passed again in treated ewes soon after treatment but counts did not reach those of control ewes. This reappearance of eggs and larvae

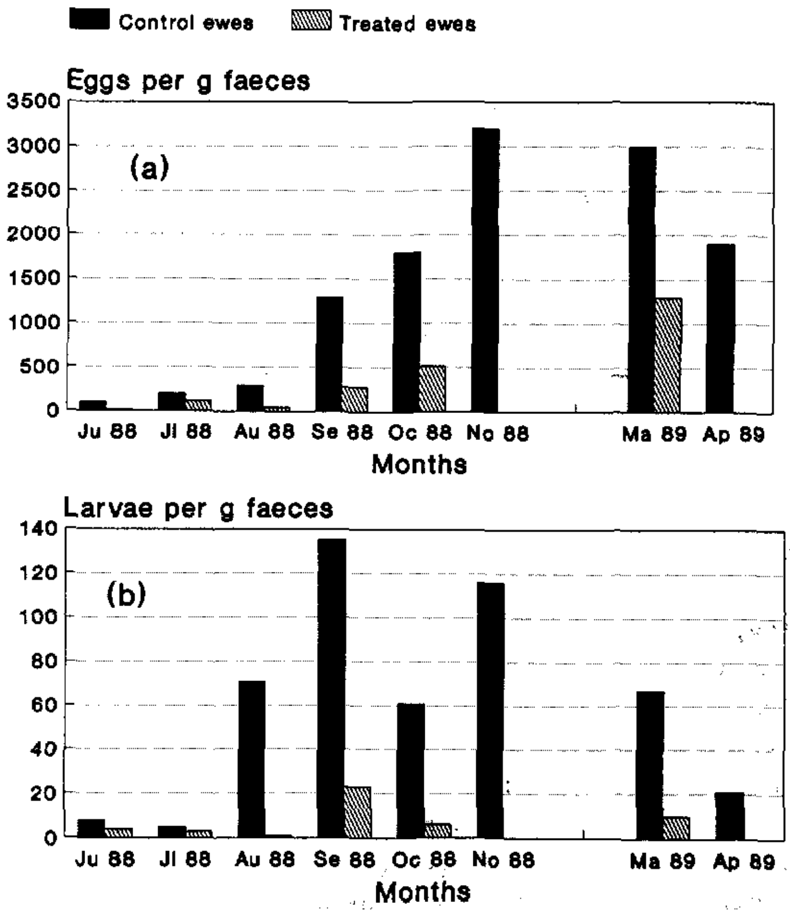

Figure 7.1. Effects of treating ewes with fenbendazole on the number of (a) eggs of gastro-intestinal helminths and (b) larvae of lungworms, on different sampling dates. (Sheep were treated prior to sampling in June 1988, November 1988, and April 1989. No sampling took place from December to February when ewes were pregnant or lactating.)

in treated ewes was related to reinfection and the ability of some adult helminths to survive treatment. Two strategically timed treatments in autumn and spring were therefore quite sufficient to keep helminth burdens at a low level.

Type of helminth parasites. The majority of the lungworm larvae were protostrongylids (Cystocaulus and Muellerius spp.) which need snails as intermediate hosts to complete their life cycle. These helminths dwell in the lung parenchyma tissue. Dictyocaulus filaria, which lives free in the lung bronchi and bronchioles, did not exceed 10% of the total larval count and was usually much less.

In June 1987, five untreated ewes from two flocks in the sample were slaughtered to identify and count adult parasites in the abomasum, in the small and large intestine (Table 7.3), and in the lungs (Table 7.4). Only helminths of the genera Ostertagia/Marshallagia were present in the abomasum. Subsequent culture of faecal samples from the sample farms indicated that 99% of the abomasal worms were from these two genera. This is significant in the epidemiology of gastrointestinal infections. Ostertagia species can inhibit their own growth and development in the host (type II ostertagiasis), while Marshallagia species are particularly suited for survival in hot, dry climates. These two species will be difficult to control and are highly infective under environmentally favourable conditions.

Death due to parasitic infection was not confirmed although it would appear to be possible if conditions are appropriate. For example, in one ewe the number of immature larvae in the abomasum, all of which were Ostertagia species, suggested release of inhibited larvae which could be potentially life-threatening. Studies on the impact of these genera on sheep productivity and their epidemiology should be part of an overall strategy to improve flock husbandry.

Table 7.3. Total counts of adult parasites and immature larvae in the abomasum and the small and large intestines at autopsy (means and standard deviation, n=5).

Species	Abomasum[1]	Small intestine[2]	Large intestine[2]
Adult parasites			
Marshallagia spp.	1205±1185.4	--	--
Ostertagia circumcincta	617± 433.0	--	--
Nematodirus fillicolis	--	150± 83.7	--
Trichostrongylus capricola	--	192±276.3	--
Trichostrongylus vitrinus	--	60±134.2	--
Trichuris ovis	--	--	5.8±5.11
Immature larvae	5162±8553.6	184±215.2	--

[1]Based on washings, scrapings, and acid/pepsin digestion.
[2]Based on washings and scrapings.

Table 7.4. Total counts (per sheep) of adult parasites and immature larvae in the lungs at autopsy (mean and standard deviation (SD), n = 5).

	Dict.[1]	Cyst.[2]	Muel.[3]
Adult parasites	7±10.4	2± 3.2	0± 0.0
Immature larvae	8±14.7	188±250.9	8±11.1

[1]Dict. = *Dictyocaulus* spp.
[2]Cyst. = *Cystocaulus* spp.
[3]Muel. = *Muellerius* spp.

Counting numbers of adult protostrongylid lungworms is difficult because they live embedded in the lung tissue. Larvae are often found in faeces but at slaughter the adult females are not identifiable in lung tissue. Also, the number of larvae shed is not directly proportional to the number of females or males present. Consequently, the true effect of the parasites is difficult to judge. From Moroccan studies (Dakkak and Ouhelli 1988) it appears that the major damage to sheep by parasites is due to protostrongylid lungworms and not gastrointestinal worms. This point remains unclear in Syrian sheep.

