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1.1 THE ROLE OF RAINFED AGRICULTURE IN THE NEAR EAST REGION: SUMMARY OF PRESENT SITUATION, POTENTIAL AND CONSTRAINTS

by

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SUMMARY

Plant ecology and productivity in the Near and Middle East Region are mainly determined by the amount and seasonal distribution of rainfall and to a lesser extent by soil type, topography and elevation. Rainfall is low, unpredictable, highly variable and extended droughts are more the rule than the exception. Temperatures and evaporation rates are high. Most of the countries are classified by FAO (1974) as low rainfall, in that most of their land could be termed either arid or semi-arid by Meig's definition. This is clearly displayed by the rainfall data in Table 1. From these data it could be noted that the arid and semi-arid areas amount to about 96 percent of the total geographic area in North Africa and the Near East Region, 87 percent in the Middle East countries, 74 percent in Somalia and 48 percent in Sudan.

Natural aridity is a major constraint to production and there is very little that can be done to alter it. However, man could balance his actions with respect to the hydrological cycle so that a given amount of water could serve his needs without undesirable side effects such as desertification. Water is the most manageable of the natural resources in that it can be transported, stored, diverted and recycled. However, the concept of managing the hydrological cycle involves more than hydrology and engineering, it also involves ecological and physiological fundamentals.

The concept of managing the hydrological cycle is not new. It has been tried with success in some watersheds in the western United States. Water supply was in effect increased through the use of rainfall recovery techniques and the development of ecosystems with balanced and efficient water regimes. Water demand was also decreased through improved irrigation systems and techniques and vegetation manipulations on both the watershed and the irrigated areas.

It is proposed that the key to desertification control and rehabilitation and increased productivity within the Near and Middle East lies in the realm of management of the hydrological cycle. This paper is not intended to be an exhaustive review of the various aspects and ramifications of this enormous subject. It is anticipated that other papers to be delivered at this Seminar will deal with this aspect which will include examples of some fundamentals, principles and techniques which are applicable to the Region and which could be incorporated into an integrated land and water management system aimed at controlling the hydrological cycle with emphasis upon the effects that this could have upon livestock and crop production.

The potential productivity of rainfed agriculture has been perhaps seriously underestimated. This together with the fact that progress in rainfed agriculture is dependent upon a series of complex measures to be undertaken by Governments has until recently led to its neglect in many countries of the Near East.

In the Sudan, agricultural development in rainfed agriculture is being vigorously pursued by expanding the cultivated area, where huge potential for expansion exists. However, the problem of raising or even maintaining yields on the same plot of land has not received sufficient attention. While only in the Mediterranean region limited possibilities exist for horizontal expansion, agricultural and livestock production and productivity per

hectare of presently utilized areas can rise considerably through the abolition of fallow and the introduction of forage or other crops in its place and through the increased use of nitrogen and phosphorus fertilizers, together with other cultural practices such as early sowing, weed and pests and disease control.

Various constraints, some of them very serious, such as the fragmentation and small size of holdings, lack of credit facilities, lack of marketing facilities and infrastructure and pricing policy and unfavourable input/output price relationships, must be eliminated in order to ensure the application of improved practices and to ensure a rise in productivity. A group insurance programme for rainfed crops will eventually result in higher production for the country, will stabilize the income of rainfed farmers, and will spread the weather risks also over the total national population.

The range which occupies a large portion of total utilized areas, i.e. about 4 land units of range to one land unit of arable, has not been adequately studied and the problems of efficient range management have not been solved. Because of its great importance to animal production, the range should be given very serious attention.

Development in agriculture depends on the availability of efficient government services for research, extension, soil conservation, range management etc. In order to ensure sustained production in agriculture, additional data are needed which can be supplied only by research. However, the research effort in the field of rainfed agriculture has in general not received adequate support. The drive for increased production presupposes the availability of efficient extension, soil conservation, range management and other government agencies. In many countries, such agencies are either non-existent or are poorly organized.

In view of the fact that rainfed agriculture accounts for most of the land under crops and for most of the population engaged in agriculture, a concentrated effort is called for by the governments concerned to remove the various obstacles in the way of progress and for the formulation and resolute implementation of a policy for the development of rainfed agriculture. This may within a relatively short time double the volume of production from this sector of the economy. The effectiveness of the drive for raising production will be greatly enhanced if regional cooperation is established in the field of research, training and exchange of experience. With this in mind, the establishment of a Regional Agricultural Research Institute and Regional Range Management and Fodder Production Institute has been recommended in the past.

