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PASTURE, FORAGE AND LIVESTOCK PROGRAM

Annual Report for 1986

ICARDA

PASTURE, FORAGE AND LIVESTOCK PROGRAM

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CONTENTS

PASTURE, FORAGE AND LIVESTOCK PROGRAM

The Pasture, Forage and Livestock Program (PFLP) has the broad objective of improving the livestock production of rainfed farming systems in west Asia and north Africa. In attempting to do so it has identified two major agroecosystems: farms in the cereal zone whose basic product is wheat or barley, and marginal land within and adjacent to the cereal zone. The Program is structured into four major projects: (1) annual pastures to replace fallow, (2) forage breeding, (3) marginal-land improvement, and (4) livestock management and nutrition. It is committed to the development of stable farming systems.

The first two projects are designed for the first agroecosystem, specifically to replace fallow in cereal/fallow rotations with either annually resown forages or self-regenerating pastures. In the case of forages, the objectives are to breed adapted cultivars of vetch (Vicia spp.), forage pea (Pisum sativum), and chickling (Lathyrus spp.). In the case of annual pastures the objectives are to introduce self-regenerating populations of annual legumes, and to devise farming systems involving annual pastures suitable for local economic and social conditions.

The objective of the marginal land project is to increase stability and productivity of the second agroecosystem, marginal land within and adjacent to the cereal zone. The specific aim of the work is to define the resource base: nature and fertility status of soils, kind of plants found, productivity, and management practices. From these studies new proposals are being formulated to develop this greatly undervalued resource. We have attempted to highlight the marginal-land work in the 1986 Report.

Livestock management and nutrition is the Program's integrating project. Under this heading, scientists test the various production systems from the point of view of the Program's 'commodity', namely sheep. Increasingly, the work of livestock scientists is being reported, as it should be, under the heading of the farming system concerned. For example, work on palatability of vetches appears in this Report under the broad heading 'Introducing annually resown forage legumes into rotations with cereals'. Similarly, grazing management of medic pastures appears under the heading 'Introducing self-regenerating pastures into rotations with cereals', and so on. About half of the work conducted by this project continues to appear under a separate heading, involving the feeding of sheep with straw and supplements.

In the continuing discussion on 'upstream' and 'downstream' research it is worth making the point that work on farmers fields is not necessarily 'downstream'. For example the work on medic pastures being conducted at ICARDA includes an element of 'on farm' research which is designed to test and modify an experimental farming system. Without the help of farmers, scientists would not receive the feed-back which is essential for the continuation of their work. In the case of our work with forages, the feedback has resulted in new plant breeding programs (for chickling) and the development of new breeding objectives. There is no similar on farm work with either forages or medics in the ICARDA region.

Throughout the 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), Narbon vetch (V. narbonensis), bitter vetch (V. ervilia) and woollypod vetch (V. villosa subsp. dasycarpa).

chickling - Lathyrus sativus

forage pea - Pisum sativum

medics - various species of Medicago: of these only barrel medic (M. truncatula), snail medic (M. scutellata), strand medic (M. littoralis) and gama medic (M. rugosa) have widely accepted common names. M. polymorpha, although often called bur medic, is referred to by its scientific name.

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

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

accession - 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.

cultivar - a group of similar genotypes, or an ecotype which is used in agriculture, including locally evolved 'landraces'.

forage - this term is used to describe 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.

herbage - plant material.

herbage yield - the mass of dry herbage produced. This term replaces 'dry-matter yield', which is often used elsewhere. Drying is normally at 80-90^{o}C.

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

marginal land - land receiving more than 200mm of rain which is too dry, too steep, or where the soil is too shallow for cultivation.

ME - metabolizable energy.

MBS - metabolic body size: liveweight raised to the power 0.75.

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 - resulting from selection within an accession. 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 which receive (in Syria) less than 200mm of rainfall.

strain - is a general term to cover accession, selection, variety and cultivar. It is also used 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 in its botanical sense, where it is a taxonomic unit beneath species.

Research highlights

Some of the research highlights are presented below.

(1) An ecogeographic survey of Syrian native legumes was completed. The results show that the natural distribution of M. rigidula and M. rotata includes the cereal zone, and that, outside the cereal zone, M. rigidula and M. radiata are common in the driest areas surveyed. In contrast the species which constitute commercial medics are confined to the high rainfall coast and ranges. Most species showed ecotypic differentiation in flowering time.

(2) Native pasture at Tel Hadya responded to superphosphate and this was reflected in ewe liveweights. The helminth population of ewes was not affected by stocking rate.

(3) A survey showed that similar factors - low plant density and low legume population - affect biomass yield of both low and high rainfall marginal land. Another survey revealed that phosphorus deficiency occurs on about 25% of all marginal land.

(4) After three years work it is clear that, on farmers fields, growing of forage crops does not reduce the yield of the barley crop which follows. The work also reveals that in the dry areas, chickling is preferred to common vetch, but both forages, whether harvested as straw and seed, grazed by lactating ewes, or grazed by lambs, improve economic returns compared to land under a barley-fallow rotation..

(5) Selections of common vetch with wide adaptation have been identified. These are now being screened for resistance to fungal disease, and attack by nematodes. A breeding program to combine adaptation and non-shattering pods has completed the F1 generation.

(6) The palatability of woollypod vetch is inferior to that of common vetch at the pre-flowering stage, and that of Narbon vetch is slightly inferior at the straw stage.

(7) Common vetch has been shown to respond to inoculation with rhizobia.

(8) M. rigidula failed to nodulate with previously recommended strains of rhizobia. A new strain has been isolated. Several other medics also show strain specificity.

(9) Nitrogen fixed by medic stands was 90-100kg/ha.

(10) On farmers fields, wheat sown after medic was not depressed compared with wheat sown after watermelons. However the usual requirement, that wheat requires nitrogen fertilizer, was replaced by the need to use a herbicide.

(11) A large grazing management experiment was commenced in which the productivity of medic pastures is being compared with lentils, watermelons, and fallow. Although difficulties were experienced in establishing the medic, final pod yields should ensure satisfactory regeneration.

(12) A diet of straw and concentrates was used to measure the milk production of Awassi ewes. The ewes responded to feed levels above those which were expected, indicating that feeding for milk production is very profitable. The best-fed ewes produced about 140kg of milk during the total lactation of 146 days.

(13) A protein supplement of cottonseed meal was as good for fattening lambs as soyabean meal. Since it is half the price and does not have to be imported this has clear economic implications.

(14) Laboratory analyis of straw indicated that genotypic differences in straw quality were of greater significance than environmental differences, the latter being the result of different seasons at the same site.

(15) Access to marginal land increased the milk production of ewes being fed concentrates, even those fed rations which supposedly met their requirements.

- P.S. Cocks

THE ECOLOGY AND PRODUCTIVITY OF MARGINAL LAND

In this Report we are highlighting our research on marginal land. Previous to 1983/84 the ICARDA research on marginal land was confined to studies on the productivity and longevity of certain perennial grasses, and was often conducted on deeper soils than is normal for marginal land. While the studies revealed the potential of some Mediterranean grasses, we felt firstly that grasses in general were likely to be unproductive on these poor soils, secondly that we needed to concentrate our efforts on improved management systems, and thirdly that we needed much more basic information on the ecology of marginal land. Accordingly we designed studies which would give broad information on the soil, climate, and existing plant resources of marginal land, and on the reaction of native pastures to two management practices: application of phosphorus and use of different stocking rates.

In designing this work we made several assumptions, some of which, as will be seen later, have proved to be unreliable. Firstly we assumed that marginal land is not arable: this is true by definition, the reasons being that the land is often steep, usually stony, and the soil is shallow. We assumed also, on the basis of poor growth of vegetation, that soils were likely to be infertile, and plant populations low. We assumed that the population of legumes, as a proportion of the whole population, would also be low. Finally we assumed that as a result of our research, it will be possible to increase pasture, and hence animal, production.

We believe that the progress we have made in three years is impressive. Not only have we conducted a broad survey, but also more detailed surveys of particular situations. Not only are we studying the ecology of plant communities, but we have extended them to include the health of grazing sheep. Most of our results have been obtained directly from the field, but we also have greenhouse studies.

Before presenting the results in detail we should acknowledge the assistance provided by the Government of Italy and the collaboration of the University of Perugia. We believe this assistance is a recognition that the problem of low productivity of marginal land is widespread in the Mediterranean basin.

Experiment 1: ecogeographic survey of the legumes inhabiting marginal land (Preschedule M5)

The first experiment has objectives which link research on marginal land with research on 'annual pastures', results of the latter appearing later in this report. The reason is simple: the plant resources of marginal lands are those which can be developed for use elsewhere as self regenerating pastures growing in rotation with cereals. They are also, of course, the resources available for developing the marginal land itself, whether indirectly by use of fertilizers or improved grazing management, or directly through the sowing of selected varieties.

The pasture scientist, whether he works with marginal land or annual pastures, works with plant populations whose characteristics resemble those of wild populations. To make progress he must acquire the greatest possible genetic diversity and understand the ecology of the plants so acquired. In doing so he is also able to contribute significantly to genetic conservation.

Conservation of plants on marginal land is doubly important: firstly their very existence is at risk, especially in the dry areas, and secondly the genes which are contained in wild populations are of great value to plant breeders. A recent survey, conducted by IBPGR, lists many of the native plants, whose habitat is the marginal land of west Asia, as being at extreme risk of genetic erosion. Species listed include Medicago rigidula, most other medics, many clovers including subterranean clover (Trifolium subterranean), and other legumes of potential significance. Perhaps even more important however, is the need to understand how these species (especially those at severe risk of genetic erosion) continue to exist in such unfavourable conditions, and what factors of the environment, including the soil and climate, are limiting their distribution.

The objectives of Experiment 1 were therefore; (1) to sample the genetic diversity of annual legumes in Syria with a view to its conservation, and (2) to relate distribution of species and genetic characters to soil, climate and natural vegetation.

Method

The annual legumes present at 207 sites (Fig.1) were collected throughout Syria including the coastal plain, the Jebel al Ansariye (the mountains separating the coastal plain from the interior), the cereal zone east of the range, the Jezirah in the north east, and

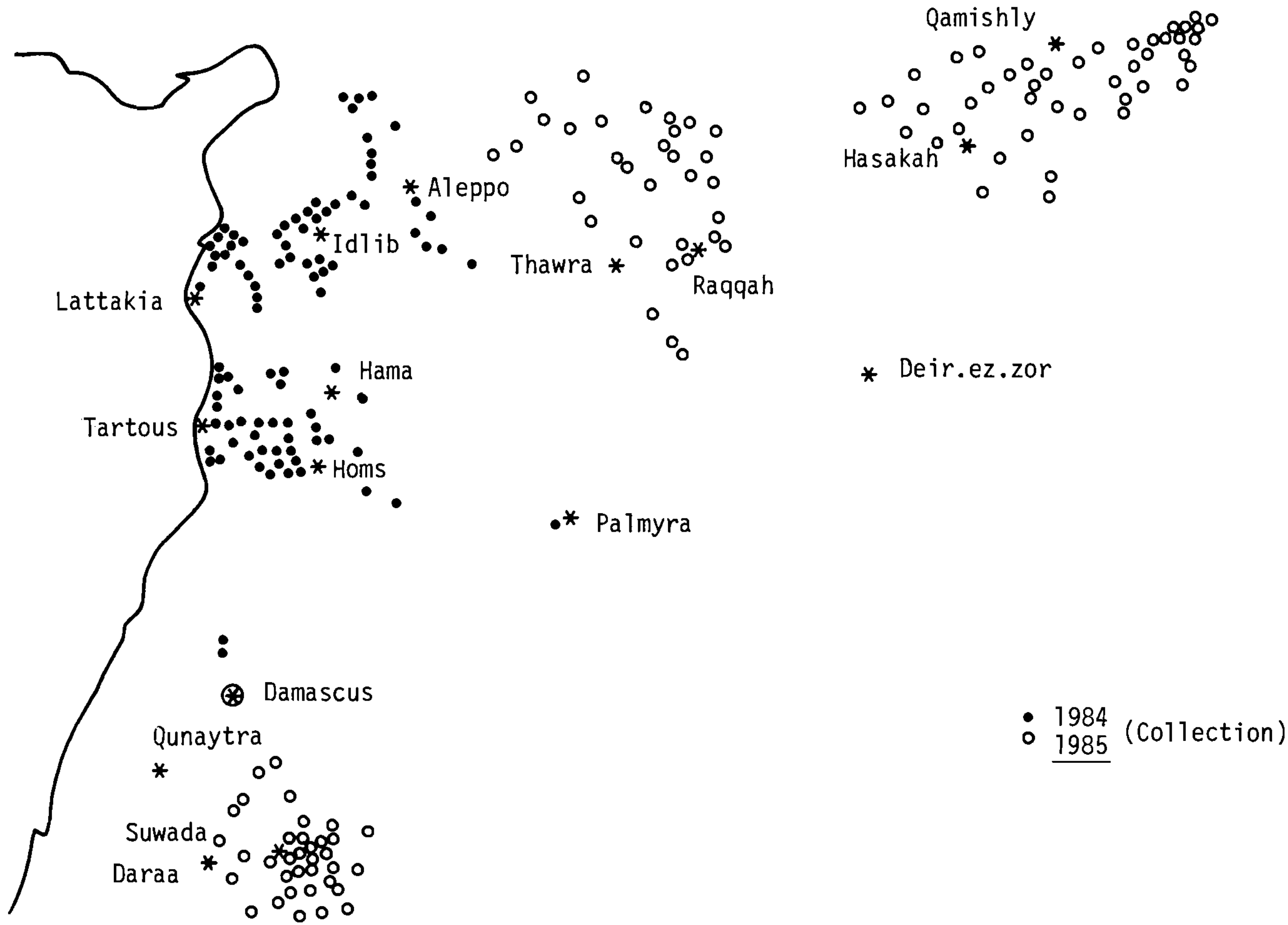


Fig.1: Distribution of collection sites in Syria. The legumes were collected in 1984 (closed circles) and 1985 (open circles) at 207 sites.

the plains south of Damascus. Of the 207 sites, 95 were sampled in 1984, and 112 in 1985. The sites were located at intervals of 5 - 15km along routes chosen to traverse the main ecological zones, and to encompass a diversity of topography and dominant perennial vegetation types. To sample genetic diversity, seeds were collected from areas of approximately 0.5ha at each site. Where possible a minimum of 50 pods of each species was collected, a number considered by Marshall and Brown (1983) to contain most of the allelic diversity present at a site. In the case of smaller populations all seed which could be located, was collected. To record population size the vegetation of a $25m^2$ area, typical of the site as a whole, was sampled, the legumes were separated into species on the basis of their pods, and the seed population was assessed after cleaning and threshing. All sites were sampled in July and August, either in 1984 or 1985. Voucher specimens of all accessions are housed at ICARDA headquarters.

Meteorological information was obtained from reading isolines in maps published by the Syrian Ministry of Defence (1977). From these we obtained estimates of mean annual rainfall, mean monthly maximum and minimum temperature, and mean number of days per month when temperature was either below $5^{o}C$ or above $35^{o}C$. To obtain information on soils, each site was sampled to a depth of 10cm and analysed for pH, available phosphorus, percentage sand, silt, and clay, pecentage calcium carbonate, percentage organic matter, and electro-conductivity.

In summary, the data obtained from the samples was the presence of legume species, an estimate of their number, and descriptions of the climate and soils at each site from which they were collected.

Soil and climate of the marginal land

To interpret the data, cluster analysis was used to form 14 clusters of soils and 12 of climate. The clusters, now referred to as 'soil groups' and 'climatic regions' are listed in Tables 1 and 2 respectively, while their relationship is shown in Fig.2. The climatic regions fall easily into geographic units: region 1 is the coastal plain where rainfall is high, and both winters and summers mild, region 2 is the western foothills where rainfall is higher than in region 1 and temperature lower, and so on. Rainfall is highest in the coastal mountains, winter temperatures are coldest in the inland mountains (near Damascus), and summer temperatures highest in the northern and western barley belt (the desert interior of Syria was not sampled).

Soils are widely distributed in relation to climatic type (Fig.2) although there is a tendency for high rainfall areas to have neutral, noncalcareous soils, and drier areas to have alkaline, calcareous soils. Soil groups 5-10 are widely distributed: these are all alkaline soils, mainly calcareous, whose distribution is clearly related to parent material. Table 1 also shows that, in all groups, the mean level of available phosphorus is greater than the critical level. More detailed examination shows that about 25% of the soils are, in fact, deficient in phosphorus (Fig.3), a most important point in relation to Experiment 2 (see later). Availability of phosphorus was weakly related to rainfall in the 95 sites of the 1984 sampling: in those sites phosphorus was more likely to be low in the highest rainfall sites. However, if all 207 sites are included in the analysis there is no relationship with rainfall, soils from dry sites being as likely to be low in phosphorus as soils from wet sites.

Table 1. Values for the variables used to characterise soil groups. Values for which superscripts differ are significantly different at $P<0.05$ (on the basis of average stepwise t-test groupings).

	pH	P (mg/l)	Clay %	Silt %	Sand %	Organic matter %	$CaCO_3$ %	Conductivity mMhos/ml
1	$7.1^{(1)}$	$46^{(1)}$	$40^{(1)}$	$42^{(1)}$	$14^{(1)}$	$3.3^{(1)}$	$2^{(1)}$	$0.5^{(1)}$
2	$7.0^{(1)}$	$18^{(1)}$	$37^{(1)}$	$37^{(1)}$	$23^{(2)}$	$3.3^{(1)}$	$2^{(1)}$	$0.4^{(1)}$
3	$7.3^{(1)}$	$14^{(2)}$	$21^{(2)}$	$23^{(2)}$	$52^{(3)}$	$2.9^{(1)}$	$9^{(2)}$	$0.5^{(1)}$
4	$7.7^{(2)}$	$23^{(2)}$	$58^{(3)}$	$30^{(1)}$	$8^{(4)}$	$8.0^{(2)}$	$7^{(2)}$	$0.4^{(1)}$
5	$7.7^{(2)}$	$14^{(2)}$	$60^{(3)}$	$28^{(1)}$	$9^{(4)}$	$3.1^{(1)}$	$5^{(2)}$	$0.4^{(1)}$
6	$7.8^{(2)}$	$14^{(2)}$	$23^{(2)}$	$31^{(1)}$	$42^{(3)}$	$3.0^{(1)}$	$6^{(2)}$	$0.4^{(1)}$
7	$7.9^{(2)}$	$12^{(2)}$	$39^{(1)}$	$40^{(1)}$	$18^{(2)}$	$2.9^{(1)}$	$28^{(3)}$	$0.6^{(1)}$
8	$7.6^{(2)}$	$21^{(2)}$	$26^{(1)}$	$42^{(1)}$	$28^{(2)}$	$3.3^{(1)}$	$38^{(3)}$	$2.3^{(2)}$
9	$7.8^{(2)}$	$56^{(1)}$	$26^{(1)}$	$35^{(1)}$	$36^{(2,3)}$	$4.6^{(1)}$	$45^{(4)}$	$0.6^{(1)}$
10	$7.9^{(2)}$	$13^{(2)}$	$30^{(1)}$	$40^{(1)}$	$27^{(2)}$	$3.3^{(1)}$	$56^{(4)}$	$0.6^{(1)}$
11	$7.7^{(2)}$	$34^{(1,2)}$	$37^{(1)}$	$45^{(1)}$	$14^{(1)}$	$3.3^{(1)}$	$32^{(3)}$	$5.0^{(3)}$
12	$7.7^{(2)}$	$21^{(2)}$	-*	-	-	$3.5^{(1)}$	$21^{(3)}$	-
13	$8.3^{(3)}$	$13^{(2)}$	$7^{(4)}$	$11^{(3)}$	$88^{(5)}$	$2.9^{(1)}$	$19^{(3)}$	$0.5^{(1)}$
14	$7.9^{(2)}$	$19^{(2)}$	$9^{(3)}$	$7^{(3)}$	$80^{(5)}$	$1.2^{(1)}$	$63^{(4)}$	$2.9^{(2)}$

* Values for clay, silt, sand, and conductivity are not applicable to gypsic soils.

Table 2. Values for variables used to characterize 12 climatic regions. Values with superscripts which differ are significantly different at $P<0.05$ (on the basis of average stepwise t-test groupings).

	Climatic region	Av. rain (mm)	No. days>35^{0}	No. days<5^{0}
1	Coastal plain	$920^{(1)}$	$13^{(1)}$	$19^{(1)}$
2	Western foothills	$1160^{(1)}$	$3^{(1)}$	$41^{(2)}$
3	Coastal mountains	$1200^{(1)}$	$3^{(1)}$	$62^{(3)}$
4	Eastern foothills	$727^{(1)}$	$9^{(1)}$	$52^{(3)}$
5	High rainfall plains	$520^{(3)}$	$24^{(2)}$	$63^{(3)}$
6	High rainfall in the north east	$530^{(3)}$	$91^{(3)}$	$76^{(4)}$
7	Inland mountains	$412^{(4)}$	$6^{(1)}$	$105^{(5)}$
8	South western cereal belt	$300^{(5)}$	$35^{(2)}$	$80^{(4)}$
9	Western cereal belt	$350^{(5)}$	$95^{(3)}$	$85^{(4)}$
10	Northern and Western barley belt	$260^{(6)}$	$96^{(3)}$	$88^{(4)}$
11	Southern steppe	$220^{(6)}$	$31^{(2)}$	$86^{(4)}$
12	Central steppe	$150^{(7)}$	$87^{(3)}$	$79^{(4)}$

Fig.2: The relationship between soil type and climatic region at the 207 sites collected in 1984 (open circles) and 1985 (closed circles). Both soil types and climatic regions are arranged so that groups of greatest similarity are together. In the case of climate mild, wet environments are at the base of the y-axis while cold, dry environments are at the apex. In the case of soils neutral non-calcareous are at the left of the x-axis, and alkaline, calcareous or saline soils at the right Descriptions of the soil types and climate regions are in Table 1 and 2 respectively.

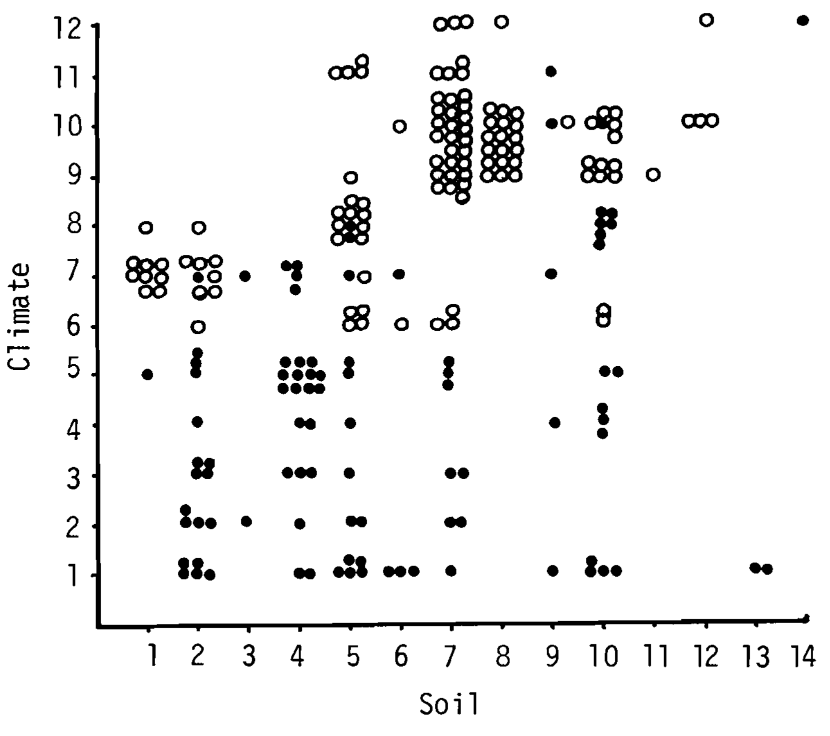
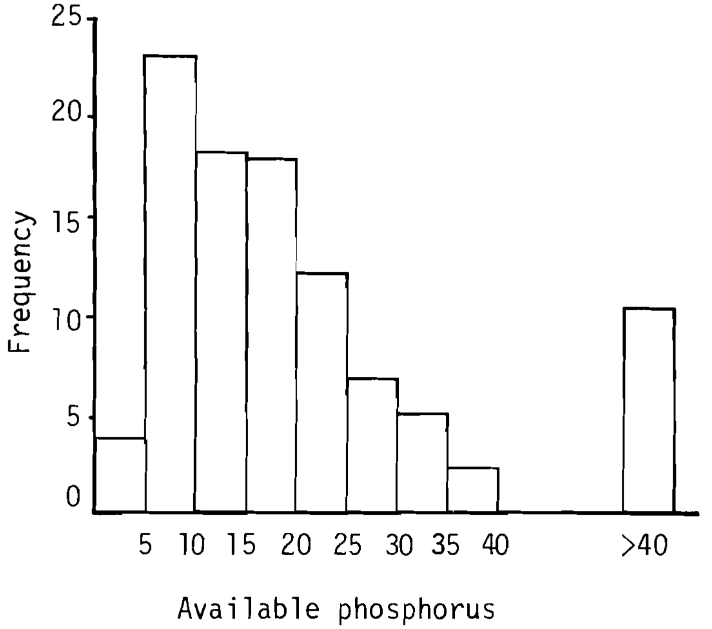


Fig.3: The frequency distribution of available phosphorus (Olsen P) in 207 marginal-land soils.



Distribution of native legumes

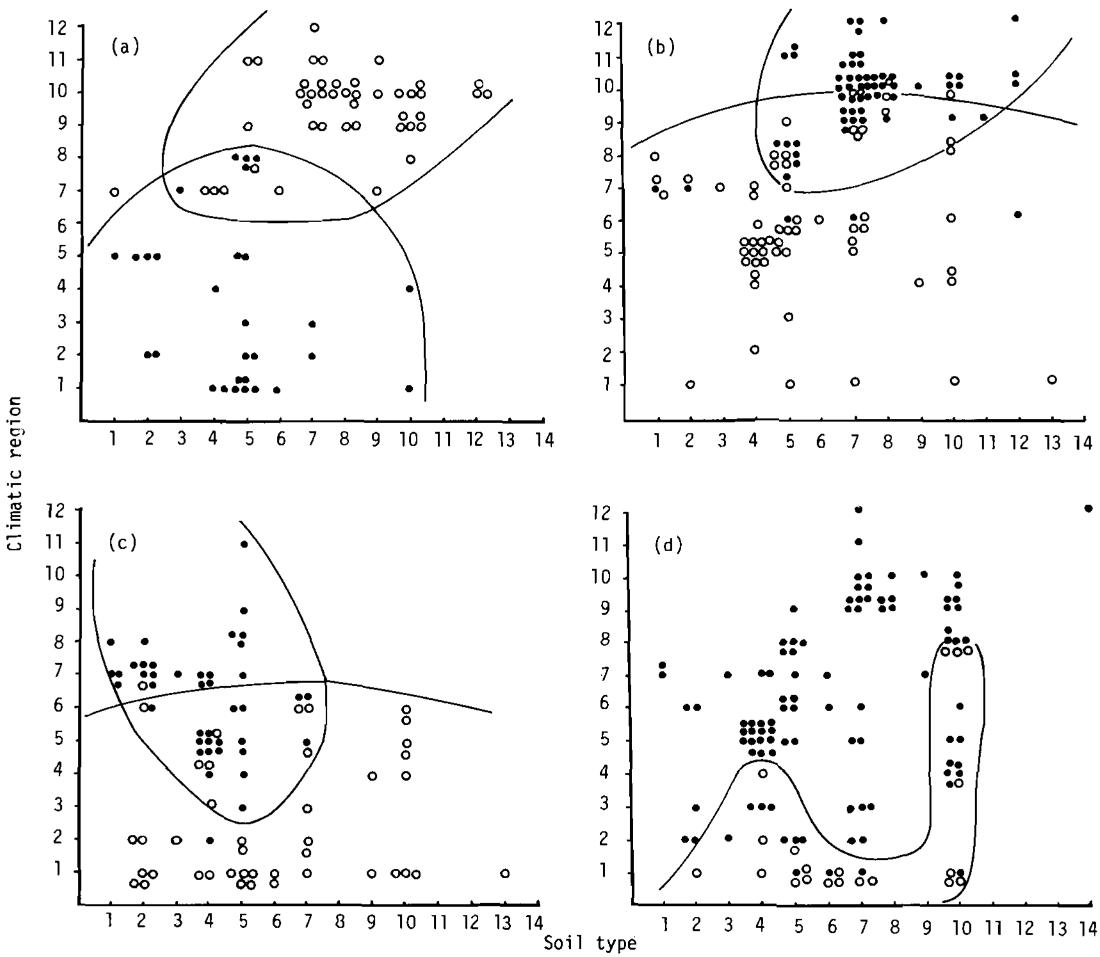
More than 2100 accessions of 97 species were collected (Table 3). Of the 17 genera there were 34 species of Trifolium, 23 of Medicago, and 9 each of Astragalus and Trigonella. The medics represent nearly all of the 28 annual species (Small 1981), while the clovers, although an impressive collection, represent only a small proportion of the annual species as a whole. In terms of the number of accessions the clovers (775 accessions) and medics (531 accessions) again predominate, although there were large collections of Astragalus (204 accessions), Trigonella (179 accessions), and Onobrychis (107 accessions).

Because of lack of space it is not possible to show the distribution of all 97 species in relation to soil and climate: in Fig.4 the distributions of seven species are displayed. In Fig.4b Astragalus asterias is shown to be a species of arid areas, in contrast to A. hamosus, which is rare in the arid areas and common in the higher rainfall areas. In Fig.4a there is a similar separation of M. radiata (in the dry areas) and M. blancheana in the wetter areas. In Fig.4c the distribution of Trifolium pilulare is affected more by soil type: it is restricted to the less calcareous soils, although it is also absent from the coastal plain. In contrast T. lappaceum is restricted to areas of high rainfall regardless of soil type. Finally in Fig.4d the distribution of M. rigidula is contrasted with the Australian species (those used in commerce in Australia), M. rigidula occurring throughout Syria

Table 3. Genera collected from 207 marginal land sites sampled in 1984 and 1985, and the number of species and the number of accession of each genus.

Genus	Number of species	Number of accessions
Anthyllis	1	8
Astragalus	9	204
Biserrula	1	7
Coronilla	2	28
Hippocrepis	1	48
Hymenocarpis	1	74
Lathyrus	3	24
Lens	1	5
Medicago	23	531
Onobrychis	4	107
Ornithopus	1	9
Pisum	1	2
Scorpiurus	1	42
Securigera	1	7
Trifolium	34	775
Trigonella	9	179
Vicia	4	55
Total	97	2105

Fig.4: The distribution of (a) Medicago radiata (open circles) and M. blancheana (closed), (b) Astragalus hamosus (open and A. asterias (closed), (c) Trifolium lappaceum (open) and T. pilulare (closed), (d) M. rigidula (closed) in relation to all collections of species with Australian cultivars (open). The climatic regions and soil types are arranged as in Fig.2.

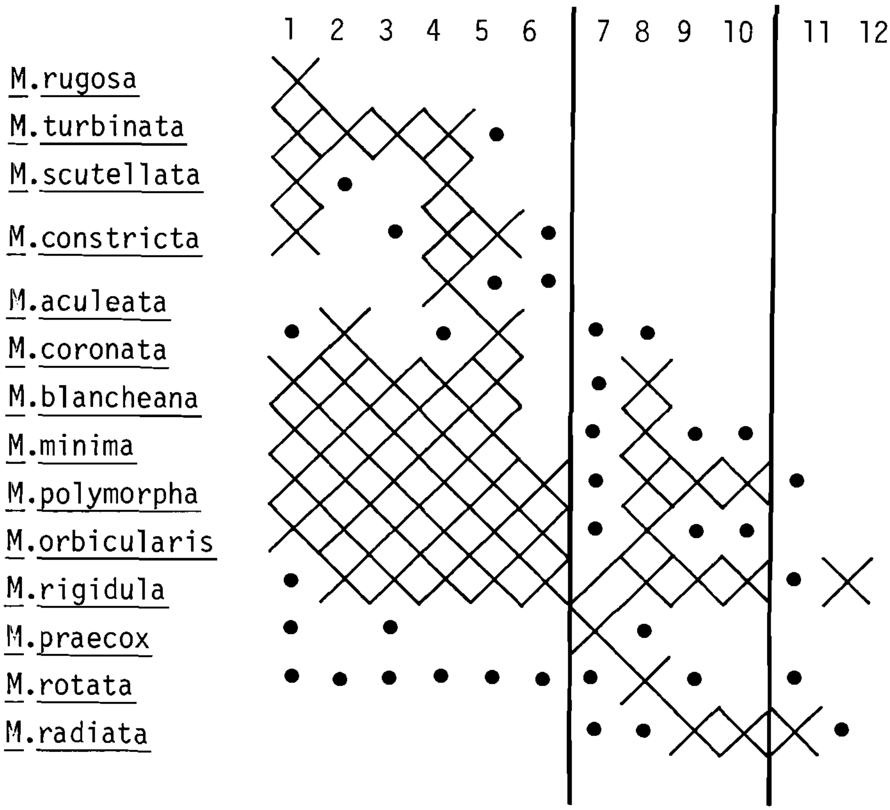


(although it is rare along the coast), while the Australian species are either confined to areas of mild climate or, (in the case of M. truncatula) confined to soil group 10.

The effect of climate on the distribution of medics is further clarified in Fig.5. The climatic regions are arranged in order of severity from left to right, the presence of a cross indicates that a particular species occurs in more than 20% of the sites, while the circle indicates its presence at a lower frequency. The Syrian cereal zone is confined to regions within the vertical lines. It is clear that most medics are common in the least severe environments, 11 species being classified as frequent in one or other of the higher rainfall regions. Within the cereal zone there are eight frequent species, three of them, M. praecox, M. rotata, and M. radiata, being not frequent in high rainfall regions. Easily the most frequent species in the cereal zone are M. rigidula and M. polymorpha. In the two most arid environments only M. radiata and M. rigidula are classified as frequent. Again it is worth noting that the Australian species appear to be confined to the high rainfall regions, M. rugosa being frequent only in region 1, M. scutellata in regions 1 and 4, M. littoralis rare in group 1, and M. truncatula very rare in regions 1 and 2, with an outlier in region 8. The other medics, not shown in Fig.5, were never frequent: these are M. disciformis (a first recording for Syria, in region 5), M. granadensis (regions 1 and 5), M. intertexta (regions 1 and 3) M. murex (regions 1, 5, and 6), and M. noeana (region 6).

