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9. ABSTRACT
USAID was asked by the Government of Morocco to plan a five year program of applied dryland agronomic research and complementary socioeconomic research to produce a technical basis and an applied research capability for increasing agricultural development in the drier portions of Morocco's rainfed agricultural areas. About 50% of the arable land of Morocco is in the Central Plains and Central Plateau provinces, a region with an annual precipitation of 200-400 mm. The major crops are barley and wheat, but the yields are low. Most of the farms are less than six hectares in size. The dryland farming team arrived in Morocco at the start of the planting season in 1976. Stops were made at many fields to analyze soil moisture conditions as influenced by present farming practice, the types of soil, and the weed problems. Special attention was given to seeding practices. Team members studied statistics on land, crop production, and population as well as reports and analyses on fertilizers, wheat breeding and varieties, range management programs, the supply and marketing system and government programs. It is concluded that the yield potential of the small farms is much higher than present yields. Present tillage and planting implements are inadequate. Major emphasis in the five year program is given to training Moroccan staff; Morocco does not have personnel with the special training and experience required to develop and implement the comprehensive applied research program needed. A U.S. university contract team is proposed to guide development of the research program. Applied research in the socioeconomic situation is also essential because achieving increased production from the small farmers and improving their standard of living depends on general changes in the culture, social, and economic organization through the provinces.

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A REPORT
APPLIED AGRONOMIC RESEARCH PROGRAM FOR DRYLAND FARMING IN 200 - 400 MM. RAINFALL ZONE OF MOROCCO
DIRECTED TO THE SMALL FARMER

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Period in Morocco: November 2 - December 18, 1976

Prepared by
MidAmerican International Agriculture Consortium
Dryland Farming Team

Under
Contract No. AID/NE-C-1284
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FIGURE 1. MOROCCO

EIGHT SHADED PROVINCES REPRESENT THE PROPOSED PROJECT AREA FOR THE APPLIED AGRONOMIC RESEARCH PROGRAM

(OMITTING RECENT ADDITION OF THE SPANISH SAHARA)

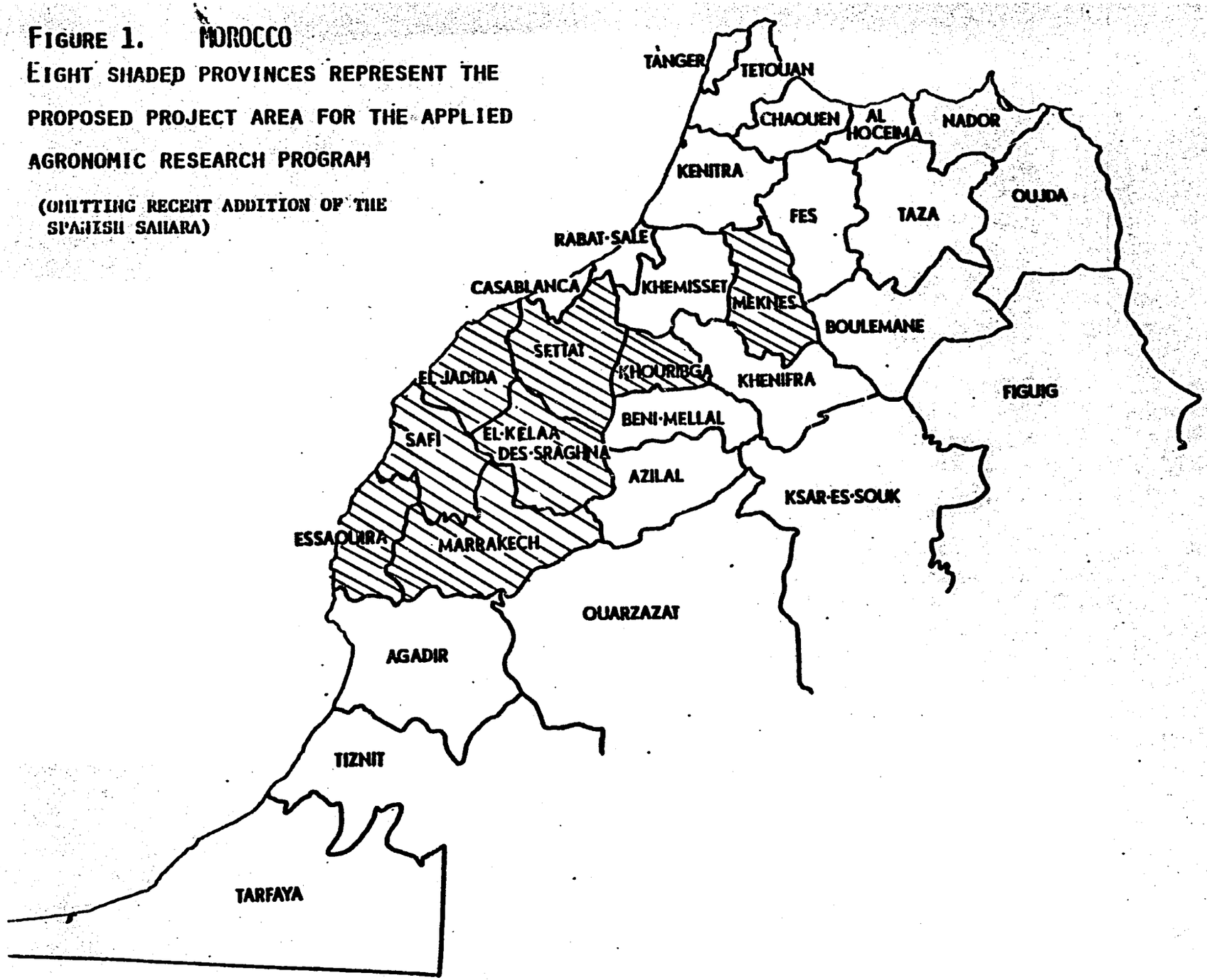

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TABLE 1. Conversion Tables and Factors

Dirhams (DH)

Exchange rate in November, 1976 Approximately 4.5 DH = $1.00 U.S.
1.0 DH = $0.22 U.S.

Land Measure

1 Hectare (ha) = 2.471 acres (a) / 1 acre (a) = 0.4047 hectare (ha)

1 Kilometer^2 (km) = 0.3861 miles^2 (mi) / 1 mile^2 (mi) = 2.5900 kilometers^2

1 Kilometer^2 = 247.1 acres / 1 acre (a) = 40.470 kilometers^2

Weights

1 Metric Ton (MT) = 1000 Kilograms (kg) = 2,204.62 pounds (lb) or 36.7 bushels (bu.) wheat
45.7 bushels barley
39.4 bushels corn

1 Quintal (q or Q) = 100 Kilograms = 220.46 pounds or 3.67 bushels wheat
4.57 bushels barley
3.94 bushels corn

1000 grams (g) = 1 Kilogram = 2.2046 pounds

Linear Measure

1 Millimeter (mm) = 0.10 Centimeter (cm) = 0.03937 inch

1 Inch (in) = .0254 Meters = 25.40 millimeters

1 Meter (M or m) = 1000 Millimeters (mm) = 39.37 inches

1 Kilometer = .62137 Miles / 1 Mile = 1.6093 Kilometers

Centigrade to Fahrenheit Temperatures:

C	F	C	F
-20°	-4°	20°	68°
-15	5	25	77
-10	14	30	86
- 5	23	35	95
0	32	40	104
5	41	45	113
10	50	50	122
15	59		

$$F = \frac{9C}{5} + 32 \qquad C = 5\,\frac{(F-32)}{9}$$

Metric tons or quintals per hectare to bushels per acre:

Wheat	-	MT/ha x 14.87 = bu/a	Q/ha x 1.487 = bu/a
Barley	-	MT/ha x 18.59 = bu/a	Q/ha x 1.859 = bu/a
Corn	-	MT/ha x 15.93 = bu/a	Q/ha x 1.593 = bu/a

Bushels per acre to metric tons or quintals per hectares:

		Metric tons	Quintals
Wheat	-	Bu/a x 0.06725 = MT/ha	Bu/a x 0.6725 = Q/ha
Barley	-	Bu/a x 0.05380 = MT/ha	Bu/a x 0.5380 = Q/ha
Corn	-	Bu/a x 0.06319 = MT/ha	Bu/a x 0.5319 = Q/ha

Metric tons or quintals per hectare to pounds per acre:

MT/ha x 892.18 = lb/a

Q/ha x 89.218 = lb/a

Pounds per acre to metric tons or quintals per hectare:

lb/a x 0.00112 = MT/ha

lb/a x 0.0112 = Q/ha

ABBREVIATIONS USED IN THE REPORT

USAID - United States Agency for International Development

FAO - Food and Agriculture Organization, United Nations
UNDP - United Nations Development Program

GOM - Government of Morocco

MARA - Ministry of Agriculture (Ministere de l'Agriculture et la Reforme Agraire)
DMV - Directorate of Development (Direction de la Mise en Valeur)
DPA - Division of Crop Production (Division de la Production Agricole)
DRA - Directorate of Agronomic Research (Direction de la Recherche Agronomique)

CLCA - Local Agricultural Credit Bank (Caisse Locale de Credit Agricole)
CNCA - National Agricultural Credit Bank (Caisse National de Credit Agricole)
CRCA - Regional Agricultural Credit Bank
CT - Work Center (Centre de Travaux)
OCIC - National Cereals Office

CIMMYT - International Maize and Wheat Improvement Center
ICARDA - International Center for Agricultural Research in Dry Areas
ICRISAT - International Crops Research Institu e for the Semi-Arid Tropics

INTRODUCTION

Morocco became an independent nation in 1956. It occupies the northwest corner of the African continent with coastlines on the Atlantic Ocean and the Mediterranean Sea. It extended from 28° to 36° North Latitude and 2° to 14° West Longitude prior to the recent annexation of the Spanish Sahara.

The total area of Morocco before the annexation was approximately 50 million hectares. About 18.5 million hectares are considered agricultural lands including those used for grazing and forests. The arable land area is 7.3 million hectares of which about one million hectares are potentially irrigable and less than half are now developed for irrigation.

The population of Morocco now exceeds 17 million people with approximately 50% eighteen years of age or less. Rate of population increase is 3.0% annually. In recent years production of cereals has not been meeting the national requirement, and imports have been required to meet the increasing food needs of the nation.

About 50% of the arable land of Morocco is in the Central Plains and Central Plateau provinces, a region with an annual precipitation of 200-400 mm. Barley and wheat are the major crops grown in these areas, and yields are low. Most of the farm units in this central region are less than six hectares in size, and the farmers live at a subsistence level.

The Government of Morocco (GOM) asked the United States Agency for International Development (USAID) to provide a Dryland Farming Team to "plan a Five-Year program of applied dryland agronomic research and complementary socio-economic research to produce a technical basis, and an applied research capability, for increasing agricultural development in the drier portions (12-16 inch rainfall belt) of Morocco's rainfed agricultural areas."

Conclusions and Recommendations

1. The team concludes that the yield potential of the small dryland farms of the 200-400 mm rainfall area is much higher than present yields.

2. The development of a continuing applied agronomic research capability is highly desirable because very little information is now available for guiding the important production and infrastructure development programs that will be necessary in development of this dryland farming area.

3. Achieving increased production from the small farmers and improving their standard of living depends on general changes in the cultural, social, and economic organization through the provinces. Applied research in the socio-economic situation is essential to guide decisions on development of extension and other essential government

programs. It is necessary that information on new technologies be effectively presented to the small farmers and the necessary infrastructure be developed to provide the materials for the technological changes and also to handle the increased marketing requirements so that benefits are realized by the farmer and he is motivated to adopt the new technologies.

4. Present tillage and planting implements are very inadequate. High priority must be given to developing suitable animal-drawn tillage implements and drills for seeding and fertilizer application and getting such implements in general use by farmers.

5. Morocco does not have personnel with the special training and experience required to develop and implement the comprehensive applied research program needed in crop production in this region. Therefore, major emphasis in the proposed program in the first five years is given to the training of Moroccan staff to M.S. and Ph.D. levels in United States universities. Major development of the applied research program in the eight provinces defined as the project area will occur during the last half of a ten-year program when the Moroccan participants have returned from training.

6. A U.S. university contract team is proposed to guide development of the applied research program. Since their role is to assist the Moroccans in developing the program, a small team not to exceed three scientists on long-term assignments is proposed. This is to be supplemented by a larger number of specialists who will be involved in repeated short-term assignments.

7. If GOM will commit the necessary personnel for training and provide the support required to implement the proposed program, Morocco will have the applied research capability at the end of ten years to make its low rainfall, dryland farming area much more productive in the national interest. Morocco will also have a sound base for improving the standard of living of the millions of people in this area who now live at the subsistence level.

<u>Team Members</u>:

Dr. Rex R. Campbell, Professor and Chairman, Department of Rural Sociology, University of Missouri; also Farm owner and manager.

Dr. R. Hunter Follett, Associate Professor, Department of Agronomy (Soils), Kansas State University.

Prof. Herbert B. Howell, Professor, Department of Agricultural Economics, Iowa State University.

Mr. Richard Riddle, Ph.D. candidate, Department of Sociology, University of Missouri.

Dr. James T. Stubbendieck, Assistant Professor, Department of Agronomy (Range Science), University of Nebraska.

Dr. Donald G. Hanway (Team Leader), Professor, Department of Agronomy, University of Nebraska.

People Interviewed:

United States Embassy
The Honorable Robert Anderson, Ambassador to Morocco
Mr. Jerry Kuhl, Agricultural Attache

USAID/Rabat
Dr. Albert P. Desdier, Director, USAID/Morocco
Dr. J. Gerard Neptune, Food and Agriculture Officer
Mr. Herbert Woods, F & A Program Officer
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Ministry of Agriculture
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FAO
Mr. Orvil Godman, Leader, Range Management Project

Peace Corps
Mr. Daniel Butler, FAO Range Improvement Project

Compagnie Marocaine (Massey Ferguson Agency)
M. Gey Chabineiz, Chief, Technical Services

Dryland Farming Team Activities:

The dryland farming team arrived in Morocco on November 2, 1976 at the start of the planting season. This year general rains had occurred in late October over the entire dryland farming area. Rains continued to November 10 and then stopped through the rest of November. General rains did not resume until December 16. Between November 5 and November 12 the team travelled to observe the farming situation in Berrechid, Benahmed, Settat, El Borouj, El Kelaa des Srarhna, Marrakech, Chichaoua, Essaouira, Safi, Youssoufia, Sidi Bennour, Meknes, and Sidi Slimane. On November 26 the team travelled to Merchouch, Maaziz, Khemisset, and Tiflet. On December 1 three members of the team visited the King Ranch at Adarouch. On December 9 the team re-visited the area around El Gara and Berrechid to observe progress of crops and effects of the extended dry period on soil moisture as related to tillage practices. On December 13 three members of the team visited a Work Center northeast of Rabat to observe a Massey-Ferguson drill modified for deep furrow planting.

Visits were made to Work Centers (TCs) and experiment stations for conferences about farming practices. Stops were made at many fields to analyze the soil moisture condition as influenced by present farming practice, the types of soil, and the weed problems. Soil samples were taken at a number of widespread locations to send to soil testing laboratories in the United States for analysis. Special attention was given to studying present seeding practices. The agricultural economist, sociologist and farmer observed the activities of the people, the roads, markets, services available, etc.

Dryland farming team members studied statistics on land, crop production, population and the like as well as the reports and analysis of TVA on fertilizers, of CIMMYT on wheat breeding and varieties, of range management programs, of several studies on the small farmer and his status as affected by land tenure, the supply and marketing system, and government programs. They had conferences with staff members of the Hassan II Institute of Agronomic and Veterinary Science, the Dryland Farming Bureau, Range Management in the Livestock Directorate, the Directorate of Agronomic Research, and others acquainted with dryland farming and the farmers operating farms less than ten hectares in size. They found very little information from studies or research directly pertinent to crop production or efforts to improve productivity of the small farmers in the 200-400 mm rainfall zone.

APPLIED AGRONOMIC RESEARCH PROGRAM FOR DRYLAND FARMING DIRECTED TO THE SMALL FARMER IN THE 200-400 MM RAINFALL ZONE OF MOROCCO

SUMMARY OF ANALYSIS AND PROPOSED APPLIED RESEARCH PROGRAM

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SUMMARY OF ANALYSIS AND PROPOSED APPLIED RESEARCH PROGRAM

Brief Technical Analysis Of Dryland Farming In The Low Rainfall Zone

The assignment of the Dryland Farming Team was to develop a plan for an applied research program to guide development decisions for dryland farming with particular attention directed to small farmers in the 200-400 mm rainfall zone. See Annex A, pages 24-38, for an analysis of the rationale for such an applied or adaptive research program in Morocco. Other detailed technical analyses made by team member specialists are included as annexes to this report.

The project area for the applied agronomic research program has been defined to include eight provinces: Settat, El Jadida, Safi, Essaouira, Khouribga, El Kelaa des Srarhna, Marrakech and Meknes, all in the low rainfall area except Meknes which is an important dryland farming province to the north to serve as a desirable check in a situation with more rainfall and deeper soils. See Figure 1 for a map and Annex C, pages 48-51, for details on definition of this area.

The population of these eight provinces was estimated in 1975 at 5,214,000 or 31% of the population of Morocco. About 3.8 million or 73% of the population are classified as rural. The project area had 569,500 farm units with 431,700 or 76% less than 6 hectares in size. They contain 40% of the arable land and have 50% of the cattle, 48% of the sheep, and 24% of the goats in Morocco. This is an agricultural sector that contributes significantly to both livestock and cereal crop production but which has received little attention in agricultural development except for irrigation perimeters. Improving the productivity and the welfare of the people of this area is an important goal for political, economic and humanitarian reasons. See Annex H, page 115, for more economic details on the project area.

The limited amount and erratic nature of the rainfall in this area is recognized. Still the rainy season coincides with the growing season of cool-season crops, and temperatures permit continuous development from planting in November or December to maturity in April or May. Cool temperatures from November to March and periods of sunshine interspersed between relatively short rainy periods are favorable for photosynthesis and efficient moisture use.

The soils in much of the low rainfall area are shallow, often rocky, and low in fertility. This means a low capacity to store moisture and produce good yields. Usually they are dry at harvest time. Rains in this area of Morocco are usually slow and gentle. Soils can absorb the rain as fast as it falls. Only occasionally does rain occur long enough to saturate the surface soil and cause runoff. When runoff occurs, the loose soil of tilled land erodes much more severely than firm soil which is protected by growing crops or crop residues on the soil surface.

The climatic conditions are conducive for production far

higher than is being attained. It appears that poor production practices are more responsible for the low yields now harvested than lack of rainfall. See Annex B, pages 39-47, for more detail on the rainfall factor.

The production potential of the project area is much higher than present production levels. Emphasis should be given to developing new technologies that will conserve more of the rain that falls and will then increase the efficiency with which crops use the available soil moisture for production. Great improvements in yield levels and in stability of production seem possible.

Observations of the team have led to tentative conclusions in regard to potential production increases. Before discussing the basis for these conclusions, it must be strongly emphasized that the following discussion is presented as tentative and that the practices must be thoroughly researched in Morocco under Moroccan farming conditions before final conclusions are drawn and decisions on implementation are made. This is the meaning of applied research.

Present practices used for seedbed preparation are based on the premise that deep tillage is necessary to save water. Actually they appear to be the cause of serious and unnecessary losses of moisture. They are also wasting energy and are not controlling weeds nor providing a desirable seedbed.

Stirring and loosening the soil by deep tillage is unnecessary for storing moisture in the soil. Actually present tillage practices on sloping land that leave the surface loose and bare are responsible for serious and widespread sheet erosion. This is serious on any soil, but it is a direct threat to retaining the long-time productivity of shallow soils. Falling rain seals over the surface of bare soil, reducing its ability to absorb water, thus causing more runoff and erosion than when vegetative cover protects the soil surface from falling raindrops.

Present planting practices almost universally consist of broadcasting crop seed and mixing it along with any surface weed seeds through a loosened zone of 75 to 100 mm of surface soil with small wooden or steel plows pulled by animals or a covercrop (tandem disc) pulled by tractors. The few small farmers who use fertilizer broadcast it on the surface and mix it into the soil by plowing in the same way that they plant seeds. Moisture losses due to weed growth are continuous from planting time through the crop season. The system used for planting is wasteful of seed. It plants the weed seeds just as well as the crop. Similarly broadcasting superphosphate or starter fertilizer greatly reduces its effectiveness compared with placing it with the seed. The present practice of broadcasting seed and starter fertilizer must change before major increases in yields from other improved practices can be achieved. This applies to the large, mechanized farmer just as much as it does to the small traditional farmer.

"Summer fallow" is practiced in dryland farming systems in the United States to conserve water from one rainy season to supplement that of the next rainy season as a means of increasing and stabilizing yields. "Fallow" land in Morocco at the present time is used for livestock pasture rather than being managed to build up a reserve of moisture and nutrients in the soil. Summer fallow practices to conserve water have little or no place in the low rainfall and shallow soil areas of Morocco because keeping moisture stored in the soil through the long, hot dry season will be impossible. Morocco should develop annual cropping systems to conserve and use the rain that falls each year as efficiently as possible. In these systems there is probably no place for deep tillage.

Shallow tillage just before or at planting time, on the other hand, is essential to destroy weeds that are present so that the crop, when planted properly with a drill, can get started with an advantage over the weeds that will germinate later. The greatest yield reduction is caused by competition from weeds in the first six or eight weeks after planting. Applied research may show that certain herbicides in the future can be used to control weeds at planting time to replace the shallow tillage that is now necessary. Applied research in Morocco is also essential to determine the potential for using herbicides to control broadleaf weeds and such grassy weeds as wild oats in the growing crop that now seriously reduce grain yields.

Increased use of fertilizers in Morocco has raised yields in recent years. Some farmers in the low rainfall area are using fertilizer, but the soils generally appear to be particularly low in organic matter and nitrogen. Phosphate fertilizer is probably needed generally in the calcareous soils. Some soil fertility research by DRA and the Hassan II Institute suggest that potassium in the soils is adequate to meet needs of all crops and that none needs to be added. Soil tests are needed to determine the nutrient status of soils in the area to guide a sound program of fertilizer procurement and use. There is a high probability that phosphate fertilizer applied in the row with the seed by a drill at planting time will be needed on most farms.

The following changes are essential because of direct effects on increasing yield as well as permitting additional benefits to be made by other changes in technology such as improved varieties and better insect and disease control:

1. General adoption of planting with a properly designed drill that places starter fertilizer with the seed.
2. Use of shallow tillage only as a means of controlling weeds without destroying the firmness of the seedbed with associated loss of water.
3. Improved weed control in the growing crop, probably requiring use of herbicides.
4. Drilling starter fertilizer with the seed and top dressing added nitrogen in late winter or early spring when available moisture justifies it.

The changes mentioned above require that appropriate sweep tillage implements and drills be designed and manufactured that can be

drawn by the animal power available to the small farmer. With such machines and other practices tested in an applied research program the small farmer can achieve just as high yields as the big farmer with tractor power could get on the same land.

The kind of tillage and planting equipment needed to fit the unique situation of the Moroccan farmer does not exist anywhere in the world. It must be designed and tested in prototype before manufacturing can start. Morocco does have the capability to do the manufacturing. All of these must be done in Morocco before equipment can be available for any farmer to use. See Annex G, page 107, on Machinery and Equipment Development for a more detailed analysis and recommendations.

The present infrastructure in Morocco is not adequate to supply fertilizer, seed and such equipment to all small farmers and also meet their credit needs for making purchases. The present extension organization does not have the capability of carrying out the programs required to explain new practices to all small farmers, demonstrate how to carry them out, and show the benefits from using them. Nor is the extension service organized to communicate the farmers' problems back to the researchers.

The principal crop of the small dryland farmers of the project area is barley which is grown on 1,863,600 hectares or 49% of the arable land. Spring wheat is grown on 701,900 hectares. The major part is durum wheat; the rest is bread wheat. Pulses (broad beans, chick peas, small peas and lentils) are grown on 231,800 hectares, primarily for human food. Maize, sorghum and oats are cereals of secondary importance. See Table 21, page 118, of Annex H.

Variety testing and experiments to improve cultural practices are particularly important for barley, durum wheat, bread wheat, and the pulses. These are the crops that Morocco should also emphasize in plant breeding programs needed to serve the project area. Early varieties of sorghum, pearl millet and proso millet may have special value in the cropping systems. Close contact should be maintained with the appropriate international research centers (CIMMYT, ICRISAT and ICARDA) for improved varieties and technologies that can be tested for use in Morocco.

Livestock production is a major component of the agriculture in the project area. Lack of feed is the principal factor limiting production. At present there are three sources of feed for livestock: (1) the straw from harvested crops; (2) grazing of the fields after harvest and the weeds and volunteer of "fallow" fields from which crops are not harvested; (3) range and forest land; and (4) a small amount of barley grain for draft animals and a few other selected livestock. Straw is poor quality feed for cattle and sheep. Closely grazed weeds in "fallow" fields produce very little forage.

Applied research in forages may well determine varieties of certain

annual and perennial grasses and legumes and practices for growing them that will greatly increase the quantity and quality of forage produced for the livestock. This would mean added income to the farmer and more food for Morocco's people.

Forage production, as such, hardly exists on small farms in the project area now. Even very shallow soils and steep slopes are being tilled because of the great population pressure on the land. The facts that the project area produces about half of the cattle and sheep of Morocco and that lack of feed is the principal limiting factor in livestock production makes improvement of forage production a goal with high priority. Details of the forage situation and the proposed program are given in Annex F, pages 83-105.

Observations and information available indicates that few of the rural families in the project area raise vegetable gardens. There are many cool season vegetables such as peas, carrots, potatoes and beets that could be raised with family labor. A small plot of land could produce enough vegetables to improve the family diet. This would be particularly important to young, growing children.

Applied research activities in the different soil and climatic situations across the project area will be required to determine what vegetables would be adapted and the conditions for growing them. Getting families to grow and use vegetables that are new to them will require development of information both on their production and on recipes for their preparation and use. Getting families to grow gardens when they have not done so in the past will be a major change. This will require not only much educational work by extension but also government development of services to supply seed and garden tools. If a sound applied research program is developed, making progress on family gardens would seem possible. This would improve the health of the rural population of Morocco.

Planning programs of any type on paper is easy. Those who plan research or other programs must never forget that higher yields and greater production depend on what the farmers do. The small farmer works hard. He owns little or no land, has little capital, and cannot afford to take risks. If small farmers are to buy drills and more fertilizer, they must be sure of getting rewards in the form of higher, more stable income that can mean a higher standard of living and a greater self-respect and personal dignity from the success of their efforts.

The GOM with assistance from USAID can develop a permanent applied research program to guide sound developments in the dryland farming sector. Such a program alone, however, will not be sufficient to achieve the desired objective. Only the GOM can set the stage for manufacture of the required implements. Only the GOM can take the actions and set the "climate" through government agencies involved in supplies, credit and marketing and in the extension service so that

necessary changes in actions and attitudes will occur toward serving the small farmer.

There are few, if any, studies in Morocco that the GOM can use in making decisions on how to proceed. Socio-economic research relating to farmers and the rural population of the project area will be extremely valuable in guiding these decisions. Similarly, pilot extension programs working with applied researchers are essential if the potential for increased production is to be achieved after applied research has tested the preliminary observations made in the previous discussion along with other leads which will occur as a research program is developed.

Much research and experience around the world indicates that farmers will change much more readily if they can be involved in the decisions that affect them. Only GOM can create the "climate" for development of farmer organizations that consider their own needs and accept a responsibility for guiding applied research programs in determining problems needing attention and in guiding local extension programs so as to achieve greater effectiveness.

Increased production will be obtained only if the innovations are adopted by the hundreds of thousands of small dryland farmers. If the goal of increased yields is to be reached, the applied technological research portion of the program must be combined with an applied social science research portion.

The objectives of the social science research is to determine:

1. the cultural acceptability of the improved farming practices;
2. the economic impacts of any proposed changes; and
3. the most effective methods of disseminating information about the innovations and methods of increasing their adoption.

For the total program to be effective, a system for the two-way flow of information between the researcher and the farmers must be established. This permits information about new technologies to flow to the farmers and their reactions and problems to flow back to the applied researcher. To determine the best methods of doing this and encouraging adoption, a small experimental outreach extension program will be developed to work very closely with the technological scientists.

A proposed applied sociological research plan and a pilot extension program are discussed in Annex I, page 145. Alternative methods of carrying out a farmer-to-farmer program are presented in Annex J, pages 184-188.

Proposed Program

The Dryland Farming Team developed its recommendations from the basic premise that the program goal is twofold: (1) an established applied agronomic research program with trained Moroccans in charge and with the capability to continue the program and further expand and develop it; and (2) an associated socio-economic research program in

progress and the capability of continuing the development of the information base needed to guide extension and the other agency input-output infrastructures required to implement adoption of tested technologies. Having this operational applied research capability is the foundation that Morocco must have for continuing development of its agriculture. It is the key to adapting further advances in agricultural science and technology around the world for the use and benefit of Morocco and its people.

Training the necessary personnel and establishing an operational, productive applied research program in the low rainfall, dryland farming area of Morocco will require ten years. This is an important institutional development effort. Table 4, page 16, shows that training of Moroccan staff will be the major activity of the first five years. Not many research results will be available at the end of five years although significant progress will have been made on priority problems such as characterizing the soil moisture regime and development of improved tillage and planting equipment.

Major expansion of program activities will occur in the second five years. At the end of ten years Morocco will have an established program in applied research that will make its rainfed agriculture much more productive than today. By that time the information base from the program will guide sound development so that the dryland farming sector will serve Morocco and its expanding population much more effectively than it does today.

The prime essential for successful development of an applied agronomic research program is an adequate number of properly trained Moroccans. At this time there is no reservoir of trained Moroccans from which to draw the capabilities needed to initiate such a program. Each year demands for personnel from other expanding sectors of Morocco's agriculture exceeds the supply of new graduates from all agricultural schools. Unless the commitment of personnel, adequate both in numbers and basic training, will be made by GOM, the goal of having an effective applied agronomic research program cannot be met.

If the Moroccan personnel and essential support are provided, then a U.S. university contract to provide (1) the participant training and (2) a team of agricultural scientists experienced in applied agronomic and related research will permit developing a competent, productive applied research organization in The Ministry of Agriculture.

<u>Participant Training of Moroccans</u>: Participant training is proposed tentatively for 32 Moroccans, 16 for Ph.D. degrees and 16 for Masters degrees, with starting dates of U.S. training indicated in Table 2.

All participants recommended for Ph.D. degrees are proposed for the national staff where this level of training is required. One should be designated to be director or chief in charge of the national program. The numbers of Ingenieurs d'Etat to be sent for Ph.D. training are 7 the first year, 6 the second year, and 3 the third year. Ingenieurs d'Etat are already at the Masters level. Upon returning from Ph.D. programs

Table 2. Number Of Moroccans Entering Training In The United States

Area of Study	1977	1978	1979	1980	1981	Total
Production Agronomy	1N*, 1P	1N*,1P	1P	1P	1P	7
Soils Science	1N*	1N	1N*			3
Weed Science	1N*		1N			2
Forage and Range Science	1N*	1N*	1P	1P	1P	5
Livestock Management and Nutrition	1N*	1N*				2
Plant Pathology	1N*		1N			2
Entomology	1N*			1N		2
Production Economics	1N	1N*	1N*			3
Rural Sociology	1N	1N*		1N		3
Horticulture		1N*		1N		2
Agriculture Marketing Economics			1N*			1
Total	10	8	7	5	2	32
Ingenieur d'Etat for Ph.D.	7	6	3	0	0	16
Ingenieur d'Application for M.S.	3	2	4	5	2	16

N = National level position in Morocco

P = Provincial level position in Morocco

* = Ph.D. level trainee

they can assume the primary responsibilities for the applied research on a continuing basis by approximately the fifth and sixth years of the program. They will not require a subsequent break for added training as may well occur for participants at the Masters level.

The GOM and participants must each agree that the participants will commit a minimum of 4 years to the applied research program in dryland farming after return from training. The policy of GOM must recognize the value of the training and capabilities of this group by providing the rewards in terms of salary and recognized status necessary to keep them in the applied research program. This is essential if continuity of leadership and program momentum is to be maintained for rapid development of the applied research capability to serve the dryland farming sector of the project area in Morocco.

Eleven areas of study are proposed for Ph.D. participants (See Table 3). Two are proposed for each of five areas of particular importance to provide some depth in capability at the national level.

Sixteen participants are proposed for Masters degrees. One of these is to earn a Masters degree in Soil Science with emphasis on soil fertility and soil testing preparing to serve as manager of the analytical, forage and soil testing research service laboratory. Five are proposed to get Masters degrees in production agronomy preparing to head provincial applied research teams. Three are proposed for Masters degrees in the area of forage and range science to serve as part of provincial teams to carry out applied research with forages. The remaining seven are tentatively indicated to add research depth at the national level. Again it is emphasized that all of the national staff are expected to be actively involved in field experiments in the provinces, visiting them frequently, helping train support personnel, resolving problems that may occur, and assuring that high standards in experimental techniques are maintained.

The proposed program includes approximately 90 participant-years of advanced training, 40 at the Masters and 50 at the Ph.D. level. The research expertise and program capability that this represents can assure continuing development of the applied research organization.

The pattern of participant schedules is shown in Table 4. Return of participants to carry out part or all of their thesis research in Morocco is recommended. Their advisers in U.S. universities will have guided the planning of thesis research and literature review before their return. A short-term visit of advisers at the initiation of research in Morocco is desirable with subsequent short visits, if necessary. Long-term contract team members in Morocco will give assistance and guidance as needed. When thesis data are complete, it is proposed that the participant would return to the United States to complete his thesis and take his final oral examinations as required by universities. Tentative dates for expected completion of the advanced degrees are indicated in Table 4.

TABLE 3. Participant Years Of Training Proposed By Area Of Study

Area of Study	Degree	No.	Time In U.S. (Years)	Participant Years M.S.	Ph.D.	Total
Production Agronomy	M.S.	5 1/	2.5	12.5		19.5
	Ph.D.	2 2/	3.5		7.0	
Soil Science	M.S.	1 3/	2.5	2.5		9.5
	Ph.D.	2	3.5		7.0	
Weed Science	M.S.	1	2.5	2.5		6.0
	Ph.D.	1	3.5		3.5	
Forage and Range Science	M.S.	3 4/	2.5	7.5		14.5
	Ph.D.	2	3.5		7.0	
Livestock Management and Nutrition	Ph.D.	2	3.5		7.0	7.0
Plant Pathology	M.S.	1	2.5	2.5		6.0
	Ph.D.	1	3.5		3.5	
Entomology	M.S.	1	2.5	2.5		6.0
	Ph.D.	1	3.5		3.5	
Production Economics	M.S.	1	2.5	2.5		9.5
	Ph.D.	2	3.5		7.0	
Rural Sociology	M.S.	2	2.5	5		8.5
	Ph.D.	1	3.5		3.5	
Horticulture	M.S.	1	2.5	2.5		6.0
	Ph.D.	1	3.5		3.5	
Agricultural Marketing Economics	M.S.	0	-	0		3.5
	Ph.D.	1	3.5		3.5	
TOTAL		32		40	56	96

1/ To head provincial programs.
2/ All Ph.D. participants are for national staff.
3/ To be manager of Analytical, Forage and Soil Testing Research Service Laboratory
4/ To be on provincial staffs involved in forage and range research.

TABLE 4. Course Work Training of Moroccans in United States

AREA OF STUDY	1977 1/	1978	1979	1980	1981	1982	1983	1984	1985	1986
AGRONOMY	++++	++++++	++++++	++++++		●				
		++++	++++++	++++++	++++++		●			
	xxxx	xxxxxx	xxxxxx		●					
		xxxx	xxxxxx	xxxxxx		●				
			xxxx	xxxxxx	xxxxxx		●			
				xxxx	xxxxxx	xxxxxx		●		
					xxxx	xxxxxx	xxxxxx		●	
SOIL SCIENCE	++++	++++++	++++++	++++++		●				
		xxxx	xxxxxx	xxxxxx		●				
			++++	++++++	++++++	++++++		●		
WEED SCIENCE	++++	++++++	++++++	++++++		●				
			xxxx	xxxxxx	xxxxxx		●			
FORAGE & RANGE SCIENCE	++++	++++++	++++++	++++++		●				
		++++	++++++	++++++	++++++		●			
			xxxx	xxxxxx	xxxxxx		●			
				xxxx	xxxxxx	xxxxxx		●		
					xxxx	xxxxxx	xxxxxx		●	
LIVESTOCK MNG & NUTRITION	++++	++++++	++++++	++++++		●				
		++++	++++++	++++++	++++++		●			
PLANT PATHOLOGY	++++	++++++	++++++	++++++		●				
			xxxx	xxxxxx	xxxxxx		●			
ENTOMOLOGY	++++	++++++	++++++	++++++		●				
				xxxx	xxxxxx	xxxxxx		●		
PRODUCTION ECONOMICS	xxxx	xxxxxx	xxxxxx		●					
		++++	++++++	++++++	++++++		●			
			++++	++++++	++++++	++++++		●		
RURAL SOCIOLOGY	xxxx	xxxxxx	xxxxxx		●					
		++++	++++++	++++++	++++++		●			
				xxxx	xxxxxx	xxxxxx		●		
HORTICULTURE		++++	++++++	++++++	++++++		●			
				xxxx	xxxxxx	xxxxxx		●		
AGRICULTURE MARKETING ECONOMICS			++++	++++++	++++++	++++++		●		
TOTAL TRAINEE YEARS 2/	5.8	14.7	22.1	24.9	19.2	10.00	2.00			
RETURNING STUDENTS			3 M.S.	2 M.S. 7 PhD	4 M.S. 6 PhD	5 M.S. 3 PhD	2 M.S			
DEGREES COMPLETED ●					3 M.S.	2 M.S. 7 PhD	4 M.S. 6 PhD	5 M.S. 3 PhD	2 M.S	

1/ Calendar years

2/ Assumes June start & December 21 ending for course work program

M.S = 2.5 years course work - xxxxxxxxx

Ph.D = 3.5 years course work - +++++++++

Tentative Degree completion - ● Three months in U.S. to complete thesis and examinations

Selection of Participants: The date of return of trained participants will depend on when they start training. Having participants start as early as possible will assure their return and involvement in program development in Morocco at the earliest date. Delays in starting participants in training will delay development of the applied research program.

Selection of this first group of ten participants is very important because they are to become the primary leadership group in subsequent development of the program. The areas of study are indicated in Table 3. The following procedure is suggested for their selection:

1. The Ministry of Agriculture should develop a list of 12-15 Ingenieurs d'Etat and 6-10 Ingenieurs d'Application who are interested in careers in this program and appear to have the potential required.
2. Personal data pertinent to review of the qualifications of each individual should be developed. A statement should be included from each individual describing his special subject matter interests.
3. The files of personal data should be submitted to USAID for review. Review by a representative of the U.S. contract team would also be desirable.
4. Decisions on the participants should be jointly worked out in a conference involving officials of The Ministry of Agriculture, USAID, and the U.S. contractor, if possible.
5. Completion and filing of appropriate Graduate School applications should follow promptly.

After a U.S. contract team is in Morocco, its staff can counsel on selection of Moroccans for participant training and the universities they should attend. Those selected for Ph.D. programs must have the Ingenieur d'Etat degree. Those for Masters degrees should have Ingenieur d'Application degrees. Each will have to apply and be accepted by the Graduate College of the Institution that he will attend before departure from Morocco.

Graduate Colleges always refer applications of foreign students for advanced study to the departments in which they will study for review of their credentials and the recommendation of the department on whether or not to accept the student. The department considers the area of interest of the student and determines whether a staff member wishes to advise and work with the student on an advanced degree program.

Most Moroccan students will not be proficient enough in English to carry a full program their first semester. Experience has shown that foreign students with limited capabilities in English require one semester with a light load and, preferably, familiar subject matter to gain a necessary level of proficiency to take more advanced courses.