1. PRESENT FOOD SITUATION IN THE REGION

The recent upsurge in population and increasing pressure on land and water resources have brought about a problem of imbalance between agricultural growth and food demand. As a result, the Near East Region has changed from a net exporter of food to a net importer of more than 50 percent of its food requirements. In the Arab world this problem is particularly serious, firstly because the average increase of population is about 3 percent per annum which will push the number of the population to about 190 millions by 1985, and secondly because of the increasing purchasing power in many of the countries including the quality of food and its quantity. At the same time the average increase of agricultural production is less than the average increase in population. This resulted in dependence on the import of food which is increasing with time. In 1961-65 the Arab countries imported an average 4.4 million tons of cereals per annum (3.2 million tons of wheat alone) which increased to 10 million tons per annum for the period 1973-75 (7.8 million tons of wheat) and it is expected that this figure will rise to about 13.0 million tons/year in 1985 (9.2 million tons of wheat). In the case of wheat only, the value of its import in 1975 amounted to $ 1 316 million and it is expected to rise to $ 3 414 million per annum by the end of this century. The total value of wheat imports by the Arab countries is estimated at $ 75 billion for the coming 20 years. In the case of animal products, the value of imports reached about $ 150 million in 1965 and rose to about $ 200 million in 1975. At present the shortage is about 200 000 tons of meat and 1.5 million tons of milk per annum, and this shortage is expected to double by 1985.

2. ROLE OF RAINFED AGRICULTURE

According to Meig's definition, most of the countries of the Near East and North Africa Region are classified as either arid or at best semi-arid (Table 1). This agricultural production and productivity in rainfed areas is to the greatest extent dependent on the amount and seasonal distribution of rainfall.

Table 1 EXTENT OF ARIDITY IN FAO NEAR EAST REGION AS REFLECTED BY RAINFALL DATA

Region or Country	Total Area 1000 km^2	Amount of Rainfall				Total
		A Less than 100 mm		B 100-400 mm		A + B % of Total
		Area 1000 km^2	%	Area 1000 km^2	%	
North Africa 1/	5 751	4 864	85	653	11	96
Near East 2/	3 705	3 033	79	589	16	95
Middle East 3/	3 100	548	18	2 132	69	87
Sudan	2 625	764	29	500	19	48
Somalia	637	170	27	300	47	74
	15 818	9 379	60	4 174	26	86

1/ Algeria, Egypt, Libya, Morocco and Tunisia

2/ Bahrain, Cyprus, Iraq, Jordan, Kuwait, Oman, People's Democratic Republic of Yemen, Qatar, Saudi Arabia, Syria, United Arab Emirates, Yemen Arab Republic

3/ Afghanistan, Iran and Pakistan

It has been estimated for the low rainfall countries of the world, including most countries of the Near East Region, that agriculture contributes about 40 percent of the GNP, employs about 67 percent of the active population and contributes more than 60 percent to the total export. It has also been estimated that in developing countries about 70 percent of the population live in the low rainfall areas.

The importance of rainfed agriculture in the countries of this Region may be judged from the figures compiled in Table 2. It can be noted that the total area under cultivation in the Near East Region is about 87 million ha, of which about 60 percent is rainfed while the total cultivated area in the Arab world is about 46 million ha, 80 percent of which is rainfed agriculture and the remaining 20 percent under irrigation.

It is also known that yields of less than one ton per hectare and intensity of cropping (about 57 percent) are much lower in rainfed agriculture than under irrigation. Consequently rainfed areas, in the Region, account for only about 26 percent of the total value of agricultural production. However, there are large differences in this respect between countries, each of which merits a separate study. Due to the limited use of modern techniques as well as the low and erratic rainfall, yields are not only low, but show wide annual fluctuations.