Protostrongylid lungworms will be difficult to control due to the wide distribution of their intermediate hosts. Their influence on productivity will include not only their direct effect, but indirect effects making sheep more susceptible to secondary, opportunistic respiratory infections following verminous pneumonia.

Flock husbandry also affects the genera of parasites found in the flocks. For example, Muellerius species are the dominant lungworms in Al Tah (Idlib Province, Syria) village flocks, while Cystocaulus species predominate at Al Bab (Aleppo Province, Syria). Overall, the standard of management of the flocks at Al Tah is lower than at Al Bab. In addition, sheep at Al Tah are penned indoors at night in poorly ventilated barns, whereas at Al Bab they are kept in open sheep folds. Poor management in Al Tah flocks appears to be a strong determinant of the epidemiology of infection.

Introduction of deworming protocols in flocks can be a source of problems. The presence of adult worms in the abomasum inhibits the development of the mucosa-dwelling larvae. Deworming may lead to the release of L4 larvae and if the parasite burden is primarily due to Ostertagia species, an overwhelming ostertagiasis results.

Selection for genetic resistance to parasites. As farm management gets better, improvement of local breeds will become a key step towards higher productivity. Sheep will be selected for efficiency in utilizing feeds, measured as increased weight gains, survivability, and lambing rate. Genetic resistance to parasitism should therefore also be investigated by screening flocks for sheep with natural resistance to helminth infections. Once several rams and ewes had been identified, they would be challenged with artificial infections to confirm the suspected resistance. If resistance did appear to exist, then rams and ewes would be selected and used to develop a nucleus flock. Research on this subject is already well advanced in Australia although the number of species being investigated is very limited (Albers et al. 1987) and one of them, Haemonchus, does not appear to be present in Syrian sheep.

Conclusion

Previous studies in Morocco demonstrated decreased ewe mortality and increased fertility in dewormed research-station flocks. The present study shows comparable results under Syrian farm conditions. The results indicate that sheep in semi-arid areas can carry subclinical infections of helminth parasites that reduce productivity. - **E.F. Thomson; G. Orita, JICA consultant; F.A. Bahhady; C. Rhodes, consultant.**

Acknowledgement

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Chapter 8

TRAINING ACTIVITIES AND WORKSHOPS

The Pasture, Forage and Livestock Program continued to pursue its policy of strengthening National Research Programs through intensive training activities. Our training strategy aims to:

- enhance the research capacity of NARS in the field of pasture, forage, and livestock improvement as defined by the needs of national programs in West Asia and North Africa,
- build a viable network of agricultural researchers who work closely with ICARDA and each other on pasture, forage, and livestock research,
- meet the needs of selected individuals in national programs who require training in specific problem areas of research relevant to the Program's research activities, and
- assist in academic training of graduate students from the region at universities in WANA by providing opportunities for field-oriented thesis research to be conducted with the assistance and supervision of senior scientists in the Program.

This strategy was followed by offering diverse training opportunities to participants from different countries (Table 8.1). In 1988/89 a total of 32 participants received training in various disciplines.

Residential training course

The residential course was held from 1 March to 30 June 1989, at Tel Hadya with eight trainees from seven countries (China, Pakistan, Egypt, Somalia, Sudan, Syria, and Turkey) (Table 8.2). The aim of the course was to provide middle-level research personnel from national programs with the knowledge and skills necessary to conduct field research into improving the production and utilization of feeds for sheep.

Table 8.1. Summary of training activities, 1988/89.

Type of training	Topics	No. of participants	No. of countries represented
Training courses at headquarters	Residential training course	8	7
	Short course on microbiology of pasture and forage legumes	9	7
Individual non-degree, short-term courses (less than 1 month)	Germplasm evaluation of forage legumes	1	1
	Disease and nematode screening	1	1
	Quality assessments of forage	1	1
	Grassland improvement	1	1
Individual non-degree, long-term courses (4-9 months)	Sheep nutrition	1	1
	Forage/livestock on-farm trials	1	1
	Grazing medics by goats	1	1
	Lungworm of Awassi sheep	1	1
Individual degree training	Forage legume breeding (MS)	2	1
	Marginal land improvement (PhD)	2	1
	Forage pea palatability (PhD)	1	1
Visiting scientists	Forage legume breeding	1	1
	Biological N-fixation	1	1
	Total	32	27

The period of training coincided with the period of most rapid crop growth and therefore peak field activities. The syllabus focused on field and laboratory techniques for annual forage breeding, agronomy and utilization of forages, the ley farming system, biological nitrogen fixation, improving livestock nutrition, and grazing management. Every trainee was closely associated with a senior scientist and, depending on their particular interest or national program requirements, assumed responsibility for their own project, becoming an integral part of the research team as a whole. This gave the trainees experience in planning, conducting, analyzing, and reporting experimental work. The project topics used in 1988/89 are shown in Table 8.2. Field training was supported by a series of lectures and discussions dealing with practical and theoretical subjects.

At the end of the course trainees selected germplasm suitable for their own countries and they were given seeds for testing. Continued contact with the trainees will be maintained through visits and correspondence.

In the future the residential training course will be replaced with shorter courses on specific subjects and more senior participants will be invited. The first such course on fallow replacement will be conducted jointly with the Farm Resource Management Program starting in March 1990.

Short-term training course

This activity provides concise problem-oriented training on specific aspects of the Program's activities. It comprises field and laboratory work, lectures, and discussions.

Table 8.2. Projects assigned to participants in the 1988/89 residential course.