Of the clovers, an even smaller proportion have penetrated into the cereal zone, with only T. bullatum present in three of the four climatic regions of that zone. Most of the clovers which have

Fig.5: Distribution of 14 medics in relation to the climatic regions (see Table 2). The presence of a cross indicates that the species occurs at more than 20% of the sites in the region, and of a closed circle, at less than 20%. Absence of a cross or circle indicates absence of the species.



penetrated into the cereal zone and beyond are low growing, compact species with very small seeds: only T. pilulare would seem to hold promise as a pasture species. T. subterraneum, which is one of the world's important clovers, occurs commonly in groups 2, 3, 4, and 5 - the coastal mountains and the low hills immediately to the east of the ranges (Eastern foothills). T. cherleri, another commercial clover, has a similar distribution.

In climatic regions 11 and 12 easily the most common plants are Astragalus and Trigonella. While the latter, particularly T. monspeliaca, tend to be small species, some of the Astragalus show promise as pasture plants.

Ecotypic differentiation within the native populations

In order to study ecotypic differentiation, and to conduct a preliminary evaluation, the seeds collected from marginal-land sites were grown in nursery rows. Briefly, this involved germinating 20 seeds (where available) in 'Jiffy pots' in a greenhouse and, after hardening the seedlings, transplanting them to the field in rows 1.5m apart, and 50cm between plants, within rows. The following parameters were measured: time to flowering, leaf area, petiole length, internode length, length of peduncle, flowers per head, nodes to first flower, pods per head, seed per pod, and hardseededness. We will briefly discuss the relationship of time to flowering and seed size to annual rainfall, as examples of adaptation. Only the collection of 1985 will be discussed.

Table 4 lists the average rainfall at the sites from which the 25 species with 10 or more accessions were collected, the mean number of days to flowering, the correlation coefficient squared (r^2) between rainfall and flowering time, mean seed size, and the correlation coefficient (r^2) between rainfall and mean seed size. The stars indicate the degree of significance.

Of the 25 species the flowering times of 18 and the seed size of 8 were related to rainfall. The strongest correlations were amongst the clovers, and the weakest amongst Astragalus, though there were exceptions in both cases. Whenever there was an association, flowering time was later in wetter environments. Strangely, between species, there appeared to be no relationship between rainfall and flowering time; for example the mean flowering time for Astragalus tribuloides was 147 days, even though the mean rainfall for that species was only 221mm, whereas T. tomentosum, with a similar mean flowering time (146 days), occupied sites with a mean rainfall of 435mm. Clearly, while flowering time is an important adaptive character within species, different species have other methods for coping with aridity.

Seed size varies markedly between species. Onobrychis crista-galli, with its heavily spined pod, has seeds of nearly 14mg, while the paper-thin pods of T. campestre and T. tomentosum have seeds of less than 1mg: in the latter, small seeds would appear to be a protection against grazing. However the larger seeds of Scorpiurus muricatus are not protected in this way, although the pods resemble the larvae of insects, which may deter grazing. Those species which do show ecotypic differentiation for this character generally have seeds of 2-3mg, the exception again being O.

Table 4. Relationships between days to flowering and rainfall, and mean seed size and rainfall, for the 25 species collected in 1985 for which there were ten or more accessions.

Species	Number of accessions	Mean annual rainfall (mm) [(1)]	Mean days to flowering	Flowering [(2)] $100r^2$	Mean seed size (mg)	Seed [(3)] $100r^2$
Astragalus asterias	62	269	144	0.05NS	1.32	12.1** (+)
A. schimperi	11	279	135	6.9 NS	3.95	68.9*** (-)
A. hamosus	27	383	141	27.5**	3.16	14.2* (-)
A. tribuloides	25	221	147	37.6**	0.79	0 NS
Coronilla scorpioides	13	301	133	12.5 NS	2.31	39.9* (+)
Hippocrepis unisiliquosa	32	350	124	74.3***	3.59	15.0* (+)
Hymenocarpus circinnatus	24	411	128	76.8***	7.24	0.2 NS (-)
Medicago orbicularis	11	452	134	62.2**	4.50	8.38 NS (-)
M. polymorpha	49	403	134	15.6**	2.73	18.6** (+)
M. radiata	37	274	133	45.0***	2.66	8.42 NS (+)
M. rigidula	37	352	132	49.5***	4.53	0.12 NS (-)
M. rotata	14	320	132	12.0 NS	5.24	0.0 NS (+)
Onobrychis crista-galli	46	312	140	33.6***	13.89	25.0** (+)
Scorpiurus muricatus	13	461	143	4.14 NS	10.71	11.1 NS (+)
Trifolium angustifolum	13	326	148	35.3*	3.42	9.12 NS (-)
T. argutum	15	335	147	0.5 NS	1.38	22.7 NS (+)
T. bullatum	36	365	140	39.4***	0.67	1.24 NS (+)
T. campestre	28	395	141	78.4***	0.37	6.4 NS (-)
T. pilulare	20	381	145	42.0**	3.43	0.4 NS (+)
T. purpureum	10	377	156	82.6***	1.34	17.6 NS (+)
T. spumosum	10	472	149	61.4**	2.47	65.2** (-)
T. tomentosum	18	435	146	51.1**	0.73	0.8 NS (+)
Trigonella asteroides	16	266	141	58.0***	0.60	11.7 NS (+)
Tr. monantha	30	281	134	29.9**	1.00	4.4 NS (+)
Tr. monspeliaca	53	333	133	6.1 NS	0.82	4.4 NS (+)

(1) Mean rainfall at all sites from which a species was collected.

(2) $100r^2$ values (r = correlation coefficient) of the relationship between days to flowering of each accession and mean annual rainfall

(3) $100r^2$ values of the relationship between seed size of each accession and mean annual rainfall.

crista-galli. In summary variation in seed size, while important for adaptation to dry environments in some species, is clearly determined by different factors of the environment, including rainfall, and probably grazing.

Conclusion

While analysis of this work is still at a preliminary stage, it is not possible to draw final conclusions. However already there is much that is clear.

(1) The deficiency in soil phosphorus, though widespread on marginal land, is the exception rather than the rule, occurring on about 25% of sampled sites. Since the deficiency is not related to either climatic region or soil group, soil analysis would seem to be a pre-requisite before using superphosphate to improve marginal land.

(2) While few direct comparisons have been made, it seems likely that soil fertility, in chemical terms, is higher on marginal land, than adjacent arable land. One direct comparison which was made near Breda, showed that the organic matter content of marginal land (3.2%) was more than treble that of the adjacent arable land (1.1%).

(3) The legume flora is of great diversity, and constitutes a valuable resource for improving both marginal and arable land. In many cases populations are such that the degree of genetic erosion may be less than has been estimated in the past.

(4) Because of their natural distribution it seems unlikely that the species developed as pasture cultivars in Australia will be of significant value in west Asia. To replace them the widely indigenous M. rigidula would seem to be most promising. M. polymorpha (which is represented in Australia), and M. rotata, would also, on the basis of their distribution, seem promising.

(5) Even after consideration of only two characters, flowering time and seed size, almost all species show ecotypic differentiation in respect to annual rainfall. This emphasises the importance of using the native species for developing pastures on marginal and arable land. - **T.A.M. Ehrman and P.S.Cocks.**

Experiment 2: Use of superphosphate on marginal land-effect on the native pasture and on sheep productivity (Preschedule ML2)

In the previous section we discussed the availability of phosphorus on marginal land, about 25% of which is likely to be deficient in P and so respond to fertilizer application. If legumes are abundant, application of superphosphate alone may well result in substantial increases in productivity.

This single management practice, although simple in concept, is difficult to assess objectively for two reasons. Firstly, marginal land is extremely variable. Soil depth varies from a few cm, or even no soil to over 1m in isolated pockets. In these circumstances small plots exhibit excessive variability in experimental results. Secondly, even if growth of herbage increases it does not necessarily follow that there will be an increase in animal productivity. We have therefore designed an experiment in which plots are large (3ha and 6.5ha), where animal productivity is measured in addition to herbage yield, and all financial inputs and outputs are monitored.

The site chosen comprises pasture dominated by the annual grasses, *Bromus* and *Avena*. Over 40 legume species are also present, the most abundant being *Trifolium campestre*, *T. tomentosum*, and *T. stellatum*, all of which are common on marginal land in most parts of Syria (see previous section).

The experiment is factorial with three rates of superphosphate equivalent to 0, 12 and 28 kg P/ha, and two stocking rates: low (0.8

ewes/ha) and high (1.7 ewes/ha). The treatments are arranged in a randomised complete block, replicated three times, the total area being approximately 83 ha.

Superphosphate was broadcast in November 1984 and the effect on vegetation and herbage yield was monitored during the following growing season (reported last year). Sheep were introduced to the plots in October 1985, after having been previously mated in August and September. Ninety Awassi ewes were divided into groups of five, each containing 2, 3, 4, 5 and 6 year old ewes. Each group was then permanently assigned to large (6.5ha) or small (3ha) plots representing the low and high stocking rates respectively in each of the fertilizer treatments. During the season the sheep grazed the plots from early morning to sunset and were sheltered at night. The sheep were fed with barley grain during late pregnancy and early lactation (December to February), and in July and August when in preparation for mating. Barley was also fed (700 g/ewe/day) whenever the average liveweight in the group was less than 46kg. Superphosphate was again applied to the plots in September 1986.

Sheep mass was recorded on a weekly basis throughout the season. Milk production was also recorded - on a daily basis - for each group following removal of the eight-week-old lambs for sale in March.

Herbage was sampled on seven occasions in 1985/86: at monthly intervals from December to February and then at 2 to 3 week interval in March and April. At each occasion, 30 samples were collected from each plot along a transect between opposite corners. Fifteen of these were from inside protective cages (60 x 60cm x 30cm high) and the remainder were from matched sites near the same cages. The cages were placed on new sites after each sampling: thus herbage availability (outside the cages) and herbage yield (growth between harvests inside cages) was measured. Each sample consisted of four cylindrical units (10.5cm diameter) taken to a depth of 10cm, and the plants, together with a large portion of their root systems, were removed. These were separated in the laboratory into legumes, grasses, and herbs and the number of plants of each were recorded. The roots were separated and discarded and the shoot portion of each category dried and weighed. Samples were stored for chemical analysis. Soil was sampled to a depth of 10cm in March and analysed for available phosphorus.

Seed yield was measured in June. Thirty samples (20 x 20cm) were taken (from quadrats inside and outside the cages) in each plot, all vegetation was removed together with the top 1cm of soil, and seeds were separated from soil and trash, bulked, counted and weighed.

Results

The phosphorus level in the soil has improved as a result of phosphate application (Fig.6). While 83% of the samples analysed in the control treatment had values less than 10ppm of P (approximately the critical level), the medium and high treatments always gave values greater than 10 and 15 ppm respectively. It is clear that use of fertilizer has corrected the phosphorus deficiency.

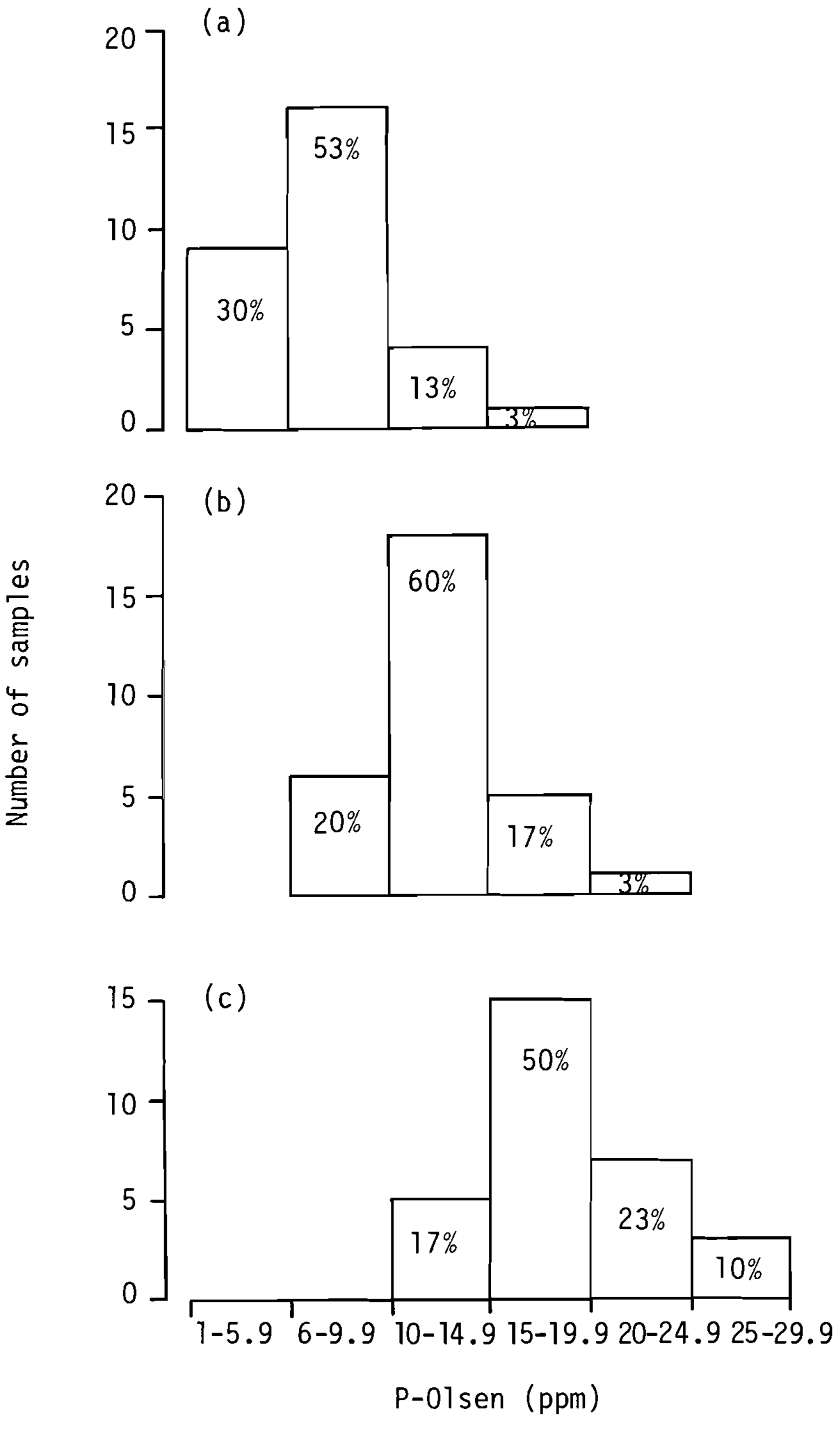


Fig.6: Frequency distribution of available phosphorus level (Olsen P) in marginal-land soils at Tel Hadya after

The response of grasses to phosphorus was slight and not significant (Fig.7a), while that of the legumes was substantial and significant (Fig.7b). The response in legumes occurred in pasture availability (open quadrats) as well as in total growth (protected quadrats): indeed it appears likely that the response in available pasture was the greater (in that there appeared to be a response to high over medium application rate). Productivity before March was low, about equal to that of the preceeding year, and was unlikely to have contributed signficantly to animal production (but see later).

Where productivity is less than 1t/ha it is likely that the difference between herbage inside and outside the quadrats is close to the amount consumed by animals. If this is so, utilization of the pasture was low, probably not more than 20%. However, higher utilizations would probably damage the pastures capacity to produce seed, and so reduce the future potential.

The effect of phosphate fertilization and stocking rate on total herbage availability during the season is shown in Fig.8. Phosphorus application resulted in significantly higher herbage biomass over the control in spring, while the availability of herbage was significantly greater under low compared with high stocking rate in April. These differences in herbage availability were reflected in liveweight, and, as shall be seen, in the amount of supplementary feeding necessary to maintain weight. Sheep grazing fertilized pasture were consistently heavier than control sheep and sheep at low stocking were significantly heavier than sheep at high stocking rate during February to July (Fig.9) - even though, as stated earlier, pasture availability was extremely low in February.

Fig.7: Productivity of (a) the grass component of native pasture and (b) the legume component after two years application of zero phosphorus (left), 12kg/ha of phosphorus (centre), and 28kg/ha of phosphorus (right). Sampling dates are indicated by day/ month.

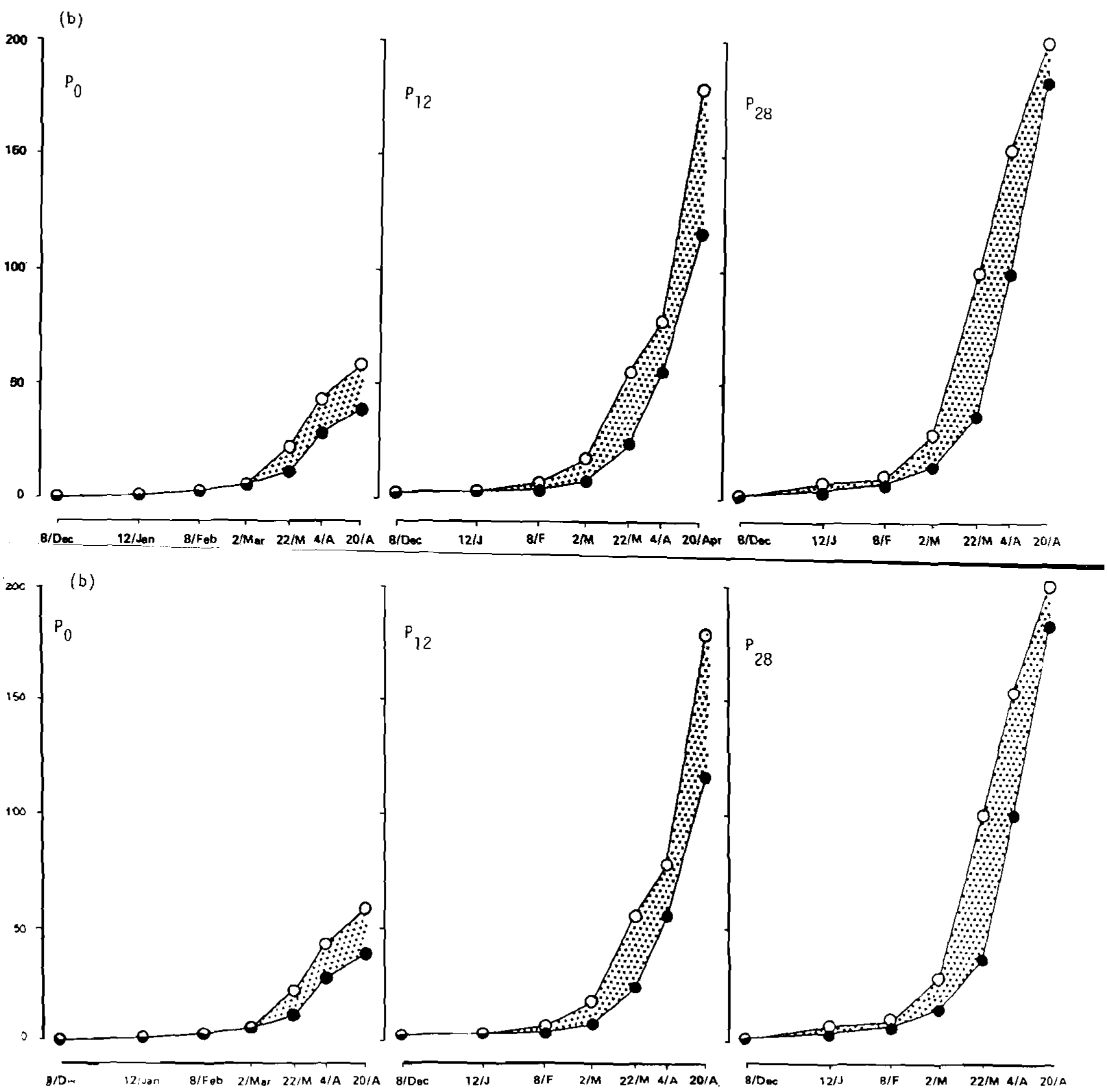


Fig.8: Herbage available at various dates in 1986 under sheep grazing at (a) the three levels of phosphorus, zero (closed circles), 12kg/ha (open circles) and 28kg/ha (triangles), and (b) two stocking rates, low (open circles) and high (closed circles). The bars are LSD at P<0.05 (Fig.8a) and P<0.01 (Fig.8b).

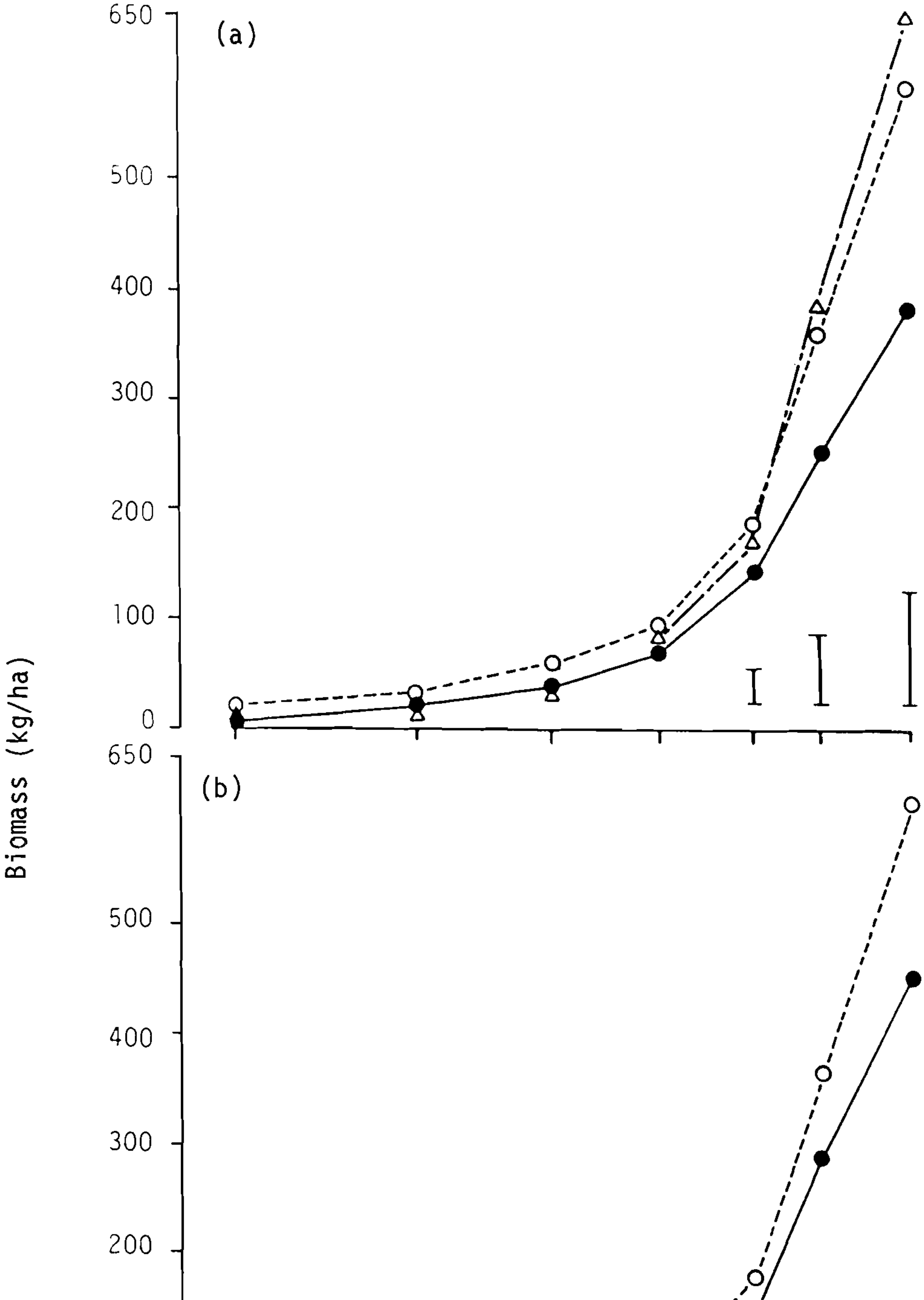
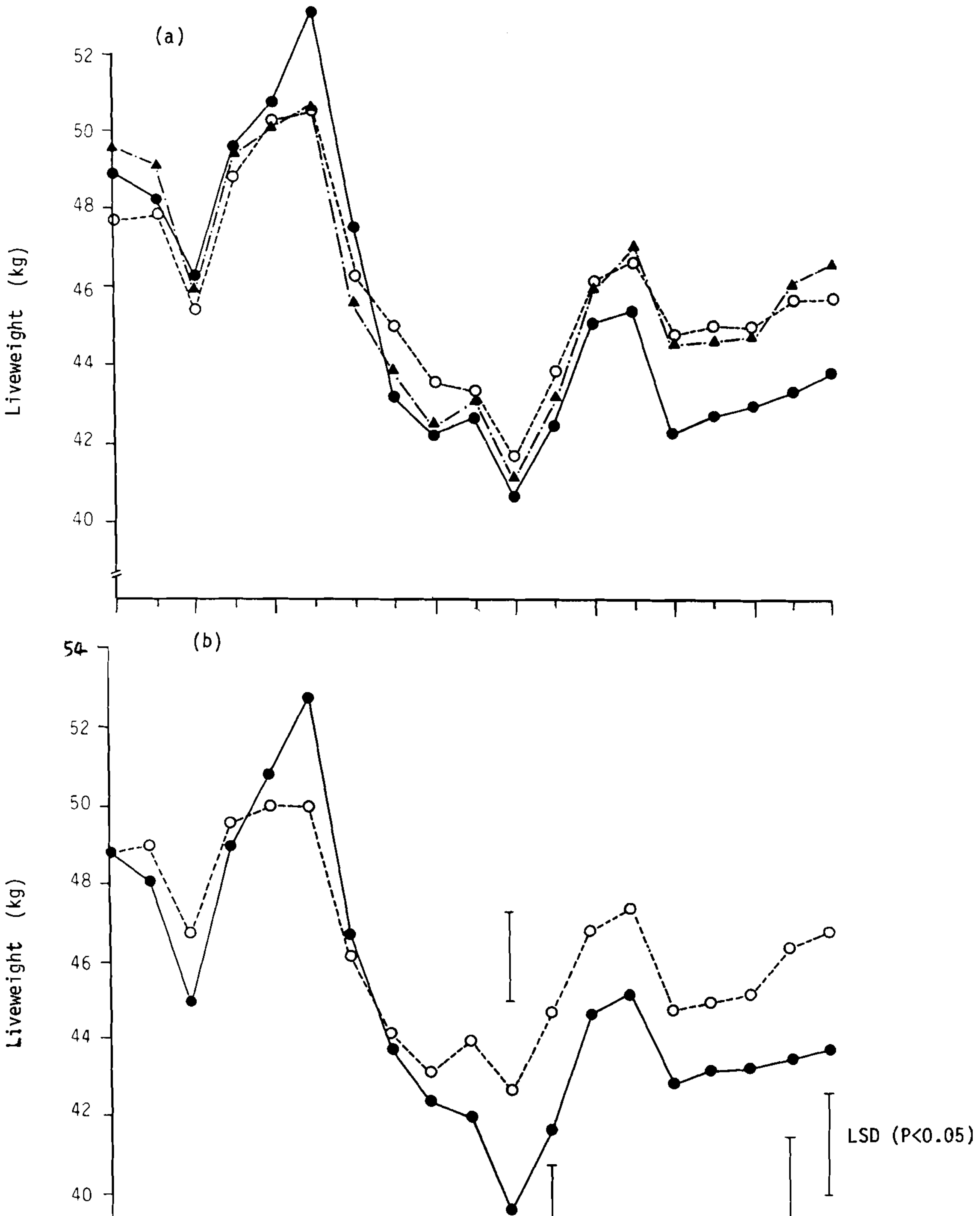


Fig.9: Mean liveweight of ewes at various dates in 1986 as a result of (a) three levels of phosphorus, zero (closed circles), 12kg/ha (open circles) and 28kg/ha (closed triangles), and (b) two stocking rates, low (open circles) and high (closed circles).



Increases in ewe liveweight, although not saleable, are important for proper reproductive function and fertility at mating (Thomson and Bahhady in ICARDA Annual Report, 1985). In this study all groups with average liveweight less than 46kg/ewe are fed with a supplement of barley grain. The data in Table 5 show that ewes grazing on phosphate-treated pasture at low stocking rate did not require any supplementary feeding, while all other treatments did: this is reflected in the amount of barley fed to the ewes, which is shown in Table 6.

Unlike liveweight, milk production (Table 7) seems un-affected by phosphorus and stocking rate although the level of production was generally better at the low stocking rate.

Ultimately we believe the response to phosphorus will be through its effect on the proportion of legumes in the pasture, the legumes supplying nitrogen which is deficient on marginal lands. In 1985/6 the effect of phosphate on legume seed mass and number at the end of the grazing season is shown in Table 8. Both mass and number were significantly higher as the result of using the fertilizer (especially the high phosphate rate), thus confirming the previous season's results and, at least to date, confirming the hypothesis that phosphate encourages legumes. - **A.E. Osman, L. Russi and E.F. Thomson**

Table 5. Effect of phosphate fertilizer and stocking rate on sheep liveweight (kg)* at the end of the 1986 grazing season.

Phosphate rate (kg P/ha)	Stocking rate	
	Low (1.3 ha/ewe)	High (0.6 ha/ewe)
0	45.1	42.5
12	48.4	42.9
28	47.0	45.9

* Each value is an average of 15 ewes; all treatments with value <46 kg were supplementary fed (July - August with 700g barley/ewe/day for one month).

Table 6. Amounts of barley grain fed to six flocks (kg barley/ewe) grazing marginal land receiving nil, medium and high superphosphate at low and high stocking rates

	P applied (kg/ha)		
Stocking rate (ewes/ha)	0	12	28
0.8	20.4	0	0
1.7	20.4	20.4	19.6

Table 7. Average milk production (g/ewe/day) during the first 10 weeks of lactation in 1986, in relation to phosphorus[1] and stocking[2] rate treatments.

Treatment	Week following lamb weaning in March									
	1	2	3	4	5	6	7	8	9	10
a) Fertilizer rate (kg/ha)										
0	943	997	979	884	806	691	654	545	446	427
12	942	870	825	796	788	690	713	611	505	423
28	776	772	785	806	771	722	731	560	505	395
b) Stocking rate										
Low	947	977	887	834	763	684	630	512	437	418
High	828	863	842	814	749	708	606	527	451	412

[1] Each value is an average of 30 ewes

[2] Each value is an average of 45 ewes

Table 8. Effect of rate of superphosphate fertilizer application to marginal land on seed yield* and seed number* for pasture legumes.

Fertilizer rate (kg P/ha)	Seed yield (kg/ha)	Seed number/ (per m^2)
0	13.4	1475
12	19.9	1936
28	38.7	3226
LSD ($P<0.05$)	10	730

* Each value is an average of 90 quadrat samples.

Experiment 3: helminth parasites in sheep
(Preschedule ML2)

In studies of grazing management an important factor is the health of livestock. Especially at high rates of set-stocking, the risk of internal parasites is significant and presents to farmers a problem which may not exist in traditional systems. While it is not the aim of Experiment 2 to study internal parasites - indeed the sheep are drenched as a matter of routine - it seemed a good opportunity to monitor internal parasites, especially lungworms, and see if there was any indication of a build-up in numbers at high rates of stocking.

Preliminary work in 1984/85 had already indicated that lungworms are a greater threat to sheep than the gastro-intestinal helminths. Of the lungworms, *Dictyocaulus filaria*, a species living freely in the lung passages, is less common than the parenchyma dwelling parasites of the *Protostrongylidae*.

In 1985/86 rectal samples of faeces were taken at monthly intervals from November to July from four of the five sheep in each treatment of experiment 2. The four sheep were paired and the faeces bulked for each pair. Helminth eggs were counted using the McMaster technique and lungworm larvae counted after extraction from faeces. All sheep were drenched with Tetramizol in February 1986 to remove any differences between flocks.

The percentages of ewes infected with lungworms and gastro-intestinal helminths are shown in Table 9, together with the number of lungworm larvae in faeces. Rates of infection with

ble 9. Percentage of ewes infected with gastro-intestinal and lung worms and faecal revelance of lungworm larvae. Ewes were treated on 16.2.86.

te of sampling	26.11	19.12	24.1	18.2	27.2	5.3	23.4	27.5	19.6	24.7	Mean
astro-intestinal worms (percent ewes infected)											
arshallagia	72	81	67	83	11	7	31	19	11	11	29.3
ematodirus	28	31	19	31	0	1	3	0	3	0	11.6
rongylids	67	67	11	42	0	47	72	56	6	33	40.0
ungworms (percent ewes infected)											
ictyocaulus	36	50	3	67	6	6	17	8	11	8	21.1
otostrongylids	69	83	61	72	81	64	47	44	42	67	63.1
ungworms; larvae per g faeces in infected ewes											
ictyocaulus	-	-	-	41	0	1	2	2	5	3	-
otostrongylids	-	-	-	425	208	362	275	14	6	6	-

gastro-intestinal helminths were high in autumn, associated with the increased egg-laying activity of adults which is normal at that time. Infections with Nematodirus were about half those of Marshallagia and the Strongylids. Drenching in February halted egg laying, probably by removing most adults, but eggs re-appeared in faeces when surviving adults recommenced egg-laying, and larvae reached maturity. However, except in the case of the Protostrongylids, re-infection rates were low: egg counts were generally below 500/g faeces, a number considered to be insufficient to reduce productivity. However this rate of survival presents a long-term danger since it is likely that new populations will be resistant to the drenches and become more difficult to control.

Of the lungworms, the Protostrongylids were the most common, confirming the findings of the 1984/85 experiment. Only 21.1% of ewes were infected with Dictyocaulus filaria, while 63.1% were infected with the Protostrongylids. Furthermore, the free-living Dictyocaulus filaria appeared to be susceptible to the anthelmintic used, while the Protostrongylids were not. Not only were there more ewes infected by the latter, but also infection was more severe. While drenched ewes were voiding Dictyocaulus larvae at very low levels, counts of Protostrongylid larvae remained high.

In summary, after one year of the experiment there was no effect of stocking rate on number of parasites. This is to be expected since, if stocking rate has an effect it will be in the second or third year of the experiment.

In the broader view, Protostrongylids appear most likely to have a detrimental effect on productivity in the region. Since they form permanent calcified nodules in the lungs, damage becomes progressively worse as sheep get older. These increase the probability of mechanical pneumonia, and eventual death. Control is difficult, not only because Protostrongylids are well protected in the lungs from anthelminthics, but also because they use snails, as intermediate hosts and these are difficult control.

Expertise at ICARDA in identifying lungworms is increasing and more detailed studies are planned. These should also be conducted on farm flocks to confirm the findings, and to establish research priorities relevant to the real farm environment. Ultimately this research should expand to north Africa and other west Asian countries since tha Protostrongylids are known to be a widespread problem. - **G. Orita, E. F. Thomson, A.E. Osman**

Experiment 4: ecology and productivity of marginal land at Adamy
(Preschedule ML8)

Adamy is a small village about 100km south-east of Aleppo on the boundary between the cereal-cropping zone and the steppe. This land is marginal because of low rainfall whereas that at Tel Hadya is marginal because of poor soil. Previously our studies have been restricted to the latter, but it is clearly of importance that we should understand the former since it occupies a huge area of land. It is also the land most prone to 'desertification'.