The main production of rainfed lands is cereals and livestock. Cereals occupy 62 percent of the areas with the remainder being mainly in fallow in rotation with cereal crops. About 40 percent of the total cereal production is rainfed while the balance is produced on irrigated areas. Livestock in rainfed lands contributes about 32 percent to

Table 2 PRESENT LAND USE IN THE COUNTRIES OF THE NEAR EAST REGION
(in 1000 ha)

Country	Cultivated Area including Fallow Land			
	Total	Rainfed	Irrigated	% of Rainfed to Total
Algeria	7 000	6 750	250	96.4
Bahrain	2		2	0.0
Egypt	2 650	10	2 640	0.03
Iraq	5 920	3 000	2 920	50.7
Jordan	529	490	39	92.6
Kuwait	1		1	0.0
Lebanon	276	196	80	71.0
Libya	2 520	2 395	125	95.0
Morocco	7 040	6 590	450	93.6
Mauritania	263	260	3	98.9
Oman	36	4	32	11.1
PDRY	252	162	90	64.3
Qatar	2		2	0.0
Saudi Arabia	897	720	177	80.3
Somalia	960	800	160	83.3
Sudan	7 800	6 240	1 560	80.0
Syria	5 470	4 960	510	90.7
Tunisia	3 500	3 360	140	96.0
UAE	20	16	4	80.0
YAR	1 200	1 100	100	91.7
Subtotal	46 338	37 053	9 285	80.0
Afghanistan	4 900	1 816	3 084	37.1
Cyprus	433	389	44	89.8
Iran	16 000	5 550	10 450	34.7
Pakistan	19 200	5 700	13 500	29.7
Subtotal	40 533	13 455	27 078	33.2
GRAND TOTAL	86 871	50 508	36 363	58.1

GNP from agriculture. This is more than in any other region, except the temperate areas of Latin America and East Africa. In this respect it may be mentioned that most of the developing countries, including nearly all countries of the Near East Region, have a relatively small portion of their total area in arable land, one land unit arable to four land units of rangeland. Hence, making the best use of the rangelands would appear to be a key element in agricultural development of these countries.

The Region includes countries with tropical semi-arid climate and summer rainfall, such as Sudan, Somalia, the two Yemens, Saudi Arabia and Oman, while most of the other countries of the Region could be considered as of a Mediterranean climate, i.e. dry summer and winter rainfall. Hence, the similarity of ecological conditions should always be borne in mind when attempting to transfer successful experience from one country to another. The land tenure system should also not be overlooked. However, even within a single country, conditions vary widely from one locality to another and cultural practices valid for one locality may not be valid for another. Consequently, before a given practice is introduced into a certain locality, it has to be tested under local conditions.

3. CONSTRAINTS

Under rainfed agriculture, moisture available to the growing plant is the most significant single factor limiting yields. In addition, constraints to increased productivity from rainfed areas include organizational aspects (i.e. research, extension, soil conservation and range management services), pricing policy, credit marketing facilities, crop insurance, infrastructures, land tenure and development policy. These problems also vary widely from one country to another. For instance, research organization is more advanced in some countries, while is hardly existent in others. The small and fragmented holdings, which are very common in the Region, often cause difficulties in modern soil conservation practices and farm mechanization, and only Sudan has no land tenure problems. The organizational structure and agricultural policy in any given country merits a separate study with a view to eliminating bottlenecks and constraints inhibiting progress.

4. IDENTIFICATION OF POTENTIAL

From Table 2 it can be noted that the present total arable area under dryland farming in the Region is about 50.5 million ha, which represents 58 percent of the total arable land (42 percent irrigated), while for the Arab world the total arable land under dryland farming is about 37 million ha or 80 percent of the total arable land (20 percent under irrigation). In certain countries, such as Afghanistan, Iran and the Sudan, there are substantial reserves of land available for the extension of rainfed agriculture. In the Sudan these reserves are huge, about 80 million ha are of potential value for rainfed agriculture (400-800 mm of rainfall), out of which only about 6 million ha are now being utilized in a very extensive way for crop production. The exact figures must await the results of detailed soil and climatic studies as yet to be undertaken. Most of the uncropped area is used as cattle, sheep, goat and camel range. The potential carrying capacity of the range has not been determined, but it appears that there is severe overgrazing of abundant water points for man and animals and undergrazing elsewhere. Uncontrolled fires also have a disastrous effect on the quality of the range.