The academic year in U.S. universities starts near the end of August or in September. Since one of the very essential aspects of training for Moroccan students in the U.S. will be to gain as much experience as possible in field experimentation, having students arrive about the first of June would permit them to begin getting acquainted with field experimental programs during the summer. Working with their adviser-professors and other graduate students would help improve their English. The information gained about crops and experimental procedures would also be helpful as they begin their course work.

The first participants must be selected and committed for advanced degree training in the U.S. before a U.S. contract team leaves for Morocco. The program proposal suggests that seven Ingenieurs d'Etat and three Ingenieurs d'Application begin training in the first year of the program. These should be identified and start studying English as soon as possible. Applications for admission to selected Graduate Schools should be submitted just as soon as the date of required English language proficiency can be determined.

U.S. Contract Dryland Farming Team: The role of the U.S. dryland farming applied research team is to assist the Division of Crop Production in the Ministry of Agriculture in developing the capability of the Bureau of Dryland Farming to carry out a productive, comprehensive applied agronomic research program in the project area. Details of the proposal are given in Annexes to this report. Success will require the staff members to have a high level of scientific and administrative skills. Thus, selection of the team members, both long-term and short-term, must be based on their scientific and administrative expertise. While they must develop a working competency in the French language, this must be considered secondary in the selection process.

Since the role of the U.S. team is to guide and assist in developing Moroccan capability and program, the number of long-term members should be kept minimal and complemented with several short-term members representing the several areas of technical expertise needed in the program. (See Table 5.) A maximum of three long-term scientists is recommended at any one time while eight scientists are suggested for short-term assignments as continuing team members on the project. They will be expected to make repeated short-term visits to Morocco as necessary to guide developments in the program in their areas of scientific expertise.

Universities in the United States have their senior scientists responsible for continuing research, teaching and extension programs. They can permit such personnel to take repeated short-term assignments and keep their programs at home productive assuming appropriate support is provided. Universities must develop their staffing plans and organization so senior scientists with interests and capability in international program efforts can be committed to these on long-term assignments, when needed, and other senior staff will provide the continuity required to maintain productivity in home programs.

TABLE 5. U.S. Contract Dryland Farming Team

Technical Staff			Months[1/]
Long-term:	1.	Agronomist (Chief of Party - continuous)	60
	2.	Soil Scientist (Years 1-4)	46
	3.	Forage Production and Range Scientist, (Years 2-5)	48
Short-term:	1.	Weed Scientist	15
	2.	Plant Pathologist	12
	3.	Entomologist	12
	4.	Production Agriculture Economist (Micro)	12
	5.	Rural Sociologist	12
	6.	Horticulturist	12
	7.	Livestock Management And Nutrition Specialist	15
	8.	Contingency short-term scientists, possibly climatologist, statistician, economist or other as deemed necessary	24
	9.	Equipment development team (includes agricultural engineer for short-term staff)	30
	10.	Technical Performance Evaluation Team (3 @ 3 wks/yr for 4 years)	9
		Scientist Total	309
Administrative and Service Support Staff			
In Morocco:	1.	Administrative assistant	60
In United States:			
	1.	Scientist-administrator, half time	30
	2.	Secretary, full-time	60
		Administrative Total	150

[1/] Proposed duration within the first five-year segment of a ten-year program.

Funds to provide appropriate backup personnel and support to departments to keep home institution programs moving without loss of momentum while senior staff are on short-term contract assignments are an essential component of contract costs.

The recommendation of heavy emphasis on team members for repeated short-term assignments will let the Moroccan program benefit from involvement of more senior scientists which will give both more scientific breadth and depth to guiding program development than would be possible under a long-term assignment policy. The short-term members will be able to advise graduate student participants while they are in the United States and assist them both with their thesis programs in Morocco and with development of their component of applied research program activities.

Short-term team members should be encouraged but not required to develop their capability in the French language.

Personnel

The U.S. technical and support personnel requirements are shown in Tables 5 and 6.

The Team Leader or Chief of Party should be a production agronomist who has had research, administrative and, preferably, international experience. A very significant part of his time will be involved in administrative tasks. To permit him to go to the field and carry the role of production agronomist as well will require that he have the help of a very capable administrative assistant in Morocco who must be able to speak French.

A program involving the proposed number of U.S. staff and Moroccan participants will require effective backup support in the United States. At least half the time of a scientist-administrator and a full-time secretary will be needed.

Detailed descriptions of the assignments of individual team members are given in the pertinent Annexes.

Evaluation Team

A system of continuing program evaluation by the contracting university(ies) is proposed to help the Chief of Party and the responsible university administrators meet program requirements. The program recommended has two parts: (1) self-evaluation by members of the team, and (2) evaluation by an external team of three technical specialists from the university(ies) involved. Need outside evaluation NO!

The self-evaluation should consist of a carefully prepared annual plan of work for each member of the team which lists specific measurable objectives for the year. At the end of the year each team member should prepare an annual report discussing the achievements and non-achievements related to each stated objective for the year. Both the plan of work

TABLE 6. Schedule of United States Dryland Farming Team in Morocco

	First Year 1977	Second Year 1978	Third Year 1979	Fourth Year 1980	Fifth Year 1981
	FULL TIME ASSIGNMENTS				
PRODUCTION AGRONOMIST (Team Leader)	Language training (if needed) Arrival in Morocco July 1				
SOIL SCIENTIST	Language training (if needed) Arrival in Morocco September 1				
FORAGE AND RANGE SPECIALIST	Selection of - Orientation trip to Morocco. Language training (if needed) Seed collection in U.S.	Arrival in Morocco July 1			
	PART TIME ASSIGNMENTS				
WEED SPECIALIST	Selection				
LIVESTOCK SPECIALIST	Language training (optional but desirable)		SHORT-TERM ASSIGNMENTS AS REQUESTED BY FULL-TIME TEAM		
PLANT PATHOLOGIST					
ENTOMOLOGIST					
AGRICULTURAL ENGINEER*	Orientation trip to Morocco				
PRODUCTION ECONOMIST					
RURAL SOCIOLOGIST					
HORTICULTURIST					

* Member of equipment development team - alternatively an agronomist experienced with improving dryland farming equipment.

over staffed by U.S. Personnel.

and the annual report should be reviewed by the U.S. team leader and his Moroccan counterpart in the program. A similar plan should be encouraged for the Moroccan scientific counterpart staff.

Why Universities? They cost too much. No Fallen from AID priorities Business

The external team should consist of three senior scientists from the contract university(ies): an agronomist, a forage and range specialist, and a social scientist. Members of this team should be involved in related research programs and serve through the contract period to give continuity to the evaluation effort.

The first visit of the evaluation team to Morocco for about two weeks should occur at the end of the first contract year. Its purpose is to permit the team members to become acquainted with the project, the crop production situation in the project area, and the setting in Morocco in which the project operates. The specific assignment of the team should be to make a careful annual evaluation of the progress of the project and recommend any desirable adjustments to the contract university(ies) for their consideration and with GOM and USAID. Copies of the annual evaluation reports should be sent to appropriate administrators in the contracting institution(s), USAID and GOM.

Other USAID Support to the Applied Research Program in Morocco – Chief of Party should be AID DIR. HIRE.

The USAID through its contract will supply the following kinds of support in addition to participant training and salaries of U.S. team members and support personnel:

1. Funds for travel, in-country housing, project transportation for U.S. team members, and such other commonly recognized support required or allowed for proper functioning of such staff.
2. Modest amounts of commodity support for the laboratory and field experimental equipment needed to get the program initiated. The GOM should provide the budget to cover facilities, equipment available in Morocco, and operating costs from the outset as normal and necessary support for their program.

Required Moroccan Inputs

The inputs of the GOM must represent full commitment to the objective of establishing the permanent capability for a comprehensive, continuing applied research program to provide the information base required for guiding development of its dryland farming sector. They can be summarized as follows:

1. The commitment of 32 capable Ingenieurs for participant training in the U.S., 16 for Ph.D. and 16 for M.S. programs. The GOM and participants must each agree that the participants will commit a minimum of 4 years to the applied research program after return from training.

No

Not realistic! Ask Cynthia what their experience in this regard in Morocco! Impossible!

Sounds great for Nat. but won't work here

When they return from training beginning in the third year and continuing through at least the eighth year, this group will be the technical staff at national and provincial levels having primary responsibility for program development. Functioning as a team, they will be actively involved in planning and conducting experiments in their areas of expertise, training lower level support personnel, developing and assembling necessary facilities and research equipment, and working with extension personnel and small farmers in demonstrating new tested technologies for general adoption and use by farmers.

When will they come from?

The first commitment of 32 participants is essential to initiation of a sound program. The GOM should expect to continue identification of additional persons for advanced training to meet needs for further expansion of applied research activities in crop production in Morocco and to replace any individuals who drop out of the program for any reason.

This is nearly impossible!

2. Morocco must also commit Ingenieurs as counterparts for the long-term U.S. production agronomist and soil scientist who will be long term U.S. team members the first year and for the forage production and range scientist starting the second year. The initial counterparts in Morocco may be scheduled for participant training in the U.S. when trained participants return to assume program leadership in these areas.

Morocco must also provide support technicians, some Adjoints Techniques and other Agents Techniques to assist scientists with field experiments and laboratory activities. Necessary secretarial assistance must also be provided.

Doubtful if this will be done

3. Morocco must provide appropriate facilities for offices and laboratories of the national dryland farming team in Rabat. This must include appropriate facilities to permit development of the analytical, forate and soil testing research service laboratory.

4. As an applied research program is initiated in any province, suitable office, laboratory, and service facilities must be provided to serve the needs of the provincial staff. Laboratory facilities needed in the provinces will be relatively simple. Suitable land must be available for on-station experimental activity. This suggests that location of the provincial applied research centers might well be associated with or adjacent to DRA experiment stations.

Too many offices.

Not Possible Not Realistic This is not the USA. but Morocco or similar Devel-country

Provincial centers must have necessary vehicles and trailers to transport research equipment needed to carry out experiments on farms in the province as the program plans find desirable.

Dreaming again!

5. The Minister of Agriculture should establish a Dryland Farming Council of at least five members under the Secretary-General. This should have representation from the following Directorates: Development (DMV), Livestock (Elevage), Agronomic Research (DRA), Agricultural Education (Enseignement), and Land Conservation and Survey (Conservation Fonciers). This Council should meet at least twice a year to consider broad program policies for the dryland farming applied research program, review progress, and assure that there is effective cooperation among agencies supporting the program.

The bureaucrats have tried with wheat & other programs but failed!

Annex A. RATIONALE FOR AN APPLIED OR ADAPTIVE RESEARCH PROGRAM IN CROP PRODUCTION FOR THE 200-400 MM RAINFALL REGIONS OF MOROCCO

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Annex A. RATIONALE FOR AN APPLIED OR ADAPTIVE RESEARCH PROGRAM IN CROP PRODUCTION FOR THE 200-400 MM RAINFALL REGIONS OF MOROCCO

Developed countries have effective applied research programs supported on a continuing basis to develop or adapt new technologies resulting from advances in fields of science. Information from these programs permits farmers to use the most advanced technologies that are shown to be adapted and useful in their situations. The existence of good applied research programs is one important reason for continuing increases in the yield and productivity of agriculture in the developed countries.

With its present population Morocco must import substantial amounts of cereals and other food products. With an annual population growth rate of about 3.0% and about 50% of its population under the age of 18, continuing rapid growth in population for the next twenty years seems certain. The need for added food will increase accordingly. The population will increase by three million in five years, the proposed duration of the first stage of the applied research project.

The Central Plains and Central Plateau regions make up a large agricultural area devoted primarily to production of cereals and livestock. While part of the land is included in irrigation perimeters, the major portion is dependent on rainfed crop production. The seven provinces of Khouribga, Settat, El Jadida, El Kelaa des Srarhna, Marrakech, Essaouira and Safi in these regions and Meknes in the higher rainfall region to the north represent the principal rainfed cereal producing areas. Consideration of the Meknes Province, even though annual rainfall is above 400 mm , is desirable to permit the applied research program to span the range of rainfall and soil across the primary cereal production region. See Figure 1, page ii.

The population of these eight provinces was 4.8 million in 1971 or 31% of the total population of Morocco.

Although some of the dryland farmers own and operate farms with more than 10 hectares using "modern" equipment, most of the region is divided into farms of less than 6 hectares and is farmed with traditional systems. Crop yields are low, livestock production is low because of limited feed, and the farm families live at a subsistence level.

In Morocco as a whole 69% of the rural households either own no land or have less than two hectares. Of the households engaged in agriculture 90% use traditional methods of farming. Production in the dryland areas was reported as stagnant during the period of 1968-72, and the standard of living of the rural people continued to decline (Griffin, p. 323).

What factors limit yields in these regions? If new methods of crop production practices were employed, how much can the yield potential be increased? Will the yield increases be economical when costs of the new methods are considered?

Dryland farming systems in use elsewhere have established certain principles. Soils, crops, rainfall, land tenure, and other factors in Morocco are unique. Practices as applied elsewhere will not fit without being adapted through an applied research program to determine the combination that applies the principles most effectively in the area where they are to be used.

Some of the factors that limit yields are well known. Limited rainfall with erratic distribution during the winter rainy season and an extended dry summer season are the dominant factors. Large areas have shallow, rocky soils over a layer of limestone rock or caliche. Others have broken rocks through a deeper profile. A wide range of soil textures exists ranging from clay loams to sands. Although cropped continuously for many years, little fertilizer has been added. Organic matter and nitrogen levels are low. High pH associated with the limestone-based soils probably means that phosphate available to plants is low. Potassium may be generally adequate although the question of need is not yet fully determined. Weeds are not effectively controlled. The quality of the seed planted and the varieties used, without doubt, often hold yields below the potential of the land and the season.

Just as the soils, climate, and other physical and environmental factors make each major growing area unique and necessitate applied or adaptive research in that area, the social and economic environment of each area is also unique because of variations in religion, communications, traditions, etc. These two groups of factors, social and agronomic, combine to produce the agricultural practices of the area. The dryland farming area can be characterized as rural, traditional, Moslem and Arabic in culture. This has resulted in patterns of land holding and farming practices of which little is known. Only when the two types of research, agronomic and social, are combined can a sufficient data base be generated to support sound development.

There is a delicate balance in this erratic 200-400 mm rainfall area with small farms between production practices and subsistence living. These farmers cannot afford to experiment or try new risky practices. Improvements clearly shown in an applied research program to have potential for increasing production must be tried and gradually fitted into his system by each farmer, mastering the new concepts by personal experience. Increased stability of production would have great value. Costs requiring capital must be low.

Agronomic Production Systems

Approximately 50% of the arable land in Morocco occurs in the eight provinces proposed for attention in this applied research project. The potential for production, in spite of the limitations, is much higher than is being realized. The GOM, sectors of the economy, individual farmers, and all the people of Morocco will benefit from increased production if it can be economically achieved. There is an urgent need for an applied or adaptive agronomic research program to compare alternative actions for (1) improving the various components of the production system for each important crop and for the cropping sequences used, (2) identifying the changes that can most readily be accomplished, and (3) estimating the potential production increases from improved practices and their costs and benefits. Such data from sound field experiments at appropriate sites are essential for sound planning and as an information base to motivate and guide farmers in adopting new practices.

For the purpose of this analysis the dryland production system for each crop can be considered as having the following ten components:

1. Variety
2. Cultural or tillage practices
3. Weed control
4. Soil fertility
5. Conservation of soil and water
6. Nutritional value of the grain or forage
7. Insect control
8. Disease control
9. Mechanization
10. Economics

Each of the ten items is to be interpreted as a broad, inclusive term. The term "variety" means all the characteristics of the seed that is planted. Is it pure seed of a variety tested in the area and known to have high yield potential for the particular environment? Is it good quality with high germination?

The term "cultural practices" refers to all tillage practices involved in seedbed preparation and to date of planting, method of planting, depth of covering the seed, rate of planting, etc.

Similarly, the other terms are to be interpreted broadly. "Mechanization" includes tillage implements, planters, pesticide sprayers, harvest implements, seed cleaners, storage bins, etc. Each component of the system has costs involved, and each contributes to the product harvested. Thus, the term "economics" involves all the cost factors required in production and the returns from marketing the product.

The ten components are not listed in any order of priority. Each is a component of the total system for each crop. The value of production is a result of functioning of the total system and not of single or selected components. Any component, however, may limit yields and value, thus reducing returns from investment in other components. For example, an investment in fertilizer will not increase grain yields if weeds are serious or if a disease seriously damages the crop.

The cropping sequence or crop rotation is also important and subject to evaluation in an applied research program. The effect of nitrogen fixed by a grain legume crop or legumes in a forage crop will influence fertilizer recommendations for the following cereal crop.

Components of an Applied or Adaptive Agronomic Research Program

To determine what crop production potentials are and the best cultural practices to use, the applied research program must include experiments of the following general kinds:

1. Alternative crop rotations or cropping sequences.
2. Variety comparisons for each important crop.
3. Cultural practices (land preparation, methods, time and rate of planting, etc.).
4. Kinds and rates of fertilizers.
5. Alternative systems of weed control.
6. Effectiveness of different machines for tillage and planting, sprayers for weed control, implements for harvesting, and storage structures.

7. Alternative methods of disease control.
8. Alternative methods of insect management.
9. Production economics of the small farmer and potential effects of changes in practices.
10. The social system as it relates to knowledge and use of various farming practices.

Observations on insect damage and plant diseases should be made on all experiments by experienced entomologists and plant pathologists, on growth and development of each crop and on conservation of soil and water by an experienced agronomist at frequent intervals through each crop season to record notes on observable factors affecting the crop.

Of great importance in the first few years will be special efforts to measure soil water through the entire year, characterizing the soil moisture and soil temperature regimes as influenced by each crop grown and the effect of fallowing with and without straw mulch with no tillage and with different tillage treatments.

The scientist responsible for planning each experiment must have frequent personal contact with it in the field if he is to understand what factors influenced growth and development through the season when he undertakes interpretation of his results. He must combine the information with knowledge of the social structure for development of recommendations.

Certain measurements must be recorded at each experimental site in addition to measurements on the crop itself:

1. Soil moisture depth and amount at planting time.
2. Dates and amounts of rainfall.
3. Soil moisture at crop maturity.
4. Soil test evaluation of pH, organic matter, available phosphorus, potassium and nitrogen, if possible, in the root zone.

Essentials for Reliable Results from Applied or Adaptive Agronomic Research

Carrying out field experiments in an applied agronomic research program so that valid comparisons are possible among the various treatments included in the experimental plan is difficult. Great care is needed to achieve adequate uniformity of all factors influencing the results except the treatment or variables being compared. Differences measured among treatments must be shown to be real by rigorous statistical analysis rather than just due to randomly variable factors (experimental error).

The field area selected for any experimental site must be uniform in soil, in slope and in past use. No part of the area should be favored by such factors as extra water. Such operations as land preparation, seeding rates and methods, fertilization, and weed control must be handled very uniformly over the entire experimental area unless one is a treatment variable in the experiment. Applied research must be carried out at the locations and under the environmental conditions at which the problem under study occurs and for which the experimental data and resulting recommendations are to apply. Usually, experiment stations are developed at locations that

are generally representative of the soils and the environment of a relatively broad area. Many experiments in an applied research program, however, must be conducted at sites off experiment stations because the conditions are different and data from the experiment station may not apply. Sometimes experiment stations are located on good soils and under favorable conditions. Experimental data from them must be used with care, because they may not represent the conditions for which a decision on management must be made.

Because applied field research is very difficult to conduct, the personnel responsible for it must have good training in experimental design so that experiments are planned to permit rigorous analysis of the data collected. They must have experience in field research under experienced investigators to learn good field plot techniques. They must have access to necessary field equipment adapted as necessary for use in plot experiments so that each operation can be carried out properly. They must have capable technicians to help get each operation completed properly and on time. Technicians become capable only by training and close supervision by the scientist through at least two years. Newly employed technicians will not understand the exacting requirements and care required in field experimentation. Even under close supervision new employees will make mistakes that reduce the value of the experiments because they do not understand what is needed.

Socio-Economic Research

The methods and procedures in applied socio-economic research are as meticulous as those required for field experimentation. The researchers must have a thorough knowledge of Moroccan culture. They must also be trained in sampling, data collection and statistical procedures. The selection of appropriate areas to be included in the sample is critical. The eight provinces contain a wide variation in subcultures. Thus the difficulties of sampling are greatly compounded.

Similar statements could be made about data and analysis. One example is that many of the farming practices are closely tied to tradition, superstitions, and other social factors. If an individual attempts to interpret data without detailed knowledge of the cultures, erroneous conclusions are a high probability.

Organizational Framework for an Applied or Adaptive Agronomic Research Program

Morocco will have a continuing permanent need for the results from an effective applied or adaptive research program in dryland farming as well as in other components of its agriculture. Scientists in Morocco and around the world will be developing improved technologies that must be tried and adapted to Moroccan conditions so that farmers can continue to increase their productivity. The pressure of rapid population increases and increased needs for food production by the dryland farming sector suggest that the relatively modest investment required to establish and maintain an active applied research program in dryland farming could well prove to be one of the best investments the nation can make in the public interest.

Where does the dryland farming applied research program fit into the Ministry of Agriculture? What staffing organization is necessary to carry out an effective, continuing program? Where in the government's organizational structure should the applied research organization be developed in order to serve its purposes most effectively?

Place of the Dryland Farming Applied Research Program in the Ministry of Agriculture and Agrarian Reform (Ministre de l'Agriculture et de la Reforme Agraire - M.A.R.A.)

The Government of Morocco (GOM) has a vertically stratified structure with limited lateral communcation. Logically the applied research program in dryland farming should be developed in the Ministry of Agriculture (MARA). This Ministry is divided into seven "Directions" (Directorates) as shown in the attached organizational chart. (Fig. 2) The following five directorates have some relation to or involvement in the dryland farming sector:

Directorate of Livestock - Direction des Services Veterinaries et de l'Elevage
Directorate of Agronomic Research - Direction de la Recherche Agronomique (DRA)
Directorate of Agricultural Education - Direction de l'Enseignement Agricole
Directorate of Lani Conservation and Survey - Direction de la Conservation Fonciere et Service Topographique.
Directorate of Development - Direction de la Mise en Valeur (DMV)

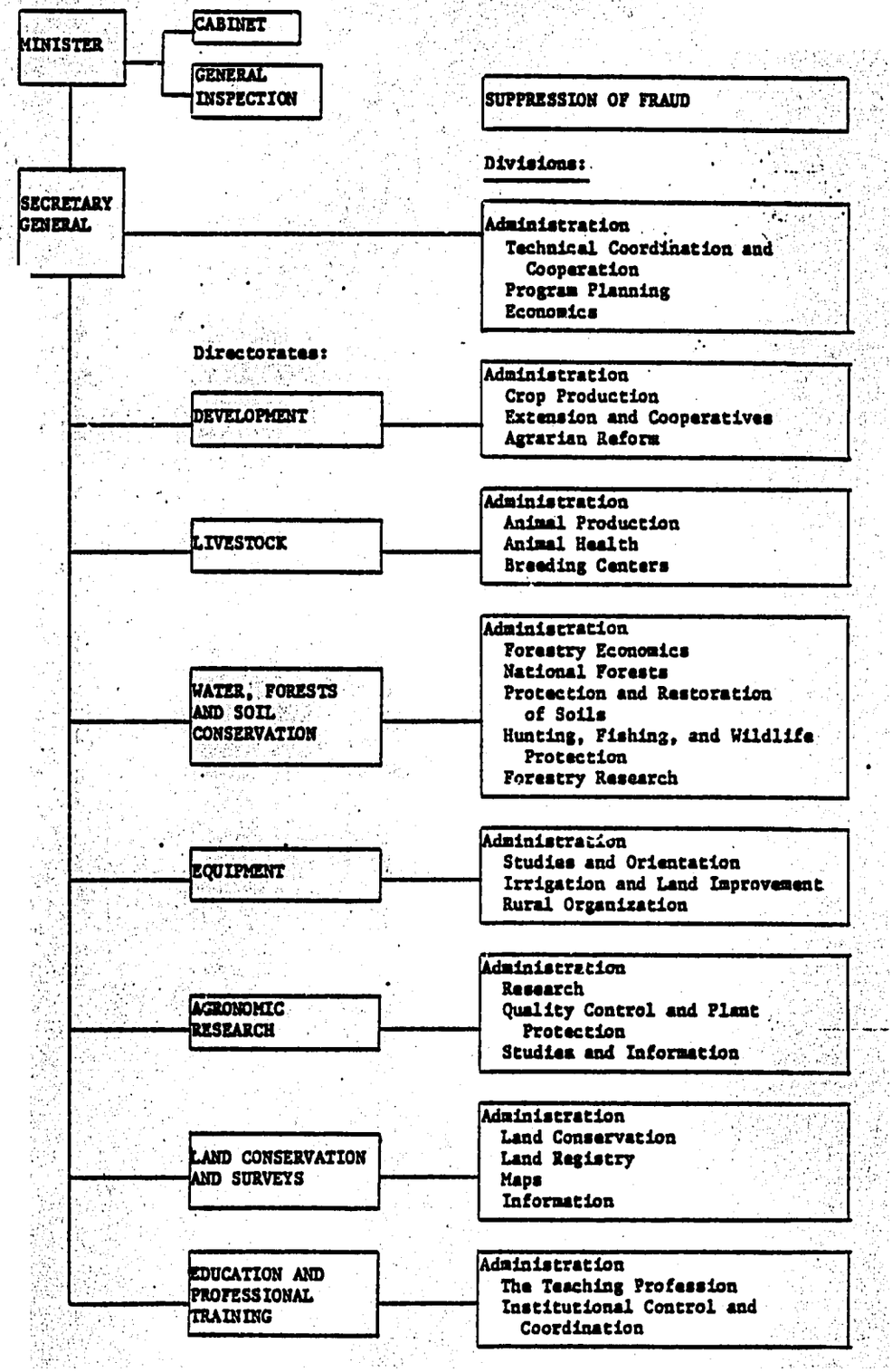
The two "directions" omitted deal with forests and with equipment and engineering for irrigation.

The Directorate of Livestock includes range management and veterinary services as well as other aspects of livestock production.

The Directorate of Agronomic Research (DRA) is responsible for more fundamental research activities. It has established experiment stations at several locations in Morocco to deal with the special crop production problems of those areas. The information and technologies coming from the more fundamental research programs of DRA in plant breeding, agronomy, soil science, weed science, plant pathology, entomology, agricultural engineering, and animal science will be important inputs to effective applied and adaptive research and extension activities.

The Directorate of Agricultural Education is responsible for the formal education programs of the Hassan II Agronomic Institute at Rabat, the National Agricultural School at Meknes, and a number of other agricultural technical training schools. Graduates of the Hassan II Institute receive "Ingenieur d'Etat" degrees in a 6-year program. This is approximately equivalent to a Masters degree in U.S. universities. Graduates of the school at Meknes receive "Ingenieur d'Application" degrees in a 4-year program. Staff members of the Hassan II Institute are involved in research professionally and in training advanced students.

FIGURE 2. Minister of Agriculture and Agrarian Reform



The Directorate of Land Conservation and Survey has an obvious relation although major activities to date have related to irrigation development.

The Directorate of Development (DMV) has four divisions:

Division of Administration - (same)
Division of Crop Production - Division de la Production Agricole (DPA)
Division of Extension and Cooperatives - Division de la Vulgarisation et Cooperation
Division of Agrarian Reform - Division de la Reforme Agraire

The Division of Crop Production (DPA) in the DMV is responsible for supply activities in government programs relating to crop production. These involve providing such production needs as seed, fertilizer, chemicals, etc. A Bureau of Dryland Farming has been established in DPA with a professional staff of one man and two women. It has initiated several demonstrations to compare drilling with broadcasting seed in a few provinces as the first effort toward an applied research program.

The Division of Extension and Cooperatives in the DMV is responsible for servicing farmer needs. The Division operates Work Centers (CTs) in the provinces which distribute such inputs as seed and fertilizer, provide tractors and some machinery for hire, and administer such government programs involving farmers as "cooperatives". In communities around Work Centers are extension agents who are the primary service and assistance contacts for farmers. Educational activities receive less time and emphasis than the supply and service functions.

The Division of Agrarian Reform is involved in land redistribution programs and the support of the land cooperatives created for development of the redistributed land. Such activity is very limited in the provinces included in the project area.

Alternatives in the Organization of the Ministry of Agriculture for a Dryland Farming Applied Research Program

A program of applied research in crop production in Morocco must relate effectively to extension and development activities in the Directorate of Development, to more fundamental research in the Directorate of Agronomic Research, and to the education of professional and technical support personnel in the Directorate of Agricultural Education. Logical reasons can be developed for assigning primary responsibility for the applied research program in crop production to each of the three. A fourth alternative would be to establish a new Directorate of Applied Research and Extension in Crop Production.

These alternatives are ranked in the following order of priority by the Dryland Farming Team:

Alternative 1. Establish a new Directorate of Applied Research and Extension in Crop Production. This will give the program equal status with DMV, DRA, and the Directorate of Agricultural Education. It should make cooperation and coordination of applied research activities easier to accomplish with these three as well as with the Directorate of Livestock and the Directorate of Land Conservation and Survey.

Assigning the responsibility for extension education to the new Directorate would seem a logical way to facilitate most prompt and effective use of the information obtained from productive applied research in educational programs for farmers and agricultural agencies. The Division of Crop Production of DMV will have an expanding role in Moroccan agriculture in providing additional seed, fertilizer, chemicals, and machinery inputs. These functions are not closely related to either applied research or extension education. The Division of Extension and Cooperatives of DMV will have expanding activities in carrying out government development programs. Experience in other nations has shown that administration of action programs is often not compatible with effective extension education. Administrators of action programs are seen by farmers as authorities who must be obeyed rather than as teachers with information to be explained for the farmers' benefits.

Mutual support and close cooperation of an applied research and extension program with the five Directorates listed on page are essential. To achieve this close cooperation, it is recommended the the Minister of Agriculture establish under the Secretary-General a Dryland Farming Council with high level representation from each of the five Directorates and the new Directorate of Applied Research and Extension in Crop Production. This Council should meet at least twice a year to consider broad program policies, review progress, and assure that there is effective cooperation among all agencies relating to and supporting the program.

Alternative 2. Expand the Bureau of Dryland Farming, presently a Bureau under the Division of Crop Production (DPA) in DMV, and raise it to the level of "Division", possibly establishing it as the Division of Applied Research and Extension in Crop Production in the DMV. This would maintain a close administrative relationship with the action programs in DMV. Similar to explanations in Alternative 1 above, placing the responsibility for extension education in the same division as applied research would seem desirable.

As suggested in Alternative 1, the establishment by the Minister of a Dryland Farming Council under the Secretary-General would be essential to achieve necessary coordination.

Alternative 3. Develop and expand the Bureau of Dryland Farming in DPA to carry out the applied research program. The Director of DPA has already indicated a definite interest in the program by establishing the Bureau. As a component of DPA, this places applied research in the same Directorate as present extension activities, recognizing that these are directed more to services than to farmer education.

Alternative 4. Reorganize and develop the Directorate of Agronomic Research (DRA) so that it is responsible for a productive applied research program as well as for the more fundamental research that represents its present responsibility. This would require special efforts to develop close coordination between applied research and extension if the responsibility for extension remained in DMV. While DRA has both special experiment stations and some experiments in its program of rather direct application to farm problems, few relate to the special crop production problems of the small dryland farmer in the 200 to 400 mm. rainfall zone. There is little evidence of a strong DRA interest in dryland farming problems.

Alternative 5. Place the responsibility for applied research in the Directorate of Agricultural Education. This Directorate is responsible for formal education of professional and technical support personnel in agricultural. There is no evidence of interest by this Directorate for assuming the responsibility for applied research and developing the additional organization required. If responsibility for applied research were given to this Directorate, it should also be given the responsibility for extension education.

Organization of Applied Research Staff

The effectiveness of any applied research program will be determined by the personnel employed to carry it out and the resource support provided for their activities. The rationale of this analysis and proposal is that U.S. assistance is to help Morocco in training Moroccans for handling the entire program and turning full responsibility for it over to them within a period of about ten years. The key to success must be the definite commitment by the GOM of an adequate number of qualified personnel, support for their necessary training, and assurance of their continued assignment to the dryland farming applied research program. Without such a definite commitment the program cannot meet Moroccan objectives for providing an information base for decisions in development of this agricultural sector.

Ultimate success of this program will be directly related to (1) the competence of the Moroccan personnel employed, (2) the adequacy of their training, (3) their personal experience in the field research, (4) their capability to plan and organize good field experiments, (5) their ability to marshal necessary equipment and resources and train supporting staff needed to carry out the experiments and summarize data, and (6) their capability to interpret results and translate conclusions into actions feasible for farmers to adopt.

Ministry of Agriculture and other government officials must recognize that initiating a new activity of this kind will require two or three years for development in which only a relatively small number of experiments can be conducted. Few, if any, conclusive results can be expected in less than five

years. The scientists in charge must arrange for and train their provincial and other support personnel, assemble and/or develop necessary research equipment, arrange for and organize necessary facilities, and gain experience in recognizing and handling the special problems involved in getting good data from experiments in the several provinces. Moroccan experience with Mexican wheat demonstrated clearly the need for adequate testing and adaptation of new technologies before a great investment is made in rapid change.

An effective, continuing program must be carefully and soundly planned with priority of experimental objectives jointly determined by provincial and national personnel giving due consideration to farmer and extension suggestions on needs. Scientists at the national level must assure that the planning and conducting experiments in the several provinces are integrated so that data obtained can be compared, and, in some cases, combined in a composite analysis.

One scientist must be designated in each province to have primary operational responsibility for all experiments in that province and to serve as the principal liaison in program planning, evaluation and interpretation of results. Provincial scientists should assure that research planned and conducted in the province is appropriate in kind and priority in relation to needs in the province.

When the applied research program has been fully developed and staffed by Moroccans, it will have one Ingenieur d'Application (possibly Adjoint Techniques, if adequate special training and experience is provided) responsible for the program in each rural commune in which the program is conducted. The programs of the Ingenieurs in the communes will be coordinated by the Ingenieur d'Etat who is responsible for the program in the Province.

The Director or Chief of applied research at the national level must have a doctorate (Ph.D. or equivalent) degree in production agronomy or a closely related field and several years experience in field research activities so that he understands the problems of carrying out meaningful research and sees the great value of a soundly planned and well integrated program. He should have a staff of trained scientists with the following specializations:

1. Production agronomist
2. Soil scientist (fertility and management)
3. Weed scientist
4. Forage production and range
5. Animal scientist (management and nutrition)
6. Plant pathologist
7. Entomologist
8. Horticulturist
9. Agricultural production economist
10. Rural sociologist
11. Agricultural marketing economist

Participant Training

An adequate number of staff with proper training and experience in applied research is essential if Morocco is to have the continuing capability it needs to provide the best technologies and a sound information base for its dryland farming sector. The research program must include the following kinds of experiments or comparisons: (1) alternative cropping systems, (2) different varieties of each crop, (3) tillage and planting methods, (4) rates and methods of applying different fertilizers, (5) various herbicides and tillage methods for weed control, (6) forage production and management systems, (7) livestock management systems, (8) disease control, (9) insect control, etc. Therefore, the staff must include agronomists, soil scientists, weed scientists, forage and range scientists, animal scientists, plant pathologists and entomologists. In addition the staff must include agricultural economists and rural sociologists who will provide economic assessments of the potential of new technologies and guide the development of effective programs in extension, supply distribution, and marketing that will lead to adoption of new practices by farmers.

An applied research program is much more complex than a demonstration program. Applied research in crop production requires soundly planned, replicated and carefully conducted experiments so that the scientist can determine by rigorous statistical analysis whether the differences among measurements of yield and other attributes are due to the applied treatment or to some chance effects of variation in soil, weed growth, or other factors. Demonstrations, on the other hand, are often adjacent field areas receiving different treatments to permit farmers to observe their effects. If experiments in applied research show that a new practice is much superior to the one being used by farmers, demonstrations will let the farmers observe the differences. Demonstrations are not a replacement for applied research. Rather they are useful in extension programs to let farmers see the improved procedures that applied research has shown to be superior. Sound experiments may be used effectively for demonstration purposes, but simple demonstrations will not provide sound experimental data.

Many Agronomy Departments in U.S. land-grant universities have developed extensive applied research programs. U.S. agricultural scientists have developed special field procedures and experimental techniques that achieve the level of experimental precision required to make meaningful comparisons among treatments being tested. Students working for advanced degrees under these scientists are given both training and experience in field experimentation for at least two years. This gives graduates the background and confidence needed to assume responsibility for such programs. This is the kind of training that Moroccan participants need to prepare for the responsibilities of developing an applied research program in Morocco.

The science involved in modern agriculture has advanced to the stage that the scientists responsible for applied research programs must have the background and understanding that can most readily be achieved by earning the Ph.D. degree. The national leaders of Morocco's applied research program must be trained to the Ph.D. level. Under such scientists

who can counsel and advise, other participants trained to the Masters level can help implement a sound program.

The network of international institutes that has been formed should be considered as a good place for participants to receive training in field experimentation and applied research methods. Some of these institutes have developed formal relationships with certain U.S. institutions that permit part or all of the thesis research to be conducted at the institute. Because advanced degree programs are essential for Moroccan participants and the institutes themselves do not offer degree programs, the participants should be programmed to appropriate U.S. universities. The international institutes may well be used in cases where they can be advantageous in providing applied research experience in conjunction with degree programs. The following institutes appear to be pertinent to the Moroccan program:

International Maize and Wheat Improvement Center (CIMMYT)
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
International Center for Agricultural Research in Dry Areas (ICARDA)

Several past technical assistance programs in Morocco have been developed by U.S. or other foreign personnel without getting Moroccans trained to carry them on. Such programs do not continue when the foreign personnel are withdrawn.

Previous Moroccan participants have had problems when they returned with advanced degrees from U.S. institutions. The problems were mainly: (1) difficulty in securing GOM recognition of the status of U.S. advanced degrees, (2) adequate monetary compensation for having the degree and investing the time to secure it, and (3) receiving appropriate job opportunities to use the knowledge and skills gained in training. The kind of training being proposed for participants in this program will make them as competent as the best agricultural scientists now in other countries or in Morocco. The importance of the returning participants to Morocco's future should be recognized and care taken that they do not encounter similar problems. (Reference: Floyd L. Corty, Participant Training in Agriculture in Morocco, USAID, April, 1967.)

The highest formal degree in agriculture now given in Morocco is the "Ingenieur d'Etat" which is the approximate equivalent of a Masters degree from a U.S. institution. A total of 296 Moroccans had earned the Ingenieur d'Etat through 1974. Plans called for educating 292 from 1973 to 1977, a goal that probably will not be met. A total of 523 persons in Morocco had earned "Ingenieur d'Application" degrees in agriculture through 1974, the equivalent of B.S. degrees in the United States. While actions have been taken to expand higher education in agriculture further, Morocco will continue to lack the trained manpower it needs for agricultural development. Particularly it lacks people trained to the Ph.D. level, the level at which both applied and basic agricultural acientists around the world function today.

An Ingenieur d'Application from Morocco will require about 2½ years to complete course work for a Masters degree in most U.S. institutions. This is the minimum level of training necessary for responsible roles in planning and conducting research. An Ingenieur d'Etat will require about 3½ years to complete course work requirements for a Ph.D. The length of time indicated recognizes that most students will initially have problems with the English language. After completing an advanced degree an individual will require two to four years to initiate experiments and carry them through procedures to the point of having reliable results. Thus, four or five years will elapse between the time a participant is sent to the United States to begin an advanced degree program and the time that he can begin to report research results to Morocco. Thus, getting participants started in the advanced training as soon as possible will mean research results for use at the earliest possible date.

ANNEX B. ANALYSIS OF THE RAINFALL FACTOR IN DRYLAND FARMING IN THE EIGHT-PROVINCE PROJECT AREA

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Annex B. ANALYSIS OF THE RAINFALL FACTOR IN DRYLAND FARMING IN THE EIGHT-PROVINCE PROJECT AREA

The primary objective of this project is the development of an applied research program that would provide an information base for increasing agricultural development in the 200-400 mm. rainfall belt of Morocco. In Morocco the zone of 200-300 mm. is considered arid and 300-400 mm. semi-arid. See Figure 3, page 47.