The marginal land at Adamy is typical of many countries of the region where, although animal grazing is the primary use, every now and then cereal crops are grown in years of relatively high rainfall. It is this cultivation which is probably the main cause of desertification, abandoned fields being a common feature. These fields either remain as bare ground for several years or gradually become covered with unpalatable weeds. Moreover the areas which are as yet not cultivated are intensively grazed in the spring by sheep and goats from nearby villages.

The work was carried out in 1985/86 with the objectives of:

- Defining the biological and environmental resource base of grazing land at Adamy.

- Relating soil fertility, plant genetic resources and plant numbers to available herbage and primary productivity.

- Studying pasture productivity and species composition in relation to different periods of protection from grazing

The study area consisted of land which was open to grazing and land which had been protected for two to several years following planting with shrubs (*Atriplex* spp.). Three transects, each of 200m, were identified: the first open grazing land, the second land which had received protection for two years, and the third land which had been protected for five years. Along each transect, plant numbers and available herbage were measured at 50 sites together with depth of soil and chemical analysis of the 0-10cm layer of soil. Available herbage was measured four times at monthly intervals, starting in mid-January 1986. Additionally, total herbage (protected by cages) was measured on the open grazing area at the end of the season: this was not necessary in the other two transects since they were not grazed.

Seed yield was measured in 0.2m x 0.1m quadrats in mid May 1986 on all three transects. Fifty quadrat samples were collected along each transect and a further 50 in the cages.

Results

Grasses were the most dominant component of the herbaceous vegetation in winter. For example, in January, grasses constituted 96%, 98% and 99% of total herbage yield in the grazed area, and the areas protected for two and five years respectively. In April, however the corresponding values were 32%, 49% and 68%, where the weeds (species other than grasses and legumes) had gained importance, especially in the grazed area. Relating herbage yield of grass to number of plants (Fig.10) indicated a strong relationship ($100\ r^2 = 85^{***}$) in January. This confirms earlier work on higher rainfall marginal land. Also confirming earlier work was the result that this relationship weakened with time: only 52% of variability in the herbage yield in April could be attributed to variation in the number of plants (Fig.10b), although plant number clearly remained an important determinant of yield.

The effect of protection on grass density and yield is shown in Table 10. Protected areas had 3 to 9 times more plants than unprotected areas, and these differences were reflected in yield. On the other hand, difference between two and five years protection was observed only in spring: in March the former exceeded the latter by 45% in numbers and by 40% in yield, and in April, by 56 and 109%, respectively. It seems that the *Atriplex* shrubs when fully grown might compete with and replace the herbaceous cover even in the absence of grazing.

Even one year of protection from grazing substantially benefits seed yield. Seed number almost doubled inside compared with outside the cages, and seed mass was also (but not proportionately) greater (Table 11). Total seed yield after two and five years protection was respectively 426% and 87% higher than under open grazing, while yield of grass was respectively 211% and 100% higher compared with open grazing.

Also of interest is the difference in botanical composition of seed in the different treatments. In the protected areas the number

Fig.10: The relationship between herbage yield and number of grass plants in (a) January and (b) April.

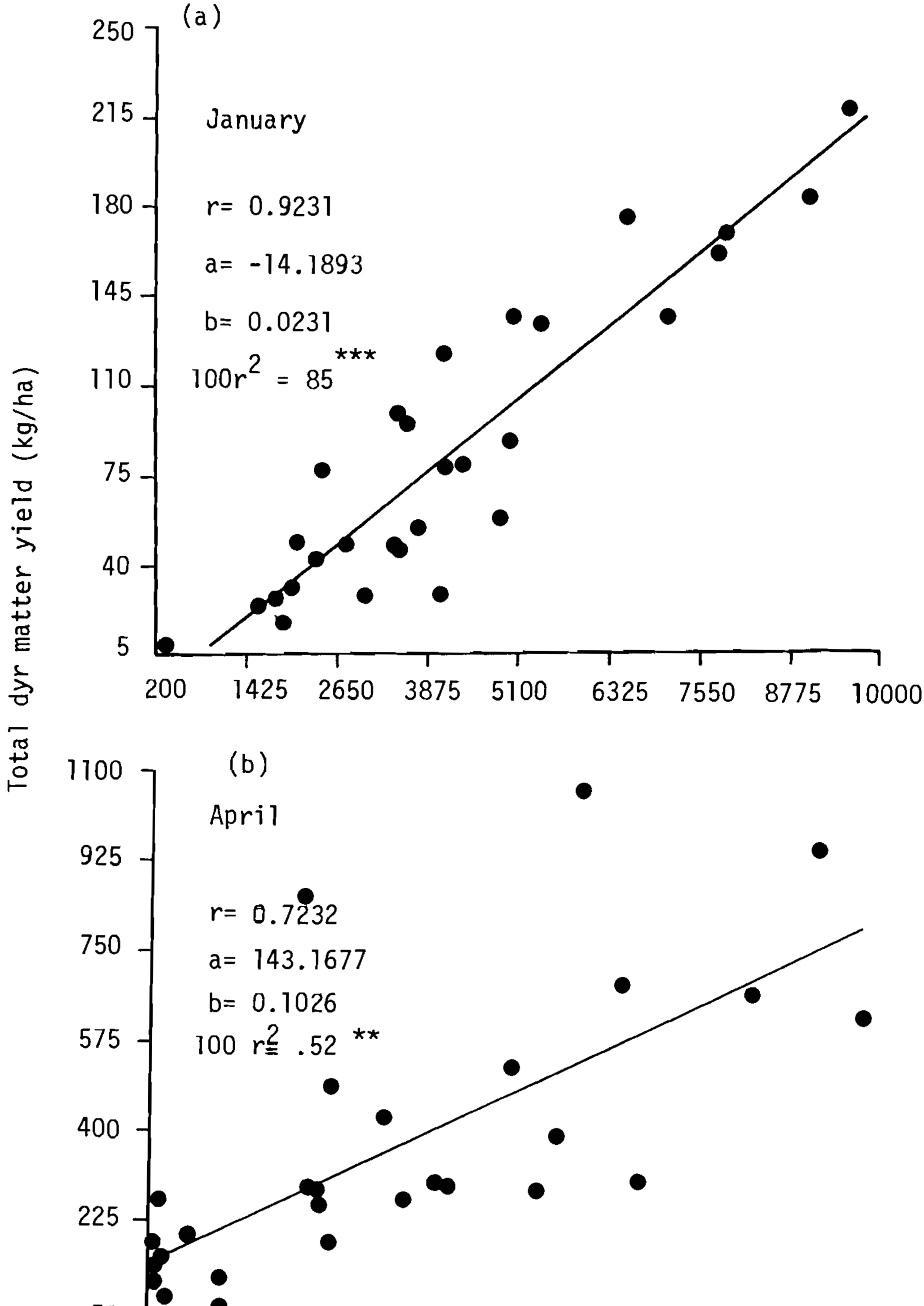


Table 10. Grass plant density (number/m^2) and yield (kg/ha) on marginal land at Adamy in four months in 1986 in relation to grazing.

Level of protection	Month							
	January		February		March		April	
	Density	Yield	Density	Yield	Density	Yield	Density	Yield
Unprotected (opengrazing)	1374	16.0	1511	24.3	1680	34.4	381	31.6
Two years protection	5585	102.0	5559	136.3	6555	264.9	2983	303.9
Five years protection	5233	99.7	6309	172.8	4520	188.9	1912	145.3

Table 11. Number of seeds and seed yield at the end of the growing season (May 1986) in relation to different levels of protection from grazing at Adamy.

Level of grazing	Total (grass+legume+others)		Grasses	
Open grazing:	number (per m^2)	mass (g/m^2)	number (per m^2)	mass (g/m^2)
outside cages	2960	3.0	781	2.6
Inside cages	5789	3.8	1027	2.9
Two years protection	4956	15.8	4119	8.1
Five years protection	2620	5.6	2159	5.2

[1] Grasses+legumes+weeds

of grass seeds represented over 80% of the total, while in the open grazing area it represented only 26%, suggesting that grazing favours weed species. In none of the areas were legumes a significant component.

The study has revealed that many of the findings in the higher rainfall marginal lands apply at Adamy: for example yield depends on plant number, grazing depresses seed production, and primary productivity is very low. One important difference however is the lack of legumes. If ICARDA's philosophy of dependence on pasture legumes is to apply in these dry areas it seems likely that the sowing of leguminous pastures will be necessary. We clearly face a formidable task in selecting adapted species, developing appropriate establishment techniques, and devising suitable grazing systems if the productivity of this land is to be increased. **-A.E. Osman and L. Russi.**

Experiment 5: effect of phosphate application on some pasture legumes native to marginal land (Preschedule ML6)

In understanding the ecology of marginal land, and in particular the ecology of response to superphosphate application, it is necessary to know not only what happens to plant communities as a whole but also what happens to components of the communities. The first step in doing this is to study the response of species individually: in this way the most responsive species will be revealed. Of course it is impossible to test each of the 97 legumes reported in Experiment 1, but it is important to know if variation in response is likely to exist, and to find easily determined indications of its existence.

In this experiment seven species (M. polymorpha selection from Tah, see Experiment 25, M. rigidula selection 716, M. noeana selection 2124, M. rotata selection 1943, M. truncatula cv. Jemalong, Astragalus hamosus, and Trigonella foenum-graecum) were sown at three rates of phosphorus (0, 10, and 40kg/ha) at five sites (Tel Hadya, Breda, El Bab, Jinderis, and Jableh, for rainfall see Table 12). The species were chosen on the basis of their being native plants of Syria and adequate amounts of seed being available. Trigonella foenum-graecum was included to give diversity: it was absent in Experiment 1 revealing that it is rare in Syria.

The treatments were arranged in a randomized complete block design with three replicates and a total area of 0.1ha. Prior to sowing the soil was sampled at depths of 0 - 15cm, 15 - 30cm and 30 - 45cm for available phosphorus: on the skeletal soils at El Bab

Table 12. Effect of phosphorus treatment on herbage yield (kg/ha) (a) in winter* and (bO in spring at five sites (annual rainfall given). Data are the mean for seven legume species.

Treatment P (kg/ha)	Breda (281 mm)	El Bab (305 mm)	Jableh (864 mm)	Jinderis (471 mm)	Tel Hadya (328 mm)
			(a) winter		
0	357[b]	90[a]	2941[a]	109[c]	269[a]
10	359[b]	101[a]	3454[a]	226[b]	271[a]
40	475[a]	98[a]	3706[a]	356[a]	305[a]
Mean	395	96	3367	231	282
LSD	90	18	809	72	90
			(b) spring		
0	1563[a]	240[a]	9600[a]	1324[a]	1245[a]
10	1488[a]	302[a]	9209[a]	1913[b]	1296[a]
40	1734[a]	230[a]	10952[a]	3283[c]	1380[a]
Mean	1595	257	9920	2173	1307
LSD	320	70	2177	534	214

* Means at each season followed by the same letter do not differ significantly. The means are compared vertically only, that is within each site ($P<0.05$).

however it was possible to sample to 0 - 15cm only. The results of soil sampling (Fig.11) indicate that, on the basis of a critical phosphorus level of 10ppm (Olsen phosphorus) responses were to be expected at all sites except Jableh.

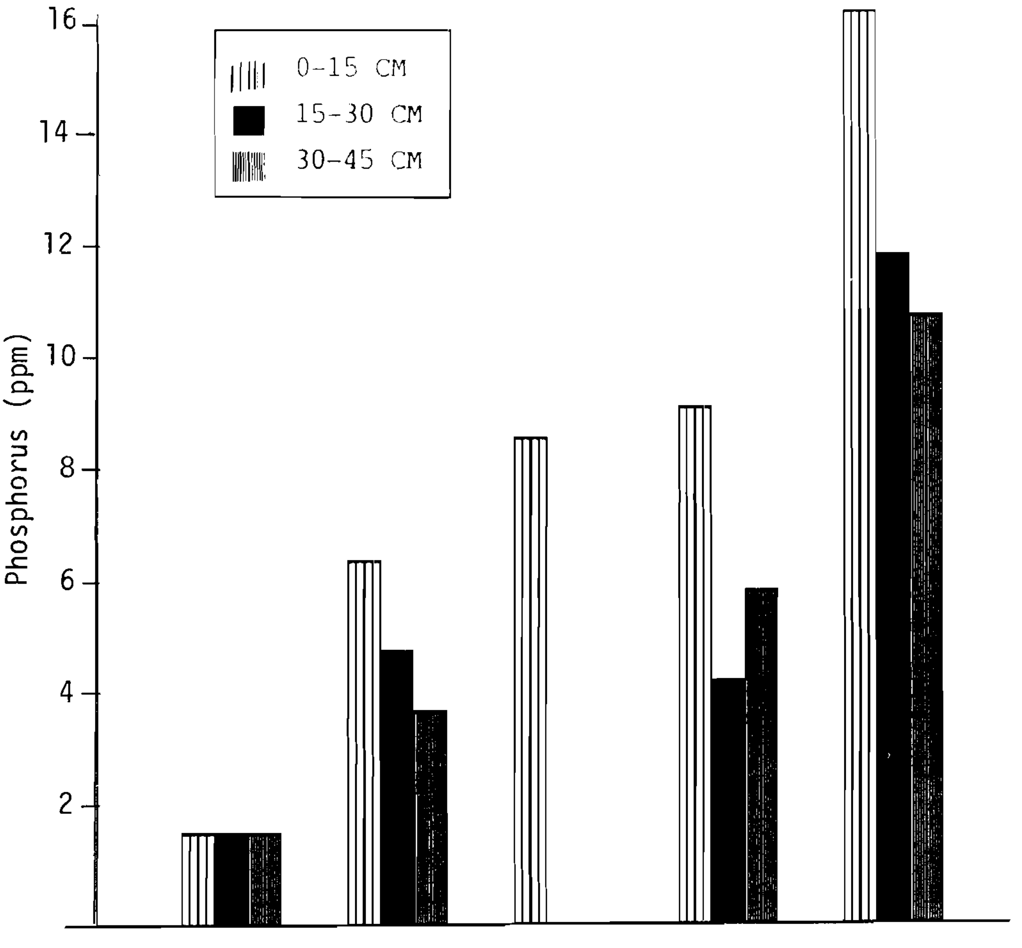
Plots were sown on November 15 at 30kg/ha, the seeds being broadcast on the surface of the soil, and covered by hand raking. Herbage was harvested on two occasions, winter and spring: at each harvest plants were cut to ground level in 1m x 1.5m quadrats. Plant number, herbage yield, plant height, root length and root weight were estimated at each harvest. The samples have been stored for chemical analysis.

Seed yield was measured in June, in quadrats of 1m x 1.5m, pods were separated from soil and other residues, threshed and the seed mass recorded.

Herbage production

The data in Table 12 show the average response in herbage yield of all species at the five sites in winter and spring. At El Bab, Jableh and Tel Hadya there was no significant difference in herbage yield at either harvest, while at Breda there was a response to only the highest phosphorus rate (40kg/ha) in spring. At Jinderis, application of 40kg/ha produced significantly more herbage than 10kg/ha which in turn produced significantly more than zero phosphorus, in both winter and spring.

Fig.11: Phosphorus content (Olsen P) of the soil at (from left to right) Jinderis, Tel Hadya, El Bab, Breda, and Jableh at three depths 0-15 cm, 15-30 cm, and 30-45 cm.



Of the sites the lowest herbage yield was at El Bab: 96 and 257kg/ha in winter and spring respectively. This contrasted with Jableh where yields were 3367 and 9920kg/ha. The high yields at Jableh compared with all other sites is attributed to its mild winter (less than 15 days under $5^{o}C$) and high rainfall (over 800mm per year).

Seed production

Effect of phosphorus on seed yield is shown in Table 13. As with herbage, there was no response to phosphorus at Breda, Jableh and Tel Hadya, except that at Breda, within the species *M. polymorpha* and at Tel Hadya *T. foenum-graecum* produced significantly higher yields at 40 kg P/ha than at zero phosphorus. Seed yield at El Bab was not recorded because of losses from the plots associated with high wind.

Seed production at Jinderis is shown in Fig.12. Although there were some increases in seed yield the only significant ones were in *T. foenum-graecum*, *M. polymorpha*, and *M. rotata*. Evidently seed yield was less sensitive to phosphorus than herbage yield. Further results from this experiment await chemical analysis. - **M.A. Turk, P.S. Cocks, and Prof. A.J. Willis (University of Sheffield).**

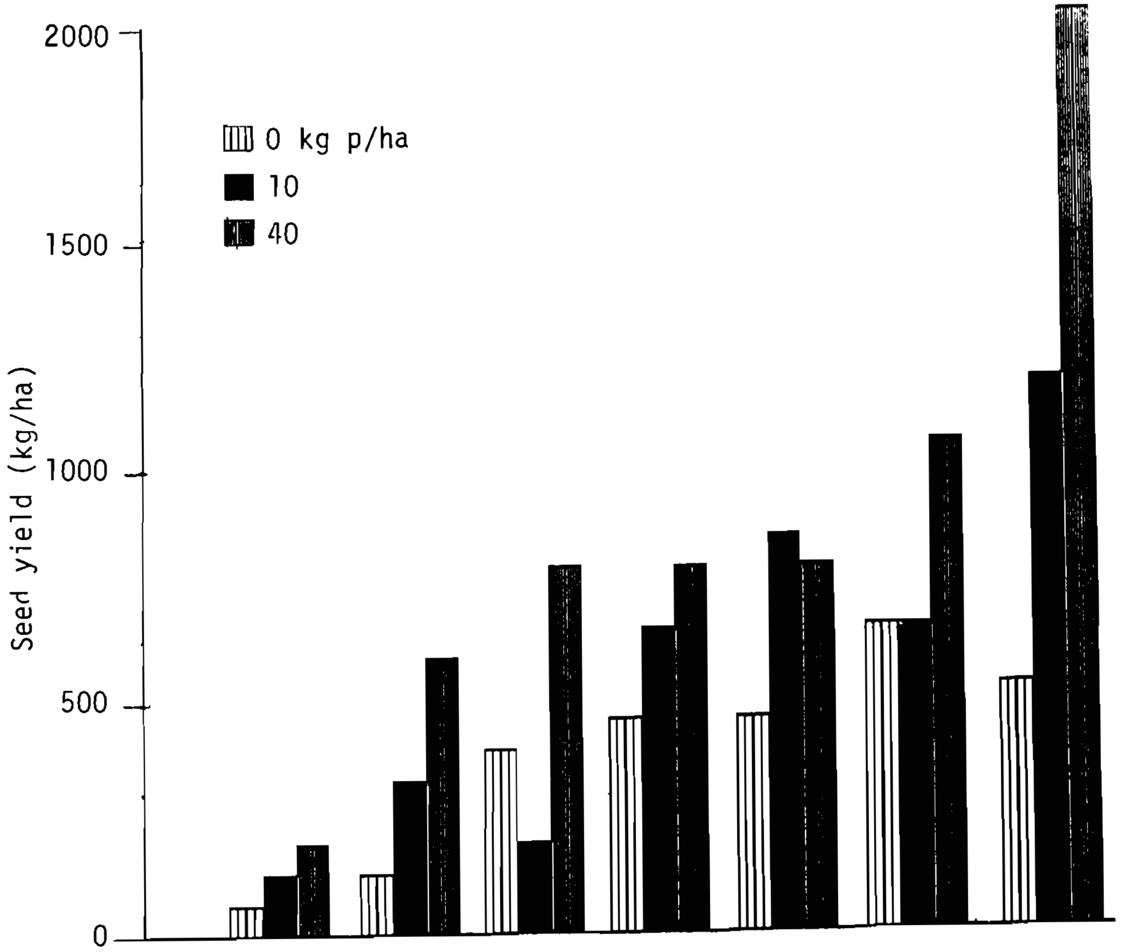
Table 13. Effect of phosphorus application on seed yield (kg/ha)*.

Treatment P (kg/ha)	Breda	El Bab	Jableh	Jinderis	Tel Hadya
0	400[a]	N.A**	935[a]	414[c]	336[a]
10	393[a]	N.A	796[a]	612[b]	325[a]
40	463[a]	N.A	863[a]	914[a]	389[a]
Mean	419		864	647	350
LSD	106		323	164	92

* Means followed by the same letter do not differ significantly. The means are compared vertically only, that is within each site ($P<0.05$).

** N.A. not available

Fig.12: Effect on seed yield of applying phosphorus at Jinderis to (from left to right) *Medicago truncatula*, *Astragalus hamosus*, *M. polymorpha* *M. rigidula*, *M. noeana*, *M. rotata*, and *Trigonella foenum-graecum*.



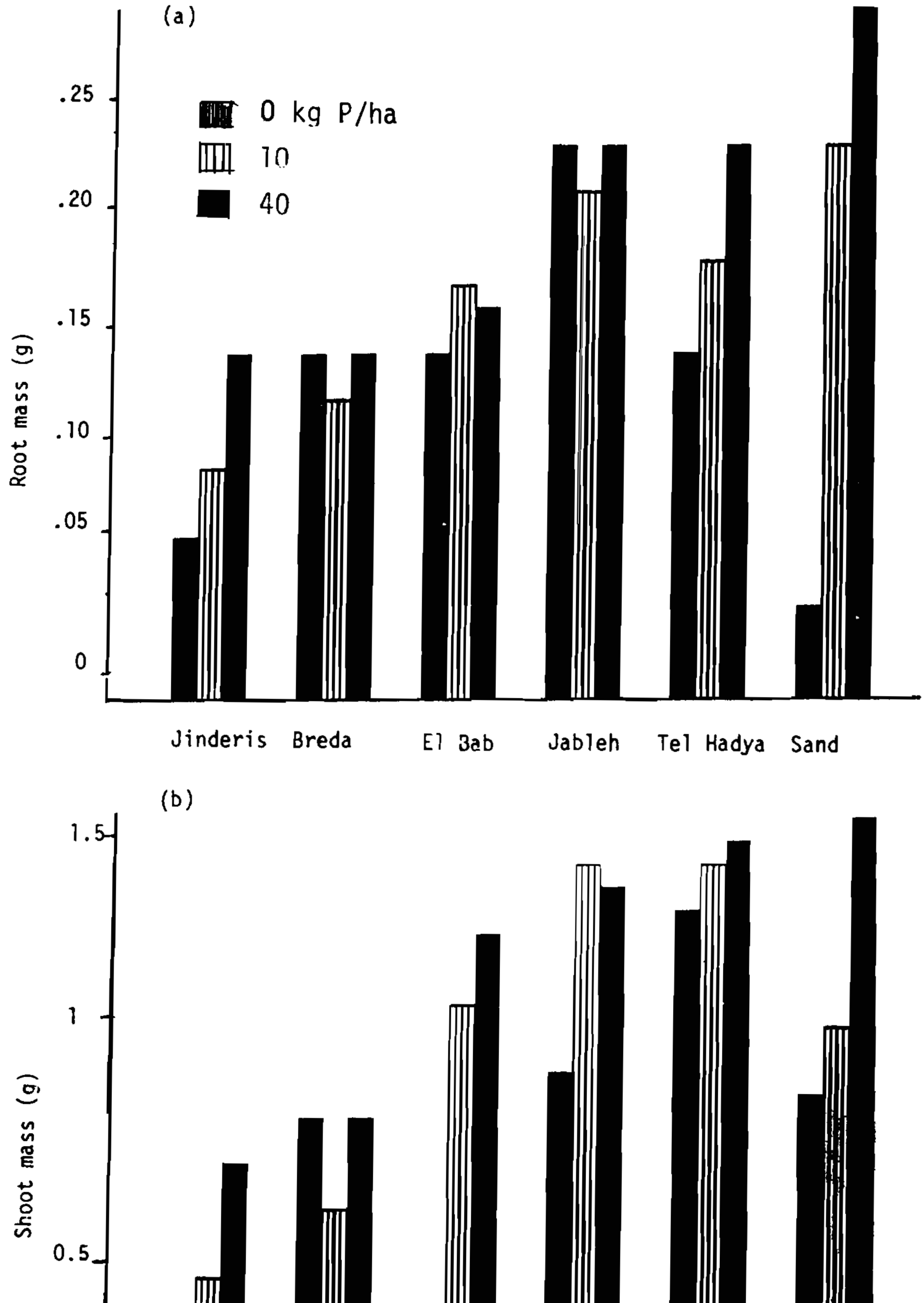
Experiment 6: response of legumes to phosphorus in controlled conditions (Preschedule ML6)

The objective of Experiment 6 was to eliminate the climatic variable that existed in Experiment 5: the same legumes were treated with the same levels of phosphorus in the same soils, but the experiment was in the greenhouse at Tel Hadya. Ten seeds from each species were sown in polyethylene bags (30cm x 10cm) and thinned to five. The three phosphorus levels were added according to the surface area of the bags, the sand having previously been washed with 5% HCl to remove nutrients. All nutrients except phosphorus were added to the sand according to Rorison's nutrient solution which was added to each bag twice a week.

Root and shoot mass were measured at five harvests at approximately ten days intervals: in this short report only the results of harvest 3 are presented. The effect of phosphorus on root and shoot mass is shown in Fig.13: there were significant responses to phosphorus using the Jinderis, El Bab and Tel Hadya soils, and a very large response in the washed sand. Plants in soils from Breda and Jableh failed to respond. Responses in the greenhouse tended to be larger then in the field, and the order of fertility of soils changed, the Tel Hadya soil being equally productive as that at Jableh. It was also interesting that roots were more responsive than shoots.

This experiment is at a very early stage of its analysis. The most important result - whether there are differences between species - awaits final statistical analysis. - **M.A. Turk, P.S. Cocks, and Prof. A.J. Willis (University of Sheffield).**

Fig.13: Effect of phosphorus on (a) root mass (g/plant) and (b) shoot mass (g/plant) of plants grown in washed sand or soils obtained from the sites indicated. The values are means for all sown species



INTRODUCING ANNUALLY RESOWN FORAGE LEGUMES INTO ROTATIONS WITH CEREALS

Forages are an alternative to fallow in cereal/fallow rotations. They are defined as legumes which are grown for hay, straw or grain and which may also be grazed. They are not managed for self-seeding, and are not expected to regenerate spontaneously as would be the case with annual pastures. They are not used extensively: in Syria about 8% of zone 1, and about 5% of zone 2. In some countries they are sown as mixtures with cereals.

In view of the huge diversity of Mediterranean legumes surprisingly few have been used as forages. Kernick (1978) notes that three species of chickling and nine of vetch are potentially important, but of these very few have been tested and used. In Syria there are very small areas of chickling (where the rainfall is less than 300 mm), and slightly larger areas of bitter vetch (where rainfall is more than 400 mm), and common vetch (rainfall is 300 to 500 mm). Several other species have been tried, most notably forage peas and possibly Scorpiurus muricatus, some annual clovers, and snail medic.

Because of the restricted use of forages, .especially in dry areas (less than 300 mm), the question of how forages are to be used is of great importance. Until recently ICARDA has assumed that they will be used for hay production. Alternative uses, for example grazing andseed and straw production, are recognized, but important as these practices may be, they do not form part of the objectives of genetic improvement projects. In finding out how important they are, ICARDA scientists, working with farmers, have arrived at certain conclusions which alter our concepts both of utilization and the most appropriate species. The point has already been made in

In line with this reasoning, and partly as a result of on-farm experimentation, the palatability of forages is also being tested. The principal stimulus for this work came from the discovery, recorded in the 1985 Report, that forage peas are unpalatable. That work has now been extended to other forages - Narbon, woollypod and common vetch.

The breeding work itself has several objectives: to select cultivars of wide adaptation to ensure success in contrasting environments, to select for resistance to several leaf (bacterial blight, and downy and powdery mildew) and root (root knot and cyst nematode) diseases, and to select for non-shattering seed pods in common vetch. Selection of improved Narbon vetch, woollypod vetch and chickling was further expanded in 1985/86. All selection of forages is made in pure legume communities: we believe that mixtures of cereals and legumes are likely to reduce yields of subsequent cereal crops.

Experiment 7: on-farm forage and livestock experiments at Breda (Preschedule L9)

The on-farm work was conducted at Breda, a small village about 40 km east of Tel Hadya where rainfall is about 280mm. The farmers are barley and livestock producers, their source of income being livestock products using barley (grain and straw) as the main source of feed. They practice two rotations: continuous barley and barley/fallow. Previous surveys have shown that feed availability is the main factor limiting livestock production.

The aim of Experiment 7 was firstly, to study the utilization of forage crops by these resource-poor farmers, secondly, to provide information to plant breeders and agronomists which will help them set realistic objectives, thirdly, to test the concept that forage crops can be introduced into barley/fallow rotations without reducing the yield of barley, and finally, to measure the productivity and profitability of barley/forage rotations. The experiment is an example of a systems approach to crop improvement which provides a vehicle for finding solutions acceptable to farmers to problems identified by both farmers and scientists. It is an essential part of our work with forage crops.

The experiment is a collaboration between PFLP and FSP, and, since the experiment uses large areas of land, has had the full involvement of farmers. Recently the Syrian Ministry of Agriculture and Agrarian Reform has also become involved. It has now completed three cropping seasons and some of the highlights are presented here. A fuller report, including complete statistical analysis, will be presented next year.

The experiment was conducted on up to 10 farms each year and on each farm adjacent areas were sown to vetch (V) and chickling (C) respectively. Each species was separated by a 10m fallow strip and 20 kg/ha of phosphorus was applied to half the area. After each year of forage a uniform,unfertilized barley crop was sown, and grain and straw yields were measured. The forages were utilized either for grazing by lactating ewes, grazing by lambs, or they were allowed to mature for seed and straw. Very early in the experiment the hay option was found to be unrealistic because of the high cost of harvesting.

Average grain and straw yields, with and without phosphorus, (average of three years) are shown in Table 14. Seed yields of chickling were substantially higher than those of vetch, whether or not phosphorus was applied. Indeed, chickling was clearly the farmer's choice for straw and seed production. At both levels of phosphorus, straw yields of the two species were similar, although there was a strong response to phosphorus. The yields are similar to those reported in on-farm forage agronomy trials conducted by FSP.

Barley grain and straw yields after fallow and after the two forage crops are shown in Table 15. Differences in grain and straw yields in the absence of phosphorus were small and probably not statistically significant. However, the barley derived considerable benefit from the residual phosphorus applied to the preceeding forage. The higher yields of grain and straw after chickling may be associated with its higher nitrogen-fixing potential and lower susceptibility to sitona weevil damage than vetch (ICARDA, 1985, p 31), although this remains to be proved. These results are of great importance because they demonstrate that, on farmer's fields, forages do not reduce barley yields, something which has always worried farmers.

The second way of using forages is by direct grazing to produce milk or to fatten lambs (Table 16). Traditionally communal grazing land, which is available in most villages, would be used to produce these sheep products. Grazing of both forages and marginal land

Table 14. Grain and straw yields (kg/ha) of vetch and chickling, with and without phosphorus (average of three years) - the results of experiments on farmers' fields.

	Vetch		Chickling	
	-P	+P	-P	+P
Grain yield (n=19)	297	575	648	893
Straw yield (n=19)	981	1413	931	1284

Table 15. Grain and straw yields (kg/ha) of barley after fallow, vetch (V), and chickling (C), with and without phosphorus (average of three years).

	Preceding crop				
	Fallow	V -P	V +P	C -P	C +P
Grain yield (n=13)	791	735	1029	878	1181
Straw yield (n=9)	1049	1039	1364	1133	1426

Table 16. On-farm trials: productivity of farm flocks grazing annual forage crops (F) and communal grazing (C) in three years.

	1983/84	1984/85		1985/86	
	F	C	F[1]	C	F
Number of flocks	1	5	5	2	4
Stocking rate (sheep/ha)	6.6	-	20.1	-	22.4
Duration of grazing (days)	35	31	31	28	28
Herbage yield (kg/ha)	383	-	844	-	950
Herbage available	2.2	-	2.3	-	0.9
Daily milk yield (g)	731	542	535	771	815
Milk yield (kg/ha)	168	-	349	-	508
Daily gain (g)	53	211	256	28	214
Gains (kg/ha)	12	-	91	-	141

[1] Forage in 1984/85 was chickling+vetch combined.

usually begins in late March when the forages and native pasture are rapidly passing from the vegetative to reproductive stage. In order to utilize the forages while their nutritive value is still high, high stocking rates were applied in all years except the drought year of 1983-84. Average daily milk yields were in the range 500 to 800g in all flocks. The similarity in milk yield is a reflection of the relatively good quality (not quantity) of communal grazing on marginal land: as we discussed earlier, the legume content of these pastures is often high. Farmers are therefore inclined to use marginal land to feed ewes, and feel that the forages are better reserved for fattening lambs, even though, as will be seen below, the reverse might be more profitable.

It now remains to compare the relative profitability of firstly, the rotation options, and secondly the grazing options. Comparison of different rotations, or between milk and meat, are fairly simple. Comparison between, on the one hand, grain and straw and on the other milk and meat is more difficult because, in the former, there is no conversion loss of plant to animal product to take into account. However, since farmers have the option of selling forages or using them for their own sheep, estimates of relative profitability are of great interest.

In Table 17 the relative profitability of the various rotations is presented, based on production of grain and straw. The use of fallow land, even for vetches without phosphorus, resulted in a 50 percent increase in net revenue from the rotation. If either vetch with phosphorus or chickling without phosphorus are used, profitability more than doubles, and chickling plus phosphorus was more than three times as profitable as barley/fallow (without

Table 17. Net benefits from barley-fallow and barley-forage rotations (abbreviations in the table are: BF = barley-fallow; BV = barley-vetch; BC = barley-chickling; P = phosphorus).

	Rotation				
	BF	BV -P	BV +P	BL -P	BL +P
Gross revenue; (SL/ha per 2 years)					
Forage grain	0	1115	2156	2430	3349
Forage straw	0	785	1130	745	1027
Barley grain	1305	1213	1698	1449	1949
Barley straw	839	831	1091	906	1141
Total per 2 years	2144	3944	6075	5530	7466
Total per year	1072	1972	3038	2765	3733
Direct costs; (SL/ha per 2 years)					
Cultivations	200	400	400	400	400
Broadcasting	127	254	381	254	381
Seed (140 kg/ha)	231	756	756	756	756
Fertilizer	0	0	120	0	120
Hand harvest[1]	300	600	900[2]	600	900[2]
Total per 2 years	858	2010	2557	2010	2557
Total per year	429	1005	1279	1005	1279
Net revenue SL/ha (per year)	643	967	1760	1760	2455
$/ha	64	97	176	176	246

Prices and costs in November 1986: forage grain SL 3.75/kg; barley grain SL 1.65/kg; all straws SL 0.80/kg; seed costs = grain prices; fertilizer SL 1.1/kg TSP; hand-harvest costs based on SL 20 per labourer day and 15 labour days/ha.

