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REHABILITATION OF DEGRADED GRASSLANDS IN NORTH SYRIA: USE OF FARMER PARTICIPATORY RESEARCH TO ENCOURAGE THE SOWING OF ANNUAL PASTURE LEGUMES

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SUMMARY

A series of experiments on communally-owned grasslands in the barley–livestock zone of north Syria were conducted to test the hypothesis that introduction of Mediterranean annual legumes will increase productivity. The experiments were preceded by a survey to determine farmers' attitudes, describe the farming systems and to select appropriate collaborators. The first experiment examined the establishment of medics (*Medicago* spp.) and clovers (*Trifolium* spp.) distributed by hand, and monitored their effects on biomass and seedbank size. Later experiments extended these results to other villages. The principles of farmer participation in research were used to overcome the constraints imposed by the communal ownership of land.

The survey revealed that the average size of the 20 villages was 36 families and that each village owned 887 sheep and 790 ha land. All villages had access to communally-owned grasslands, although their dependence on income from sheep varied greatly. These villages were subsequently divided into groups of high, intermediate and low potential.

Of the 11 clovers sown in the first experiment, seed numbers of *T. tomentosum*, *T. purpureum*, *T. haussknechtii*, *T. pilulare* and *T. resupinatum* increased over three years. By 1996, there were more than 3000 legume seeds m^{-2} in the seeded treatment compared with less than 2000 in the unseeded treatment (mainly the naturally-occurring *Trigonella monspeliaca*). The number of medic and clover seedlings also increased significantly, while the number of *Trigonella* seedlings decreased significantly. Biomass production increased in the final two years and there was no response to added phosphorus.

There were similar results in the later experiments. Seedbank size was greater in seeded treatments than in unseeded treatments, there were more seedlings in the seeded treatments, and the most successful species were *T. campestre*, *T. tomentosum*, *T. speciosum* and *M. rigidula*. The response in biomass was limited to the legume component, although total biomass increased in at least one of the two years. The highest biomass produced was 1112 kg ha^{-1} and there was no response to added phosphorus.

The results suggested that the on-station research previously conducted at ICARDA headquarters was applicable to communally-owned land, although important modifications were needed. For example, at ICARDA phosphorus was necessary to stimulate the growth of legumes; in contrast, it was necessary to sow legumes at the four villages involved in these experiments. The results also suggested that the grasslands were common property, owned and controlled by defined groups of farmers.

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INTRODUCTION

Before the advent of agriculture much of what is now Mediterranean grasslands supported woody plants and shrubs. The subsequent land degradation was caused by greatly increased populations of people and livestock, which led to overgrazing, the uprooting of shrubs and trees for fuel and the encroachment of cultivation. As a result, the original perennial vegetation has been replaced by low densities of annuals and unpalatable spiny species. Herbage availability is low, particularly in winter, and there is no green feed in summer. There are indications that there is often insufficient feed to maintain sheep liveweights, especially in the driest areas (Cocks and Osman, 1996).

The origins of the work reported in this paper lie in the improvement of the grasslands of southern Australia with phosphorus fertilizer and Mediterranean annual legumes, which replaced the native perennial grasses (Robinson and Lazenby, 1976). Russell (1960) indicated that phosphate application to pasture sharply increases livestock production, and the widespread use of subterranean clover in southern Australia has been dependent in large measure on the associated use of superphosphate to correct widespread phosphorus deficiencies (Wild, 1958; Stephens and Donald, 1958). Sustained grassland productivity also depends on the capacity to control stocking rate; when stocking rates exceed certain levels, subterranean clover is replaced by many of the small-seeded annual clovers (*T. glomeratum* and *T. tomentosum*) common in the Mediterranean Basin (Brown, 1976).

Attempts to emulate the Australian experience in the Mediterranean Basin have been reported by Masson *et al.* (1990) and Cocks and Gintzburger (1993). Annual self-reseeding legumes can be used to reclaim uncultivated land and to reduce the environmental impact of cultivation (Masson and Gintzburger, 1989). In the cold mountains of Mediterranean France, there was a significant increase in biomass production after the application of phosphate fertilizer to grassland containing *Medicago rigidula* (Dauro and Gintzburger, 1987).

Unfortunately, the Australian experience is not always directly relevant to Mediterranean conditions. Biologically, most Australian cultivars of annual legumes are not tolerant to the frosts that they are likely to experience in West Asia and North Africa (Cocks and Ehrman, 1987). From the human point of view, the social problems are usually overlooked (Springborg, 1986). The simplistic transfer of the enormously successful Australian approach to Mediterranean conditions as advocated by Chatterton and Chatterton (1984) has actually made matters worse in that where problems have arisen, as they inevitably do in a different cultural and biological background, the principles and not the details have been discarded.

In a long-term experiment at the research station of the International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria, Osman *et al.* (1991) identified three strategies to improve degraded West Asian grasslands: (1) where the seedbank is insufficient, overseed with indigenous legume species,

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(2) where soil phosphorus is deficient, apply phosphate fertilizer and (3) for any communally-owned grassland, improve the control of grazing, or an appropriate combination of these strategies. The first two are easily applied (where necessary) to most grasslands; only the third needs universal application and remains to be tested away from the research station.