The Wheat Production Manual assembled by F.V. Pumphrey, Training Adviser from Oregon State University, for use in Turkey states (p. II-2) that "Recent research indicates that approximately 300 mm. of water are used in evapotranspiration to grow the wheat plant. Each mm. of water used in evapotranspiration above 300 mm. will produce approximately 2 kg/decare (20 kg/hectare) of wheat grain." If that level of efficiency could be achieved in Morocco, farmers receiving 400 mm. of rainfall could produce two metric tons (MT) of wheat per hectare; those receiving 350 mm., one MT, and no grain would be produced where rainfall was 200 mm. or less.

Most of the wheat in Morocco is produced in areas receiving more than 400 mm. of rainfall. Still the 5-year average yield from 1970-74 was less than one MT per hectare or less than half the potential that research elsewhere indicates to exist here.

What factors are keeping Moroccan farmers from reaching the potential wheat yields of 2 MT/hectare for 400 mm. of rainfall? The answer lies in two considerations: (1) failure to store and keep the rain that falls in the root zone for use by the crop and (2) failure to meet the growth requirements of the crop so it can use the soil moisture efficiently in growth and grain production. The same factors are involved in the low yields attained for barley and other crops.

Fortunately the rainy season in this region of Morocco coincides with the season of cooler temperatures. The period with conditions favorable for cool season crops is long enough to produce high yields if rainfall is reasonably well distributed and good production practices are used. Temperatures do not fall low enough to vernalize winter varieties of barley, wheat, and other small grains. Spring varieties have a continuous growing period from planting in November or early December, benefiting from increasing daylength from January until about May when the rainy season ends and daytime temperatures rapidly increase. Varieties must be selected that mature early enough to avoid the hot, dry weather that follows the end of the rainy season. Avoiding the "chergui", hot (perhaps 40°C), dry winds from the desert is important. Although these occur occasionally in April and May, they are much more likely to occur in June and July.

Cloudy periods during the rainy season are interspersed with clear, sunny periods and daytime temperatures favorable to photosynthesis, particularly as daylength increases after January. Heavy dews are common through parts of the rainy season which increase efficiency with which soil moisture is used. These conditions are favorable for cool season field

crops such as barley, wheat, and certain forage crops and pulses. They are also favorable to many cool-season vegetables such as carrots, beets, potatoes, cabbage, and cauliflower. The warm, dry weather of May and June are favorable for harvest of cereal crops.

Many Moroccans are producing barley in areas receiving less than 300 mm. of rainfall. This is evidence that barley does not need 300 mm. just to produce the plant. Gains in soil moisture conserved and in the efficiency with which barley uses the moisture will increase potential yields of barley in drier zones. The favorable climate for wheat in Morocco through the rainy season may reduce the rainfall needed to grow the plant to 250 mm. If applied research would prove this to be true and determine practices that will increase efficiency with which moisture is conserved and used, then the area planted to wheat could be expanded into that now producing only barley. This might be economically desirable.

Maintaining a supply of available soil moisture from time of planting through crop maturity is the principal problem restricting potential yields. The great variability and erratic nature of the rainfall patterns from year to year in timing and amount, when considered in relation to the low total of annual precipitation, introduce considerable risk in crop production. They make highly important the development and use of crop production systems and production practices that conserve the rain that falls and maximize the efficiency with which crops use that water.

Conserving Rainfall as Soil Moisture

Rain that falls can run off the surface, evaporate from the surface, or infiltrate the root zone. The water that infiltrates the soil may be used by the crop plant, wasted by transpiration of weeds, or percolate through the soil to the water table if enough is received to move deeper than the root zone. Storing a maximum of the rain that falls in the root zone is essential in arid and semi-arid climates.

Factors that influence runoff are intensity and duration of the rain, degree of saturation of the soil surface, infiltration rate of the soil, slope of the land, and the amount and distribution of plant residue or vegetative cover to protect the surface. Most of the rains in Morocco are slow and gentle. Only occasionally and on certain fine-textured soils is the duration such that soils become saturated in the topsoil zone so rain intensity exceeds the infiltration rate. When it does, runoff will occur. If the soil surface is bare and the land is sloping, severe sheet erosion occurs. There is evidence of extensive erosion and severe soil losses of this kind on sloping land in Morocco.

Much research shows that raindrops falling on bare soil break down the soil granules and partially seal the surface, greatly reducing the infiltration rate. Farming practices in Morocco with the plow and covercrop (disc) usually destroy all surface cover and leave the surface bare. Intense grazing of all stubble fields and pasture areas leave few residues for soil protection. Very probably the extent of bare soil contributes more to causing runoff and the serious soil erosion observed

than any other factor. Much of this precious moisture lost in runoff would infiltrate the soil if residues were left on the surface, both saving more moisture for the crop and greatly reducing soil losses due to erosion.

Effective weed control is essential if water that has infiltrated the soil is to be saved for the crop rather than transpired by weeds. Weed scientists have shown repeatedly that weeds, on the average, use as much water as crop plants in producing one kilogram of dry matter. They have also shown that weeds have their greatest effect in reducing crop yields when they compete with crop seedlings in the first six to eight weeks after planting. Thus, effective weed control practices must kill all weeds at or before the time of planting and then keep them under control during the life of the crop.

In dry periods after a rain, water evaporates directly from the surface of the soil until the surface becomes dry. Water continues to evaporate as heat in the soil changes liquid water to water vapor that diffuses through the soil pores and into the atmosphere. The rate of loss of soil moisture by this diffusion process is directly related to soil temperature. Bare, exposed soil gets hotter than soil with a crop residue or vegetative cover to intercept and reflect some of the sun's rays. In a dry period such as the summer dry season in Morocco soil moisture can be lost to considerable depths by evaporation from the soil surface after diffusing as vapor from lower depths. If soil moisture has not penetrated deeper than 500 mm. or if the soil is no deeper than that, probably all moisture in the soil may evaporate from the surface during the summer. In such cases fallowing practices to conserve moisture will accomplish nothing because there is no moisture in a zone deep enough to be protected from evaporation. Annual cropping systems designed to conserve and use the rain that falls as efficiently as possible each year will be most productive.

In soils of one meter or more in depth carrying soil moisture through the dry season should be possible if it is stored below 500 mm. in the root zone and weed growth is controlled. Leaving land fallow for an entire year during which weeds are controlled as a means of storing soil moisture for the following crop probably has little place in Morocco. Applied research will provide a basis for decisions on the question of fallow or annual cropping.

Two situations can greatly increase the rate of water evaporation from a soil with a dry surface. One is soil cracking. Water vapor escapes readily from a fine-textured soilthat develops deep cracks as it dries. If crop residues do not provide enough surface protection to reduce deep cracking to tolerable levels, shallow surface tillage to keep the cracks filled may be worthwhile to reduce water loss from soils that have a deep profile.

The second situation is tillage. Plows, discs, and other implements that stir or turn the soil may expose moist soil to the sun and atmosphere where it quickly evaporates. The surface soil loosened by tillage permits water vapor to escape faster than it would through the small pores of an

undisturbed soil. Soil moisture loss due to tillage operations from observations made in the field in Morocco is a very serious loss and one that can and should be greatly reduced.

In late October of 1976 most of central Morocco received rain sufficient to wet the soil to a depth of over 300 mm. Some rain continued until November 10. No rain fell from November 10 to November 26 when observations were made. Many fields disced with a covercrop or plowed soon after November 10 were dry to a depth of 100 mm. or more when adjacent fields that had not been tilled had readily available moisture at 20 mm. Because tillage loosened the surface soil, many fields lost an estimated 10 mm. or more of soil moisture. The surface soil in the deeply tilled fields on November 26 was so dry that grain seeded in it would not germinate until more rain came. The farmers may well get lower yields because their crop was delayed in germination beyond the optimum date. Certainly loss of the water will mean loss of potential yield. If loss of the 10 mm. of water had been avoided by not tilling and each mm. meant 20 kg. of grain per hectare, then loss of the water should mean a reduction of potential yield of 200 kg. per hectare.

Is plowing or discing necessary to prepare soil for planting? The answer is probably, "NO". High priority in an applied research program should be given to answering this question. The only definite benefit from the plowing and discing was destroying most of the weeds that had germinated after the rains. Disadvantages from the plowing and discing were: (1) loss of valuable soil moisture, (2) cost of machinery energy and labor required, (3) destruction of the desired firmness of a seedbed, (4) delayed planting of the crop because the surface was too dry, and (5) a bare soil surface subject to runoff and water erosion when it does rain. These disadvantages are serious when the only benefit seems to be some weed control in the operation that also plants the crop seed. Most tillage is carried out because of tradition rather than because it meets a scientific requirement for crop production.

Is there an alternative way to control weeds at or just before planting that would avoid many of the disadvantages of plowing or discing? An applied research program should include experiments to evaluate very shallow tillage with "sweeps" set to operate no more than 50 mm. below the soil surface. The purpose is to kill all germinated weeds without loosening the soil below 50 mm. and exposing it to water loss. This would retain moisture near enough to the surface that a drill could place seed and starter fertilizer in firm moist soil and assure uniform, prompt germination.

Shallow tillage with sweeps is one alternative. A second alternative to be included in experiments in an applied research program is spraying with selected herbicides to kill the weeds and then planting directly in undisturbed soil with a drill that also applies starter fertilizer with the seed. This is the "no-tillage" system.

In the future spraying herbicides to control weeds may substitute for the traditional tillage that is practiced today. Applied research will

determine which herbicides are effective and the time and method of application. Use of herbicides is a new technology, only about 30 years old. For thousands of years farmers had no alternative to tillage for weed control. Where use of herbicides can substitute for tillage as determined by applied research, then the disadvantages from tillage can be avoided.

The widespread practices of traditional discing and plowing used by Moroccan farmers appear to be wasting much water and energy. They are used by "modern" as well as by traditional farmers. A "sweep" machine run at a shallow depth would require much less energy, would leave crop residues on the surface, reduce runoff and erosion, save more rainfall and control weeds if done timely and properly. Alternatively herbicide applications may be developed that will control weeds at planting time without any tillage. Either method would permit drilling in a firm seedbed, placing starter fertilizer with the seed, if needed, and assure prompt germination and uniform stand establishment.

Morocco should avoid investments for plows, chisel plows, and other machines for the purpose of deep tillage in dryland farming until replicated, well designed and conducted research trials indicate that they are needed and are necessary for high yields that cannot be achieved with shallow tillage or "no-tillage" procedures. Getting results that support deep tillage seems very unlikely. Such implements and the power required for them make their use very expensive. The need for deep tillage has not been proven in comparative trials in Morocco. There is much recent work in the United States to show that deep tillage is not necessary — that every tillage operation uses energy and wastes valuable soil water in dry climates where water is the principal limiting factor for crop production.

Meeting Growth Requirements of the Crop

For any field the farmer must decide what crop he will grow and what variety he will plant. The farmer should know that the variety is adapted to his situation either from his experience with it or from the results of reliable crop variety trials in his area. The seeds should have good germination and be clean and free of weed seed and other crop seed.

When good seed of the selected variety is available, the farmer should choose the date to plant that has been shown by good date-of-planting research to be best for his crop and conditions.

The common method of planting cereals by broadcasting seed and mixing it into the surface soil with a disc or plow is very poor practice because it fails to meet the requirements of the seed for germination. It gives weed seeds the same opportunity to germinate and grow that crop seeds have.

What are the requirements for the crop seed? First, the germinating seed needs to take up enough water from the soil to germinate and develop into a seedling. If seeds germinate and then dry out, the seedlings will

die and replanting will be necessary. Present planting methods that mix seed with loose soil make drying out after germination very likely if additional rain fails to come promptly.

Planting should be done with a drill to place the seed along with starter fertilizer, if needed, on firm soil at the bottom of a narrow furrow opened by a "hoe", pressed in place by a seed wheel, and covered with 25-40 mm. of soil, perhaps 50-60 mm. if sandy. This method of planting meets the seed's requirements for germination. The seed is placed in contact with moist soil that is firm and can continuously supply moisture from below without drying out. The roots of the seedling penetrate immediately into the firm, moist soil. This reduces the likelihood of drying out and dying so that the need for replanting can be greatly reduced. Having the starter fertilizer in association with the germinating seedling assures that it will get the nutrients needed for a vigorous start. Weed seeds in between the seeded rows will be in a poorer position than the crop seed to germinate and benefit from the fertilizer. A uniform stand of vigorous crop seedlings will help suppress subsequent weed growth by having a competitive advantage.

Changing planting methods in Morocco from broadcasting to drilling is essential. This change, along with improved weed control at planting time, will boost potential yields by achieving good stands at a desirable planting date, especially in years when fall rainfall is below normal. There is much research to show that drilling permits reducing the amount of seed planted by 1/3 to 1/2. Moroccans plant barley on about 2 million hectares and wheat on 1.9 million hectares. Assuming that drilling in place of broadcasting would save 20 kg. of seed per hectare, this change would save Morocco 40,000 MT of barley and 39,000 MT of wheat annually.

Another requirement for crop growth is an adequate supply of essential plant nutrients. Much research, primarily in the higher rainfall and irrigated areas of Morocco, has shown the need for applications of nitrogen fertilizer. Experiments have also shown widespread needs for phosphate fertilizer and little, if any, need for potassium. There appears to be no research demonstrating deficiencies of any other elements.

Although there have been few, if any, experiments in the arid and semi-arid areas, applied research involving different rates, forms, and times of application will show what elements are needed. Probably such tests will show that nitrogen and phosphate fertilizer are also needed in these areas.

Protection from pests is another requirement for plant growth. Bred-in resistance to diseases or insects in varieties is a desirable type of protection. Except for seed treatment, use of chemicals to control diseases of cereal crops is not a common practice. Occasionally insecticides are needed for protection from insects.

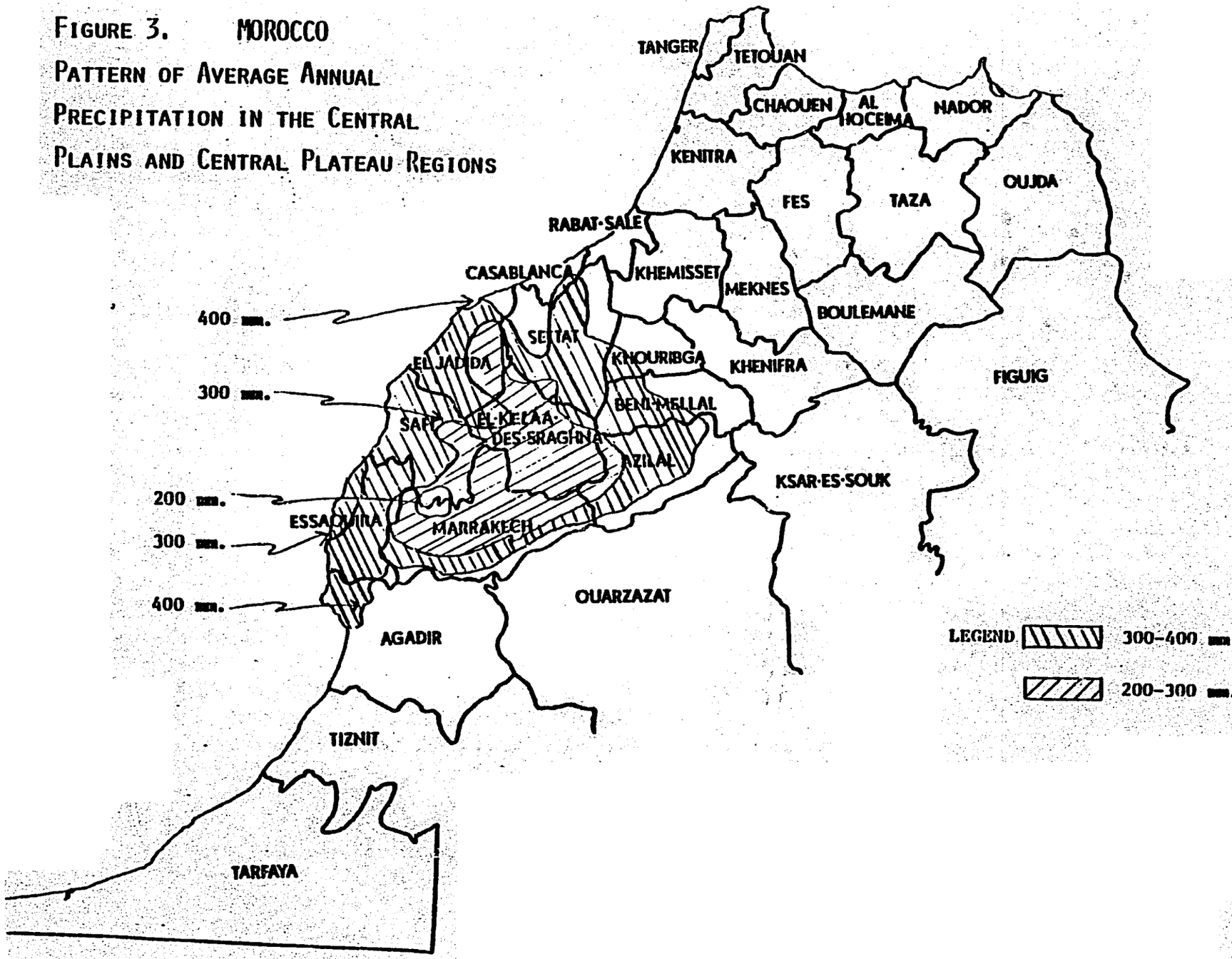
Weeds are a pest more serious in reducing yields than either insects or diseases in most dryland cropping areas. Weeds reduce crop yields by

reducing the water and nutrients available for the crop and compete for space and light. Effective weed control is essential in productive cropping systems.

High yields can be achieved only if the growth requirements of the crop are met for water, nutrients, and protection from pests. Vigorous, healthy plants use water more efficiently than weak, starved or pest damaged plants.

In summary, the production systems now in use in the dryland farming sector of Morocco can be greatly improved in increasing the storage of rainfall in the root zone and the efficiency with which crop plants use it. The applied research program can determine what practices will be most effective in both areas of potential improvement.

FIGURE 3. MOROCCO
PATTERN OF AVERAGE ANNUAL PRECIPITATION IN THE CENTRAL PLAINS AND CENTRAL PLATEAU REGIONS



ANNEX C. DEFINITION OF AREA RECOMMENDED FOR INCLUSION

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Annex C. DEFINITION OF AREA RECOMMENDED FOR INCLUSION

The portion of Morocco that falls within the 200-400 mm. (12-16 inch) rainfall belt and that has cereal and pulse production as its primary and almost sole crop enterprise is the Central Plains and Central Plateau areas extending northward from the Marrakech-Essaouira zone to the Khouribga-Settat-El Jadida zone. Since an applied research program must be implemented through governmental agencies, it must be organized so that it can be implemented through development of the existing agencies and political subdivisions representing this region.

Sites of applied research activity will be necessary in all eight provinces if the information is to be adapted to the different climatic, soil, and socio-economic conditions that exist.

Currently, this region is comprised of seven provinces:

1. Settat
2. Khouribga
3. El Jadida
4. Safi]
5. Essaouira] combined in Safi Province until 1976
6. El Kelaa des Srarhna]
7. Marrakech] combined in Marrakech Province until 1976

Inclusion of the Meknes Province to make a total of eight provinces in the project is strongly recommended, even though it lies in a more favorable rainfall zone to the north. Reasons for including the Meknes Province are as follows:

1. Having the experiments conducted in one higher rainfall province is valuable to the research in covering a broader range of rainfall, Meknes serving as a check for comparison.

2. It can prove very valuable economically to the nation if the results are shown to be adapted so application of the information base is broadened.

3. The National School of Agriculture at Meknes has indicated an interest in cooperating in the program. One site of experiments at the School could prove very valuable to the long range development of the program since that school will be training many of the Ingenieurs d'Application who will be involved in applied research, extension, and other positions in government related to development of dryland farming. If changes in existing concepts are clearly demonstrated to the students from having experiments there, the long range value to the program will be great.

4. Meknes and the surrounding provinces are important in cereal production. Its population is 52% rural and includes still a large number of traditional small farmers.

5. The general characteristics of the cultural and soil management practices used by Meknes farmers are similar to those used in the lower rainfall region to the south.

Therefore, the dryland farming applied research project is recommended for eight current provinces, Meknes plus the seven listed above. Since statistics and data available all pertained to the Safi and Marrakech provinces before division in 1976, they are so given and should be so interpreted. They do represent the total area involved.

Demographic and Economic Significance of the Area

The eight provinces proposed for inclusion in this project had an estimated population in 1975 of 5,214,208 or 31% of the population of Morocco. Of these 3,796,937 or 73% are classified as rural. They make up 632,800 rural households or 35% of those in Morocco and operate 569,500 farm units. The arable land in the provinces is estimated at 3,807,700 hectares or 6.7 hectares per farm unit. This is 52% of the arable land in Morocco. Over 75% of the farm units or 431,700 are less than 6 hectares in size and represent about 40% of the arable land of the project area.

The majority of the population is very poor and at a low subsistence level. In 1973-74 it is estimated that these provinces produced barley on 1,874,000 hectares, durum and bread wheat on 701,900 hectares and pulses on 231,800 hectares. Barley is the principal cereal of the region. It is grown on about 60% of the arable land. The hectares of barley in these provinces represents 95% of the land used for barley in Morocco. The area in wheat is 37% and in pulses 40% of the total land in these crops in Morocco.

These provinces have 50% of the cattle, 48% of the sheep, and 24% of the goats in Morocco. Per farm unit there is an average of 2.8 cattle, 13.5 sheep and 2.9 goats.

Therefore, this area represents a substantial part of the poverty sector of Morocco that contributes significantly to both livestock and cereal crop production. Improving the productivity and the welfare of the people of this area must be recognized as an important goal for political, humanitarian and economic reasons.

Selection of Sites and Schedule of Program Expansion

The first year of the project will involve much assembling of equipment, developing of facilities, and recruiting and training Moroccan scientific and support staff. U.S. staff members must become acquainted with related Moroccan personnel, agencies, procedures, and operational infrastructure. The location of experiments the first year will be restricted to one site in one province. The second year should expand to a number of sites on farms in the same province, again placing emphasis on staff training and development of appropriate field experimental equipment and procedures. Third year activities will include

development of the applied research center facilities in the second province. The tentative sequence for establishing applied research programs in the eight provinces is as follows:

1977 - Settat	1981 - Essaouira
1979 - El Kelaa des Srarhna	1982 - El Jadida
1980 - Safi	1982 - Marrakech
1981 - Meknes	1982 - Khouribga

Starting in the Settat Province is logical because (1) proximity to Rabat will be advantageous in program development and initial training phases, (2) relatively favorable rainfall conditions for initial development phases, and (3) importance in both barley and wheat production. The second province can well be in a drier, different situation. El Kelaa des Srarhna meets this requirement and seems to project already an active interest in working with the Bureau of Dryland Farming.

A desirable site within each province to develop as the center for the applied research activities would seem to be adjacent to or in conjunction with an established DRA experiment station. Such a site would make effective communication and cooperation easier than if geographically separated.

Annex D. AGRONOMIC ANALYSIS

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Annex D. AGRONOMIC ANALYSIS

Crops, Cropping Patterns, and Farming Techniques Presently Used by the Small Dryland Farmer

The principal crop of the small dryland farmers is barley followed in order by durum wheat and bread wheat. Hectares of the three in Morocco are 1,972,600, 1,388,400, and 528,500, respectively. A major part of this production is in the 8-province area to which this report is directed. Maize, sorghum and oats are cereals of secondary importance. Broad beans, chick peas, small peas and lentils are legumes grown primarily for grain.

Barley is the principal breadgrain of the rural people of the more arid and semi-arid parts of Morocco. It comprises most of the limited amount of grain fed by small farmers to livestock. Experience has undoubtedly led these farmers to choose barley as the most reliable grain crop they can grow. Varieties used mature two weeks earlier than wheat, a distinct advantage where rainfall, even in spring months, is low and highly erratic in amount. Durum wheat is used in couscous, a common food even among the poor. It is more widely grown and used by subsistence farmers than bread wheat. Bread wheat is grown where rainfall is more favorable.

Production practices of the small farmer for barley, wheat and oats are essentially the same, except for use of fertilizer. Wheat, as a higher value crop encouraged by government programs, is more often fertilized. Where applied, fertilizer is broadcast by hand. Seed is also broadcast by hand. To cover the seed and fertilizer, when used, the farmer uses a plow. In the lower rainfall areas this is the primitive wooden plow that just stirs the top two or three inches of soil. It is pulled by a team of animals, most frequently a camel with a horse or mule, or sometimes perhaps horses, donkeys, oxen or combination. Thus, the draft power is dependent on the particular animals available and how well fed they are. In the 400 mm. rainfall area the farmer is more likely to have a steel walking plow that turns the soil more effectively than the more primitive wooden plow. Seed is not planted at a uniform depth, and weed seed on the surface is planted just as effectively as the crop seed.

A few farmers plow the land before broadcasting seed, sometimes plowing down broadcast fertilizer. The seed is then broadcast by hand and mixed into the topsoil with a spiketooth harrow. Farmers with tractors in dryland production also broadcast both seed and fertilizer perhaps with a fertilizer spreader or cyclone seeder. They use a covercrop (tandem disc) for covering or incorporating the seed almost universally. Drills for seeding small grains or any crop are rare.

Thus, seed is distributed at various depths through loose soil. Seeding usually occurs after fall rains have moistened the surface few inches, at least. The seed is often placed in moist soil. A subsequent warm, dry period can result in germination; but drying out of the loose, tilled layer can result in loss of seedlings and the need to replant.

Because the broadcast seeding rate is high, replanting is costly. To avoid possible loss of stand from drying out, the tendency is to delay seeding, perhaps beyond the optimum date for best yields.

The small farmer commonly broadcasts the seed on the surface among the very light residues, weeds and volunteer that exist after pasturing with his sheep and other animals from the time of the last grain harvest. A single plowing operation represents both seedbed preparation and planting. To the extent that growing weeds, including volunteer or perennial vegetation, are not destroyed by the plowing operation, such plants actually have an advantage over the planted crop.

The small steel plow has a distinct advantage over the traditional wooden plow in destroying growing plants. Still it is very poor in placing seed in contact with firm, moist soil needed for prompt germination and reliable stand establishment. It does not permit placing starter fertilizer with the seed. It exposes soil moisture to evaporation and leaves a loose zone of soil from which water readily evaporates. Benefits from all other efforts to improve production of the dryland farmer will be severely limited if planting practices are not changed. Development of small drills to plant the seed properly and place starter fertilizer with it should get highest priority.

Weeds are serious in many cereal fields, wild oats being very serious in some areas. Commonly weeds are pulled from the growing crop and fed to livestock. Competition from weeds has its greatest effect in reducing crop yields during the early stages of crop development. Thus, the timing of weed removal practices does not benefit crop yields. They merely provide livestock feed. One of the critical needs is a method of effective weed control in cereal fields. Certainly timely use of herbicides applied with small sprayers merits research attention along with use of small sweep tillage machines to determine the most feasible way of controlling weeds that waste part of the precious soil water needed by the crop.

Some farmers purchase certified seed from the DMV work centers. This is a very small part of the seed planted, however. Most farmers plant seed from their own previous harvest. Some give attention to cleaning weeds and other materials from their seed. When farmers plant seed from their own bins, none will be tested for germination. The quality of seed planted, therefore, ranges from poor to good. The variety is commonly unknown. Through seeding surveys and experimental trials of samples of seed being planted, a clear picture could be gained of quality of seed in use and a base established for a program to achieve improvement. There are seed cleaners located at some "souks" or market places where farmers can get seed cleaned.

Almost certainly the genetic potential of the varieties in use exceeds the yield potential of the rest of the production system. Gains from improved varieties, as long as good quality seed is planted, may not justify major investment in changing to seed of improved varieties until the more limiting factors of planting method, fertilization, and weed control are addressed.

General practices for production of grain legumes and maize are similar except that seed is dribbled by hand along furrows of irregular lengths and spacing and then covered by the plowing operation.

Harvesting of cereals and grain legumes on small dryland farms is accomplished primarily with hand sickles. The grain is carried or hauled and temporarily piled near the threshing floor. Animals driven over the dry grain spread over the threshing floor accomplishes the threshing. Winnowing is by wind from straw and grain being tossed into the air by pitchfork. Observation of volunteer grain in fields indicates considerable shattering loss in the harvest processes.

Farms with tractors commonly have self-propelled combines for harvest. Many of the fields observed that had been harvested with combines had heavy stands of volunteer grain, particularly in the path of the combine separator, indicating improper adjustment of the machines at harvest.

Storage is reported to be in underground chambers that will hold approximately 100 quintals. Quality of this storage has not been carefully studied. Apparently insect losses in them are not great, but a question of loss due to moisture remains. Farmers market carryover grain first and hold new grain. Sharecroppers and renters deliver the owner's component of harvest at harvest time.

A substantial area of arable land each year is used for so-called "fallow". Little, if any, of this is managed to prevent weed growth so as to conserve moisture and permit mineralization of available nutrients such as nitrogen. It is more properly considered an annual crop of weeds and volunteer for livestock grazing.

The pressure for livestock feed is great. Through the cereal cropping areas of the eight provinces considered here, little permanent perennial forage exists. Essentially every hectare even of thin marginal soils is planted quite regularly to barley or other cereal. Harvest with a sickle removes most of the straw with the grain. From the time of harvest until the next crop is planted, livestock repeatedly graze the fields. They are dependent on the straw, weeds, and volunteer that grows for their basic forage needs. Some of this land will not be planted each year but will be used for livestock grazing. This is not "fallow" in terms of being managed to conserve water and nutrients for the next cereal crop, rather it is an annual crop of weeds and volunteer that is grazed closely and continuously. Forage production is low. The soil is kept nearly bare and subject to sheet erosion by water.

Instead of a very unproductive crop of weeds from such land, a much larger amount of quality forage could be produced if this land were planted to an annual forage crop, possibly grass and/or legume, and cut for hay at timely intervals rather than being grazed. While this would involve a change in livestock management practice, it would greatly increase the feed supply for livestock that now so seriously limits livestock production.

Observation and inquiry indicates that few of the families dependent on the small dryland farms of the Central Plains and Plateau areas of Morocco for their livelihood have family gardens to supplement the bread, pulses and limited milk and meat that comprise most of their diet.

Just as cool-season cereals may be planted in November with the start of the rainy season, so many cool-season vegetables might be planted in November and provide a continuing supply of such vegetables as green, leafy members of the cabbage and mustard families, peas, root crops, and potatoes through at least six months of the year. Relatively small areas tended with hand hoes and dependent on rainfall might make an important contribution to improved health, particularly of growing children.

Morocco has a productive vegetable industry for export and to supply urban areas. Millions of the small farm families do not get significant benefits from this production for lack of purchasing power. They do have the time and labor available to raise a small garden. With the climate as it is, productivity should be high enough to justify the small area involved, even on a very small farm. An active program through extension based on an applied research program is needed to identify the best garden crops and production practices for different areas.

One explanation for families not having a practice of producing vegetable gardens was that tradition requires sharing food between and among families in ways that would limit the benefits that a single family might receive for its efforts. One way of approaching this problem of sharing would be to attempt to get as many as possible in a village or "douar" to start gardens at the same time. This would require an organized effort. It can succeed only if it meets a perceived need on the part of the rural families. Getting one or more Moroccan families who are accepted within the village as average or above in social status to undertake growing a garden may contribute to getting the practice accepted. The extension service working with a farmer organization will have an important role to play in supplying information and also assuring supplies of seeds, tools, recipes, etc. on a continuing basis.

Production Potentials of Farmers Under Alternative Crop Combinations And/Or Production Techniques

Programs of GOM to date have been directed to farms larger than 10 hectares in size and in the rainfall areas of over 400 mm. Essentially no information exists that characterizes the soils and soil moisture regimes or measures the potential in the arid and semi-arid areas of the Central Plains and Plateau.

The only tillage and planting implement now used by most traditional, small subsistence farmers is a wooden or steel plow. Occasionally one has a small spike-tooth harrow. These are pulled by a team of animals, often small with limited draft capabilities. Tillage accomplished wastes water since it comes after fall rains and is inefficient in weed control. Seeds

are broadcast and mixed in the surface soil, an extremely poor planting procedure. Weed seeds are planted as effectively as crop seed, and weed competition is continuous and severe. Most farmers plant seed from their own harvest, the variety and quality mostly unknown. Essentially the same system is used for all crops grown, with cool-season crops planted in November or December and warm-season crops in February.

Soils through much of the project area are shallow, offering no opportunity for fallowing through one year to accumulate some added moisture to increase yields and add stability to production in a two-year crop fallow system. The dry season is probably too long and hot to permit carrying significant soil moisture in these shallow soils through the long dry season.

Fortunately temperatures are such that cool-season crops such as spring barley and wheat will grow continuously from planting in November until maturity in April or early May. For such crops the rainy season coincides with the growing season, and a major part seems to have daily temperatures at a level to keep transpiration rates low but with sunshine favorable for photosynthesis.

Thus annual cropping offers the opportunity to increase yields markedly if applied research can (1) characterize the soil moisture regime through year, (2) develop machinery for tillage and seeding and patterns for their use that will conserve moisture and achieve good stand establishment, (3) develop effective weed control practices, (4) develop fertilizer recommendations and application times and methods that are economic in terms of increased yields, (5) identify improved varieties adapted to the diverse conditions through the project areas, and (6) motivate and guide those governmental actions and farmer responses necessary to achieve use of improved machinery and production practices.

Grain crops that should receive primary attention are spring barley, spring wheat (durum and bread), broad beans, chickpeas, peas and lentils. Benefits from growing cereals and pulses in alternating sequences should be evaluated. Forage crops need the same level of attention as grain crops because feed for livestock is a critical need. Primary forage species to be considered are detailed in Annex F. Forage and Range Analysis.

A substantial acreage of maize is produced. The tops are cut off starting after pollination and fed to livestock. Both its forage and grain yields are low. Maize needs to be compared to sorghum and pearl millet. Short season varieties of sorghum, pearl millet and proso[1/] should be evaluated as emergency grain crops to salvage some production from a season where rainfall distribution restricts the cool-season cereals. These may be more efficient in producing grain in a short spring season than corn or other crops.

Careful field testing of different vegetables and varieties of vegetables, production methods, and recipes for use should be conducted.

1/ Pearl millet - Pennisetum typhoides; proso millet - Panicum miliaceum.

Necessarily, systems of seed production and distribution will be essential for those found to be desired and useful. Recommendations that fail to meet farm family expectations will build attitudes inhibitory to trying other innovations. The opposite will also be true. Initial successes are important and are dependent on an adequate, effective applied research effort.

Statements have been made that the production potential is two or three times present levels. In addition to increasing grain yields the possibility of greatly increasing forage production seems promising. Although such gains do appear possible, they are speculative.

Because there is no way that farmers with present equipment can do a satisfactory job of planting any crop, fertilizing it efficiently and achieving weed control, the development of small, simple, low-draft implements that will do the job must receive priority attention. Making major gains in achieving manufacture, distribution and adoption after design and adequate testing will take time and will require a major program effort itself.

There is no evident, easy way to make major gains in agricultural production in the project area. A vigorous applied research program is the right place to start in developing the technologies and information needed for sound decisions for implementation of a program that will take advantage of the substantial potential that appears to exist in the area.

Program of Agronomics and Plant Protection

The applied and adaptive agronomic research program eventually must include the following kinds of experiments:

1. Alternative crop rotations or cropping sequences.
2. Variety experiments for each important crop including forages and garden crops.
3. Cultural practices such as tillage and planting methods, date and rate of planting, etc.
4. Weed control, chemical and mechanical.
5. Timing of harvest.
6. Control of insects and diseases.

These experiments will be closely coordinated and integrated with experiments on equipment, in soil fertility and management, and in forages and range.

The network of international agricultural research institutes that has been established should be used as an important resource in developing the applied agronomic research program in Morocco. The various institutes will be important sources of varieties to be tested and of new production practices to be adapted. The following institutes will be particularly important because of the crops with which they work:

Institute	Crops
International Maize and Wheat Improvement Center (CIMMYT)	Wheat, barley, maize, triticale
International Crops Research Institute for Semi-Arid Tropics (ICRISAT)	Chickpeas, pigeon peas, sorghum, millets.
International Center for Agricultural Research in Dry Areas (ICARDA)	Wheat, barley, lentils, broad beans, oilseeds.

Schedule of Development of Agronomic Research

FIRST YEAR

The first year's experimental program will be in one province, preferably sited on or adjacent to an existing DRA provincial experiment station. There would be little or no off-station activity on farms. Much U.S. staff time will be spent in developing working relations and procedures with Moroccan staff and agencies, arranging and developing facilities, assembling and checking experimental equipment under Moroccan conditions, and training staff in experimental procedures and operation of experimental equipment.

The first year's experiments will place emphasis on developing an understanding of the soil moisture regime in cereal crops in traditional compared to improved, shallow tillage systems and in different "fallow" treatments. These will be jointly planned and conducted by the agronomist and soil scientist.

A. U.S. Contract Personnel
   1. Full-time Production Agronomist (Chief of Party)
   2. Full-time Soil Scientist (See Annex E)
   3. Part-time: a. Weed scientist
      b. Plant pathologist
      c. Entomologist
      d. Horticulturist

A four-week trip of the assigned short-term project team members is necessary to establish for them an information base and acquaintance with Moroccan dryland farming conditions for effective subsequent activity in their scientific areas of expertise and for more effective training of associated graduate students. Each should be encouraged, but optionally, to take French language training.

B. Moroccan Personnel
   1. Counterpart scientific staff
      a. One Ingenieur d'Etat - designated Chief (or Acting) counterpart to Chief-of-Party.
      b. Two other Ingenieurs to work with contract staff in developing plans and facilities, becoming trained in applied research procedures, and preparing for later participant assignments.
   2. Participant training (See also Annexes E, F, H and I)
      a. Ingenieur d'Etat tentatively expected to become Chief of the Dryland Farming Applied Research Program - for Ph.D. training in the U.S. Minimum time in U.S. 3 years if thesis research in Morocco is feasible.
      b. Ingenieur d'Etat for Ph.D. role as plant pathologist on the national staff.
      c. Ingenieur d'Etat for Ph.D. training in U.S. in weed science for role on national staff.
      d. Ingenieur d'Etat for Ph.D. training in U.S. in entomology for role on national staff.
      e. Ingenieur d'Application for M.S. degree in Production Agronomy to be a provincial program leader.

C. Commodities
   1. Vehicle - van or pickup
   2. Equipment trailer (12-foot)
   3. Nursery planter
   4. Plot thresher (Vogel type)
   5. Sprayers for weed and insect control
   6. Miscellaneous small field research and laboratory equipment, tools, supplies, etc.

SECOND YEAR

A. U.S. Contract Personnel
   1. Add a full-time Forage and Range Scientist (See Annex F.)

B. Moroccan Personnel
   1. Counterpart scientific staff
      a. Three added Ingenieurs for in-service training by U.S. staff and assistance in expanding field research into an off-station component and to prepare for future participant assignments.
   2. Participant training
      a. Ingenieur d'Etat for Ph.D. training for role as production agronomist on national staff.
      b. Ingenieur d'Etat for Ph.D. training in vegetable horticulture for role on national staff.
      c. One or two Ingenieurs d'Application for M.S. degree in production agronomy for leadership role in provincial program.

C. Commodities
1. Miscellaneous and contingency items.

THIRD YEAR

A. U.S. Contract Personnel
(Same as first two years except that short-term assignment staff may require additional trips or time.)

B. Moroccan Personnel
1. Counterpart scientific staff
   a. Three added Ingenieurs as in Second Year.
2. Participant training
   a. Ingenieur d' Application for M.S. training in weed science for national program staff.
   b. Ingenieur d' Application for M.S. training in plant pathology for national program staff.
   c. One or two Ingenieurs d' Application for M.S. training in Agronomy for leadership role in provincial programs.