Name	Country	Title of the project	Supervisor
Zhao Lai Xu	China	Selection criteria of annual forage legumes	A.A. El Moneim
Imtiaz Ahmed	Pakistan	Evaluation of woollypod vetch	A.A. El Moneim
Mohamed Ibrahim	Egypt	Evaluation of narbon vetch	A.A. El Moneim
Mohamed Nahas	Syria	Effect of seed rate and row spacing on the productivity of vetches and chicklings	A.A. El Moneim
Mohamed Majed	Syria	Monitoring pasture productivity in marginal land following application of phosphorus	A.E. Osman
Abd El-Aziz Abd El-Gader	Sudan	The use of antibiotic resistant mutants for identification of rhizobia	L.A. Materon
Zafer Ulutaz	Turkey	Fattening lambs on different protein sources	F.A. Bahhady
Abdi Yassin	Somalia	Fattening lambs on different protein sources	F.A. Bahhady

From 19 to 31 March 1989, a short training course was conducted at headquarters on "Microbiology of Pastures and Forage Legumes". Nine participants from seven countries (Tunisia, Algeria, Yemen Arab Republic, Jordan, Syria, Pakistan, and Sudan) were trained on various aspects of legume microbiology, including theoretical and practical aspects of nitrogen fixation by pasture legumes, selection of strains, and production of inoculants. The objectives of this course were to provide participants with basic and practical knowledge on manipulation of rhizobia from isolation to inoculation of seed and to provide information on methodologies commonly used in biological nitrogen fixation research.

Individual non-degree short-term training

This kind of training comprises field and laboratory work on a specific discipline, as requested by national programs, over a period not exceeding 4 weeks. In April 1989, two candidates from Syria were trained for 2 weeks, one on screening methodologies for diseases and nematodes of pasture and forage legumes and one on quality assessment of forages. One trainee from Sudan was trained on marginal land improvement for 3 weeks starting in May.

Individual non-degree long-term training

This type of highly specialized training involves junior scientists from countries of WANA. The participants are involved in research of mutual interest to ICARDA and national programs. In 1989, four trainees from Syria were based at the Program's sheep unit and conducted projects on the following specific topics:

1. Feeding Awassi sheep on marginal lands (Preschedule ML2).
2. Forage and livestock on-farm trials (Preschedule L34).
3. Effects of lungworms on lamb productivity (Preschedule L88).
4. Grazing medics by goats.

The duration of training varied from 4 to 9 months and each trainee was attached to an ongoing project. One benefit of this long-term training is that trainees get direct experience of project management and take responsibility for day to day decisions. The project mentioned in Chapter 4 (see pages 91-95) is managed exclusively by former long-term trainees.

Graduate degree training

The Program works jointly with universities to select and supervise graduate students. This cooperation establishes links between our scientists and those at universities in WANA and outside and, at the same time, provides an excellent working environment for graduate students. The Program has provided four places for graduate degree training in the past 2 years. The number will increase with another three students in 1990.

Visiting scientists

The Program offers opportunities to experienced scientists from national programs to conduct research on topics of mutual interest. In 1989 there were two visiting scientists. Dr Mujgan Engin from Cukurova University, Adana, Turkey conducted field experiments in collaboration with Dr Luis Materon for 6 weeks. She tested the effectiveness of medic rhizobial strains suitable for pasture legumes growing in the Anatolian region of Turkey. Dr Ali Nawar, from Alexandria University, Egypt, conducted research on the selection criteria for forage legumes. He selected materials which might be suited to the coastal zone of northern Egypt. He remained at Tel Hadya for 4 months. - **A.A. Moneim**

Workshops

In June 1989 a successful workshop was held in Perugia, Italy, on "Introducing the Ley Farming System in the Mediterranean Region". The workshop, generously supported by the Italian Government and IBPGR, was attended by participants from nine WANA countries, five advanced research institutes, and several international institutions (FAO, IBPGR, GTZ, MIAC, SAGRIC, CIAT).

The objectives of the workshop were to:

- discuss research and progress of the ley farming system in the WANA region and elsewhere,
- formulate a strategy to implement and develop annual medic-cereal rotation systems in the Mediterranean region, and
- define guidelines for the establishment of a network to collect and conserve genetic resources of annual <u>Medicago</u>.

The following recommendations were formulated at the conclusion of the workshop.

1. Specific target areas for ley farming should be developed. In doing so account should be taken of climate and soil, farm size, and existing farming systems. While further research is needed, the workshop considered that ley farming is likely to be most useful where farmers own livestock, use weedy fallows, and cultivate shallow (less than 1 m deep) soils in lower (250-350 mm) rainfall areas.

2. The workshop highlighted the fact that good management is the key to introducing ley farming and that management systems based on Australian experience are unlikely to succeed. It recommended that appropriate management be developed in close consultation with farmers and that the concepts of farming systems research and farmer participatory research be used to the fullest extent possible.

3. The rate of population increase in WANA and its effect on traditional land use should be considered in all policy, research, and extension issues. The workshop recognized that the population will more than treble by the year 2030 (when it should plateau at 1.5 billion) and this will have an enormous impact on land use. It recommended that governments influence these changes by considering land tenure, grazing rights, and pricing policies.

4. It is helpful to consider ley farming as an improved weedy fallow system. Emphasis on improving existing weedy fallows should include use of fertilizer and improved grazing management.

5. The workshop participants expressed concern about the effect of imminent changes in climate and recommended that future research on the sustainability of ley farming take this factor into account.

6. The workshop recommended that training be strengthened in six areas:

- networks should be established on a regional (WANA) and sub-regional (e.g. North Africa) basis, where scientists can share experiences and co-ordinate their research;
- ICARDA should widen its existing training to include

the training of extension agents in extension methodology and ley farming practices;
- ICARDA and FAO should continue and strengthen training in seed production;
- specialists in ley farming should be trained to provide back-up for extension agents;
- future research training should focus on higher level training, possibly leading to higher degrees;
- a training manual should be developed.

7. Extension: the workshop supported the concept that extension should be closely linked with research and that both should involve farmers. It strongly recommended that extension agents receive more field support and drew attention to the training and visiting methodology of the World Bank.

8. In developing ley farming, scientists should look beyond annual medics and subterranean clover, though it is recognized that, in the short term at least, these species are likely to be the most useful. Greater grazing tolerance in pasture legumes is needed.

9. Local ecotypes of pasture legumes should be multiplied. The workshop considered that the maintenance of seed purity is not a high priority and recommended that the use of mixtures of several species should be used in commercial sowings.