Wider adoption is constrained by a mix of technical and socio-economic factors, which make grassland improvement ideally suited to farmer participatory research (Farrington and Martin, 1988). In particular, grazing management, and by implication land tenure, looms as the greatest limitation to adoption of the technology. The term 'common property' has been largely misunderstood and falsely interpreted since the late 1970s. Ciriacy and Bishop (1975) reported that common property represents private property for the group (since all others are excluded from its use and management), and that individuals have rights in common property. Common-property regimes are not the free-for-all that some commentators believe, but are well-structured arrangements in which group size is known and enforced, management rules are developed, incentives exist for co-owners to follow the accepted institutional arrangements and sanctions work to ensure compliance.

Farmer participation in research (FPR) is a methodology that attempts to overcome the socio-economic constraints of new technologies, and is especially relevant to issues such as land tenure and the technical improvement of common property. The principal argument for the FPR approach is that constraints at the farm level limit the adoption of new technologies that come from outside the system (Gartner, 1990).

This paper examines the rehabilitation of 'communally-owned' grasslands by applying the technical concepts developed by Osman *et al.* (1991; 1994) and Osman and Cocks (1992). It used the farmer participatory approach, in which farmers collaborated with researchers throughout the research to overcome problems imposed by local land-tenure systems.

MATERIALS AND METHODS

Survey of grassland farming systems in the El-Bab area

There were two objectives to the survey: (1) to assess the opinion and interest of local farmers in improving degraded grasslands and (2) to identify potential villages in which to conduct further research.

A total of 20 villages with access to grasslands were selected for the study. The villages were in the El-Bab area (50 km north-east of Aleppo), located within the barley–livestock zone of north Syria (Cooper *et al.*, 1987). Open questionnaire and semi-structured interview techniques were used, and in most cases respondents were village heads (*mukhtars*), although in all cases other village residents were present and participated in the discussions. The survey questions included the following: how many farmers use the grasslands, how many sheep do they own, what is the area of land available for grazing and what recent changes have taken

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place in agricultural practice (for example, increased cultivation, further land degradation)?

Analysis of the results was in two stages. First, they were used to provide a description of the production systems and to identify constraints to grassland improvement. Second, the villages with the greatest potential for grassland improvement were identified using answers to the questionnaires and advice from the *mukhtars*. This involved selection of villages where stocking rates were not excessive, farm size was adequate to support families, and the number of families was small.

To identify their potential for land improvement, the villages were divided into groups. The first subdivision was based on whether or not grassland improvement was considered beneficial. The second was based on the capacity to guard the land from trespassers. The third and fourth were based on potential stocking rate and the numbers of families. Too many families or too high a stocking rate could cause conflicts over protection and management. The final subdivision was based on the total number of sheep and the amount of land per family, indicating the relative dependence on sheep and crop production for village survival.

Improvement of communally-owned grassland at Batajek using small-seeded legumes and phosphate fertilizer

The objectives of the research at Batajek were (1) to study seedling establishment of medics and clovers from pods and seeds distributed by hand, and (2) to monitor biomass and seedbank size after improvement with seed and fertilizer.

Batajek is 70 km north-east of Aleppo (lat 36°33′N, long 37°35′E). The mean annual rainfall is 270 mm and the above average rainfall during the three years of the experiment is shown in Fig. 1. The underlying rock is limestone and grassland

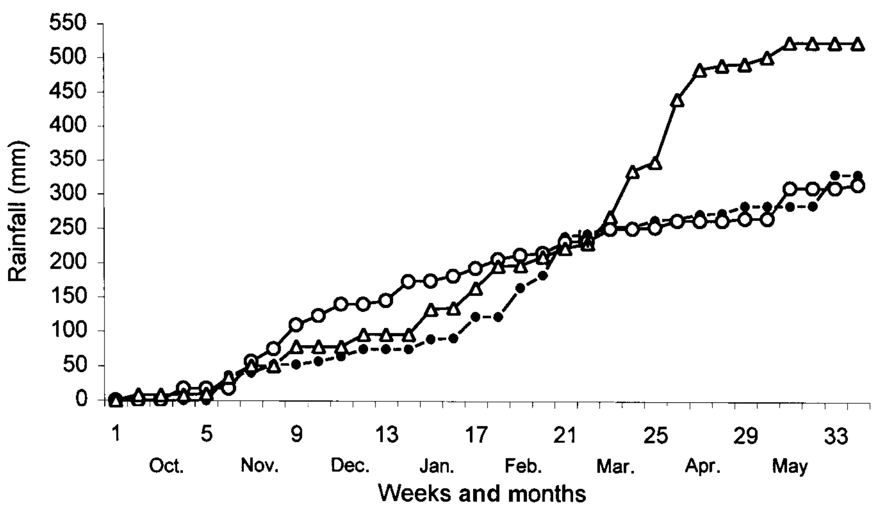

Fig. 1. Cumulative weekly rainfall at Batajek, north Syria during 1993–94 (—●—, 330 mm), 1994–95 (—○—, 316 mm) and 1995–96 (—△—, 523 mm).

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Table 1. Description of the four villages in north Syria used for on-farm research to improve communally-owned grasslands.

Village	Families (number)	Sheep (number)	Sheep per family	Barley (ha)	Other crops (ha)	Grassland (ha)
Batajek	3	300	100	100	50	70
Tarhin	3	300	100	200	50	50
Tel-Jerji	5	2000	400	800	240	50
Tel-Atia	30	700	23	700	300	200

soils are predominantly shallow; soil depth ranges from 0 to 0.5 m and there is an abundance of stones making cultivation impossible. The grasslands are located within sight of the village itself and occupy an area of 70 ha (Table 1). Vegetation comprises mainly *Poa bulbosa* and *Carex stenophylla*, along with the most common legume species, *Trigonella monspeliaca*. A few other legumes are also present (*Astragalus* spp., *Onobrychis crista-galli* and *Vicia sativa* ssp. *amphicarpa*). Although the grasslands are 'owned' by three brothers, they are traditionally considered to be common property and, before the experiment began, they were available to two neighbouring villages. The brothers refer to their grasslands as their 'hill' (Arabic *tel*).

