

EXAMINATION OF NORTH AFRICAN AND
MIDDLE EAST WHEAT IMPROVEMENT PROGRAMMES

(November, 1970)

J. B. Doolette

Special Consultant to CIMMYT



CENTRO INTERNACIONAL DE MEJORAMIENTO DE MAIZ Y TRIGO

INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER

Mexico

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As a Special Consultant to CIMMYT, Mr. J. B. Doolette, Head of the Agronomy Division of the South Australian Department of Agriculture, visited the wheat improvement projects in Lebanon, Tunisia and Morocco to determine the extent to which Southern Australian technology might usefully be employed in these programmes.

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Wheat improvement projects in Tunisia and to a lesser extent in Lebanon and Morocco, were examined during November 1970 to determine the "extent to which Southern Australian technology might usefully be employed in these programmes". Southern Australian technology is interpreted to include cultural and land use techniques, machinery, training facilities and scientists.

The Environment

The similarities between the climate, soils and topography in Southern Australia and the Mediterranean countries Lebanon, Morocco and particularly Tunisia, are immediately apparent. The so-called Mediterranean climates in either the Northern or Southern hemispheres allow rainfed crop culture in which spring type cereals can be planted in the early winter and grow over a long period (> 150 days).

The features of the environment which are of greatest significance are those which display considerable variability between locations or between seasons at any given location. These include not only total annual rainfall, but the onset and length of the growing season, the time of occurrence of stress periods, soil depth, soil structure and water holding capacity. These factors are largely concerned with the amount of water available to the plant during the growing season. The spring drought and to a lesser extent moisture stresses earlier in the growth cycle, are a feature rather than an occasional occurrence.

The variability of these environmental factors creates more decisions for the farmer and causes a more compromising approach to decision-making.

Variations in soil fertility are less important as they can be defined and corrected.

Light, temperature and winds vary but presumably to no greater extent than in other agricultural situations.

The whole approach to crop culture viz variety selection, fertilization, time and rate of planting, disease resistance etc. has to be considered within this framework.

Plant Nutrition

It is clear that both phosphorus and nitrogen are generally deficient, and organic matter is low in the soils in the countries visited.

1. PHOSPHORUS

Statistics available suggest that the annual usage of P_2O_5 per hectare of arable land is 3-4 kgs. in Morocco and Tunisia (16 kgs in Lebanon). Despite the low mean grain yields of 4-600 kg/ha the phosphorus use is only about half the maintenance requirement. Both countries are exporters of phosphorus fertilizer and it has been readily available for a long time.

The lack of response to phosphorus in trials appears to be an inconsistency but is probably due to the fact that:

a) above average farms are chosen for trial sites and these have generally had generous applications in the past. In the 1969-70 trials in Tunisia, the available P determined by the Olsen method on samples from trial sites, all exceeded 70 ppm, whereas a response is unlikely at half this level. However, this situation is unlikely to apply through the majority of the wheat growing areas.

b) the low level of yield due to inferior varieties and nitrogen deficiency has not allowed past applications to be fully used up.

Research with Phosphorus

Current work is largely unrewarding for the reasons mentioned above. Several main areas of work remain when suitable experimental sites are available.

(1) The first is to demonstrate the yield advantages of banding the phosphorus with the seed. Work in Southern Australia shows that broadcasting the fertilizer gives lower yields than drilling, and that the difference is least when the phosphate is broadcast close to seeding and incorporated into the soil with the last cultivation before planting. Drilling the fertilizer with the seed requires a seed drill complete with a fertilizer box such as those used almost universally in Australia. The results of these experiments will determine the priority to be placed on this technique.

(2) The second, is the establishment of economic growth response curves in which the yield response to increasing rates of phosphorus are related to preplanting analyses of available phosphorus in the soil.

This will ultimately lead to much greater precision in fertilizer usage.

(3) In order to determine the general level of available phosphorus throughout the wheat farms, a survey might well be undertaken in which samples are taken from fields in a range of situations. The method of sampling requires careful consideration and so also does the time of the year that samples are taken. Recent evidence in South Australia suggests large fluctuations throughout the year with the level of available phosphorus, increasing from a low value at the end of summer to a peak in spring and then decreasing. The most useful guide is obtained from samples taken at planting time although sampling in the preceding spring may be just as appropriate.