10. The workshop recognized that availability of seeds is a major constraint. However, it recommended that more appropriate seed harvesting technologies be developed to replace the existing, expensive suction machine.

11. Economic evaluation of ley farming is badly needed and the workshop recommended that this should be a high priority for research.

12. The workshop considered that, not withstanding some of the outstanding problems, work on ley farming should proceed to an extension phase. It recommended that a high priority task of the networks should be to seek funding for a co-ordinated training and extension project to take ley farming to farmers. In doing so, full account should be taken of experience gained in the earlier work. - **P.S. Cocks; L.A. Materon; M. Falcinelli, University of Perugia.**

APPENDIXES

Appendix 1. Publications.

Papers in refereed journals

Abd El Moneim, A.M., Cocks, P.S. and Mawlawi, B. Genotype-environment interactions and stability analysis for herbage and seed yields of forage peas under rainfed conditions. Plant Breeding. In press.

Abd El Moneim, A.M., Khair, M.A. and Cocks, P.S. Growth analysis, herbage and seed yield of certain forage legume species under rainfed conditions. Journal of Agronomy and Crop Science. In press.

Abd El Moneim, A.M., Khair, M.A. and Rihawi, S. Effect of genotypes and plant maturity on forage quality of certain forage legume species under rainfed conditions. Journal of Agronomy and Crop Science. In press.

Beale, P.E. 1989. Registration of <u>Trifolium</u> <u>subterraneum</u> var. <u>brachycalycinum</u> cv. Rosedale. Australian Journal of Experimental Agriculture 29: 295.

Capper, B.S., Thomson, E.F. and Rihawi, S. 1989. Voluntary intake and digestibility of barley straw as influenced by variety and supplementation with either barley grain or cottonseed cake. Animal Feed Science and Technology 26: 105-118.

Cocks, P.S. Dynamics of flower and pod production in annual medics. I. In spaced plants. Australian Journal of Agricultural Research. In press.

Cocks, P.S. Dynamics of flower and pod production in annual medics. II. In swards at low and high density. Australian Journal of Agricultural Research. In press.

Eardley, B.D., Materon, L.A., Johnson, D. and Selander, R.K. The genetic structure of natural populations of the nitrogen-fixing bacterium Rhizobium meliloti. Journal of Applied and Environmental Microbiology. In press.

Ehrman, T.A.M. and Cocks, P.S. Ecogeography of annual legumes in Syria: distribution pattern. Journal of Applied Ecology. In press.

Erskine, E., Rihawi, S. and Capper, B.S. Variation in lentil straw quality. Animal Feed Science and Technology. In press.

Evers, G.W., Smith, G.R. and Beale, P.E. 1988. Subterranean clover reseeding. Agronomy Journal 80 (6): 855-59.

Little, D.L. and Beale, P.E. 1988. Renovation of yarloop subterranean clover pasture with Trikkala. Australian Journal of Experimental Agriculture 28: 737-45.

Materon, L.A. and Danso, S.K. Nitrogen fixation in two annual medic legumes as affected by inoculation and seed density. Field Crops Research. In press.

Thomson, E.F., Rihawi, S. and Nersoyan, N. Nutritive value and yields of some forage legumes and barley harvested as immature herbage, hay and straw in north-west Syria. Experimental Agriculture. In press.

Thomson, E.F., Rihawi, S., Cocks, P.S., Osman, A.E. and Russi, L. Recovery and germination rates of Mediterranean medics and clovers offered to sheep at a single meal or continuously. Journal of Agricultural Science, Cambridge. In press.

Conference Papers

Abd El Moneim, A.M. Breeding for non-shattering forage vetch, Vicia sativa, L. Pages 321-322 in Proceedings of the XVI International Grassland Congress, Nice, France, 4-11 October 1989.

Beale, P.E. 1989. Introducing ley farming - management: the limiting factor. In Proceedings of a workshop on introducing the ley farming system to the Mediterranean basin, Perugia, Italy, June 1989. In press.

Cocks, P.S. The ICARDA approach to introducing ley farming. In Proceedings of a workshop on introducing the ley farming system to the Mediterranean basin, Perugia, Italy, June 1989. In press.

Cocks, P.S. Improving livestock production from grasslands in the developing countries of the Mediterranean basin. In Proceedings of the XVI International Grassland Conference, Nice, France, 4-11 October 1989.

Eardley, B.D. and Materon, L.A. The chromosomal genetic structure of Rhizobium meliloti populations in southwest Asia. In Proceedings of a workshop on introducing the ley farming system to the Mediterranean basin, Perugia, Italy, June 1989. In press.

Osman, A.E., Jones, M.J., Harris, H. and Nersoyan, N. 1989. Fallow replacement by pasture and forage crops and the impact on subsequent cereal crops under rainfed conditions. In Proceedings of a workshop on soil and crop management for improving water use efficiency, Ankara, Turkey, 15-19 May 1989. In press.

Osman, A.E., Pagnotta, M., Russi, L., Cocks, P.S. and Falcinelli, M. 1990. The role of legumes in improving marginal lands. Pages 205-216 in Proceedings of a workshop on The Role of Legumes in the Farming Systems of Mediterranean Areas (Osman, A.E., Ibrahim, M.G. and Jones, M.A., eds). Tunis, Tunisia, 20-24 June 1988. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Osman, A.E., Cocks, P.S., Thomson, E.F. and Russi, L. 1989. Improving marginal land productivity in the Mediterranean environment using phosphate fertilizer. Pages 1589-1590 in Proceedings of the XVI International Grassland Congress, Nice, France, 4-11 October 1989.

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Osman, A.E., Ibrahim, M.H. and Jones, M.A. (eds). 1990. The Role of Legumes in the Farming Systems of Mediterranean Areas. 20-24 June 1988, Tunis, Tunisia. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Other Publications

Stanley, M., Beale, P.E. and Cooper, J. 1989. Rosedale Subclover - A Clare-Type Subclover for Red-brown Earths.

South Australian Department of Agriculture Fact Sheet 1/88.