In November 1993 an experiment was established with the following treatments: native (unseeded) grassland without fertilizer, unseeded with fertilizer, seeded without fertilizer and seeded with fertilizer. The fertilized plots received 25 kg P_2O_5 ha^{-1} broadcast on the surface. The treatments were arranged in a randomized complete block with three replicates. Plot size was 3 ha for two of the replicates and 2 ha for the third, resulting in a total area of 32 ha.

Table 2 shows the species included in the seed mix. All except the medics were mixed and broadcast at a seed rate of 9.6 kg ha^{-1}; the medics were sown at a rate of 100 kg pods ha^{-1} (25 kg ha^{-1} for each accession). The two mixes were sown separately by the farmers who were expert at hand-broadcasting (most of their cereal crops are sown in this way). None of the seeds were softened artificially (made permeable to water), and the hardseededness of the medics in particular would have been 85–95%. To ensure that the seed spread was even each farmer traversed each plot several times. The fertilizer was also hand-broadcast, but kept separate to reduce possible toxic effects. After sowing and fertilizing, two transects were laid out from opposite corners of each plot. All subsequent measurements were based on these transects.

Soils were sampled in September 1995 and November 1996. There were five soil samples from each plot for a total of 60 samples in the experiment as a whole. The soil was analysed for Olsen-P (Watanabe and Olsen, 1965).

Available herbage was measured in April each year for three consecutive seasons. There were 40 samples in each plot, except for the first season when only 20 samples per plot were taken. Since the pasture was often too short to cut, each

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Table 2. Composition of the 41 kg of legume seed mixture for reseeding Batajek grassland near El Bab, north Syria (1993) and the number of seeds m^{-2} found in the seedbank in the following three years. (Figures in parentheses are standard errors.)

Legume species	Com-position (kg)	1994		1995		1996	
		Unseeded	Seeded	Unseeded	Seeded	Unseeded	Seeded
Trigonella monspeliaca	—	4234(433)	3909(370)	2672(385)	2576(316)	1884(160)	1704(155)
Trifolium angustifolium	0.19	0	0	0	0	0	0
Trifolium campestre	0.81	0	71(16)	2(1)	173(61)	0	85(25)
Trifolium haussknechtii	1.06	0	4(1)	0	36(13)	0	141(46)
Trifolium lappaceum	1.06	0	2(0.9)	0	22(8)	0	0
Trifolium pilulare	1.06	0	1(0.7)	0	6(3)	0	49(18)
Trifolium purpureum	1.06	0	27(18)	4(4)	249(122)	2(1)	270(84)
Trifolium resupinatum	1.06	0	0	0	1(1)	0	8(3)
Trifolium scabrum	0.09	1(1)	3(1)	0	0	45(45)	24(13)
Trifolium speciosum	1.06	0	0	0	0	0	0
Trifolium stellatum	0.09	0	0	0	0	0	0
Trifolium tomentosum	1.06	0	107(47)	79(76)	121(52)	11(9)	343(106)
Medicago rigidula sel. 1919 and 716	13.5	0	179(24)	1(1)	682(110)	2(0.8)	317(40)
Medicago noeana	7.8	0	97(15)	0	224(41)	0	114(17)
Medicago rotata	10.6	1(1)	117(18)	0	93(28)	0	20(4)
Hippocrepis unisiliquosa	0.13	0	0	0	0	0	0
Scorpiurus muricatus	0.19	0	0	0	0	0	0
Total seeds	41	4236(433)	4517(388)	2759(371)	4183(366)	1945(170)	3078(229)
Total sown species seeds	41	2(2)	608(92)	86(77)	1607(218)	60(45)	1371(183)

of the samples comprised four cores (10.4 cm diam.) to a depth of 3–5 cm. The plants with a large portion of roots were removed from the cores in the laboratory. They were then separated into legumes, grasses and other species, and the number of each was recorded. The roots were discarded and the shoot portion of each category was dried at 75 °C and weighed. The remaining soil from each sample was kept for checking seedbank size. Legumes were further separated into three groups – medics, clovers and *Trigonella* – to distinguish the species used for reseeding (medics and clovers) and the species already present (*Trigonella monspeliaca*).

Seedbank samples were taken in June each year. Except for the last season 20 samples were taken along the transects in each plot: in the final season there were 40 samples per plot. Each sample comprised four cores each of 10.4 cm diam. to a depth of 5 cm. In the laboratory, legume seeds were hand-sorted as far as possible, the material was then washed through a fine sieve, dried and the remaining seeds hand-sorted again. The first sorting aimed to remove as many seeds as possible and reduce the chance that soft seeds would imbibe and be lost during the sieving process. Seeds and pods were then threshed, identified to the species level and counted.

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Extension of the results at Batajek to other villages in the El-Bab area

In 1993, Batajek was selected for detailed work on the basis that, if the programme was to succeed, it was most likely to succeed there. One year later it was considered necessary to test the ideas at other villages in the area, including those where success was considered less likely. The villages chosen were Tarhin, Tel-Jerji and Tel-Atia. Details of these villages are shown in Table 1.

