UTILIZATION OF LOCAL RESOURCES FOR PASTURE PLANT CULTIVARS

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ABSTRACT

The paper discusses the use of local plant resources for developing integrated livestock/cereal producing farming systems using pastures of annual legumes. The discussion centers on north-western Syria which is considered typical, in many respects, of the high elevation areas of Syria, Iraq, Jordan, Tunisia, Algeria, and Morocco.

Local resources are considered useful because there is a good chance that they will be adapted to local conditions. Adapted in the sense of annual legume pastures, means able to reproduce in sufficient numbers to form dense swards. The adaptability of wild populations is discussed, particularly of natural pastures, and it is shown that very delicate relationships between plant genotypes and micro-environments can evolve. Even where native pasture species are unavailable, as in Australia, the most successful cultivars have originated from exotic flora which have become naturalized.

The plant resources of northern Syria are briefly described. It is noted that, of commercial annual legumes, very few are widespread. Instead the leguminous flora is dominated by *Medicago rigidula, M. polymorpha, M. orbicularis* and several small-seeded annual clovers (*Trifolium* spp.). In small plots near Aleppo, *M. rigidula* in particular, is very productive, and *M. rotata, M. blancheana*, and *M. aculeata*, also native to the Region, show promise.

Detailed studies of growth rates of *M. rigidula* indicate that it is as productive in northern Syria as subterranean clover (*T. subterraneum*) is in Australia. Growth rates of more than 150 kg/ha have been recorded in spring. Its adaptability comprises at least two constituents, disease resistance, and ability to form a symbiotic relationship with local rhizobia. However it originated in permanent grazing land and forest, and is therefore not necessarily adapted to an integrated livestock/cereal producing farming system. Evidence from Iraq, which shows that Australian cultivars, selected from within such a farming system, are better adapted to the system than local material, is produced. It is concluded that the best adapted pasture legumes will be local material which has undergone selection within the farming system in which it will ultimately be used.

Introduction

The theme of this paper is that local plant resources, where available, are more likely to provide adapted pasture plants than imported cultivars. It will center on the attempt being made at ICARDA to introduce an integrated livestock/cereal farming system, based on self-regenerating pastures, to Syria, and other countries in the Middle East and North Africa.

Agriculture in Syria is typical of North Africa, Jordan, and Iraq. Livestock are an important component of agriculture comprising nearly 50% of its total value. They are produced using by-products of cereals, grazing of non arable lands and weedy fallows, and feeding of concentrates, the latter often comprising cereal grain produced on the farm itself. However livestock and cereal production are not completely integrated in that often the owners of livestock do not own the land from which cereals are produced.

The model for an integrated livestock/cereal producing system is that of southern Australia. In this system weedy fallows are replaced by self-regenerating pastures of, most commonly, subterranean clover (*Trifolium subterraneum*) or barrel medic (*Medicago truncatula*). In the year of first sowing they set sufficient seed to re-establish naturally in what

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becomes the pasture phase of a cereal/pasture rotation. The herbage is harvested directly by grazing animals, usually sheep, which are maintained either on the pastures themselves, or on cereal stubbles, for the whole of the year. The pastures also fix sufficient nitrogen to eliminate the need to apply nitrogenous fertilizers to the cereal phase. The system has increased livestock numbers fourfold and doubled cereal production since its introduction to Australia about 30 years ago (Webber *et al*., 1976). Clearly a worthwhile objective is to introduce such a system to the North Africa and Middle East Regions.

However direct transfer of the system has proved difficult. One reason has been the poor adaptation of Australian cultivars to the soils and climate of the Region. Adaptation is of special significance to plants which must, like weeds, become naturalized in the farmer's fields. Use of poorly adapted pasture plants is far more likely to lead to total failure than use of say, a poorly adapted cereal.

Since medics and clovers are natives of the Region (Heyn, 1963; Hossain, 1961) local species are of great interest in the development of the pasture system. At Tel Hadya, near Aleppo, in northern Syria, a large collection of annual legumes has been evaluated. This paper briefly outlines the plant resources, presents some early results, and discusses some of the methods being used to evaluate the new genotypes.

Theoretical aspects

There are two theoretical aspects to be briefly considered: firstly the close relationship between adaptability (or ability to survive) and agronomic performance; and secondly the nature of adaptability in wild populations.

It is not always recognized that, in pastures, productivity is most strongly influenced by plant population. For example Donald's (1976) opinion that plants with ability to survive will differ in their features from plants of agronomic value goes too far: they may differ, especially in the presence of toxic compounds, but if a plant produces large numbers of germinable seeds (in annual pastures), or maintains high populations of living plants (in perennial pastures), then the chances are that it will also be the most productive.