In the remaining countries of the Region there are practically no land reserves for the expansion of rainfed agriculture. Indeed, in many countries, it may be found advantageous to abandon marginal lands in the 200-250 mm rainfall zone and to allow them to revert to range. The situation may be different in Iran and Afghanistan and to a lesser extent in Morocco, Algeria, Libya and Tunisia where a few million hectares are still available for the expansion of cultivation under rainfed conditions. In these same countries as well as in Iraq, Syria, Jordan and North Yemen, reduction of fallow may increase the cultivated area by about 2 million ha.

Shifting cultivation has traditionally been practised in the Sudan especially on the sandy soils. This consists of clearing a plot of the Savanna, growing sorghum, millet, sesame and groundnuts for 3-4 years and allowing the land to revert to Savanna for 10-12 years in order to restore its fertility. Acacia Senegal is often planted before the plot is abandoned. In recent years, because of increased production and increased tendency of nomads to settle, land may be cropped for longer periods and be allowed less time to recover. This leads to reduction of yields and to wind erosion. Also, since agriculture has expanded to the lower rainfall areas below 400 mm, there are reports of steady encroachment of the desert. Both burning and overgrazing are a formidable combination in accelerating the desert creep. Thus the Sudan has a very high potential for expansion of the area under rainfed agriculture, but at present this is done at the expense of soil fertility and loss of soil by erosion. The introduction of improved rotations, the use of fertilizers and weed killers and the adoption of simple soil conservation practices will probably double the present level of yields and ensure the establishment of a system of permanent agriculture on the same land and the abandonment of shifting cultivation.

In most of the Mediterranean countries of the Region, production under rainfed agriculture can be increased mainly by raising productivity per hectare through the sound selection and application of physical inputs together with the increased intensity of cropping in the relatively high rainfall areas (>400 mm). To illustrate plans for increasing production from rainfed areas in the Arab countries Table 3 can be used. It can be noted that an increase of about 1.40 million ha of cropped area is anticipated due to intensification of cropping (i.e. reduction of fallow), mainly in the North African countries, Syria, Iraq, Jordan and the Yemen Arab Republic; also about 2.85 million ha of new land of which 2.1 million ha is expected to be brought under rainfed cultivation (in Sudan alone) by 1985. It is also estimated that by the year 2000 the present cropping intensity of 57 percent under rainfed agriculture in the Near East Region will increase to about 67 percent.

Table 3 PRESENT RAINFED AREAS IN THE ARAB WORLD AND THE EXPECTED INCREASE BY 1985 UNDER THE MOST FAVOURABLE CONDITIONS (in 1000 ha)

Country	Present rainfed areas including fallow	Maximum increase by 1985 1/			Total arable rainfed by 1985
		Reduction in fallow	New Extension	Total	
Algeria	6 750	500	100	600	7 350
Egypt	10	-	-	-	10
Iran	3 000	200	50	250	3 250
Jordan	490	25	50	75	565
Lebanon	196	-	50	50	246
Libya	2 395	-	150	150	2 545
Morocco	6 590	500	100	600	7 190
Mauritania	260	-	-	-	260
Oman	4	-	-	-	4
PDRY	162	-	25	25	187
Saudi Arabia	720	-	25	25	745
Somalia	800	-	50	50	850
Sudan	6 240	-	2 100	2 100	8 340
Syria	4 960	100	25	125	5 085
Tunisia	3 360	50	100	150	3 510
UAE	16	-	-	-	16
Yemen AR	1 100	25	25	50	1 150

1/ Aboukhalid (1977)

5. AGRO-ECOLOGICAL ZONE STUDY

In this connection it may be mentioned that FAO, in cooperation with ICARDA, has started in 1978 a joint study for the assessment of the production potential of the Near East land resources. The Agro-ecological Zone Study takes into account soil production capabilities, length of growing season, as defined by moisture availability and cold hazards, identifies suitability classes for cultivation of the major crops under rainfed conditions. The study is planned to be completed in early 1980, and will provide country-by-country information on maps of scale 1:2 000 000. The information will be presented as land classes, or "land and water situations" which will reflect productivity differentials for individual crops and between individual crops on different lands and also provide an indication of the constraints which need to be mitigated if yields are to be raised. By identifying the specific development of improvement costs related to these lands, better estimates for the investment costs for agricultural development under rainfed farming will be made possible.