C. Commodities
1. Miscellaneous and contingency items.

FOURTH AND SUBSEQUENT YEARS

Follow general staff program summarized in Tables 4 and 6 . With return of participants from training in the U.S., the rate of expansion of program to added provinces and of scope of program within provinces should increase accordingly. Adjust as applied research results and progress of program indicate to be desirable.

Annex E. SOIL SCIENCE AND SOIL TESTING ANALYSIS

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Annex E. SOIL SCIENCE AND SOIL TESTING ANALYSIS

Introduction

Moroccan agriculture is characterized by a complex land ownership and tenure pattern. Of the 8 million hectares of arable land, there are almost 6 million hectares in the traditional sector and about 1.5 million in the modern sector. The remaining 0.5 million hectares are in "fallow".

The Traditional Sector - Most traditional farms in Morocco are small. These are subsistence farms in which land is worked by the farmer and his family with wooden or steel plows drawn by animals. Fragmentation of land among heirs resulting from the provisions of inheritance laws has created large numbers of minute and irregularly shaped plots that are inefficient to cultivate or fertilize.

A lack of understanding of the use of fertilizers and the absence of means to acquire them contribute to the low yields on the vast majority of farms. Continuous cropping without addition of fertilizers has continued to lower the soil fertility. The land that is left in fallow does not build up its fertility status during the fallow period because it is allowed to grow weeds and other annual plants as a source of forage for livestock. As a result, the yields on land which has been fallowed are not significantly greater than on continuously cropped land. Fallow land in the Great Plains of the United States is generally kept relatively free of weeds. Consequently there is a build-up of available nutrients, particularly nitrogen, during the fallow period.

The physical situation, i.e. rocky, shallow and steep, makes it difficult to use mechanized equipment and, together with extreme poverty, ties the peasant to the hoes and wooden plows used by his ancestors. Harvesting and threshing on these small holdings is done by hand sickles. Droughts, weeds and insects which result in low yields and frequent crop failure make the life of the subsistence farmer precarious.

Fertilizer has been used to a limited extent for many years in Morocco. Fertilizers are not usually used unless they are subsidized. A tour of the dryland areas revealed that very few of the small farmers applied fertilizer. Most of the traditional farmers broadcast the seed, fertilize, if at all, by hand broadcasting, and then stir the topsoil with a wooden plow.

The "Modern" Sector - The "modern" sector was introduced to Moroccan agriculture in the second and third decades of the twentieth century. The land which was located on the better soils in higher rainfall areas was mostly owned by foreigners and a few Moroccans. After independence, much of this was acquired by the Government of Morocco.

In general, the "modern" sector uses more advanced farming techniques including the use of tractors and chemical fertilizers. As a

result of the fertilizers and higher rainfall, the yields are much higher in the "modern" sector as compared to the traditional sector. The modern farms primarily produce high-value cash crops for the export market with some going to the local markets.

Soils Of Morocco

The soils of Morocco can be divided into two broad groups: those of the humid or semi-humid Atlantic area in the Northwestern part of the country and those of the arid or semi-arid regions in the Southeastern part of Morocco. The soils of the arid and semi-arid regions are relatively fertile for nutrient elements other than nitrogen. Rainfall is not sufficient for these soils to have been leached of soluble minerals. These soils are high in gypsum and calcium carbonate. Usually they are quite shallow and have weakly developed horizons. Rocky outcrops and broad expanses of stony land are common. All factors of soil development have been operative in Morocco. A wide variety of soils has resulted.

The variability of the soils in the rainfed dryland areas was quite apparent as we toured these regions. The various rock outcroppings in the dryland areas consisted of both igneous (gneiss, granite, schists) and sedimentary rocks (sandstones, limestones, shales). Soil textures ranged from clays to loamy sands. This variability in parent materials and soils points to the difficulty of making blanket recommendations for fertilizers, tillage equipment or other soil management practices in these areas.

One of the most striking features observed in many of the soils was a calcium carbonate accumulation zone or caliche layer. This caliche layer varied in depth from a few centimeters to one or two meters below the soil surface. The presence of this caliche layer explains why most soils in this region are calcareous.

The internal drainage of the uplands and high plateaus appeared to be quite good. Depth to bedrocks was variable and rock outcrops frequent. Stony lands were also frequent. Although stoniness improves drainage and water penetration, it also interferes with the preparation of good seedbeds.

Soil erosion appeared to be a problem in many areas. Land that should have been in permanent vegetation was being cultivated. In many cases fields with slopes of 20 to 45 degrees were being plowed and planted to cereals. Some plowing on the contour was observed, but most plowing was done up and down the slopes. Considerable erosion is occurring on the cultivated lands in Morocco. This is especially true during periods of high rainfall. Many of the soils in Morocco are already quite shallow. The continual loss of topsoil represents a serious problem. An applied research program needs to be directed towards tillage systems that minimize the potential for soil erosion.

The soils have been cropped for many years with almost the complete removal of plant residues and with little manure or fertilizer added. Therefore, the organic matter level in the soils would be low. Organic matter is a reservoir for certain nutrients such as nitrogen and phosphorus. The calcareous nature of the soils tends to make phosphorus less available because phosphorus forms insoluble compounds in calcareous soils. Consequently, the available forms of nitrogen and phosphorus are normally low in the rainfed small grain areas.

Extension Work Centers

Farmers that are under the supervision of an Extension Work Center are more likely to use fertilizer. A visit to an Extension Work Center at Berrechid revealed that the majority of farms (approximately 75%) cooperating with the Work Center were using fertilizer. The records shown to us by the Assistant Director of the Work Center indicated that the average size farm in the province covered by the Work Center was between 10 and 20 hectares. Farmers cooperating with the Work Center received a subsidy of 20% for fertilizer, 30% for seed and 50% for equipment (steel plow). The Assistant Director indicated that there was no attempt to evaluate fertilizer needs of the soils through the use of soil tests.

Fertilizer Materials

Morocco has over half of the world's phosphate reserves and is the world's largest exporter of this commodity. Morocco is able to supply most of its phosphate requirements, but it still must import most of the nitrogen and potassium fertilizers. Some phosphate fertilizer is imported in the form of various mixed fertilizers (see Table 7). Morocco produces a large part of the mixed fertilizer used in the country.

A review of the various fertilizers available at several different locations indicated a rather large variety of mixed fertilizers on the market (see Table 8). This large number of fertilizer materials is excessively high for a developing nation to produce and use. The extremely large number of mixed fertilizers increases the complexity of handling, storage, making fertilizer recommendations and conducting an educational program. The large array of fertilizers offered for sale must certainly present a dilemma to the farmer in deciding which material to purchase. The farmer is more likely to receive the particular grade of fertilizer available that day instead of the grade that is most appropriate to his situation.

Fertilizer Recommendations

The amount of fertilizer recommended in Morocco is generally based on a standard set of fertilizer recommendation tables suggested

TABLE 7. Selected Fertilizer Materials Imported into Morocco, Total Imports, and the Total Exports, 1971-75

Fertilizer	1971	1972	1973	1974	1975
Ammonium Nitrate	16,069	17,242	18,951	21,519	45,637
Ammonium Sulfate	75,700	67,046	87,316	79,784	57,179
Urea	-	-	28,183	35,408	39,048
Potassium Sulfate	21,121	24,847	15,924	40,607	33,270
Potassium Chloride	16,769	24,847	23,230	17,317	38,183
Mixed Fertilizer (N,P,K)	-	37,069	69,617	86,486	33,694
Total Imports	261,877	170,239	218,306	264,223	211,583
Total Exports (Phosphate Rock)	11,867,946	13,580,791	16,101,895	18,700,126	13,110,058

SOURCE: Statistiques du Commerce Exterieur. Ministere des Finances, Office des Changes, Rabat, Maroc, variously pages, 1971, 1972, 1973, 1974, 1975.

TABLE 8. Fertilizer Materials Marketed at Different Locations: Agadir, Safi, Berrechid, Casablanca, Kenitra, Meknes, 1975-1976

Fertilizer Material	Price for Bagged Fertilizer at Kenitra		
	Price per Quintal (DH)	Price per Ton ($)	Price per Lb Nutrient ($)
Ammonium Sulfate (21%)	37.99	76.51	0.18
Ammonium Nitrate (33.5%)	52.31	105.35	0.16
Ammonium Nitrate (34.8%)	53.89	108.53	0.16
Urea (46%)	62.77	126.42	0.14
Potassium Chloride (60%)			
Potassium Chloride (60%)			
a) pulverized	36.87	74.26	0.06
b) grandulated	40.66	81.89	0.07
Potassium Sulfate (50%)	47.97	96.61	0.10
Superphosphate (18%)	16.92	34.08	0.09
T.S.P. (45%)	42.32	85.23	0.09
A.S.P. 19-38-0	56.94	114.68	0.10
14-28-14	62.93	126.74	0.11
14-14-14	55.76	112.30	0.13
0-30-15	47.59	95.85	0.11
6-25-18	53.50	107.75	0.11
18-9-17	57.50	115.81	0.13
17-17-14	60.50	121.85	0.13
13-26-13 + Boron	83.50	168.17	0.16
9-18-25	56.55	113.89	0.11
13-26-13	56.80	114.40	0.11
0-25-26	46.37	93.39	0.09
0-18-36	46.32	93.29	0.14
0-16-30	51.06	102.83	0.11
12-29-0	53.96	108.68	0.13
5-15-0	31.33	63.10	0.14
12-12-18	55.82	112.42	0.13
11-22-25	55.14	111.05	0.10
13-13-20	53.42	107.59	0.12
5-9-12	36.41	73.33	0.14
6-10-10	37.07	74.66	0.14

SOURCE: Statistiques du Commerce Exterieur. Ministere des Finances, Office des Changes, Rabat, Maroc. 1975. page 121.

by the Directorate of Agronomic Research. (see Table 9). In the drier areas (less than 300 mm. rainfall annually), fertilizer is usually not recommended. The hazard of cereal production is considered too great to economically justify fertilization. Nitrogen recommendations are split to include a topdress application on sandy soils or when rainfall conditions are up to certain standards for the period of October through January. In most cases, the fertilizer recommendations include nitrogen, phosphorus and potassium. Soil tests are needed to determine the best rates of fertilizer to recommend for a certain field.

The price of fertilizer in Morocco is similar to fertilizer costs in the United States. For example, the cost per pound of nitrogen ranges from 14 to 18¢, phosphorus costs about 9¢ per pound and potassium about 6¢ for potassium chloride (Table 8).

The Potassium Situation

According to the T.V.A. Report (1967), practically all soils in Morocco are calcareous with the soil pH in excess of 7.0. A few soils in the high rainfall areas, especially in the Sebou flood plains around Kenitra, are acid. This indicates that very little leaching of soluble minerals has occurred, especially on soils with a silt loam or heavier texture. Such soils should be relatively high in available potassium. Lloyd L. Corty (1966) reported that most soils in Morocco are amply supplied with potassium. However, we can only speculate on the potassium status of soils in Morocco because of the lack of soil testing data.

A soils researcher at the Agronomic Institute reported that he attended a recent meeting where they were still debating whether or not potassium should be included as a general fertilizer recommendation. Potassium is an element that can be readily determined with a soil test.

The DRA (Direction de la Recherche Agronomique) has summarized several years of potash tests on corn, sugarbeets, potatoes, and onions (DRA Rapport d'Activite Campagne, 1976). The DRA report concluded that potassium fertilizer proves to have essentially no effect on the crop yield and after several years without potash fertilizer the soils and the crops do not show any sign of a potassium depletion. A response to potassium fertilizer for cereals was not found in the limited research data that we were able to locate. There appears to be little justification for including potassium fertilizer as a general recommendation for cereal grains. It is safe to assume that much of the potassium now used is being applied on soils which are high in potassium.

At the present time, most of the potassium fertilizer used in Morocco is imported. In 1975, a total of 71,453 MT of potassium sulfate and potassium chloride was imported (see Table 7). This represents

TABLE 9. Fertilizer Recommendations for Wheat: Institute National de la Recherche Agronomique

Area or Region	$N-P_2O_5 - K_2O$	Remarks
	kg/ha	
Rabat	50-20-30	Sandy soils
Rabat	40-65-55	Heavy soils
Taza	20-25-30	-
Fes-Meknes	40-40-0	N applied in fall/spring split
Rgarb	40-40-0	N application delayed until after floods
Chaouia	40-25-30	-
Doukkala	50-20-30	Sandy soils
300-400mm of rainfall	20-40-0	-
400-600mm of rainfall	40-40-0	-

SOURCE: Morocco: Role of Fertilizer in Agricultural Development, T.V.A. 1967

a total value of 36,405,150 Dirhams ($8,809,003), a substantial drain on the nation's economy. Therefore, a properly oriented soil testing program could more than pay for itself by reducing the amount of potassium fertilizer imported.

In conclusion, Morocco has not extended an effective fertilization program to the traditional dryland farmer. Most of the soils on these farms have a long history of crop production with virtually complete removal of straw and grain. Consequently, the soils are low in nitrogen, available phosphorus and possibly other nutrients. The only fertility restored to most of these lands is through slight manuring of grazing animals and from the spreading of some manure on a few fields.

Present Situation

The planting of most cereals in Morocco is by broadcasting the seed on the surface by hand and then covering the seed with a small wooden plow, steel plow or in a few cases tractors and covercrops (tandem discs). Fertilizer is also broadcast on the surface and incorporated in this manner when it is used. This type of system does not permit the extra response expected from applying phosphorus fertilizer with the seed in calcareous soils.

A mixed grade of fertilizer containing all three nutrients (Nitrogen, phosphorus, and potassium) is the most common fertilizer used at planting time. When small grains are topdressed, it is usually with a straight nitrogen fertilizer.

The modern sector with tractors and covercrops also use the old traditional method of broadcasting the seed and fertilizer followed by some type of incorporation, usually with a covercrop. In a very few cases drills were observed being used by the modern sector.

What Is Needed

A drill for planting the seed and dropping the fertilizer with the seed in the furrow is needed in order to get the full potential benefits from the phosphorus fertilizer on the calcareous soils of Morocco. Phosphorus fertilizer tends to form insoluble calcium phosphate compounds in calcareous soils and, consequently, becomes less available for crop use.

The placement of phosphorus in a band with the seed makes the phosphorus more efficient than broadcast applications (Table 10). At least twice as much phosphorus is required if it is broadcast rather than banded.

There is a need to develop a small drill to plant cereal or forage seed at the proper depth for better seed germination. The

TABLE 10. Effect of Band versus Broadcast Phosphorus Rates on Winter Wheat Yields - Avg. of 8 Sites, 1966-74

Phosphorus Rate P_2O_5 Pounds/Acre	Average Yield Broadcast	Bushels/Acre Banded
0	27.5	27.5
12	28.3	31.2
23	29.3	33.5
46	30.8	35.2
92	33.8	36.5

SOURCE: Thompson, Carlyle A. Fertilizing Dryland Wheat. Kansas State University Experiment Station Bul.590. 1975. 27p.

drill should be small enough to permit its use on the small irregular sized fields that are farmed by the traditional farmer. The drill should also have the capability of being pulled by animals such as burros, horses, or camels. The drill should have a seed box and a fertilizer attachment which runs the fertilizer into the furrow with the grain. This type of drill in effect provides and fertilizes a good "seed bed" in the row but leaves a poorly fertilized "weed bed" between rows.

However, it should be pointed out that this fertilizer attachment should be used primarily for phosphate or ammonium phosphate types of fertilizer. Nitrogen and potassium can also be applied as a starter fertilizer, but it should be recognized that they have a high salt index and can cause damage to seed germination. Therefore, nitrogen and potassium forms of fertilizer placed in direct contact with the seed should be limited to no more than 20 kg/ha (Whitney, 1974).

Nitrogen and potassium fertilizer can be broadcast and incorporated with the traditional plow or covercrop. These two nutrients do not react with the soil and form insoluble compounds that are not available to plants in the way that phosphorous does.

The top dressing of wheat with nitrogen in the spring is commonly recommended in Morocco if there has been sufficient rainfall. It is important to realize that the urea form of nitrogen is not suitable for top dressing small grains under certain situations. Urea nitrogen is subject to volatilization losses when applied to the surface of an alkaline soil (pH greater than 7.0) and during periods of relatively warm weather. This loss can be avoided if the urea is incorporated or if it rains shortly after it was applied. Of course, it is not possible to incorporate the urea when topdressing wheat nor is it possible to be sure that it will rain. The other forms of nitrogen fertilizers (ammonium nitrate and ammonium sulfate) are subject to much lower volatilization losses.

It is extremely important that the proper balance of fertilizer be used under dryland conditions. Most of the area in the 200-400mm. rainfall area is probably very low in available phosphorus. Unless the phosphorus requirements are met, the addition of nitrogen under limited moisture conditions will produce only slight yield increases. Nitrogen fertilizer tends to stimulate vegetative growth during periods of adequate moisture which in turn will deplete the available soil moisture before grain is produced. A balanced fertilizer program of phosphorus and nitrogen fertilizer that is applied in relation to the available moisture supply can increase the yields. A blanket fertilizer recommendation for dryland crop areas is a dangerous approach because of the highly variable climatic conditions.

Soil Testing

The most reliable means of determining fertilizer need is by

soil tests. After several consultations with various officials and researchers, it was found that no soil testing facility exists in Morocco for the purpose of making routine soil analysis for farmers. A certain amount of soil testing has been done for making physical and pedological measurements on research samples.

The proper amount and kind of fertilizer to apply depends on the plant nutrients already present in the soil and certain other soil characteristics such as acidity or alkalinity (soil pH). Different crops vary greatly in their plant food requirements. Climate also affects the ability of crops to use fertilizer. Thus, no two situations are exactly the same.

Chemical analysis, conducted under controlled conditions, can determine accurately the characteristics of a soil sample. Soil tests indicate the nutrient status of a particular soil whether it is low, medium or high. The analytical procedures used should be selected for the particular soil conditions that exist in Morocco. Analytical methods that are used for soil classification purposes are not suitable for evaluating the fertilizer requirements of a soil. Soil tests must be correlated with crop yield responses obtained from field tests conducted with a range of different fertilizer rates over the range of soils that exist in the areas where a particular crop will be grown. Sound fertilizer recommendations require a substantial background of field trials conducted over a period of several years on many different soil types. Fertilizer recommendations are based on soil test correlations.

Soil tests usually include a determination of soil pH (acidity or alkalinity), available phosphate and available potash. A buffer pH is run on soils with an acid soil pH to determine the lime requirement. Nitrogen determinations may be made in some cases. The nutrient status of phosphorus and potassium can be determined with a relatively high degree of accuracy. The available nitrogen level in the soil can also be determined by soil tests but not to the degree of accuracy as potassium or phosphorus. Accumulations of available nitrogen are likely to occur in fields receiving high nitrogen additions from either fertilizer or manure. Accumulations of nitrogen can occur under summer fallow conditions. Under these situations an available nitrogen test would be used to adjust the basic nitrogen recommendation.

Soil Testing Laboratory Capabilities

The laboratory should provide the soil tests needed to make the basic fertilizer recommendations for the dryland cereal crop areas. In addition, the laboratory should have the capability to determine the lime and fertilizer needs of the many other types of crops produced in Morocco. The soil testing laboratory should also provide a number of special tests. For example, zinc deficiencies

frequently occur for such crops as corn, sorghum, beans and citrus on calcareous soils and on recently leveled or eroded areas. Zinc deficient soils can be identified by soil tests and an appropriate zinc fertilizer can be recommended to correct the deficiency. The excessive application of phosphorus can, in some cases, induce a zinc deficiency. In order to avoid this type of nutrient interaction, soils that test high in available phosphorus should not receive additional phosphorus until the soil tests indicate a need for phosphorus.

The laboratory should be able check the boron level in the soils for the sugar beet growing areas. A standard recommendation for sugar beets is a fertilizer that contains N-P205-K20 plus boron (T.V.A. Report, 1967). Although boron deficiency symptoms have not been observed in sugar beets and no analyses have been made for available boron in the soil, the use of this micronutrient is still recommended. It is possible to build up toxic levels of boron in the soil by repeated applications of this micronutrient. The boron levels in the soil should be determined by soil tests before the soils have accumulated toxic levels of this element.

Soil salinity problems are known to exist in the Gharb, the Tadla, the Doukkala, Lower Moulouya and Souss Valley areas of Morocco. This indicates that the soil testing laboratory should be able to evaluate saline and sodic (alkali) soil conditions. An area with salinity problems can be identified with a few simple tests such as soil pH, conductivity, and exchangeable sodium percentage. Areas with potential salinity problems should be tested before large investments are made for such projects as irrigation development. Saline and sodic soils are very difficult to correct in many cases. These soils may have been caused by a drainage problem which can be very expensive to correct.

The soil testing laboratory should function as a service laboratory on a national basis and would eventually provide a wide range of testing services. The testing services should include routine soil samples for fertilizer recommendations, samples taken in support of the dryland research team, micronutrient tests (zinc, boron, etc), salinity tests, irrigation water quality tests, plant analysis, and forage samples.

Land Productivity Under Alternate Soil Management Systems

In order to evaluate the land productivity it is necessary to consider yields presently being obtained under the current management systems. Accurate information of this type is difficult to obtain. However, some interesting data were developed from a handbook of Agricultural Statistics (Table 11). The average yields shown in the table are high compared to some other reference material, but they do indicate that there is great potential for improvement.

Wheat yields of 14 bu/a (9.5 q/ha), barley yields of 20 bu/a

(10.8 q/ha) and corn yields of 11.5 bu/a (7.2 q/ha) are very low compared to U. S. standards. It is reasonable to assume that yield increases of 50 to 100% could be achieved with the use of fertilizer combined with proper cultural practices. Fertilizer demonstrations conducted by FAO have shown that such yield increases are possible, (Table 12).

TABLE 11. Yields Of The Major Cereal Crops For Morocco, Five Year Average. 1970-74

Crop	Quintals per hectare	Bushels per acre
Wheat - durum	9.90	14.7
Wheat - bread	9.19	13.7
Barley	10.84	20.1
Corn	7.20	11.5
Sorghum	11.07	16.5

SOURCE: Data developed l'Agriculture Morocaine en Chiffres 1969-1974, Ministere de l'Agriculture et la Reforme Agraire, Rabat. p.167

TABLE 12 . Summary Of FAO Fertilizer Demonstrations For Morocco 1961-1965

Number of Demonstrations	Crop	Treatment $N-P_2O_5-K_2O$ kg/ha	Yield kg/ha	Increase %
29	Soft Wheat	40-60-40	757	81
146	Hard Wheat	40-60-40	464	58

SOURCE: De Geus, J.G. Fertilizer Guide for Tropical and Subtropical Farming, 1967 p.103

In order to achieve satisfactory yield responses from fertilizer, other management factors must also be considered. The first priority is to achieve a satisfactory plant population. A sparse stand of wheat will not give a very large response to fertilizer. There will simply not be enough stress put on the soil's nutrient supplying power by a thin stand of wheat to require much additional fertilizer. Secondly, effective weed control must be attained, because weeds compete for soil moisture and nutrients just as effectively as the grain crop. The use of fertilizer materials without attention to other elements of the production

package under dryland conditions is a dangerous approach for two reasons:

1. It may not increase the yields. In fact, it could reduce yields in some instances.
2. Poor results on farmers' demonstration plots may discourage fertilizer use.

The ultimate objection of an alternative soil management system is to get a significant number of farmers to adopt the system. Therefore, the new system must be something that is relatively inexpensive, simple to use and can fit into the farmers' situation. This would immediately exclude the use of tractors, chisel plows and other big equipment. This type of equipment is not very practical, for example, on an irregular shaped, small, rocky piece of land with a 35° slope.

The alternate soil management system proposed here is to make available to the traditional farmer a small drill that can be pulled by animals. This drill would have an adjustable seed box for either cereal or forage seed and a fertilizer attachment for the placing of primarily phosphorus fertilizer with the seed.

The farmer would have available a supply of nitrogen fertilizer for top dressing the cereal grains in the spring if moisture conditions were favorable for a nitrogen response.

A very important part of this alternate soil management system is an effective Extension Service to demonstrate and advise how to use the small drill and, likewise, proper use of fertilizer. The Extension Service would need to periodically have some soil samples tested for some of the farmers that are in their extension area. It is only necessary to sample a certain field for a soil test about once every three or four years. If records are kept for a certain field then a soil test can be used for at least three years to make fertilizer recommendations.

The job of keeping fertilizer recommendations would be greatly simplified if there were fewer mixed fertilizers on the market. About all that is needed for the dryland small grain areas is the straight nitrogen fertilizers, superphosphate (18-20%) or triple superphosphate (45%), and 0-25-25. The large array of mixed fertilizer materials on the market is confusing to both the farmer and the one who has to make fertilizer recommendations.

Therefore, the alternate soil management system suggested here would use a "sweep" machine to till the soil for weed control and a small drill with a fertilizer attachment to plant the seed and fertilize with phosphorus (or perhaps a combination of nitrogen and phosphorus). After farmers had adjusted to the use of the drill and were using fertilizers, then the use of herbicides could be introduced for weed control in problem fields. Of course an effective Extension Service is a

necessary part of this system. Land productivity could be at least doubled compared to the present yields if farmers were provided with basic tools for planting and fertilizing their small grain crops.

There are three important components necessary to maximize yield and efficient use of fertilizer under dryland conditions.

1. Fertilizer recommendations should be based on soil tests.
2. Fertilizer should be placed where it can be utilized most efficiently. The phosphorus should be placed as a starter fertilizer with the seed. Part of the nitrogen (up to 20 kg/ha) can either be applied with the phosphorus fertilizer or applied broadcast at seeding time.
3. The total amount of nitrogen applied should be based on the moisture conditions. This means that the nitrogen applications should be split. The part of the nitrogen would be applied at seeding time and the rest as a topdressed application in the spring. The spring application would be applied if moisture conditions were favorable. If possible, the topdressed application of nitrogen should be a form of nitrogen not subject to volatilization. An effort should be made to use the ammonium nitrate and ammonium sulfate form instead of urea.

Present Soil Fertility Research Program In Morocco

There is very little published research on fertilizer materials, rates, time and method of application for dryland cereal crops. Nearly all research in Morocco has been conducted on the experiment stations under favorable conditions. Very little research information is available relative to fertilizer response under average field conditions of either the traditional or modern farmer. A large number of FAO fertilizer demonstrations were conducted under field conditions in Morocco (TVA report 1967). These demonstrations provided some valuable information relative to fertilizer response. The FAO demonstrations were not replicated except over time and numbers and, therefore, do not provide reliable data required for firm fertilizer recommendations or the correlation of soil tests with fertilizer responses.

The Bureau of Dryland Farming within the DMV (Direction de la Mise en Valeur) has initiated a dryland research program. This program is staffed by a chief and two women assistants. An interview with the Chief revealed that he is a capable young man who could turn out some valuable research information if he is provided with the necessary training, personnel, equipment and support. He is working with the extension centers to locate and establish research plots on farmer fields.

Tillage And Moisture Relationships

A significant part of the soils research program should be

directed towards tillage operations and moisture relationships. Tillage is a major element in the crop production system in Morocco. Concepts of seedbed preparation and weed control have long been based exclusively on tillage. Tillage operations per se waste water. Soil moisture is the primary limiting factor for crop production in the 200-400 mm rainfall area. Field observations taken during the latter part of November, 1976 demonstrated the loss of moisture from tilled fields compared to adjacent non-tilled fields. Some of the tilled fields had lost most of the moisture to the depth of tillage.

The climate of Morocco is unique compared to the dryland farming areas of the United States. Most of the moisture falls during the growing season of cool season crops between October and April. Annual precipitation is subject to much variation from year to year. The long, hot dry summers in the dryland cereal producing areas do not allow moisture to accumulate under fallow conditions. Fall preparation for seeding cannot start until the fall rains have moistened the soil. Winter temperatures are not cold enough to vernalize winter wheat or barley. Therefore, spring wheat and barley must be planted. There is a continuous growing season from planting time in October through December until April.

Therefore, a part of the soils research program should involve method and depth of tillage as related to soil moisture. If a small drill to plant cereal grains can be developed, this may provide a method to conserve soil moisture. Certainly this should be investigated along with other tillage methods. Soil moisture neutron probes or similar equipment should be available to study the various moisture relationships.

Proposed Field Research Program

There has been very little soils research directed to the small grain dryland areas in the 200-400 mm, rainfall zone. As the applied research program is moved to the field, there are several different variables that require investigation. The research variables listed below are not necessarily listed in order of their importance.

1. Assemble soil test information from the eight different provinces. This would require the services of a soil testing laboratory.
2. Nitrogen, phosphorus and potassium rate studies.
3. Soil test correlation studies. All experimental locations should have soil samples taken before the study and after the study was completed.
4. Method of applying fall fertilizers, such as broadcast, with or near the seed, and including depth of application.
5. Relationship of October through January rainfall to rate of nitrogen fertilization.
6. Topdressing studies with nitrogen to include rates and source of nitrogen.

7. Fall versus spring application of nitrogen.
8. The effects of method and depth of tillage as related to soil moisture.
9. Residual effects of fertilizers following a dry year.
10. Effect of previous crop on fertilizer requirements for small grain.
11. Time of seeding and rate of fertilization.

The soils research program should be coordinated and combined with the agronomic and plant protection programs as much as is practical. Field experiments can be designed to accomplish several purposes. For example, insect and disease observations can be taken on a nitrogen and/or phosphorus field experiment. A variety trial could be placed adjacent to a fertilizer trial. This would facilitate transporting of personnel, planting equipment and fertilizers needed for both field trials. Soil samples could also be taken from both experimental sites at the same time.

Qualifications Of The Soils Specialist From The U.S.A.

Qualification of the individual filling the position of the Soils Specialist should include a Ph.D. in Agronomy (Soils). This individual should have a minimum of five years of experience in field research in soil fertility and management. In addition, the individual should have some soil testing experience and be knowledgeable about the instrumentation and chemical procedures used in a soil testing laboratory. The individual should be able to train technicians to operate a soil testing laboratory or to conduct field research. Ability to communicate in French is necessary. The Soils Specialist should have a strong desire and commitment to work with people in a developing country.

Personnel Training In Soil Science

The success of the soil fertility and management program depends upon the training of Moroccan counterparts to continue and expand the program. Two Moroccans should be identified early in the program for soil science training in the U.S.A. to prepare for key roles in the dryland farming research program. These individuals should enroll in land-grant universities and major in agronomy (soil science). The students should be active in applied research programs in the U.S.A. to gain a background of personal experience in research techniques and procedures. They should write a thesis, rather than pursuing a non-thesis degree. Research should be conducted in areas closely related to soil fertility and soil management problems encountered in the dryland farming areas in Morocco. Research requirements should be flexible enough to be conducted either in the U.S.A. or Morocco or perhaps both locations.

One of the students identified for training the first year should be programmed for a Ph.D. degree. Preferably, this student would be a

graduate of Hassan II Institute or currently hold a M.S. Degree. Therefore, he could obtain his degree after spending approximately three years in the U.S.A. This individual should have an opportunity to work on an applied soil fertility research program for his Ph.D. Upon his return to Morocco, this individual would assume overall leadership of the soil fertility and soil management program. It is highly desirable that this individual receive his Ph.D. and be on the job for at least a year before the U.S.A. Soils Specialist leaves.

The second Moroccan student selected for advanced training in soil science should work towards a M.S. Degree and return to Morocco by the end of the third year. This individual should have experience working in a soil testing laboratory. The research for his thesis should be in the area of soil fertility experiments and soil test correlations. Upon his return to Morocco, this individual would help set up and supervise the soil testing laboratory. This individual should also be on the job for at least a year before the U.S.A. Soils Specialist leaves.

A third individual should be selected for advanced training in soil science starting in 1979. This individual should work toward a Ph.D. degree in an applied soil fertility research program. Upon his return to Morocco he would work with the dryland applied research team in a role to be most effective in program development at that time.

Individuals selected for soil science training after 1979 should be determined by the needs of the overall project. Area of training emphasis in the classroom and in the research field should also be regulated by the projected needs of the dryland programs.

Analytical, Forage, and Soil Testing Research Service Laboratory

Plans should be made the first year to start construction of a building or fix up a suitable facility to house the research service laboratory. The laboratory should include provisions for forage quality analysis. This would permit more efficient utilization of facilities, equipment and technicians. The laboratory should be ready to start testing soil and plant samples by the beginning of the fourth year. This would coincide with the return of the Moroccan student sent to the U.S.A. for a M.S. degree in soil science and to receive experience working in an analytical and soil testing laboratory.

Personnel Requirements For Laboratory

There will be a need for some secretarial assistance and technician help for the research service laboratory. This help will be required at the beginning of the fourth year when the laboratory becomes operational. Two laboratory technicians will be needed the fourth year. As the workload of the laboratory increases, an additional two laboratory technicians will be needed for the fifth year.

The two technicians hired the fourth year should have had courses in chemistry, biology and mathematics. They should be Ingenieurs d'Application graduates. One of these two technicians could be designated the chief technician in charge of soil testing and the other designated as chief technician in charge of forage quality analysis. The additional technicians hired the fifth year could be Adjoints Techniques.

Equipment List - Soil Fertility Research and Soil Testing Laboratory

First Year:

Vehicle (pickup or small truck)
Power soil probe to mount on vehicle
Equipment trailer - 12 ft.
Small seed drill with fertilizer attachment
Small grain thresher
Moisture meters (neutron probes, 3 units)
Drying oven
Balance (Mettler top loading, P 1200)
Miscellaneous (soil probes, tapes, etc.)

Second Year:

Tillage equipment
Small tractor

Third Year: (Order equipment for Analytical, Forage, and Soil Testing Laboratory)

Spectrophotometer
Meter (pH)
Atomic absorption spectrophotometer (with emission capabilities)
Soil grinder (Nasco-asplin)
Analytical balance
Shaker (two)
Refrigerator
Conductivity bridge
Kjeldahl apparatus
Chemicals and glassware
Water still
Fume hood
Mill (large samples), stainless steel
Mill (small samples), stainless steel
Hot plate
Drying oven
Automatic dispensers (3 units)
Miscellaneous (bottle racks, lab carts, etc.)

Fourth Year:

Miscellaneous

Fifth Year:

Miscellaneous

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Annex F. FORAGE AND RANGE ANALYSIS

Livestock Enterprises of the Small Farmer

Livestock production in Morocco has been important since early history. Until the French Protectorate was established in 1912, livestock production constituted the major source of income for most of the rural population. Frequent migrations and changes in occupancy of the land were common. Under these uncertain circumstances, livestock ownership was a more stable investment, and livestock husbandry was more attractive than crop production.

Today, livestock production and distribution of meat and meat products involve 70% of the population of Morocco. A large percentage of the livestock is produced on nearly 7 million ha. of the dryland area. It is estimated that livestock accounts for nearly one-half of the total value of agricultural output in the traditional sector.

The chief characteristic of the livestock industry is the great number of animals (Table 13). Numbers of sheep have more than doubled since 1930, while cattle and goats have increased by 67 and 68 percent, respectively, over the same period of time. Total stocking intensity increased by 84 percent between 1930 and 1974. A significant proportion of Moroccan livestock is produced in the eight provinces in the dryland farming region (Table 14). This area produces 48 percent of the sheep, 50 percent of the cattle and 24 percent of the goats. Most animals are multipurpose. Sheep commonly provide meat, milk and wool, while goats provide meat, milk and mohair. Cattle are dual purpose animals for meat and milk. In some regions cattle are used to pull farm implements. Dairy cattle are kept only in more favorable areas. These are generally irrigated areas near cities. Mixed types of animals are seen in most flocks and herds, while special improved breeds are virtually unknown. The horse, donkey and camel are draft animals.

Many years of mismanagement and overstocking have reduced forage production in the dryland farming area. Grazing intensities are three to seven times the actual carrying capacity (Table 15). This has resulted in the destruction of most of the native perennial grasses. Ironically, as the rangeland deteriorates, more animals are crowded on the land to offset the reduction in gains. The problem is compounded by increasing population and the ever increasing demand for meat.

Forage for livestock is classified as coming from four sources (Table 15). These sources are rangeland, fallowland, forests open to grazing and grazing stubble. Nearly all of the dryland region is used for grazing sometime during the year. Rangeland is generally too steep, dry and/or rocky to farm. It totals 1,973,500 ha. in the dryland farming regions of the provinces of El Jadida, El Kelaa des Srarhna, Essaouira, Khouribga, Marrakech, Meknes, Safi and Settat. Forests open to grazing make up a total of 1,057,500 ha. Grazing on forestland is largely controlled by the Government of Morocco, as contrasted to virtually no

TABLE 13. Trends in Livestock Population in Morocco, 1930-1974[1/]

	1930	1940	1950	1960	1969	1974
	(000)					
Sheep	7,716	11,141	10,000	14,000	13,233	16,000
Cattle	2,039	2,050	1,900	2,800	2,964	3,400
Goats	3,932	6,487	7,000	7,000	6,879	7,000
Camels	140	150	183	230	209	200
Hogs	97	85	100	47	13	11
Horses, Mules & Donkeys	885	887	920	1,600	1,806	1,860
Total Stocking in UGB[2/]	4,951	6,169	5,943	8,030	8,098	9,130

[1/] Source: 1930-1969; Livestock Marketing in Morocco, Food & Agriculture Division, USAID/Morocco, March 1971-1974; l'Agriculture Marocaine en Chiffres, 1969-1974 Ministere de l'Agriculture et de la Reforme Agraire, Juin 1975.

[2/] UGB (Unite de Gros Betail) or unit of big livestock, as follows: Cattle or camel = 1 UGB; Sheep or goat = 1/5 UGB; Horses, mules and donkeys = 1/2 UGB.

TABLE 14. Numbers of Sheep, Cattle and Goats by Province, 1974[1/].

	Sheep	Cattle	Goats
		(000)	
El Jadida	640	374	14
Khouribga	480	72	56
Marrakech[2/]	2,400	374	770
Meknes	1,760	272	350
Safi[3/]	1,280	238	420
Settat	1,120	374	56
Total	7,680	1,704	1,666

[1/] Source: l'Agriculture Marocaine en Chiffres 1969-1974 Ministere de l'Agriculture et de la Reforme Agraire, Juin 1975.

[2/] Currently divided into Marrakech and El Kelaa des Srarhna.

[3/] Currently divided into Safi and Essaouira.

TABLE 15. Grazing Resources[1/]

	Rangeland	Fallowland	Forests Open to Grazing	Grazing Stubble	Actual Carrying Capacity in UGB[2/] (000)	Total Stocking in UGB (000)	Ratio of Over-Grazing
	Hectares (000)						
El Jadida	70.0	60.0	5.5	509.0	64.5	450.4	7.0
Khouribga	92.1	6.1	6.4	224.0	32.9	226.5	6.9
Marrakech[3/]	1059.3	251.9	476.7	825.9	261.4	911.9	3.5
Meknes	435.0	50.0	299.0	272.4	105.6	599.4	5.7
Safi[4/]	115.5	155.0	234.4	666.2	117.1	351.3	3.0
Settat	201.6	135.6	35.5	540.0	91.3	350.5	3.8
Total	1973.5	658.6	1057.5	3037.5	672.8	2890.0	4.3

1/ Source: Livestock Marketing in Morocco, Food & Agriculture Division, USAID/Morocco - March 1971.

2/ UGB (Unite de Gros Betail) or unit of big livestock, as follows: Cattle or Camel = 1 UGB; Sheep or goat = 1/5 UGB

3/ Currently divided into Marrakech and El Kelaa des Srarhna.

4/ Currently divided into Safi and Essaouira.

grazing control on rangeland. Approximately 658,600 ha. of fallowland are grazed in the dryland farming region. This land may or may not be planted to a crop, and livestock utilize weeds and other plants. If planted, it is sacrificed for grazing because of expected low grain yield.

Forage production on fallowland is understandably low because grasses and weeds are grazed so closely that they are unproductive. But, it is an important complement to other forage resources. The major grazing resource in the area is classified as stubble, which is found on approximately 3,037,500 ha. Livestock is placed on these fields following the crop harvest. Livestock consume the crop residue as well as any weeds. The amount of stubble available is highly dependent on season and yearly growing conditions.