1 Excludes cost of transport and threshing.

2 Increased by 50% due to higher crop density.

phosphorus). It is clear, therefore, that replacing fallow with forage leads to substantial increases in farm income. Actual net revenues from the straw and seed will probably be lower than in Table 16 because of losses during harvest compared with our sampling: nevertheless introduction of chickling, in particular, is an exciting possibility for farmers in these dry areas.

Table 18 compares net revenues as a result of using forages for milk and for fattening lambs. In each case, a "poor" and "good" production level has been used, based on the outputs in Table 16. The price of milk is based on the current wholesale price of yoghurt. There was no charge for shepherding because this depends on flock size and the availability of family labour: in any event cost of shepherding will affect the profitability of each option equally. The results show that under high levels of productivity, the use of forages for lactating ewes is highly profitable, even ignoring the value of the gains in liveweight.

Under high levels of forage productivity, the net revenue from fattening lambs was lower than for producing milk, even after subtracting the cost of feeding lambs 400 to 800g/day of concentrate in order to get satisfactory growth rates. Feeding of concentrates was particularly necessary at 'poor' levels of productivity where lamb fattening was less attractive than producing grain and straw.

After three years work we now feel confident that replacing fallow with forage will substantially increase feed supply and hence farm income. However, the experiment also has important implications for ICARDA forage research. Firstly, we should reinstate chickling into the breeding project: it had clear

Table 18. Net revenue from a barley-forage rotation in which the forages are used for either milk production or lamb fattening under 'poor' and 'good' levels of productivity.

	Milk production		Lamb fattening	
	Poor	Good	Poor	Good
Output[1] kg/ha)				
Milk	170	500	-	-
Liveweight gain	10	140	100	350
Barley grain[2]	807	1105	807	1105
Barley straw[2]	1086	1395	1086	1395
Gross revenue[3] (SL/ha per 2 years)				
Milk	1700	5000	-	-
Liveweight gain	240	3360	2400	8400
Barley[2] (grain+straw)	2200	2950	2200	2950
Total per 2 years	4140	11310	4600	11350
Total per year	2070	5655	2300	5675
Direct costs (SL/ha per 2 years)				
Crop establishment[4]	1410	1537	1410	1537
Harvest cost (barley)	300	450	300	450
Concentrate feed[4]	-	-	700	1100
Total per 2 years	1710	1987	2410	3087
Total per year	855	995	1205	1544
Net revenue per year (SL/ha)	1215	4660	1095	4131
($/ha)	122	466	110	413

advantages over vetch and was originally deleted because of poor performance at Tel Hadya. Secondly we should place more emphasis on seed and straw production and less on herbage yield at full flowering - when hay is made. Thirdly, where we do measure herbage yield it should be with grazing in mind and, as will be seen later, include measurement of palatability. Finally, we should continue, and probably increase, our work on forages for dry sites relative to wetter sites. In the following sections we will discuss how consideration of these points will affect the objectives and procedures of our forage breeding. - **E.F. Thomson and M. Oglah (FSP).**

Experiment 8: selection for wide adaptation in forage crops (Preschedules F1, F12, F15)

In developing the forage crop alternative to fallow it is desirable to have widely adapted cultivars, at least to the extent that they can be recommended for particular rainfall zones. At present, while there are varieties available in most local markets, there are few officially registered cultivars the performance of which is documented and which can be widely recommended, while in Syria there are none.

The process of selecting for wide adaptation involves: firstly, preliminary plant screening and multiplication of seed in nursery rows; secondly, evaluation in microplots and advanced yield experiments differing from microplots in having fewer entries and larger plots; and thirdly, multilocation (regional) testing at five sites in Syria and Lebanon. Disease screening occurs at all stages and the palatability of the most promising lines is monitored.

In 1985/86 only woollypod vetch and Narbon vetch were screened in nursery rows. Strains of chickling were tested in microplots, while chickling, common vetch and Narbon vetch, were tested in advanced yield experiments. In the multilocation testing common vetch was the main species, although one variety of woollypod vetch, and one of Narbon vetch were also included.

Preliminary screening in nursery rows

One-hundred and thirteen accessions of woollypod vetch and 51 of Narbon vetch were screened in nursery rows in a cubic lattice design with three replicates. The accessions were scored on a 1-5 scale for establishment, seedling vigour, winter and spring growth, leafiness, growth habit, plant vigour, time to flowering and maturity, and susceptibility to disease. Woollypod vetch was also screened for leaf retention.

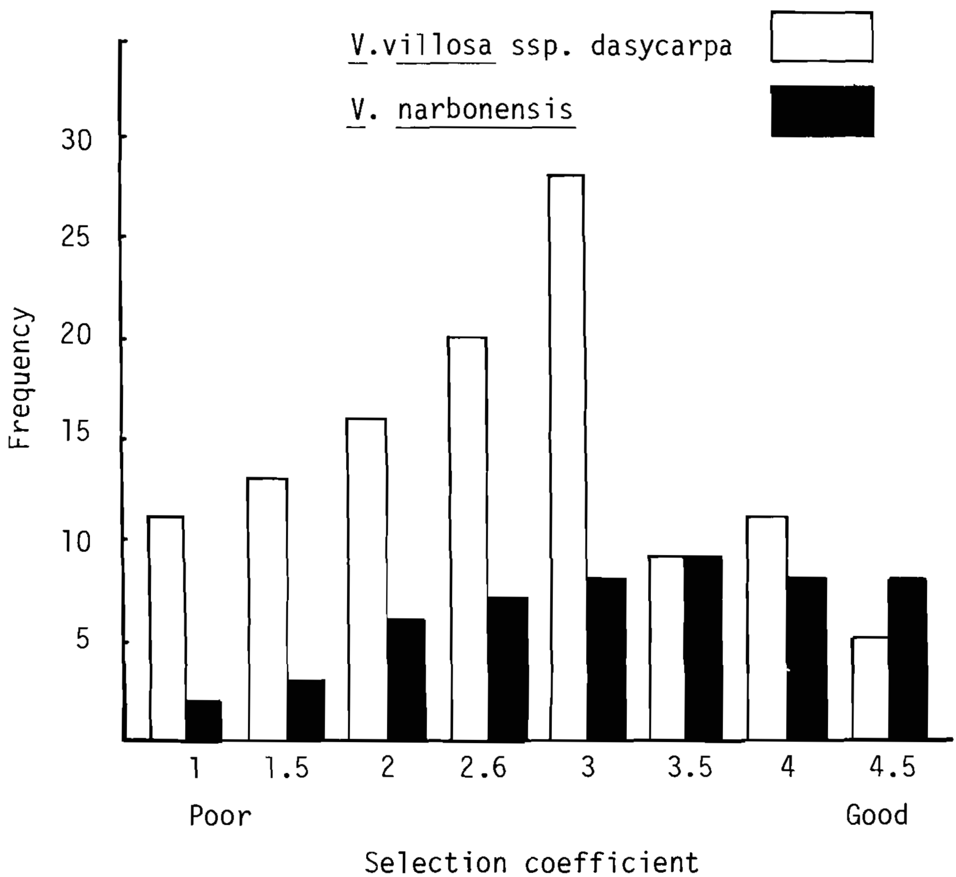
There was a wide range of variability in the mean score for all characters (the 'selection coefficient') (Fig.14). The twenty five best varieties of both Narbon and woollypod vetch were selected for further testing: the score of selected varieties ranged from 3.5 to 4.5. They will be included in microplot field trials at Tel Hadya and Breda in 1986/87.

Evaluation in microplots

Microplots provide the first opportunity for breeders to examine the agronomic characteristics of their material. Selection for traits such as high herbage production, seed yield, and early flowering begins in microplots.

Chickling was planted in 3.5m^2 microplots in a triple lattice design. The seeding rate was 80kg/ha and 16kg/ha of phosphorus was used. The whole trial was duplicated: one was harvested at the 100% flowering stage for the determination of herbage yield and the other was allowed to mature to measure seed yield and other agronomic traits.

Fig.14: Variability in the selection coefficient (1=poor, 5=good) of 113 accessions of woollypod vetch and 51 of Narbon vetch in nursery rows at Tel Hadya.



Forty-nine selections of chickling (three *Lathyrus ochrus*, two *L. cicera*, and 44 *L. sativus*) were tested in 1985/86. Herbage yield varied from 1830kg/ha to 4550kg/ha. The results in Table 19 show only the top 15 selections with seed yields ranging from 937kg/ha to 2039kg/ha. There was no control variety in the experiment because, as mentioned earlier, there are no official cultivars. However particular strains will be maintained in the experiments to measure genetic progress.

Days to 100% flowering varied from 104 to 120. Seed yield was significantly correlated with days to 100% flowering and also to date of full maturity (r = -0.43 and -0.39 respectively, P<0.01), whereas herbage yield was not so related. It is possible that the early maturing selections yielded more because they escaped the severe attacks of broomrape, (*Orobanche crenata*), and powdery mildew (*Erysiphe pisi*), both of which had severe effects on the seed yield of late-flowering selections.

It is worth noting that the seed yields in Table 19 are considerably in excess of those of common vetch (Table 20). This has also been observed on farmer's fields and is one of the reasons why farmers seem to prefer chickling in the dry areas. The great variability in herbage and seed yield and in flowering time gives us the opportunity to improve chickling very rapidly.

Advanced yield trials with chickling and common vetch

Under this heading there were two experiments to evaluate promising selections. In the first, 15 common vetches were

Table 19. Mean herbage and seed yields, and number of days to 100% flowering, for selection of chickling (Lathyrus spp.) grown in 1985/86.

Selection No	Herbage yield kg/ha	Seed yield kg/ha	Days to 100% flowering
461	4551	1919	118
451	4294	1244	117
464	4273	1676	114
54	4254	937	116
479	4192	1543	118
481	4188	1713	120
436	4136	1322	120
460	4071	1619	119
438	3941	1199	119
440	3864	1817	117
435	3833	1520	118
456	3803	1634	119
434	3746	1597	117
56	3718	2039	119
484	3702	1446	118
Mean	3414	1567	116
LSD ($P<0.05$)	991	354	2.34

Table 20. Mean herbage and seed yields, and number of days to 100% flowering, for 15 selections of common vetch (Vicia sativa L.) grown in advanced yield trials, 1985/86.

Selection No.	Herbage yield kg/ha	Seed yield kg/ha	Days to 100% flowering
2003	3039	1364	111
2020	3836	805	121
2021	3362	846	121
2023	3080	855	118
2024	3377	581	120
2025	3278	750	122
2027	2942	651	118
2023	2225	785	106
2040	2390	1081	103
2068	2982	903	116
2073	2490	1358	111
2100	2776	1110	115
1429	2441	1040	109
Acc. No. 713*	2762	1137	107
Acc. No. 2541* (local)	2944	1505	108
Mean	2929	985	114
LSD (P<0.05)	991	354	2.4

* Strain which was promising and sufficiently uniform to be tested as a complete accession, hence no selection number.

evaluated at Tel Hadya, and in the second, 16 chicklings (four *Lathyrus ochrus*, one *L. cicera*, and eleven *L. sativus*) were evaluated at Tel Hadya and Breda. Both groups of legumes were sown and managed in the same way as the microplots except that plot size was larger ($28m^2$).

Herbage yield of the promising common vetches varied from 2225kg/ha to 3836kg/ha (Table 20), while seed yield ranged from 581kg/ha to 1505kg/ha. Time to 100% flowering varied from 103 days to 122 days: seed yield was negatively correlated with this character ($r = -0.61$, $P<0.05$), the results indicating a clear need to continue the search for early maturing genotypes combining high, stable herbage yield with high seed production. As in microplots, great variability was found between selections at both Tel Hadya and Breda and there was also a highly significant site x genotype interaction.

Herbage production and seed yield were larger at Tel Hadya than at Breda, the means respectively being 2602 and 844kg/ha at Tel Hadya and 503 and 198kg/ha at Breda (Table 21). The poor production at Breda may have been due to lack of rhizobia, and there was also a severe weed problem. Two selections of *Lathyrus ochrus* (sels 104 and 385) produced large herbage and seed yields at both sites. The results further indicate the need to collect and test a far larger number of accessions of these species, especially from within the region, to establish a still wider range of genetic diversity from which to select.

The results with chickling are of special importance because they are the first following their reinstatement into the breeding

Table 21. Mean herbage and seed yields for 16 selections of chickling grown in advanced yield trials at Tel Hadya and Breda, 1985/86.

Selection No.	Tel Hadya		Breda	
	Herbage yield kg/ha	Seed yield kg/ha	Herbage yield kg/ha	Seed yield kg/ha
439	3019	736	547	157
104	3022	1941	680	192
385	2873	1984	601	182
38	2870	781	433	186
384	2777	2074	359	230
Acc. 347	2754	725	413	230
463	2747	362	445	137
455	2731	350	677	175
452	2713	422	401	89
185	2640	1843	409	275
476	2601	321	483	113
471	2423	488	376	154
459	2413	267	509	141
29	2319	343	430	129
453	1917	162	634	146
311	1901	750	620	283
Mean	2602	846	503	198
LSD (P<0.05)	1303	476	126	60.0

program. They had previously been discarded because of poor performance at Tel Hadya (compared with vetches): they have been re-instated because of their good performance in on-farm trials (Experiment 7). While they did not grow particularly well at Breda this year, the results are sufficiently encouraging for work to continue.

Multilocation testing of vetches

In the selection of widely adapted vetches in Syria, the multi-location stage has now been completed: testing at Tel Hadya, Kamishly, Izraa, and Homs (in Syria) and Terbol, in Lebanon. Testing of the 25 selections has been over three years which, if the five sites and three years are considered separately, gives 15 environments, ranging from poor to very good. There remains now only the task of testing the varieties in farmer's fields before recommending that the best selections be released. The experiment comprised 23 selections of common vetch, (chosen on the basis of performance at Tel Hadya), and one each of Narbon vetch and woollypod vetch. The experiment was conducted in 1983/84, 1984/85, and 1985/86 at the above five locations chosen to represent the range of environments likely to be encountered in Syria and Lebanon. Meteorological data from the five sites in the three years are presented in Table 22.

The multi-location testing has, at all stages, been conducted in collaboration with the Syrian Ministry of Agriculture and Agrarian Reform.

Table 22. Location and meteorological data for five sites in Syria and Lebanon where multilocation testing of vetches took place in 1983/84, 1984/85 and 1985/86.

Location	Latitude	Longtitude	altitude (m)	Air temperature °C (Oct. - May) Mean Maximum 1983/84	1984/85	1985/86	Mean Minimum 1983/84	1984/85	1985/86	Rainfall(mm) 1983/84	1984/85	1985/86
Syria												
Tel Hadya	35°55'N	36°55E	362	19.7	24.3	20.0	6.5	10.4	6.45	227	373	315
Kamishly	37°03'N	41°13E	467	23.3	28.0	23.7	6.8	9.6	5.7	206	364	368
Homs	34°45'N	36°43E	487	22.3	27.0	23.0	4.2	8.0	4.6	319	392	266
Izra'a	32°51'N	36°15E	575	26.5	28.2	26.1	1.1	5.9	3.3	300	222	195
Lebanon												
Terbol	33°50'N	36°00E	950	19.2	20.4	18.9	1.7	2.9	3.08	597	516	392

At each site, selections were sown in $28m^2$ plots using a randomized complete block design, with three replicates. Sowing rate was 80kg/ha and the sites were fertilized with 16kg/ha of phosphorus. The experiments were sown with an Oyjord seed drill, the number of rows per plot was 32, of which 16 were harvested for herbage yield at the 100% flowering stage, and 16 left for seed yield. It is important to emphasize that, as with all our work, the selections were grown under rainfed conditions there being no supplementary irrigation.

Differences among selections for herbage and seed yield were highly significant. Mean herbage yield of the 25 entries ranged from 2500kg/ha to 3830kg/ha, and mean seed yield from 720kg/ha to 2140kg/ha (Table 23). Woollypod vetch yielded the most herbage, followed by Narbon vetch. The highest seed yield was obtained from Narbon vetch which produced significantly more than all other selections.

Variation among environments was also highly significant. Mean herbage yield varied from 800kg/ha at Kamishly, 1984/85, to 7920kg/ha, at Terbol, 1983/84, and of seed yield from 120kg/ha at Izra'a, 1985/86, to 2270kg/ha at Kamishly, 1985/86, (Table 24).

Variance analysis of the combined data and estimation of the variance components were done following the procedure described by Miller et al (1959). Broad sense heritability (H) was estimated for both herbage and seed yields as follows (Bliss et al, 1973):

$$\sigma^2_g / \sigma^2_{ph} = \sigma^2 g / H \ (\sigma^2_g + \sigma^2_{gy} + \sigma^2_{gl} + \sigma^2_{gyl} + \sigma^2_e)$$

Table 23. Mean herbage and seed yields (kg/ha) and estimates of stability parameters for 25 selections, forage vetch based on 5 sites in Syria and Lebanon and 3 years 1983/84, 1984/85 and 1985/86.

Nö	Selections	Herbage yield					Seed yield				
		$\bar{X}$	b	$\pm sb$	$S^2d(1000)^{-1}$	R^2	$\bar{X}$	b	$\pm sb$	$S^2d(1000)^{-1}$	R^2
1	683/-	3828	0.98	0.08	169.9*	0.91	956	0.73	0.14	74.1**	0.61
2	67/-	3636	0.96	0.18	1100.0**	0.68	2144	1.61**	0.22	229.2**	0.80
3	715/-	3590	1.12	0.11	415.5*	0.88	1504	1.49**	0.09	12.7	0.95
4	708/2037	3589	0.96	0.08	174.0*	0.90	718	0.73*	0.09	19.9	0.81
5	534/2065	3431	1.07	0.07	106.2	0.94	884	0.72*	0.11	32.8*	0.77
6	1361/1448	3364	1.24*	0.10	331.1*	0.91	884	0.89	0.10	29.3*	0.84
7	1416/-	3141	0.96	0.09	247.6*	0.88	748	0.72**	0.06	12.7	0.92
8	1331/1437	3127	1.23*	0.10	273.1*	0.92	808	0.90	0.11	40.8*	0.82
9	2541	3118	1.02	0.06	46.3	0.94	1724	1.47	0.25	308.8**	0.71
10	1458/2106	3074	1.09	0.09	191.7*	0.92	766	0.68*	0.12	55.5*	0.68
11	709/-	3064	0.98	0.14	672.6**	0.80	1515	1.21	0.17	122.2**	0.79
12	7/1135	3063	1.06	0.06	9.3	0.96	768	0.91	0.15	88.6**	0.73
13	7/1136	3063	1.06	0.05	25.7	0.96	880	1.00	0.11	38.2*	0.85
14	1652/2086	3031	0.85	0.09	210.2*	0.87	973	0.95	0.08	6.8	0.90
15	716/-	3025	0.95	0.06	62.6	0.93	1359	1.01	0.20	180.8**	0.66
16	507/2019	2958	0.85*	0.06	7.9	0.93	1260	1.25*	0.11	41.3*	0.89
17	2/1134	2937	0.99	0.06	1.8	0.96	749	0.83	0.13	64.1**	0.74
18	384/2062	2926	1.00	0.06	66.8	0.94	1390	1.15	0.13	65.8**	0.84
19	1459/2044	2919	0.97	0.08	138.5*	0.92	921	1.17	0.09	20.9	0.91
20	1485/2108	2910	1.05	0.06	28.2	0.97	803	1.03	0.10	26.2*	0.88
21	1812/2083	2909	0.93	0.08	164.8*	0.90	1049	0.89	0.11	41.7**	0.81
22	2/845	2877	0.89	0.09	239.2*	0.96	774	0.84*	0.07	4.2	0.91
23	1486/2109	2833	0.93	0.07	66.7	0.93	1260	1.25*	0.11	9.2	0.89
24	4/2057	2629	0.84*	0.07	50.9	0.92	769	0.79*	0.09	12.4	0.86
25	482/2096	2556	0.95	0.05	41.1	0.94	866	1.03	0.13	66.7**	0.81

*,**, Significantly different from 1.0 for the regression coefficients and from 0 for deviations mean squares at the 0.05 and 0.01 level of probability respectively.

Table 24. Mean herbage and seed yields (kg/ha) for 15 environments and their ranks.

Environments (locations & years)	Herbage yield	Rank	Mean seed yield	Rank
Tel Hadya, 1983/84	3458	6	1227	5
Tel Hadya, 1984/85	1610	12	694	10
Tel Hadya, 1985/86	2513	11	930	9
Homs, 1983/84	4095	3	1537	4
Homs, 1984/85	3877	4	1561	3
Homs, 1985/86	2655	9	410	13
Kamishly, 1983/84	913	14	375	14
Kamishly, 1984/85	885	15	556	12
Kamishly, 1985/86	2983	7	2271	1
Izra'a, 1983/84	3859	5	1996	2
Izra'a, 1984/85	2600	10	1023	7
Izra'a, 1985/86	1403	13	118	15
Terbol, 1983/84	7915	1	671	11
Terbol, 1984/85	4990	2	995	8
Terbol, 1985/86	2799	8	1120	6
Mean	3104		1032	
LSD (P<0.05)	672.0		914	

Where σ^2_g = genetic variance

σ^2_p = phenotypic variance

σ^2_{gl} = variance due to interaction of genotypes with locations

σ^2_{gy} = variance due to interaction of genotypes with years

σ^2_{gyl} = variance due to interaction of genotypes, years and locations

σ^2_e = error variance

Estimates of the variance components are presented in (Table 25). These indicate that the selections responded differently when grown in different environments, although their precise meaning is not clear. The significant first order interactions for herbage yields, selections x years and selections x locations, indicate that there were changes in ranking, among the selections in the different years and locations. The second order interaction, selections x years x locations was of considerable magnitude and highly significant for both herbage and seed yields.

In the case of seed yield, the selections x years interaction was very small and non-signifiacnt, and the selection x location interaction, though significant, was considerably smaller than the second order interaction. It follows that the selections ranked

Table 25. Variance components and broad sense heritability estimates for herbage and seed yields from combined analysis of 25 selections of forage vetch (*Vicia* spp.) grown at 5 locations for 3 years

Variance source	Herbage yield	Seed yield
Genetic selections (σ^2_g)	50.742**	130.926**
Genetic selections x years (σ^2_{gy})	53.739**	613.0 NS
Genetic selections x locations (σ^2_{gl})	43.040*	7.459*
Genetic selections x years x locations (σ^2_{gyl})	142.769**	76.444**
Error (σ^2_e)	437.738	105.865
Heritability (H)	0.12	0.39

*,**, Significant at 0.05 and 0.01 level of probability.

NS Not significant.

approximately the same in each of the 3 years of testing when averaged over locations and altered only slightly at the different locations. Indeed all interactions involving seed yield were small compared to the effect of genotype, and indicate wider adaptability for this parameter than for herbage yield.

The stability parameters suggested by Finlay and Wilkinson (1963), and Eberhart and Russel (1966) were also calculated. For these calculations each location in a given year was considered as a separate environment. In the Finlay and Wilkinson (1963) analysis, the mean yield of all selections at each environment is referred to as the "environment mean": it is a simple, easily obtained numerical description of the complex natural environment. Stability is measured as the linear regression (value b) of the yield of each entry on the environment mean. In the Eberhard and Russell analysis the mean square of deviation from the same regression (S^{-2}_{d}) is calculated for each selection. The linear regression coefficient itself measures the linear response to enviromental change, and the mean square deviation from the regression measures the stability or consistency of that response. Any significant deviation from the average response (b=1.0) can be considered a selection x environment interaction. Eberhard and Russell (1966) considered that ideally a genotype should have the highest mean yield over all environments, a regression coefficient of one, and a deviation mean square of nearly zero.

Coefficients of determination, (r^2), were also computed from the linear regression analysis (Pinthus 1973). This coefficient is a better index for measuring the validity of the linear regression, because its value always ranges between zero and one regardless of the measurement scale of the individual selection mean. The nearer it is to 1.0, the better is the fit of the linear regression.

The regression coefficient (b) ranged from 0.84 to 1.12 and 0.68 to 1.61 for herbage and seed yield respectively (Table 23). The deviations from the mean squares ($\bar{S}^2 d$) for individual selections were not homogenous, many of them being significantly more than zero. Coefficients of determination (r^2) varied from 0.68 to 0.97 and from 0.61 to 0.95 for herbage and seed yield, respectively, indicating marked differences in stability among the entries.

Turning to the performance of individual selections, most of those producing the highest herbage yield had regression coefficients close to 1.0, indicating that they maintained their good performance in most environments. Two of them, sel. 554/2065, and sel. 2541 also had deviations from the regression which were close to zero: these selections would be considered good by Eberhard and Russell (1966). Two other selections with high mean yields, selections 1561/1448 and 1531/1437 had regression values significantly greater than 1.0: it is concluded that these selections are more sensitive to environment and yield best in good environments. Other selections, although having low mean yields, had regression coefficients less than 1.0 and are probably suitable for poor environments: 507/2019 and 4/2057 are examples. Similar conclusions can be drawn regarding seed yield: in this respect selection 2541 seems to be the best, although its relatively high deviation suggests that its response to environment is not consistent.

The major problem with this kind of analysis is that there is no indication of what constitutes a poor or good environment. Thus in our experiments the instability in Narbon vetch (sel.67) is probably associated with infection by Orobanche crenata at some locations. Other environments may be poor through low rainfall, deficiencies in plant nutrients, lack of rhizobia, or impact of severe frost. While the analysis is clearly useful it would be much better if it were associated with careful monitoring of the environment.

Selection 2541, which is perhaps the most promising common vetch, originated in the local market at Aleppo. On the basis of the extensive testing reported here, serious consideration should be given to releasing this variety officially. Another candidate is accession 715 which also has high herbage and seed yield and wide adaptation. These vetches, and woollypod vetch, will be the subject of on-farm verification trials. In future the vetch breeding program will become more strongly oriented towards specific problems - for example pod shattering, disease resistance, and so on - the desirable genes being incorporated into the existing widely adapted material.

There is one last point: the results in Table 23 make it clear that high herbage yield usually demands a sacrifice in seed yield and vice versa. It is here that on-farm research on the utilization of forage crops - whether they are grown for hay, straw, or seed - will provide essential information for plant breeders as they set their objectives. - **A.M. Abd El Moneim**

Experiment 9: screening for resistance to stem and leaf diseases (Preschedule F17)

One of the more important of the specific objectives referred to earlier, is to select forage crops resistant to the various stem and leaf diseases. This year 39 promising selections of common vetch, and 16 of chickling were screened in the disease nursery plots. Artificial infections of *Ascochyta* (leaf spot, stem blight, and foot rot), powdery mildew, (*Erysiphe pisi*), and downy mildew, (*Peronospora viciae*) were used for common vetch and *Ascochyta* blight, downy mildew (*Peronospora trifolium*), powdery mildew, (*Erysiphe martii* f. sp. *Kathyir*) and bacterial blight, (*Pseudomonas* sp.) were used for chickling. The screening under artificial epiphytotic conditions, revealed several sources of resistance as follows: two selections of common vetch (selections 2023 and 2065), one of woollypod vetch (accession 683), and one of Narbon vetch (accession 67), were resistant to *Ascochyta* blight, downy mildew and powdery mildew; and four selections of chickling (selections 459, 455, 439 and 476), were resistant to *Ascochyta* blight, downy mildew, powdery mildew and bacterial blight. These sources of resistance will be provided to national programs in the ICARDA region for use in their breeding work. Systematic screening for multiple disease resistance will continue. - **A.M. Abd El Moneim**

Experiment 10: screening for resistance to nematodes (Preschedule F7)

A most important new objective in our breeding and selection program is the search for resistance to root knot nematodes

(*Meloidogyne artiella*) in common vetches and cyst nematodes (*Heterodera rosii*) in peas. While neither nematode is considered to be a widespread problem at present, as the sowing of legumes increases the scale of the problems will also increase. The two nematodes being studied are problems shared by ICARDA's two legume Programs - PFLP and the Food Legume Improvement Program.

Resistance to root knot nematode in vetches

In the previous year (the first year in which nematode screening was conducted) 30 selections of the three vetch species (common vetch, Narbon vetch and woollypod vetch) were classified as tolerant of the root knot nematode. The screening was conducted in the field so there were reservations that field variation in nematode population may have accounted for the good growth of some selections. It was therefore decided to repeat the screening of the 30 selections, firstly in the original field - which is being maintained for screening work - and secondly in the greenhouse. Nematode populations in the field were again high (Table 26), with numbers up to 2700 larvae/kg of soil, a number in excess of 1984/85.

The greenhouse screening was conducted by artificially infecting the soil with 20000 eggs/kg: there were six replicates of each selection, and three plants/pot. The results confirmed that woollypod vetch (selection 683) is highly resistant under both field and greenhouse conditions. Narbon vetch (selection 67) and 13 of the 28 common vetches showed tolerance, while 15 of the common vetches failed to repeat their performance of the previous year.

Table 26. Mean number of cyst and root knot nematodes present in soil of field A18 on six sampling occasions.

Sampling date	Cyst nematode[1]	Root knot nematode[2]
6.11.1985	160	600
31.12.1985	220	1120
30.01.1986	200	1116
3.03.1986	210	2660
8.04.1986	185	2720
5.05.1986	165	2270
Mean	19.0	1748
LSD (P<0.05)	19.5	394

[1] Cysts per kg soil.

[2] Root knot larvae per kg soil

The results are extremely promising. It is clear that resistance or tolerance to root knot nematode is not difficult to find in vetches. It should be relatively simple to incorporate resistance in future breeding programs.

Resistance to cyst nematode in forage peas

Twenty two selections of forage peas were selected from the initial field screening in 1984/85. Of these, one was classified as resistant and 21 as tolerant. As with the vetches these selections were further assessed in 1985/86 in artificially infested soil in the greenhouse. Infection rate was 400 cysts/kg soil, there were six replicates and 3 plants/pot. At the beginning of flowering the roots were washed and assessed for presence of cysts.

The greenhouse screening did not reveal any selections which could be classified as resistant (Fig.15). Selection 61, which had previously been so classified, did not repeat its performance in artificial conditions. However there are five selections which have repeatedly shown tolerance (including selection 61). The other 16 selections were moderately susceptible (6), susceptible (9) and highly susceptible (1).

Resistance to cyst nematode in two chickling species (*L. sativus* and *L. ochrus*)

Chicklings are also known to be susceptible to cyst nematodes. In line with the renewed emphasis on chickling, screening for

Fig.15: Variability in tolerance among 22 accessions of forage peas to artificially inoculated cyst nematode (<u>Heterodera rosii</u>) when grown in a greenhouse. Score values are as follows :

1 = resistant, no galls or very light galling with no plant damage.
2 = tolerant, light galling
3 = moderately susceptible, moderate galling
4 = susceptible, heavy galling
5 = very susceptible, very heavy galling and severe plant damage

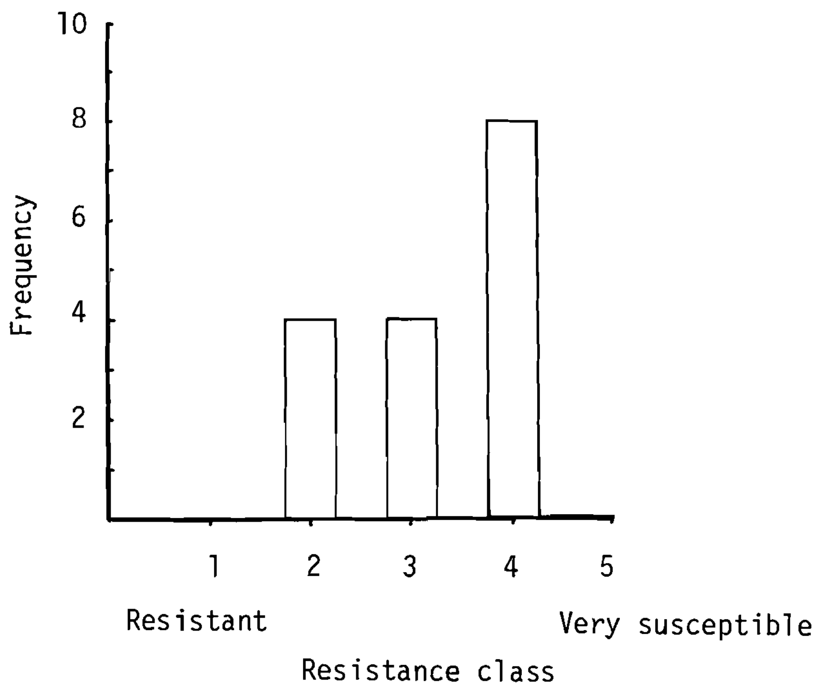
resistance and tolerance to cyst nematode began in 1985/86. Sixteen promising selections were screened in a field highly infested with cyst nematode, (Heterodera rosii), and under artificial infection in the greenhouse, using the same procedures as with forage peas. Under field condition the mean number of cysts/g root varied from 13 to 218 (average of 125), and in the plastic house from 20 to 319 cyst/g root (average of 146). Lathyrus ochrus (Selection 185), was resistant under field conditions and possessed tolerance, along with three other selections (384, 385 and 185), in the plastic house (Fig.16). The other selections were classified as moderately susceptible or susceptible. - **A.M. Abd El Moneim**

Experiment 11: breeding for non-shattering seed pods in common vetch (Preschedule F6)

One of the major weaknesses in common vetch is the tendency for seed pods to shatter before harvesting. This results in much lower seed yields and hence a reluctance by farmers to grow the crop. In 1983/84 certain accessions were identified in which the seed pods did not shatter: however these were agronomically unsuitable in that herbage production was poor and maturity very late. In 1984/85 it was decided to attempt to combine the non shattering trait of these selections with the high herbage yield, early maturation, and disease resistance of our most promising vetches.

Six crosses were done in the plastic house using the method described by Moriya (1966). Gene markers (pod and straw colour, and seed colour), were used to eliminate pods which might have developed from selfing, and to identify the F1 hybrids.

Fig.16: Variability in tolerance among 16 strains of chickling to artificially inoculated cyst nematode (<u>Heterodera rosii</u>) when grown in a greenhouse. Score values are described in Fig.15.



In 1985/86 the seeds obtained from the original crosses (ICARDA, Annual Report, 1985, pp 295 Table 18), were sown in the field as spaced plants so that individual F1 plants could be examined along with their parents (Table 27). In June and July, when intense summer heat is conducive to pod shattering, the performance of the F1 plants indicated that non-shattering is either completely or partially dominant over shattering.

In 1986/87, seeds obtained from the F1 plants, and seeds from naturally self-pollinated parent plants, will be sown as spaced plants, and the pods will be classified as shattering or non-shattering to verify the genetic behaviour. Plants combining both completely non-shattering pods and early flowering will be selected to establish F3 families. - **A.M. Abd El Moneim**

Experiment 12: yield and palatability of vetch species (Preschedule L14)

In 1984/85 a comparison was made of the nutritive value of common vetch, chickling, peas, and barley. It was found that voluntary intake of peas at the pre-flowering stage was only one-fifth that of common vetch. As straw, intake of peas was still less than the other legumes, and exceeded only that of barley. In 1985/86 it was decided to check whether some of the other vetch species were as nutritious as common vetch, especially woollypod vetch which, according to some reports, is less palatable in the pre-flowering and flowering stages.