Thomson, E.F., Bahhady, F.A. and Martin, A. 1989. Sheep husbandry at the cultivated margin of the north-west Syrian Steppe. ICARDA-148En. 92 pp.

Appendix Table 2.1. Monthly precipitation (mm) for the 1988/89 season.

	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	Total
<u>Tel Hadya</u>													
1988/89 season	0.0	41.2	60.8	83.9	10.0	5.8	17.8	0.0	14.9	0.0	0.0	0.0	234.4
Long term average (11s.)	0.5	27.7	46.3	58.4	62.8	51.6	44.4	28.8	14.4	3.4	0.0	0.1	338.4
% of long term average	0	149	131	144	159	104	40	0	103	0	n/a	0	69
<u>Breda</u>													
1988/89 season	0.0	52.8	45.6	65.4	1.2	2.0	12.6	0.0	14.2	1.0	0.0	0.0	194.8
Long term average (31s.)	1.4	14.5	30.0	52.6	47.2	27.8	32.7	32.5	15.7	1.6	0.2	0.0	256.2
% of long term average	0	364	152	3	3	7	39	0	90	63	0	n/a	76
<u>Terbol</u>													
1988/89 season	0.0	38.2	48.8	145.6	36.2	22.2	39.4	7.2	6.0	0.0	0.0	0.0	343.6
Long term average (9s.)	0.0	29.5	59.3	90.0	122.0	101.8	99.8	24.4	10.9	1.3	0.0	0.0	539.2
% of long term average	n/a	129	82	162	30	22	39	30	55	0	n/a	n/a	64

Appendix Table 2.2. Monthly air temperature (^{o}C) for the 1988/89 season

	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
Tel Hadya												
Mean max.	34.8	32.5	15.6	12.3	11.9	15.2	20.1	30.8	31.8	33.8	38.0	36.7
Mean min.	17.4	11.5	4.6	2.6	-2.3	-1.4	6.1	9.7	12.8	17.4	21.9	21.6
Average	26.1	18.5	10.1	7.5	4.8	6.9	13.1	20.2	22.3	25.6	30.0	29.2
Abs. max.	40.5	35.5	23.6	18.2	17.0	23.0	24.6	37.1	38.8	39.3	41.7	40.9
Abs. min.	13.2	4.8	-6.6	-4.5	-9.7	-9.9	-1.1	2.9	7.7	12.2	19.9	18.8
Breda												
Mean max.	34.5	25.1	15.2	11.7	11.3	15.0	20.9	31.3	31.9	34.3	38.5	36.9
Mean min.	15.4	10.8	4.3	2.1	-2.4	-0.9	6.0	10.0	12.8	17.2	19.9	20.1
Average	25.0	18.0	9.7	6.9	4.5	7.1	13.4	20.7	22.4	25.7	29.2	28.5
Abs. max.	40.0	35.0	22.9	17.0	16.5	24.0	26.2	36.9	39.0	39.4	42.9	40.5
Abs. min.	12.3	5.7	-5.8	-4.0	-8.8	-9.4	-0.8	4.0	8.0	12.7	16.0	16.2
Terbol												
Mean max.	31.0	23.9	16.2	12.2	8.4	13.0	17.2	27.5	27.7	29.9	33.0	33.2
Mean min.	11.2	8.0	2.8	1.6	-3.0	-2.6	2.1	5.9	7.8	10.0	12.8	11.5
Average	21.1	16.0	9.5	6.9	2.7	5.2	9.7	16.7	17.8	20.0	23.0	22.3
Abs. max.	36.5	31.5	23.5	21.5	16.0	23.5	23.5	32.5	34.0	37.0	36.0	36.0
Abs. min.	8.0	4.0	-8.0	-5.0	-8.5	-10.0	-3.5	0.0	2.0	5.0	9.0	7.5

Appendix Table 2.3. Frost events during the 1988/89 season

	OCT	NOV	DEC	JAN	FEB	MAR	APR	SEASON
<u>Tel Hadya</u>								
No. of frost days	-	4	5	23	18	2	-	52
Abs. min. (°C)	-	-6.6	-4.5	-9.7	-9.9	-1.1	-	-9.9
<u>Breda</u>								
No. of frost days	-	4	8	22	16	2	-	52
Abs. min. (°C)	-	-5.8	-4.0	-8.8	-9.4	-0.8	-	-9.4
<u>Terbol</u>								
No. of frost days	-	10	11	27	22	7	1	78
Abs. min. (°C)	-	-8.0	-5.0	-8.5	-10.0	-3.5	0	-10.0

Appendix Table 2.4. Frost events at 5 cm above the ground during the 1988/89 season.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	SEASON
<u>Tel Hadya</u>								
Frost days	-	5	7	25	19	2	-	58
Abs. min.	-	-8.3	-5.5	-10.5	-11.3	-2.0	-	-11.3

Appendix 3. List of Preschedules since 1984.

Note: not all collaborating organizations are shown after short titles.

Abbreviations shown in parentheses after short titles:

AAM = Ali Abdel Moneim
ACSAD = Arab Center for Studies of Arid Zones and Dry Areas, Damascus
AYT = Advanced Yield Trial
Br = Breda station
CSIRO = Commonwealth Scientific and Industrial Research Organization (Australia)
DSAR = Directorate of Agricultural Scientific Research, Damascus
FRMP = Farm Resource Management Program (ICARDA)
INRA = Institut National de la Recherche Agronomique (Morocco)
MS = Master of Science research
NCARTT= National Center for Agricultural Research and Technology Transfer (Jordan)
ODNRI = Overseas Development Natural Resources Institute (London)
PhD = Doctor of Philosophy research
RVC = Royal Veterinary College (London)
SSD = Syrian Steppe Directorate
TH = Tel Hadya station
Uni = University
WANA = West Asia and North Africa (region)

Appendix 3.1. List of Preschedules since 1984

Research activity: Forage legume breeding (FB), agronomy (FA), pathology (FP), medic pathology (MP)
Preschedule codes: FB/FA/FP/MP
Principal Scientist: A.A. El Moneim   Appointment year: 1983