No pastures are sown specifically to provide grazing in the field. In the few instances where improved forages are grown, they are invariably cut and fed to confined livestock. Relatively little effort has been made to improve the forage supply either by improving rangeland or by sowing improved species. The system of tenure and land use leaves little incentive for improvement of the grazing land.

The traditional sector provides a precarious existence for livestock as well as man. In addition to facing extremes in climate, the farmer must contend with insufficient capital, land and technical understanding. Herds are much too large when compared to the ability of the land to produce forage. Wealth and prestige are measured in numbers of animals with little attention being given to saleable increase in weight and meat products.

Lack of forage is the principal limiting factor to livestock production. The majority of the animals are undernourished. ~~That the problem is increasing~~ is reflected in the fact that the average carcass weight of sheep went from 14.5 kgs. in 1955 down to 10.5 kgs. in 1973. It is estimated that losses from mortality and emaciation amount to nearly 140,000 metric tons a year while consumption is 130,000 tons.[1/] When droughts occur, a lack of reserve forage, often combined with a sensitive market, condemn the farmer to either forced sales or a high rate of mortality in his flock.

Nearly all of the farmers in the dryland farming region own sheep. Flock size varies greatly. A smaller number own cattle and/or goats. Lambing, kidding and calving begins at the start of the rainy season. Animals are not castrated or docked. Disease prevention measures are seldom practiced. Animals are placed on any available grazing resource. Annual grasses and weeds are common at this time of year. Free forage on rights-of-way and crop borders are also utilized.

After the planting of cereals, animals are generally restricted from grazing the emerging and developing seedlings. Animals have access to the cereal fields after harvest. The stubble is largely regenerated into

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1/ Three-year plan, 1965-67, GOM.

communal pasture and constitutes reserve summer pasturage. These stubble fields are grazed primarily during the hot, dry summer months. If available, large amounts of cereal straw are cut and stacked for reserve forage. This is fed from late summer until shortly after the start of the rainy season. Cereal straw, either fed as hay or grazed, is an extremely low quality livestock feed. Animals do not receive the necessary levels of many important nutrients, such as protein. Loss in weight is common, and the potential for disease is high in undernourished animals. Annual grasses and weeds, which appear after the start of the fall rains, are generally high in nutrient content while actively growing, but the quantity of this source of forage is often insufficient.

Most of the livestock is marketed in community souks, which are scattered throughout the country. Livestock is sold by the head through a process of individual bargaining between buyers and sellers. It is common for farmers to bring the same animals to market several times before finally selling. Most souks do not have weighing facilities whereby a farmer can find out the exact weight of his animals. There are no standards or established grades, therefore, farmers are not keenly aware of weight and quality differences in their animals.

A number of religious factors strongly influence the production and marketing of livestock in Morocco. The religious feast of Aid el Kebir has an important impact because one-fourth of the annual sheep and goat slaughter is associated with this feast. The feast currently falls at the start of December. This tends to compound the problem of forage supply because too many animals are held over the long dry season in order to take advantage of the higher prices before the feast. This holiday moves back approximately 11 days each year. Therefore, it will be a factor in holding animals for many years to come.

The commercial slaughter level is nearly 28,000 metric tons in the eight dryland farming provinces (Table 16). Commercial slaughter of beef is nearly three times the level of sheep slaughter. Goats and camels rate a distant third and fourth place, respectively.

The basic reason for low returns from livestock production is the fact that the dryland farmers do not care adequately for their flocks and herds and use even less care with their forage producing land. The existing livestock could produce higher yields if they were better fed. It is generally agreed that improvements in forage production, livestock quality and markets are basic to improving the livestock production systems of dryland farmers.

Alternate Approaches to Livestock Systems

Twenty years ago livestock production met the needs of the people of Morocco. But, with the increase in population and earnings of the middle class enabling a higher standard of living, the demand has outgrown the supply.

TABLE 16. Commercial Slaughter[1/]

	Mutton	Beef	Goats	Camels	Hogs	Horses & Mules	Total
	Metric Tons[2/]						
El Jadida	690.6	3,299.9	13.1	141.4	0.3		4,145.3
Khouribga	690.0	1,163.7	45.9	235.2		3.5	2,138.3
Marrakech[3/]	1,763.7	3,933.5	333.2	250.4	17.8	52.3	6,350.9
Meknes	1,014.4	4,728.9	782.2	59.7	89.2	39.4	6,713.8
Safi[4/]	1,334.8	1,963.6	621.3	304.2	6.4		4,230.3
Settat	893.9	3,038.3	125.5	123.4			4,181.1
Total	6,387.4	18, 127.9	1,921.2	1,114.3	113.7	95.2	27,759.7

1/ Source: Livestock Marketing in Morocco, Food & Agriculture Division, USAID/Morocco - March 1971.
2/ 1969 data
3/ Currently divided into Marrakech and El Kelaa des Srarhna.
4/ Currently divided into Safi and Essaouira.

Many alternate approaches to livestock production are possible for the dryland farmers. The first consideration is number of animals. The current forage supply is inadequate for the current livestock population. Therefore, numbers should be reduced or forage production increased. When one considers the increasing demand for meat, it is apparent that increased forage production is the most plausible choice. Increased emphasis in the area of forage production should be placed not only on increasing quantity but also on improving quality.

Total land area is limited, and the major land use in the dryland farming region is for cereal production. Increasing forage production at the expense of decreasing cereal production is not a sound approach. If cereal production per hectare could be increased, some of the cereal land could be freed for forage production. Currently, large amounts of farmland are fallowed. The main purpose of this practice is to supply forage in the form of low producing weeds and annual grasses for livestock. Occasionally it is land that has been seeded to a crop but is sacrificed for grazing because of expected low yields of grain. This constitutes an inefficient land use. The fallow hectares may well be used for forage production.

Most Moroccan dryland farmers own more than one type of livestock. This diversification helps to guarantee income, but it may not be the most efficient method of production. Efficiency gained in specialization to one type of livestock could increase livestock production by up to 25 percent. Due primarily to social factors, the dryland farmer will probably continue to own sheep and cattle for meat, milk, wool and investment purposes. He will own goats for meat, milk and mohair in areas where brush and weeds are available for pasturage. A smaller number of donkeys, horses, mules and/or camels will be maintained for transportation and draft animals.

Another alternative is specialization within one type of livestock. An example would be a farmer that purchased only young animals and grew them to slaughter size. Other farmers could maintain the breeding herds and produce the young animals. This can be contrasted with the current situation in which the full cycle from breeding through attaining slaughter size is accomplished on the same farm. The concept of wealth as numbers of livestock may be a barrier to this type of enterprise.

Management of dairy cattle is an example of one of the most intensive forms of specialization. Dairy products have the potential to increase the nutritional status of the rural people. However, dairy production is dependent on a large supply of high quality forage throughout the year. Such a supply will probably not become available in the dryland farming region. Dairy production is best adapted to higher rainfall or irrigated areas and should be attempted only by those possessing the highest managerial skills.

The most common cattle breeds are Brun Atlas and Oulmes. Many of the cattle in the dryland farming region are crosses between these two

breeds. The population of sheep is made up of indeterminate crosses of several breeds. The only breeding goal of most dryland farmers is to increase numbers. A few European breeds of cattle have been introduced into Morocco, primarily Limousin and Charolais. The introduction of these blood lines with their desirable characteristics of meat, milk and thriftiness has improved production even with low levels of management. The King Ranch at Adarouch has imported a relatively high number of Santa Gertrudis cattle. Production could be increased through selective crossing with this breed. Improved bloodlines coupled with a sound breeding program could increase cattle production by from 40 to 60 percent. Introduction of improved sheep breeding stock from Europe, Australia or the United States could improve sheep production by up to 60 percent.

Increased levels of livestock management would be productive. Uncastrated animals are allowed to remain with flocks and herds year around. The result is extended periods of lambing, calving and kidding. Animals could be bred to produce offspring over a shorter and possibly more opportune period. Death loss is high if the young are born before the rainy season begins. The level of nutritional intake both before and after birth is of prime importance. A minimum increase of 15 percent could be realized if lambing, calving and kidding could be synchronized to occur approximately two months following the start of the rainy season. Additional increases could be obtained with systematic weaning of young. Separating mature male animals, weaned young and female animals would increase demands on management.

Livestock health could be improved with relatively small inputs in management. Disease prevention practices such as immunizations could increase long-term livestock production by as much as 10 percent. It would greatly lessen the possibility of catastrophic losses during a disease epidemic. The simple improved practices of castrating, dehorning and docking could also increase returns. The major problem associated with all of these management practices is education of the livestock producers.

Cross Culture & Reg. Zinc & Balila

The current livestock system does not use weighing facilities. In addition, there are no established livestock grades or standards. Therefore, there is little incentive to improve livestock quality and production. Emphasis remains on production of numbers, not quality. It would be highly desirable to reform the marketing system in order to properly reward livestock producers for improving their product.

Any alternate approach to livestock production must include an increase in the forage supply. Without it, these practices are of little value.

Improved Forage Systems

Production of forage crops in rotation with cereals and on fallow land in the rainfed region offers a substantial source of livestock feed.

This source would be less costly and would be more satisfactory than constructing large central forage centers and stockpiling hay and grain for subsequent sale during periods of need.

Forage crops would be beneficial in crop rotation systems. Properly inoculated (Rhizobium spp.) leguminous plants would fix atmospheric nitrogen into a form of nitrogen that all plants can use. Therefore, soil fertility would be increased and the following crop would benefit. These forage crops would also have a good influence on the physical structure of the soil.

A number of possible alternative forage crops must be evaluated. These include annual crops, annual grasses and legumes and perennial grasses and legumes. Annual crops such as cereals have a considerable potential to improve forage supply and could use technology similar to that used for cereal grain production. Wheat, barley or oats could be planted in the fall and grazed throughout the winter or harvested for hay. Light grazing in mid-winter followed by removal of animals may allow grain production at reduced levels. Rye could be managed similarly, but it could withstand higher grazing intensity. Oats mixed with vetch is used occasionally in the dryland farming region of Morocco. This practice needs to be encouraged.

Grasses other than cereals should also be considered. Sudangrass, sudan-sorghum hybrids and sorghum almum are consistently high yielding forage crops. These are warm season plants that would take advantage of increasing spring temperatures. The availability of germ plasm that would have a favorable rate of growth in the cooler months should be explored.

The millets are another group of annuals that have the potential to become high yielding forage crops in Morocco. Millet has the ability to use soil moisture efficiently. Research on both pearl millet (Pennisetum typhoides) and foxtail millet (Setaria italica) has shown that sizeable forage yields can be attained in a relatively short growing period.

Small amounts of corn are grown for grain and forage in Morocco. The tops of corn plants are commonly removed after kernel set and fed to livestock. This practice undoubtedly reduces grain yields. Corn should be grown for grain or forage, not both. Under the dryland situation, crops other than corn would be more desirable forage crops.

Annual leguminous plants are grown for forage in parts of the dryland farming region, and their use should be explored further. Yields of berseem clover (Trifolium alexandrinum) can approach 50 metric tons of green weight per hectare but are less under non-irrigated cultivation. Vetch (Vicia sativa or V. narboneensis) mixed with oats is occasionally used for forage and soil improvement in a crop rotation system. Black medic (Medicago spp.) has been successfully produced in some countries in Northern Africa. It is an annual but easily reseeds itself. Townsville lucerne (Stylosanthes humilis) is another alternative. It produces high quality forage, thrives at high temperatures and is drought tolerant. Other annual clovers that should be evaluated include: T. angustifolium, T. hirtum, T. incarnatum, T. isodon, T. resupinatum, T. spumosum, T. pratense

and T. subterraneum. Other annual broadleaf plants such as rape (Brassica campestris) and mustards (Sinapis spp.) should also be evaluated.

Perennial forages have a distinct advantage over annuals because annuals must be seeded each year. The use of perennials would eliminate yearly seed, labor and equipment needs. One disadvantage of perennials is that many are slow to establish. This necessitates a temporary forage supply during the establishment period. This could be accomplished by growing an annual forage crop.

Perennial forages may be grazed or harvested for hay. Grazing intensity must be controlled to maintain the plant stand or the major advantage of the perennial would be eliminated.

There are a large number of both cool and warm season grass species adapted to the dryland farming region. Cool season grasses are able to take advantage of the existing available moisture and cool temperatures during winter. Cool season grasses generally are easier to establish, and establishment time is shorter than for warm season grasses.

Trial plantings of several wheatgrasses have been made by USAID personnel near Midelt, and large increases in production have been obtained. Wheatgrasses with potential include intermediate (Agropyron intermedium), crested (A. cristatum and A. desertorum), tall (A. elongatum), slender (A. trachycaulum) and western (A. smithii). One additional advantage is that some of these have large seeds that could be planted with grain drills. Many other perennial cool season grasses hve the potential to become valuable forage plants. These include: oatgrasses (Arrhenatherum spp.), bromegrasses (Bromus spp.), orchardgrass (Dactylis glomerata), veldtgrass (Ehrharta calycina), wildryes (Elymus spp.), fescues (Festuca spp.), ryegrasses (Lolium spp.), smilograss (Oryzopsis miliacea), hardinggrass (Phalaris tuberosa), bluegrasses (Poa spp.), and needlegrasses (Stipa spp.).

Warm season perennial grasses do not have the potential to fully utilize winter rainfall unless it can be stored in the soil. Many of these grasses are more difficult to establish than cool season grasses. Several should be evaluated. These include: yellow bluestem (Bothriochloa ischaemum), gramagrasses (Bouteloua spp.), rhodesgrass (Chloris gayana), bermudagrasses (Cynodon spp.), Japanese millet (Echinochoa crusgalli), lovegrasses (Eragrostis spp.), curly mesquite (Hilaria belangeri), panicgrasses (Panicum spp.), bristlegrasses (Pennisetum spp.), and dropseeds (Sporobolus spp.).

Perennial legumes have long been used for forage throughout the world. Varieties have been developed for use on dryland. High levels of breeding and selection have gone into alfalfa. These dryland varieties and others should be evaluated extensively in Morocco. The potential for other perennial legumes such as Astragalus spp., Lupinus spp., Lotus spp. and Onobrychis spp. should be established.

Mixtures of grasses and legumes have an advantage over either alone. In addition to providing forage of high quality, the legume provides nitrogen to stimulate and sustain its own growth and the growth of the grass.

These mixtures should be evaluated in detail. Timing of harvest is of prime importance in a forage program, and special attention must be paid to this component.

The choices of grasses and legumes to be included in mixtures for the dryland farming region must be compatible with each other and with soil and climatic conditions. Even when the selected species are apparently adapted, there will be differences in forage yielding capacity, palatability and nutritive values of the forage and seasonal rates of growth. To fully capitalize on each species, local field trials should be made. These performance data along with livestock preferences would be highly useful.

Program of Applied Research in Forage and Range Management

The ultimate goal of an applied research program in forage and range management is to improve the standard of living of farm families in the dryland region through increased livestock production. This can be accomplished by increasing the quantity and quality of forage available to livestock. This applied research program must be approached in an orderly, step-by-step manner to help assure that the overall goal will be reached (Table 17). It is essential that equipment needs are met (Table 18). Personnel training must be one of the prime considerations throughout the research program. Moroccans must be involved in each step of the program to help insure that it will remain viable and continuing.

Selection of Species: The first step in the applied forage and range management research program would be to select species that have the potential to increase forage production in the dryland farming region of Morocco. Priority should be placed on species listed in the Improved Forage Systems section of this proposal, but selection should not be limited to these suggested species. Representative species of all forage classes must be assembled. These should include both annual and perennial grasses and legumes, but other annual broadleaf plants and woody shrubs should not be overlooked. It will be important to obtain a broad range of genetic material. Special attention should be given to improved varieties. Continuous assembly and refinement of plant materials should occur throughout the applied research program.

The basic requirement for success is selection of a species that is adapted to the climatic and soil conditions and fits within the cultural practices of the area. Selected species must be able to make rapid growth and should not be highly susceptible to area diseases and insects.

Ease of planting is a crucial consideration. Ideally these forages could be seeded with an improved, simple drill that could also seed cereals. Seed size and type become important considerations.

The main limiting factor for forage production in the dryland farming region is precipitation. Both amount and seasonal distribution are important. Therefore, species with relatively high water-use efficiencies would

TABLE 17. Projected Scheduling for Forage and Range Program

Year	Projected Activity
First	- Select Forage Specialist; Preliminary assessment trip to Morocco; Assemble potential plant materials and research equipment.
Second	- Move to Morocco; Locate research areas; Train personnel; Establish a plant materials nursery; Continue plant materials assembly; Initiate field research with emphasis on screening annual forage species (for forage production and as a component of a crop rotation system); Initiate evaluation of cultural practices: seedbeed preparation, fertility, time of seeding, seeding methods, methods of harvest and storage, etc.
Third	- Continue plant materials assembly; Continue training personnel; Continue field research with annual forage species; Continue to evaluate and refine cultural practices; Initiate field research on perennial forage species.
Fourth	- Continue plant materials assembly; Continue training personnel; Continue field research with annual and perennial species; Continue to evaluate and refine cultural methods; Initiate evaluation of forage quality; Increase sites of field research.
Fifth and beyond	- Continue plant materials assembly; Continue field research with annual and perennial species; Continue to evaluate and refine cultural methods; Continue evaluation of forage quality; Initiate research on grazing management; Further expand sites of experiment.

TABLE 18. Estimated Equipment Needs for Forage & Range Management

Plant Materials Center

Tractor, 20-25 H.P.

Planter, small plot

Tillage equipment, small plot

Seed thresher

Seed separator

Seed cleaner

Balance, laboratory

Drying oven

Calculator

Miscellaneous (tapes, clippers, etc.)

Field Research

Vehicle (Pick-up or small truck)

Equipment trailer, 12 ft.

Drying oven, large, variable control

Balance

Calculator

Miscellaneous (fertilizer applicator, tapes, etc.)

be desirable. A high degree of competitiveness along with rapid seedling growth during the relatively cool rainy season would be essential for successful establishment.

Other factors also warrant consideration. The nitrogen fixing capacity of legumes is important. Some species are inherently able to fix larger quantities of nitrogen than others. Closely related is the varying fertility requirements of different species. Ease of stand destruction is a factor that must be considered if species are to be used in a rotation system with crops. If the forage crop is not completely removed, it will compete with the following crop. Ease of harvesting, curing, storage, and seed production must also be considered.

Special attention must be given to the compatibility of components of forage mixtures. Simple mixtures are generally better than complex mixtures. These species must have similar patterns of establishment and growth to avoid excessive competition. Similar palatability of the species components is important if the mixture is to be grazed.

Establishment of a Plant Materials Center: The second step in the applied research program would be to establish a plant materials center. The purposes of this center would be initial screening and refinement of the assembled varieties and species. Seeds of promising species would be increased for testing in the applied research program. Emphasis should be placed on adaptability and potential seed and forage production.

The center should be located in the dryland farming region. The average annual precipitation should be high enough to promote seed set in most years. Availability of supplemental irrigation to assure seed set would be desirable, although not necessary. One possible location would be on the GOM Station Experimentale de Merchouch, near Rommani. The center should be operated on a dynamic basis. New species and varieties should be continually added, and the less desirable plant materials should be eliminated.

Field Research: Sites selected for field research should have a broad representation of the soils and climatic conditions of the dryland farming region. A small number of sites should be selected for the initial phase of field research. The number of sites should increase each year as additional research locations are evaluated.

Annual forages have the highest potential to rapidly improve supply. Therefore, first emphasis should be placed on annuals in the applied research program in forage and range management. Research on perennials is also important and should be initiated during the second year of field research.

Cultural Practices to be Investigated:

1. Seedbed Preparation

Lack of moisture is the main enemy of forage seeds during germination. Therefore, proper preparation of the seedbed is probably the most critical challenge, and a major thrust of the applied research program should be in this direction.

Many forage seeds are small. Therefore, a firm but mellow seedbed is important to allow seed contact with the soil. Planting on rough, coarsely prepared soil usually results in losing seed from improper seed placement and lack of soil moisture. Adequate soil moisture may be present for many seeds to germinate, but it may be inadequate for seedling emergence and establishment.

Ideally, a seedbed should be moist, firm, fertile and free of weeds. Research should be directed to find the most economical method of soil preparation to reach this ideal. Equipment needed for forage and cereal seedbed preparation should be similar. The forage and range specialist should work closely with the agronomist and agricultural engineer in any design of new equipment.

2. Soil Fertility

Seeds will germinate with or without fertilizer, but young plants quickly use all the stored nutrients from the seed. A proper balance of nutrients in the soil will help assure a productive stand and will increase the nutrient content of forages. The proper fertility levels for the various forage crops in Morocco, precipitation zones and soils are not known. Research should be directed to obtain this information.

The beginning emphasis should be placed on the major elements of nitrogen and phosphorus. Phosphorus is the key element for establishment of both grasses and legumes. Effect of placement of this nutrient, as well as levels , should be thoroughly researched. Nitrogen is the key element for growth and root development. Properly inoculated legumes have the ability to fix atmospheric nitrogen into forms that legumes use for their own growth and contribute to the soil nitrogen supply for other crops. Contacts with inoculum producing companies must be made early to assure availability of the proper Rhizobium for each legume. Work with inoculation of the various legumes as well as economics of fertility programs must be integral parts of the applied research program.

3. Seeding Methods

A number of methods may be used in seeding forages. The simplest, but least effective, is broadcasting. Insufficient seed contact with the soil is a common problem. Grain drills may also be used. They are often less than satisfactory because of limited settings for small seeds and lack of a proper feeding mechanism for light, fluffy forage seeds. Special grassland drills have been designed to properly handle the task. But, they are expensive and are too large for most of the farmers in the dryland region to handle with existing

power sources. Research emphasis should be placed on development of a simple drill that would plant both cereals and forages. The drill should be small enough to be pulled by draft animals and should have an attachment that would enable fertilizer placement near the seed. This work should be done in cooperation with the agronomist and agricultural engineer.

4. Time of Seeding

Part of the research effort should be directed to determining the most favorable planting dates for the various forages. These dates may vary considerably between cool and warm season plants. Seeding time must be closely coupled to available soil moisture and probability of precipitation. Seeding in anticipation of rain is hazardous since light rains may stimulate germination, but not enough moisture will be present for establishment and growth.

5. Management and Protection of Seedlings

Research on proper seedling management should begin with emergence. Necessary levels of protection of new forage seedlings from grazing or other types of harvest must be determined by applied research. This knowledge will enhance maintenance of stand, forage production and nitrogen fixation by legumes.

6. Weed Control

Research must be designed to determine economical and effective weed control measures. Chemical, cultural, mechanical and biological types of control should be evaluated.

7. Harvesting and Storage

Forage that has been properly cut, cured and stored maintains its nutritive content. Time of cutting is critical. High quality forage is cut when it is leafy, before stems become woody. Protein in grasses can decline from 12 to 15 percent in growing plants down to 2 to 3 percent in mature, dry plants. The decline in protein content of legumes is even more pronounced. The levels of many minerals necessary for proper animal nutrition also decline as plants mature. Major reductions in nutrient levels can occur over a period of only two to three weeks.

On the other hand, forages can be harvested too early. The result is hay of high quality but low in yield. Only a well designed and executed program of applied research will identify the proper cutting time of various forage species.

Method of harvesting and storage should also be investigated. Emphasis should not be placed upon mechanical harvest methods alone. Work should focus on traditional methods which would be more acceptable to the dryland farmer. Expanded use of the scythe rather than the hand sickle may be one way to approach the problem.

Curing and storage also need to be investigated. Proper methods of curing or drying are necessary to maintain forage quality. Excessive drying causes loss of the high quality leaves, while inadequate reduction in moisture content may result in losses due to molding. The most economical method of storing harvested forage, while maintaining quality, must be identified. The largest losses of stored forage are due to water infiltration following improper stacking. Methods of stacking the various forages for storage and later use should be investigated.

Development of a Forage Quality Laboratory: Forage quality is determined by laboratory analyses. It will be necessary to have samples processed in existing laboratories in Morocco or the USA or develop a new forage quality laboratory. Existing laboratories in Morocco would process the samples, but they would be placed at a low priority. These laboratories would not set a definite cost per sample. Shipping samples to the USA would be costly, and there is always a risk of losing them. Therefore, a small forage quality laboratory would be justified. This development should be worked into the overall schedule at the start of the fourth year (Table 17), and should concentrate first on simple, routine protein analysis. This laboratory could also be utilized by the agronomist for analysis of cereals and could be set up in conjunction with a soils laboratory at the main station. The laboratory would complement the plant materials center, but it does not need to be located with it because forage samples can be brought into the laboratory from any distance. Future development of the program may warrant expanding the laboratory to include determinations of in vitro dry matter disappearance, phosphorus and others.

Grazing Management: The aim of management is to obtain the maximum amount of animal products without diminishing the forage resource. In addition, this must be economically sound. Not all of the forages produced in Morocco are, or will be, harvested. Productive forage when properly grazed is the cheapest feed for livestock. The cost when harvested is increased by the amount of labor involved. Research on management and utilization of forages by grazing animals is lower in priority than the previously mentioned research needs. But it must be done because plants respond differently to harvesting than to grazing.

Assuming that the applied research project will be continued, grazing research should begin by the fifth year of the program. Research must be designed and conducted on various forages to furnish information on stocking rates, fertilization requirements and application of rotational grazing procedures.

Forage Seed Production

The success of a forage improvement program depends on the availability of seed. Adequate quantities of forage seed are not available in Morocco. In addition, many species and improved varieties are not available. This lack of adequate quantities of seed has been a constraint to the current range improvement program. Purchase of seed from other countries has been expensive and undependable.

A forage seed nursery must be established in Morocco if a forage and range improvement program is to be a success. This need has been recognized earlier because USAID has planned a Forage Seed Nursery Feasibility Study to be completed in 1977. Forage seed needs for the dryland regions must be taken into consideration by the evaluating team. A coordinated effort should be made to meet the overall needs for annual and perennial grasses and legumes in the dryland farming region as well as in the rest of Morocco.

The Forage Seed Production Nursery should be closely associated with or a part of the Plant Materials Center. Research at the Plant Materials Center and in the field would indicate which varieties and species should be increased for seed at the Forage Seed Production Nursery.

Personnel Training in Forage and Range Management and in Livestock Management and Nutrition

Long-term success in the area of forage and range improvement will depend upon the training of Moroccans. These counterparts must be able to continue and expand the program. All students sent to the U.S.A. for training in forage and range management should enroll in land grant Universities and major in agronomy (forages) or range science. Livestock management participants should enroll in animal science departments and give emphasis in their programs to ruminant nutrition and the management of ruminant animals. Students should be active in applied research programs there through at least two years to gain a background of personal experience in research techniques and procedures. Each student should write a thesis rather than pursuing a non-thesis degree. Research should be conducted in areas closely related to forage and livestock production in the dryland farming areas of Morocco. Research requirements should be flexible enough to be conducted either in the U.S.A. or Morocco.

The following participant training is proposed for personnel in forage and range management and in livestock nutrition and management:

For National Applied Research Program staff:

1. Two Ingenieurs d'Etat for Ph.D. degrees in forage and range management.
2. Two Ingenieurs d'Etat for Ph.D. degrees in ruminant nutrition and management.

For Provincial Applied Research Program staffs:

1. Three Ingenieurs d' Application for M.S. degrees in forage and range management, including some courses in livestock nutrition and management.

One Moroccan should be identified as soon as possible for forage and range training in the U.S.A. to prepare for a role in the dryland farming applied research program. This individual should be encouraged to obtain a Ph.D. Preferably this student should be a graduate of Hassan II Institute or currently hold a M.S. degree. Therefore, he could complete his course work after spending approximately three years in the U.S.A. After his return to Morocco, he would become the forage and range leader and specialist on the national staff.

The second student should obtain a Ph.D. in forage plant materials evaluation and forage seed technology. This individual would become responsible for the Plant Materials Center and Forage Seed Production Nursery.

The two participants proposed for Ph.D. degree training in livestock nutrition and management will be team members on the national staff working closely with the forage and range specialists. They will give particular attention to improving livestock production through better feeding and management in the project area.

Because of the great importance of livestock in the project area and the special problems involved in improving forages to increase the feed supply, it is proposed that an Ingenieur d' Application be started on a Masters degree program each year beginning in the third year to prepare for working with forages and livestock on the provincial staffs. The first one should emphasize applied research on seeding and management of forage crops. The second should receive training in grazing management and livestock production. The third should have the same emphasis as the first for work in a different province.

Eventually there should be a trained forage and livestock specialist on each provincial staff team. Selection from the fifth year and beyond (See Table 4, page 16) and the emphasis in training should be determined by the needs of the program as it develops.

The laboratory needs for quality evaluation of forages can most efficiently be met by developing this capability in the proposed "Analytical, Forages and Soil Testing Research Service Laboratory" proposed to serve the total applied research program. The person in charge of this laboratory should give some attention to methods of forage quality evaluation in his training.

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Annex G. MACHINERY AND EQUIPMENT DEVELOPMENT FOR THE SMALL DRYLAND FARMER

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Annex G. MACHINERY AND EQUIPMENT DEVELOPMENT FOR THE SMALL DRYLAND FARMER

The Present Situation

The limited amounts and erratic distribution of rainfall limit the potential yields of the dryland farmer in Morocco. Changing these is not possible.

Other factors in present production systems also effectively limit the yields obtained, and these are subject to change. Ineffective tillage operations, poor seeding practices, inadequate weed control, varieties with limited potential, and low fertility in present systems are all important factors limiting the yields of dryland farms. Lack of suitable implements for tillage, seeding and weed control must be corrected as an essential foundation for any major advance in crop yields. There are no simple practices that can be instituted that will have a major effect until the small, traditional farmer is using suitable implements in his production operations.

Implements for tillage and planting now used by the small traditional farmer consist either of the traditional wooden plow or a small steel plow and occasionally a harrow - nothing else. These are pulled by teams of animals - camels, horses, mules, donkeys, oxen or various combinations. These machines as presently used waste precious moisture in the process of seedbed preparation and planting, do a very poor job of planting broadcasted seed, do not permit starter fertilizer placement with the seed, plant weed seeds as effectively as the crop, and only partly destroy weeds and growing vegetation at planting time. In spite of heavy seeding rates, prompt emergence and uniform stands are often not achieved. Placement of starter fertilizer with the seed would permit getting the same yield response at about half the rate of fertilizer required in broadcast applications. Crops undergo serious weed competition from germination to maturity.

The small traditional farmer cuts his grain with a hand sickle and threshes it by driving animals over it on the threshing floor. Both operations are very slow and tedious. Even though a lot of family and some itinerant or non-landholding labor can be assembled for harvest, heavy stands of volunteer grain in the fields is an indication of serious harvest losses, further subtracting from the low yields produced. Improved harvesting equipment would add productivity and dignity to the farmer's labor and save grain that is now produced but lost. The same sickles are used for the limited forage harvests now made.

Weed control after planting consists mainly of hand pulling weeds through the season to provide feed for livestock.

"Modern" farmers on larger farms most commonly use tractors and covercrops (tandem discs) for tillage. Both seed and fertilizer are broadcast and mixed with the surface soil with the covercrop. Except that the tractor-drawn covercrop controls weeds more effectively than the steel or wooden plows of the small farmer, it has the same shortcomings

otherwise. Actually, loss of soil moisture by tillage with tractor-drawn plows and covercrops is greater than for the implements of the small farmer. The "modern" farmers need implements similar in functional design to the small farmer, that is, "sweep" machines for shallow tillage and effective weed control with minimum loss of water and drills for planting seed effectively and placing starter fertilizer with the seed.

Most of the farmers owning tractors own or have access to self-propelled combines for harvest. Heavy stands of volunteer grain in fields harvested with combines is a common sight, indicating that improper adjustment and poor maintenance are common.

Machinery And Equipment Requirements For Improved Crop Production

Improving the productivity of the small dryland farmer in Morocco is dependent on general adoption and use of (1) "sweep" machines to control weeds effectively at or just ahead of planting by shallow tillage that will waste little water and leave a firm seedbed and (2) appropriately designed drills for planting seed and placing starter fertilizer with it. These two items must be designed for simple maintenance and operation and small enough in size to be pulled by the relatively small animals now being used. They are essential to progress.

Perhaps a machine can be designed that permits mounting the seeding and fertilizer units so the hoes making the furrows follow immediately behind the sweep. This would permit the shallow tillage for weed control, planting and starter fertilizer application in a single operation. With the planting equipment removed, the sweep machine part could be used for shallow tillage for weed control.

The only feasible way to effectively control some weeds, primarily broadleafs, in the growing cereal crop is by spraying with herbicides such as 2, 4-D. There are herbicides that control wild oats in spring wheat, a serious weed in some areas in Morocco. DRA has done effective research on this. In spite of problems associated with illiteracy of the small farmers, effective extension work will permit gradually expanding use of herbicides. This is dependent on either knapsack sprayers or sprayers mounted on light animal-drawn carts. Small sprayers dependent on simple hand operated pressure devices or no-pressure sprayers would be adequate, practical and inexpensive enough for small farmers to own and use if applied research shows that yield losses due to weeds justifies the cost of equipment and herbicide. Such units would also permit emergency control of insects if loss of crop were threatened.

Cutting grain or forage with a hand sickle is slow and tedious. Justifying a mechanical mowing machine for the small farmer in the near future seems out of the question. The use of scythes and cradles in place of sickles, however, justifies consideration, especially if greatly increased productivity is obtained for forages to be harvested, and cured, and stacked for hay or cut as green feed for livestock. Use of

well-designed scythes will greatly increase the area that one person can harvest in a day. This gain in timeliness will be essential if high yielding forages are to be cut in the relatively short period of time necessary to preserve their high quality for feeding. Use of scythes or cradles may also speed cereal grain harvest and reduce harvest losses.

Use of animal activity on a threshing floor as a means of threshing grain is slow and reduces the potential quality of the threshed grain. Simple mechanical threshers should be developed that individual small farmers or family groups might use to thresh the seed from the heads. Even though winnowing by hand were still involved, such machines should shorten the threshing season and result in improved quality of grain.

Socio-Economic Considerations For Mechanization Of Small Farms

Three major factors need to be taken into account in any discussion of mechanization of farm operations in Morocco. First, the current mechanical ability of Moroccan farmers, second, the infrastructure available in rural areas to support such mechanization, and third, the ability of the Moroccan economy to support such mechanization.

The average Moroccan small farmer is non-literate (this is in no way any indication of native ability). Thus the communication of information concerning use and care of any mechanical devices would have to be visual and by demonstration. The average Moroccan farmstead appears to include almost no mechanical devices. Thus farmers are not acquainted with the techniques of care and repair of such devices and the education to use any machines would have to be very elementary.

The lack of mechanical devices in general use in rural Moroccan areas has prohibited the development of any supportive system such as dealers to sell and service such items. Even in the larger cities which include significant numbers of automobiles, motorbikes, household appliances, etc., the dealer and service support system seems still to be in the process of developing. Therefore, the introduction of any significant mechanical device which requires maintenance such as replacement of parts or of the total device would require the development of a system of distribution and service including local service personnel and dealers.

The third factor, which will be only briefly mentioned here, is the ability of the Moroccan economy to finance such a system including the importation or the manufacture of the devices and any necessary parts. Obviously, any mechanical devices to be introduced would have to result in sufficient additional products such as wheat or barley which enter the cash market in sufficient quantities to more than offset the costs of producing, distributing and servicing such devices. The phrase

"cash market" presupposes a system which for many products and/or for many areas is weak or non-existent and again requires a developmental process.

The conclusion to be drawn from this discussion seems obvious: any mechanical devices to be considered must be simple, cheap, and require very little maintenance. The introduction and diffusion must be gradual to allow time for a service network to develop.

Design And Performance Requirements Of Needed Machinery And Equipment

The fact that the small farmers of Morocco must have different machinery than they now use, if they are to increase their yields and productivity, makes the design of such equipment and the construction and testing of prototypes an essential component of the applied research program. Indications are that Morocco has the manufacturing capability to produce the kinds of relatively simple machines that are needed.

There is great merit in using prototype machines in as many field experiment activities of the applied research program as possible with scientists soliciting farmer assistance in supplying the animal power for the machines in putting out experiments. As soon as available, production machines should be used in experiments whenever possible with no more modification than necessary to permit meeting the objectives of the experimental designs used in research.

The "sweep" machine should be designed to be drawn by a team of small horses or donkeys. It may have two 400 mm. (16 inch) sweeps and till a width of 700 to 750 mm. (28-30 inches). Perhaps it may even need to be only 500-600 mm. wide with three "duckfoot" shovels to meet draft limitations. The machine needs wheels and a design for controlling the depth of tillage from a uniform depth of about 50 mm., or in sandy soils or special conditions up to 75 mm. Recognizing the limited power of a team of small draft animals, the machine needs to be simple and sturdy but no heavier than necessary to get penetration and function properly. Essentially all straw is removed from grain fields of small farmers. Thus, rolling coulters may not be commonly necessary. Provision for attachment of coulters ahead of the sweep shanks may be necessary for those cases where crop residues make them necessary.

The following are principles that operate in seed germination:

1. Seed planted must be viable;
2. Adequate water must be absorbed from the soil to permit the cells of the seed to resume active division and growth;
3. Oxygen must be available to meet requirements for respiration;
4. The temperature must be suitable.

While it is well to have a germination test of any lot of seed just prior to planting, seed will probably germinate well that is from

the present year's harvest and that matured properly, was harvested and threshed without damage, and was stored at less than 13% moisture in day storage conditions. (Cleaning seed to remove weed seeds and other foreign material is always desirable).

If soil is not waterlogged, there should be sufficient oxygen in the soil air to support germination. In the Central Plains and Central Plateau areas of Morocco soil temperature will probably be very suitable for germination anytime between October and May. Thus, water is the essential factor to be considered.

The moisture requirement for germination can best be met by a drill or planter that opens a narrow furrow with a hoe or disc and places the seed firmly on moist soil at the bottom of the furrow. The seed should then be covered with 25-50 mm. of soil. It is important that the soil below the planted seed be firm and moist. Thus, it will provide an ample amount of water to wet the seed and start the germination process and a zone of wet soil for the seedling roots to penetrate and assure establishment. The amount and firmness of soil above the seed is much less important than that below the seed, soil covering the seed should usually be less than 50 mm.

Requirements for the small drill are generally similar to the sweep machine. Draft must permit operation with a small team of animals for power. Thus, width will be restricted to from 500 to 900 mm. (18 to 36 inches). If 7 or 8 inch row spacings are used, perhaps it will plant 3 to 5 rows at a time. It must have wheels that provide depth control of the hoe furrow openers from perhaps one inch for forages to no more than 3 inches for cereals. A seed press wheel following immediately behind the hoe and firming the seed at the bottom of the furrow ahead of a simple covering device seems almost essential. The metering devices of the seed and fertilizer boxes must have simple positive drives and function with little friction and low power requirement. They should give relatively precise metering of a wide range of seeds including wheat, barley, oats, lentils, peas, chickpeas, forage grasses and legumes, and even maize and horse beans, if possible.

If the planting and fertilizer mechanisms could feasibly be developed as attachments for the basic sweep machine, this should be considered.

In any case the drills must be simple, sturdy, easy to operate and maintain, and positive in effectively planting seed and placing fertilizer, and their draft requirements must not exceed the power commonly available on the small farms.

If not already in progress, manufacturers in Morocco should get designs and tool up for manufacture of knapsack and small mounted sprayers.

The possible advantage of scythes and cradles over sickles should be explored by foreign purchase of a few hundred units for testing by

farmers willing to work at mastering their proper use. If they have anticipated advantages, certainly Morocco has manufacturers that can make them.

The agricultural engineer and American small machinery manufacturer should address the problem of simple threshing devices at the same time or just subsequent to development of prototypes of drills and sweep machines. Development of threshers, while not essential to the other components of the applied research program, appears to be justified as a means of increasing the productivity of the small traditional farmer.

Implement And Equipment Development Team

For development of the small "sweep" machine and drill, a team of three persons is proposed to work with a Moroccan manufacturer: (1) a U.S. agricultural engineer, (2) an agronomist experienced with tillage and planting equipment used in the U.S. dry farming area, and (3) an innovative American small machinery manufacturer. This team should be assembled and initiate its activities as soon after July 1, 1977 as possible. They may benefit from a visit to countries in the Far East or other areas where much attention has been given to developing machinery for small farms.