Table 27. Number of shattering and non-shattering F1 plants obtained from six crosses of common vetch.

Nature of cross*	No. of F1 plants	Non-shattering	shattering
716 x 1416	214	201	13
2541 x 1416	321	301	20
716 x 1361	55	40	15
2541 x 1361	394	349	45
2541 x 2014	171	169	2
716 x 2014	212	202	10

Lines No. 1361, 1416 and 2014 are characterized by late flowering, and non shattering, and lines No. 716 and 2541 characterized by early flowering and shattering pods.

Experiment 12 was conducted to compare common vetch (accession 2541), woollypod vetch (accession 683), and Narbon vetch (accession 67), offered as fresh herbage (pre-flowering), hay (late flowering) or straw (full maturity). The vetches were sown in November 1985 using a randomised complete block design with two replicates. Starting on 12 March 1986 at the pre-flowering stage, fresh herbage, harvested daily, was offered to three sheep per species for a period of 21 days. A fresh area of each species was cut on 14 April at the late flowering stage and the resulting hay cured, chopped and offered to four sheep per species. The mature crops were hand-harvested on 2 May, and after threshing, the straw was fed to four sheep per species as before. Regrowth was measured four weeks after the early cut, and the yield of pods, pod walls, straw, baled hay, and the residue after making the hay were recorded. Voluntary intake and digestibility of the three species were measured at the three stages of crop maturity.

Herbage yields, yield of hay, residue yields, and the apparent losses when making hay, are shown in Table 28. At the pre-flowering stage, woollypod vetch yielded significantly ($P<0.05$) more herbage than the other species. By the late flowering stage Narbon vetch yielded 500kg/ha more herbage than either of the other species (NS), and produced significantly ($P<0.05$) more regrowth. At the mature stage, yields were about equal although Narbon vetch produced the most seed (NS).

The amount of baled hay was similar for all species although only about 40 percent of the total herbage was actually baled. Inefficiencies of this order represent a significant cost to the farmer and mean that hay-making of pure forage stands tends to be

Table 28. Dry matter yield (kg/ha) of three vetch species harvested at three stages of maturity, hay yields and apparent harvest losses.

	Vetch species			LSD
	Common	Narbon	Woollypod	(P<0.05)
Dry matter yield[1]				
Pre-flowering	1069[a]	1054[a]	1295[b]	200.1
Regrowth	1344[a]	1942[b]	1395[a]	376
Late flowering	2950	3636	2923	NS
Mature stage[2]	3684	3934	4411	NS
- straw	1768	1410	3386	NS
- pod walls	449	406	360	NS
- seeds	1434	1813	678	1413.8
Hay yield[3]				
In bales	1072	1388	1027	NS
Residue	1760	2036	1814	376
Total	2831	3434	2841	NS
Apparent harvest losses[4]	63.7	61.8	64.9	-

[1] Quadrat sampling at ground level.
[2] Hand-harvested
[3] Weighing of bales and quadrat sampling of residue.
[4] Hay in bales as percentage of yield at late-flowering

Means within each row followed by different superscripts are statistically different (P<0.05).

far less attractive than it should be. Indeed, hay-making is most uncommon in Syria, mainly because farms are often small, and machinery costly and poorly available. It is recognized that the residues can be recovered by grazing if the farmer owns a flock of sheep. In this experiment the total of hay and residues represented about 96 percent of the total herbage determined using quadrats.

Herbage and ME intake of woollypod vetch at the pre-flowering stage was significantly ($P<0.05$) lower than common and Narbon vetch (Table 29). This was partly related to digestibility of dry matter and acid detergent fibre which were lower ($P<0.05$) for woollypod vetch compared with common vetch. At late flowering and as straw there were no significant differences between woollypod and common vetch either intake of ME or digestibility between woollypod and common vetch. The results therefore suggest that woollypod vetch is not the best species for grazing, but that it is appropriate for both hay-making and the production of straw.

Turning to Narbon vetch, the significantly lower digestibility of acid-detergent fibre of this species, possibly causing the lower intake shown described in Table 29, may not make the species ideal for straw production. A similar, but lesser, difference compared with the other species was observed at hay-making. It seems probable that selection for leaf retention in this species will be necessary if its high herbage production is to be reflected in straw and hay quality.

Daily liveweight gains reflected the intake of ME, with sheep offered woollypod vetch as fresh herbage loosing weight, and sheep gaining liveweight when fed all three species at the other stages.

Table 29. Ad-libitum intake and liveweight changes of Awassi sheep offered common vetch (CV), Narbon vetch (NV) woollypod vetch (WPV) harvested at three stages of maturity.

	Pre-flowering				Late flowering				Mature stage			
	CV	NV	WPV	SED	CV	NV	WPV	SED	CV	NV	WPV	SED
Daily intakes:												
- Dry matter (g)	1599^{a}	1351^{a}	397^{b}	159.9	2027	1848	1863	145.1	1594^{a}	1271^{b}	1424^{ab}	118.8
- Met. energy (MJ)	17.8^{a}	14.7^{a}	4.1^{b}	1.83	19.6	17.4	16.9	1.28	11.5^{a}	8.2^{b}	9.8^{ab}	0.77
Intakes (per kg MBS)[1]:												
- Dry matter (g)	97.6^{a}	82.2^{a}	25.8^{b}	9.56	108.7	99.8	109.7	5.24	82.9^{a}	67.6^{b}	81.2^{a}	4.33
- Met. energy (kJ)	1088^{a}	898^{a}	269^{b}	111.5	1049	940	996	50.4	602^{a}	437^{b}	557^{a}	27.9
Digestibility:												
- Dry matter (%)	81.3^{a}	77.2^{ab}	75.3^{b}	2.08	67.5^{b}	66.1^{ab}	64.4^{a}	0.94	52.9^{a}	47.9^{b}	50.2^{ab}	1.60
- AD fibre[2] (%)	72.8^{a}	64.6^{b}	62.7^{b}	3.74	43.9^{a}	36.0^{b}	40.3^{ab}	0.89	40.9^{a}	27.6^{b}	45.7^{a}	2.93
Daily gains (g)	71^{a}	24^{a}	-280^{b}	33.1	272	219	263	60.0	179	134	143	30.1

[1] MBS = metabolic body size (liveweight $^{0.75}$).
[2] Acid detergent fibre.
Means followed by different superscripts are statistically different ($P<0.05$), within each row of data.

The results confirm that woollypod vetch has a low nutritive value at early flowering. It is not possible, at this stage, to state with certainly whether low intake is due to low palatability, though this seems likely. As in previous studies, harvest losses were very high but the residues could probably be recovered by grazing sheep. Harvesting forage crops at the mature stage still appears to have the greatest yield advantages, and this is reflected in common usage. - **E.F. Thomson, S. Rihawi and N. Nersoyan.**

Experiment 13: inoculation of vetches (Preschedule F9)

Rhizobium-related research should be conducted simultaneously with plant selection to ensure maximum genetic progress in both nitrogen fixation and productivity. To this end an experiment was designed to observe and evaluate the response of several promising vetches to three rates of inoculation (1, 5 and 10x the recommended rate) with *Rhizobium* strain ICARDA V3. The experiment was sown at two sites: Tel Hadya and Breda. The yields of both forage and seed were recorded.

No differences were observed due to rate of inoculation except that herbage yields of all inoculated plots were superior to the non-inoculated plots (Table 30). All four selections of *Vicia sativa* responded positively, as did *V. narbonensis* and *V. dasycarpa*. Since these soils have previously been used to grow vetches the results suggest that nodulation with indigenous *R. leguminosarum* fail to achieve the potential productivity of this crop. Increases of this order exceed, at least in the short term, increases to be gained through plant breeding.

Table 30. Response of vetches to inoculation with R. leguminosarum strain ICARDA V3.

	Herbage yield (t/ha)			
	Tel Hadya		Breda	
	Inoculated	Not inoculated	Inoculated	Not inoculated
V. dasycarpa (sel.683)	5.3	4.5	1.3	0.8
V. narbonensis (sel.67)	4.7	3.5	1.2	1.0
V. sativa[1]	3.1	2.2	0.6	0.1
LSD (P<0.05)	1.1		0.3	

[1] Pooled means from selections 2073, 2083, 2086 and 2541

Herbage yield at Breda was significantly lower than that at Tel Hadya, possibly due either to drier conditions after planting, or to inability of the rhizobia to thrive at Breda. Based on this preliminary result, seed of selected lines of vetch will be inoculated with several strains of R. leguminosarum at both sites in the coming year. - **L.A. Materon and A.M. Abd El Moneim**

INTRODUCING SELF-REGENERATING PASTURE PLANTS TO REPLACE FALLOW IN CEREAL/FALLOW ROTATIONS

The idea of using annual pasture legumes to replace fallow in cereal/fallow rotations originated in southern Australia, where pastures provide nutritious grazing throughout the year, replenish soil fertility, and provide a disease-controlling break between cereal crops. In the 30 years since it was introduced the ley farming system, as farming using temporary pastures is called, has increased livestock numbers by up to four times and doubled cereal yields.

The main advantage of annual pastures over annual forages is that, by using appropriate species there is no need to resow after the initial year of establishment: the 'appropriate' species can self-regenerate as a result of seed dormancy, a character not possessed by currently-used forages. Not only does this save farmers the expense of re-sowing but also the natural re-seeding rates are much higher than farmers can afford to use, resulting in rapid early establishment and a much longer period of grazing. Ideally, livestock are introduced to the pasture in early winter: since annual legumes are prostrate and many weed species are erect, winter grazing is a good method of controlling weeds. The sheep continue to graze in spring and summer. The main problems for new pastures are: in spring being to ensure good flowering and seed set, and in summer, when sheep eat the nutritious seed pods, to ensure that an adequate seed population remains for pasture regeneration.

In the second year the farmer waits until the autumn rains and then, after germination of weeds, prepares a seed bed and sows the cereal. Most of the legume seed produced in the previous year remains dormant (through seedcoat impermeability, sometimes referred to as hardseededness): it is therefore important that depth of

Success of the system depends on several factors. Firstly the time of greatest feed shortage is usually autumn and winter, when low temperatures and low light intensity inhibit plant growth. Rapid pasture growth in winter, and resistance to frost are therefore important attributes. Secondly the seeds must resist germination in the crop year and germinate promptly in the third, or pasture year. Thirdly survival depends on ability to produce enough material, including seed, to provide grazing in summer, with enough seed remaining for dense germination two years later. Finally the pasture must fulfill its role as a source of nitrogen, and, in association with rhizobia, fix sufficient atmospheric nitrogen for its own and the cereal's requirements.

Certain native medics show great promise for use in the ley farming system. These are *M. rigidula*, *M. rotata*, *M. noeana* and *M. polymorpha*, all of which, in west Asia, produce more herbage than Australian cultivars of *M. truncatula*, *M. littoralis*, *M. rugosa*, and *M. scutellata*. Our research is now directed towards fitting these species into workable farming systems: in particular the adaptation of native medics to crop rotations, their response to grazing animals, plant/*Rhizobium* interactions and the development of workable farming system.

In this year's Report we highlight our studies on rhizobia. Very significant responses to inoculation were observed in barrel medic, *M. orbicularis*, and *M. polymorpha* at Tel Hadya. But of even more importance was the discovery, previously masked by its ability to nodulate with indigenous rhizobia, that *M. rigidula* is not nodulated by the currently recommended strains of rhizobia. This finding was made possible by the use of more sophisticated techniques than had hitherto been available at ICARDA.

The work on selection of adapted medics is reported - in cereal/pasture rotations M. rigidula and M. rotata are emerging as being very well adapted and, for the first time, we are able to report on our grazing management experiments. The on-farm work with medics continued and this year we measured the effect of medics on subsequent cereal yields. Finally we present a report which is of special interest because of the involvement of trainees - this is our work on the agronomy of medic seed production.

Experiment 14: inoculation of six medic species by a collection of indigenous rhizobia (Preschedule M18)

The first component of a successful ley farming system is effective nodulation of the medic. In the past many people have assumed that, since medics are native to West Asia, effective rhizobia will invariably be present. While this was undoubtedly true before the advent of agriculture, farmers in West Asia have discouraged the growth of medics in arable land by treating them as weeds. In consequence the population of rhizobia has declined to such an extent that, several years ago, the ICARDA microbiologist was unable to detect R. meliloti at Breda outstation. It is therefore of great importance to understand the often quite complex interactions between medic, Rhizobium, and environment.

Indeed productive legumes are usually the result of successful symbioses with adapted rhizobia. Even where R. meliloti is abundant there could be problems due to host-strain specificities: a question of extreme importance. To find the answer, rhizobia were isolated from 94 soil samples collected from arable and non-arable sites in northern, western and southern Syria.

The isolates were grown in yeast mannitol broth and used to inoculate seedlings of M. rigidula, M. noeana, M. orbicularis, M. rotata, M. polymorpha cv Circle Valley and M. truncatula cv Jemalong. Aseptically-grown seedlings were transferred into test tubes containing vermiculite and gravel, and allowed to grow for 7 weeks at which time symbiotic responses (plant mass, nodule number and appearance) were evaluated. Based on these parameters, we were able to rank the response of each medic to each of the 94 isolates.

The results indicate that the indigenous medic rhizobia vary significantly in their ability to nodulate the six medic species. More than half of the isolates induced functional nodules in M. rigidula, M. noeana and M. rotata (Table 31). In contrast less than a third of the isolates produced effective nodules in M. orbicularis and the Australian-developed cultivars of M. polymorpha and M. truncatula (Table 31). At least for M. orbicularis and M. polymorpha this result is surprising since both species are widespread in the sites at which the isolates were collected. However, it supports the idea, mentioned earlier, that the Australian medics are poorly adapted to the region. In many instances cultures ineffective on one species were effective on others, indicating that considerable host specifity occurs with the indigenous population.

Table 31. Nodulation performance of 94 indigenous *Rhizobium* isolates on a range of annual medic species. The number of isolates (% in brackets) is given for each nodulation category.

	Effective nodules		Partially effective nodules		Ineffective nodules		Nodules lacking	
M. rigidula	36	(38)	31	(33)	17	(18)	10	(10)
M. noeana	44	(47)	28	(30)	4	(4)	18	(19)
M. rotata	52	(55)	19	(20)	1	(1)	22	(23)
M. orbicularis	13	(14)	14	(15)	22	(23)	45	(48)
M. polymorpha[1]	17	(18)	12	(13)	35	(37)	30	(32)
M. truncatula[2]	13	(14)	6	(6)	56	(60)	19	(20)

[1] Cultivar Circle Valley.
[2] Cultivar Jemalong.

Two conclusions can be drawn: firstly that in all species there is a chance of nodulation failure, even in non-cultivated soils, and secondly, the diversity of rhizobia that are present in Syrian soils is such as to provide an opportunity of selecting competitive and persistent strains compatible for particular medic hosts. The isolates which gave a positive response will be used to conduct further and more rigorous screening in plant-soil systems to evaluate their ability to survive and compete against other native rhizobia. - **L.A. Materon**

Experiment 15: specificity of rhizobia strain WSM244 for *M. rigidula* (Preschedule M20)

Strain WSM244 was originally isolated from *M. polymorpha* growing in northern Iraq (D. Chatel, pers. comm.). It has since proven to be a useful strain with many medics, including *M. truncatula*. Its value with *M. rigidula* is uncertain, since, in ICARDA's work at Tel Hadya, inoculation of *M. rigidula* has not been necessary. In extended sowings however, it is very likely that inoculation will be required, and it is therefore of great importance to determine whether WSM244 is effective on *M. rigidula*.

It is possible to detect whether a particular strain of rhizobia is effective on its host by using mutants which are resistant to certain antibiotics. In the case of WSM244 a mutant was selected which is resistant to high concentrations (150 micrograms/ml) of streptomycin sulphate in the normal yeast mannitol agar (YMA) medium. The micro-organisms had previously been shown to have unaltered nitrogen fixing capacity and symbiotic response. It is therefore simple to test whether the rhizobia isolated from plants previously inoculated with WSM244 correspond to that particular strain.

The experiment consisted of a split-plot design with three medic species (*M. rigidula* selection 716, *M. truncatula* cv. Jemalong, and *M. polymorpha* cv. Circle Valley) as main plots and three inoculation rates (1x, 5x, 10x the recommended rate of WSM244) as subplots. Sowing rate was $3g/m^2$, and the plots received a basal dressing of 18kg/ha of phosphorus before sowing. The plots were sown on 12 November after light rain: germinating rain fell in late December. On 28 March 100 nodules from each species (distributed over all replicates) were collected and the rhizobia therein were grown on yeast mannitol agar supplemented with streptomycin for identification. Total herbage yield was measured on 28 April.

The effect of inoculation rate on nodule number was not significant, ($P<0.05$). However, there was a marked response to inoculation in both *M. polymorpha* and *M. truncatula* (Table 32), yields after inoculation being double than that where the plants were not inoculated. In these two species it was found that the nodules were occupied almost exclusively by the mutant strain (96% and 95% respectively) of WSM244 whereas, in the case of *M. rigidula*, WSM244 was not detected. Since *M. rigidula* neither responded nor required inoculation (its yield was similar to the non-inoculated controls and greater than either of the other species) it is clear that the native rhizobia are both effective and compatible with *M. rigidula*, and neither effective nor compatible with the other species. It also seems unlikely that WSM244, previously recommended, is effective with *M. rigidula*, a finding of great

Table 32. Proportion of nodules produced by inoculant strain WSM244 at Tel Hadya (1985/86).

Species	%nodules produced by: WSM244	%nodules produced by: native rhizobia	Mean nodule number per plant	Herbage mass at harvest (kg/ha): Inoculated	Herbage mass at harvest (kg/ha): Uninoculated
M. rigidula	0	100	10.9	3753	3190
M. polymorpha	96	4	3.2	1427*	568
M. truncatula	95	5	6.5	1359*	730
LSD (P<0.05)			1.3		

* Significantly exceeded the uninoculated check.

future use of this species. A local rhizobia, obtained from near Tel Hadya, is now being used to inoculate new sowings of M. rigidula.

Persistence of WSM244 in soil in the absence of plants, and its ability to nodulate seedlings from uninoculated seed, will be monitored in the oncoming season. - **L.A. Materon**

Experiment 16: selection of new strains of medic rhizobia (Preschedule M26)

Since WSM244 is ineffective with M. rigidula it is necessary to find strains that are effective: the decision presented in the previous section to use the Tel Hadya strain is temporary pending a more detailed search for compatible rhizobia. There is also a need to determine whether some other of the local species - for example M. noeana and M. orbicularis - have special requirements, and to check whether WSM244 and CC169 are in fact the best for M. rotata, M. polymorpha, and M. truncatula.

Fifteen strains of R. meliloti were tested in the field on the basis of their response to six medics: M. rigidula sel. 716, M. noeana, M. rotata, M. orbicularis and the Australian cultivars Jemalong (M. truncatula) and Circle Valley (M. polymorpha). Two sites were chosen, Breda and Tel Hadya. The experiments consisted of randomized complete blocks with three replicates and were sown on 13 November (Tel Hadya) and 22 December (Breda). The plots were harvested on 25 April.

Symbiotic response was measured by comparing herbage mass of each species with non-inoculated plots. Table 33 summarises the most important findings of the experiments in terms of the number of times herbage increased compared to the control. All increases shown in Table 33 were significant: non significant increases have been omitted from the Table. At Tel Hadya when the Australian cultivars were inoculated with ICARDA M28 they produced up to four times more herbage than when not inoculated while at Breda, the inoculants almost doubled their yield. The other medic species, with the exception of M. noeana, responded positively when inoculated with ICARDA M28. Strain WSM244 was efficient with all species except M. rigidula and, surprisingly, M. polymorpha (WSM244 was isolated from this species). M. noeana responded to strain ICARDA M33.

Specific profiles for symbiotic response have been drawn for each of the strains on each of the species: the results are summarized in Fig.17. Using the same approach a larger number of strains will be evaluated for symbiotic effectiveness at both sites next season. - **L.A. Materon**

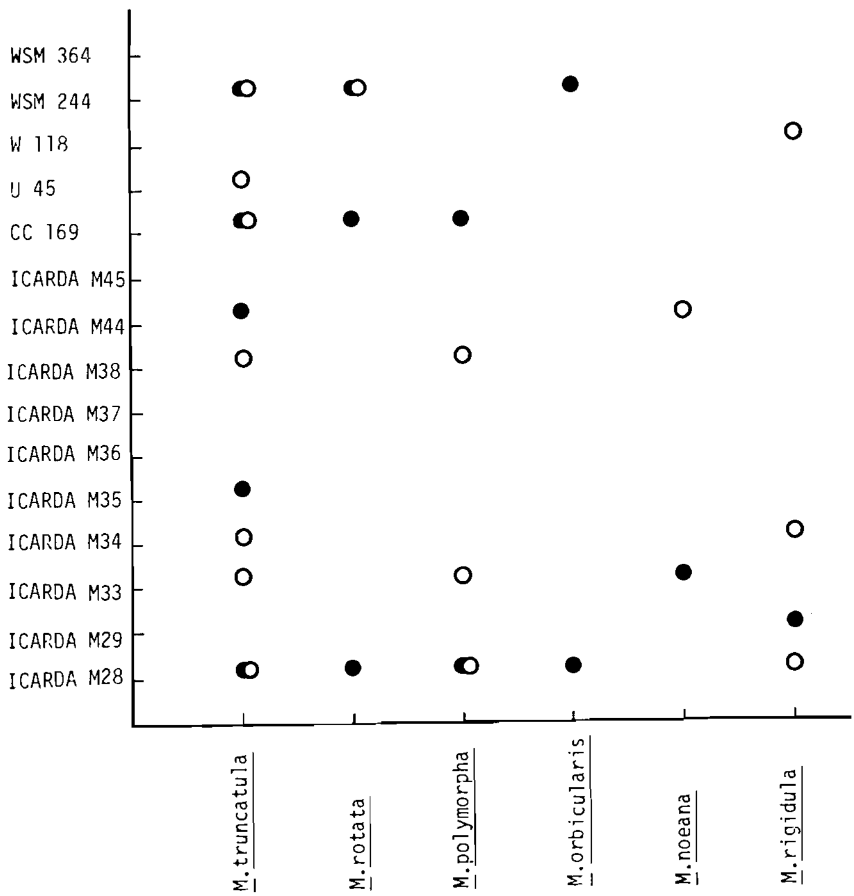
Experiment 17: status of the Rhizobium collection (Preschedule M19)

As in plant breeding, it is essential to base improvement of rhizobia on an extensive collection of cultures with origins as broadly-based as possible, geographically as well as taxonomically. To that end ICARDA commenced collecting rhizobia in 1985/86.

Table 33. Magnitude of the increase in herbage yield due to inoculation: ratio of the yields of inoculated and non-inoculated plots. Results are given for growth at Breda (B) and Tel Hadya (TH) in 1985/86.

Medic host	Strain of *Rhizobium meliloti*				
	M28	M33	M34	CC169	WSM244
M. rigidula	B 1.5		B 1.5		
M. polymorpha	B 2.3	B 2.5			
	TH 4.1			TH 6.2	
M. truncatula	B 1.7	B 1.9	B 1.8	B 2.3	B 1.8
	TH 4.9			TH 3.5	TH 4.5
M. orbicularis	TH 2.8				TH 4.3
M. rotata					B 2.2
	TH 2.8			TH 1.4	TH 1.9
M. noeana		TH 1.5			

Fig.17: Compatibility of 15 strains of rhizobia with six medic species at Tel Hadya (closed circles) and Breda (open circles). Presence of either a closed or open circle indicates that the strain caused a significant increase in herbage yield over not inoculated medics: absence indicates no significant response.



Most of the cultures were isolated from soil samples collected from native pastures throughout Syria, from nodules collected during field trips, and from overseas germplasm collections. In the case of R. meliloti, and to confirm the nitrogen fixing potential of the microorganisms, M. rigidula and M. noeana have been used as 'trap species'. Seedlings are grown in the samples of soil and rhizobia isolated from the nodules.

Currently, the collection consists of purified cultures of Rhizobium meliloti (171), R. trifolii (15) and R. leguminosarum (40 obtained from forage legumes). In future, the collection will be enlarged with cultures from north Africa and elsewhere in west Asia, through cooperators from national institutions, IBPGR, and ICARDA.

At present, rhizobial cultures are maintained at $4^{o}C$ in bottles (20ml) containing YMA. In future it is hoped to use the process of culture lyophilization, in which freeze-dried cultures can be stored in ampoules or small vials. This will result in longer preservation and minimize genetic variability.

The laboratory is now prepared to supply or exchange rhizobia upon request. Small amounts of peat-based inoculants may also be prepared for interested researchers in the ICARDA region. - **L.A. Materon**

Experiment 18: techniques for inoculating medics (Preschedules M21 and M22)

If medics require to be inoculated there are several techniques which have been developed in various parts of the world. For example, if the soil is acid, pelleting the seed and rhizobia with lime increases the survival of the rhizobia on the seed coat. Some legumes have toxic seed coats: activated charcoal is known to improve nodulation in these species. Even if pelleting is not necessary, a substance which physically attaches the rhizobia to the seed, or provides an organic substrate, is known to improve nodulation. In west Asia it is often necessary to sow medics before the onset of the first autumn rains. If this is done the rhizobia must survive on the seed coat in dry soils, sometimes for several weeks. Covering the inoculated seed with a protective coat will surely give extra protection to the microorganisms.

To test the different adhesives an experiment in two parts was designed. In the first part seeds of M. rigidula selection 716, M. polymorpha cv. Circle Valley, M. rotata selection 1943, and M. truncatula cv. Jemalong were inoculated with strain WSM244, using a slurry of peat and solutions (25%w/v) of the following adhesives: gum arabic, gum cellulose, beet molasses, sucrose, corn oil, and water. Inoculant was added to provide approximately 10000 rhizobial cells per seed. An uninoculated control was included in the design which was replicated three times. The treatments were duplicated at Breda and Tel Hadya.

Sowing took place on 16 October after light rains of 2 and 6mm at Breda and Tel Hadya, respectively. Basal dressings of 18kg/ha of phosphorus were applied, and herbage was harvested on 21 April at Breda and 30 April at Tel Hadya. Because of the early sowing and light rains, germination was patchy, and the results were analysed by analysis of covariance taking into account the variable germination. Gum arabic, sucrose and molasses were found to be superior to the other adhesives, but, at Breda, only with M. rotata (Table 34). At Tel Hadya, Jemalong, Circle Valley, and M. rotata significantly responded to inoculation but there was no effect of adhesive (data not shown).

The second part of the experiment was designed to test the seed coatings. The same accessions as before were coated with finely ground calcium carbonate, sodium molybdate, activated charcoal, vermiculite, and rock phosphate. Strain WSM244 was again used with beet molasses as the adhesive agent, and the design was similar to that in which the adhesives were tested. Sowing took place on 16 October at Breda and Tel Hadya.

The results are shown in Table 35. At Breda, Jemalong and M. rotata responded to inoculation, and, with Jemalong, there was a further response to coating with vermiculite. At Tel Hadya the results were similar except that there was no effect of the vermiculite coating. This investigation will be repeated in 1986/87 using several different strains of rhizobia. - **L.A. Materon**

Experiment 19: nitrogen fixation of local and introduced medics (Preschedule M23)

In studying farming systems involving annual medics it is important that we estimate their potential to fix atmospheric nitrogen. Indeed many scientists have stated that the prime objective of using medic is to improve cereal yields through improved nitrogen nutrition. We disagree that this is the primary objective - that remains the feeding of livestock - but it is clearly essential that the effect of medic on cereals is understood, including their ability to fix nitrogen.

Two species, *M. truncatula* cv Jemalong and *M. rigidula* selection 716, were sown at three densities, 5, 30, and 500kg/ha of seed, and inoculated with either WSM244 or CC169. To follow seasonal patterns of nitrogen fixation the experiment was sampled eight times, and dry matter and nitrogen percentage was recorded at each harvest. Nitrogen fixation was assessed in three ways: using the acetylene reduction technique, using the ^{15}N isotope dilution technique, and by the difference method.

As in Experiment 17 samples of 100 nodules from each species were collected and the identity of the organisms determined using their ability to tolerate high concentrations of streptomycin sulphate (mutants of both strains had been identified and were used for inoculation). The experiment was replicated six times, plot size was 10m x 2m, and the experiment was sown on November 13.

Neither inoculant was successful in producing more than 10% of the nodules of *M. rigidula*, while both successfully nodulated *M.*

Table 34. Response of medics to inoculation with Rhizobium (strain WSM244) and the used of adhesives on inoculated seed sown in dry soil (Breda).

Treatment	Herbage yield (kg/ha)			
	M. polymorpha	M. truncatula	M. rotata	M. rigidula
Adhesive agents				
Gum arabic	613	810	1759	984
Gum cellulose	540	827	1236	1557
Sucrose	447	814	1670	1915
Beet molasses	667	811	1727	1073
Corn oil	629	847	1388	1501
Water	736	924	1235	1430
Non-inoculated seed	739	690	1184	1263
LSD ($P<0.05$)	NS	NS	458	742
CV (%)	36.9	27.8	17.4	29.4

Table 35. Response of medics to inoculation with Rhizobium (strain WSM244) and the use of coating agents on inoculated seed sown in dry soil (Breda).

Treatment	Herbage yield (kg/ha)			
	M. polymorpha	M. truncatula	M. rotata	M. rigidula
Coating agents				
Calcium carbonate	627	1469	747	1026
Sodium molybdate	774	1572	821	1094
Activated charcoal	523	1440	737	1290
Vermiculite	568	1447	901	1033
Rock phosphate	584	1384	778	1297
Uncoated	791	1272	672	1261
Non-inoculated seed	415	962	669	979
LSD ($P<0.05$)	NS	440	223	NS
CV (%)	29.2	16.7	16.3	29.2

truncatula (Table 36). The latter result is not unexpected in view of the fact that CC169 in particular, was selected for compatibility with M. truncatula. It highlights once again the fact that indigenous rhizobia often fail to effectively nodulate this species. M. rigidula, as before (Experiment 17), was successfully nodulated by indigenous rhizobia.

In view of its successful nodulation by indigenous rhizobia there was no response of herbage yield in M. rigidula to inoculation. M. truncatula however responded sharply, producing between 1.65 and 3.22 times more herbage after inoculation compared with controls at the same density (Table 37). Even so, inoculated M. truncatula produced significantly less herbage than M. rigidula, whether inoculated or not.

The response to inoculation in M. truncatula at various times in the growing season is shown in Fig.17 (for clarity, only the results for inoculation with CC169 are shown - there was in fact, no significant difference between strains). There was no response to inoculation until 9 March (at high seeding rate) 6 April (medium seeding rate), and 19 April (low seeding rate), but thereafter uninoculated treatments virtually ceased growing.

Nitrogen fixation was estimated by the difference method using the amount of nitrogen absorbed by a dense stand of pure ryegrass (Lolium rigidum) as an indication of the amount of available soil nitrogen. Since nodules of M. rigidula were not occupied by either WSM244 or CC169, fixation is attributable to the native bacteria. Rate of fixation of M. rigidula varied from 0.1 to more than 4 kg N/ha/day during the growing season, with maximum activity at the

Table 36. Proportion of nodules produced by the inoculant strains at Tel Hadya (1985/86)[1].

Species	Nodules due to	
	WSM244	CC169
M. rigidula	9	8
M. truncatula	92	100

[1] Rhizobia from non-inoculated plots were not able to grow on antibiotic-supplemented YMA medium.

Table 37. Inoculation response of *Medicago truncatula* cv Jemalong to *Rhizobium meliloti* strain WSM244 at Tel Hadya, 1985/86.

Seed density kg/ha	Herbage yield (kg/ha)		Increase due to inoculation (%)
	Inoculated	Non-inoculated	
5	276	104	165
30	1474	349	322
500	4072	1254	225
LSD (P<0.05)	849	779	
CV (%)	25	38	

late flowering and pod filling stage in late April (Fig.18). *M. truncatula*, when nodulated by either strain, despite a marked response to inoculation, fixed less nitrogen than *M. rigidula* especially at low and medium densities. Nitrogen fixation and herbage yield at low seeding rate was clearly reduced by low plant number. In addition, the amount of nitrogen fixed by the medics was measured by the acetylene reduction assay, and by the ^{15}N dilution techniques. The former proved to be an unsatisfactory method, while the latter agrees closely with the difference method. Data on total nitrogen fixation calculated by the difference and isotopic dilution method are presented in Table 38. Analyses of samples containing ^{15}N were conducted by the International Atomic Energy Agency in its Seibersdorf Laboratory in Austria. - **L.A. Materon and P.S. Cocks**

Experiment 20: natural selection of medics in a two-course rotation of wheat and pasture (Preschedule M4)

While a great deal of information has been collected on the adaptation of medics to Syria (see Experiment 1), information is badly needed on adaptation to use in real farming systems. For example, although well adapted to the cereal zone, *M. rigidula* may be poorly adapted to survival in a wheat/pasture rotation. Without testing it in such a rotation it is impossible to predict whether it will succeed or fail.

A two-course rotation experiment began at Tel Hadya in 1983 with three major objectives: (1) to compare economic returns from seven different rotations, (2) to monitor important variables associated

Fig.18: (a) Herbage yield of Jemalong barrel medic either inoculated with rhizobia strain CC169 or not inoculated, at three densities, high (500kg/ha), medium (30kg/ha) and low (5kg/ha) (b) Time course in rate of nitrogen fixation of M. rigidula (solid lines) and Jemalong barrel medic (broken line), inoculated with strain CC169 (closed circles) and WSM244 (open circles). Nitrogen fixation was calculated by the differences method and checked by the ^{15}N isotope dilution method (see text).