Preschedule Number New	Preschedule Number Old	Short title of project	Year Start	Year End
FB1	F1	G X E interactions of vetches/peas	83	85
FB2	F2	Microplot evaluation of peas	84	85
FB3	F3	Advanced yield trials of peas	84	85
FB4	F4	Selection of highly productive vetches	84	85
FB5	F5	Microplot evaluation of vetches	84	85
FB6	F6	Breeding non-shattering vetches	84	87
FP7	F7	Nematodes of vetches and peas	84	85
-	F8	See FA8 (ML series)	--	--
FB8	F9	Inoculation of vetches (See also MM4)	84	85
-	F10	Missing	--	--
FB9	F11	Advanced yield trials of vetches	85	86
FB10	F12	Evaluation of woollypod vetch	85	86
-	F13	Missing	--	--
-	F14	Missing	--	--
FB11	F15	Adaptation of <u>Lathyrus</u> spp.	85	87
FB12	F16	Evaluation of <u>Lathyrus</u> spp.	85	86
FP13	F17	Disease resist. in vetches/chicklings	85	86
-	F18	Cancelled	85	--
-	F19	See FA19 (ML series)	--	--
FB14	F20	Microplot eval. of woollypod vetch	86	87
FB15	F21	Evaluation of narbon vetch at TH & Br	86	87
FB16	F22	Evaluation of <u>Lathyrus</u> spp. in AYT	86	87
FB17	F23	Seasonal product. <u>Lathyrus</u>/<u>Vicia</u> spp.	86	87
-	-	Preschedules F24 to F59 all missing	--	--
FB18	F60	Screening vetches/chicklings for dis.	87	88
FB18	F61	Yield/quality of <u>Lathyrus</u>/<u>Vicia</u> spp.	87	88
MP20	M43	Screening medics for nematode resist.	87	88
FB21	F62	Microplot evaluation of <u>L</u>. <u>sativa</u>	87	88
FB22	F63	Microplot evaluation of <u>L</u>. <u>ochrus</u>	87	88
FB23	F64	Microplot evaluation of <u>L</u>. <u>cicera</u>	87	88
FB24	F65	Adaptability of chickling spp. at TH/Br	87	88
FB25	F66	Germplasm evaluation of <u>Vicia</u> spp.	87	88
FB26	F67	Microplot evaluation of narbon vetch	87	88
FB27	F68	Selecting narbon vetches in AYTs	87	88
FB28	F69	Early selection of non-shatt. <u>Vicia</u>	87	89
FM29	F70	Potential of subterranean vetch (MS)	87	89

(FB series continued)

Preschedule Number		Short title of project	Year	
New	Old		Start	End
FB30	F31	Microplot evaluation of woollypod vetch	87	88
FB31	F72	Highly productive woollypod vetch	87	88
-	F73	Missing	--	--
MP32	M83	Nematode resistance of medics (DSAR)	88	92
FB33	F74	Microplot eval. of three _Vicia_ spp.	88	89
FB34	F75	Microplot evaluation of common vetch	88	89
FB35	F76	Adaptability of _Lathyrus_ spp. at TH/Br	88	90
FB36	F77	Narbon vetch AYT at drier areas (TH/Br)	88	89
FB37	F78	Woollypod vetch AYT	88	89
FB38	F79	AYT of non-shattering vetch (cont. F69)	88	90
FA39	F80	Grazing potential of subterranean vetch	89	90
FP40	F81	Screening vetches/chicklings for disea.	88	90
FP41	F82	_Orobanche_ on food and feed legumes	88	90
-	-	Preschedules F83 to 86 missing	--	--
-	F87	Cancelled	88	--
FB42	F88	Assessment of _Lathyrus_ spp. germplasm	89	90

Appendix 3.2. List of Preschedules since 1984

Research activity: Medic ecology, surveys and systems (M) (with some of ML series)
Preschedule codes: M (with some ML series)
Principal Scientist: P.S. Cocks Appointment year: 1983

Preschedule Number New	Old	Short title of project	Year Start	End
-	ML1	Marginal land study in Bueda village	84	85
-	ML3	Changes in the quality of range plants	84	85
-	ML6	Adapt. of native legumes and phosphate	85	87
-	ML10	Seed dormancy of native legumes (PhD)	86	89
-	ML11	Phenology of medics/other taxa (PhD)	86	87
-	ML13	Studies on four native clovers (PhD)	87	89
M1	M1	Seasonal production of medic species	84	85
M2	M2	Eco-survey of medics/annual legumes	84	86
-	M3	See MM1 (MM series)	--	--
M3	M5	Eco-survey of wild legumes in Syria	84	86
M4	M4	Natural selection of grazed medics	85	86
M5	M8	Sowing date, medic species, N fixation	84	85
M6	M6	The Tah project - ley farming (DSAR)	84	92
-	M7	See MA1 (MA series)	--	--
-	M9	Cancelled	84	--
M7	M10	Eval. common taxa from marginal land	84	85
M8	M11	Selection of medics suited to NE Iraq	84	85
-	M12	See MM2 (MM series)	--	--
-	M13	See MM3 (MM series)	--	--
-	M14	See MM4 (MM series)	--	--
-	M15	See MM5 (MM series)	--	--
-	M16	See MM6 (MM series)	--	--
-	M17	See MM7 (MM series)	--	--
-	M18	See MM8 (MM series)	--	--
-	M19	See MM9 (MM series)	--	--
-	M20	See MM10 (MM series)	--	--
-	M21	See MM11 (MM series)	--	--
-	M22	See MM12 (MM series)	--	--
-	M23	See MM13 (MM series)	--	--
M9	M24	Seed prod./harvest effic. of medics	85	86
M10	M25	Selection of medics adapted to Breda	85	86
-	M26	See MM14 (MM series)	--	--
M11	M27	Medic international nursery	86	92
M12	M28	Flower prod. and pod survival of medics	86	87
-	M29	Cancelled	86	--
-	M30	See MA2 (MA series)	--	--