At Tel Hadya the effect of plant population is best illustrated by the development of leaf area index (LAI) in pastures of *M. rigidula*. It is well known that LAI determines crop growth rate, low values of LAI limiting growth by limiting the pasture's ability to intercept light (i.e. Black, 1963). Maximum growth rate is achieved at LAI values of between 3 and 5, depending on the intensity of solar radiation. The data in Fig. 1 indicate that such values were reached 6 weeks earlier in a pasture sown at 512 kg/ha than in a pasture sown at 16 kg/ha. This was reflected in a difference in yield of 2.9 ton/ha, compared with only 0.6 ton/ha between the best and worst cultivars in the same experiment. The data show, most strikingly, the strong relationship between population, and hence adaptability, and yield. That 512 kg/ha is not an unreasonably high sowing rate is indicated in Table 1, which shows seed yields of the best genotypes of seven medic species at Tel Hadya.

We turn now to the nature of adaptability in wild populations. The most striking features of wild populations are firstly that they vary from place to place, and secondly that they are diverse, even within local communities. Often the diversity is a manifestation of spatial change in micro-environment: when this is not so it may be a manifestation of temporal change. In either event it indicates close adaptation to local environments.

That this occurs in pastures is also known. Perhaps the best example is that where *Agrostis tenuis* developed resistance to what for other plants would be toxic levels of lead, copper, and zinc. Resistant and susceptible populations were found within meters of each other, even in the absence of a barrier to gene flow, depending on the heavy metal content of the soil (Jain and Bradshaw, 1966). An even more delicate relationship between plant and micro-environment was observed by Turkington (quoted by Harper, 1976) who found that

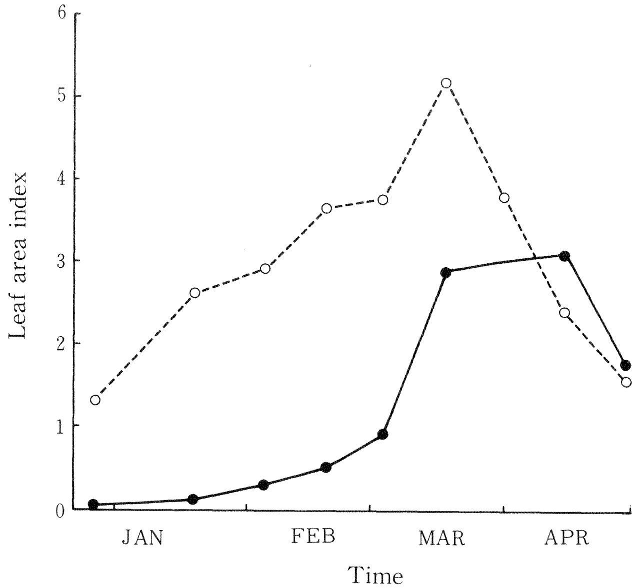

Fig. 1 The development of leaf area index during the winter and spring of swards of *M. rigidula* sown at 16 kg/ha (solid line) and 512 kg/ha (broken line), at Tel Hadya, 1984.

Table 1 Seed yields of the best genotypes of six wild medic species and *M. truncatula* at Tel Hadya, 1982/83*

Species	Seed yield (kg/ha)
M. *rotata*	1,581
M. *rigidula*	1,178
M. *aculeata*	1,160
M. *turbinata*	936
M. *blancheana*	922
M. *noeana*	915
M. *truncatula*	615

* Data of Dr. A.A. Moneim (unpublished)

different races of white clover (*Trifolium repens*) were adapted to growing with different perennial grasses as neighbors. With such fine balance it is hardly surprising that local ecotypes have more potential value than imported cultivars in any new locality: the greater the difference between the new locality and the environment from which the cultivar originated the greater the likelihood that local ecotypes will be of value.

In some cases it is impossible to use local resources. A good example is Australia itself, which has no native legumes of value as pasture plants (Donalds, 1970). In southern Australia several species have been domesticated of which the two mentioned earlier, subterranean clover and barrel medic, are of greatest importance. In both cases the most successful cultivars were drawn from naturalized populations which had passed through many generations (at least 40 for subterranean clover and perhaps 60 for barrel medic) of natural selection in their new environment. In northern Australia, it was only by very carefully matching the Australian and native habitats that successful cultivars of *Stylosanthes* spp. were identified (Burt *et al.*, 1980).

Fortunately Syria has a rich leguminous flora from which to draw adapted plants.