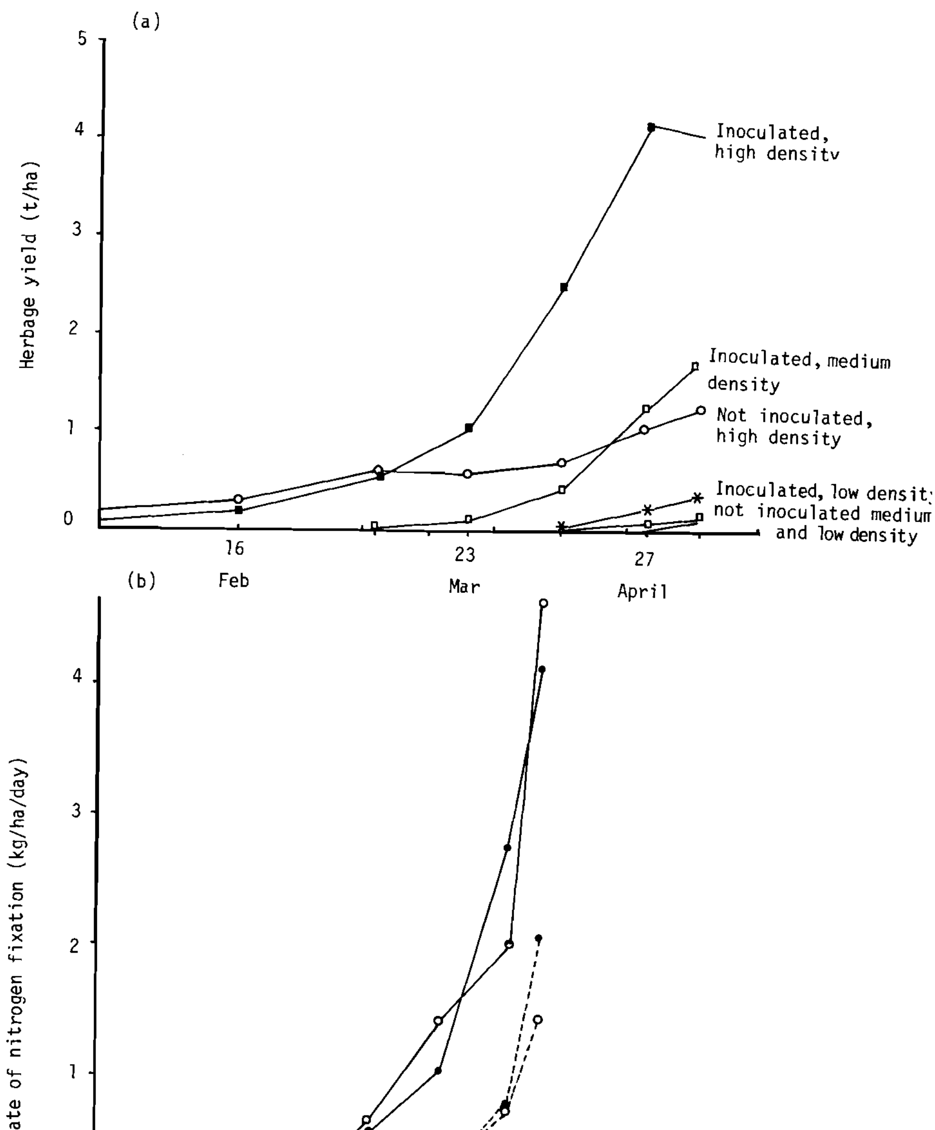


Table 38. Estimates by two methods of the amount (kg N/ha) of atmospheric nitrogen fixed by two medic species at Tel Hadya, 1985-1986.

Species	Seed rate			
	medium	high	medium	high
	by difference		by ^{15}N method	
M. rigidula	80.0	98.5	82.7	94.3
M. truncatula	19.2	71.0	22.0	68.8

with the rotations, and (3) to use a pasture/cereal rotation for the natural selection of medics. The experiment has 2-phase entry: both crops in the rotation are sown each year. There are three replicates of each of the phases.

It is recognized that the 2-course rotation experiment is still not the real world of farming. Indeed, absence of existing medic farms is a serious handicap to all of our work on medics, and, as will be seen later, is one of the major reasons for our important work with farmers. On the other hand, without adapted cultivars it is unlikely that the medic system will be adopted. Use of the two-phase rotation experiment to select adapted medics is an important part of the process of breaking this nexus.

To this end a mixture of 113 accessions was sown in 1984, and again in 1985 in the first and second phases of the rotation. The mixture consisted of the 12 species listed in Table 39, the most frequent being *M. rigidula*, *M. aculeata*, *M. truncatula*, and *M. rotata*.

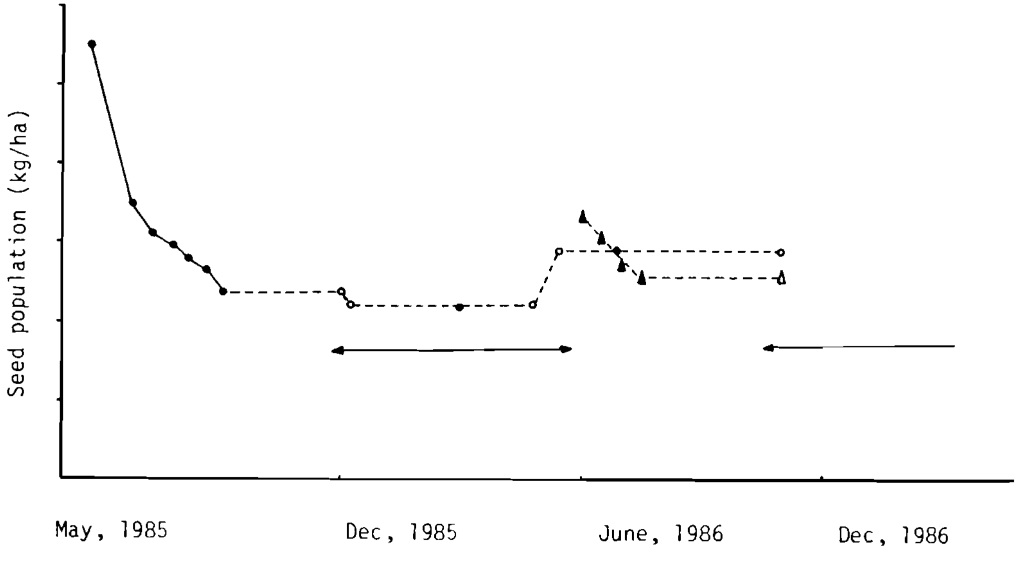
The plots are grazed at 8 sheep/ha in spring as the medic grows and pods develop. Grazing continues in the summer when the plants are dead and the mature pods are the main source of feed: the sheep remain in the plots until the quantity of seed falls to 200 kg/ha, usually in September. To monitor the size of the seed population it is therefore necessary to sample regularly during the summer grazing: this was done seven times in the summer of 1985, and four in the summer of 1986 (Fig.19). In the year of establishment seed was harvested simply by scraping the pods from the surface of the soil: 60 quadrats, each of $0.125m^2$, were so harvested, on each

e 39. Index of success (see text) of the medics undergoing natural selection in a cereal/pasture
tion at Tel Hadya. Positive signs indicate that the species is increasing with time, and negative
s that it is decreasing.

	Phase 1 After pasture growth Spring 1985	Phase 1 After grazing medic residues Autumn 1985	Phase 1 After wheat Autumn 1986	Phase 2 After pasture growth Spring 1986	Phase 2 After grazing medic residues Autumn 1986	Mean
culeata	-0.49	-0.54	-0.80	-0.92	-1.00	-0.75
lancheana	+0.12	0.00	-0.12	-0.85	-1.52	-0.47
onstricta	-0.72	-0.56	-0.70	-0.92	-1.52	-0.88
ittoralis	-0.96	-1.00	absent	-1.05	-1.00	-1.20*
eana	+0.21	+0.28	+0.24	-0.19	-0.16	+0.08
olymorpha	-1.40	-0.89	absent	-0.92	-0.74	-1.19*
igidula	+0.31	+0.33	+0.35	+0.05	+0.05	+0.22
otata	+0.10	+0.03	+0.03	+0.76	+0.76	+0.34
ugosa	absent	absent	absent	-0.80	-0.77	-1.51*
cutellata	absent	absent	absent	-1.30	absent	-1.86*
runcatula	-1.00	-1.05	-1.40	-1.22	-1.40	-1.21
urbinata	-0.49	-0.55	-0.62	-0.96	-0.96	-0.72

calculate means 'absent' is entered as -2.0

Fig.19: The seed population of medic in both phases of a wheat/medic rotation. The lines with arrowheads indicate the growing seasons in which, during 1985, wheat was grown in phase 1 (circle) and medic in phase 2 (triangles). The solid circles or triangles are actual measurements, while the open circles and triangles are extrapolations from the nearest actual measurements and indicate the time at which we believe the change in population occurred.



occasion. During the wheat phase it was necessary to sample to 10 cm since soil preparation for the crop involved cultivation to that depth. This was done using core samples: 250 per plot each of $0.0628m^2$.

Change in the total seed population is shown Fig.19. In May 1985 a total of 550kg/ha of seed was present which fell, as a result of grazing to 240kg/ha. There was a further slight fall during the wheat phase (to 220kg/ha), and an increase to 290kg/ha as a result of seed set during the crop. In June 1986 about 330kg/ha of seed was present in phase 2, which fell to 255kg/ha after grazing. Both phases seem set to produce good pastures after their respective wheat crops.

In order to detect genetic changes in the medic population due to natural selection occuring among the 113 accessions sown, a system of population-sampling has been adopted. The seed population is sampled twice in the pasture phase each year (before and after summer grazing), and in the wheat phase, and the seeds are grown in nursery rows to identify the surviving accessions. Seeds are first germinated in a greenhouse before planting in rows spaced 1.5m apart with 0.5m between plants within rows. Plants are identified by comparison with rows of the original accessions.

The success or failure of each accession or species is calculated as follows:

$$S = \log_{10}\left(\frac{a}{b}\right)$$

where S = the index of success or failure a = the percentage of the accession or species in the seed population at sampling

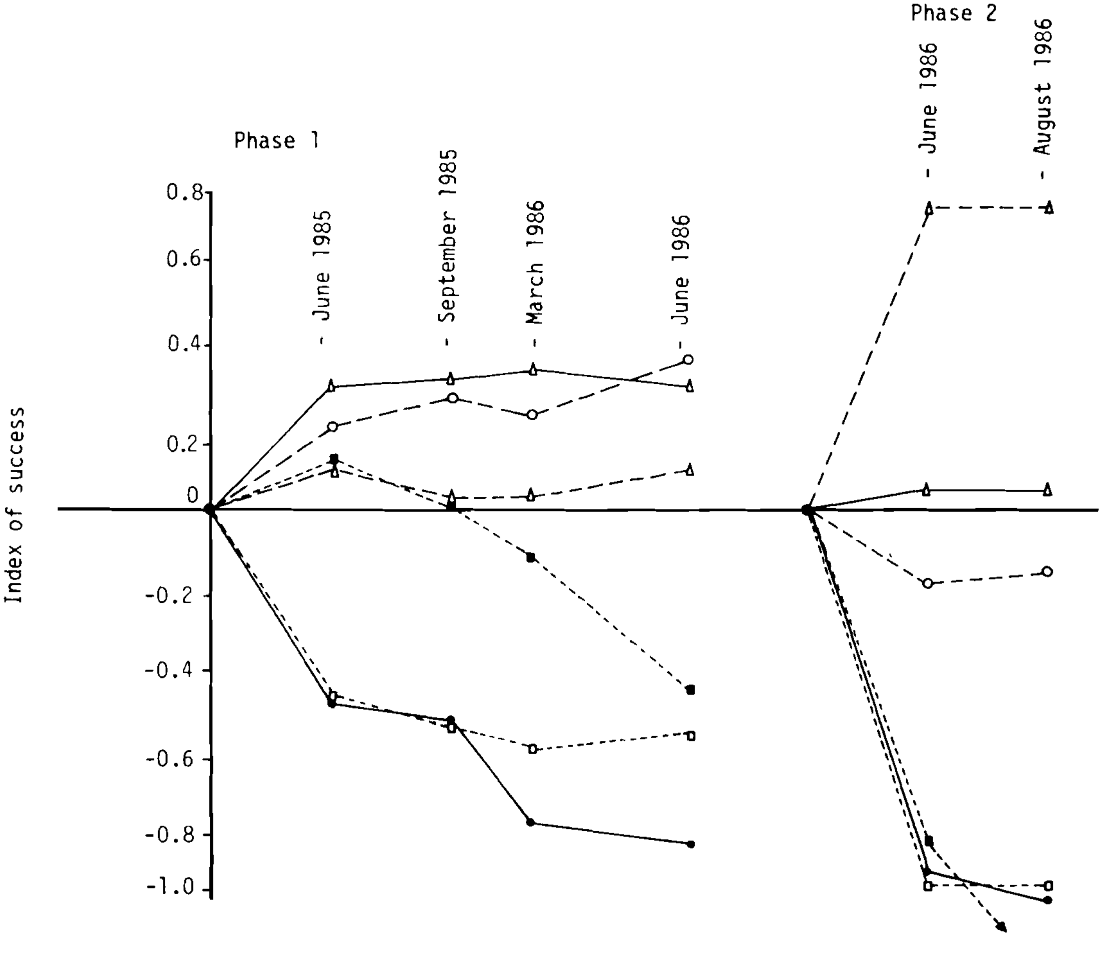
b = the percentage of the accession or species in the original seed mixture.

By converting to logarithms a steady state is indicated by zero and there should be a normal distribution about zero with negative values indicating failure and positive values success.

The index of success of the 12 species in spring and autumn (phase 2), and spring, autumn and the following autumn (phase 1) are shown in Table 39. Easily the most successful species were M. rigidula and M. rotata (Fig.20) with most of the other species showing little success. The results are consistent between years except that M. blancheana, which maintained a near steady state in phase 1 failed badly in phase 2. M. noeana also performed better in phase 1, while in phase 2, although reducing its share of the total it did not fail nearly so badly as the other species. The five least successful species were M. scutellata (-1.86), M. rugosa (-1.51), M. truncatula (-1.21), M. littoralis (-1.20), and M. polymorpha (-1.19). These, of course, are the species which have produced the Australian cultivars: indeed in most cases they were the Australian cultivars.

The outstanding success of M. rotata in phase 2 is of interest. Observations in the field suggest that M. rotata was less affected by light rains which occurred after the mixture was sown: seed of most of the other species apparently imbibed water, commenced germination, and died as the soil dried out, whereas M. rotata did

Fig.20: Changes in the indices of success (see text) with time, of six of the medic species undergoing natural selection (for seed populations see Fig.19). The species are: open triangles, solid line - M. rigidula; open circles, broken line - M. noeana; open triangles, broken line - M. rotata; closed squares, dotted line - M. blancheana; open squares, dotted line - M. turbinata; closed circles, solid line - M. aculeata.



not germinate until heavy rains in late December. It is interesting that the poor opening of the season in 1985/86 apparently exerted a stronger selection pressure on the mixture than did the severe frosts of 1984/85.

The amount of each species present in the droppings of sheep was also estimated. Although the total amount was only about 5kg/ha three species - M. rigidula, M. constricta, and M. polymorpha - were present in greater number than would be predicted on the basis of their availability (S was greater in the droppings for these species than it was in the pasture, when grazing commenced). The significance of this result is not yet clear, but ability of seeds to survive ingestion by sheep would give clear adaptive advantage for the species concerned.

Analysis at genotype level is at a preliminary stage. The results from phase 1, sampled in autumn 1985, are presented in Table 40 which lists the eight most successful accessions at that stage. Five of the eight were M. rigidula, and two of the eight were M. noeana - these were the most successful species at that harvest (Table 39). It is pleasing that M. rigidula selection 716 is one of the top eight: this accession is being widely used in our on-farm trials.

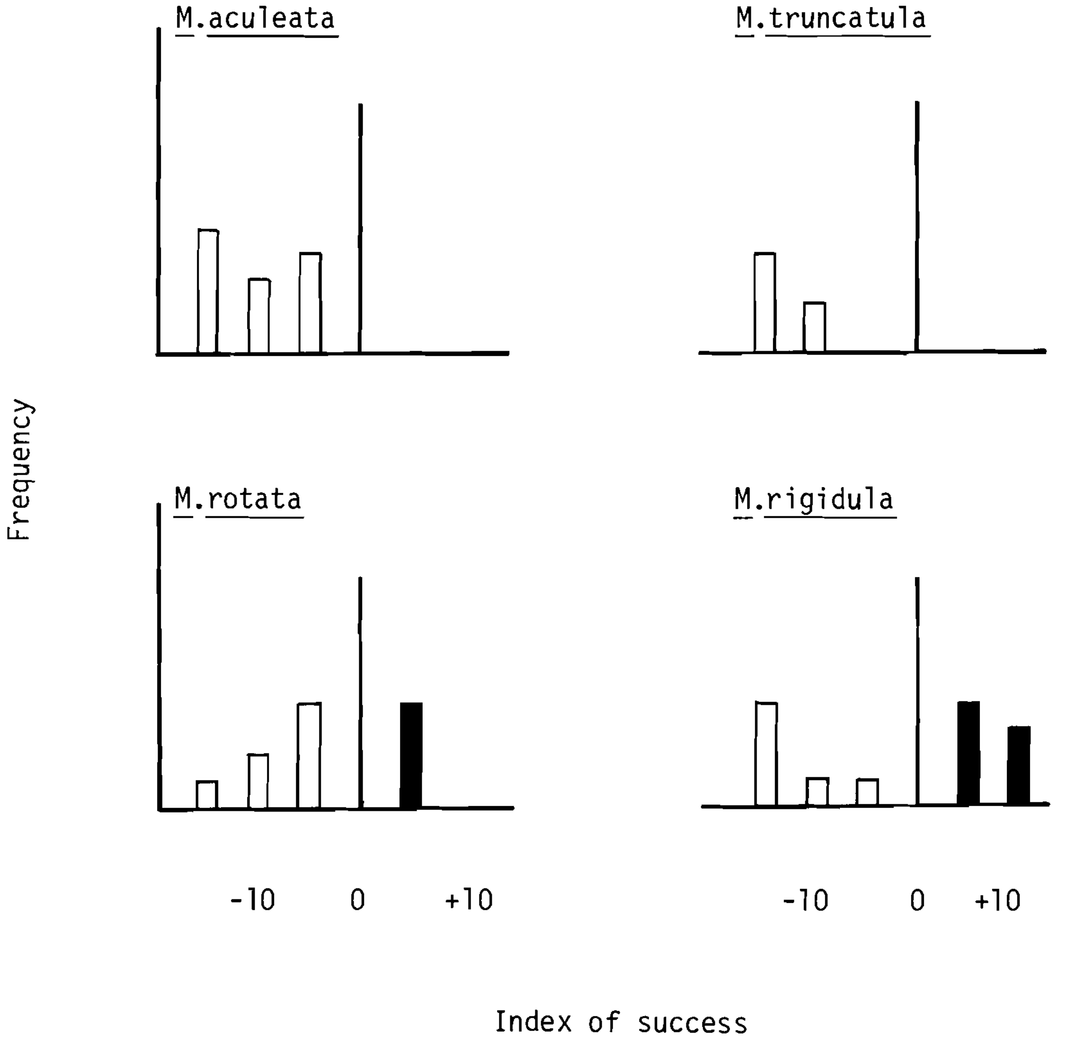
Even within M. rigidula only half of the accessions had S values greater than zero, and considerably less than half of M. rotata (Fig.21). Unfortunately the reverse was not true: those species with low success index did not have individual accessions with high S values.

Table 40. The most successful accessions of annual medics in the two-course rotation.

Species and accession	Origin	Index of success*
M. rigidula 2505/2022	Lebanon	0.977
M. rigidula 2844	Syria	0.877
M. noeana 2351	Syria	0.728
M. rigidula 835/1295	Syria	0.528
M. rigidula 2454	Syria	0.491
M. rigidula 811/716	Syria	0.428
M. rotata 2752	Jordan	0.265
M. noeana 1824	Turkey	0.225

* see text

Fig.21: Distribution of the index of success for two less successful species (*M. aculeata* and *M. truncatula*), and two of the more successful species (*M. rotata* and *M. rigidula*). The solid columns indicate successful accessions and the open columns unsuccessful accessions, the vertical line indicating a steady state.



In October 1986 a further seed sampling was conducted to determine the distribution of seed in the soil profile. Fifty cores were taken from each replicate and split into layers: 0-3cm, 3-6cm, 6-9cm, and 9-12cm. Nearly half of the seed was in the surface layer (but not on the surface) and a further 20% was in the 3-6cm layer. The remaining 31% was buried at a greater depth than 6cm, 18% of it below 9cm. Whether this seed can produce seedlings is open to question. - **P.S. Cocks**

Experiment 21: productivity of the ley farming system (Preschedule L13)

Attempts to introduce the ley farming system to west Asia and north Africa began in the 1960's. Claims of success (apparently not supported by published data) have been made in parts of north Africa, especially Libya (eg Chatterton & Chatterton 1984), but elsewhere there have been problems. Reasons put forward for the many failures include lack of adapted species (Radwan, Al Fakry & Al-Hasan 1978; Adem 1974; Puckridge & French 1983), poor nodulation (Bull 1984), and inappropriate management practices, especially grazing management (eg Springborg 1985), and tillage (Chatterton & Chatterton 1984). A further reason, inadequate research into components of the system, and into the system as a whole, is implied by most, but not all critics.

Therefore there is a clear need to demonstrate to scientists and farmers the potential livestock and cereal productivity of the ley farming system, and its economic value compared with traditional land use. This can best be done by studying the behaviour of medic pasture in simulated farming systems, which will throw light on species survival, herbage productivity, grazing management, animal production and crop rotation. Experiment 21 was designed with this in mind. The productivity of medic grazed at three rates of stocking is being compared with three traditional rotations.

The objective is as follows: to assess productivity of the ley farming system using three stocking rates and to compare its economic and biological stability with rotations of wheat/lentil, wheat/summer crop (watermelons) and wheat/fallow. There are six treatments rotating with wheat:

- medic grazed at 4 sheep/ha
- medic grazed at 7 sheep/ha
- medic grazed at 10 sheep/ha
- lentils
- watermelons
- fallow

There is two-phased entry of each treatment i.e. both alternative crops for each rotation start in years 1 and 2. The design is a randomised block with three replicates, there being little advantage in using more replicates in experiments of this kind (Large _et al_, 1985). Flock size is five sheep resulting in plot sizes of 1.25ha (4 sheep per ha), 0.71ha (7 sheep per ha), and 0.50ha (10 sheep per ha). Rotations involving lentils, watermelons, and fallow are established on plots of 0.3ha. Phase 1 was sown in October 1985, and phase 2 will be sown in 1986.

During the wheat phase each plot is split so that half receives 60kg/ha of elemental N and the other half receives no fertilizer. It is planned to also split the sheep flocks, so that half (approximately) of the lambs are weaned at two months, the ewes milked, and the lambs being fattened elsewhere, and the other half remain with their mothers for 4 months. This, however, is a project which awaits the regenerating phase (in year 3).

In the first year, pastures were managed to achieve good seed production and survival. It was intended that the sheep would be introduced gradually during March and April, building up to the planned level by May. In fact it was found necessary to adjust stocking rate in line with what proved to be less herbage availability than was expected. The actual stocking rates in 1985/86 were 3.2, 5.6 and 8.0 sheep/ha.

Rotational grazing

Extreme care was exercised in grazing the young medic pastures to avoid damage by excessive defoliation. The early growth of volunteer plants, particularly in areas which had been cropped in the previous year, resulted in many areas having a greater growth of volunteers than of medic by the beginning of March. At this time, all plants were small and there was a high proportion of bare ground so that it is unlikely that there was significant competition between the volunteers and the medic. It was clear however, that there would eventually be intense competition.

Most of the volunteers were barley, wheat, common vetch, lentils, chickling, and peas, all of which are more upright than medic. To achieve a rapid defoliation of the volunteers the sheep allocated to each of the three replicate were combined into one flock which then grazed the plots in the hope that they would not defoliate the prostrate medic: grazing took place for up to two days, the sheep being removed at night. That a reasonable measure of success resulted from the initial period of grazing was evident from the contrast of the appearance of the pasture before and after grazing. Continued presence of the sheep resulted in less selective grazing.

It would probably have been possible to achieve a better reduction of volunteer biomass by using an even higher stocking rate. This was, however, not done for three reasons: there was an insufficient number of the appropriate class of sheep at that time of the year, it would have been difficult to relate the events to a practical farm situation, and satisfactory animal production figures could not have been obtained. For purely experimental purposes, however, volunteers were cut off above the medic, and the material weighed and used for zero grazing by sheep. Cutting was carried out partly by hand, and partly by machine: it had the effect of reducing the bias produced by the siting of the project on an unusually weedy area of land. All costs involved in the labour were recorded.

Continuous grazing of the low stocking rate was started immediately after the grazing just described. It was judged that the number of animals present was so low that they would always have on offer more herbage than they could eat and that there was little possibility of overgrazing the medic.

Grazing at this stocking rate continued from March until mid-April when the animals were removed to allow maturation of a sufficient number of mature pods. The animals were re-admitted to the plots in May and June to graze the mature residues and pods. Sheep at the higher stocking rates were grazed for shorter periods.

Details of animal production (Table 41) are given only for the low stocking rate. The sheep used in each replicate comprised one ewe with twin lambs one milking ewe without its lamb, one ewe with a single male lamb, and one ewe with a single female lamb. The data are for the time period starting on 11 March until 9 July when grazing of medic and stubble ceased.

The mean quantity of seed left behind for all stocking rates was 255kg/ha. This should be sufficient for self regeneration provided that the percentage of seed germinating each year is at the expected figure of about 15%. Tests on pods sampled in October gave a value of 14%.

Yields of the crops are shown in Table 42. These yields are based on data collected in quadrats and therefore represent total yield. All crops were subsequently harvested in a manner similar to that used locally: wheat was harvested by machine, lentils and watermelons by hand. The figures in brackets are the percentage of

Table 41. Spring and summer productivity of ewes on first year medic pasture.

Days grazed on medic	51
Days fed concentrate	42
Days grazed on stubble	21
Production of lambs	26.6 kg/ha
Production of milk	61.3 litres/ha
Liveweight increase of ewes	43.5 kg/ha

Table 42. Grain and straw yields of wheat, lentils, and watermelons[1] (t/ha). These were obtained from quadrats and represent yields before harvest losses, the latter being expressed as a percentage of quadrat yield, in brackets.

	Grain/fruit	Straw and stubble
Wheat (Sham 2) - nitrogen	1.50 (7)	3.05 (61)
+ nitrogen	1.90 (7)	4.16 (61)
Lentils (local small-seeded variety)	1.76 (50)	3.14 (45)
Watermelons (local variety)	2.63 (16)	0.25

[1] For watermelons, fruit yields were measured for whole plots omitting a guard region, while residues ('straw and stubble') were measured for a sample of plants.

the original yields which was lost during harvest. For lentil grain and all forms of straw these losses were very high indeed, and may be larger than are actually experienced by farmers. It is interesting to note (not shown in Table 42) that the proportion of stubble which was successfully grazed by sheep, was greater than that successfully harvested as straw. - **A. Smith.**

Experiment 22: establishment of medic pasture
(Preschedule L13)

For the establishment of medic pastures a very shallow sowing is usually recommended, achieved by light raking or rolling after broadcasting the seed. Rather deeper seed positions are sometimes used, achieved by drilling, broadcasting and harrowing to 10cm. There is a general feeling that shallow sowing is best, but although the intended depth is 1 to 2cm, there is no guarantee that seeds are not deeper. Indeed it is possible that variation in sowing depth between 1 and 10cm gives a survival advantage over precision sowing near the surface.

Shallow sowing was adopted for Experiment 21. Later there was concern that the alternating wet and dry periods following a series of light rains would produce seeding mortality. It was decided to obtain records of sowing depth and to monitor the subsequent germination of seeds.

In Experiment 21 the land was cultivated by ducksfoot, disc-harrowed, and rolled with a corrugated roller before sowing. Seed was broadcast by hand on 27 and 28 October 1985 at 30 kg/ha, and covered by rolling in two directions at right angles leaving the soil surface as a series of small ridges 10cm apart.

Experiment 22 used the sowings of Experiment 21. Its objective was to locate the exact positions of the seeds and to determine from which layers germination was best. These were three treatments. In the first the top 1.5cm of soil was carefully removed, separated from the seeds which were counted, and returned (treatment 1). In the second the top 3.5cm of soil was removed and treated as above (treatment 2). The third was left undisturbed (treatment 3). Emergence of seedlings after the December rains was counted in each treatment. In this way it was possible to measure the number of seeds in each layer, and the number of seedlings which emerged from each layer.

The results (Fig.22) show that most seedlings originated from the second layer, and few from above or below this position. The results are attributed mainly to the death of seedlings in the upper layer prior to emergence, caused by periods of light rain with intervening drought. The results also highlight one of the major problems experienced in Experiment 21: that there was only 26% germination. - **A. Smith**

Experiment 23: medics on farmers fields - adaptation of ley farming to northern Syria (Preschedule M6)

In all our work certain assumptions are made about the management of ley farming and the self-regenerating pastures therein. For example we expect farmers to use a two-course rotation

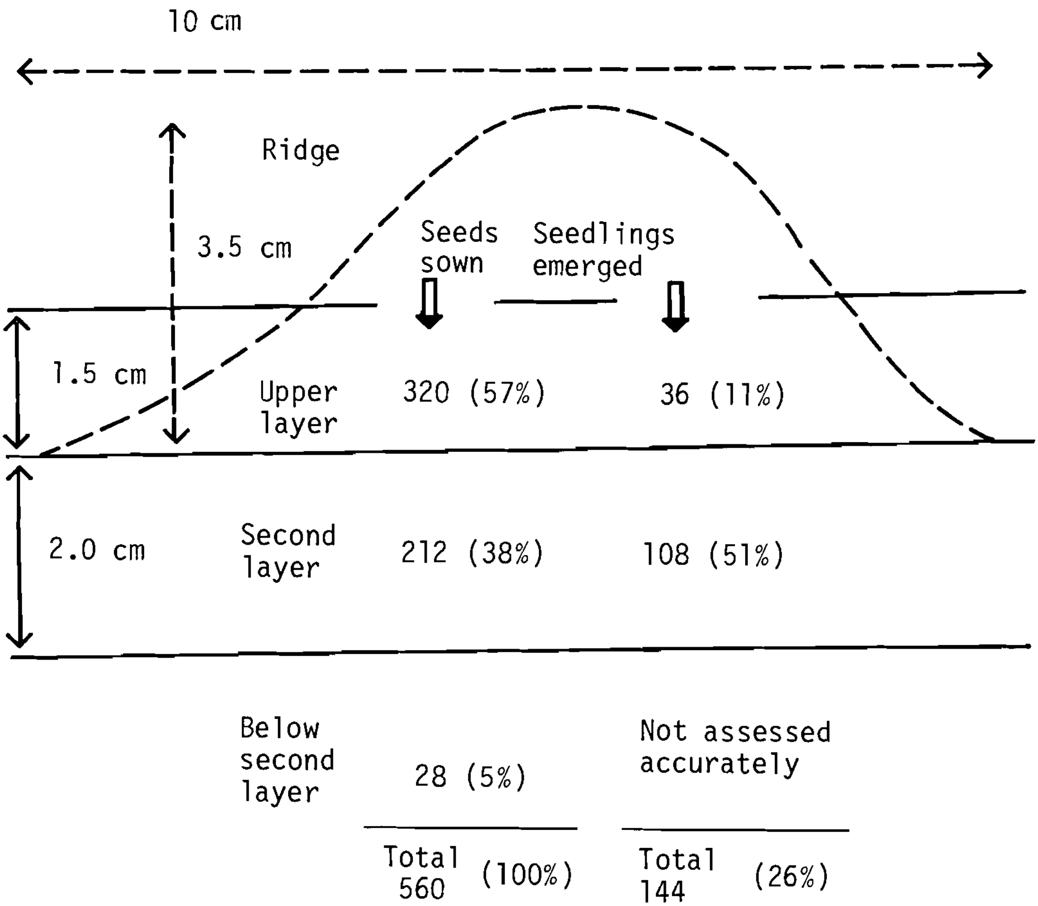


Fig.22: The number of seeds sown and seedlings emerging (g per m^2) for three depths. The percentage distribution of the seeds and the percentage germination of those at each depth are given in brackets. The thicknesses of the layers are given for the soil when it was dry: similarly the dimensions (dotted lines) are given for one of the transient ridges (dotted curve) produced by the roller, the ridges later settling to form the horizontal upper layer.

in which cereals alternate with grazed pasture. We expect cultivation for the cereal to be to no greater depth than 10cm, for the pastures to be set stocked (continuously grazed for most of the year), and the main products to be meat and milk. Without making these assumptions we would make no progress in developing the system.

However, ultimately it is not ICARDA scientists who develop farming systems, but the farmers themselves. We therefore expect west Asian and north African versions of ley farming to evolve in which the assumptions we make are no longer valid. This evolution will depend on many factors, but most importantly on the farmers own efforts. There will inevitably be problems, if only because the original assumptions are based on farming practice in southern Australia where a great many socio-economic factors differ from west Asia and north Africa. However, we believe that the role of ICARDA is to introduce concepts to farmers and, by working closely with them, to help solve problems associated with the implementation of the concepts. Accordingly a three-way collaborative project involving ICARDA, Syrian Ministry Officials, and local farmers has been established and is described below.

On 25 March 1984, Program staff visited Tah, a village a few km east of Ma'aret on the main Aleppo-Hama road. At the village the farmers showed us a field which had spontaneously become dominated by medics. At the time of the visit the pasture was extremely productive and, we thought, demonstrated the great value of medics in the region. As a result we decided to use the farm as a focal point for developing ley farming. We hoped that by using the awareness and enthusiasm of farmers at Tah, and the experience and local knowledge of Ministry of Agriculture officials, we could establish fields in which the ley farming system was working. Subsequently we measured herbage and seed yield of the spontaneous pasture and found that it produced 4.5t/ha of herbage and 500kg/ha (ungrazed) or 150kg/ha (grazed) of seed. The pasture species were M. polymorpha, M. minima, Onobrychis crista galli, wild vetches, and several annual grasses.

In 1984/85 we conducted a survey of farmers with the objective of establishing a socio-economic basis for the project, and sowed one ha of medic pastures (M. rigidula, M. polymorpha and M. truncatula) on each of six fields. Local machinery was used, and subsequent grazing was carefully monitored. The productivity of sheep on the original farm was measured, and careful assessment was again made of herbage and seed production. Several small experiments were established to test which of the various medic species was best adapted, measure their response to superphosphate, and determine the need for inoculation with rhizobia.

In 1985/86, having explained the concepts of the ley farming system, we gave the original farmers the choice of sowing a wheat crop or leaving the pasture for a second year. Five chose the former and one decided on a second year of pasture. On the five farms we split each field in two ways: half of the crops received nitrogen fertilizer, and half were sprayed to control weeds. In addition we imposed the same treatments on control crops: that is crops which were sown in the traditional manner, rotation with watermelons in this village. All crops were sown by the farmers using machinery available to the farmers.

A further five fields were sown to medic in Tah itself and in two neighbouring villages, Deir Sharky, and Jarjanaz. With one exception these fields were one ha in area, the same as the original fields. The one exception was at Jarjanaz where a field of 3ha was sown. Fields were also sown near Kamishly (in the north east of Syria) and Izraa (in the south): these fields were both approximately 3ha in area. All fields were sown at 30kg/ha of a mixture of medics including M. rigidula and M. rotata.