(M series continued)

Preschedule Number		Short title of project	Year	
New	Old		Start	End
M13	M31	Decline of yield in cont. cereal syst.	86	87
M14	M32	Decrease of plant density in cereals	86	87
M15	M33	Cereal yield decline & straw/root res.	87	87
-	M34	See MM15 (MM series)	--	--
M16	M35	Seed bank in a medic/wheat rotation	87	92
-	M36	Missing	--	--
-	M37	See MA15 (MA series)	--	--
-	M38	Missing	--	--
-	M39	See NAM1 (NA series)	--	--
-	M40	Missing	--	--
-	M41	Missing	--	--
M17	M42	Medic system in drier areas (FRMP)	87	92
-	M43	See MP20 (MP series)	--	--
-	M44	See MM16 (MM series)	--	--
-	M45	See MM17 (MM series)	--	--
-	M46	See MM18 (MM series)	--	--
-	M47	See MM19 (MM series)	--	--
-	M48	See MM20 (MM series)	--	--
-	M49	Cancelled	--	--
M18	M50	Medic seed depth and sowing method	88	90
-	M51	See MA4 (MA series)	--	--
M19	M52	Factors affecting medic seed prod.	87	88
-	M53	See MG12 (MG series)	--	--
M20	M54	Genetic selection and medic seed prod.	87	88
-	-	Preschedules M55 to M66 missing	--	--
-	M67	See MA14 (MA series)	--	--
-	-	Preschedules M68 to M82 missing	--	--
-	M83	See MP32 (MP series)	--	--
M21	M84	Jordan survey of native legumes(NCARTT)	89	90
-	M85	See MM21 (MM series)	--	--
-	M86	See MM22 (MM series)	--	--
-	M87	Missing	--	--
-	M88	Missing	--	--
-	M89	See L34 (L series)	--	--
-	M90	See MG10 (MG series)	--	--
M22	M91	Medic seed prod./yields in 3 countries	88	90
M23	M92	M. polymorpha regeneration	88	91
M24	M93	M. scutellata and balansa clover reg.	88	91
M25	M94	Herbicides/medic seed production (AAM)	88	89
-	-	Preschedules M95 to M99 missing	--	--

(M series continued)

Preschedule Number		Short title of project	Year	
New	Old		Start	End
M26	M100	Population dynamics of annual legumes	88	89
-	M101	See NAM2 (NA series)	--	--
M27	-	Responses of annual legumes to phos.	89	90
M28	-	Adapt. of medics in Jordan (NCARTT)	89	90
M29	-	Application methods of phos. on medics	89	90

Appendix 3.3. List of Preschedules since 1984

Research activity: Medic Grazing Management (MG) and Agronomy (MA)

Preschedule codes: MG/MA
Principal Scientist: A. Smith[1] Appointment year: 1985

Preschedule Number		Short title of project	Year	
New	Old		Start	End
MA1	M7	Medics in cereal/pasture rotations(AAM)	84	85
MA2	M30	Sowing depth, establish. & wheat yields	86	87
MA3	M51	Rainfall and medic sowing depth	87	88
MG4	L29	Grazing management of medics	86	87
MG5	L35	Simulated grazing and medic growth	87	87
MG6	L36	Method of defoliation of medics	87	87
-	L37	Missing	--	--
MG7	L39	Weed control in medics using grazing	88	88
MG8	L40	Simulated grazing and medic growth	88	88
MG9	L41	Grazing medics and high seed yield	88	89
MG10	M90	Cultivations & wheat yields after medic	88	89
MG11	L98	Weed control in barley by sheep/goats	88	89
MG12	L99	Grazing management in medics	88	89
MG13	L13	Medic rotations and stocking rate	85	93
MG14	M53	Goats, sheep and medic seed production	88	88
MA15	M67	Wheat yields after medic	87	88
MA16	M37	Volunteer medics and weeds in wheat	89	90
MA17	-	Medic residues and wheat yield decline	89	90

[1]Resigned April 1989, replaced by Dr Scott Christiansen in January 1990.

Appendix 3.4. List of Preschedules since 1984

Research activity: Medic Microbiology (MM)
Preschedule code: MM
Principal Scientist: L.A. Materon Appointment year: 1984

Preschedule Number New	Preschedule Number Old	Short title of project	Year Start	Year End
MM1	M3	Medic-Rhizobium interactions Syr/Jord.	84	85
MM2	M12	Rhizobia collections from diff. soils	84	85
MM3	M13	Indigenous clover rhizobia	84	85
MM4	M14	Inoculation of vetches (see also FB8)	84	85
MM5	M15	Adhesives for solid-based inoculants	85	87
MM6	M16	Inoculants and seed coatings	84	85
MM7	M17	Double antibiotic resistant mutants	85	86
MM8	M18	Screening of medic rhizobia in Syria	85	88
MM9	M19	Establi. a rhizobia collection in WANA	85	90
MM10	M20	Medic responses to diff. inoculum lev.	85	86
MM11	M21	Seed coating for medic seed	85	89
MM12	M22	Inoculant adhesives and soil moisture	85	90
MM13	M23	Nitrogen fixation and plant density	85	86
MM14	M26	Evaluating rhizobia in two environments	85	90
-	M29	Cancelled	86	--
MM15	M34	Inoculation of M. rigidula subspecies	86	87
MM16	M44	Polyvinylpyrrolidone and nodulation	86	88
MM17	M45	Ecology of rhizobia and annual medics	87	92
MM18	M46	Population dynamics of rhizobia(CSIRO)	87	90
MM19	M47	International inoculation network	86	90
MM20	M48	Microbiology with advanced institutes	87	90
-	M49	Cancelled	87	--
MM21	M85	Rhizobium/medic ecotype specificities	88	90
MM22	M86	Nitrogen cycling in ley farming	88	90
MM23	-	P nutrition & nodulation of medics, I	89	90
MM24	-	P nutrition & nodulation of medics, II	89	90
MM25	-	P nutrition & nodulation of medics, III	89	90
MM26	-	Effect of nitrate on medic nodulation	89	90
MM27	-	Soil nitrate and medic nodulation	89	90