In recent years, the increase in human population and the removal of constraints in the increase in the number of animals by disease has led to increasing pressures on the range and to its deterioration. Also the introduction of tractors has led to the cultivation of the most fertile lands of the range along wadi courses. This has not added to agricultural production to any extent but has contributed still further to the deterioration of the range. In Syria a law prohibiting the ploughing up of such lands has been successfully enforced. It should be stressed that in spite of its low carrying capacity, the huge areas of rangeland involved can support large numbers of animals at a low cost and will continue to be the main source of meat and milk in these countries. Therefore, it warrants much greater attention than it has been receiving hitherto.

6. CROP PRODUCTION AND SOIL MOISTURE CONSERVATION PRACTICES

6.1 General Principles

Agricultural production in the Region as a whole is well below its potential level and it could be maximized by applying what is already known from work carried out in the Region and from the experience of other countries. Improved crop production practices and soil and water conservation are the determining factors in increasing productivity.

It is a well accepted fact that all seeds do better if they are sown in fertile, well structured soils which have been manipulated to achieve physical, chemical and biological conditions satisfactory for the germination, emergence, establishment and growth of plants. These conditions involve such factors as the intake, holding and giving back moisture at need to the plants. They also involve the soil aeration, the development of a relatively firm soil to the seedbed, the assembling of fine soil particles at seed depth so that the seed can be placed at close and intimate contact with the soil particles and its moisture so as to achieve the germination as quickly and strongly as possible, the development of bigger soil aggregates closer to and at the soil surface, so that emergence is in no way inhibited by soil crust formation which, at the same time, enables the soil to absorb the effect of several winds without becoming subject to erosion, and weeds are controlled.

The above statement covers in a very precise manner the optimum environment required for the germination, emergence and development of crops. It implies the cultivation practices involved in the conservation of moisture in the soil, and for obtaining the optimum soil tilth and maintaining an optimum level of soil fertility by either the addition of fertilizers with the right quantities at the right time or the adoption of a suitable crop rotation, or both. To this, one has to add the work of the geneticists and plant breeders, who developed and would develop relatively high yielding varieties suitable for different environmental conditions.

Cereal grains, and most of all wheat, barley and oats, seem destined to be grown more and more under rainfed conditions and probably increasingly in the less productive soils. Irrigation waters and the easier tilled and more fertile soils are likely to be used more and more for high value crops and those more particular for their requirements.

In most semi-arid wheat producing areas of the world, moisture available to the growing plant is the most significant single factor limiting yields. It seems logical that consideration of this factor of production should therefore receive high priority. It has been calculated in other areas of the world similar to the eastern Mediterranean area, that 100 mm of moisture will grow the wheat plant without any grain yield, and every additional mm of moisture available to the plant over this will mean 16 kg of grain yield per hectare. If this formula is acceptable, the theoretical yield potential of wheat under different moisture conditions could be calculated. Under annual moisture conditions of 300 mm, the potential yield of wheat becomes 3 200 kg per hectare. This formula, of course, assumes either adequate distribution of this 300 mm throughout the growing season or adequate moisture storage in the soil reservoir to carry the plant over periods of potential moisture stress. We know also that the average wheat yield in the eastern Mediterranean, in rainfall areas of 300 to 400 mm and with a system of alternate cropping, yield rarely reaches 1 500 kg per ha. This is less that 50 percent of the potential yield mentioned above. The question now arises: What is the reason for low yields? Are the present planting dates and technique inadequate to the extent that the wheat plant is not able to develop a root system that can tap deep soil moisture reserves? Are some of the soils presently being used for wheat too shallow or too poorly structured to provide for adequate water holding capacity? Are the tillage techniques inadequate to ensure proper infiltration of precipitation both during the fallow and the growing season? Are the wheat varieties presently available unsuited to prevailing conditions of moisture occurrence and distribution? Are available plant nutrients more of a limiting factor than the available soil moisture? All these questions are directly related to moisture availability and must not only be answered but must be translated into recommendations of production practices that can and will be adopted by the farmers.

The primary purpose of all the work in the cereal field is to maximize grain yields. This requires growing varieties of the desired qualities and types, which have a place in the rotation and which are grown in suitable soil types, receive the necessary fertilizers and, above all, utilize rainfall most efficiently.