Plant resources of northern Syria

Syria is close to the center of diversity of many annual legumes. To sample this diversity, and relate it to environment, annual legumes were collected at 54 sites between the Syrian desert and the Mediterranean Sea. A total of 33 species were collected (Table 2) of which 14 were medics and 11 were clovers. Of the medics three species were widespread: *M. rigidula* was found at 30 sites, *M. polymorpha* at 23 sites, and *M. orbicularis* at 21 sites. Together these species were present at all but 11 sites: of the latter, five were occupied by *M. rotata* alone, and medics were absent from four. Environmental conditions are summarized in Table 3.

Of the less common medics it was noteworthy that *M. minima* (11 sites) and *M. constricta* (5 sites) were usually accompanied by *M. rigidula* and not by either *M. polymorpha* or *M. orbicularis*. *M. rotata* was restricted to soils low in organic matter and free calcium carbonate: in fact to black soils developed from basalt. Otherwise there were no consistent effects of soil type on distribution, even amongst clovers, many of which are not considered to inhabit alkaline soils. Rainfall had greater effect, with flowering time of several species (but not all) being related to total rainfall (for example *M. orbicularis* in Fig. 2).

Table 2 List of annual legume species found in a survey of grazing lands between the Syrian desert and the Mediterranean Sea in September/October 1983

Medicago polymorpha	*T. subterraneum* subsp. *subterraneum*
M. orbicularis	*T. scutatum*
M. rigidula	*T. campestre*
M. rotata	*T. argutum*
M. blancheana	*T. stellatum*
M. aculeata	*T. pilulare*
M. constricta	*T. scabrum*
M. scutellata	*T. resupinatum*
M. minima	*T. cherleri*
M. intertexta	*Hymenocarpus circinnatus*
M. truncatula	*Astragalus hamosus*
M. radiata	*Onobrychis cris-galli*
M. coronata	*Scorpiurus muricatus*
M. turbinata	*Hippocrepis unisiliguosa*
Trifolium tomentosum	*Trigonella monspeliensis*
T. clusii	*T. coelesyriaca*
T. subterraneum subsp. *brachycalycinum*	

Table 3 Some characteristics of the environments at which annual legume species were collected in western Syria

	Rainfall (mm)	pH	$CaCO_3$ (%)	Conductivity (m mhos/ml)	Organic matter %
Maximum	1,200	8.5	77	11.3	8.8
Mean	460	7.9	23	1.6	3.8
Minimum	250	7.0	3.2	0.6	0.9

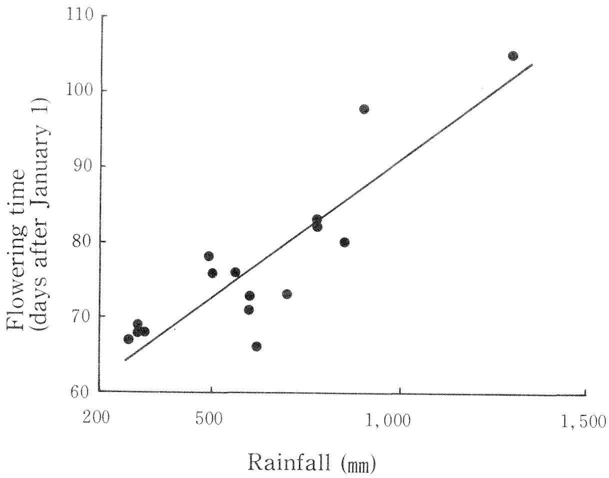

Fig. 2 The relationship between flowering time (number of days after January lst at which flowering began) and rainfall (mm) at the site at which ecotypes of *M. orbicularis* were collected (all sites were in western Syria). The two variables were significantly related ($P < 0.001$), and variation in rainfall accounted for 76% of the variation in flowering time.

Although the relationship between distribution and environment is not clear one point stands out: the commercial Australian species are not strongly represented. Thus barrel medic and subterranean clover were found at only two and six sites respectively. Of the other commercial medic species *M. scutellata* was found twice, while *M. rugosa*, and *M. littoralis* were absent.

At Tel Hadya *M. rigidula* is the most promising species in terms of herbage and seed yield. *M. rotata* also shows promise, as do *M. blancheana* and *M. aculeata*. *M. polymorpha* has been disappointing but is known to perform well at nearby sites: for example a natural stand produced 4.5 ton/ha of herbage and 350 kg/ha of seed in a year of exceptionally low rainfall. *M. polymorpha* is widely naturalized in Australia too, and two cultivars were registered recently (Mackay, 1981), one of which, Circle Valley is likely to be widely used. *M. orbicularis* has not been extensively tested.