(4) The physical nature of the phosphate granules may well be examined as differences in response to material with the same chemical composition have been noted.

Despite the doubt which has arisen due to lack of response in experiments, serious consideration should be given to continuing to recommend the use of phosphorus fertilizer at maintenance levels even though in the short term the use of the money on nitrogen would be more profitable.

2. NITROGEN

The yield response to applied nitrogen is well established, and a good deal of adaptive research is completed or will be at the end of the present crop season. Rate of application, date of application and form of fertilizer are the three main areas to be resolved from the present programme.

As there is little likelihood of a useful testing procedure for the accurate prediction of nitrate nitrogen and hence nitrogen requirements for rainfed crops in the near future, the present trial procedure of using several large increments from 0-120 kg/ha of N is appropriate and it is clear that present recommendations will be confirmed shortly. Response to nitrogen diminishes as available water in the growing season, and particularly during the period from anthesis to maturity, diminishes. So that the higher the mean rainfall, the greater will be the recommended nitrogen rate.

It is surprising that there is such a consistent response to applied nitrogen and so little adverse effect of post anthesis drought. It would be prudent to sample several more seasons as it is unlikely that these results will be obtained consistently.

Date of application is clear-cut, and it seems unlikely that continuing this line of work can be profitable. Yield will increase due to an increase

in head number per unit area, grains per head or grain weight, and the first of these is by far the most important. The number of tillers formed is influenced by nitrogen nutrition during the vegetative stages, and if the fertilizer is applied later than this, then the opportunity for yield increase will be lost. So that nitrogen available at germination or shortly after, will be the most effective. The delay from seeding time will be less important in longer growing seasons, where late tillers may have some chance. Delayed applications may even have some advantages in odd very wet situations, but the problems of application in these wet soils and the limited chances of success, would suggest that split applications be abandoned in favour of total application at planting. There is sufficient evidence to warrant avoiding banding the nitrogen fertilizer with the seed at the rates above 50 kgs/ha, and particularly where moisture is likely to be sparse at the time of planting. It is risky to make the application too long before planting, and generally the aim should be to spread it immediately before planting.

Generally, there is little to choose between the forms of nitrogen other than the cost. Many differences in response to different forms have been reported without the causes of the differences being studied. It would be wise to leave this to other investigators. For the time being, and unless the growing crop is top dressed when urea should be avoided, the choice should depend on cost.

The soil organic matter content in many areas appears to be very low. This is not surprising due to the long history of cultivation and the high proportion of plant material removed. No actual measurements of organic matter, or organic carbon or total soil nitrogen were sought so that the observations are subjective. However, the importance of organic matter for improving soil structure, increasing water holding capacity and supplying plant nutrients, particularly nitrogen, should be recognized.

A supply of organic matter with a close carbon/nitrogen ratio in the order of 12:1 is essential to improve the situation. The goal for organic matter level in the heavier soils may well be 3-4%.

Legume Pastures as a Source of Nitrogen

The unique feature of the Southern Australian crop growing technology, is the use of annual legume dominant pastures in rotation with crops. This land use system has been developed to a sophisticated extent in the last 20 years, and it is worthy of careful consideration in similar rainfed environments. Technically it is feasible in the countries visited.

It is important to understand the mechanics of it and the way the whole farming operation fits together because it involves not only nitrogen fixation, but animal nutrition and weed control as well, and changes the management skills required.

Adopting a new land use system involves a lot more than changing a variety or a single cultural practice, so that advantages have to be clear and considerable .

In South Australia the use of nitrogen fertilizer was a poor economic proposition due to its high price relative to the return, and because of the chance of no response or a negative response due to a lack of available moisture in the spring. Soil organic matter was depleted and soil structure was poor due to exploitive rotations employed.

The annual forage legume represented a means of providing nitrogen because of its nitrogen fixing ability, and also contributed considerable organic matter with a reasonable C/N ratio when incorporated into the soil. Crop legumes which are largely removed from the field are less efficient than forage legumes, because the latter are "harvested" by grazing animals, which means that the nutrients are recycled and less are removed.

The annual is preferred to the perennial, because of the ease of establishment and ease of handling in the crop phases.