6.2 Water Conservation in the Soil

The problem of conserving soil moisture in sufficient amount to improve the production of crops under dry farming conditions is a difficult one. This involves the application of principles of weed control, timely tillage, maintenance of a firm tilled layer, and the use of crop varieties well adapted to the particular seasons where the dry farming is performed.

In the USA the initial tillage operation is done early in the season before soil moisture has dissipated by using implements to preserve a straw mulch on the surface. This reduces wind and water erosion and keeps the surface open so that it receives rainfall quite rapidly. Subsequent tillage is limited to rather infrequent operations as needed to control volunteer grain and weeds. The particular timing of these operations varies with the amount and incidence of rainfall. Crop failure under low rainfall (250 to 400 mm) is rather frequent.

In their final report, an expert mission to Turkey in 1966 recommended a change in the cultural practices and seed varieties in wheat production in the Central Anatolia region of the country. They suggested a three-point programme:

- To conserve the precipitation that occurs during the fallow year, through a system of stubble mulching that utilizes improved equipment and different sequence of use, with the objective of maximizing the amount of moisture in the soil reservoir and holding the level of moisture at no more than 10-12 cm below the soil surface on or about 1 September.

- To utilize deep furrow seed drills that would allow placement of the seed in moisture on or about 1 September, i.e. adequate to germinate the seed and sustain the seedling until the autumn rains start in late October.

- To obtain and use improved varieties of wheat that have a high tillering ability, semi-dwarf growth characteristics that would allow the use of nitrogen fertilizers without the danger of lodging, which is inherent to the indigenous varieties and possess the necessary winter hardiness and disease resistance to make them feasible for use under the conditions prevailing in the central plateau of Turkey.

The suggested summer fallow practices by the above mentioned group for improving wheat yield could be summarized as follows:

1. Chisel in the autumn after harvest but before the rains to a depth of 20 to 25 cm or deep enough to break up any plough pans that might exist. The purpose of this

operation was to open the soil horizontally and shatter laterally to improve water intake during October to May rainy season. It brings also clods to the surface to aid in wind and water erosion control. It incorporates part of the straw and stubble into the top layers of soil to initiate decomposition. Lastly, it provides a desirable seedbed for annual weeds (particularly Bromus tactorum L.) so that they would germinate and emerge early to allow easier and more complete control with the initial tillage operations.

ii. Cultivate with sweeps in the spring to a depth of 15-20 cm followed immediately with a skew treader. This operation was to enable an early kill on early spring weeds, pack the soil slightly under the surface to develop a moisture evaporation barrier, and incorporate more of the straw and stubble into the surface soil.

iii. Rod weed as needed for optimum weed control, maintenance of the evaporation barrier and straw/stubble incorporation throughout the balance of the fallow period.

In Australia, cereal production is fully mechanized. Mechanization and the ability to do a fairly good cultivation job in spite of indifferent soil moisture conditions has improved the flexibility of crop growing. This has provided flexibility to time operations, and particularly seeding. Controlled time of seeding has enabled the use of most of the time during which rainfed soils are moist. The ability to get the seeds into the ground early in autumn, while temperatures are still relatively high and soils are warm, providing soil moisture is present, has resulted in a quicker and stronger germination, emergence and development of the cereal plants. The more suitable seeding time, combined with controlled depth of seeding, usually 3-6 cm below the soil surface, the relatively close row cropping (18 cm between rows) and the close but even seed dropping within the rows (2.5-5 cm), all help to give plants space and light to develop both root and top growth quickly and strongly. By the above approach to cereal growing it was possible to grow economic wheat and other cereal crops in quite arid conditions. Yields of up to 1 500 kg/ha on rainfall of 130-140 mm in the six months of the growing time have been obtained in Australia, but more usual yields would be of the order of 800-900 kg/ha. As far as the effect of soil moisture on subsequent yield is concerned, it is determined by the rainfall pattern of the growing year. When there are reasonably good rains in the growing year moisture carried through from earlier periods is not important.