Appendix 3.5. List of Preschedules since 1984

Research activity: Marginal Land (ML) (includes some FA series)

Preschedule code: ML (with some FA series)
Principal Scientist: A.E. Osman   Appointment year: 1981

Preschedule Number New	Old	Short title of project	Year Start	End
-	FA8	Grain yield of barley after forages	82	85
-	FA19	Grain yield of wheat after forages	83	87
-	-	See ML1 (M series)	--	--
ML2	-	Superphosphate on marginal land	84	90
-	-	See ML3 (M series)	--	--
ML4	-	Grazing lands of the Bekaa hills	85	86
ML5	-	Improved pastures in the Bekaa hills	85	86
-	-	See ML6 (M series)	--	--
ML7	-	Survival/hardseededness of clovers	85	86
ML8	-	*Productivity of grazing land at Adamy*	85	86
ML9	-	Seeding with Kochia scorparia spp.(SSD)	86	89
-	-	See ML10 (M series)	--	--
-	-	See ML11 (M series)	--	--
ML12	-	Native pastures at Maraga (ACSAD, SSD)	88	94
-	-	See ML13 (M series)	--	--
ML14	-	Growth of native legumes in Lebanon	88	91
ML15	-	Evaluating native legumes (MS research)	89	91

Appendix 3.6. List of Preschedules since 1984

Research activity: North Africa medics (NAM), forages (NAF)
Preschedule codes: NAM/NAF
Principal Scientist: Philip Beale   Appointment year: 1987

Preschedule Number		Short title of project	Year	
New	Old		Start	End
NAM1	M39	Eco-survey of native legumes (INRA)	88	90
NAM2	M101	Balansa clover pastures (INRA)	88	91
NAF3	-	Evaluating vetches (INRA)	88	92

Appendix 3.7. List of Preschedules since 1984

Research activity: Livestock Management and Nutrition (L)
Preschedule code: L
Principal Scientist: E.F. Thomson Appointment year: 1980

Preschedule Number		Short title of project	Year	
New	Old		Start	End
L1	L1	Unit Farm project	79	86
-	L2	Cancelled	84	--
L2	L3	Ewe liveweight at mating	82	85
-	L4	Cancelled	84	--
L3	L5	Helminth parasites of Awassi sheep	84	86
L4	L6	Nutritive value of forage legumes	84	85
L5	L7	Barley straw morphology	83	85
L6	L8	Straw intake levels by lactating ewes	84	86
L7	L9	Breda on-farm forage trials	81	88
L8	L10	Barley straw quality, nine varieties	84	85
L9	L11	Ewe supplementary feeding trial, V	84	85
L10	L12	Grazing of wheat stubbles	85	85
-	L13	See MG13 (MG series)	--	--
L11	L14	Nutritive value of vetches	85	86
L12	L15	Nutritive value of wheat straw	85	86
L13	L16	Morphology of wheat straw (ODNRI)	85	86
L14	L17	Ewe supplementary feeding trial, VI	85	86
L15	L18	Grazing barley stubbles	86	86
L16	L19	Protein levels in lamb diets	86	86
L17	L20	Nutritive value of legume straws	86	87
-	L21	Cancelled	86	--
L18	L22	Recovery of medic seed after ing., I	86	87
-	L23	Cancelled	86	--
L19	L24	El-Bab on-farm trials (DSAR)	86	92
L20	L25	Wheat straw quality & GxY interaction	86	87
L21	L26	Barley straw morphology	86	87
L22	L27	Barley straw quality (PhD, Wye College)	86	90
L23	L28	Barley straw for lactating ewes	86	88
-	L29	See MG4 (MG series)	--	--
L24	L30	Pea palatability, grazing trial	86	87
L25	L31	Pea palatability (PhD, RVC)	87	91
L26	L32	Maintenance needs and walking (trainee)	87	87
L27	L33	Performance/parasites in village sheep	87	91
L28	L34	Medic rotation trials Khamishli (DSAR)	86	92
-	L35	See MG5 (MG series)	--	--
-	L36	See MG6 (MG series)	--	--
-	L37	Missing	--	--

(L series continued)

Preschedule Number		Short title of project	Year	
New	Old		Start	End
L29	L38	Protein levels and lamb growth	87	87
-	L39	See MG7 (MG series)	--	--
-	L40	See MG8 (MG series)	--	--
-	L41	See MG9 (MG series)	--	--
L30	L88	Parasites and lamb growth (trainee)	88	89
L31	-	Ambient temperature and feed value	89	90
L32	-	Wheat straw quality (PhD, Uni Gezira)	89	91
L33	-	Genotype/stem height of barley straw	89	90
L34	-	Medic seed recovery after ingestion,II	89	90
L35	-	Harvester type/quality of wheat straw	89	90

Appendix 4. Staff List (as of 31.12.89)

Principal scientists

Program Leader: P.S. Cocks (on sabbatical leave)
Acting Program Leader/Livestock Scientist: E.F. Thomson
Pasture Ecologist: A.E. Osman
Microbiologist: L.A. Materon
Training Scientist/Forage Breeder: A. Abd El Moneim
Grazing Management Scientist: A. Smith (resigned in April)
Pasture Scientist (North Africa): P. Beale

Research associates

F. Bahhady (Ass. Livestock Scientist)
N. Nersoyan
S. Rihawi
H. Sawmy
M. Turk
M. Zaklouta
L. Russi
M. Pagnotta
S. Lorenzetti (based in Perugia)

Research assistants

M. Jabboulieh
A. Khatib Salkini
M. Bellar
A. Termanini
F. Ghassaly

Senior technicians

W. Bou Moughlabay
A. Semaan
A. Nassar

Technicians

F. Ahmed
S. Sabbouni
S. Bittar
H. Hreitani
M. Heilani
A. Badenjki
R. Abu Nakad
K. Kaddah
W. Hamo
G. Basmadji
S. Agha
M. El Razzouk

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