Tarhin (village 9) is a small village (lat 36°31′N, long 37°31′E) with three families and 300 sheep. The grasslands, located within sight of the village, have a total area of 50 ha and are characterized by shallow soils, a sloping aspect, and the presence of many stones. Average annual rainfall at the nearest station is 270 mm. The village is similar to Batajek, and the chances of transferring the technology to Tarhin were considered good.

Tel-Jerji (village 10) is another small village (lat 36°30′N, long 37°28′E) with five families. Tel-Jerji has many more sheep than Tarhin (2000 compared with 300). The grassland area of 50 ha is located within sight of the village, and is characterized by shallow soil, undulating slopes and the presence of many stones. Rainfall is similar to Tarhin.

Tel-Atia (village 16), located near El-Raei (lat 36°34′N, long 37°27′E) close to the Turkish border, is a much larger village than either Tarhin or Tel-Jerji. There are 30 families, the area of grasslands is 200 ha, and the total number of sheep is 700. The grasslands are out of sight of the village and therefore grazing is more difficult to control. They are characterized by deeper soil and higher rainfall than the other locations (no reliable rainfall measurements were available).

Soil samples were taken from treated and control plots in October 1994 and 1996 to measure Olsen-P (Watanabe and Olsen, 1965). Each sample comprised four cores of 5 cm diam. The first sampling was before the treatments were established and the second was two years later. The number of samples was 20, 20 and 10 from Tarhin, Tel-Jerji and Tel-Atia respectively.

In November 1994, two treatments (without replication) were applied at each location: (1) seeded and fertilized, and (2) control. The treated plot comprised the legume-seed mix shown in Table 3 sown at 34 kg ha^{-1}, and fertilizer applied separately at 25 kg P_2O_5 ha^{-1}. A single furrow was cultivated around each site as a border to protect the areas from unauthorized grazing. At the farmers' request, the area was not grazed in the spring and summer of 1995. The areas of the treated plots were 20, 12 and 25 ha at Tarhin, Tel-Jerji and Tel-Atia respectively, and the controls were 3, 2 and 5 ha respectively.

Herbage samples were taken in April each year in each village along 2 or 3 transects, depending on plot shape. Each sample comprised four cores (10.4 cm diam.) cut to a depth of 3–5 cm into the soil. The cores were bulked and the samples processed in the laboratory by removing the plants with their roots, and separating into legumes, grasses and other species. For the legumes, the number of plants in each core was counted. The roots were discarded and the shoot portion dried at 75 °C and weighed.

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Table 3. Legume seed species and seed rates (kg ha^{-1}) sown at three grassland locations, Tarhin, Tel-Jerji and Tel-Atia, in north Syria.

Species	Seed rate
Medicago rigidula sel. 1919	2.25
Medicago rigidula sel. 716	2.10
Medicago rigidula sel. 2792	2.25
Medicago rotata sel. 2123	13.5
Trifolium angustifolium	1.00
Trifolium campestre	1.00
Trifolium haussknechtii	1.55
Trifolium lappaceum	1.55
Trifolium pilulare	2.20
Trifolium purpureum	0.70
Trifolium resupinatum	0.70
Trifolium speciosum	4.05
Trifolium tomentosum	1.55

Seedbank samples were taken in June 1995 using the same transects and sampling frequency. The seed samples were hand-sorted into legumes and other species, the soil was sieved and dried and the remaining seeds were hand-sorted again. Legume seeds were then identified to the species level and counted. There were 80, 40 and 100 samples for both herbage and seedbank size at Tarhin, Tel-Jerji and Tel-Atia respectively, and 20 samples from each of the control plots at each village.

In order to distinguish the species used for reseeding and those native to the villages (*Trigonella monspeliaca* and *Trifolium scabrum*), the number of medics and clovers (plants or seeds) were separated from the total number of all legumes. In effect this separates *Trigonella monspeliaca* from the sown clovers as *T. scabrum* was rare. *T. tomentosum*, *Trifolium resupinatum* and *T. campestre* were counted as 'sown' clovers, although they were also present as natives.

The significance of differences between treated and control plots was tested using the *t*-test for independent samples in SPSS (1990).

RESULTS

Survey of grassland farming systems in the El-Bab area

Most of the villages have been in existence for many years: two for over 500 years, and another seven for more than 100 years. Barley (*Hordeum vulgare*) is the principal crop grown in all villages, with some also growing wheat (*Triticum aestivum*), lentil (*Lens culinaris*) and chickpea (*Cicer arietinum*). All villages reported an increase in the area cultivated during the past 10 years, either through the sowing of fallow land or encroachment of cultivation on to grassland.

The average number of families per village was 35.9 ± 7.2 (range, 3–100). The average number of sheep per village was 887 ± 138 (range, 40–2500) and the

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average village land area was 792 ± 172 ha (range, 45–800). With such large differences, the villages were grouped according to the number of sheep they owned and the amount of land to which they had access (both cropping and grassland) (Table 4). All village flocks grazed the grasslands in spring, with flocks in four villages also grazing in winter and one in summer. One village used the grassland areas all year round. In about half of the villages, some cereal stubble was rented out to other farmers or migrant herders (*bedouin* nomads from the steppe). A total of 70% of the respondents said they experienced problems with trespassers on their land, either from neighbouring villages or from the *bedouin*. However, over half (55%) said they could guard the land if necessary. Most *mukhtars* (85%) thought it would be beneficial to improve the grasslands, with 11 suggesting the best way would be simply to protect the land. Two suggested reseeding and protection, and one suggested reseeding and fertilization.