In addition, mixed farming has always been a feature of Southern Australian agriculture, where the farmer has made a substantial part of his income from livestock enterprises which are managed on a free grazing system. The improved pasture allows increased stock numbers and better nutrition. The returns from animals are a substantial part of the profit in the system.

The level of production increase due to the use of the annual legume as the dominant species in the pasture phases of the rotation, is hard to determine precisely as it varies with location, managerial skill and the extent to which better husbandry methods are employed.

The three examples which follow, demonstrate the order of yield improvement.

(a) Department of Agriculture Field Station

450 mm. annual rainfall; red brown earth soil; subterranean clover.

Nitrogen Accumulation in a Particular Field

Year of sampling	N %	Average annual increase in N (kilos/hectare) in top 10 cms. of soil	
* 1955	.089	-	
1957	.112	168	There was an average increase of 73 kilos/ha/year under all phases of the rotation including the crop.
1959	.128	95	
1961	.132	22	

*Subterranean clover was sown in 1955

Wheat yields on the whole property responded in the following manner:

Period		Average wheat yield in kilos/hectare	% increase
1912-32	when superphosphate was first used	1310	-
1933-47	during fallow-wheat rotation	1499	14%
1948-57	improved varieties	1895 (1774)	45%
1958-62	first clover sown	2836 (2984)	116%

The figures in brackets show the effect of correcting the yields for variation in seasonal rainfall - kilograms/hectare/25 mm of rainfall in the growing season divided by the average rainfall for the period.

Wool yield on the whole farm increased by 94% with average fleece weight increasing from 9.7 to 11.8 lbs.

(b) A privately owned farm nearby the field station

Period	Average wheat yield in kilos/ha	% increase
1947-50	1478	-
1951-54	1727	7
	clover pastures ploughed up	
1955-58	2910	97
1959-62	3031	105

The total annual grain output of the farm increased by 39% and the annual wool yield by 357% with a 36% increase in average fleece weight.

(c) Production data for the "Hundred of Wokurna"

A hundred is a statistical district in South Australia of approximately 100 square miles. In this particular district, the legume in the pasture is exclusively annual medic, and the average annual rainfall is appreciably lower than in the examples given above.

	Annual rainfall mms	W H E A T			BARLEY		SHEEP	
		Area in Hectares (1000)	Yield Kgs/ha	Kg/ha/cm of rain	Area in hectares in (1000)	Yield Kgs/ha	No's (1000)	Wool kg/ha
1931-40	328	7.74	786	24	1.09	633	14.9	2.0
1951-60	356	5.27	1680	47	2.07	1501	30.3	5.7
1961-65	340	6.89	1707	50	1.66	1568	37.2	6.9

A brief explanation of the way the systems operate in South Australia will draw attention to some of the principles involved.

The mean annual rainfalls of the cereal areas range from 300-500m m.

There are two distinct systems based on the genus chosen, and this in turn is determined by the soil pH. In the cereal areas of South Australia, the soils range in pH from 6.3 to 8.5 with some 30% being acid and 70% being alkaline.

Cultivars of the species Trifolium subterraneum (clovers) adapt well on the acid soils and cultivars of several species of Medicago (medics) adapt to various of the alkaline soils.

The two areas can be considered separately.

Clover Areas

The clover areas (acid soils) tend to be slightly wetter than the medic areas and the experience in South Australia has been accumulated in 375-500 mm annual rainfalls.

Clovers are a little more difficult and a little slower to establish than medics. They form a much lower percentage of hard seed (which will not germinate in the second year) than the medics, and hence there is better re-establishment in subsequent years.