Under South Australian conditions it was found that there is no moisture accumulation under long-term fallow unless there is something like 100 mm of precipitation in the last two winter months while the soil is under fallow. In New South Wales the length of fallow in most years did not increase moisture accumulation compared with land prepared by one cultivation 4-8 weeks before seeding. It did, particularly under non-legume pasture conditions, increase the available N accumulation. In Victoria it was found that 8-9 cm initial soil preparation depth reduced to 6 cm at seeding gave significantly higher yields than deeper cultivations, and that yields noticeably declined when cultivation was deeper than 12 cm. In Western Australia deep sowing was found to be a cause of poor emergence, irrespective of the moisture state of the soil. Seeding depths of 3-4 cm gave 85 percent plus germination, emergence and satisfactory plant establishment. At 10 cm seed placement depth, satisfactory plant establishment dropped to 60 percent, and this was even less at deeper seed placement depths. It was also found that seeding depth did not affect root system development. Almost irrespective of seeding depth the secondary roots developed from within 3-6 cm of the soil surface. Shallow seedbeds and shallow sowing enabled emergence to take place in five days plus, and this gave better use of wet soil days and reduced the risk of surface sealing and prevented emergence. Hence, proper physical preparation of a seedbed, resulting in one of comparatively shallow depth, with the aggregates placed correctly, and with good control of weed growth, were the important plant establishment and yield producing factors.

In Western Canada it was found that the type of surface condition left by a tillage machine is not important from a moisture conservation point of view as its efficiency is controlling weeds. Consequently, the increasing use of chemicals for weed control has lessened the need for cultivating soils for the purpose of moisture conservation. The lowering of production cost is another reason for fewer cultivations.

The efficiency of the summer fallow practice in storing moisture was found to vary with soil and environment, both in Canada and the USA. In the USA it is reported that in the Northern Great Plains, where the average annual precipitation is about 400 mm, a moisture storage efficiency during the summer fallow period of 20 percent was obtained as an average for 19 years. Moisture storage efficiency of only 15 percent was measured at the Fort Hays, Kansas, Station over a 40-year period. Winter wheat was grown in alternate years. The fallow period therefore was from July of one year until September of the following year (about 15 months). Thus, it could be observed that although summer fallow is a means of storing moisture in the soil for later use by the crops, it is very inefficient in conserving moisture. Usually, only about one-fifth of the rainfall that comes during the fallow season is stored in the soil for future crop use. Water losses by evaporation from clean-tilled fallow land are high. Small amounts are lost by runoff. Water losses by transpiration by weeds are often large.

6.3 Crop Rotation, Fertilization and Seed Variety

One of the major contributing factors in increasing cereal yields in Australia, under low precipitation conditions, without long months of fallow, has been the development and stimulated growth of legume and medic pastures, where the dominant plant is Medicago truncatulata (Barrel Medic) which is an annual plant. Before this plant, subterranean clover (Trifolium subterraneum) was the main legume used in Australia. Pastures help in improving the soil structure, soil friability, ease of working, greater ability to allow moisture infiltration, increased efficiency in storing moisture and apparently even more marked ability to make it available to plants, and increasing soil fertility, particularly nitrogen.

Phosphate (P) deficiency had almost put wheat out of production in Australia, toward the end of the last century, when yields, even on 400-500 mm of rainfall areas, fell from 500-700 to 150-300 kg/ha. It was found that timing, placement and rate of application of phosphate affect yield considerably. It was found that P fertilizers must be sown with and in intimate association with the seed. Rates of P from 6 to 20 kg/ha with an average of 9 kg/ha are being used. In an annual 410 mm precipitation district in Victoria with an average 1 475 kg/ha yield, it was found that yield dropped by 330 kg/ha if similar amounts of P were topdressed on the soil a month before seeding, compared with that applied with the seed.

The introduction of Barrel Medic and other annual legumes made soils more productive and easier to work. This and the good prices of wool during the fifties brought a marked reduction in the percentage of crops grown on fallow, and saw a big rise in sheep numbers and wool production. The seed of the legumes was sown a few hectogrammes per hectare with the seed of the cereals. In addition to the introduction of the annual legumes, mechanization allowed farmers, to some extent, to dictate timing of operations, and this led to a better time seed sowing. Fertilizer rates stepped up, because there were both cereal and pasture responses, and both crop and livestock contributed toward the increased farm production. Cereal varieties improved, and farmer knowledge and performance did also.