There were five negative or non-committal responses to the question, 'Do you see any real benefit from grassland improvement?' (Question 1). Four of these were from villages with many families and little land per family (about 10 ha or less). Sheep numbers per family were also low, being less than 20 in three cases and around 40 in the fourth. In the fifth case, there were only four families. The average land holding was 375 ha, the average flock size per family was 75, and there were only 1.5 sheep per ha grassland. The apparent reluctance of this village to consider rehabilitation arose from the fact that much of the cereal stubble was rented to *bedouin*, who would also have access to the improved land. There were four villages where the benefits of rehabilitation were recognized, but where it appeared impossible to guard the grassland (Question 2). Again there were many families (>25) in each village, with small flocks (<40 sheep) per family and, in general, small amounts of land (one village averaged 37.5 ha per family).

Eleven villages answered 'yes' to Questions 1 and 2. These were divided into two subgroups: one where the existing stocking rate was less than 11 sheep ha^{-1}, and one where it was over 40 sheep ha^{-1}. It would be difficult to undertake much rehabilitation in the latter group, where there are many families, sometimes with

Table 4. Grouping of villages in north Syria according to the number of sheep per family and the area of land (cropping and grassland) per family.

Number of villages	Sheep per family	Land per family	Description
5	10–25	<15 ha	Little land area, small flocks mainly for family consumption, mainly off-farm income.
7	10–25	>25 ha <70 ha	Small flocks mainly for family consumption, land area adequate for family income generation, augmented by seasonal off-farm income.
3	33–40	<15 ha	Flock size adequate for income generation, augmented by seasonal off-farm income.
5	75–400	>50 ha <375 ha	Large flocks and large land areas, no off-farm work required.

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less than 25 sheep per family. Within the high stocking-rate group, however, villages 2 and 10 consisted of only a few families (seven and five respectively), with more arable land and larger flocks. Rehabilitation would have been difficult because of the high stocking rates, but not impossible in this case because of the small number of families. While other variables could have been considered, such as social cohesiveness and willingness to participate, the issue was to identify those areas with the highest potential for rehabilitation. High stocking rates on common land were difficult to control, and larger villages offered more potential for disputes concerning land access.

The seven final villages used their grasslands sparingly, and four had about three families. These were classified as the ones with the greatest chance of success.

The group of 11 villages with potential for grassland improvement can be summarized as follows:

- high potential (villages 1, 3, 4 and 9) with low stocking rates and few families
- intermediate potential (villages 2, 8, 10, 15 and 16) with low stocking rates but many families, or few families but high stocking rates
- low potential (villages 5 and 13) with high stocking rates and many families

Experimental rehabilitation was undertaken first where the potential was good – in village 4 (Batajek). The work was extended later to another village of good potential, village 9 (Tarhin), and two villages of intermediate potential, villages 10 (Tel-Jerji) and 16 (Tel-Atia).

Improvement of communally-owned grassland at Batajek using small-seeded legumes and phosphate fertilizer

There was a significant effect of fertilizer on soil phosphorus in 1995 (18.0 ± 3.89 compared with 12.8 ± 1.70 mg kg^{-1} in unfertilized plots), but not in 1996 (16.4 ± 3.40 compared with 14.2 ± 2.55 mg kg^{-1} in unfertilized plots). There was no effect of seeding on soil phosphorus.

There was significantly ($p < 0.01$) more herbage available in the seeded plots compared with the unseeded plots in April 1995 and 1996 (Fig. 2). Seeding significantly increased legume dry matter in 1995 and 1996 – 153 kg ha^{-1} compared with 39 kg ha^{-1} in 1995 and 259 compared with 65 kg ha^{-1} in 1996 for the seeded and unseeded plots respectively. Available dry matter ranged between 600 and 1000 kg ha^{-1} in both the seeded and unseeded treatments. There were no significant effects of phosphate fertilizer during the experiment.

While the numbers of medic and clover seedlings (Fig. 3) increased over the three years ($p < 0.01$), the number of *Trigonella* plants declined significantly ($p < 0.01$). There were significant seeding $\times$ year interactions ($p < 0.01$).

When analysed individually, no species showed a response to phosphorus. In contrast, the effect of seeding was highly significant for all species except *Trifolium scabrum* (Table 2). The number of *Trigonella* and medic seeds in the seedbank declined significantly over the three years of the experiment, while *Trifolium tomentosum*, *T. purpureum*, *T. haussknechtii*, *T. pilulare* and *T. resupinatum* increased

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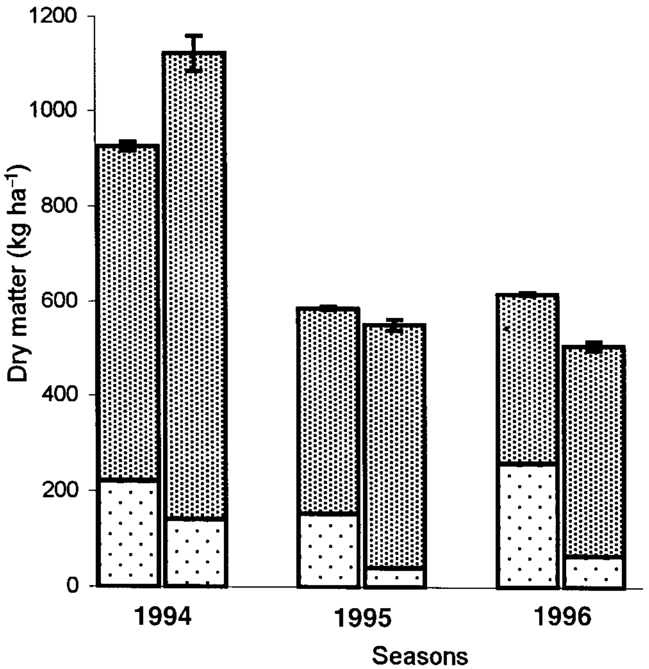

Fig. 2 Biomass production (kg ha^{-1}) of the legume (⁚⁚) and remaining grass and weed (▒) components of the grassland at Batajek, north Syria in 1994, 1995 and 1996 for the seeded (first column in each season) and unseeded (second column in each season) plots. Bars represent standard errors ($n = 40$).