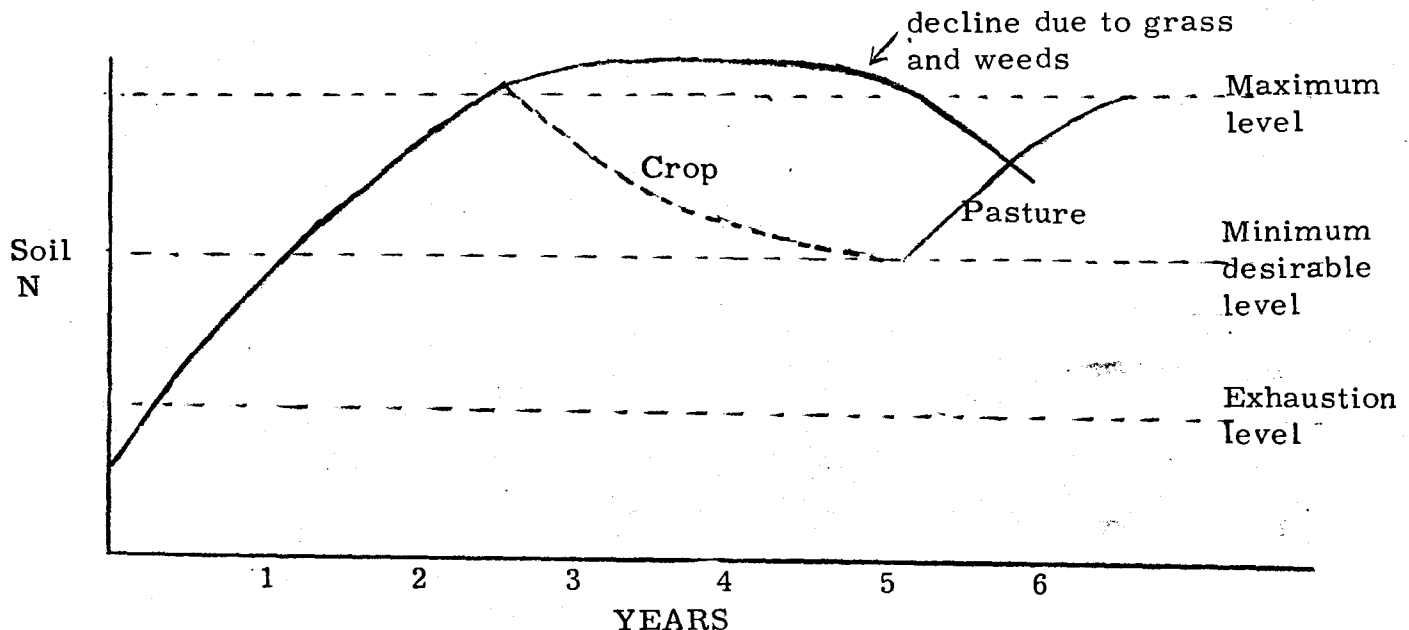
The rotations which were being followed in these areas were of the following types:

Fallow, wheat, pasture, pasture (where pasture = volunteer)
or

Fallow, wheat, peas, barley, pasture, pasture.

It became a matter of planting clover to obtain a clover dominant pasture in the "pasture" years.

The improvement in soil nitrogen is shown in the following graph:



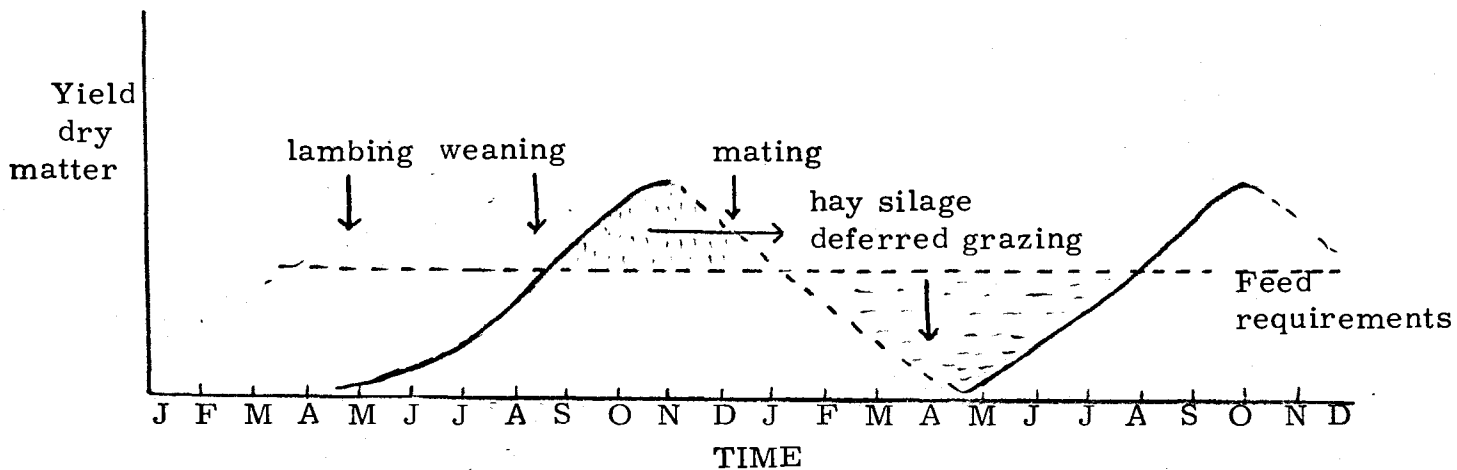
Generally, nitrogen builds up to a maximum in 2-3 years (approximately equivalent to 90-100 kg/ha applied N) and if it is not cropped will decline as a result of the grasses and weeds which it stimulates.