It should be noted that similar flora exists in most of the Mediterranean basin. A good example is the great diversity among subterranean clover present in Sardinia (Piano *et al.*, 1982).

Primary productivity of local and imported species

The carrying capacity of pastures in Mediterranean climates depends on winter growth, and the production of sufficient excess in spring for the summer grazing of dry residues. Compared with Australia, North Syria (also Iraq and parts of North Africa) experience much colder winters: the mean January temperature at both Aleppo and Mosul is 5°C compared with mean July temperatures of 11 and 13°C at Adelaide and Perth respectively. Use of local resources may be a method of increasing winter production.

As was discussed earlier plant population will influence yield most strongly, and genetic differences are likely to be of lesser importance. However Radwan *et al.* (1978), considered that the cold winters of Mosul were such as to restrict the growth of eight Australian cultivars compared with ecotypes of *M. polymorpha* and *M. orbicularis*. Sowing rates were not equal in their valuable experiments nor was herbage production measured on a seasonal basis. It seems therefore of great interest to compare seasonal growth of local material with a widely adapted imported cultivar, on a systematic basis.

Such an experiment was conducted at Tel Hadya. The genotypes chosen were *M. truncatula* cv. Jemalong, the most popular Australian barrel medic, and a north Syrian selection of *M. rigidula*. Seasonal growth was estimated from the relationship between 12 sowing rates and herbage yield at two-week intervals from December until April, when drought prevented further growth. Fig. 3 shows that although barrel medic was able to grow slightly faster during winter (in February it grew at 76 kg/ha compared with *M. rigidula* at 51 kg/ha/day) *M. rigidula* was able to maintain its growth rate throughout the season. Total yield of *M. rigidula* was 10.3 ton/ha, compared with 7.4 ton/ha for barrel medic. The difference appeared to be due to the susceptibility of barrel medic to *Phoma medicaginis* (spring blackleg), a common fungus disease of foliage to which *M. rigidula* is resistant (O. Mamluk, personal communication).

The important point is that at similar densities, local ecotypes are at least as productive as imported cultivars and, due to disease resistance in this case, may be more so. Indeed growth rates of *M. rigidula* at Tel Hadya were comparable with the very high rates achieved by Cocks (1974) with subterranean clover in South Australia.

Biological nitrogen fixation

Biological nitrogen fixation is central to using integrated cereal/livestock farming systems. The increase in cereal production of southern Australia, referred to earlier, is a direct result of the nitrogen fixing capacity of annual legumes. Estimates of the amount of nitrogen fixed vary from 30 kg/ha/year to perhaps 230 kg/ha/year depending on rainfall and length of period of measurements (Puckridge and French, 1983). While this nitrogen is available to subsequent cereals it is important to remember that the pasture itself also depends on nitrogen fixation. For example yield of pure grass at Tel Hadya seldom exceeds 3 ton/ha compared with that of 5-10 ton/ha of most legumes.

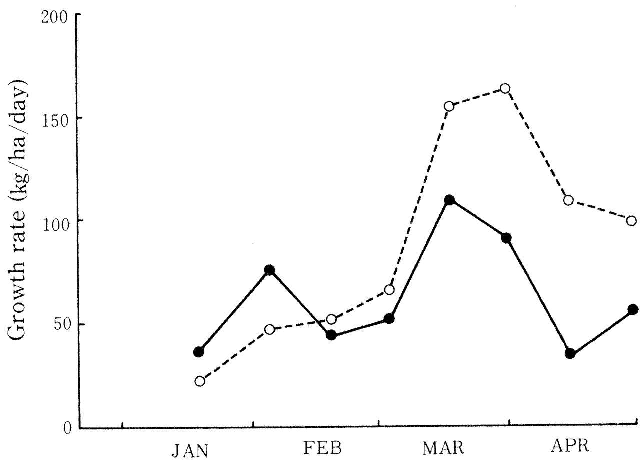

Fig. 3 Growth rate (kg/ha /day) during winter and spring of swards of *M. rigidula*, a local species (broken line), and *M. truncatula*, an imported species (solid line), at Tel Hadya, 1984.

Because medics and clovers are natives it has been easy to assume that effective rhizobia live in Middle East soils. On the face of it rhizobia genotypes seem more widely adaptable than their hosts: for example in Australia one strain is now used for all medics in all locations. Clearly it is important that adapted rhizobia are present, since without them annual legumes will fail, even those otherwise well adapted. However it is becoming clear that, for the Australian cultivars at least, agronomists cannot rely on the native population. In both Iraq (P. S. Cocks, unpublished) and Jordan (B. C. Bull, personal communication) significant responses to inoculation have been observed. Of interest was the ineffectiveness of strain U 45 until recently the only commercial strain, on all medics in Iraq.