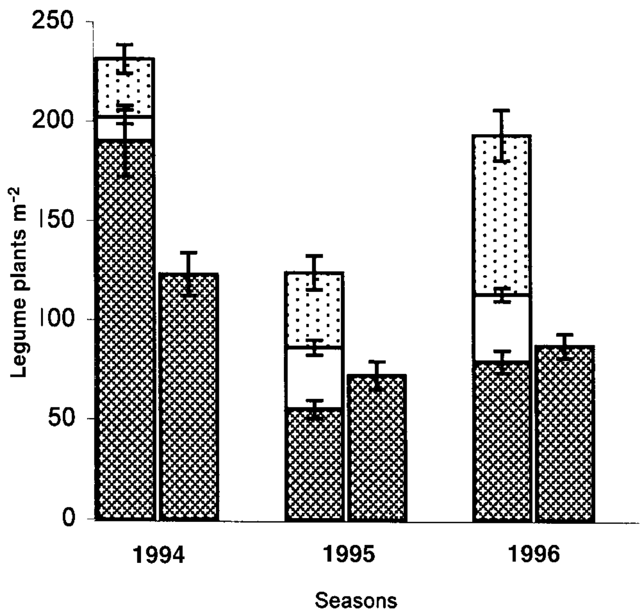

Fig. 3. The number of legume seedlings (*Trifolium* spp. (⁚⁚), Medics (□) and *Trigonella monspeliaca* (⊠) per m^2) at Batajek, north Syria in 1994, 1995 and 1996 for the seeded (first column in each season) and unseeded (second column in each season) plots. Bars represent standard errors ($n = 40$).

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significantly. By 1996, there were more than 3000 total seeds m^{-2} in the seeded treatment compared with less than 2000 seeds m^{-2} in the unseeded treatment. Of seeds in the seeded plots, 1700 seeds m^{-2} were *Trigonella*, 920 were clover and 450 were medics. These numbers compared with 1880 *Trigonella* seeds m^{-2}, 58 clover and 2 medics in the unseeded plots.

Extension of the results at Batajek to other villages in the El-Bab area

Soil analysis in 1994 revealed that available phosphorus was 8.3 ± 0.55 mg kg^{-1} at Tarhin, 11.7 ± 2.1 at Tel-Jerji and 15.3 ± 0.78 at Tel-Atia. In 1996, soil phosphorus had doubled at Tarhin (17.1 ± 2.6 mg kg^{-1}) and Tel Atia (32.6 ± 9.2) and increased by approximately 50% at Tel-Jerji (15.6 ± 0.6). In the controls, soil phosphorus remained largely unchanged although there was a small decrease at Tel-Atia.

There were few legumes present in the controls at any of the sites. The most frequent were *Trigonella monspeliaca* and *Trifolium tomentosum* at all sites and *T. campestre* at Tel-Jerji. There were small numbers of other species including *T. resupinatum* and *T. speciosum*.

The number of legume seedlings was greater in the treated plots than in the controls at all villages and in both years except at Tel-Jerji in 1996, when the difference was not significant (Table 5). Of these, the number of *Trigonella monspeliaca* seedlings did not differ significantly except in April 1996 at Tel-Jerji where there were significantly more plants in the treated plots (126 ± 26 compared with 68 ± 16 plants m^{-2}) and in April 1996 at Tel-Atia where there were significantly more in the control plots (39 ± 6 compared with 109 ± 31).

Table 5. The numbers of plants in April 1995 and 1996, and the numbers of seeds in June 1995 and 1996 in grasslands associated with the villages of Tarhin, Tel-Jerji and Tel-Atia in north Syria. Treated plots were sown with the mixture in Table 3 and fertilized with 25 kg P_2O_5 ha^{-1}. (Figures in parentheses are standard errors.)

Treatment	Tarhin	Tel-Jerji	Tel-Atia
		1995	
Plants m^{-2}			
Treated	119(26)	77(22)	244(36)
Control	15(5)	9(6)	38(13)
Seeds m^{-2}			
Treated	749(107)	2343(468)	3373(515)
Control	499(188)	418(203)	968(654)
		1996	
Plants m^{-2}			
Treated	213(39)	261(50)	212(26)
Control	35(13)	129(88)	68(17)
Seeds m^{-2}			
Treated	6181(786)	5338(1068)	5896(841)
Control	2984(588)	1766(1190)	2226(699)

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Table 6. Available legume dry matter ($kg\ ha^{-1}$) in sown and natural grassland at Tarhin, Tel Jerji and Tel Atia, north Syria in April 1995 and 1996.

	1995		1996	
Village	Treated	Control	Treated	Control
Tarhin	93(18)	53(20)	335(50)	89(29)
Tel-Jerji	89(22)	59(13)	686(134)	303(109)
Tel-Atia	239(23)	131(42)	526(89)	190(34)

Seed numbers were also greater in the treated plots except in June 1995 at Tarhin where the numbers were not significantly different (Table 5). The presence of 'seeded' species in the 'unseeded' plots (data not shown) indicated the presence of native *T. tomentosum* or other clover that was also included in the seed mixture.