The system demands cropping to reduce the nitrogen to a "minimum desirable level". Two or three consecutive crops can be grown.

In practice, it is most usual to have 3 years pasture and 2 crops. A bare fallow will precede the first crop after pasture in areas where there is an economic response to fallowing.

During the several years of the pasture and assuming favourable seasons, several hundred pounds of seed may be set. That which is not hard at the beginning of each year will germinate with the opening rains. In the crop years this will be destroyed with land preparation. There should be sufficient left after the cropping phase to re-establish the pasture.

The integration with the livestock can be seen in the next graph:



A number of cultivars of subterranean clover are available in Australia and among them there is a range of lengths of growing season.

Some of these are presently being replaced because of high oestrogen contents which affect animals in some areas. The percentage of acid soils and hence potential clover areas in Tunisia and Morocco is quite small and confined to higher rainfall, coastal areas.

Yarloop cultivar has established well in the Sedjenane area of Tunisia. It is quite reasonable to assume that suitable cultivars are available for any of these areas.

Medic Areas

The medic areas (alkaline soils) tend to be slightly drier 300-450 mm rainfall zones.

Medics are easy to establish, produce dense stands and set large quantities of seed in the first year. When grown in favourable conditions, the proportion of hard seed exceeds 90%. There is a much quicker build up of nitrogen. This all means that in the second year there is poor re-establishment of the medic due to the high proportion of hard seed and considerable stimulation of grasses and weeds.

Hence, an alternate year rotation of crop and medic pasture has established.

As was the case with the clovers, any medic seed which is soft will germinate and be killed with seed bed preparation, but this is not important because of the large quantity set and the high proportion of hard seed. During the crop year, sufficient hard seed will break down to allow a good establishment of pasture the following year.

Under this system, soil fertility has improved and extra crops have been included to make say 6 crops in 10 years.

Fallow is not feasible in the two-course rotation, but is when extra crops are grown.

This general description now applies generally to the better than 375 mm rainfall areas.

Where the rainfall is lower (300-375 mm) less medic seed is set and there is a lower proportion of hard seed, so that two or maybe three consecutive years of medic are possible and necessary to get the satisfactory nitrogen accumulation.

As is the case with the clovers there are a number of cultivars available. There is also an active plant breeding programme in the South Australian Department of Agriculture.

In Tunisia and Morocco the greater part of the wheat areas examined had medics growing alongside the roads and in the waste areas and ditches.

There is no doubt that suitable cultivars are available for the various soil types. Jemalong has been established satisfactorily. Borung, the most recent commercial cultivar in Australia was a direct introduction from Tunisia.

The present two-course rotation of wheat and so called fallow which amounts to volunteer weeds which is so common in the two countries, would lend itself to a crop - medic pasture rotation without very much change. In fact, the waste year would be replaced by a stand of medic, and both the sheep and the subsequent crop would benefit.

A proposal for a demonstration to be conducted in Tunisia appears in Appendix B.

CULTURAL PRACTICES

1. Land Preparation

There appears to be five objectives of land preparation:

- a) to produce a physical condition in the surface satisfactory for crop establishment and active root growth
- b) to reduce the competition of weeds and pathogens
- c) to provide a moisture situation at planting which will enable the plants to make best use of the expected growing season rainfall
- d) to mobilize nutrient reserves
- e) to maintain surface stability to minimize erosion.

These objectives can be met with a variety of machines, depths, frequencies, speeds and lengths of fallow.

In this context several matters seem to be worthy of discussion.

(1) Depth of Initial Cultivation

There are several valid reasons for deep ploughing e.g. reclamation of peat soils; "busting" of impermeable layers. In none of the soils visited, did any of the normal reasons appear to exist.