In those districts where legume pastures are established, responses to applied phosphate fertilizers are still obtained but responses to applied N are small and uncertain. In years of average to low rainfall, not much response was obtained to applied nitrogen even on lands which are not growing legume based pastures, although substantial responses were obtained in years of good rainfall. The figures in Table 4 indicate the effect of moisture on the response of barley yield to nitrogen application. The farm on which these crops were grown has a 62-year mean (cereal growing season) rainfall of 307 mm and mean annual rainfall of 396 mm.

Table 4 THE EFFECT OF RAINFALL ON RESPONSES OF BARLEY TO APPLIED NITROGEN

Added Nitrogen in kg/ha	1964 - A season with adequate moisture and rainfall total of 402 mm during the growing season		1965 - A season of moisture stress and a rainfall total of 267 mm during the growing season	
	Yield kg/ha	% of grain N	Yield kg/ha	% of grain N
0	1.824	1.47	1.870	2.82
22	2.131	1.44	1.859	2.89
44	2.200	1.50	1.829	2.94
88	2.496	1.75	1.728	3.00
LSD	258			

In the year of adequate moisture, additional applied N gave an increasing yield increase, while in 1965 yields tended to decline with additional N because of "haying off".

In Turkey, agriculturists have not recommended the use of nitrogen fertilizer for dryland wheat in Central Anatolia, but advocated the use of relatively small amounts of phosphorus. These recommendations were primarily based on the characteristics of the tall strawed wheat varieties available and the prevailing cultural practices both of which tended to limit yields to 1 000-1 500 kg/ha.

Scientists in other areas have stated that 1 kg of nitrogen is needed for every 20 kg of wheat yield. When yields are at the 1 000-1 500 kg/ha level, it is logical to assume that soil nitrogen will adequately meet the needs of the crop and only small amounts of phosphorus must be added. However, when yield expectations are of the order of 3 000-4 000 kg/ha additional N and P must be applied to achieve the desired results. In Turkey the State Farms fertilizer programme on the new wheat varieties prescribes the application of 100-120 kg/ha of 18-46-0 fertilizer at planting time placed with the seed followed by a spring application of 80-100 kg/ha of 21-0-0 fertilizer.

In Syria it was found that yield of wheat after legume (lentils or vetches) was higher than that after fallow. Yields after vetch were, however, slightly better than after lentils.

It is roughly estimated that a good legume crop provides about 30-40 kg of nitrogen per ha. Higher grain yield after legume as compared to fallow is attributed mainly to better soil fertility. Thus, better soil fertility results in early development of the crop with a deep root system capable of tapping soil moisture reserves during periods of high plant needs and low moisture occurrence, a critical factor in determining the level of the final yield.

Local wheat varieties while they might not lack the inherent yield capability under local optimum conditions of soil, moisture and temperature, have characteristics that severely limit their yield capability under more adverse conditions. Tall straw varieties are vulnerable to lodging. Some of the indigenous varieties do not have the tillering ability of some of the imported varieties and therefore the seeding rate needs to be higher. For future work, it is essential to encourage the development of wheat varieties that have a higher probability of overcoming adverse conditions of moisture, temperature and disease. This is most likely to be achieved by varieties of short growing period.

7. CONCLUDING REMARKS

The situation as revealed in the foregoing discussion points to the fact that this meeting may seriously consider recommending an action oriented programme as a follow-up to this Seminar:

- The need to establish a national policy for the development of rainfed agriculture so as to reduce the growing socio-economic disparity between low rainfall areas and those with more favourable environments. This will involve the solution of the problems of fragmentation and small size of holdings, lack of marketing, infrastructure facilities and pricing policy and unfavourable input/output price relationships. This will also involve the strengthening of the government services for research, extension, soil conservation and range management for rainfed areas.

- The need for the establishment of regional cooperation in the field of research, training and exchange of experience to enhance the effectiveness of the drive for raising production in rainfed areas. FAO through its Regional Office in Cairo and its ongoing Regional Projects in the field of Land and Water Use, Improvement of Field Food Crops and Animal Production and Health should consult with ICARDA in Beirut and ACSAD in Damascus to ensure the above-mentioned Regional cooperation and coordination. It is gratifying to report that a joint regional study between FAO Regional Office and Cairo, the Regional Project for Land and Water Use and ICARDA in the field of agro-ecological zone study has already been initiated. Discussions have also been started between FAO and ACSAD to initiate joint programmes.

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