At least 10 of the 13 sown species were present at all villages in April 1996. The most abundant were *T. campestre* and *M. rigidula* at Tarhin, *T. tomentosum*, *T. speciosum* and *T. campestre* at Tel-Atia and *T. campestre*, *T. speciosum* and *T. tomentosum* at Tel-Jerji. Available dry matter was greater in 1996 than in 1995 (Table 6) despite the grazing that took place in 1996. In 1995, only Tel-Jerji showed a significant response to treatment and it was only at Tel-Jerji that there was no significant response in 1996. In the latter year the response, though not significant, was substantial. Neither the grass nor the 'weed' component responded to treatment at any village in any year. However, total herbage production was significantly greater for treated plots compared with the controls at Tel-Jerji in 1995 (605 ± 49 compared with $343 \pm 52\ kg\ ha^{-1}$), at Tarhin in 1996 (1007 ± 57 compared with $738 \pm 61\ kg\ ha^{-1}$) and at Tel-Atia in 1996 (1017 ± 82 compared with $652 \pm 42\ kg\ ha^{-1}$). The highest yield was $1112 \pm 136\ kg\ ha^{-1}$ for the treated plots at Tel-Jerji in 1996 compared with $816 \pm 149\ kg\ ha^{-1}$ for the control plots.

DISCUSSION

The research throws some light on land tenure and the extent to which tenure restricts grassland improvement. The widely-held belief that all grazing lands are open access (Springborg, 1986), at least for the flocks within the four villages, does not appear to reflect the real situation. From the experience gained during this work, grassland tenure can be classified as follows:

(1) The grasslands are owned as private property; in this case, however, they are traditionally viewed as common property for the flocks of the owner and those from neighbouring villages. If at any time the owner wishes the land to revert

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to himself then that can happen. Only about 5% of the land examined is owned in this way, principally at Batajek.

(2) The grasslands are owned as common property, but certain farmers have the power and authority to control the land when needed. An interesting case in point was the shift in tenure from common to private property at Tarhin. This was because of the ancient tradition by which any improvement (especially cultivation but also seeding and the use of fertilizer) confers ownership (Lewis, 1987). Grassland improvement, therefore, may have consequences on land tenure as well as vice versa.

(3) The grasslands are owned as common property, but power to control them is vested in the *mukhtar*. This was the case for most grasslands in the study area.

(4) The grasslands are common property, but the *mukhtar* finds control difficult, either because the grasslands are far from the village (for example, at Tel-Atia), or he is involved in off-farm activity and spends most of his time away from the village.

Most of the tenure regimes were common property and all were initially managed in that way – none were open access *sensu strictu*. This simplified the task of technology transfer since grassland use was limited to a known number of farmers. In this study, grassland improvement was accepted in three of the four scenarios outlined above, regardless of whether the land was owned privately or communally. It was more difficult at Tel-Atia because the land was out of sight of the village and policing was more difficult. Nevertheless, even there the results were promising.

Apart from some surveys (Ehrman and Cocks, 1990; Beale *et al.*, 1991; Bounejmate *et al.*, 1992a; 1992b), research on improving Mediterranean grassland (seeding with appropriate species and applying phosphate fertilizer) has been conducted at research stations under controlled conditions. The single exception in West Asia is the work of Osman and Cocks (1992) in Lebanon, who failed to demonstrate any advantage in sowing subterranean clover and other legumes on high-rainfall grassland in Lebanon's Beka'a Valley. In this case, however, a farm site was used as an outstation of the research centre but the farmer had no control of the treatments, was not involved in the research process and was not even informed of the results. In contrast, the research reported here fits better into the models described by Farrington and Martin (1988) and Chambers and Jiggins (1986) who stress the need for farmer involvement at all stages. The approach does not resemble, for example, the testing of new cereal varieties where the on-farm sites are aimed mainly at increasing the agro-ecological range of testing sites. In contrast to this 'outstation' approach, the research described in this paper involved a great deal of consultation with farmers and frequent modifications of design and methods to take account of their needs.

Nevertheless, it is worth noting that the research described had an important element of researcher control, and more closely approached the work of Tripp (1982) than some of the more recent FPR (Farrington and Martin, 1988;

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Chambers and Jiggins, 1986). The difference centres around the extent of farmer participation and, in particular, the origin of the ideas tested. The ideas for this research were generated at Tel Hadya, and the farmers contributed by raising difficulties and resolving practical issues. For a seemingly intractable problem such as that of the degraded grasslands, this seems reasonable, and it is unlikely that significant progress would have occurred had the researchers stood back in the manner advocated by, for example, Chambers and Jiggins (1986).

Although total biomass production was not significantly increased as a result of seeding, the biomass of sown legumes increased sharply (Table 6). Results from the Tel Hadya site on the ICARDA research station suggest that increases in total biomass will follow in due course as soil nitrogen levels and seedbank size increase (Osman *et al.*, 1991). For example, after five years of treatment at Tel Hadya, biomass increased from 0.9 t ha^{-1} at zero phosphorus to 1.7 t ha^{-1} at high phosphorus in a year when rainfall was only 224 mm. There are, however, a number of differences between the Tel Hadya site and those in the El-Bab area that influence both the interpretation of the results and possibly the effectiveness of grassland improvement programmes.