Initial ploughing beyond about 15 cms is costly and unlikely to achieve anything worthwhile, but yet is quite common particularly in areas

where heavy tractors were available.

The subsequent effort required to provide a firm, shallow seed bed of desirable tilth is great, and it is likely that it may not be possible before the optimum seeding time arrives.

The premise used to justify deep ploughing appears to be better infiltration of water. This is hard to imagine, but if it were true then it could be achieved with the same power and with less disruption by deep ripping with a chisel plough.

Some experiments of this type being conducted in Lebanon and Morocco will demonstrate the advantages of these techniques if there are any.

(2) Timing of Initial Cultivation

Dry ploughing is possible in friable self-mulching soils which crumble easily, but there is little point in it because it is unnecessary for moisture penetration, and if the soil is dry there is unlikely to be any weed growth which could be transpiring soil water. So that only in the rare cases when planting time is approaching and opening rains have not come, should this be considered.

For the heavier soils which set hard, there can be no justification for dry ploughing. Of the objectives of land preparation, the only one it would help is to improve water penetration, but the massive clods which result make subsequent seed bed preparation extremely difficult and costly.

The practice of dry ploughing should be examined very critically by extension agronomists and discouraged where ever possible.

(3) Water Conservation by Fallowing

Strategies for water conservation are desirable when,

- a) the growing season rainfall is less than adequate, and
- b) the off season conservation is significant.

In general, to get a response to a bare fallow, the soil itself should be capable of storing water and sufficient water should be available to store. This generally means an initial cultivation in the early spring (February, March) before the transpiration losses are great and subsequent weed control through to planting time by some means which doesn't produce a fine tilth too soon.

A useful "rule of thumb" in South Australia to allow farmers to decide whether they can expect a response to fallowing is - "the soil should have 20% of clay in the 15-30 cms subsurface layer, and there should be at least 100mm of rainfall in the 2 months before spring". A similar guideline might easily be established by simple experimentation in North Africa.

The relative importance of maximum infiltration, minimum evaporative loss with a "soil mulch" and weed control is debated in the literature. Basically it is impossible to achieve the optimum for each at the same time and perhaps the soil mulch condition has the least effect on water conservation.

The only other situations when long fallow can be considered, are when soil surface structures are intractable and the limited time between the opening rains and optimum planting date is too short for satisfactory seed bed preparation.

(4) Machinery

The Australian cultivator (scarifier) which is a robust tyned implement would be very satisfactory for cultivating these types of soils. It can be used for the initial cultivation in lighter soils and for all other cultivations in both heavy and light soils. Narrow shares are fitted when soils are compacted and wider shares (approaching sweeps) are used for the shallower, weed control cultivations.

There is an Australian machine which could well be tried in North Africa.

2. Planting

The importance of time of planting, rate and planting geometry and depth of planting are apparently well appreciated, and adequate work is proceeding.

In respect to time of planting the earlier maturing varieties now being recommended, have allowed the optimum planting date to be delayed. This is desirable because there is ample evidence that a slight delay in planting date after the opening rains is an advantage. Whenever date of planting experiments have included the first planting as soon as possible after the opening rains, the yields from this treatment are generally less than from the second, regardless of the date of the opening rains. Obviously, there is better weed control and perhaps mobilization of nutrients. There is no choice in planting time in many wheat growing areas of the world, but in these rainfed Mediterranean climates, there is. The onset and length of the growing season varies from year to year and from site to site, so that some variety x cultural manipulation is possible and some additional decision-making required.

The effect of plant density upon the growth and yield of cereals has been studied extensively. Workers have looked for optimum seed rates and have found them often below those in common use and the optimum has varied between cereals and broad geographical locations. The same results are appearing in North Africa, although the extension people will need to interpret these more carefully when seed is broadcast.

The problem of planting depth is acute particularly with the shorter strawed varieties with their shorter coleoptile lengths.

Seeding machinery is vitally important and in this regard thought must be given to the Australian seed drill. It has the usual feature of planting in rows, but the additional feature of dispensing the phosphorus fertilizer in a band with the seed. Its unique feature is that it is a tyned implement and has four rows of tynes. Planting occurs behind the tynes on the middle two rows, and the first and fourth rows of tynes act as a cultivator. So that at planting, a final cultivation for weed control is achieved.