Inquiries have led to the conclusion that Morocco has manufacturers in Rabat and Casablanca with the capability of producing such machinery. The design team should work directly with these manufacturers in developing prototype units for testing. These should be available no later than the fall of 1978. The testing should be carried out in conjunction with applied research activities but adequately checking a wide range of soil conditions across the project area. Prototypes should be modified and retested as necessary to achieve a satisfactory design before manufacture for general distribution is undertaken.

It is estimated that the three members of the design team would spend initially about six months developing the first prototypes. One or two members of the team might spend two months at planting time the second year in further testing and modification. One member of the team would return the third year to check as necessary on performance and with manufacturers to be sure that production units will perform satisfactorily.

Early in the development of prototype implements, the design team should work with the agronomists of the applied research program to develop modified units to be used in field experiments such as variety tests and fertilizer trials. Use of such machines in applied research will lend credibility to use of the machines and demonstrate their value in production.

Although the development of a "sweep" tillage machine and a drill are items of highest design priority, the implement and equipment development team should also work with GOM, AID/Morocco and applied research

staff on spraying equipment, scythes and cradles and simple threshers.

Recognizing that the development team might need to purchase and import machine parts or models as well as travel to see and study other units, the following budget is suggested:

FIRST YEAR

3-man team for 6 months	18 man-months
Travel	$10,000
Commodities (equipment, parts, etc.)	$20,000

SECOND YEAR

1 or 2 men for total of 4 months	4 man-months
Travel	$3,000
Commodities	$5,000

THIRD YEAR

(Same As Second Year)

FOURTH AND FIFTH YEARS

Total of 4 man-months
Travel $3,000

TENTATIVE EQUIPMENT DEVELOPMENT BUDGET - TOTAL

Development team	30 man-months
Travel	$19,000
Commodities	$30,000

ANNEX H. ECONOMIC CHARACTERISTICS OF THE TRADITIONAL DRYLAND ARABLE REGION OF MOROCCO

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Annex H. ECONOMIC CHARACTERISTICS OF THE TRADITIONAL DRYLAND ARABLE REGION OF MOROCCO[1/]

Introduction

Economic growth in Morocco in the agricultural sector has lagged far behind the non-agricultural sector over the past several years. Agriculture accounts for about 75% of the total production and 40% of its exports. The country's population is 64% rural.

During the period of 1963-1975 the gross national production measured in 1960 prices increased at an average annual rate of 4.9% a year or a total of 59% for the 12 year period. During the same period agricultural productivity measured in terms of 1960 prices increased a total of only 19% or 1.6% per year. Agricultural production in terms of products marketed peaked in the 1973-74 production year due to heavy liquidation of livestock following the drought of the previous year and the much better growing conditions in 1973-74. It dropped about 12% in 1974-75 from the 1973-74 level in terms of 1960 prices.

In a country whose population and production are dominated by agriculture and whose population is growing at an annual rate of 3.0%, an annual growth rate in its agriculture production of only 1.6% per year results in severe maladjustments in its economy. Increased imports of food to feed its population, declining income per farm family and increased underemployment in the rural sector are among the several problems that result from lack of growth.

Within the agricultural sector there have been great inequities in the growth rate. The modern or commercial sector has about 15% of the arable land but produces 85% of the commercial production (all products sold on the market for either export or domestic consumption including bread wheat). It is modern with respect to using commercial inputs of seed, chemicals and machinery, having a well developed market, getting first priority in the use of credit and having increased its productivity rapidly.

By contrast, the traditional sector or subsistence part of agriculture has no doubt declined in its total productivity in terms of 1960 prices in the 12-year period 1963-1975.

1/ In this economic section of the report the traditional dryland arable region of Morocco refers to the eight provinces (Settat, Khouribga, El Jadida, Safi, El Kelaa des Srarhna, Essaouira, Marrakech and Meknes) defined in Annex C. as the project area.

The following is a more detailed description of the economic characteristics of the traditional dryland arable region of Moroccan agriculture. The tribal grazing lands which are a part of the traditional lands are not included in the arable (cultivable) land description except where it is found in the provinces included in assembling the data for this analysis. Included also are sufficient data for all of Morocco to make comparisons between the traditional and modern agricultural sectors.

The data identified in this report as representing the traditional dryland arable region (the project area) is based on published information from the six provinces of Meknes, Settat, Khouribga, El Jadida, Safi and Marrakech which make up a major portion of the arable dryland area. In 1976 the province of Marrakech was subdivided into two provinces namely El Kelaa des Srarhna and Marrakech and the province of Safi was subdivided into two provinces manely Essaouira and Safi. In general, a line drawn eastward from Casablanca to the Atlas Mountains divides the country between the modern and the traditional agricultural regions.

The emphasis of the information is on the small farmer whose numbers dominate the traditional sector and whose problems are the focus of this report.

Population, Rural Households and Farm Units

The population in the traditional dryland arable farming area of Morocco is dominantly rural. Based on 1975 estimates, 73% of its total population or 3,797,000 persons are classified rural out of a total of 5,214,000 people. For Morocco in total 63% of the population is classified as rural (Table 19).

In the traditional area some of the provinces are almost entirely rural. The province of Settat is 83% rural, El Jadida 84% and Safi 78%. Marrakech, the largest province in area which has one of Morocco's major cities, has 75% of its population rural. In addition, the rural population is widely dispersed throughout the rural area.

TABLE 19. Population in Morocco and the Traditional Dryland Arable Area, 1975 Estimates.

Province	Total	Urban	Rural	% Rural
Meknes	831,246	401,186	430,060	52
Settat	723,223	121,179	601,444	83
Khouribga	369,506	161,138	208,368	56
El Jadida	632,170	98,620	533,550	84
Safi	964,397	207,947	756,447	78
Marrakech	1,693,666	427,201	1,266,465	75
Total Dryland	5,214,208	1,417,271	3,796,937	73
Total Morocco	17,055,732	6,108,223	10,947,509	63

Rural farm households in 1975 are estimated at 1,824,600 in all of Morocco of which 1,459,600 represent farming units (Table 20). In all traditional dryland arable area it is estimated that there are 632,800 rural households and 659,500 farm units.

In the traditional arable area the relationship of farm units to total households is higher. The area includes few major urban areas and thus has less urban workers living in the rural area.

Table 20. Estimated Rural Households and Farm Units in Morocco and Traditional Dryland Arable Area of Morocco, 1975.

	Rural Households	Farm Units
Morocco	1,824,600	1,459,600
Traditional Dryland Arable Area	632,800	569,500
% in Dryland Area	34.6%	39.0%

Land Use in Morocco

Morocco has a total land surface estimated at 50 million hectares.[1/] Of this 7.3 million hectares are arable, 6 million are non-arable grazing lands and 5.2 million are forests. These uses account for 18.5 million hectares with the remaining 31.5 million hectares or 63% of the land surface in mountains, deserts and waste land other than the relatively small amount used for urban areas and roads.

The arable lands, totaling 7.3 million hectares, consist of about equal hectares of barley and wheat (with durum wheat accounting for three-fourths of the area in wheat). The two cereals, barley and wheat account for better than 53% of the arable land with another 10.5% in pulses, vegetables and annual industrial crops (cotton, tobacco, etc.). Broad beans, chickpeas, green peas and lentils make up most of the pulses produced. Fallow land which consists largely of weeds and volunteer cereal plant growth used for pasture makes up 22.5% of the arable land with the remaining 4.7% of the area being in fruit and olive plantations.

Much of the grazing lands are collectively owned. In addition, some of the forest lands are grazed.

The true character of the fallow land is difficult to identify. Its main use is to provide pasture for livestock during the growing season when stubbles are not available. Whether it is a planned use or represents crop failure or lack of time to prepare soil and plant is not clear. It does represent a significant area in the traditional dryland arable region.

1/ Prior to annexation of the Spanish Sahara in 1976.

Table 21. Land Use in Morocco, 1973-74.

	Hectares	% of Arable Land
I. Arable Lands		
1. Cereals		
Wheat, durum	1,388,500	19.1
Wheat, bread	528,500	7.2
Barley	1,972,600	27.1
Oats	19,000	0.3
Corn	447,200	6.1
Sorghum	70,000	1.0
Canary grass	23,600	0.3
Rice	3,800	-
Other	89,500	1.2
Total Cereals	4,542,700	62.3
2. Pulses	586,300	8.0
3. Vegetables and other annuals	180,900	2.5
Total Annual Crops	5,309,900	72.7
4. Fallow (volunteer plant growth used for pastures)	1,641,300	22.5
5. Plantations (fruit and olives)	349,400	4.7
Total Arable Lands (irrigated 406,540 Ha.)	7,300,600	100.0
II. Grazing Lands	6,000,000	
III. Forest Lands	5,216,000	
Total Agricultural Lands	18,516,600	
IV. Other (urban areas, roads, mountains, deserts, etc.)	31,483,400	
Total Land Surface of Morocco	50,000,000	

Land Use in the Traditional Dryland Arable Regions

About 51% of the total land surface in the region identified as the traditional dryland arable area is classified as arable land.

Barley dominates the production of cereals utilizing 67% of the cultivatable land and accounts for 94% of the total hectares of barley in Morocco (Table 22).

Wheat in the region accounts for 37% of the total hectares of wheat in Morocco. Due to the low rainfall the production per hectare is lower than the average for the nation.

Pulses are produced on only 231,800 hectares or 8% of the crop land cultivated annually in the dryland area, but they represent 40% of the total hectares devoted to pulses in Morocco. They no doubt are grown in the better land areas as well as on irrigated lands.

The hectares of irrigated lands in the traditional dryland area has been increasing. In April 1975 the Ministry of Agriculture reported two major projects in the area, the Doukkala in El Jadida province with 28,200 hectares and the Haouz project in Marrakech province with 58,500 hectares. This is a total of 86,700 hectares under irrigation.

Data on the crops grown on the irrigated land is not readily available. Based on observation while traveling through the area it can be concluded that fruits, vegetables, cotton and other high value crops plus durum wheat and high volume forages such as berseem clover and alfalfa make up the major uses.

Table 22. Land Use in the Traditional Dryland Region of Morocco, 1973-74.

Crop	Hectares	% of total in Morocco
Wheat (durum and bread)	701,900	37
Barley	1,863,600	94
Pulses	231,800	40
Other	10,400	
Fallow Lands (estimate)	1,000,000	60
Total Arable Lands	3,807,700	
Non-arable Lands	3,702,300	
Total Lands	7,510,000	
Arable Land - Irrigated	86,700	21

Yields of Cereal Grains and Pulses (Table 23).

The average yield data for the three major cereal crops in Morocco during the five-year period 1969-70 through 1973-74 provide some observations that are significant in looking at the future for increased productivity. First, the severity of the 1972-73 drought is very apparent and indicates the production risks involved due to climatic conditions. Wheat and barley yields which dominate the cereal crops in the dryland arable area dropped sharply. The yield per hectare in bread wheat was 25% below the 5-year average while barley yields declined 43%. Many observers believe the yields in 1972-73 were actually much lower than those reported.

Second, the relative stability of yields during the other four years plus the yield levels obtained indicate that the combination of fall and winter rains plus the cool weather provides a reasonable environment to increase the productivity levels in the dryland arable areas.

Plantings of annual cool season crops are made in the fall and early winter and harvested in the spring. Because of this, production and harvest periods are identified as two years 1969-70 indicating planting in 1969 and harvest in 1970.

Table 23. Yields of Cereal Grains and Pulses in Morocco, 1969-70 & 1973-74 Harvests
(Quintals per hectare and bushels or pounds per acre)

Crop	1969-70	1970-71	1971-72	1972-73	1973-74	1969-70 & 1973-74 5-year average
	Q /Ha	Q /Ha	Q /Ha	Q /Ha	Q /Ha	Q /Ha
Wheat, durum	9.86	10.82	10.84	8.00	9.93	9.90
Wheat, bread	8.43	10.98	10.70	6.98	8.94	9.19
Barley	10.33	12.87	12.76	6.22	12.10	10.84
Pulses 1/	8.40	7.88	8.61	6.40	12.01	8.25
	Bu /A	Bu /A	Bu /A	Bu /A	Bu /A	Bu /A
Wheat, durum	14.7	16.1	16.1	11.9	14.8	14.7
Wheat, bread	12.5	16.3	15.9	10.4	13.3	13.7
Barley	19.2	23.9	23.7	11.6	22.5	20.1
Corn	10.0	13.7	12.2	7.8	13.9	11.5
	Lb /A	Lb /A	Lb /A	Lb /A	Lb /A	Lb /A
Pulses 1/	749	703	768	434	1071	781

1/ Broad Beans, Chick and Green Peas, Lentils and other pulses.

Livestock Production

Although much emphasis is placed on crop production and its need for improved productivity in Morocco, livestock including cattle, sheep and goats are a very important part of the agricultural picture. In fact, livestock may be as important to the farmer in the dryland arable area of Morocco in capital generation and his economic security as land.

The livestock production in the traditional dryland arable area of Morocco is a significant part of the total livestock production (Table 24). 50% of the cattle are in this area plus 48% of the sheep and 19% of the goats. As one travels over the area the combinations of livestock on the farms in the arable area change as the rainfall levels decline. In the northern better rainfall areas, cattle dominate with some sheep and a few goats. Moving south and west, the annual rainfall declines and sheep become more dominant, and increasing numbers of goats are present. Small herds dominate in the same manner that small farms dominate. Any total program to improve the well-being of the farmer in the dryland arable area will have to include improving the livestock enterprise along with the improvement in crop production.

Table 24. Livestock Population in Morocco, 1974.

	Total Number in Morocco	Number in Arable Dryland Area	% in Arable Area
Cattle	3,400,000	1,704,000	50
Sheep	16,000,000	7,680,000	48
Goats	7,000,000	1,666,000	24
Hogs	11,000	N/A	
Donkeys	1,200,000	N/A	
Horses	320,000	N/A	
Camels	200,000	N/A	
Mules	360,000	N/A	

Size of Livestock Enterprises

There are 3.4 million head of cattle in Morocco including 850,000 milk cows. The bulk of cattle numbers consist of a somewhat dual purpose type cow (beef and milk) and young animals. Small herds dominate the enterprise with 50% of the cattle in herds of 5 head or less (Table 25). This is associated with the large proportion of farming units that are less than 5 hectares in the country.

Table 25. Size of Cattle Herds in Morocco.

No. of Cattle	% of Cattle Producers	% of all Cattle
1 head	10	2
2 - 5 head	68	48
6 -10 head	17	28
11 or more	5	22
	100	100

The sheep numbers, totalling 16 million head, follow somewhat the same pattern as the cattle numbers in terms of size of herds measured in animal units (1 cow equals 5 ewes) although in actual numbers they are larger. Table 26 shows that 32% of the producers have 10 or less sheep and only 6% of the total numbers in the country. The sheep enterprise provides both meat and wool with a very limited number milked.

Table 26. Size of Sheep Herds in Morocco.

No. of Sheep	% of Sheep Producers	% of All Sheep
1 - 4 head	12	1
5 -10 head	20	5
11 -20 head	26	12
21 -50 head	27	27
51-100 head	10	20
101 and more	15	35
	100	100

The goat population in Morocco is estimated at 7,000,000 head. A larger proportion of the herds are smaller than the sheep herds. Table 27 indicates 43% of the producers have 10 or less goats representing only 8% of the total. Goats can survive under rather extreme conditions and are found mostly in the very dry arable areas. They are used for both milk and meat with production at extremely low levels per animal.

Table 27. Size of Goat Herds in Morocco.

No. of Goats	% of Goat Producers	% of All Goats
1 - 4 head	21	2
5 - 10 head	22	6
11 - 20 head	20	12
21 - 50 head	23	29
51 -100 head	8	23
101 and over	6	28
	100	100

Work Animals and Tractors

The source of power for pulling equipment in the traditional dryland arable sector consists almost entirely of horses, mules, camels, donkeys, and, in many instances, cows or bulls. In addition, the donkeys which comprise 45% of the work animals provide the major source of transportation for most farmers and their families.

Table 28 gives the available data on farm power for all of Morocco. Based on an estimate of 1,459,600 farming units in the country, the 15,450 tractors are a very small part of the farm power supply. They are mostly on the large farms in the high value crop areas. The few that are found in the traditional sector are in the better rainfall areas on the larger farms or where machinery cooperatives or extension work centers are found.

Over the entire traditional arable area bicycles and motorcycles are in noticeable numbers and are rapidly increasing even in the most rural parts.

Table 28. Sources of Farm Power in Morocco, 1974.

Work Animals	No. of Animals
Horses	320,000
Mules	360,000
Camels	200,000
Donkeys	1,200,000
Total	2,080,000

Tractors	No. of Units
Wheel Tractors	12,450
Crawler Tractors	2,800
Motor Cultivators	200
Total	15,450

Marketing and Price Policies for Cereals

Cereals enter the commercial market in Morocco in two ways. The farmer, if he is a member of a cooperative, must deliver and sell to the cooperative his cereals (bread and durum wheat and barley) if he produces above his own needs for food and livestock feed. Other farmers sell to independent dealers or in the local public weekly market known as a "souk".

The cooperatives are essentially government agencies. The independent grain dealers are of two types. The small dealers have no storage space, usually own a truck and buy in small quantities at the weekly souks and sell to the so-called licensed dealers. The licensed dealers are merchants and warehousemen with storage space representing the private, well capitalized sector of the marketing process, buying from the producer and the small dealer. They function somewhat parallel to the cooperatives.

Commercial storage is reported adequate in total for normal crop years but how well it is actually used, especially if there is an above normal crop, is another question.

Morocco probably has as good a road system as any developing country, especially in the major cereal grain producing area. Trucks, both private and government owned, haul practically all the cereals that enter into commercial channels. The rail system connects all major cities but is used very little for transport of grains. There is little reason to assume that the movement of grain, once it is in commercial channels, has any serious transport problems. It, of course, peaks at harvest time, and real problems exist when there is a bumper crop.

The bread and durum wheats and barley are called the controlled cereals and the government plays a major role in the pricing of these grains. All bread wheats must move through OCIC (national cereals office) controlled marketing channels at a fixed price. In the case of durum wheat and barley the government maintains a support price (Table 29).

Table 29. Support and Fixed Prices for Controlled Cereals, March 1975.

Cereal	Support Price		
	DH/Q 1/	$/Bu	$/MT
Durum Wheat	63	3.81	139.86
Barley	40	1.93	88.80
	Fixed Price		
Bread Wheat	60	3.62	133.20

1/ DH = dirhams. In November 1976 the exchange rate was approximately 4.5 dirhams per U.S. dollar.
Q = quintal = 100 kilograms = 221 pounds.

The farmer is usually paid close to the national support price less transportation charges to designated storage areas if the size of the total crop is average or above normal. If the crop is below normal, the price for durum wheat and barley can and will go above the support level; but bread wheat cereal price is fixed. In all grains the fixed or support price is based on a standard quality. If a farmers' crop falls below these standard qualities, the resulting price to him will be below the average price. No data are readily available on the seasonality of prices, but it is safe to assume that it will vary greatly from week to week at the local weekly market (souk). Table 30 is a summary of cereal price data of larger markets or collection points. The Safi market is the only market of those listed that has a harbor facility. All others are interior markets which probably accounts for some of the variations.

Table 30. Average Prices Paid Producers for Cereals at Several Locations, 1973.

	DH per Quintal		
Market	Durum Wheat	Bread Wheat	Barley
Meknes	62	48	45
Settat	59	50	41
Khouribga	58	45	47
El Jadida	52	43	46
Safi	70	53	46
Marrakech	57	51	46
National Average			
DH/Q	65	52	51
$/Bu	3.93	3.14	2.46

This description of the marketing system for cereals does not adequately indicate the situation of the small farmer. Estimates indicate that at least 75% of the total cereal production in Morocco is utilized on the farm directly, taken to the local miller for processing and returned to the farm, or is traded in the local markets (souks) without government supervised measurement or control. In other words only 25% enters the commercial market through government supervised channels.

Based on this 75% estimate, it is safe to assume nearly 100% of the cereal grain produced by small farmers typical of the dryland arable area is home consumed or sold in the local souks in small quantities. The exception would be in the case of the small number of such farmers who are members of cooperatives. The amount that goes into the souk by the small farmer will be determined by what he has in surplus over his own needs for food and his animals. If he has borrowed funds, seed or services for growing and harvesting crops or rents the land, he may find it necessary to

deliver more than his needs for home use to make payments. In many cases where land is rented the farmer may have a deficit after he delivers the share of the crop required to pay the rent or pays for purchased products or borrowed funds.

The typical small farmer will bring his surplus cereals to the souk by donkey in either bags that hang on the side of the animal or in a burlap sack balanced on the back of the donkey. In many situations the distance involved may consume the greater part of the day in travel. How much the small farmer knows about the market price or how well he relates to the support price can only be guessed. It is safe to assume he is at the mercy of the buyers. The support price may be quoted, but discounts for quality and foreign matter will be large. In addition, when the market is glutted at harvest time the discount will be very severe. Probably his only advantage is that his transportation to market is the donkey and so he brings in only small quantities at a time. This may spread the marketing of his limited surplus over a longer period, and he may sell some in non-surplus market periods.

The grain storage on the farm is reported commonly to be an unlined pit that can be up to 4 meters deep with a 1/2 meter opening. At 4 meters depth it will hold up to 110 quintals (403 bu.) of cereal. After being filled, the top is covered with a large stone and then sealed with earth. It would appear that the cereal would deteriorate and be bug infested but reports are that cereal can be kept for several years by this method and stay in top quality condition. If this system works as well as reported, it would represent one of the securities against adverse conditions that the small farmer has developed by holding a limited quantity of cereal over long periods.

Livestock Marketing

Livestock makes up about 50% of the total value of agricultural production in Morocco. There is a greater quantity of beef entering the commercial markets, but lamb and mutton are the preferred meat by most Moroccans. In beef the supply available is related to the seasonality of the feed supply. In sheep both the seasonality of the feed supply and the religious holidays when large numbers of sheep are slaughtered by individual families influence the supply and demand at the market. Prices of sheep will average 50% higher in the winter when the feed supply is good as compared to the very dry summer months when feed is of short supply.

The demand for sheep at the time of the festivities is up sharply as rural families slaughter their own and urban families buy sheep for the ceremony and often at a great sacrifice.

Beef prices follow the same seasonal pattern as sheep prices with the high price coming during the winter months. Some believe that they follow sheep prices rather than responding to the supply of cattle at any particular time. Beef slaughter accounts for nearly two-thirds of total annual commercial meat production in the country. A higher proportion of the sheep and goats are slaughtered by families and local killers than of beef.

The government role in livestock pricing is less apparent than in cereal pricing at the farmer level. Through subsidies at the wholesale and retail level plus controlling exports and imports, the government does subsidize the consumer.

There is very little, so-called, feeding of animals to improve their condition for market. The only exception is that some grain feeding occurs with sheep previous to selling for the religious holidays to get a better market.

Part of the supply of beef comes from the dairy herds in terms of young animals and culls. In the traditional area the beef comes from the bull calves and cull cows. All heifer calves that survive must be kept for replacement because cows only calve every 20 - 24 months and there is high mortality among cows. There is a long standing tradition and prejudice against castration of male animals in Morocco. This no doubt results in a decrease in total meat production. In addition it results in indiscriminate breeding which makes improvements in livestock difficult.

Little information currently is available on livestock prices. The response to several requests for prices on livestock was that they fluctuate so widely from week to week that nobody knows the price. In addition, it is said that buyers are reluctant to tell what they paid for animals.

On an early morning visit to a souk near Rabat in late November 1976 a few days before a religious holiday, it was observed that a good sheep was selling for between 400-500 DH ($80-$100) and young bulls weighing nearly 180 kilos about 1100 DH ($220) per head. Later reports from this souk indicated that about noon the price on sheep and cattle dropped nearly 50%.

As with the cereals, the only livestock market for traditional farmers is the weekly souk in his area. He is no doubt at the mercy of the dealers who make those weekly markets day after day. The souks are community sponsored, and the schedule is arranged so there is no competition between markets in an area at the same day. Animals are sold by the head. The price per head is a bargaining process between buyer and seller and naturally involves much haggling. If the seller feels the price is too low, he may take the animal back home and return at a later date. It is fairly safe to assume that the small farmer brings the animal to market because he has to have the funds and must sell. If it is at the end of the harvest season when market livestock numbers are high, he will get a low price. His animals will be thin and of low quality, and the buyer will take advantage of all the discounts he can.

How much meat the small farmer will use for home consumption other than the sheep on religious holidays is an unknown quantity. The amount is probably very little. He will obtain milk from his cows, sheep or goats for his home needs. He may have a few eggs from his hens and eat some chicken. It is doubtful that he eats any beef except on very rare occasions.

Accessibility of Commercial Inputs

The well-developed systems of agricultural production in the modern sector of the better rainfall and irrigated areas of Morocco indicate that the availability of commercial farm inputs must be quite adequate for these farms. These no doubt have all the problems involved when everyone wants fertilizer and other chemicals at the same time, with competition for improved varieties of seed, with obtaining of import or purchase permits for large farm machines and the management problems that are related to handling local workers.

On the other end of the continuum, the typical farmer in the traditional dryland arable region uses very little if any commercial inputs in his farm business. Thus, there is little development of supply services in these communities. The more progressive small farmers who are members of cooperatives or cooperate with the extension service have a better opportunity of obtaining such supplies. But even in these situations we heard many reports of the failure of the suppliers to deliver on time or not at all, resulting in the proposed improvement never occurring.

By observation one can conclude that the weekly souks are more adequate in meeting the small farmer's needs for marketing than for providing needed farm inputs. Since his major demands are steel points and wood poles for wooden plows, draft animals, twine and rope for harnesses, sickles, wooden forks and maybe a little fuel for a lantern, little commercial supplying develops due to the demand. Services for maintaining bicycle and motorcycles are growing more rapidly in these rural communities than commercial farm supply services.

The achievement of a successful agricultural development program in the dryland arable area will require commercial inputs of seeds, chemicals and implements. Along with the development of improved production techniques, it will be essential to make needed supplies available in adequate quantities and when required. In addition, increased production will result in increased marketing. The adjustments essential in the marketing system must go hand in hand with the new technology and supply availability, or the adoption will not occur.

Data is available on qualities of fertilizer currently used in Morocco in the soil section of this project report. Other data on supplies are quite unavailable.

Agricultural Credit in Morocco

The National Bank for Agricultural Credit (Caisse Nationale de Credit Agricole) is the government owned bank which provides credit to farmers in Morocco. It has a series of local offices (CLCA) which finance small farmers, and also a series of regional offices and a national office which service cooperatives, the modern sector and the larger farms. Credit is extended at a rate of 6% to the small farmer which is much below the rate for risk funds from banks and other sources in Morocco.

An examination of the data in Table 31 indicates that very little bank credit is made available or used by the great bulk of the farmers in Morocco. In the 1973-74 season the bank made 109,418 loans totaling 593 million DH. Assuming one loan per borrower, the 109,418 farm borrowers represent only 7.5% of estimated 1,459,600 farm units in Morocco.

TABLE 31. Credit Extended by the National Bank for Agricultural Credit, 1973-74

Short Term	Amount	%
National Banks (CNCA)	244,781,786	62
Regional Offices (CRCA)	134,921,853	34
Local Offices (CLCA)	14,971,320	4
	394,674,941 DH	100
Number of Short Term Loans	54,210	-
Intermediate Term		
National Banks (CNCA)	68,456,076	34
Regional Offices (CRCA)	74,861,564	38
Local Offices (CLCA)	65,563,037	28
	198,880,677 DH	100
Number of Intermediate Term Loans	55,208	
Total Credit Extended	593,555,618 DH	
Total Number of Loans Made	109,418	
Estimated Number of Farm Units in Morocco	1,459,600	
% Farmers Borrowing from Agricultural Credit Banks	7.5%	

No data are available on merchant and dealer credit or other borrowing in either money or kind (such as seed from a neighbor that is paid for in either money or a share of the crop at harvest time). But one has to assume that these are a major source of borrowed capital used by the small farmer. In addition, of the total loans of 593 million DH, better than half are made to cooperatives which make either loans or supplies available to their members and collect in the form of products received at harvest time. It is thus apparent that unless the farmer is a member of a cooperative, his opportunity for bank credit is further restricted.

The information on the size and purpose of the bank loans adds additional insight on the development problems faced in the traditional arable area. Table 32 gives the number of loans and size of loans made by the local office (CLCA) of the national banks in the traditional arable region. CLCA loans are restricted to farmers who have less than 6 hectares of land. The average short term loan was 466 DH with about 60% of the funds used for cereal and pulse production and most of the rest equally divided between harvest and pastures.

TABLE 32. Credit Extended in Dryland Arable Areas by CLCA* (local offices of the National Agricultural Credit Bank), 1973-74.

Purpose	No. of Loans	Total Loaned DH	Av. Loan DH	Av. Loan $
Short Term				
Cereal and Pulse Production	8,396	3,737,600	445	98
Harvest	3,010	1,491,600	495	109
Pasture	2,110	1,063,500	504	111
Other	69	48,100	697	153
Total	13,585	6,340,800	466	103
Intermediate Term				
Stock Animals	3,981	3,853,200	968	213
Draft Animals	8,902	8,228,900	924	203
Wells	1,841	3,750,500	2037	448
Shelter	2,421	4,431,300	1830	402
Other	1,673	3,721,000	2224	493
Total	18,818	23,984,900	1274	280
Total All Loans	32,403	30,425,700	939	206

The intermediate term loans (up to 5 years) total 23.9 million DH as compared to 6.3 million for short term purposes by the local banks. This apparent lack of short term loans to small farmers as compared to intermediate term loans is offset by loans from the regional banks to small farmers through cooperatives for seed and fertilizer as shown in Table 33. The intermediate term loans by the local banks are dominated by loans for draft animals averaging 924 DH per loan. The large loans were for wells averaging 2,037 DH per loan and shelter averaging 1,830 DH per loan.

The credit provided in the dryland arable area by the national and regional offices of the credit bank follows a somewhat different pattern than the credit extended by the local banks (Table 33). The short term loans make up a much larger portion of the total loan fund since much of the funds extended to cooperatives is used to finance seed, fertilizer, fuel and machine service to its members. In addition the use of funds by the

* The local office (CLCA) may extend credit to small farmers only.

larger farms from this source is indicated by the number of tractor loans as well as the size of loans ranging from an average of 13,367 DH for stock animals to 3,348 DH for stone clearing and 2,669 DH for harvesting. The average loan made by the regional and national bank offices was 7,151 DH as compared to 939 DH by the local office.

TABLE 33. Credit Extended in the Dryland Arable Region by National Agricultural Credit Bank and its Regional Offices, 1973-74.

Purpose	No. of Loans	Total Loans DH	Per Loan DH	Per Loan $
Short Term				
Cereal and Pulse Production	3,299	15,819,900	4,795	1,054
Harvest	1,526	4,073,200	2,669	587
Cattle and Sheep Production	2,094	17,599,300	8,404	1,849
Other	387	1,132,300	2,926	643
Total	7,306	48,815,700	6,681	1,470
Intermediate Term				
Stock animals	308	4,117,000	13,367	2,941
Tractors	246	1,890,100	7,683	1,690
Shelter & storage	589	3,702,800	6,286	1,383
Stone clearing	197	659,500	3,348	736
Other	1,408	13,390,100	9,510	2,092
Total	2,748	23,795,500	8,659	1,905
Total All Loans	10,154	72,611,200	7,151	1,573

In summary, the agricultural credit bank made 10,134 loans in 1973-74 through its national and regional offices and 32,403 loans through its local offices which totaled 42,537 loans in the dryland arable region. There are an estimated 569,500 farm units in the region. Assuming one loan per borrower, then only 7.4% of the farmers used or had available credit from the Agricultural Credit Bank. It is also reasonable to assume that some borrowers would have more than one loan since the loans are listed by purpose, so in reality less than the 7.4% used bank credit. This analysis of available credit data indicates the meager proportion of farm operators being reached and the insufficient amounts of credit being made available by agricultural lending institutions in Morocco in total and especially in the traditional dryland region.

If this area is to develop its agriculture, an improved agricultural credit system is needed. It will need to be geared to small farmers and be tied closely to a technical assistance program that appears not to be in existence today in any appreciable degree.

Agricultural Cooperatives

Much has been written about the role of cooperatives in Morocco. All are government sponsored, directed and controlled. If one assumes that a farmer is a member of only one cooperative, the 25,166 members in total as shown in Table 34 represent only 1.7% of the estimated 1,459,700 farmers in Morocco.

The Agrarian Reform, Fruit and Dairy Cooperatives are involved in supplying farm inputs and marketing. The machinery cooperatives represent groups of farmers who own tractors and other machinery together. Limited data are available as to the extent of their activities. All four types of cooperatives are vehicles for extending agricultural credit through the regional and local offices of the National Agricultural Credit Bank. The Agrarian Reform Cooperatives are made up of farmers who have purchased small farms made available from recaptured or government lands and are required to be members.

TABLE 34. Agricultural Cooperatives

Type of Cooperative	No.	Members	Hectares Serviced
Agrarian Reform	439	13,851	204,466
Machinery	357	2,390	56,135
Fruit	217	2,925	22,680
Dairy	73	6,000	
	1,086	25,166	

Land Ownership and Tenure Patterns

Private ownership dominates the land holding patterns in Morocco. The pattern is somewhat different between the modern and the traditional farming areas of the country. In the modern or better land area, as shown in Table 35, 68.5% of the arable land is privately owned, 25.2% state owned and 5.7% charitable lands. Only 0.6% is collectively owned. The modern sector includes most of the fruit, vegetable, industrial and oil crops plus some of the wheat production.

In the traditional sector 86.7% of the land is privately owned, 7.0% state owned, 6.1% collectively owned and 0.2% are charitable lands.

TABLE 35. Estimates of Land Ownership in the Modern and Traditional Sectors of Morocco.

How Owned	Modern Sector 1000 Ha	%	Traditional Sector 1000 Ha	%	Total 1000 Ha	%
Arable Lands						
Private (Melk)	1,090	68.5	4,950	86.7	6,040	82.7
State	400	25.2	400	7.0	800	11.0
Collectively	10	0.6	350	6.1	360	4.9
Charitable	90	5.7	10	0.2	100	1.1
Total Arable	1,590	100.0	5,710	100.0	7,300	100.0
Grazing Lands						
Private (Melk)	-	-	350	5.8	350	5.8
Collectively	-	-	5,650	94.2	5,650	94.2
Total Grazing	-	-	6,000	100.0	6,000	100.0

In both the modern and traditional sector there are no data available on how much of the privately owned land is owner operated and how much is tenant operated. Of the state lands much is operated as state farms with a limited area rented to small farmers. The charitable lands are rented to the highest rent bidder at auctions held annually.

The collectively owned arable and grazing lands that are not in agrarian reform cooperatives are generally allocated to members of the tribes or groups on an annual basis. In the arable area the lands allocated to the individual may be changed each year and can be in several fragmented pieces. The pattern in the collectively owned grazing lands is not clear.

Morocco declared its independence from France in 1956 and started recapturing the large land holdings of the colonials that had not already been transferred by some method to a few Moroccans. By 1973 all remaining foreign held lands were nationalized. In addition the Agricultural Code of 1969 included plans to adjust the inequities and inefficiencies of the land holdings of Moroccans. The stated goal of the government has been to transfer the recaptured lands to small land owners and landless families. About 260,000 hectares of foreign land have been appropriated. Some of this has been retained as state farms, some used for experiment stations and similar uses and some redistributed to farmers under the direction of the Agrarian Reform Section of the Ministry of Agriculture.

By the end of 1972, 181,194 hectares from recaptured properties, state farms and king's lands had been distributed to 11,101 beneficiaries with average holdings 16.32 hectares and organized into 348 cooperatives. Known as Agrarian Reform Cooperatives, they are directed by a government appointed individual making them fully government controlled. Much publicity naturally has been given to these cooperatives; but, as of the present time, their membership represents slightly less than 1% of the farm families in Morocco who own less than 2 hectares.

The lands in the Agrarian Reform Cooperatives are divided into columns with each beneficiary assigned a column which is plowed and sprayed by the cooperative. The individual is responsible for his own weeding and harvesting. All crops are sold through the cooperative which arrange also for seed, fertilizers, mechanization and related items. Being an Agrarian Reform Cooperative, it gets discounts on seed and fertilizer of 20 to 30% from government plus up to 50% on machinery. The member also is provided a small piece of land which he can use as he pleases such as for pasture or other crops.

The cooperatives are found in both the modern and traditional sectors, with a limited number in the irrigated lands. After 1972 the program came to almost a standstill. The current five-year plan of the Moroccan Government calls for an additional 395,000 hectares to be distributed.

Rental terms in the cultivated areas of the country generally are a share of the crop for the use of the land with the tenant providing all of the inputs. Under some situations it is reported that different persons will provide land, seed, equipment and labor; and the crop is shared accordingly. But apparently this system is decreasing. Little or no data are available on the shares. Conversations with a few Moroccans indicate that the landlord gets half or more of the crop.

In the traditional area more than in the modern area, fragmentation of land holdings is a severe problem. It is largely a result of dividing the land among heirs. Current laws now forbid this and provide for the recombining into larger units. The continued fragmentation apparently has been stopped, but very little has been attempted in recombining.

In total, the landowning and tenure pattern in Morocco is far from clear. It is without question a major obstacle in agricultural development, in increasing productivity and improving the well-being of the great majority of farmers in the country. The government's stated goal is an income of 3,000 to 4,000 DH per farm family. Estimates are that this will require 10 to 25 hectares of land per farm depending on the quality of land and rainfall area. For every farm family given this opportunity who today has less than this amount of income and land, two or three other farm families will become landless.

Land Distribution by Size of Farm in the Traditional Dryland Arable Area

Inadequate census data plus the nature of how land is owned and rented make it difficult to find reliable data as to the exact number of farms by different sizes. All data do indicate the domination of the small farms and fragmented land holdings even in the lowest rainfall area of the dryland arable region.

Estimates in the dryland arable region indicate 76% of the farm units have 6 hectares or less of arable land with more than half of these less than 3 hectares (Table 36).. The 76% of the farm units of 6 hectares or less have about 40% of the arable land area. On the other hand 1.2% of the farm units, making up the large farms, control 12% of the arable area. For Morocco in total, studies indicate even a higher percent of the farm units are 2 hectares or less.

TABLE 36. Estimate of Land Distribution by Size of Farm in Traditional Dryland Arable Region.

Arable Ha.	No. of Farms	% of Farms	Arable Land Hectares	% of Arable Land	No. of Ha./Farm
0-3	230,100	40.0	571,200	15.0	2.5
3-6	201,600	35.4	971,000	25.5	4.8
6-12	74,000	13.0	723,500	19.0	9.8
12-25	57,000	10.0	1,085,200	28.5	19.0
26-50	5,700	1.0	266,500	7.0	46.8
50 & over	1,100	0.2	190,300	5.0	173.0
	569,500	100.0	3,807,700	100.0	6.7

Regardless of the exact number of farm units that are 2 hectares or less, it is very apparent that adequate sized farm units to provide a minimum of subsistence to the farm family is one of the top priority problems. The solutions include increasing productivity, recombining fragmented holdings and a gradual increase in farm size per family. The Moroccan Government estimates that 10 to 25 hectares of land is needed, depending on area of the country, to provide a minimum level of income per farm family. To achieve this goal would mean a vast movement of the farm employed population to some other part of the economy.

The Average Farmer in the Traditional Dryland Arable Region

Averages can be misleading. It is recognized that great differences exist amount the 569,500 farm units in the region included in the defined area of this program. Recognizing that the description of an "average farmer" does not describe either the typical farmer or any specific farmer, still the following description is valuable in giving a deeper, clearer perspective of the situation.