However results in Syria suggest that the medics collected locally are far less likely to require inoculation than the Australian cultivars. Table 4 shows the response at Tel Hadya of *M. rigidula* compared with barrel and snail medics to inoculation with CC 169, the commercial strain, and WSM 244, a strain isolated in Iraq (D. Chatel, personal communication). Both cultivars responded strongly, but not so the local ecotype. Note also the interaction between medic species and strain of rhizobia.

Table 4 The response of three medic species, one local (*M. rigidula*), and two introduced from Australia (*M. truncatula* and *M. scutellata*) to inoculation with two strains of *Rhizobium meliloti* ($\log_{10}$mg of plant weight)

	Rhizobium strains		
	Nil	*CC 169*	*WSM 244*
M. rigidula	1.33	1.41	1.40
M. truncatula	0.35	0.53	0.70
M. scutellata	0.66	1.30	1.16
LSD ($P<0.05$)	0.19		
LSD ($p<0.01$)	0.27		

Adaptation to specific farming systems

So far, in discussing the use of local ecotypes, we have looked at the performance of local and introduced ecotypes in situations removed from real farming practice. In theory, we argued that ecotypes which had evolved in any environment were likely to be the best adapted to the environment. In practice we looked at herbage and seed production in small plots, and considered the effect of disease and the presence or absence of adapted rhizobia. But it is important to remember that local material will be used in very different environments from their native habitat. For example, in Syria, our local ecotypes have been drawn from uncultivated grazing land, or from protected forests. A farm, where a crop is sown in alternate years, where the soil is tilled to a depth of 5-10 cm, and where grazing may be intense, places new selection pressures on the local material.

Very little work has been done on this aspect. However some data are available from an experiment in Iraq* where a mixture of 237 genotypes comprising 6 genera and 48 species was sown in a rotation of pasture/cereal/pasture. At the end of each year the seed population

* A project sponsored by the Iraqi Ministry of Agriculture and Agrarian Reform and managed by the South Australian Department of Agriculture.

was sampled and the surviving genotypes identified by germinating the seeds and growing the plants in nursery rows. The results are of great interest. In the year of sowing, a year of good rainfall where the pasture was lightly grazed, *M. orbicularis*, a local species, was dominant, comprising more than five times its original proportion of the population. After the second year, when medic grew as a weed amongst the wheat, *M. polymorpha*, another local species, was easily the most successful. But in the final year, a very dry year resulting in intense grazing, *M. truncatula*, very rare in Iraq, emerged as the most successful species. Furthermore, the Australian cultivars, themselves the result of natural selection in similar systems, were the most frequent genotypes.

While it may ultimately be possible to find characters able to predict survival, at present there seems no short cut for selecting plants adapted to specific farming systems. For example Rossiter (1977) studied the survival of subterranean clover strains in pasture continously grazed for 21 years, and found that none of the accepted characters (seed size, petiole length, hardseededness, disease susceptibility, and so on) had significant bearing on survival. Cocks *et al*. (1982), in their study of 25 strains of subterranean clover were able to link survival for 19 years with ability to bury seeds, winter growth, and presence of a toxin which may affect palatability, but recognized that the high likelihood of character x site interactions for this relatively simple system, continous grazing, would make selection on the basis of these characters, hazardous.

These results do not imply that local ecotypes are inferior, simply that they must be selected in conditions as close as possible to real life. Therefore I would like to suggest that the most appropriate method for selecting new forage cultivars, at least in Syria, is that of selecting the most persistent from as many candidates as possible, in the farming system and environment for which they are intended. Within this content it is very likely that new cultivars will be of local origin.

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Discussion

Jayawardana, A. B. P. (Sri Lanka): Was the yield of 10t/ha/year obtained in one of the local *Medicago* species with or without soil amendments?

Answer: We used only 40kg P_2O_5/ha as well as seed inoculation with *Rhizobium*. It is very important that super-phosphates are applied in the arid areas of the Middle East and North Africa where a deficiency in phosphorus is often observed.

Chen, C. P. (Malaysia): Do you consider that the poor adaptation in the Middle East of species introduced from Australia can be ascribed to differences in the soil conditions or habitat as well as management?

Answer: The differences were presumably due to the resistance to diseases and problems related to the lack of adapted rhizobia. Also the farming systems in the Middle East differ from those in Australia.

Chen, C. P. (Malaysia), **Comment:** We should definitely place emphasis on the local resources of forage crops.