3. Weed Control

This seems to be an area causing concern and in which considerable effort is required because of the limitation weeds are placing on yield.

Reference is made in land preparation to weed control and cultural means continue to be important in this regard. Chemical in-crop control however, is an important aid in control programmes. Thirdly, the influence of dense well grazed pastures in the rotation should be considered.

The weeds observed fall into 3 categories:

(a) Grassy weeds of which wild oats is the major problem. Cultural control is possible and schemes are being used to ensure the killing of successive germinations, and preventing reseeding. These schemes are ultimately going to reduce wild oats populations even though they are costly.

The use of the herbicides diallate, triallate and barban appear to be overlooked. These chemicals are effective except where surface organic matter is too high. Triallate is recommended in South Australia. It is used pre-sowing. Diallate is equally effective and is used pre-emergence. It is used as standard treatment in all cereal-experiments. Barban is an early post-emergent herbicide to which there is some varietal susceptibility.

Well managed pastures in the rotation can prevent reseeding.

(b) Broad leaved weeds . In the North African programmes 2,4-D is commonly used for broad leaved weeds, but timing of the spray is important and appears to be overlooked in some programmes.

Cereal plants are sensitive except during the fully tillered to jointing stages, and use of 2,4-D outside of this period, can result in crop damage. Prior to this stage, the weeds may be competitive and attention can be given to early post-emergence herbicides for early competing annual weeds. These include: prometryne, linuron, diuron, bromoxynil, and the new chemical metabenzthiazuron (a Bayer product registered as Tribunil in Europe and Australia), which is proving effective in South Australia against a number of weeds. For perennials, or for annuals in which early competition is not a problem, the cheaper 2,4-D should still be used.

(c) Oxalis . Oxalis is widespread in Tunisia as it is in South Australia, where although research is continuing, it still remains a problem. Presently a combination of cultural techniques in which no cultivation occurs until the time of old bulb exhaustion in early winter followed by a second cultivation two weeks later, and then planting to an early maturing cereal variety. This is aimed at reducing bulb populations, but is not successful in all circumstances. Dense legume pastures compete with Oxalis for light and have reduced the weed considerably.

A good deal of cereal weed control research is being conducted in South Australia and it is proposed to provide a number of guidelines for workers in North Africa to help reduce the magnitude of their task.

VARIETIES AND VARIETY EVALUATION

The variability of the environment in these rainfed areas of Mediterranean climate is a constant feature. To some extent, it affects the choice of varieties and to a greater extent it affects their evaluation.

Responsiveness to improved environment is required here as it is elsewhere, but some degree of stability is also necessary. Two varieties may produce the same total in 10 years but the one which may be less high yielding in the best environment and more productive in the poor situation give the farmer, the industry and the country some additional stability. The extremes of environment may well be the same site in different years. When the total rainfall available through the growing season, the onset and length of the growing season the incident of stress periods and disease are unpredictable a wide range of adaptation is required.

In measuring the performance of new varieties in these situations not climate alone, nor soil type, nor any single component of the natural

environment can be considered singly. Rather performance is to be considered in an environment changing in respect to all these factors.

Workers generally accept the existence of this variation and are not prepared to base varietal recommendations or data from one site on one year, but rather measure the performance under a wide range of conditions.

It is simply being suggested that a larger sample of environments needs to be taken in this sort of area than in irrigated more carefully controlled areas. Adequate sampling of locations and seasons is necessary, but the optimum number needs to be determined for the particular area under consideration. Country boundaries were scarcely drawn up with variety recommendation in mind, so that the definition of sub-areas for recommendation will generally be necessary also.

Varieties respond differently to particular cultural practices such as time, rate and depth of planting; fertilization; and pest control treatments, and these factors need to be borne in mind in evaluation programmes.

Varieties respond differently to chemicals used for plant protection. Insecticides, fungicides and herbicides have all induced differential varietal reaction. Two questions then arise. The first concerns the use of the chemical to protect the trial and care is necessary on the one hand to avoid limiting the genetic expression of a variety due to its susceptibility to the chemical, and on the other to protect it from the weed or pathogen. The other question concerns the screening of varieties for reaction to chemicals and this is more suitably carried out separate from the variety trial.