The original field, on which the project was based, continued to be monitored, especially in terms of livestock production. Seed populations of all medic fields were monitored, and grazing days measured. Crop yields were recorded, and the quality of cereal straw measured on the crops grown after medic. Response to phosphate and inoculation were measured at selected sites, and also the seed production of eight potentially useful species.

The number of days on which sheep grazed the medics (converted to number of ewes carried for 365 days), and the seed yield in autumn are shown in Table 43. In the Table, Farm 2 is the second year pasture referred to earlier. Three of the pastures (Farms 9, 12 and 13) carried about one ewe/ha and produced in excess of 200kg/ha of seed: these can be said to be safely established. Two other pastures (Farms 8 and 10) carried 3 ewes/ha, at the cost of severely reduced seed production. Farm 10 will probably regenerate, but Farm 8, with only 24kg/ha of seed, will need to be resown. Farm 14, where rainfall was only 170mm, still carried 1.3 ewes/ha and produced 103kg/ha of seed: this pasture will need to be carefully monitored if it is to successfully re-establish. Farm 2, the second year pasture, carried 4.1 ewe/ha and maintains 335kg/ha of seed, a most satisfactory situation.

Table 43. Grazing provided by the on-farm medic pastures.

Farm	Stocking rate [1]	Seed yield (kg/ha)	Rainfall (mm)
2 [2]	4.1	335	332
7	0.7	102	332
8	3.1	24	332
9	0.8	283	332
10	3.4	169	311
12 [3]	1.4	340	227
13	0.9	360	368
14	1.3	103	170

(1) Calculated on the basis of ewes/ha/year. All flocks also include lambs.

(2) Farm 2 was second year pasture. All others were first year pasture.

(3) The number 11 was not used.

Table 44. Seed yields (kg/ha) for six medic pastures in the year of sowing and in the following year.

Farm	After grazing 1984/85	After grazing* 1985/86
1	181	477
2	279	335
3	76	148
4	423	449
5	170	73**
6	368	769

* After grazing cereal stubble except in farm 2 which was left as second year pasture.

** Will be resown with 20 kg/ha of seed

So much for the new pastures. Table 44 shows the seed yields of the six old pastures (sown in the previous year), both in the year that they were sown (1984/85) and after the second year,in which, with the exception of Farm 2, a crop of wheat was sown. The most important result is that in all but Farm 5 the seed reserves increased, quite sharply in the cases of Farms 1 and 6. This is due to the growth of medics as weeds in the wheat which was particularly vigorous in the half not sprayed with herbicide. The seed yields in Table 44 were obtained from the fields as a whole, but in 1986/87 regeneration of medics will be measured on each of the four treatments applied to the wheat: plus and minus herbicide, and plus and minus nitrogen fertilizer. In any event the seed yields in 1985/86 are most satisfactory except in Farm 5 which will be resown. We look forward, with keen anticipation, to the pasture in Farm 6 where 769kg/ha of residual seed is present.

We mentioned earlier that all wheat crops were divided into four to receive herbicide and fertilizer treatments. Unfortunately it is in the nature of on-farm experiments for things to go wrong: in our case some of the farmers were confused by our instructions and did not apply the correct treatments to the control crops. The comparisons (which were statistically analysed using farms as replicates) are available as follows:

(1) on all farms except Farm 2 - crop yields after medics and after watermelons, all crops being both sprayed and fertilized.

(2) on all farms except Farm 2 - crop yields as a result of applying herbicide and fertilizer to crops sown after medics.

(3) on Farms 1, 3, and 6 crop yields after all treatments.

In comparison (1) the mean yield after medic was 1.7t/ha, and after watermelons 1.6t/ha - a difference which is not significant. In comparison (2) yield was 1.6t/ha when sprayed with herbicide and 0.9t/ha when not sprayed ($P<0.05$), and there was no significant effect of nitrogen fertilizer, nor was there a significant interaction. In comparison (3), where all comparisons were possible, there was a significant effect of herbicide, and a significant interaction between herbicide and rotation (Table 45): wheat after medics responded more to herbicide than wheat after watermelon. There was also a significant response to nitrogen of wheat after watermelon when sprayed with herbicide - a similar, though non-significant response occurred in unsprayed wheat after watermelon. In no instance was there a response to nitrogen after medic.

So, in the wheat/medic rotation it seems that spraying to control medic in the wheat phase will result in increased grain yields. However farmers value straw highly and it is possible that the reduction in yield will be offset by reduced straw quality assuming, as seems reasonable, that the medic will be high in protein and digestibility. In harvesting the wheat, our farmers kept two samples of straw: the first, obtained directly from the machine, comprised pure wheat straw, and the second, handraked from

Table 45. Comparison of wheat yields after medic and in traditional rotations (yields in kg/ha).

	No nitrogen	Nitrogen
No herbicide		
After medic	953	915
After control	1015	1299
Herbicide		
After medic	1584	1688
After control	1077	1555
LSD (P<0.05) = 458		

Table 46. Straw quality of wheat after medic.

	- Nitrogen		+ Nitrogen	
	Protein	DMD	Protein	DMD
- herbicide	4.54	43.9	4.56	43.4
+ herbicide	2.82	40.5	3.82	43.1

LSD (between protein) 1.35
No significant difference between DMD

Table 47. Mean seed yield of eight medic species (kg/ha) at four 'on-farm' sites (Tah, Jarjanaz, Izraa, Kamishly)

M. rigidula 811/716	455
M. rotata 2580/2099	400
M. rotata 350/1943	385
M. scutellate cv. Robinson	344
M. aculeata 1524/2008	315
M. truncatula cv. Cyprus	262
M. truncatula cv. Jemalong	247
M. polymorpha cv. Circle Valley	231

LSD ($P<0.05$)=71

the stubble, comprised both wheat straw, and, where present, medic residues. Results of analyses are in Table 46: there was no significant effect of either nitrogen or herbicide on the crude protein content and digestibility of the first sample (from the machine), but herbicide significantly reduced the crude protein content of the residues, especially in the absence of nitrogen (Table 46). The implications of this result - that removal of medics by herbicides reduces straw quality - needs further investigation. Also to take into account is lower medic seed reserves in the sprayed crops.

The effect of medic on animal production is being monitored on the original pasture - the spontaneous medic - by comparing the milk production and liveweight of 10 of the 100 ewes which are grazing the medic compared with 10 ewes being fed entirely on a diet of concentrates. Each ewe on medic produced 16 kg more milk than a ewe on concentrate, although its liveweight tended to be less (Fig.23). Multiplied by the 20 ewes/ha which grazed the pasture for the whole lactation the total extra productivity was 320kg of milk/ha, and the total productivity of milk on medic was 1600kg/ha. Economic analyses of this data await details on costs of feeding the ewes, but it is known that much less concentrate was fed to the medic ewes than to the control ewes.

The final aspect of the on-farm medic experiments were the comparison of the eight species, the need for inoculation with rhizobia, and the response to phosphorus. The mean yield of seed for the eight species is shown in Table 47: _M. rigidula_ and _M. rotata_ produced most seed, and all remaining medics produced significantly less than _M. rigidula_. The difference between _M._

Fig.23: (a) Cumulative milk yield and (b) mean liveweight of ewes in farm flocks grazing medic (closed circles) and fed concentrate rations (open circles).

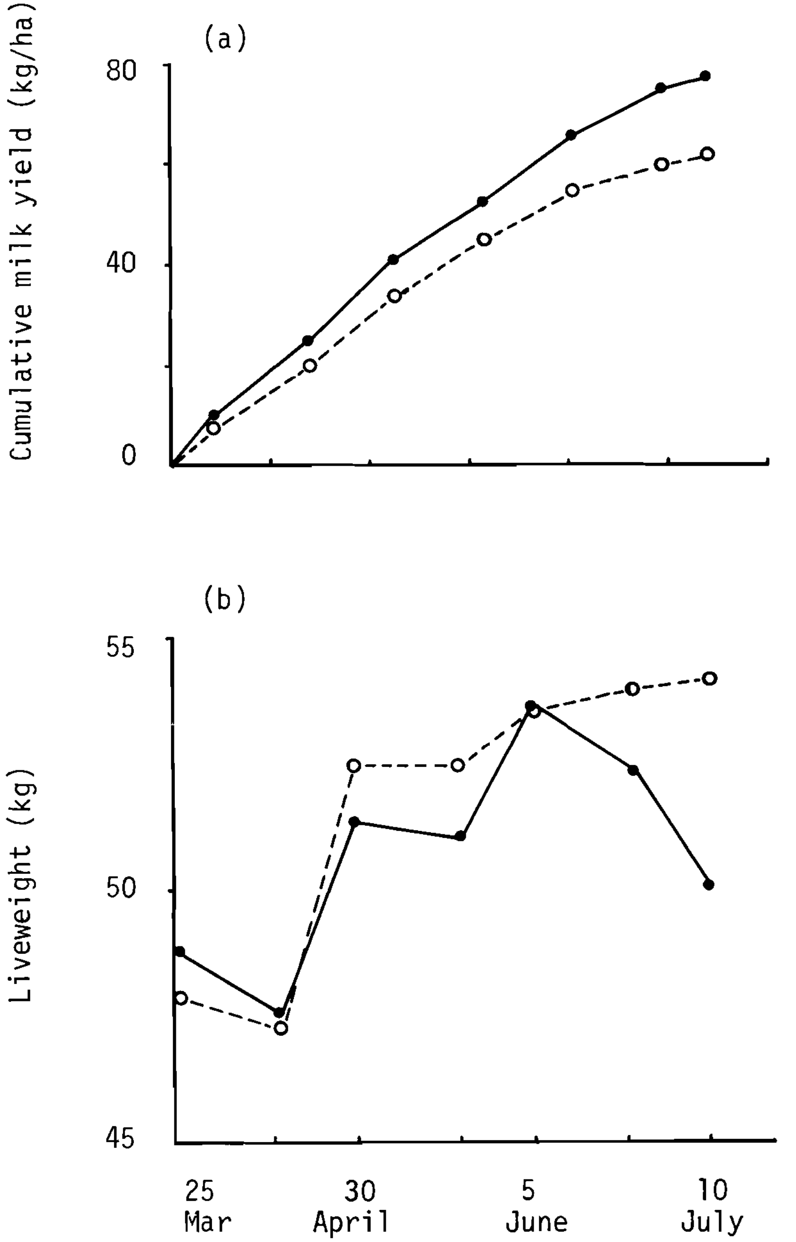
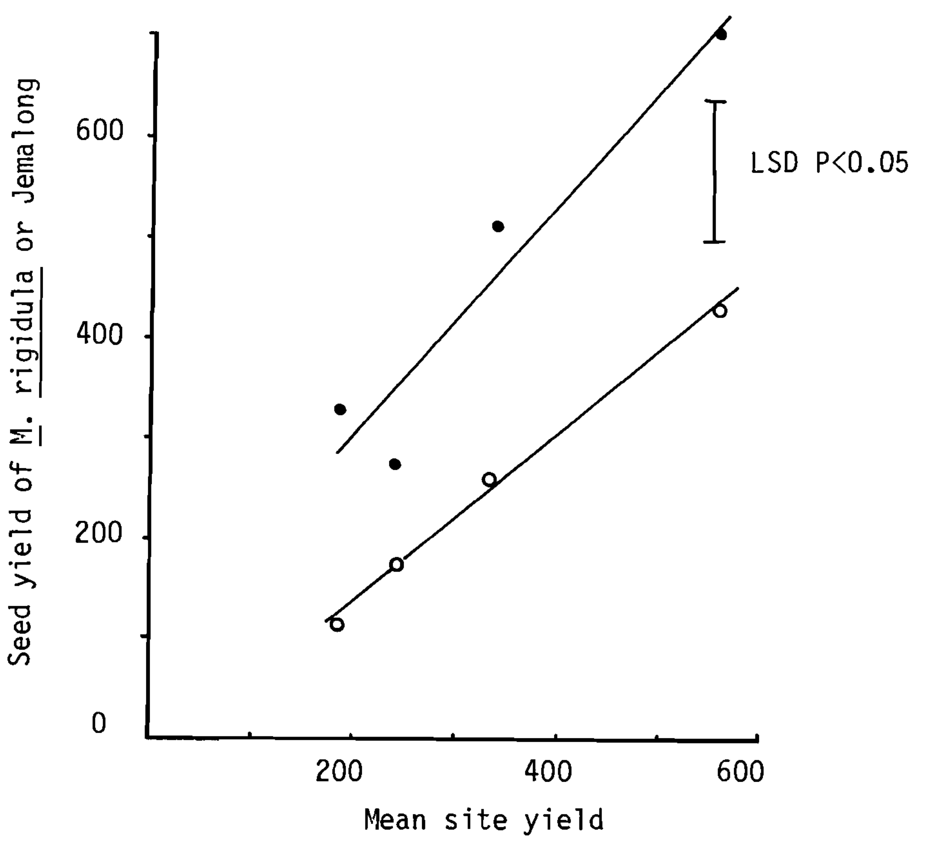


Fig.24: Seed yields of M. rigidula (closed circles) and Jemalong barrel medic (open circles) and their relationship to the mean yield of eight medic species at four sites on farmers' fields.



rigidula and M. truncatula cv. Jemalong was consistent in all sites, regardless of environment: even where rainfall was only 170mm the seed yield of M. rigidula was 330kg/ha (Fig.24). These results support those at Tel Hadya, although the differences between M. rigidula and the 'Australian' cultivars were less on the farms. On no farm was there a response to either rhizobia or phosphorus.

Conclusions

1. There are now 13 on-farm experiments with medics, mostly near the original village of Tah, but extending to Kamishly in the north-east, and Izraa in the south. Both the crop and first year pasture phases were studied in 1985/86: in the case of the latter satisfactory establishment was achieved on most farms.

2. Medic seed reserves increased as a result of seed set by medic 'weeds' in the crop on all but one farm. Seed reserves now exceed 300kg/ha on most farms, an amount more than enough for regeneration.

3. Wheat after medic produced as much as wheat after watermelons, the requirement for nitrogen fertilizer in the latter being replaced by a need to control weeds.

4. Straw quality was better when weeds were left unsprayed. This result, and the increase in medic seed reserves, offsets, at least partly, the lower yield of unsprayed crops.

5. Milk production was again greater in ewes grazing medics compared with ewes fed entirely on a diet of concentrates.

6. M. rigidula was the best of eight medic species: as in the previous year there was no response of medic to either phosphate or inoculation.

- P.S. Cocks, H. Sawmy (ICARDA), Y. Swedan, and B. Malawi (MAAR)

Experiment 24: production of medic seed (Preschedule M24)

ICARDA's first attempts to introduce M. rigidula at village level have been very successful. Recent field days have attracted interest from farmers and Ministry of Agriculture officials alike, and there is a strong demand for more seed. However beyond the 2t of seed produced at Tel Hadya (which is needed for experimental work), there is no capacity to meet this demand.

Lack of seed is therefore seen as one of the major factors limiting the use of medics. Accordingly ICARDA instigated a long term (9 month) training course in medic seed production in which trainees from Syria and Tunisia, were invited to participate. The course was field oriented, and as part of their practical experience the trainees conducted an experimental program where factors affecting seed production were investigated. The research program itself was important because M. rigidula is a new species of which little is known about seed production, and the opportunity was used

Table 48. A list of the main weeds identified by trainees in the experiments on medic seed production (in order of importance).

Herbs	Grasses
Sinapis arvensis (Cruciferae)	*Cynodon dactylon*
Vaccaria pyramida (Caryophyllacae)	*Phalaris paradoxa*
Neslia apiculata (Cruciferae)	*Triticum aestivum*
Fumaria sp. (Fumariacae)	*Lolium rigidum*

Table 49. The influence of weed control on seed yield of *M. rigidula* (kg/ha of seed).

No weed control	417
Chemical weed control	516
Hand weed control	560
LSD ($P<0.05$)	138

to help improve ICARDA's own capacity to produce seed. Furthermore published information on factors affecting medic seed production are limited, and there is a world wide need for research.

There were four experiments: they investigated the interactions between density, row spacing and weed control on yield; the effect of grazing management as a form of weed control; chemical control of grassy and broad-leaved weeds; and the influence of plant density on seed yield of M. rigidula. The main weeds, in order of importance, are shown in Table 48.

Interactions between row spacing, chemical weed control, density and seed yield

Two row spacings (15cm and 60cm) were chosen to compare past practice at ICARDA, where wide row spacing is necessary for mechanical weed control, with closer row spacing which should be possible with chemical weed control. The chemicals used were 'Fusillade' (fusil propmethyl) to control grasses, and 2,4 DB-amine to control broad-leaved weeds, the comparison being between the mixture of herbicides, no herbicides, and hand weeding. Herbicide rates were 500ml of Fusillade/ha and 3.2 litre of 2,4 D-B/ha. Finally, two densities were chosen which reflect ICARDA experience (30kg/ha) and commercial recommendations (15kg/ha). A split-split design was chosen where row spacings were the main plots, weed controls were the sub-plots, and seeding rates the sub-subplots. There were four replicates. Seed yield was measured in June by scraping all pods from within quadrats and hand-threshing.

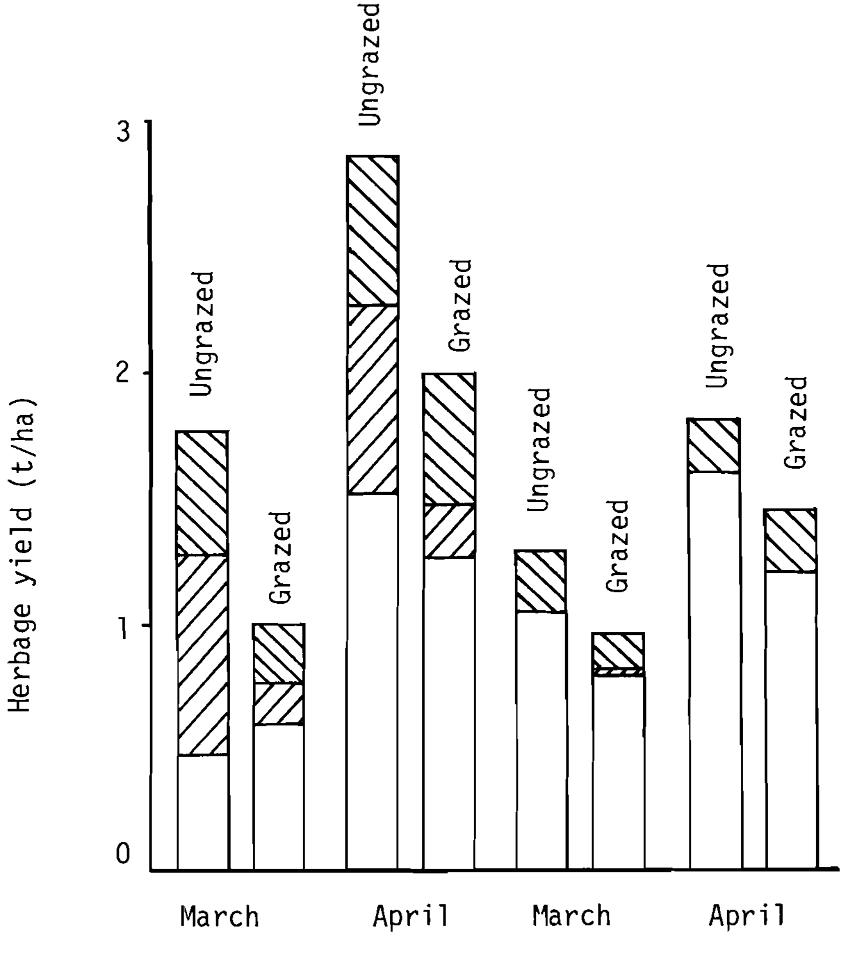
Only weed control affected final yield of seed, where both hand weeding and chemical control were superior to no control (Table 49). In the other main effects high seed rate resulted in slightly more seed than low seed rate (526kg/ha compared with 469kg/ha), and wide row spacing slightly more than narrow row spacing (527kg/ha compared with 469kg/ha), but neither differences were significant.

The influence of grazing in March or April on seed production of annual medics

The objective of this experiment was to assess whether weed control by chemicals could be replaced by grazing, the hypothesis being that many weeds are taller than the medics and will be grazed in preference. The advantage of using grazing to control weeds is obvious: not only is the cost of herbicide avoided but also there is a direct economic return through livestock products. Grazing in March before the medics begin to flower would seem to be better than April grazing.

Three grazing treatments were chosen: no grazing, grazing in March and grazing in April. The grazing treatments were split and chemical control of weeds (a mixture of Fusillade and 2,4 DB amine) was compared to no chemical on each half of the main plots. Dry weights of medic and weeds were measured before and after each grazing, and seed yield was measured in four (1m x 1m) quadrats in June. Each main plot was 45m x 20m in area, enough to provide grazing for 25 sheep for one day.

Fig.25: Histograms showing the herbage yields of broad-leaved weeds (top of each column), grasses (centre of each column) and medic (base of each column) after grazing in March and April. The four columns on the left are from plots without chemical weed control, and the four on the right are from plots sprayed to control both broad-leaved and grass weeds.



The effect of grazing and weed control on herbage yield of medics, grass, and broad-leaved weeds is shown in Fig.25. Chemical weed control eliminated the grasses and greatly reduced the broad-leaved weeds. Its effect on medics was to increase yield in March, and have little effect in April, the March effect presumably being caused by removal of competition. Grazing in March reduced both the grassy and broad-leaved components of the mixture without affecting the medics, but in April, although reducing the grass yield, there was little effect on either broad-leaved weeds or medics. In general chemical weed control was more effective in controlling weeds than was grazing.

It seems that, far from being able to substitute grazing for chemical weed control, the two practices are complimentary (Table 50). For example by applying herbicides the yield of seed increased from 512kg/ha to 821kg/ha when the medic was grazed in March, both yields (the latter significantly) being higher than yields without grazing. As expected grazing in April was detrimental to seed yield, although more so in the absence of chemical weed control.

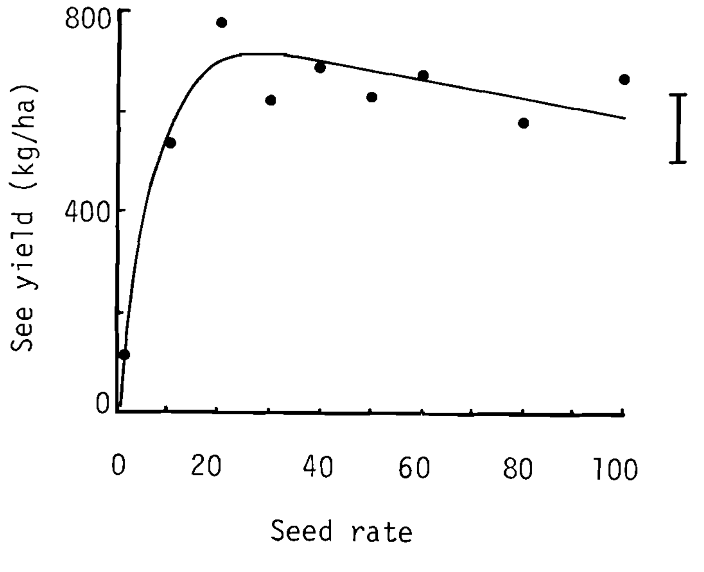
The effect of seeding rate on the yield of seed

There is a mounting body of evidence that seed rates of about 30kg/ha produce the most seed. However inclusion of this small experiment in the trainee program was justified by the high price of seed and the necessity for precise knowledge of the optimum seed rate. Nine rates were chosen - 1, 10, 20, 30, 40, 50, 60, 80, and 100kg/ha - row spacing was 15cm and weeds were controlled with Fusillade and 2,4 DB-amine. A randomized complete block design was used with four replicates.

Table 50. The effect of grazing and chemical weed control on the yield of medic seed.

Grazing	No weed control	Chemical weed control
March	512	821
April	354	498
None	486	572
LSD (P<0.05)	91	

Fig.26: The relationship between seed yield of *M. rigidula* and seed rate. The bar represents LSD at $P<0.05$.



The results are shown in Fig.26. They show that there is clear need for at least 15kg/ha of seed, and the optimum appears to be between 20 and 30kg/ha (20kg/ha gave the highest yield). High seeding rates, which resulted in high herbage yields (data not shown) are not necessary for seed production.

The effect of two herbicides, used alone and together, on medic seed yield

This experiment was designed to separate the effects of Fusillade and 2,4 D-B amine on M. rigidula. There were ten herbicide treatments: no herbicide, Fusillade at three rates (250, 500 and 1000ml/ha), 2,4 D-B amine at three rates (250, 500, and 1000g active ingredient/ha), and mixtures with each component at the same three rates. A randomized block design was used with four replicates. Plot size was 5m x 2m. Herbage yields were measured in April and seed yields in July.

It is clear from the results in Table 51 that the two herbicides killed the groups of weeds for which they were used: there is also an indication that 2,4 D-B was toxic to the medic, although the mixture of the two herbicides gave the highest yields of medic herbage. In general differences in herbage yields were reflected in seed yields, the highest seed yield (494kg/ha) being the result of spraying with the highest rate of the mixture.

Conclusions

1. For good seed production it is necessary to control weeds.

2. Grazing in March results in increased seed yield, an effect which is enhanced by the use of herbicides. Indeed only by grazing and spraying did seed yields exceed 800kg/ha.

3. Fusillade is very successful in controlling grass weeds, but the toxcity of 2,4 D-B amine to M. rigidula is of concern. Other broad-leaved herbicides should be tested.

4. Row spacing of 15 or 60cm produced equal yields; seeding rates should be in the range 20-30kg/ha.

- P.S. Cocks and A.M. Abd El Moneim

Table 51. Herbage yields of medic, grass, and broad-leaved weeds (kg/ha) and seed yield of medic (kg/ha) after treatment with Fusillade, 2,4 D-B, and a mixture of Fusillade and 2,4, D-B.

		Herbage yield			
Mixture	Rate	Medic	Grass	Broad-leaved weeds	Seed yield
Control		870	1980	770	261
Fusillade	250	860	440	1560	443
	500	1080	430	1200	361
	1000	1330	150	1460	417
24 DB amine	250	600	2380	380	129
	500	950	1390	240	254
	1000	760	2890	70	169
Mixture	250	1250	750	460	396
	500	1460	340	200	402
	1000	1370	330	290	494
LSD ($P<0.05$)		650	920	600	171

USING STRAW AND CONCENTRATES FOR LIVESTOCK PRODUCTION

In contrast to pastures and forages, straws are resources already widely used in the ICARDA region. The first objective of the work reported in this section is to improve the nutritive value of straw, either by supplementing it with protein, or improving it through plant breeding. The point should also be made that improved cereal cultivars are unlikely to be popular with farmers unless straw quality is good: an understanding of straw quality should therefore be part of the breeding process.

The second objective in this section concerns the feeding of concentrate diets, and their interaction with the grazing of marginal land. In most villages ewes survive the autumn and winter period on concentrate diets (which usually include straw) but are also taken to marginal land. Concentrates therefore represent one of the main costs in producing livestock, and it is essential that they be used as economically as possible. The extent to which grazing substitutes or complements the feeding of concentrates is important.

In describing the work on straw the collaboration with the Tropical Development and Research Institute (in particular Mr Brian Capper) is again gratefully acknowledged.

Experiment 25: straw in diets of lactating Awassi ewes (Preschedule L8)

Over the last four years, research on straw has focused on relationships between the morphological fractions of mature cereal using pregnant and lactating ewes. In Experiment 25, the first in a series, the objective was to define the level of concentrate intake which maximize straw intake. This level will be used in future to give maximum expression to differences in straw quality.

Ad-libitum straw and four levels of concentrate were offered to groups of four lactating ewes in a completely randomized design. Intake of concentrate and straw, production of milk, and changes in liveweight of ewes and lambs were measured. The trial was divided into two periods: week 1 of lactation to week 8 when lambs were weaned, and week 9 to week 20. Isonitrogenous diets contained whole-barley grain, soyabean meal, wheat bran, salt, and dicalcium phosphate. They were fed at rates calculated to supply 50%, 70%, 90% and 110% of ME requirements.

Results for the first 8 weeks are shown in Table 52. Concentrate intake doubled from the low to very high level ($P<0.05$), while straw intake fell, though at a much lower rate, with the highest straw intake being associated with the medium level of concentrate. As a result, the differences in total ME intake per kg metabolic body size (MBS) across the three highest levels of concentrate were very small (NS).

There were no significant differences in ewe liveweight gains across treatments but daily gains of lambs (Table 52), and daily and total production of milk (Table 53), improved as the level of ewe nutrition improved.

The data in Table 53 are of special interest in that they again show the milk-producing potential of genetically unimproved Awassi

Table 52. Daily intake of dry matter, metabolizable energy and crude protein, and liveweight changes of ewes and lambs offered four levels of concentrate and barley straw _ad-libitum_ during the first 56 days lactation

	Level of concentrate				
	Low	Medium	High	V. High	SED
Intake (DM)					
Concentrate (g)	649[c]	889[bc]	1136[ab]	1310[a]	183.6
Straw (g)	911[ab]	1012[a]	761[bc]	672[c]	93.1
Total (g)	1560[b]	1900[a]	1897[a]	1982[a]	83.1
Met. energy (MJ)	15.2[d]	19.1[c]	20.5[b]	21.7[a]	0.57
Crude protein (g)	273[b]	301[a]	309[a]	293[ab]	10.4
Total intake (per kg MBS)					
Dry matter (g)	84.7[b]	101.3[a]	99.4[a]	99.6[a]	6.29
Met. energy (kJ)	826[b]	1022[a]	1075[a]	1092[a]	58.7
Ewe daily gain (g)	-22	-5	-32	-17	30.8
Lamb daily gain (g)	172[c]	182[bc]	234[ab]	244[a]	25.1

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

Table 53. Milk yield during the first 56 days and for the complete lactation (146 days) from ewes offered four levels of concentrate and ad-libitum barley straw.

	Level of concentrate				
	Low	Medium	High	V. High	SED
Daily milk yield (g)					
First 56 days	1097[a]	1257[ab]	1401[ab]	1637[b]	215.7
Complete lactation	702	779	888	997	146.3
Total yield (kg)					
First 56 days	61.4[a]	70.4[ab]	78.5[ab]	91.7[b]	12.1
Complete lactation	98.0	109.0	124.0	140.0	20.5

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

ewes (see Experiment 28). To measure milk yield, the ewes were first hand milked and then suckled by their lambs, the amount of milk released to the lambs being the difference in mass of the lambs before and after suckling. The results indicate the importance of the suckling stimulus, since the amount suckled (unobtainable by hand milking) represented about 40 percent of the total milk. About 64 percent of the total milk was produced in the first eight weeks of lactation and the milk was converted to lamb liveweight at 6.54 litres milk/kg gain.

The ewes produced between 37 and 48kg of milk in the last 84 days of lactation. This is below that found in surveys of farmers' flocks where the range was from 40 to 60kg depending on feeding level and availability of native pasture. The discrepancy between these and the Tel Hadya values may have two causes: firstly lactation in farm sheep may last more than 84 days, and secondly farmers may over-estimate their milk yields. It suggests however that the nutrition of farm ewes is very good, a conclusion which is confirmed by survey results which indicate that farmers offer 18 to 20 MJ ME supplementary feed daily to ewes in winter. However, our surveys have shown that gains in lamb liveweights on farms are only about 60 percent of those found in this experiment.

Assuming that concentrate and straw cost SL1.65 and SL0.8 per kg, respectively, it costs SL1.64 and SL1.65 per kg to produce milk on the low and very high concentrate diets respectively. This means that farmers should choose the diet which maximizes milk production, since the cost of an extra kg milk remains the same. Assuming a price of SL13 per kg milk, the margin-over-feed costs is SL1013 and SL1429 for ewes on the lowest and highest levels of concentrate.

Since fixed costs are similar, it is not surprising that farmers choose to feed high levels of supplements during lactation. The results also suggest that, since milk production and lamb growth rates continued to rise to the very highest level of concentrate, supplementation at this level did not in fact supply 110% of the ewe's ME requirements, and that still higher levels would have been profitable.

It is hoped that by using genetically superior ewes, even more milk can be produced from the same amount of feed, so further increasing farmers' profits. - **E.F. Thomson and F. Bahhady.**

Experiment 26: the effect of year and genotype on straw quality (Preschedule L16

As a result of past work with straw we know that certain morphological characteristics such as the proportion of leaf and stem length are useful in predicting straw quality. However before using these characteristics in breeding programs it is necessary to know how variable they are from year to year, and in particular whether there are genotype x year interactions which disguise, or make difficult to interpret, the main genotype effects.

The first approach was to conduct analyses of variance using crude protein, neutral detergent fibre and in-vitro digestibility data from the grain recovery experiments of 1983/84 and 1984/85 and the dual purpose barley experiments of 1982/83 and 1983/84. In the former experiment 20 varieties were grown, while in the latter there were 18, with and without grazing. In all three sets of data (Table

Table 54. Comparison of genotype mean squares and genotype x year interaction mean squares in some laboratory measures of barley straw quality.

Number of cultivars	Effect	Crude protein	Neutral detergent fibre	In-vitro D value[1]
18	Genotype	1.18**	14.05**	29.10**
	Genotype x year	0.71	13.64**	14.88
20	Genotype	3.13**	17.71	12.79
	Genotype x year	1.18**	15.01	7.59
20[2]	Genotype	6.09***	16.80*	18.23**
	Genotype x year	2.72	5.58	6.17

[1] g digestible organic matter per 100 g dry matter

[2] Barley grazed at the tillering stage.

Significance; *, P<0.05; **, P<0.01; ***, P<0.001.

54) genotype mean squares exceeded genotype x year mean squares, indicating that genotypic differences in straw quality remain consistent.

In 1986/7 straw samples from F4 bulk populations, and land races from ICARDA's barley breeding program, are being examined for proportions of leaf blade, leaf sheath and stem, and analysed for crude protein, neutral detergent fibre, and in vitro digestibility. The same material has been planted at three sites expected to receive different amounts of rainfall: Tel Hadya, Breda and Bouider. The results will be available in 1987 and should allow comparison of genotypic variation in straw quality with the genotype x environment interaction. - **B.S. Capper (TDRI), S. Rihawi, S. Ceccarelli (CP).**

Experiment 27: quality of wheat straw
(Preschedule L15)

Previously we studied the nutritive value of straws from eight cultivars of barley, both with and without supplementation with protein and energy: it was shown that days to maturity and proportion of leaf dictate straw quality. Since ICARDA has recently released two cultivars of wheat, Sham 1 (durum wheat) and Sham 2 (bread wheat), an experiment was conducted to assess the nutritive value of these straws in comparison with locally grown Hourani wheat. In addition, the effect of stem length, which affects leaf proportion and therefore nutritive value, was studied since short, medium and long straws from Hourani and Sham 1, and medium and long straws from Sham 2, were available from crops produced in soils of various depths. The effect of adding cottonseed meal to the long straws was also studied in the experiments.