(1) The land at Tel Hadya was continuously stocked at a rate that was considered sustainable. By doing this the seedbank size increased even without additional phosphorus. In contrast, the village land was grazed at very high stocking rates because it was impossible for shepherds to introduce sufficiently small flocks to make grazing safe. Inevitably, such management tended to reduce seed production. Even so, in the third year of the experiment at the El-Bab villages (Tarhin, Tel-Atia and Tel-Jerji), the seedbank size of the seeded treatment increased by 1, 2 and 1.6 times respectively over the unseeded control (Table 5).

(2) The Tel Hadya site responded to phosphorus, while the Batajek site did not. Almost certainly this was the result of different levels of native phosphorus – 4.6–9.5 mg Olsen-P kg^{-1} at Tel Hadya compared with 11.5 mg kg^{-1} at Batajek. It was likely that there would be responses to phosphorous at the other villages, especially Tel-Jerji. However, Ehrman and Cocks (1990) suggested that only about 30% of grassland sites in Syria were likely to respond to phosphorus.

(3) There was a far greater legume diversity at Tel Hadya compared with Batajek. Although the total size of the seedbank was similar, there were more than 40 legume species at Tel Hadya compared with only *Trigonella monspeliaca* at Batajek.

Little is known about the agronomy and ecology of this species, certainly much less than about the clovers and medics that are common at Tel Hadya. It is at least possible that *T. monspeliaca* is less responsive to phosphorus, less palatable to livestock, and produces less biomass. While Table 2 suggests that the problem of

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low diversity in the village land has been largely overcome by seeding, the effect of diversity on productivity and stability needs further investigation.

There are, however, similarities. For example, rainfall at Batajek was 330, 316 and 523 mm in the three years of the experiment. This compared with an annual range of 224–499 mm at Tel Hadya. Seedbank size was, if anything, greater at Batajek than at Tel Hadya before the respective experiments began.

The most successful of the introduced legumes were *Trifolium campestre*, *T. tomentosum* and *T. purpureum* (Table 2). They have a small seed size in common, the first two, at least, with seeds less than 0.5 mg. *Trifolium campestre* and *T. tomentosum* were two of the three most common legumes at Tel Hadya, which suggests they were well adapted to grazing on these degraded grasslands. It is possible that the reason for their success is their ability to survive ingestion by sheep, which puts them less at risk of overgrazing than larger-seeded species (Thomson *et al.*, 1990). The larger-seeded medics, for example, had declined in the seedbank by the third year (Table 2). To make matters worse, medic seeds remain in the pods, which are easily prehended by sheep in summer (Cocks, 1988). Differences in hardseededness at sowing also contributed to differences in seedling establishment, ultimately seedbank size and the success of species.

While the increases in seedbank-size are encouraging, they suggest that the grasslands have some way to go before they can be considered productive. In the wheat belt of Western Australia, where rainfall is similar to that at Batajek, populations as high as 120 000 seeds m^{-2} have been recorded, mainly of the small-seeded *T. glomeratum* (Fortune *et al.*, 1995). At Tel Hadya, in protected grasslands, populations of 25 000–35 000 seeds m^{-2} were achieved after 4–5 years of treatment with phosphorus fertilizer (Osman *et al.*, 1991). In the Tel Hadya experiment, the untreated controls had populations of around 4000 m^{-2}, similar to those at Batajek but substantially more than at the other villages.

There is little doubt that low plant populations are restricting herbage production. Abd El Moneim and Cocks (1986) demonstrated that the productivity of medic pasture increased until populations reached 2000–4000 plants m^{-2}. Since the seed populations comprise both hard and soft seeds, the number of soft and therefore germinable seeds will be much less than the seedbanks indicate. This is reflected in seedling numbers, which ranged between 10 and 250 m^{-2}, far short of the required amount (Fig. 3). Biomass production, not unexpectedly, falls far short of that recorded where plant populations are higher: 5–6 t ha^{-1} at Tel Hadya (Abd El Moneim and Cocks, 1986), up to 3 t ha^{-1} at Tel Hadya (Osman *et al.*, 1991) and 10 t ha^{-1} in South Australia (Brown, 1976). Nevertheless, the increase in seedbank population at the village sites suggests that in time biomass will increase to something approaching the potential recorded at other sites with similar rainfall (for example, at Tel Hadya).

Indeed, biomass production on unimproved grassland in West Asia is surprisingly constant. For example, at two sites east of Aleppo (Bueda and Noumania) where rainfall ranges between 200 and 270 mm, herbage yields ranged from 490 to 1150 kg ha^{-1} (Cocks and Osman, 1996). Similarly, in Lebanon where rainfall

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exceeds 600 mm, herbage production of unimproved grassland remained well below 2 t ha^{-1}. At unimproved Tel Hadya sites, herbage yields ranged from 700 to 2000 kg ha^{-1}, the latter when rainfall was 500 mm (Osman *et al*., 1991). At all three sites, legume plant numbers were below the 1000 plants m^{-2} that Abd El Moneim and Cocks (1986) believed necessary. In the case of Tel Hadya, addition of phosphorus was sufficient to increase the seedbank size such that plant numbers approached and even surpassed the critical value of 1000 plants m^{-2}.

The results in this paper suggest that the ideas put forward by Osman and his colleagues (Osman *et al*., 1991; 1994) can be modified and placed in a practical context. If their results are applied to communally-owned grasslands throughout West Asia, as this paper suggests is possible, then the implications are profound. Perhaps it will be possible to reverse the land degradation of centuries through the simple practices advocated in this paper.

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