MACHINERY

Several references have been made earlier to machinery requirements but they can be summarized as follows:

1. For Commercial Use

- (1) An Australian cultivator (scarifier) - see earlier reference.
- (2) An Australian seed drill with the extra cultivating tynes - see earlier reference.
- (3) A stone picker - there is available a particularly useful stone picker of simple but robust construction which would transform some of the stony areas.

For example, areas with small surface stones 60-100 kms north of Marrakech in Morocco and similar areas elsewhere, could be cleared simply.

2. For Experimental Purposes

A seed drill which plants 8 rows has been constructed in South Australia and a replica of this would be useful in several of the programmes.

Its special features are:

- a) It can be mounted on the 3-point linkage of a small tractor.
- b) It has tynes which means that it could be used before planting to give the experiment site a final cultivation if the farmer's machine is not available.
- c) It has 3 boxes - seed box, standard fertilizer box for phosphorus and an additional fertilizer box for nitrogen.
- d) It has a spray rig to enable the plots to be sprayed with a pre-emergence wild oat herbicide at planting. This unit would give greater flexibility to some programmes and would allow many drill strip experiments to be planted with only one visit to the site.

TRAINING

Some training of both foreign experts and local workers could take place in Southern Australia with considerable profit.

The following are recommended:

- (1) A visit to Southern Australia in the spring of 1971 by one of the CIMMYT leaders engaged in the Mediterranean programmes.

Approximately 3 weeks in Australia would allow an adequate examination of the crop-legume system in South Australia, and a quick comparison of South Australia with conditions in Victoria and Southern New South Wales.

Obviously, time would be allowed to visit appropriate institutions engaged in plant breeding and agronomy research organizations.

- (2) Senior officials of the Ministry of Agriculture who are concerned with policy decisions should visit Southern Australia to appreciate the technology peculiar to this area.

- (3) At a later date when adequate engineers and technicians are available in Tunisia and Morocco, a few should work in South Australia from planting time to harvest for production experience.

- (4) Of the engineers who are selected for higher degrees, a few should be sent to the University of Adelaide or Western Australia.

APPENDIX A

Itinerary

October 30	Depart Adelaide
31	Arrive Lebanon
November 1-5	Lebanon (including visit to Beka's valley)
6-7	Rome
8-17	Tunisia (including many visits to country)
18-22	Morocco (including tour of country areas)
23-25	Tunisia
25	Rome
26	Rome to London
27	Cambridge
28-29	London
30	Travel to Mexico
December 1-5	Mexico
6	Return to Australia

People with whom discussions were held

Lebanon	O. Brough, Ford Foundation
	H. Walker "
	I. Narvaez "
	O. Aresvik "
	J. McCrary "
	W. Hardison "
Rome	J. Stafford, Australian Embassy
	P. Oram, FAO
	M. Quaix, FAO
	E. Bennett, FAO
	E. Hartmans, FAO
Tunisia	W. McCuiston, CIMMYT
	K. Wilhelmi, CIMMYT
	T. Lyons, CIMMYT
	P. Marko, CIMMYT
	G. de Spoelberch, Ford Foundation
	P. Bronzi, Ford Foundation
	G. Walker, U.S. AID
Morocco	C. Ferguson, U.S. AID
	R. Edwards, U.S. AID
	H. Floyd, N.E. Foundation
	F. Bidinger, CIMMYT
	W. Hall, CIMMYT
	A. Acosta, CIMMYT

APPENDIX B

The following layout would demonstrate the advantage of a crop-medic rotation over the present 2-year rotation of crop^u"fallow".

"Fallow" in this context is the usual volunteer growth in the wheat stubble.

		1	2	3	
Treatments	1971	medic			
	1972	wheat	medic		
	1973	medic	wheat	medic	50 m.
	1974	wheat	medic	wheat	
Control	1971	"fallow"			
	1972	wheat	"fallow"		
	1973	"fallow"	wheat	"fallow"	50 m.
	1974	wheat	"fallow"	wheat	
		20 m.	20 m.	20 m.	

This would be sown at 3 sites in Tunisia viz 350 mm, 450 mm, and 550 mm rainfall.

All the details would be provided direct to the staff in Tunis.

At the same time very small demonstrations would be planted to demonstrate the usefulness of several cultivars and the need for the use of rhizobia inoculum.