For the area under study the average farm is described in Table 37. It has 6.68 hectares of arable land. Barley uses 3.29 hectares or 49% of the land base and accounts for 65% of the value of crops produced. 26% of the land is in fallow (see land use section for discussion on the nature of fallow). The fallow area plus stubble used after harvest for grazing livestock have not been assigned a value in developing the crop income, but it makes a real contribution through livestock to the income of the farm. Total harvested crop production per farm based on 1969-70 to 1973-74, 5-year average yields and 1975 prices amounted to 2,208 DH per farm. To obtain an overall farm gross income, one would need to add the livestock income from the 2.8 cattle, 13.5 sheep and 2.9 goats per farm less the farm-used barley they consumed.

No data are available to determine how much of the 6.68 hectares are owned and how much is rented, but it is safe to assume some of it will be rented and a share of the crop will be given the owner. In addition the farm will be fragmented in many situations.

Expenses for production will be small. Tools will include a wooden plow with a steel point, hand sickles, wood forks, simple harnesses made mostly of twine plus a little wire and chain, and related items. In addition there may be some years when seed is purchased, but most years the farmer will use his own grain for seed. The average farmer uses a small amount of purchased fertilizer, but a very large percent uses none at all.

The farmstead consists of a rectangular shaped adobe house, sometimes with a metal roof, with cloth windows plus some livestock shelter. The livestock shelter is used mostly for young animals and will be made of reed mats or other fibrous materials although sometimes adobe will be used. The grain storage may be a separate structure, a pit or a part of the house. The only fences are for confining the livestock at night at the building site and are either made of stalks or adobe.

There is no source of water in most situations at the building site. Water for human and animal consumption is hauled from community wells in rubber jugs, barrels and cans. The wells are relatively deep, and the water is pulled up by a rope wrapped on a drum which is cranked by hand. Distances to the wells will vary from close by to several kilometers away.

Donkeys are the work animals plus the main form of transportation. They pull the plow, haul the water, haul products to and from the market and are often ridden by all members of the family. They may pull a cart, but more often a large basket or woven bag is carried on each side for products along with bulky items tied on top. In addition to the donkey, the typical farmer

TABLE 37. The Average of All Farms in the Traditional Dryland Arable Region (The Average Farmer).

Crop	Hectares per Farm	Q per Ha 1/	Total Prod. Q	DH/Q 1975	Total Value Crop Prod. DH 2/
Wheat, durum	.93	7.42	6.90	63	435
Wheat, bread	.30	6.89	2.07	60	124
Barley	3.29	10.84	35.66	40	1,426
Pulses	.41	6.12	2.51	89	223
Fallow	1.75				
Total Ha/farm	6.68		Total harvested crops/farm		2,208 DH

	Acres per farm	Bu or Lb / Acre 1/	Total Prod. Bu or Lb	$/Bu 1975	Total Value Crops Produced
Wheat, durum	2.30	11.03	25.35	3.81	$ 98.37
Wheat, bread	.74	10.38	7.68	3.62	27.80
Barley	8.13	20.14	163.73	1.93	316.01
Pulses	1.01	546.00 lb	551.46 lb	0.09 lb	49.63
Fallow	4.33				
Total A./farm	16.51		Total harvested crops/farm		$491.81 2/

1/ Crop yields are estimated based on the reported natural 1969-70 to 1973-74 5-year averages.
For wheat, 37% of the hectares of land in wheat in Morocco are in this region. Considering the rainfall level and soils the yield for the dryland region is estimated at 75% of the national average.
For barley, with 94% of the hectares in Morocco in this region, the estimated yield is assumed to be the same as the national average.
For pulses, 40% of the total lands in pulses are in this area. Assuming that these crops would get a priority use of the better lands in the region yields are estimated at 85% of the national average.

2/ 4.5 DH per $1.00, approximate exchange rate in November, 1976.

may have a camel, a horse or a mule. Much of the plowing will be done with a pair of animals such as a camel and a horse, a donkey and a cow or some other combination. Quite often it will be two animals of different species.

There are estimates that about 1/3 of the barley raised is used for feeding the animals, 1/3 will be hauled to town for processing and returned for home use and the balance will be marketed. Some of the wheat and pulses may also be marketed. Most of the meat animal production will be marketed at the weekly souk except for the sheep that are used for the religious holidays. Wool will be used for home weaving or sold. The milk from cows, goats and sheep will be largely used at home on the typical farm. Most farms have a few chickens. Animals always appear thin and undernourished.

Very few farmers have available or use bank credit. There are no data on dealer, merchant or other sources of funds, goods or services that the farmer may borrow locally and repay at harvest time, but this is probably the major source used by the average farmer when he needs credit.

The average of all farms will include a part of a bicycle and a motorcycle or even a 4-wheel rubber-tired wagon. Most farmers will not have them.

The farm household on this average farm will consist of about 6 persons including at least one grandparent in addition to the husband, wife and children. None will be able to read or write, and their language will be Arabic. The chances are about one in fifteen that a child of school age in the rural area will attend school. The major job of children is hauling water and herding livestock.

The farmer and his family believe they are very busy, but by any standard of measurement they are productively underemployed.

This is an attempt to describe the farm that the average farmer and his family in the traditional dryland arable region of Morocco operates. He has his own set of values and beliefs. Each farmer and his family will be a little different from his neighbor.

It is in this environment that the new technology needed to increase the efficiency of production of crops and livestock in the area is expected to be adopted.

Proposed Economic Research

This proposal for the agricultural economic research phases of this project recognizes the following situation. First, we have been unable to identify any trained agricultural production economists (micro) in the government or research institutes. In the agricultural university bookkeeping taught in the traditional form is identified as agricultural economics. In addition, one course in economic principles is taught. There are trained economists (macro) and statisticians in the ministries and universities, but those trained in agricultural economics including planning, pricing, tenure and marketing are very few or non-existent.

The second fact, as would be expected based on the unavailability of personnel described above, is the lack of any comprehensive data or analyses of the agriculture sector in Morocco. Annual statistics are published concerning land use and aggregate production. When attempting to transfer land use and production into production per hectare, many claim that the resulting average yields are too high. Whether the error is in the number of hectares or the total production, no one seems to know. In addition, the limited data published describing areas such as land ownership and tenure are probably more speculative than factual. When requesting information on livestock prices, the responses were that they vary so much that no information is available.

In view of this situation there is no limit to the needed economic research in the agriculture sector. The challenge is to determine where to put the first priority.

In developing this proposal it is assumed that the economic research will be an integrated part of the proposed agronomic or crop production applied research program with its goal of developing an information base on crops and cropping practices relating to small farmers in the project area. In addition and equally important it is assumed that the final product of the applied research will be directed toward increasing the net benefits from the farm as a unit rather than increasing the productivity of a specific farm product.

The first step in the economic research program will involve the establishment of baselines that will more accurately define the "state of the arts" in agronomic production in the arable dryland region. This is essential in determining the added costs and added returns from the adoption of the new technology in the farm business. The first step is determining the cost and returns of presently used technology. This establishes the base for evaluating the added benefits from the new technology. The costs will not only include such items as seed, chemicals, implements and animal power but will also need to value the farmer and his family's labor input. In the final analysis the level of benefits from the adoption of the new technology will be the motivation bringing about the acceptance by the farmer.

The research will involve determining an adequate sample to identify the details of the current practices and their results, the development of the questionnaires, gathering the data and summarizing in a usable form. In its first stage informal surveys to determine the scope of the information will be essential.

The second step in the economic research program will involve the evaluation of the changes in the individual farm business that will occur as the new technology is adopted and benefits increase. This research will measure benefits of the total farm business as compared to the first step which evaluates the individual enterprise. The several possible alternative combinations of resource use by the individual farmer will be examined. Alternative land use systems with needed annual inputs and implement and power components plus livestock enterprises considering type, size and combination will make up the main components of the analysis. The goal of the analysis will be to determine the combinations of resources giving greatest benefits based on the capital restrictions imposed on the farm unit by the individual farmer. The data should provide guidelines in rationalizing the use of the increased capital that will become available as benefits increase. The capital allocation will have to consider the demands not only in the farm business but also for family living use.

This research in the second step will require the development of detailed budgets covering the cost and returns for the several different crop enterprises as developed from the data obtained in the first step plus the addition of the impact of the new technology. These budgets will become the basis for testing alternative systems starting with comparisons developed by assembling budgets of a few relatively simple combinations of enterprises that appear to have possibilities. This should be followed with the development of a linear programmed model that will provide the opportunity to consider the truly many restrictions and consider a far greater range of alternatives in examining the benefits from the many combinations.

In reality the research outlined above is not so much a step one and a step two program. The two phases go hand in hand. Once the data become available, the economic analyses of both the enterprise and the farm business in total go ahead.

It will become obvious as these phases of the economic applied research develops that the technology of the livestock production and its improvement will become an essential part of the improving of the benefits from the farm business. In fact it may well be that the inefficiencies in livestock production will offset much of the gains in the agronomic areas.

As the production economics research program develops, the institutional arrangements such as the fragmentation of land holdings, land tenure, availability of credit, marketing or government price control and subsidies may be the major hindrances in the adoption of the new technology.

These areas become a far bigger challenge in identifying where to start and what to do with the limited resources available for economic research than in the production economics area.

At this time, research in the government's pricing and subsidies in the agriculture sector and the marketing and farm price system at the

local market level (souk and local dealer) appear to be major problems that could limit the profitable adoption of agronomic technology. The research in these areas, as in the production economics area, will need to start with bringing together the information on the current situation so that possible alternatives can be evaluated.

One cannot emphasize enough the need for developing methods and personnel to extend the new knowledge if this is to be successful in aiding the Moroccan farmer. A most important goal of the applied research program in agricultural economics will be the need to develop the results into such form that they can be used by those who will have to change if the well-being of the farmer is to improve. These include the farmer himself plus all of those who will be involved in helping him improve his situation. Extension workers, researchers and teachers at all levels, government officials and suppliers and buyers in the private sector, all must be reached. It is safe to assume that if the results are in such form that the farmer will be motivated, the others will be able to understand. To obtain these results, inservice training programs for those who extend the knowledge must be a planned part of the final product.

In summary, the economics research sector of the proposed applied agronomic research program is as follows:

1. Analysis of the added cost and added returns of the new technology of the individual farm enterprise (Enterprise planning).

2. Analysis of the impact of the new technology on the total farm business and the evaluation of the benefits from alternative resource uses when the new technology is adopted (Total farm planning).

3. Analysis of current government pricing and subsidy programs in agriculture to determine their effectiveness in getting the new technology adopted.

4. Analysis of the marketing and supply systems at the farm and community level to determine their effectiveness.

5. A high priority will have to be given to the transfer of the knowledge gained by this economic research to all those who will benefit. This will involve procedures, training and materials.

Counterpart and Participant Training in Economics

Any proposal program must recognize the problem and its possible solutions in view of the restrictions and resources available. Assuming that it is a fact that no production economists in agriculture are available in Morocco, then the advanced training of Moroccan participants should be given top priority. The program should be consistent with the advanced training proposals as set forth in the project. The following are listed in order of time the participant would enter into the training.

1. An agricultural production economist with emphasis on enterprise analysis who would obtain a Masters degree and return to Morocco as soon as feasible to support the early stages of the economic research in applying new technology to the farm business. Departure date before September,1977.

2. An agricultural production economist with emphasis on total farm planning who would plan to obtain a Ph.D. degree. Departure date in 1978.

3. An agricultural production economist who would be trained in farm planning with considerable emphasis on the development of tools to use in extending the results to the farmer. This would be either a Ph.D or M.S. program. Departure date 1979.

4. An agricultural marketing economist who would be trained in areas concerned with farm marketing and making farm supplies available at the local level. This would be a Ph.D. program with departure date in 1979.

Staff - Short-Term

An agricultural production economist should be identified in the first year as a member of the U.S. contract team to begin getting acquainted by a short visit to Morocco along with other short-term team members. When the first participant trained in agricultural economics returns, a term of two or three months in Morocco will be desirable to help guide the initiation of the program in this area. If this team member is also the graduate program adviser of the participant, the program of thesis research should also be initiated. If he is not, having the student's adviser in Morocco for a short term may also be advisable.

The staff member in the economics of agricultural production would help to initiate early phases of identifying the "state of the art" and developing sample enterprise budgets. These would form the basis later for the more in-depth analysis proposed. In addition bringing together information on pricing and related relevant economic information would greatly support the understanding of all staff members of the current situation.

Other short-term assignments will be of two types: (1) Those of adviser-professors travelling to Morocco to guide the participant in developing the framework and details of proceeding with his thesis research. This should be consistent with the scope of the overall project; and (2) those of economists with special backgrounds to assist with problems that cannot be foreseen but may prove important.

At this point a summary analysis of government pricing and subsidies in the agriculture sector could be best handled by an economist in this area on a short-term basis.

As the survey of the "state of the art" in agriculture is developed, a specialist in sampling procedures and training interviewers could be used on a short-term basis.

The role of cooperatives could well be examined by a specialist on a short-term assignment to determine the needs for applied research in this specialized area.

Support

Equipment	- Calculators - Desk for staff use Desk for clerical use Pocket for field use by staff - Desks, typewriters, etc.
Operating funds	- For hiring computer service - For hiring clerks, interviewers and secretaries - For travel expense of interviewers - For in-country travel of staff

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Annex I. SOCIAL ANALYSIS

Introduction

A comprehensive analysis of the social issues that need to be addressed in the development and implementation of a dryland agricultural applied research program must focus on two different social organizational levels. The first level is that of governmental administration, the focus of power and source of external resources; while the other is the local level, the rural social structural milieu which forms the setting for the day-to-day activities of the small farmer. Decisions will be made at both of these levels, decisions that are crucial to the ultimate success or failure of the program in effecting a favorable development in the dryland farming sector. The factors that constrain and impinge upon decision making in these two different settings must be understood if there is to occur the integration of activity and commitment essential to the success of the program.

The social perspective of the program must not only give prominent consideration to the local setting of small farming activities, but also more attention than has been given in the past to governmental-administrative patterns and interorganizational linkages that relate to the development and implementation of the program. The importance of addressing administrative issues is underscored by the fact that previous project designs have repeatedly encountered insurmountable bureaucratic hurdles when there was an attempt to effect implementation even though thorough analyses of social constraints at the local levels were provided.

Administrative issues which must be addressed include: (1) the administrative structure of the GOM agencies to be involved in the development and implementation of the various phases of the project; (2) linkages between GOM agencies, USAID, and other institutions (such as universities) that may be involved; and (3) the characteristics of the interorganizational linkages between those agencies within the GOM that are to be involved in the program.

The linkage between USAID and the GOM is discussed later, but the social question which must be repeatedly asked is whether or not the concerned agencies within the GOM have made or are willing to make the necessary commitments of power, personnel and other resources to the program and also to guarantee the inter-agency coordination essential to the success of the program. This question is crucial because past experience has demonstrated the lack of such commitments and guarantees in USAID programs, resulting in less than satisfactory results. The degree of commitment on the part of the GOM to the proposed program is still not clear.

The Social Environment as it Relates to Dryland Farming

The social environment in any culture is complex. To describe it in any detail requires a large amount of resources and would result in volumes of material. Our attempt to do so for the eight provinces of the dryland

farming program is limited by two factors: (1) the social environment appears to be very complex with considerable variation, and (2) conversely, very little current, well-documented information is available on the social milieu of the small farmers. Such a situation presented us with two choices: either to make a few sweeping generalizations which would have very little depth or to limit our discussion to a few, highly pertinent subjects utilizing the best information available to us. The latter approach was selected because it seemed to make the greater contribution to this project proposal.

The topics to be discussed are: the agricultural work force, land tenancy including contractual arrangements for usage, and the role of livestock in the farming operations. The point must be made very strongly that we consider this list to be inadequate, but the lack of good research data severely limited our topics. Knowing how farmers get information and make decisions regarding farming is vital to the proposed program. So also are information on farmer attitudes, the extent of their involvement with the agricultural infrastructure, the social structure of the community and other topics. The need for research in these areas is critical, and a research plan is proposed in the social science research appendix.

The Agricultural Work Force in Morocco: The problem presented by the increased number of workers is perhaps more complex in agricultural areas than in the urban areas in Morocco. The rapid growth in manpower tends not only to create problems in employment but also to multiply the number of individual farming operations, creating a serious regressive evolutionary pattern in size of operation. A fuller understanding of the effects of this demographic pressure requires a closer examination of the patterns of employment. Attention will first be given to a brief general description of various employment categories, followed by a more detailed review of prevailing forms of work contracts found in the traditional Moroccan agricultural sector.

Types of Employment: A Brief Description.

1. The farmer-worker (fellah) is a man, using the help of his immediate family, who works the land which belongs to him or which he is entitled to use according to contractual agreements (rent or association). The farmer-worker has more control of his own activities than do those in other forms of farming, participates directly in production, and is rewarded with benefits from his own labor. These farmers make their own decisions in attempting to achieve the oftentimes precarious balance among the various production sub-systems of their farming operations which are necessary to maintain their level of living.

2. The associated-employee (khammes) executes the order of his patron, and is reimbursed for his labor with one-fifth of the harvest that he has directey participated in producing. This form of relationship is an old one and bears a strong resemblance to patronage relationships found in feudal societies. The khammes

is not provided with a salary but often enjoys some benefits accruing from the patronage relationship that the salaried employee lacks such as greater employment security.

Now that the traditional agricultural sector is increasingly being drawn into a money economy, however, the khammesat relationship is on the wane as an increasing number of agricultural workers choose salaried positions, even though they may be less secure.

3. The salaried agricultural worker first appeared during the period of colonization when European forms of production organization were introduced and quickly assumed a great importance.

Salared workers can be considered as consisting of two basic categories: permanent workers and occasional or seasonal workers.

a. Permanent workers provide the minimum essential work force required for good general production on the large modern farm. The workers often have specialized duties such as security guards, equipment operators and drivers, mechanics, grafters, etc. The assurance of a fixed salary makes these workers a relatively privileged class in the countryside. They earn an average of 4.5 to 5.5 dirhams (DH)[1/] for less skilled work and up to 8 and 10 DH per day for drivers and foremen responsible for work crews.

b. Occasional and seasonal workers are employed as a function of the agricultural calendar. The highest demand for seasonal workers occurs at harvest time in the late spring. There is also a demand during the fall plowing season. Harvesting crews averaging between eight and ten men travel along the roads looking for fields to harvest. Such work brings in about 5 DH per crew member for eight hours of work, to which can be added a lunch supplied by the employing farmer worth about 1.5 DH. One man can harvest about 6 ares (.06 hectare) in an eight-hour work day during an average harvest. It is very important to note that this eight-hour shift does not really constitute the entire work day for harvesters but only that portion of work that is productive. After such eight-hour shifts harvesters spend some time trying to arrange their next job.

A major characteristic of work in the traditional sector is the amount of time that is devoted to finding

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[1/] The exchange rate in November 1976 was approximately 4.5 dirhams (DH) per U.S. dollar.

and setting up working arrangements. The large numbers of men who appear to be idle along the roads or at the souks (markets) are often engaged in this sort of unproductive but essential activity. Such negotiations are often of a subtle and delicate, time-consuming nature.

It is interesting to note that a farmer and his family will often refrain from harvesting activity so long as the employed harvesters are working in his fields, although the farmer and his family may do some harvesting in the afternoon after the workers have left. Social rank plays an important role even here.

Women's Work Activities in Agriculture: The importance of the work done by women in agriculture must be given greater attention in the future. Available comments on women's work activities usually cite the complementary nature of their work to that of the men. In farm operations women commonly tend livestock, weed the crops, and assume responsibility for getting firewood and water. Considerable time is taken for the performance of domestic activities associated with rearing children, cooking, etc., all of which must be accomplished through very labor-intensive techniques.

The care of animals is the most demanding work for women. For an hour or more every evening women must cut grass, weeds or lucerne to feed the livestock. Some of the forage must be dried and stored to feed the animals during the dry summer and barren, early winter period.

The processing of plant and animal products involves the weeding of wheat fields from March to May and feeding the tares to the animals. Women may be employed winnowing wheat in June and stripping maize cobs in October. Women are also responsible for milking goats and cows.

Types of Contractual Arrangements in the Traditional Sector: Agricultural household heads who have at their disposal the total means for accomplishing their farming work are rare. Almost all farming households must enter into contracts in order to procure the means they are lacking as well as to commit those that they have in excess. A landonwer can either rent his land to someone who wants to work it or cultivate it himself by acquiring that which he lacks, such as labor or additional tillage equipment. The farmer who possesses no land or other means of production can either enter into a khammesat contract with a landowner or sell his labor as an agricultural worker. He might also be able to obtain land, work or livestock to tend through a rental or sharecropping arrangement. These are simplified examples: there are innumerable variations in relation to the different aspects of rural productive activity.

Contracts of Association (Bel Khobza): As has been noted previously, farming associations play an important role in traditional Moroccan agriculture. Under the general title of the bel khobza or cultivation association, there is great diversity ranging from sharecropping contracts with large landowners to more cooperative agreements between small farmers of more or less equal stature in relation to the means of production they contribute to the association.

1. A major type of association contract is one in which a landed property owner rents one or several parcels of land for a share of the harvest. The proprietor is not concerned with actual production practices until harvest time when either he or his representative will be present. This kind of contract is widely represented in the Chaouia region of the cereal producing plains. For example, there are variations which may require that a certain crop must be grown.

   This form of association doesn't comply with traditional Islamic religious laws since the owner receives a portion of the harvest without actively sharing in the risks. This fact in itself can be seen as an indication of changes in values occurring in the countryside. Once again it should be stressed that traditional agriculture can only truly be called "traditional" in the sense that it can be distinguished from the dominant "modern" sector that constitutes the other component of a dynamic dual system. Agricultural production patterns and practices in the traditional sector experience continual change and development along with the modern sector.

2. A second major type is those associations wherein an individual furnishes land and one or several other factors of production without participating in the decisions concerning cultivation. This form of contract concerns absentee or invalid landowners for the most part. With a few exceptions this arrangement provides that the landowner furnish a portion, usually half, of the seed. Through the choice of seed the landowner has an active role in determining which crops will be grown. This type of association more closely corresponds to traditional religious prescriptions in that both parties are sharing in the risk.

3. Finally, there are those associations in which the factors of production are equally divided among the various parties, and all the parties to the association make decisions together. These contracts are true associations between fellahs, the peasant farmers. All of the participants are actively engaged in the farming operation. Such associations are becoming fewer. This trend can be largely attributed to the increasing value placed

upon land as an element in production. This has resulted from demographic pressures on land and a continuing process of concentration in larger land holdings.

Duration of Contracts of Association: The contracts of association are considered terminated when the grain from the harvest has been divided on the threshing floor into the respective shares of the landowner and the associate(s).

Formally the duration of such associations is limited to only one growing season, although in practice they can be repeated between the same partners for several successive years. The contract is always renewed in a formal manner, however, and never continued in a tacit and informal way. There are exceptions to this requirement for annual renewal such as when legumes are grown a situation that is termed bernicha. If the landowner doesn't cultivate the land himself, the association partner who grew the legumes has a right to a second year of use.

It is very important to emphasize that the practice of formal annual renewal of these cultivation associations results in considerable uncertainty for those who must maintain subsistence levels. The property owner almost always makes an effort to create this sense of uncertainty. This serves to both reaffirm his property rights (which may sometimes be somewhat hazy in regard to actual registered title) and to assure that he will receive larger gifts from those seeking to contract for land.

Gift giving is a system of sealed bids. Each farmer desiring to sharecrop a plot will present a gift to the landowner. The one who provides the largest gift is awarded the contract, and the other gifts are returned. Such gifts can be of considerable size and must be included in the total cost of sharecropping. Such gifts are only given by smaller farmers to larger landowners. If a wealthy farmer should wish to rent land from a smaller farmer, no gifts are offered. As one anecdote puts it, "sheiks only receive, they don't give."

Factors Which Play a Role in Determing Land Rent: Traditional farmers, while not having a shophisticated information base, are nevertheless keenly aware of the importance of variations in soils, some of the effects of types of crops grown, etc. They utilize this limited knowledge, in combination with other factors, to arrive at the productive value of different plots of land and to determine the amount of rent that should be paid.

Soil quality is a very important factor. A smaller portion of the harvest may be apportioned to the landowner when the plot being cultivated consists of poorer soil. The previous cropping history can have a direct influence on rental value. For example, the landowner usually demands an increased share after a fallow period.

Labor requirements of different crops are taken into consideration. The share allotted to the landed proprietor may be less when legumes are grown since they require more labor in cultivation and harvest.

The distance between the douar (village) and the plot can be a factor with increasing distance inversely correlated with the share that is asked.

Social relationships are very important. The element of trust is taken into consideration. A farmer often prefers a less economically advantageous association to an association in which he lacks confidence. Small farmers are most likely to trust friends, and their friends are most likely to be of the same economic status. It follows that many small farmers prefer to form associations with other small farmers.

This outline of some of the types of farming arrangements presents only their basic features. In actual practice a very complex intertwining of contractual arrangements of various kinds exists. Such complexities are evident in the following hypothetical example:

- one farm owner may directly farm one portion with salaried worker,

- he may let out a second portion to a sharecropper who in turn lets out a portion of that same land to a "sub-sharecropper"

- and finally, he may rent out a third portion to a farmer who again sub-lets it to another farmer who in turn employs salaried workers.

Recent developments indicate that the total amount of land let out in association or to sharecroppers by big landowners has diminished as the larger landowners adopt more modernized management practices and mechanization. The large landowners, although the least numerous, are those who have let out most of the acreage to smaller sharecropping farmers in the past. Over the past several years an increasing number of large landowners, have purchased tractors and now cultivate the land themselves. This development has had the effect of either depriving former sharecroppers of adequate land to till or of changing their status to one of salaried employees. An overall effect has been to provoke disequilibrium in the traditional agricultural system. The small farmer who needs to supplement his agricultural base to maintain a subsistence level is the victim of this change. The present situation suggests that associations are more exclusively contracted among small peasant farmers, while the

larger fellahs are operating all the land they own. Mechanization greatly changes the relations which formerly existed between the large and small landed farmers. It increases the social distance between the two groups.

The types of associations as well as other work relationships differ widely within relatively small geographical areas. For example, the literature indicates that many of the associations in the Haouz region near Marrakech are the type in which a group of small fellahs makes decisions and works together. Such associations between equals appear to be on the wane in the Chaouia area where there is more sharecropping in which the proprietor does not play an active role in production. This may appear to conflict with the previous observation that associations are more frequently entered into by small farmers. In this case the proprietor may actually own only a relatively small amount of land in comparison with the big landowners who can afford to modernize. Still he owns more than he can till himself with traditional technology.

Suggestions for Social Research: Future social research should focus on the structure of work, land and other production relationships in the traditional agricultural sector. Such research should give attention to how these relationships in the traditional milieu may be articulated with the modern sector.

Contractual relationships create the environment for decision making. They function as constraints upon the type and scope of decisions, and they locate the most important decisions at certain levels according to the relative status of the contracting parties. Attention should be given to discovering what alternatives exist in the traditional milieu if an agricultural development program is to succeed in actually becoming a program of and for small farmers. A program imposed from above could result in social disruption instead of increased production with an overall improvement of the small farmers' condition.

The System of Livestock Production: Livestock production has always been of importance in Moroccan traditional agriculture. In fact many of the contradictions or tensions which today characterize the traditional agricultural sector originated through the adaptation of agricultural production practices to a nomadic, pastoral way of life. The relative tenuousness of ties between man and the land is one example.

Today most small farming households own some livestock, perhaps one or two draft animals and a small herd of cattle, sheep or goats. These animals play a very important and integral role in the small farmer's attempt to balance the various components of production in his total farming operation.

Problems arise from traditional livestock production practices because of the many functions that these animals serve. Livestock serve as capital, a savings account, and a source of income. They also supply power for land tillage, provide milk, wool and meat, and finally function as a primary criterion of social prestige.

The lack of available capital encourages the farmer to make several uses of the livestock he acquires and to ignore livestock specialization, especially at times of financial crisis. For example, a pair of cows purchased in October may be used as a draft team until January, after which, from January to April, they are used to furnish milk for the household; then they are sold in the first part of May to permit the hiring of personnel for the harvest.

The combination of economic and social functions prevents the adoption of more specialized animal husbandry techniques. Livestock which satisfy the greatest number of functions are usually the ones acquired, even though each of these functions may be poorly accomplished. It is essential to gain a thorough knowledge of the various functions livestock perform in the maintenance of the economic equilibrium of the farming operation if there is to be an attempt to change the behavior of the farmer in the direction of more rational livestock management. Suppose, for example, one wanted to introduce pure-breed cattle into a small farming operation, such as cattle bred for milk production. The farmer would have to add the purchase cost of additional animals for draft power to the credit and new costs involved in the care and maintenance of pure-bred cows. The replacing of a "traditional" cow with a more specialized one is not a perfect substitution. The former will assure, even if poorly, the accomplishment of the functions which the latter one won't, especially if it is forbidden because of credit agreements to sell the pure-bred cattle at harvest time.

Different Functions Performed by Livestock:

1. The Work Animal: Less than 15% of the cultivated land in Morocco is tilled with tractor-drawn implements. Tilling, weeding, harvesting, threshing, and transporting are mostly done by means of manual and animal power, an adaptation to the low level of capital accumulation and technology of traditional farmers.

   Rather than complete mechanization which would replace animals with machines, it seems necessary to follow a more modest route by improving the productivity of draft animals. The improvement of animal-drawn tillage equipment, the gradual selection of stronger animals, the elimination of milk cows as a source of power (although this is not too extensively practiced), and castration practices would all lead to increased efficiency and productivity. Such new equipment and practices would require distribution of additional credit.

2. Livestock as a Source of Income: Cattle and sheep are the primary income producing livestock. Not all of this livestock is sold. A portion is consumed by the farm household itself. Except in suburban areas milk production is a non-market product. Milk and butter are almost entirely consumed by the family. This is not surprising when one considers that an average milk cow produces only two to four liters of milk daily during lactation, and the average size of a family is five. An important point to consider is that increased milk production through improved husbandry would require a transformation of the market and distribution networks that now exist. Otherwise there would result an increase in farming costs without the generation of new income.

   Both meat and wool are marketed products from sheep. Formerly wool was almost entirely used or processed by the family. Today it is increasingly sold in raw form destined for urban centers. A very significant amount of wook, however, is still accumulated and saved by the family and used to stuff mattresses and other furniture in the home. This collected wool constitutes a form of savings and an insurance against variations in the purchasing power of money.

   The marketing of sheep for meat is similar to that of cattle. As household financial needs rise, a farmer will sell one or two head of sheep at the local market (souk). Customs and religious obligations create a special market at the time of the Islamic feast day of Aid el Kebir. At this time each male household head customarily sacrifices a ram for the feast. In one or two weeks an enormous number of male sheep (about two million) are sold.

3. Livestock as a Savings Account: Decisions on the sale of livestock are determined by the financial needs of the farming operation rather than market prices. In traditional agriculture an animal is sold to meet an urgent need for liquid assets. The traditional herd is sometimes referred to as a kind of bank. It is in fact a savings account that is very well adapted to the rudimentary level of capitalization in the traditional agricultural sector. Replacing this function of the herd would certainly be among the first requirements in instituting a more rationalized pattern of livestock management. This would necessitate profound changes in the current system of banking and credit at the level of the small farmer. An entire banking network would have to be created along with a whole host of banking personnel, etc. Thus the herd, for better or for worse, satisfies many of the functions of a banking system when complemented by the local moneylender who provides some intermediate term credit.

4. Livestock as a Source of Prestige: The ownership of livestock plays a very important role in determining the social status of a farmer. The number of head of sheep and cattle is an index of available capital. It is a bank account visible to all. This has important psychological, social and political consequences in regard to social ranking, alliances, and marriage, etc. Thus the peasant has reasons for increasing the number of livestock in his farming operation that are not strictly economic. The prestige afforded by livestock in traditional society is a basis for influence and power at the local community level. Livestock is a form of social as well as financial capital that is not subject to the same fluctuations in value as money.

A Brief History of the Evolution of Land Tenancy in Morocco: A true understanding of the present structures of rural Moroccan society cannot be adequately grasped without a consideration of their historical evolution. The use of the land and the patterns of land tenancy have played a very important role in the evolution of farming practices in the cereal producing plains.

Land Tenancy in the Past: Although it is difficult to ascertain exactly that relations previously existed between the land and its occupants, historians have characterized these as relatively loose ties, a state of affairs which corresponded to the preponderance of a pastoral orientation and a type of agriculture which featured long periods of fallow. Population density was low. The nomadic way of life and frequent shifts in the balance of tribal powers fostered geographic mobility.

Because of the overall abundance of land, uncultivated areas were common. It was available in seemingly unlimited quantities. Any individual or group could take possession of a field by marking it off and using it. The principle of "vivification" of "dead" land was the only recognized basis for establishing possession. Land was not considered to be held if active cultivation were terminated. Individual or private control of a plot was not dependent on the value of the land itself as much as on the amount of work and capital invested in it. At the end of the 19th century landed property was considered to be the land which an individual and the members of his social unit such as the family or tribe (the distinction between the two being somewhat vague) could cultivate or use as pasturage for their livestock herds and which could be defended from the encroachments of others. The power of individuals or social units to control their domain was the important factor. Limits were not definite. The dimensions of such holdings around a central cultivated core could increase or diminish according to the strength of its "owner" or occupant. Beyond the limits of effective control vast areas of uncultivated land and common pastureland existed which were very fluid in legal status and which offered room for unlimited expansion.

About the turn of the 20th century true private freehold property (juridically referred to as melk) made its appearnace.

Melk landholdings have their origin in lands that had previously been acquired through the "vivification" practice discussed previously. Use of the land was continued without interruption and held by the same individual or group. Subsequently, through a series of sales or other legal transactions the land acquired the new legal status of melk (freehold) property. The total amount of melk land was still quite small at this time. Most of it was centered in the vincinity of permanently established villages or tribal groups that were relatively sedentary and who repeatedly used the same land. The familial or patriarchal aspect of landholding was reflected in the concept of indivisibility as regards inheritance. This indicated the cohesion of the patriarchal plan on the one hand and a relative weakness of the concept of individual possession on the other. The practice of indivision occurs in a limited fashion today with more than one descendant inheriting joint title to a parcel of land. This is done to prevent further fragmentation of parcels of land.

A category of land to be distinguished from melk land is bled jemâa, or collective lands. These are "lands of cultivation and pasturage used by tribes, villages or other indigenous groups under collective title, following traditional modes of production and use", as defined by a dahir (decree) of 1919. Some have argued that there was no such collective land with a special legal status before the intrusion of European influence, and that bled jemâa was in fact a creation of the Protectorate that gave the state, an entity that did not exist previously, ultimate guardianship of this land.

Changes in the Land Tenure System Following European Penetration: The intrusion of European colonials into Morocco was accompanied by a great increase in melkisation, the conversion of untitled land into privately held property with legal title. Early accounts attributed this increase in titled land to a reduction of internal strife brought about by the Protectorate, a necessary condition for the development of a private landholding system. More recent studies, however, have attributed much of the movement towards melkisation to a defensive reaction on the part of the Moroccan peasants who quickly saw that land without clear title was subject to appropriation by Europeans as well as by other Moroccans who possessed both the means and the power necessary for enlarging their holdings. The notion of an "establishment of order" may have expressed the viewpoint of the colonizer, but for the Moroccan peasant the insecurity associated with tribal quarrels and shifts in power was replaced by an insecurity that was due to colonial manipulations.

Melkisation rapidly accelerated the division of former common lands into privately held fragments. The distribution and configuration of plots reflected the location and relative

power of families and individuals at the particular time of this development. This occured between World War I and World War II. It was by no means the result of a gradual evolution of land ownership.

The period between the two world wars was also marked by an increasing differentiation between large and small landowners. A process of increasing fragmentation continued among small landowners resulting from Islamic laws requiring equal inheritance and from demographic growth in limited space. This fragmentation contributed to a growing disparity between large and small landowners. Farms that fell below a minimum size for viability were often purchased by the larger proprietors, especially during periods of drought. The larger proprietor then became the most important source of land for sharecropping. This source is now beginning to decline as the larger farmers can afford to mechanize and move toward owner operation.

By the time of World War II the picture of immense ammounts of untilled land, which characterized the situation at the turn of the century had changed drastically. The limits of potentially arable land had been reached. By the end of the Protectorate Europeans had acquired about a million hectares of the best land which is about one-fourth of the total arable land in Morocco. The amount of land available for the Moroccan peasant had diminished considerably. In addition rapid demographic growth began to be acutely felt just at the time when horizontal expansion was no longer possible. The average amount of land surface per person was decreasing rapidly.

The current land tenure pattern is discussed under Appendix H.

The Role of Women in the Dryland Farming Project

Morocco is a Moslem state characterized by considerable variation in behavior and values, both among and within different sectors of the society. Some urban areas have adopted many features of European culture in life-style and attitudes. Much of the rural population continues to respect and adhere to those values which have developed from the contact and intermingling of different Islamic and, more specifically, Moroccan cultures. These sets of values are rich in tradition. Variable contributions of European, Islamic, and Moroccan cultural features are reflected in cultural differences that exist among the several regions.

Variation in behavior and values can be observed in the role of women in various sectors of the society. They range from an educated, professional role to a minimally (formally) educated, secluded and highly restricted role. The overall configuration of roles appears to be changing rapidly, especially in the urban areas. Differences between generations in dress and other outward manifestations are sometimes quite striking. It is not unusual to see a veiled mother accompanied by her teen-aged daughter dressed in the latest European style.

In rural areas tradition remains strong. There is a high degree of differentiation between the roles of men and women which is articulated throughout many aspects of rural life. There are symbolically significant differences in dress and sexually differentiated kinds of social organizations for men and women. According to Moselm tradition, women are confined to the home and domestic activities: cooking, childrearing, and helping to tend livestock (see the section on Women's Work Activities under The Agricultural Work Force in Morocco). The proportion of women engaged in labor intensive work, some of which may be outside the home, is much higher in lower socio-economic conditions than among middle income groups. The seclusion of women may be an ideal which can be adhered to by those with an adequate income, but economic conditions necessitate compromises with the ideal. An interesting result of this situation is that the role of the woman and the amount of productive work done by her may very well decrease as a family's socio-economic situation improves, and as the ideal of seclusion becomes more economically attainable.

As Vanessa Maher observes, women need help in the performance of their domestic tasks. This is true not only in special circumstances such as illness, childbirth, or the preparation of feasts at life crises, but also for the completion of routine domestic tasks which must be accomplished at a labor intensive, low technological level. Given the segregation between men's and women's roles in the society, the interdependence of women becomes an important factor. Just as men's dependence on each other is structured through extra-familial organizational forms surrounding agricultural production, so is the dependence of women on other women articulated through forms of social organization unique to the women's world. The links of cooperation between women are to a large degree independent of, and are not necessarily mirrored by, those between their male kin and affines.

Maher distinguishes different criteria for status and social identity existing in men's and women's social worlds. Men can acquire social identity through their relationships to the extra-familial world of production on the basis of skills, wealth, or public achievements, all in addition to kinship status. The social identify of women is more often an ascribed one based more on kinship and one which cannot be changed through their own activity outside the home, which is the world of men. Women play a major part in choosing spouses for their kinsmen and close acquaintances. Marriage is an important event in determining a woman's relationship to other women, going beyond the mere joining of a man and wife. A girl's change in status through marriage has far reaching implications for her female network, while a man's relationships with other men are not affected by marriage to nearly such an important extent.

As Fatima Mernissi points out, past development plans have devoted considerable attention to the mechanization of agriculture, irrigation projects, banking, etc., but only a few pages to the family and the condition of women. A development proposal must thoroughly examine all the potentials already present in the society or social group concerned as well as all forms of work being done, including those for which there

may be no remuneration and much of which appears unproductive. Such a thorough examination must devote attention to the condition of women in the society, their roles and the work they do as well as patterns of social organization in which they participate. This increase in comprehensiveness could well reveal important potential alternatives that are already present within the society and upon which aspects of a development program can be based. Approaches should be used which seek to discover and then build upon existing potentials rather than those which impose formulas from above that may be in serious disjuncture with existing social relations and values. They will have much greater chances for success in achieving the overall goal of improved living conditions and greater productivity in the social group concerned.