Four latin squares (4 x 4) balanced for residual effects were used. The treatments were as follows (with abbreviations); stem length - short (S), medium (M), and long (L); and supplementation - with (+CSM) and without (-CSM) cottonseed meal. The treatments were allocated to the squares as follows:

Square 1: Hourani S, Hourani M, Sham 1S, Sham 1M.
Square 2: Hourani L, Sham 1L, Sham 2M, Sham 2L.
Square 3: Hourani L-CSM, Hourani L+CSM, Sham 2L-CSM, Sham 2L+CSM.
Square 4: Sham 1L-CSM, Sham 1L+CSM, Sham 2L-CSM, Sham 2L+CSM.

Straws were offered to Awassi castrates during 28-day periods at a rate of 1.2 times the average intake of the previous three days. Faeces were collected during the last 14 days and voluntary intake and digestibility were calculated using information from those 14 days. Cottonseed meal was offered at 2.85g/kg liveweight measured at the beginning of each period. Between periods, sheep were given good quality legume hay for 14 days. The digestibility of straw in the presence of CSM was calculated using a measured value of CSM digestibility.

Even though plant morphological data have not yet been analysed statistically, some trends in the results deserve comment. Because of large variation within cultivars, the cultivar means shown in Table 55 are averages of the soil-related stem lengths, and the stem lengths are averages of the three cultivars. Indeed, there were

Table 55. Stem length and leaf proportion in relation to plant height and cultivar of wheat (combined results for 0, 15 and 30 cm cutting heights).

	Cultivar			Plant height		
	Hourani	Sham 1	Sham 2	Short	Medium	Tall
Stem length (cm)	31.8	31.1	32.7	22.6	26.6	43.1
Leaf proportion	64.1	59.2	67.0	59.3	70.1	58.3

apparently no significant differences in stem lengths between cultivars but we found that long stems, collected from deep soils, were nearly twice as long as short stems, from shallow soils. Leaf proportion was lowest in Sham 1 and highest in Sham 2 and, of the stem lengths, medium stem length had the highest proportion of leaf.

The nutritive values of the straws did not always agree with what we expected, based on our earlier results with barley (Table 56). For example, intake of Hourani M was significantly ($P<0.05$) higher than Hourani S and Hourani L, whereas, based on findings with barley, we would have expected intake of Hourani M to be greatest. Similarly, intakes of medium and long straws of Sham 1 and 2 were similar, whereas in our previous work medium straw length would have been preferred. Therefore, in order to answer the main question of the experiment, whether straw quality of the new wheats is satisfactory, nutritive values of the three stem lengths have been pooled (Table 56).

Differences in intakes between cultivars were small except that, in the absence of cottonseed meal, Hourani tended to have a higher nutritive value than Sham 1 and Sham 2, often significantly so. Furthermore, loss in liveweight was significantly ($P<0.05$) less for the sheep eating Hourani straw alone. While this result seems to throw some doubt on the value of the new cultivars, the results should be treated with caution until the experiment can be repeated.

Adding protein to the straw markedly improved intake and digestibility (Table 57). The increases in intake of dry matter, ME and crude protein were all significant ($P<0.05$) but their magnitude was greater in Hourani and Sham 1 than in Sham 2. In respect to

Table 56. Nutritive value of straw of three wheat cultivars.

	Cultivar of wheat			
	Hourani	Sham 1	Sham 2	S[1]
Number of observations	12	12	8	-
Intakes:				
Dry matter (g)	699[a]	628[b]	680[a]	79.1
Dry matter (g/MBS)	45.4[a]	40.5[b]	39.3[b]	3.74
Met. energy (MJ)	4.40	4.03	4.15	0.675
Met. energy (kJ/MBS)	285	259	253	35.3
Crude protein (g)	22.4[a]	17.4[b]	20.6[b]	3.78
Digestibility of DM (%)	42.6[a]	43.4[b]	44.5[b]	0.36
Daily gain (g)	-69[a]	-127[b]	-115[b]	48.6

[1] Residual standard deviation averaged over 2 latin squares.
Means followed by different superscripts are significantly different (P<0.05).

Table 57. Nutritive value of straw from three cultivars of wheat with (+CSM) and without (-CSM) a cottonseed meal supplement.

	Cultivar	Hourani		Sham 1		Sham 2		
	Supplement	-CSM	+CSM	-CSM	+CSM	-CSM	+CSM	S[1]
Number of observations		4	4	4	4	8	7	-
Intakes								
Dry matter	-straw	671[cd]	1051[a]	635[d]	1024[ab]	745[c]	935[b]	75.31
(g)	-CSM	-	121	-	117	-	115	-
Dry matter	-straw	38.7[c]	59.6[a]	37.2[c]	57.4[a]	44.3[b]	54.8[a]	3.73
(g/MBS)	-CSM	-	6.8	-	6.6	-	6.7	-
Met. energy	-straw	4.0[c]	6.5[b]	4.0[c]	7.8[a]	4.7[c]	6.5[b]	0.66
(MJ)	-CSM	-	0.6	-	0.5	-	0.5	-
Met. energy	-straw	230[d]	366[b]	238[d]	440[a]	278[c]	380[b]	30.1
(kJ/MBS)	-CSM	-	35	-	25	-	30	-
Crude protein	-straw	16.6[c]	26.0[b]	18.7[c]	31.5[a]	25.5[b]	31.8[a]	2.18
(g)	-CSM	-	43.0	-	41.7	-	40.9	-
Digestibility of DM (%)								
	-straw	41.6[d]	36.9[e]	42.4[c]	48.6[a]	42.3[c]	43.5[b]	0.29
	-straw+CSM	-	40.3	-	50.8	-	46.4	-
Daily gain (g)		-169[c]	52.0[b]	-115[c]	159[a]	-112[c]	79[b]	57.5

[1] Residual standard deviation averaged over 2 latin squares.

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

digestibility however, the effect of CSM on straw digestibility varied according to cultivar: in Hourani, digestibility decreased ($P<0.05$), and in Sham 1 and Sham 2 it increased ($P<0.05$). Digestibility of total diets comprising the new cultivars and CSM increased as would be expected, but not so in the case of Hourani. Finally, adding protein to the diet changed considerable losses of liveweight into significant gains, the greatest gains after supplementation being with Sham 1.

This experiment has shown that, if there were effects of stem length and leaf proportion on nutritive value, the _in_-_vivo_ experiments were unable to detect it. This may be for two reasons: firstly there may simply be no effect - in strong contrast to barley where both characteristics are known to effect straw quality. Secondly the _in_-_vivo_ technique may be insufficiently sensitive to detect the differences. However, there is a third possibility: the difficulty may lie with the sampling and description of the straws, rather than the _in_-_vivo_ technique itself. Indeed the coefficient of variation for daily dry matter intake, the parameter most susceptible to between - animal variation, is less than 12 percent, a satisfactory value considering that the sheep were fed a very low-quality diet.

In future more attention must be paid to describing the straws if plant morphological characteristics are to be of value in predicting nutritive value _in_-_vivo_. It may even be necessary to increase the number of samples for measuring stem length and leaf proportion in the crop itself. However, this would not solve the problem of describing the straw actually consumed by the sheep. It will be essential to increase the sampling frequency of straws offered and refused during feeding experiments and to manually separate the material into leaf and stem. - **E.F. Thomson, B.S. Capper and S. Rihawi.**

Experiment 28: supplementary feeding of ewes (Preschedule L17)

In past seasons experiments on supplementary feeding used the three experimental flocks which were maintained at Tel Hadya for several years. The long-term objective was to compare the productivity of sheep subjected to low, traditional (ie 'medium'), and high levels of nutrition. The results were valuable for generating data under these three feeding levels and are being used as base-data for whole-farm analyses of various combinations of farm resources (Nordblom and Thomson, 1987). However the data collected were confounded since liveweight and level of feeding were not always separated. This makes it difficult to recommend optimum ewe liveweights and feeding levels for best biological and economic returns.

Therefore, an experiment was conducted at Tel Hadya in which the objectives were to study the effect of liveweight after lambing, the level of supplementary feeding, and the role of marginal land in the nutrition of lactating ewes. The treatments were as follows: three liveweights after lambing (less than 42kg, between 43 and 47kg, and greater than 48kg); three levels of feeding defined by the percentage contribution of supplement to metabolizable energy (ME) needs (low = 70%, medium = 100% and high = 130%); and two management systems, access and no access to grazing of marginal land. The effect of access to marginal land was introduced to the experiment to test whether there is any benefit from this widespread practice. Indeed, in some cases we believe that the contrary is true: marginal land is so poor that farmers apparently fed more to ewes which graze compared with penned ewes (Jaubert and Oglah, 1985). There were 150 ewes in the experiment.

The following parameters were measured: (1) between December and May monthly growth of herbage on the marginal land and the amount on offer inside and outside protective cages, the cages being re-sited after each sampling; (2) daily gains or losses in liveweight of lambs and ewes, the latter being adjusted using the date of lambing as a covariate; (3) milk production measured at weekly intervals on three ewes per treatment. To measure milk yield, the lambs were separated from their mothers at consecutive milkings spaced 12 hours apart, and the ewes hand-milked before being suckled by their lambs. Residual milk (milk remaining after the hand milking) is defined as the difference in liveweight of lambs before and after suckling.

The main effects - level of feeding, liveweight group and management - are shown in Table 58: there were no significant interactions. The post-lambing liveweights of ewes at the three levels of feeding were almost identical, so level of feeding was not confounded by ewe liveweight at the start of lactation: one of the major objectives of the experiment was thus achieved. As would be expected, ewe liveweight losses decreased ($P<0.05$), and lamb daily gains increased ($P<0.05$), as level of feeding increased.

Intake of dry matter and ME (per kg metabolic body size) was significantly ($P<0.05$) less for the high liveweight group than for

Table 58. Daily intake, liveweight and daily gain of ewes, and lamb daily gain and liveweight at weaning, according to level of feeding, liveweight group and management system during the first 56 days of lactation.

	Level of feeding			Liveweight group			Management		
	Low	Med	High	Low	Med	High	Grazing	Penned	S[1]
Ewes									
Number of ewes	55	46	49	46	52	52	72	78	-
Intakes:									
Dry matter (g)	947[a]	1281[b]	1608[c]	1196[a]	1263[b]	1328[c]	1263	1267	56.2
Dry matter (g/MBS)	62.8[a]	81.3[b]	96.9[c]	81.7[a]	81.1[a]	75.9[b]	78.2[a]	80.3[b]	5.25
Met. energy (MJ)	9.6[a]	13.7[b]	17.3[c]	12.7[a]	13.5[b]	14.3[c]	13.5	13.5	0.65
Met. energy (kJ/MBS)	639[a]	870[b]	1068[c]	865[a]	866[a]	816[b]	840[a]	856[b]	56.1
Crude protein (g)	103[a]	140[b]	177[c]	131[a]	138[b]	145[c]	138	139	6.5
Liveweight post-lambing (kg)	45.3	45.0	45.3	39.9[a]	43.9[b]	51.1[c]	45.0	45.4	3.38
Ewe daily gain (g)	-162[a]	-107[b]	-38[c]	-84[a]	-95[a]	-133[b]	-80[a]	-129[b]	58.0
Lambs									
Number of lambs	46	39	40	38	41	46	63	62	-
Lamb daily gain[2] (g)	157[a]	203[b]	215[c]	173[a]	187[b]	208[c]	213[a]	167[b]	31.3
Lamb weaning mass (g)	13.9	16.7	17.3	14.6	15.7	17.0	17.2	14.4	2.25

[1] Residual standard deviation.
[2] Means adjusted for lambing date by covarience analysis.
Means followed by different superscripts are significantly different ($P<0.05$) within main effects.

the other liveweight groups and this is reflected in the weight losses. Nevertheless, lambs from this group gained weight at a significantly ($P<0.05$) higher rate than lambs in the other liveweight treatments.

Intake of concentrates by penned and grazing ewes were almost identical but the penned ewes lost more weight ($P<0.05$) and the penned lambs gained less weight ($P<0.05$) than the grazing ewes and lambs. These differences were smaller than might be expected on the basis of pasture availability, the pasture growing at a rate of 6kg/ha daily over the whole period. However, in December, January and February growth rate of pasture was close to zero, while in March and April it was at least 12kg/ha. Since early born lambs were therefore at a disadvantage compared with late born lambs it was necessary to adjust lamb daily gains by covariance. Adjusted value are shown in Table 58.

Milk yield of ewes was not affected by the liveweight treatments and the results were therefore pooled (Table 59). Total milk yield for the first 56 days of lactation was, on average, 9 percent higher in the grazed compared with the penned ewes. Although not significant at the levels of pasture availability found, the results support the practice of grazing marginal land. They also suggest that farmers, by using the marginal land, are generally obtaining increased productivity from their sheep.

The importance of measuring residual milk is seen since it represents 40% of total milk yield. However, since hand-milked yield is closely correlated with total yield ($r^2 = 0.79$, $P<0.001$) it can still be used to predict the latter, thereby avoiding the need

Table 59. Effect of management system on total milk yield (kg) of ewes offered a low, medium or high level of supplementary feed during the first 56 days of lactation.

	Level of feeding			
	Low	Medium	High	SED
Management system				
Penned	52.1	73.1	79.3	10.71
Grazing	58.4	72.9	86.0	10.71

to measure suckled yield, which is labour intensive. It has been shown elsewhere that as few as three milkings early in lactation can be used to predict total lactation yield. This hypothesis should be tested on existing ICARDA data and, if true, used in the screening of the Tel Hadya flock for milk production.

This large experiment served to provide essential background information on the effect of ewe liveweight, level of feeding, and management system on ewe and lamb performance. More detailed analyses, including economic analysis, should make it possible to define more clearly the optimum combinations of liveweight and feeding strategies which lead to the greatest economic returns. Further studies on the contribution of native pasture to productivity are currently in progress (eg experiment 2) and these should further help to define threshold levels at which pasture availability has a beneficial effect on milk yields and economic returns. - **E.F. Thomson and F. Bahhady.**

Experiment 29: protein sources in diets for fattening lambs (Preschedule L19)

Intensive fattening of lambs has become a widespread commercial activity in many parts of Syria, particularly around Aleppo, Hama and Homs. Diets contain a high content of barley, and a whole range of other ingredients, depending on price and availability (Nygaard, Martin and Bahhady, 1982). These ingredients include cottonseed meal, wheat bran, cottonseed hulls, wheat and vetch grain, legume straw, fish oil, and dried bread.

A pilot study on the fattening performance of Awassi lambs was conducted in 1985. In that study a diet based on whole-barley grain, soyabean meal and a vitamin-mineral mix was used, and male lambs gained 250 to 300g daily with an extremely good feed conversion ratio of 4 to 1. However, soyabean meal is imported while cottonseed meal is freely available from the local cotton producing industry. An experiment was therefore designed with the objective of comparing the fattening performance of lambs fed diets containing different amounts of cottonseed meal and soyabean meal. The experiment also gave us the opportunity to study the effect of lamb growth rate during suckling on subsequent growth.

There were four diets, containing soyabean meal and cottonseed meal in the following ratios, based on crude protein: 100:0 (100% protein from soyabean meal and no protein from cottonseed meal), 67:33, 33:67 and 0:100. The rest of the diet comprised whole barley grain, chopped barley straw, salt, and dicalcium phosphate so that diets were balanced for ME and protein. Each diet was allocated to nine lambs, balanced for past nutritional status: three lambs were obtained from each level of nutrition (low, medium and high) of Experiment 28. The experiment was thus a factorial design with four diets, and three previous growth rates.

The comparison between soyabean meal and cottonseed meal in the 28 and 70 day periods are shown in Tables 60 and 61 respectively. There were no significant differences in intake of dry matter, ME or in initial and final liveweight, daily gain, and feed conversion ratio, regardless of which protein supplement was used. There seems little doubt that cottonseed meal can replace soyabean meal without affecting lamb performance, a finding which has important

Table 60. Feed intake, growth rate and feed conversion ratio of male lambs offered diets containing varying ratios of soyabean meal and cottonseed meal during a 28 day starter phase.

	Soyabean: cottonseed ratio				
	100:0	67:33	33:67	0:100	SED
Number of lambs	9	8	9	9	-
Intake:					
Dry matter (g)	617	725	663	593	64.4
Dry matter (g/MBS)	66.8	73.4	71.6	64.7	5.26
Met. energy (MJ)	6.9	8.1	7.3	6.4	0.71
Met. energy (kJ/MBS)	748	818	785	703	58.1
Crude protein (g)	119[ab]	145[a]	123[ab]	106[b]	12.3
Liveweight:					
Initial (kg)	16.4	17.0	16.2	15.8	1.01
Final (kg)	22.9	25.6	23.1	23.0	1.19
Daily gain (g)	234	307	247	257	24.6
Feed conversion ratio[1]	2.6	2.4	2.7	2.3	0.28

[1] Kg feed DM per kg daily gain.
Means followed by different superscripts are significantly different ($P<0.05$).

Table 61. Feed intake, growth rate and feed conversion ratio of male lambs offered diets containing different proportions of soyabean meal and cottonseed meal during a 70 day finisher phase.

	Soyabean: cottonseed ratio				
	100:0	67:33	33:67	0:100	SED
Number of lambs	8	9	9	9	-
Intake:					
Dry matter (g)	1148	1070	1115	1080	79.8
Dry matter (g/MBS)	84.2	76.4	82.7	80.6	6.04
Met. energy (MJ)	13.3	12.1	12.7	11.7	0.91
Met. energy (kJ/MBS)	971	864	940	872	68.7
Crude protein (g)	214	206	207	196	15.0
Liveweight:					
Initial (kg)	23.5	24.8	23.1	23.0	1.19
Final (kg)	40.9	40.7	40.0	39.1	1.95
Daily gain (g)	249	228	242	229	24.0
Feed conversion ratio[1]	4.6	4.7	4.6	4.7	0.64

[1] Kg feed DM per kg daily gain.

implications for lamb fatteners who can buy local material for less than the imported soyabean meal. Indeed, at current prices cottonseed meal is only 50 percent the price of soyabean meal. Thus a farmer who used only cottonseed meal would reduce his feed costs by about 15 percent compared with a diet containing only soyabean meal. Since feed costs are a high proportion of total costs in feedlot systems, this reduction in feed costs would have a beneficial effect on overall profits.

The results also showed that liveweight at the start and end of the starter (28 days) and finishing (70 days) periods were significantly ($P<0.05$) better when growth rate during the suckling phase was high (Table 62). Of more importance, during the first 28 days, daily rate of gain was 15 percent higher if lamb weight on entry was higher, a difference which certainly has economic importance. The experiment confirms the earlier result that feed conversion ratios of 3 to 5 kilogram of feed for every kilogram of gain can be expected from male Awassi lambs in the weight range 20 to 40kg. These conversions are about twice as good as obtained in commercial feedlots. - **E.F. Thomson and F. Bahhady.**

YIELD DECLINE IN CONTINUOUS CROPPING SYSTEMS

In the continuous cropping of cereals there is a distinct reduction in plant growth and a lower grain yield compared with cereal grown after fallow. This "decline" is thought to have many possible causes, including reduction of available plant nutrients in the soil, a general loss of soil fertility and structure, diseases of the roots and stem bases, inhibition of the growth of the cereal by phytotoxins arising from cereal residues (allelopathy), poor water-use due to changes in soil structure, and the build up of cereal weed populations.

The object of the present project is to understand the causes of the decline under the rainfed conditions of the eastern Mediterranean region. Four rotation experiments were available to study the decline in the field and additional experiments were set up under artificial conditions.

Experiment 30: Field studies
(Preschedule M32)

The results given in the present report were obtained from the following experiments conducted by the Farming Systems Program:

Experiment A at Breda using barley, cv. Beecher

Rotation	Cropping year					
	1981	82	83	84	85	86
Barley/Barley	B	B	B	B	B	B
Barley/Fallow	F	B	F	B	F	B
Barley/Vetch	V	B	V	B	V	B

Experiment B at Breda and Tel Hadya using barley, cv. Arabi Aswad

Rotation	Cropping year				
	1982	83	84	85	86
Barley/Barley	B	B	B	B	B
Barley/Fallow	B	F	B	F	B
Barley/Vetch	B	V	B	V	B

Experiment C at Tel Hadya using durum wheat, cv. Hourani (W_1) and cv. Sham 1 (W_2)

Rotation	Cropping year					
	1981	82	83	84	85	86
Wheat/Wheat	W_1	W_1	W_1	W_1	W_1	W_2
Wheat/Fallow	F	W_1	F	W_1	F	W_2
Wheat/Medic	M	W_1	M	W_1	M	W_2

Plant density declined dramatically ($P<0.05$) during the first 2 months after establishemnt in continuous monocultures of Experiment A. In Experiment C, establishment was significantly lower in continuous monoculture ($P<0.05$). These results are illustrated in Table 63.

Table 63. Change in plant density of cereals (1985/86).

Expt	Crop	Seedlings established as % of seeds sown (January)	% of seedlings which died later (March)
	Barley after barley	104*	-40
A	Barley after fallow	85	-21
	Barley after vetch	86	-24
	Wheat after wheat	60	-40
C	Wheat after fallow	86	-45
	Wheat after medics	77	-42

* Included seedlings from seed not harvested in the previous year.

Plant height during the months January to March was also lower ($P<0.05$) in continuous monocultures than after fallow (Table 64).

Table 64. Plant height in cereals.

Expt	Crop	Relative plant height (% of barley or wheat after fallow) (January/March)
	Barley after barley	85
A	Barley after fallow	100
	Barley after vetch	96
	Wheat after wheat	79
B	Wheat after fallow	100
	Wheat after medics	86

Herbage growth also declined, but was improved by additional fertilizer nitrogen (Table 65).

Table 65: Plant mass in cereals.

Expt	Crop	Relative herbage mass (% of barley or wheat after fallow) No nitrogen	90 kg/ha
	Barley after barley	61	-
A	Barley after fallow	100	-
	Barley after vetch	95	-
	Wheat after wheat	52	77
B	Wheat after fallow	100	100
	Wheat after medics	73	78

There was a decline in grain yield under continuous cropping arising variously (according to variety) from a reduction of plant density, number of tillers, spike density, number of seeds per spike and individual grain mass. This is illustrated in Fig.27 for barley (Experiment B). Differences among rotations are significant for each component.

A study was made of the presence of pathogens in cereal plants in various rotations at different times of the year. Species present in Experiment A, pathogenic on roots and stem bases, were Pyrenophora sativa, Fusarium acuminatum and Truncatella angustata; in Experiment B Pyrenophora sativa, Fusarium acuminatum and Phialophora hoffmannii; and in Experiment C as in Experiment B plus

Fig.27: The components of grain yield for barley grown in three rotations: after fallow, barley or vetch in the previous year (Expr.2, Tel Hadya).

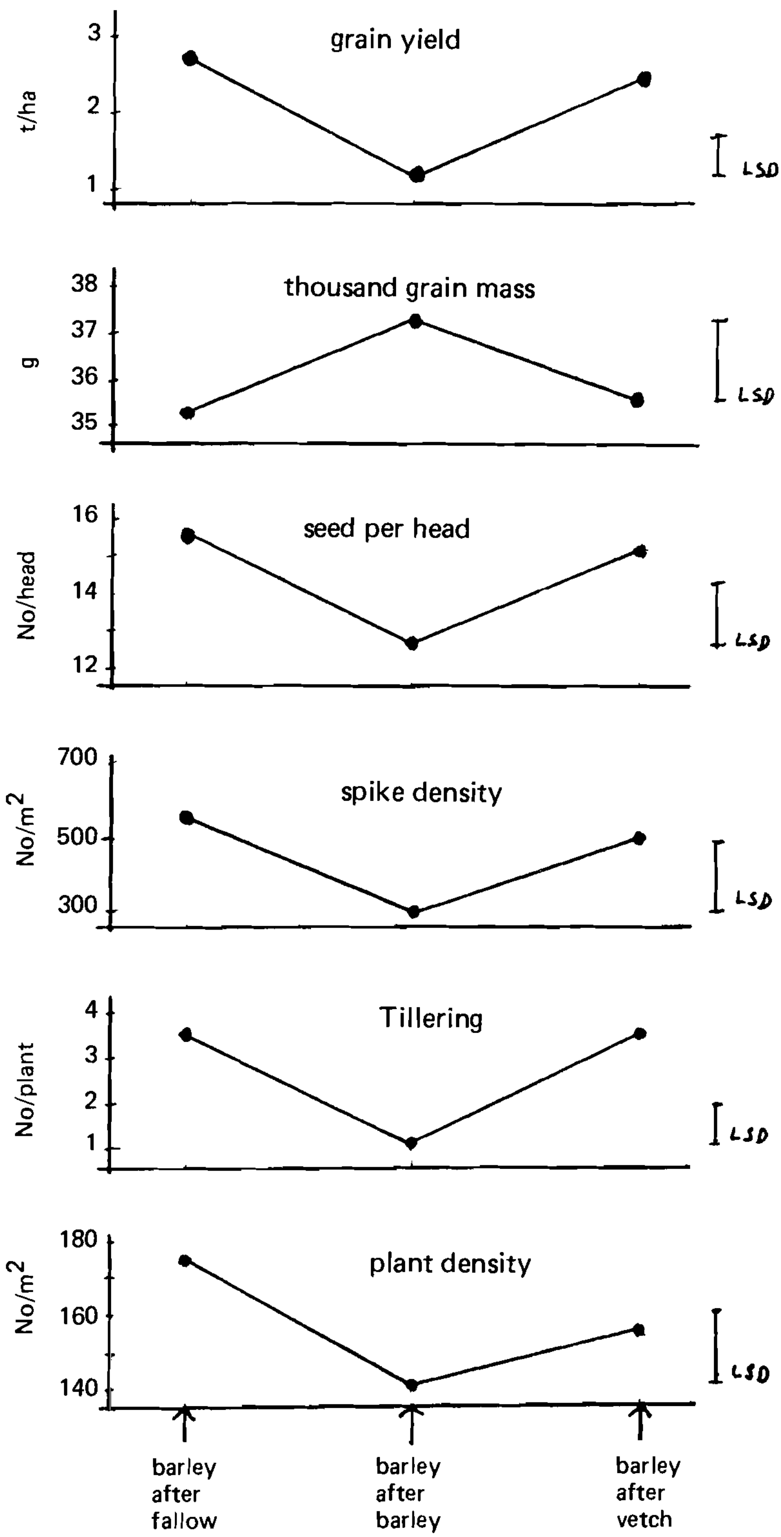
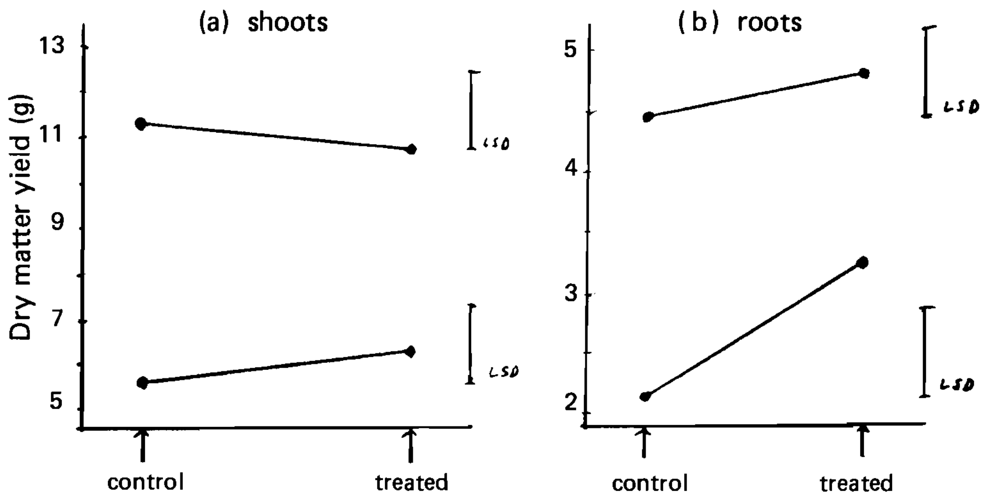


Fig.28: Influence of selective antifungal treatment of soil (by "Ridomil") on the growth (DM yield) of shoots (a) and roots (b) of wheat.



Fusarium oxysporum. Common root rot - the general browning of roots and stem bases - was generally low, but highest in Experiment A and lowest in Experiment C.

In Experiment B at Tel Hadya, and in Experiment C, common root rot appeared more severely in continuous monocultures than in cereals after fallow. However, the results indicate that the browning of roots can be considered as only a secondary infection rather than a factor causing the decline. Stunting is obviously a characteristic symptom of the decline in all experiments, with the addition in Experiment B of discolouration of stem bases and leaves (Feb 86, $P<0.05$) and in Experiment C of straightening of leaves ($P<0.05$). It is hypothesized that the typical "decline" symptoms which are observed are due to physiological (e.g. nutrition and self-allelopathy) rather than pathological factors (but see next section).

Cereal cyst nematodes (Heterodera spp.) were present in barley trials (Tel Hadya, Breda, Bouider and Ghererife), especially in Experiment A where a high number of cysts, eggs and larvae occurred. It would therefore be worthwhile studying the damage and loss caused by them.

Experiment 31: studies under artificial conditions (Preschedules 31 and 33)

More detailed studies of the decline were made in experiments conducted under the artificial conditions of the plastic house and growth chamber.

When plants of Arabi Aswad barley, grown in soils taken from continuous monoculture were compared with plants grown in fallow soil, the 'decline' was clearly observed. There were significant reductions in plant size, dry mass of shoots, and root size. By contrast, there was little decline in cultivar Beecher: significant changes occurred only in plant size and dry mass of shoots. The decline could also be seen in the growth of wheat: in cultivar Hourani (Durum Wheat) it appeared stronger than in cv. Sham 2 (bread wheat) in plant size and dry mass of shoots ($P<0.05$).

The use of different soil and seed sterilisation treatments for soil of continuous monoculture and of fallow gave some significant plant growth effects: from using steam, and heating at $85^{o}C$ for both barley and wheat rotations ($P<0.05$), Ridomil after continuous wheat ($P<0.05$), and Vitavax after continuous barley ($P<0.05$). Fig.28 illustrates the effect of the Ridomil treatment (a fungicide against "lower fungi" (e.g. Pythium spp) of order peronosporales, Worthing and Walker, 1983.

It can therefore be concluded that microbial populations are detrimental to continuous cereals and in cereal after fallow. One of the "lower fungi", possibly *Pythium* spp. may be involved in continuous wheat and "higher fungi" (e.g. *Pyrenophora sativa*) in continuous barley. **- S. Krause., P.S. Cocks and O.F. Mamluk (Cereal Program).**

TRAINING

Training has an important role in the Program's activities. It aims to improve the technical skills, and help countries in the ICARDA region create a cadre of well trained scientists working on the subject of pastures, forages and livestock. The training offered by PFLP also seeks to achieve a network of research workers within the region. At present it is the main out-reach activity of the Program.

As far as possible we attempt to link our training to our research. This is particularly so in the individual training where, in consultation with national programs, we associate the trainees with projects of relevance to their own countries and to our proposals for their countries. A good example is the training in on-farm research methodology, where we are able to train the assistants who will later work with the Program on farmers fields. We also attempt, as far as possible, to assign field projects to trainees which are, on the one hand, part of our main-stream research, while, on the other, complete within themselves, the trainee being involved in the whole research process, planning and implementating the field work, analysing the results, and writing the report.

The following training courses were offered in 1985/86.

1. A residential course of 3 month duration (March 2 - June 5).

2. Long-term courses of 9 months duration

(a) seed production of annual medics

(b) management of experimental sheep flocks

(c) livestock on-farm trials

3. Short-term individual training courses

The residential course

The overall objectives of the residential course were firstly to improve the capabilities of junior scientists from developing countries in the ICARDA region, and secondly, assist in establishing links with national programs.

Ten trainees, from 8 countries (Syria, Egypt, Pakistan, Sudan, South Yemen, Ethiopia, Iran and China), participated in the course, which covered field and laboratory techniques in the breeding, agronomy and utilization of forages, the ley farming system, biological nitrogen fixation, improving livestock nutrition, marginal-land improvement, quality assessment of forages and grazing management.

Each participant was assigned a small experiment which was supervised by a senior scientist. Details are given in Table 63.

Table 66. Experiments assigned to 1986, residential course participants, and their supervisors.

Name of trainee	Country	Title of experiment	Supervisor
1. Omar Ankouz	Syria	Monitoring pasture productivity in marginal land following phosphate application.	Dr Ahmed Osman
2. Samir Tawfik	Syria	Cultural practice of medic seed production	Dr P.S. Cocks/Dr Ali Abd El Moneim
3. Wahid Salamah	Egypt	Monitoring pasture productivity in marginal land following application of phosphorus.	Dr Ahmed Osman
4. Fatima Rahman	Pakistan	Forage vetch germplasm evaluation and utilization.	Dr Ali Abd El Moneim
5. Mohamed Ibrahim	Sudan	Effect of Rhizobium inoculation on the agronomic characters of certain forage vetches.	Dr Ali Abd El Moneim Dr L. Materon
6. Ahmed Mukred	S. Yemen	Fattening of Awassi lambs	Dr E.F. Thomson/Mr F. Bahhady
7. Hassan Ali	Ethiopia	Nutritive value of forages and straw	Dr E.F. Thomson
8. Mohamed Mahdi Khademian	Iran	The effect of defoliation on the growth and yield of medic.	Dr A. Smith
9. Asgar Mousavi	Iran	The effect of defoliation on the growth and yield of medic.	Dr A. Smith
10. Chen Kedong	China	Forage germplasm evaluation and utilization.	Dr Ali Abd El Moneim

Long-term courses

One of the major constraints restricting the use of annual medics is the lack of experience in seed production. A long term training course, from November 1985 to July 1986, with one trainee from Tunisia and 2 from Syria, concentrated on practical aspects of medic seed production, including sowing, use of herbicides, the effect of grazing and harvesting, and use of the suction harvester. The results of the research component of their studies are reported in Experiment 26.

One trainee from Syria was trained from November 1985 to July 1986 on the management of experimental sheep flocks-milking, weighing, feeding, keeping records, and reporting results. The results of her work are reported in Experiment 9.

A trainee from Syria studied methodology of livestock on-farm experiment from January to July 1986. He worked with experiment 7.

Short-term courses

A Tunisian trainee studied biological nitrogen fixation, and the production of rhizobia. The specific problem was lack of nodulation by Hedysarum carnosum, an annual legume of value in the dry areas of Tunisia.

Another Tunisian was trained on breeding methods and selection citeria in forage legumes. He will initiate a forage breeding program in Tunisia.

Three demonstrators from Tchreen University were trained for one week on screening for disease and nematodes in forage crops, quality assessment of forage, and biological nitrogen fixation respectively.

These courses are designed to fit specific needs of national programs and are usually initiated at their request. In 1985/86 there were three such courses. - **A.M. Abd El Moneim**

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