Suggestions for Social Research on the Roles of Women: An improvement in agricultural practices and production should result in an improvement in the standard of living for the entire agricultural household. But a failure to adequately address the situation and role of women and the forms of social organization in which they participate could lead to an underevaluation of potential resources and alternatives as well as problems. Improvements might be effected that would be restricted to the world of men's work and possibly result in the creation of serious disjunctures between men's and women's spheres of activity as well as fail to tap important resources.

The contribution of women to the agricultural enterprise must be studied for possible improvements in their world of work, both at the level of the individual farming operation and at the broader organizational level. Perhaps development programs for women should be based on existing forms of women's organization.

On the basis of presently available material only a minimal outline of the woman's role and her working and social world in the dryland farming area can be sketched. Future social research must attempt to identify variations by geographical region as well as by social situation. Studies of the family as a production and consumption unit are underway in the Departement des Sciences Humaines at the Hassan II Agricultural Institute. These studies could be expanded to include the gathering of more information concerning kinship and social organizational patterns as they specifically relate to women and the kinds of change that they are already experiencing. On the basis of the analysis of such data, possible models suited to varying conditions could be proposed for integrating women more directly into a Dryland Farming Project.

USAID also has other projects in Morocco which will contribute to improving the role of women in Morocco. These include: Non-formal Education for Women, Family Planning Support, Nutrition Systems Study Unit and others.

Participation of the Government of Morocco in the Applied Research Program

Participation by the government of Morocco is crucial to attainment of the objectives and goals of the dryland farming applied research project. For purposes of discussion this can be divided into two aspects: (1) amount and (2) type of participation.

Amount of Participation: The amount of Moroccan participation in past projects sponsored by USAID has varied from very little to significant. One of the major weaknesses common to many of the evaluations or final reports of such projects (Livestock Production & Marketing, 1963-1968; Livestock Breed Improvement, 1969-1970; Livestock & Rangeland Development Project, 1969-1974; Improvement in Cereals, and Wheat Improvement in North Africa), has been the lack of adequate Moroccan participation. The following are possible reasons for such problems:

1. An inadequate number of Moroccan personnel with suitable training available to fill the counterpart roles.

2. A lack of appropriate invitations or opportunities for Moroccans to become involved in the project, especially early in the planning stages; to ask for Moroccan help after the project is fully planned or for them to work in roles which are viewed as meaningless or degrading is not appropriate or good personnel management.

3. A perception on the part of the GOM that it may be easier to get foreign assistance to carry out a series of projects than it is to provide government support to continue a project after foreign assistance has ended.

Regardless of the reason for inadequate participation in past projects, the point to be made is that the proposed applied research project must be a Moroccan project which they identify as their project. The Moroccan involvement must be continuous from the earliest planning stages. USAID can help the Moroccans establish the program by providing opportunities for participant training, guidance and counsel through an American university contract team.

Type of Participation: The bureaucratic structure of the GOM is patterned on European models inherited from the Protectorate which is a relatively rigidly and vertically structured system in which almost all decision making and other power is retained at the highest levels. This structure is characterized by a flow of orders and information from the top down within various administrative components and by a high degree of blockage not only between agencies but also between strata within agencies. The lower levels in such a system are very reluctant to take

any initiative such as working across agency lines or tyring innovative activities with client groups. Promotion and other awards are normally on the basis of length of service and not upon merit, even though occupants of various levels may be fairly well trained and desirous of performing at high levels of efficiency.

The recent establishment of coordinating councils at the provincial levels is a step in improving coordination. Even so, the orientation remains from the top down, that is, the orientation of the lower level personnel is to higher administrators and not toward the people whose interests they are supposed to serve.

Also a great amount of time is devoted to bureaucratic paperwork. Communication and coordination between functionally related agencies is often so difficult as to be non-existent. Improving the functioning of the bureaucratic structure becomes very important in the proposed research program because the primary purpose of the program is to achieve increased food production, especially by the small dryland farmers. Such an objective assumes that the research will be productive and that research results are to be used by the farmers. This process can be termed agricultural development.

The process of national development in which agricultural development is a very important part has recently been reevaluated to find what methods have been successful. (See Owens & Shaw: Development Reconsidered) The current ideas are that the process by which development occurs is directly related to the form of government. Owens and Shaw have classified government structures as either dual or modernizing. Dual societies are defined as an extension of the ruler-ruled relationship of traditional societies in which decisions are made at the top and passed down to the people. In modernizing societies there are explicit attempts to involve the populace in planning their own futures (p. 4). They point out that dual societies have been relatively unsuccessful in their attempts at development. Instead the net result of most attempts at development within the dual framework is increased wealth of the elite and very little or no effect on the poor. While GOM has many of the characteristics of a dual society, some high level officials in the GOM have indicated a desire to change the structure to make it more effective in helping people, a change to a modernizing type. (A more detailed discussion of what constitutes dual and modernizing societies is available in Owens and Shaw.)

These authors identify three essential elements of a problem-solving system which enable modernizing government to carry out development:

1. "a decision making system which allows decisions to be made at the appropriate level";

2. "a system of building a knowledge base for the masses and making it accessible to all so that decisions will be based on applied knowledge and experience";

3. "effective linkages between levels of the system." (p. 20).

For the latter point, the development of provincial coordinating councils in Morocco may be a useful step. However, the effectiveness of these is still unknown. Still lacking is similar coordination at the local levels within the provinces. The effectiveness of the present extension system is an unknown quantity. However, its top downward orientation and isolation from other related units does not suggest great effectiveness.

A major weakness in the Moroccan system is that decision-making is kept at high levels. The essence of an effective development program is that individuals are motivated to make decisions to change their own behavior. They are much more likely to do this if they are participants in the process of decision-making. They must feel that the program is their program designed to meet their needs. In other words, communication must flow up the system to research workers and administrators as well as down to the farmers.

Cooperation with Other Agencies within GOM: An applied research program must have the active cooperation and support of a number of other agencies. The research itself is only one portion of a large and complex system. The research design must be formulated to fit needs recognized and stated by the farmer. A common way for linkage to occur between farmer and research worker is through an outreach program commonly called extension. Such a two-way flow of information requires that the research planners have direct contact with the lower level extension workers. Further, extension workers must recognize their duty to communicate the problems of the farmers to the researchers who must be, in turn, sympathetic to attacking the problems.

The applied research workers also should have direct communication with the general, fundamental or basic research programs. Such contacts serve a number of useful functions: (1) they provide the applied workers with access to other researchers who may be able to contribute information or suggestions; (2) they help the applied researchers keep current; (3) they may provide access to equipment and facilities not available otherwise; and (4) they may address fundamental problems identified by the applied research activities.

The ultimate implementation of the results of the applied research program is dependent upon a number of other institutions with which the research worker needs effective contact. For example, if one of the recommendations were to introduce a new breed of sheep to produce a larger and higher quality carcass, the buyers in the markets would have to be knowledgeable enough to distinguish between qualities and willing to pay more for the higher quality carcass. The same types of comments can be made for supplying institutions. The relationship remains the same whether the markets or the supplying institutions are private, cooperative or state institutions.

Another major group of institutions with which researchers need contact are credit agencies. Implementing new technologies involves cost. If the recommendation for change is a new variety, the seed must

be available for distribution or purchase. The situation is similar for chemicals or equipment. Most Moroccan dryland farmers do not have the cash resources to finance increased cost. Therefore credit or subsidies must be available.

Necessarily this is a brief description of the complex interrelationships which must be developed if an applied agronomic research project is to result in anything more than some research reports read only by other researchers and graduate students. Figure 4 demonstrates them.

Some of the structure and many of the operating interrelationships required for implementation of research results do not now exist in GOM. If the proposed program is successful as an applied research project involving a multidisciplinary approach, can the GOM develop effective coordinating mechanisms so that the program activities will be well integrated and supported by the actions of related groups to the extent that the overall program will function successfully? For this to occur strong action will have to be taken at high GOM administrative levels. Adequate coordination of implementation activities may well be the most important factor in determining the success of the program.

An early indicator of the government's commitment to the program will be the willingness of the GOM to make personnel available for training and other purposes. If a sufficient number of individuals is not made available for training, the program will have almost no chance for success.

Diffusion and Adoption of New Technologies from the Applied Research Program

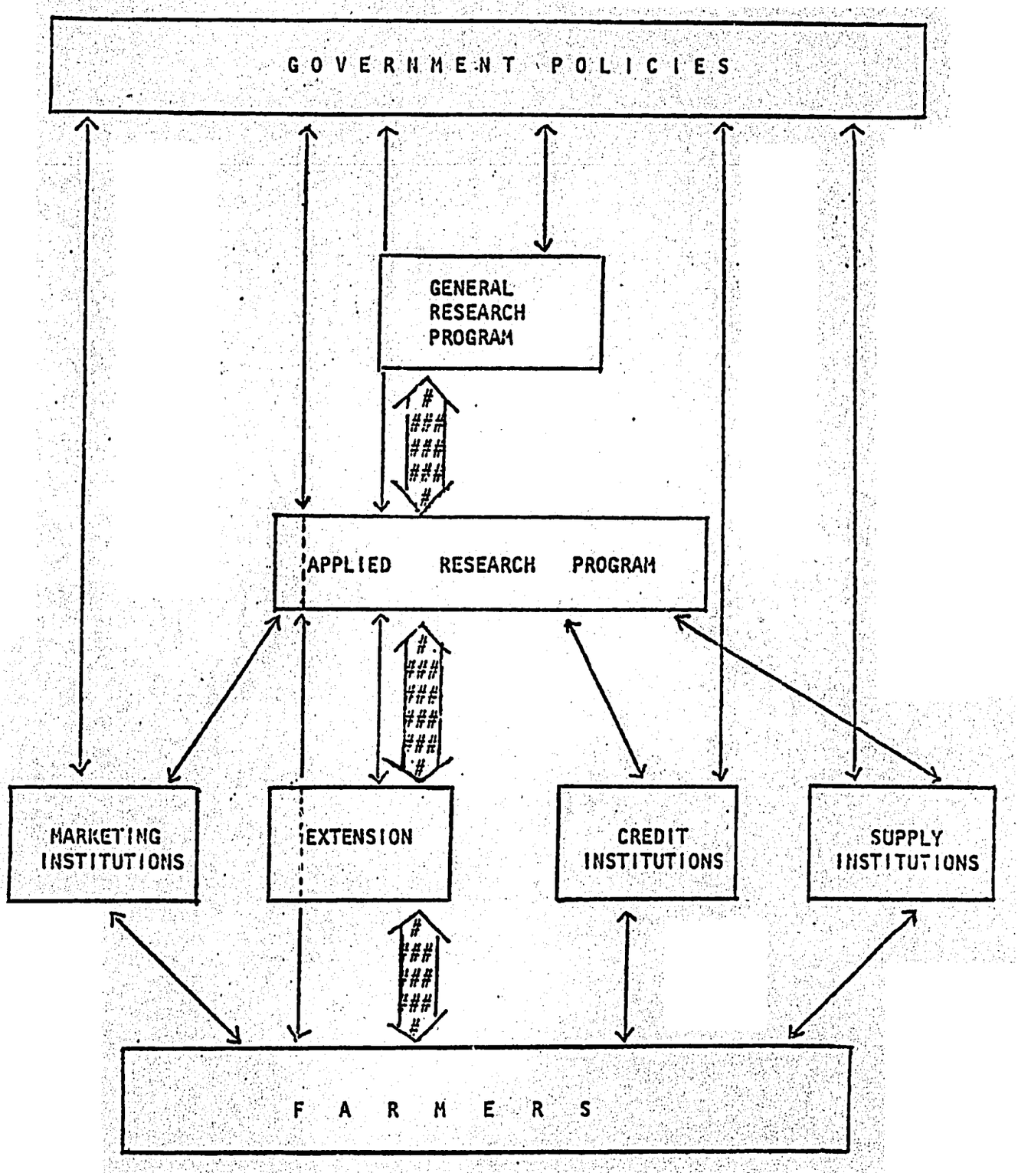
The ultimate goal of an applied agronomic research program is to bring about increased food production by developing better farming methods and practices. The development of new technologies is only one step in a process that ends with the adoption and utilization of the technologies by tens of thousands of individual Moroccan farmers. Each must make his or her own decisions based upon his or her unique circumstances

While the central focus in this proposal is the development of technologies adapted to the project area in Morocco, it is clearly realized that other elements are involved for the larger goal of the program to be reached. Applied research must be complemented especially by a successful method of securing adoption by farmers of innovations that will improve productivity.

The first step in bringing about changes in farming practices is to make the farmers aware that there are alternative ways of doing things. Making them aware of new practices requires an effective communications system.

Most small dryland farmers are non-literate and are not oriented to accept change readily. For them printed material is not effective as a communication device. With few exceptions, most newspaper coverage

FIGURE 4. Model of Essential Communications Flow for a Successful Applied Agronomic Research Program.



is limited to urban centers. TV has even more limited coverage because of the small numbers of stations and the expense of sets and their operation. Radio transmission covers virtually all the proposed study area. According to one source (Area Handbook for Morocco) almost all Moroccan households and many public places contain radios. Therefore, radio offers one potential method of communicating information about new farming practices.

Moroccan farmers are oriented to the "present" and are used to dealing with real situations rather than handling abstract ideas. This suggests that the only function that radio, movies and slide shows can serve is make farmers aware of a new practice. Only by observing a new practice under conditions similar to his own will a farmer be convinced of its utility, and only then if he receives support from people he knows and trusts. The research on diffusion and adoption of innovations has clearly shown that mass media have some efficiency in making people aware of new practices but have relatively little effectiveness in convincing people to adopt new practices. It is here that the interpersonal communications and the actual experience becomes important. These are especially important with traditional subsistence farmers.

The small amount of research on Moroccan farmers does not examine this point, but the probability is high that the only way they will voluntarily adopt practices is by seeing the practices being used in situations similar to theirs and performed by people they trust. To emphasize again, widespread adoption will occur only if people have the feeling that the practice will help them. This will not occur just because some government agent says either in person or by radio that it is good.

It is important for the program that a two-way communication channel with farmers be established to allow models of alternative new practices to flow downward and responses and problems to flow upward. In most countries the mechanism by which this occurs is called an "extension" program. Morocco has an extensive "extension" organization, the division of "Vulgarisation et Cooperation" in the "Direction de la Mise en Valeur", which is in the Ministry of Agriculture. Based upon the evidence available, this program is oriented from the top down, does not have adequate information to diffuse, is not oriented to the needs of small farmers, and is not generally effective for bringing about changes in farming practices.

The USAID/Rabat is considering the possibility of bringing a short-term U.S. team to Morocco to evaluate at least some portions of the Extension program. This team will probably not have the opportunity to do a thorough job of evaluating the entire structure and functioning of the Moroccan extension service. This inopportunity could result from at least two major factors: (1) lack of an adequate knowledge of the rural Moroccan culture by the team members; and (2) lack of access to the necessary Moroccan officials and users of the service.

Any evaluation is regarded as a threatening situation to the group being evaluated. Unless there is a major commitment by the personnel to

the achievement of the objectives of the unit, the common tendency is to defend one's domain by restricting access to information which may be harmful to one's position. It would take the strongest support from the GOM to achieve a thorough and objective evaluation of Extension. Probably one or two organizational experts working with Moroccan counterparts over a longer period of time could achieve much more than a short-term team. Even here productive results are likely to be limited. Establishing functional contacts and confidences between individuals on the team and GOM personnel are necessary. These take considerable time to develop. Without them, the team would be forced to deal with superficial impressions.

A more feasible approach for bringing about changes in the Extension service is to demonstrate a more effective alternative type of organization. This can be done as part of this program on a small scale project. The principle of change here is the same as it is for the farmers, an actual demonstration of utility.

An observation made by several agricultural consultants to Morocco as well as by Moroccans is that many of the small subsistence farmers may have knowledge of and be willing to adopt new practices, but they do not do so because of the assumption or the reality that they cannot afford the practices. The practices are seen as being suitable for the larger and more wealthy farmers. Two conclusions can be drawn from this. The first is that the present policy of the Moroccan Extension for working with the more wealthy "leaders" in each duoar probably will not have the desired "trickle down" effect. Secondly, the introduction of technology must be accompanied by availability of credit. This emphasizes the need for an appropriate supportive infrastructure to be developed along with the diffusion of the new technology.

Given the uncertainty of having an effective extension service to serve as an outreach arm for the applied research team, it is important that provisions be included within the project itself to attain these needs.

In changing his agricultural practices, the small farmer will be repeatedly confronted with new situations that will require increased decision making on his part at every stage of the production process. Traditional behavioral models will not be adequate to solve the new problems he will encounter. It is, therefore, imperative that the farmer be encouraged to participate in decision making concerning his production practices from the very outset. The ability of the small farmer to assess new alternatives and make his own decision relating to them will constitute the core of effective and lasting change. The evidence from other development programs (see Owens and Shaw: Development Reconsidered) is very clear: agricultural development and essential changes in farming practices occur much quicker and easier if the farmers participate in an organized manner in making the decisions involved. In other words, the program must become their program.

A pilot or experimental outreach program is proposed which would achieve two purposes: (1) serve as a communicative and diffusion linkage between the project and the farmers, and (2) test various techniques of communicating with farmers.

The exact techniques which might be used to organize farmers into more effective units for purposes of communication and action are unclear at this time. It is suggested that the detailed descriptions of organizational types and methods recommended by the FAO for the Sebou irrigation project in Morocco probably have considerable merit and would serve as a place to start. (The technical aspects of the FAO proposal were accepted and the social-organizational aspects rejected).

An important need is to get extension personnel to recognize that they are primarily working for and with the farmers rather than a bureaucracy located in Rabat. The present system, however, has a from-the-top-down orientation rather than two-way flow of information. To change the orientation of extension personnel and to create a feeling of some power on the part of farmers' organizations, it is suggested that an experiment be conducted in which all travel expense monies are given to farmer organizations, perhaps in the form of credits, for them to dispense to the extension workers. The monies should be "earmarked" for use only as expense monies for extension workers. The o nizations should have the prerogative of either dispensing these monies or of leaving the money unspent if they did not think the extension workers were meeting their needs, thus returning it to the extension service. The latter event should be a clear signal to the service to change either their program or personnel or both. Initiating such a change would require a careful educational program of extension personnel and farmers prior to start of the procedure.

The need will exist beginning about the second or third year for an outreach worker trained in rural sociology or social anthropology and action work to initiate a program in one commune near one of the provincial experiment stations. The outreach worker should be a part of the provincial extension service which, in turn, is coordinated with the national service. The first activity for this individual in the commune is to do some "baseline" descriptive research on the farming practices, social structure, etc. This should be done in consultation with the U.S. sociological consultant and a Moroccan sociologist. The next step would be to take well-tested and proven technical farming recommendations from the applied research program and use them as a basis for organizing the farmers. Great care must be taken at this stage to ensure that this is <u>their</u> (the farmers') <u>organization and their program</u>.

After testing the methods and forms of organizations and communications, these could be diffused into other dryland communities. Care should be taken to ensure that all personnel are adequately trained for this further diffusion.

As a concluding comment, it has been observed by the Dryland Farming team that attempts have been made to bring about more rapid adoption

of farming practices in Morocco by incorporating them into a package which is forced upon the farmers. The imposition of prepackaged technological practices, often disconnected and related to specific aspects of agricultural production, will not assist the farmer in confronting and solving the many potential new problems these practices may entail. The efficient producer must be an active agent in the process, modern in the true sense, rather than a mere recipient. The failure to encourage active involvement of the farmer would only result in his being changed from a recipient of traditional practices to a recipient of state imposed practices. He would not be a true actor. The process may result in relatively quick, short-term gains in productivity, but it will probably inhibit future gains and delay desired long-range development.

Sociological Research and a Proposed Pilot Extension Program

Introduction: Two of the necessary elements in an agricultural development program are improved technology and the adoption of the technology by farmers in the development area. Research results which remain in the laboratory or in professional journals make no contribution to development. Ideally the process of development is carried on by a group of professionals working in close collaboration and representing a number of disciplines such as applied research, technological development, extension and others. Each contributes from his or her disciplinary perspective.

The applied research program in dryland agriculture is directed toward the development of agriculture in the 200-400 mm. rainfall area of Morocco. To achieve this purpose improved technology must be developed which, in turn, must be utilized by the predominantly small dryland farmers. This technology must be suitable to the unique Moroccan, Arabic, and Moslem culture found in the communities within this area. The literature on developmemt is filled with examples of technology and other innovations which failed because they were not compatible with the native culture. In fact, this is probably the most common reason for failure.

The need to adjust technology to culture is one of the important reasons for including a program of applied sociological research. Another is that the sociological research base for rural Morocco is very limited. Only one study was found which had specific application to the proposed study area, and this was limited to a very few villages. Paul Pascon with his students has been collecting data on selected areas of rural Morocco for several years. These data have had limited analysis and, for the most part, were not collected in the dryland research zone. However, they do have considerable potential for providing background information.

The second reason for including a program of applied sociological research is that the extension service in Morocco is of questionable efficiency and probably does not provide a reliable means of disseminating research information to small dryland farmers, securing the adoption of

practices and, most importantly, providing a channel of two-way communication with farmers. This was discussed previously in the section on diffusion.

For these reasons a small pilot extension program is proposed which would be carried out in conjunction with an applied sociological research program. Since the sociological research program has not been presented elsewhere, it will be discussed in greater detail here. A discussion of the pilot extension program will follow.

An Applied Sociological Research Plan: Professor Paul Pascon with his students at the Institut Agronomique et Veterinaire Hassan II has been conducting socio-economic research on farms and rural families in Morocco for several years. The policy has been to select one region each year and to concentrate the data collection on villages within this region. Data are collected by teams of 3rd year students from Hassan II. Several regions, mostly outlying, have been surveyed.

A large quantity of data has been collected and analyzed only in a general way. Most of the data are still in an unprocessed or raw form although some student papers have been written. Few of the regions surveyed have been from the proposed dryland program area.

These surveys gather information on a large number of items. Three time periods are included for each of the following items:

1. Characteristics of the villages such as:
   a. the general history
   b. land area
   c. agricultural area
   d. cultivated area by types of crops, soils, slope of land, climate

2. Characteristics of the farm:
   a. animals: types, number, age, breeding, condition, husbandry
   b. equipment: types, condition
   c. management: cropping history, rotations, cultivation practices, sources of supplies, disposal of products
   d. economics: prices and amounts of items bought and sold, contracts for land, household finances

3. Characteristics of the family:
   a. composition of family and household
   b. personal characteristics: health, age, sex, education
   c. kinship and genealogy within the village
   d. food consumption and sources
   e. work groups, activities, schedules, division of labor

These data are very comprehensive of physical atrributes but are lacking in elements of social interaction, power, knowledge and attitudes. The Pascon data, if systematically analyzed and compared, would provide very valuable baseline and comparative information.

As a part of the dryland farming program, it is proposed that a cooperative program with Pascon be established which would include the following elements:

1. Provide Pascon with funds sufficient to permit him to put the data collected from past surveys into machine form.

2. Contract with an American university and a rural sociologist to cooperate with Pascon in providing computer statistical analyses and substantives of the above data. The rural sociologist should be trained in agriculture and should also serve as a short-term consultant for the dryland farming applied research team. This individual should serve as a liaison between Pascon and other members of the team. He or she should also interpret the research findings to the team and work with Pascon in designing additional research to meet the specific needs of the project. This role should be taken over by a Moroccan with continuing U.S. team counsel as soon as one returns from training in the United States.

3. Contract with the Hassan II Institut to relieve Pascon of a substantial portion of his institutional teaching responsibilities in order for him to devote more time to analyze and publish the results of the data analyses or provide another rural sociologist to work with Pascon in analyzing and publishing his data. At the present time he has virtually no time to devote to this task. Unless additional professional assistance is provided him, it is unlikely that these data will be effectively utilized.

4. Provide an opportunity for Pascon to visit some of the outstanding departments of Rural Sociology in the United States. It is preferable if this could be in the form of leave which would allow him to spend a semester or a year at an institution.

5. Provide Pascon with sufficient funds to conduct the additional necessary research in the dryland farming area and provide the U.S. university with funds to give the necessary analytical support.

6. Send three Moroccans who have completed the "Ingenieur" degree to the United States for training in rural sociology or social anthropology. The first should leave immediately to begin training for the Masters degree. This person should return as quickly as possible to become involved in the research and extension program. The second individual would work toward a Ph.D. When he had completed his degree, he would assume and enlarge the role of the U.S. sociological consultant. A third individual should secure a Masters degree to further strengthen the team.

Because of the cultural heterogenity of the eight provinces, it is estimated that research will be needed in at least three additional years beyond those studied by Pascon. These communities should be purposely selected to represent the range of the cultural variation found within the region. Because of the lack of prior research on the eight provinces, it is impossible to specify the exact number of communities that will be needed. Thus, it is recommended that one of the first tasks undertaken be a systematic examination of the 1971 census data and other secondary source data to develop some parameters of the amount of cultural variation within the eight provinces.

The additional community research should include the same basic data included in previous work by Pascon. In addition to this the following categories of information should be included:

1. Information concerning the process of decision making, especially those related to farming practices. This would include the sources of information, values, influencials, prestige, etc;

2. The conception and the utilization of time in various activities;

3. The methods of contracting for land and other farming activities and the changes which are occurring in these;

4. The social organization as it relates to farming activities;

5. The role of women, children and other members of the family in relation to farming;

6. Additional categories based upon discussion between Pascon, the rural sociologist and the agricultural economist.

Because of the lack of prior sociological research, a careful evaluation should be conducted each year in relation to the needs of the dryland farming applied research team and plans modified on the basis of experience and new information.

If the necessary arrangements cannot be developed with Pascon, Chaouhi Benazzou, Directeur de l'Institut National de Statistique et d' Economie Appliquee has indicated an interest in participating in a portion of the above research. It may be that Pascon may decide that the proposed program is more than he wants to undertake.

<u>A Pilot Extension Program</u>: As discussed in the sections on Diffusion and Government of Morocco, the need exists for an outreach program to be developed as an integral part of the project. Evidence to support this need will be summarized here.

By definition, an applied research program needs to have a linkage mechanism through which the research worker can test his recommendations and innovations under actual farm conditions and receive reports back on

the problems encountered in their usage. He also needs to receive reports of farmer problems in order to direct his research to meet their needs. A process of this type requires: (1) an extension service which is capable of two-way flow of communications; (2) research workers who are farmer-problem oriented; (3) a close linkage between research workers and the outreach or extension workers; and (4) extension workers who are oriented to the needs of the small farmers.

Repeated studies and experiences of persons both within and outside the GOM indicate that the GOM and its extension service is a system in which information tends to flow only from the top down. The reason for this is subject to speculation but is not important to the present discussion. The fact is that very little information moves up the existing system. Thus, considerable difficulty exists for obtaining two-way flow of information.

The Ministry of Agriculture appears to be rather rigidly and vertically stratified with very few mechanisms for communication between divisions (vertical strata). This problem has been recognized, at least in part, by GOM in the recent estabishment of provincial coordinating councils. This seems to be a desirable step, but the results are yet uncertain. Even if they do succeed, major problems will remain. The Extension Service is organized as a separate entity with very limited connection with the research division or other operating units. This separation greatly increases the difficulty of effective applied research activity because of inadequate communication between research and extension in the existing organization.

A third major difficulty is the orientation of both researchers and extension workers toward the needs of the larger and commercial farmers. This has resulted, in part, because of the past attitudes and recommendations of United States and other foreign experts that farm operators with less than 10 hectares had no future, and rapid production gains could be achieved only on larger farms. While the GOM has indicated that a program to help the small dryland farmer is needed, this has not been translated into effective action except for the agricultural reform programs (very limited), cooperatives (marginal in effectiveness and limited in coverage) and credit (a small program). The orientation toward supporting larger units is reflected in the extension service and in the research where the needs of the irrigated areas, higher rainfall areas, export crops, and larger farmers have all received more attention.

The stated general objective of the dryland program is to bring about agricultural development in the dryland farming area of Morocco. The term development suggests that the applied research results are going to be adopted and incorporated into the farming practices. Owens and Shaw, in their review of past development efforts (Development Reconsidered), reach the conclusion that the only successful efforts have been those in which the farmers were active participants in the decision making process as to the development and direction of the process of change itself. It must be their program. The authors recommend that farmer organizations

(in their words: cooperatives) be established to serve as the basic mechanism for development.

A recommendation to Morocco for the development of such groups has been made in the past by several advisory groups. The most detailed description of such a recommendation is the FAO report on the Sebou irrigation project. These recommendations have not been accepted by the GOM, with the possible exception of the so-called cooperatives which do not fill the required function. The need which was noted in the past still exists. If development is to occur, one of the necessary prerequisites is for some type of group or organization to be formed which permits small dryland farmers to become involved in the planning of the development process. This might help make a very important change in the farmers attitudes and outlook. At present, the small farmers are probably fatalistic, lacking orientation to the future, and feeling powerless. As the proposed organizations become effective, some of the above attitudes will begin to change. This is a most important step if agricultural development is to occur.

The Program Proposal: Since the proposed procedures are entirely new to Morocco, it is important to label the program as experimental and recognize that the suggested procedures must be evaluated carefully on an annual basis and modified accordingly.

The first requirement is the selection of an area. One question which arises is what social unit should be utilized. This cannot be answered with any certainty at the present time. The "douar" (village) is the smallest possible unit. Douars vary in size from about 50 people to several thousand. The next possible level is the "souk" (market). These range up to a few thousand. This is probably the largest unit within which regular social interaction and acquaintance occurs. The largest possible unit is the "commune" (county) which averages 25,000-30,000 population. This is the local governmental level. It is too large for the majority of people to know each other. The question as to which of these units will best serve the desired purpose can be asnwered as a result of the research in the first two years of the project.

After the community is selected, a Moroccan trained in social science, preferably rural sociology or social anthropology and community action (either a type of extension training or community development) should start work in the community in close cooperation with the Moroccan sociologist and the U.S. rural sociologist. Political and social protocol should be carefully observed and respected in entering the community. The appropriate political and other clearances should be obtained before starting. The worker should first attempt to gain the acquaintance and confidence of the community and its leaders. At the same time he should be studying the social structures and other elements of the community.

At the end of this year (third year of the applied research program) some preliminary decisions can be made as to feasible types of organizations to be utilized in agricultural development. If possible, the farmers organization should follow any functioning social units. No new types of organization should be created unless it is determined that existing social structures cannot be adapted. The primary characteristic of the farmer organizations must be just that, they are farmers' organizations. These organizations will be the mechanism through which innovations are introduced. Great care must be used in selecting the first innovation to be tried. It must be successful at the farmer level. Before it is introduced, determinations should be made to ensure that the existing infrastructure (marketing and supply) is sufficient to meet the needs which may arise from use of the innovation.

If the pilot project is successful and permits a thorough testing of methods and procedures, they can then be utilized in other areas. Before they are released to be used in the entire dryland area, they should be tested in one or two other communities. During this time modifications could be made, if necessary, and training and other procedures could be developed for larger scale utilization.

One of the important attributes of this proposal is that it allows testing of a system which, if successful, could serve as a better alternative than the existing system. The risk is relatively small. The resources required are not great. A maximum of five to ten Moroccans will be needed. Two of which would go to the United States for advanced training and the remainder would work as technicians.

Farmer organizations are the key to agricultural development in the dryland areas. Morocco's future is uncertain without that development.

If an effective system is not developed which makes the innovations available to the small farmers and facilitates their adoption, the benefits of an applied research program will accrue only to the larger commercial farmers. The economic and social distance between the groups will grow larger. An increased number of small farmers will be forced to sell their land to larger farmers and join the unemployed in the crowded cities. The rich will grow richer and the poor poorer--a situation which is unlikely to contribute to political stability.

Annual Plan of Work for Sociological Research and a Pilot Extension Program in Morocco as Part of the Dryland Farming Research Program:

1st Year

1. Facilitate analysis of Pascon's already collected research data.

2. Secure and analyze detailed Moroccan census data on eight provinces of program area.

2nd Year

1. Continue analysis of Pascon's data.
2. Conduct field research in three communities in the program area.
3. Evaluate prior years' activities.

3rd Year

1. Analyze field research data from the three communities.
2. Select one community as a site for pilot outreach program and begin preliminary in-community work.
3. Evaluate prior years' activities.

4th Year

1. Conduct field research in additional communities if results from previous years suggest need.
2. Begin organizing farmer groups and introducing innovations on an experimental basis.
3. Evaluate prior years' activities.

5th Year

1. Continuation of four years' activities with a very careful evaluation of methods of organizing farmers and the results thereof for two purposes: (a) modification and improvement, and (b) possible dissemination to be used in other communities.

Equipment

1 four-wheel drive passenger vehicle
3 calculators - desk
1 calculator - portable

Personnel

Paul Pascon, part time and/or another rural sociologist
A U.S. Rural Sociologist, short term appointment (2½ months per year)
3 to 5 clerical and coding assistants, part-time
3 Moroccan students for training in the U.S.
Other Moroccan technical personnel as program develops

Position Description of U.S. Rural Sociologist:

Ph.D., 5 years research experience beyond the Ph.D. Specialization or training in apricultural sociology or social change. Previous experience in LDCs desirable. French required. French language training may be obtained. Arabic desirable.

Roles:

1. to consult with and collaborate with Moroccan counterpart personnel on research design and analysis with primary emphasis on social factors influencing farming practices.

2. to consult with other members of the U.S. team as to types of current research and their relationship to Moroccan farming practices.

3. to serve as an adviser to Moroccan graduate students in the United States especially in regard to their thesis work which is to be done in Morocco.

Social Constraints on Agricultural Development in Morocco

1st Constraint: Low level of social and cultural development of rural people. The low level of social and cultural development of the small dryland farmers is one of the most important of constraints inhibiting development of the small farms.

While Morocco possesses a small educated elite population competent to operate in the scientific world, the great masses of the people, especially the rural people, live, think and derive their sense of security from the traditions of the past and are relatively isolated from science and technology. Almost no new technology has been introduced to or adopted by the farmers. The constraint is the underdevelopment of the human beings who presently have limited capacity to encompass the meaning of science and technology and lack skills and managerial competence for applying new farming technology.

The literacy rate for the country is about 25 percent, perhaps 15 percent in rural areas. Only a small fraction of the rural children are enrolled in school. Many of these attend a very few years.

If agricultural development is to occur, the rural people themselves must give leadership to change. They must decide they want to change; they must decide what changes they will make. Finally, they must make the changes. The small farmer will do all these things only as he develops as a total human being, having a mind to understand, to weigh evidence, and to make decisions knowing there are alternatives. Finally, he must have the motivations to change, first to change self and then, through self, to make effective changes in his farming practices.

2nd Constraint: Lack of political commitment to small farm agriculture. One important prerequisite for success in development is political commitment, the political will and power to effect needed changes. In at least the past two five-year plans Morocco has implied that the agricultural plans were for all agriculture and all farmers. In effect most programs have by-passed the small farmers. The needed reforms for both land and institutions have not been carried out with vigor. Because land and institutional reforms have not been implemented sufficiently to help the small dryland farmers, small farm agriculture remains stagnant while the elite farmers have further institutionalized their positions in the economic and political power structures.

The constraint to small farmers moving from traditional to modernizing agriculture is lack of government's political commitment to impose and enforce both land tenure and institutional reforms.

3rd Constraint: Lack of institutional infrastructure and institutional services for small farmers. In their thinking about agriculture, government officials either have not differentiated between the larger cash crop and small subsistence farmers or have chosen to ignore the small farmers. Government officials have seemed to assume that whatever institutions they have to serve agriculture will serve all farmers, large and small.

The one possible exception to this generalization is the small loan program carried out by Caisse Locale du Credit Agricole. In 1973-1974, slightly over 40,000 loans of different types were made under this program. This is a very small fraction of the need. Even these loans were generally limited to the larger of the small farmers.

It is not an overstatement to assert that few of the small farmers will risk changing from traditional and subsistence agriculture to accepting and integrating new technologies into their farming patterns until educational, credit and supply institutions are developed to serve their needs. While the institutions needed to provide supplies, services and education are essential, stable and trusted markets must also exist if small farmers are to accept and apply new technologies.

4th Constraint: Low energy efficiency and output. The chief sources of power (energy) for the hundreds of thousands of small farmers in Morocco are animal and human power. With few exceptions most of the work animals are poorly fed and lack strength for heavy tillage. The human labor force for small farms has a high input to output ratio largely because of malnutrition and antique tools. Farm work is highly seasonal, resulting in a highly distorted pattern of seasonal underemployment. Many farms are too small to allow for optimal utilization of the productive capacity of many small farmers. (See 8th Constraint.)

The emphasis in modernizing small farm agriculture should be on labor intensity. If the families of small farm agriculture are to integrate new agricultural technologies into their farming practices, animal and human labor must become more efficient and much of the drudgery must be removed from human labor.

5th Constraint: Limited agricultural technology adapted to the small farmer's resources and managerial competence. Little research effort in Morocco has been directed to the needs of the small dryland farmer. The package of Green Revolution wheat production technologies was oriented to the larger farmers in irrigated or higher rainfall areas. The package which involved short-stemmed varieties, high fertility, favorable moisture, and high managerial competence had limited application on small dryland farms. Moisture in these rainfed areas is uncertain and limited. Resources and managerial competence of the farmers are low.

Research must be oriented to helping the small farmer improve his present situation. It must be designed to develop new technologies

that the small farmer can fit into both his farming and family living patterns. Otherwise they will not be adopted, and production will not increase.

6th Constraint: Limited understanding about traditional rural cultures of which small farm agriculture is an integral part. Lack of understanding that small farm agriculture is an integral part of the rural culture, both in terms of values and family patterns of living, greatly complicates program design, implementation and expectations. The past emphasis on improving production, while occasionally paying lip service to the cultural approach, has largely ignored the complexities of the cultural setting of small farm agriculture and persisted in taking the Western approach that farming, wherever it took place, was an occupation and a business that could be easily abstracted from the social context of farming activity.

In deciding to take up new farming practices, the small farmers' risks are both socio-cultural and economic. In many cases, even when the economic risks are minimized, the potential cultural costs of change may be greater than the small farm family will want to risk.

7th Constraint: Lack of knowledge about the mentality of the small farmers and the way their values are intertwined in the rural culture. Knowledge of how to design and implement educational and communication programs for small dryland farmers in Morocco is almost nonexistent. The small farmer must want to change. He must be helped by governmental institutions through the risk taking process. Then he must feel secure in the new technology and have confidence that he can trust the institutions to continue to serve his interests and needs. Unless he believes that his interests and external institutional interests are the same or complementary, the small farmer will not listen and respond to messages. There will be no effective communication.

8th Constraint: Small uneconomical holdings and limited off-farm employment opportunities. Small uneconomical holdings and landless laborers are major constraints to modernizing small farm agriculture.

A case must be made for land reform programs which provide the needed incentive for those who till the soil to invest both their limited available capital and labor in improved agricultural practices. An equally strong case must be made for policies that will provide the conditions for consolidation or "reorganization" of millions of small uneconomical holdings into units that will permit small farmers to apply new technologies, make the necessary investments and achieve economic viability.

If small farm agriculture is to emphasize labor intensity as it should, then labor will have to be made more productive and the work less arduous. If the plight of the landless laborers, now at the bottom of the poverty heap, is to substantially improve and the small farmers are to have labor available at crucial agricultural seasons, then national policies implemented through active programs must provide for off-farm employment within the rural areas. This off-farm work can be a combination of rural public works programs and small industries. Coordination

of the off-farm work with the farm work will be important. Labor must be available for agriculture when needed, and the off-farm work must be available in the slack farm employment periods.

This will be difficult. Still it is imperative if the small farmers are to modernize, and the landless laborers are to have the right to earn enough to become free of the fear of hunger and to improve their level of living. FAO, UNDP, and others have repeatedly called for programs. The Moroccan government has also voiced support for such programs, but effective action has been very limited.

9th Constraint: Rapid population growth. The present population of Morocco is about 17.5 million with an annual growth rate of about 3.0 percent. This rate will double the population in 23 years. That is the length of a single generation. The crude birth rate continues high at 46 per thousand population and the crude death rate is moderate at 16 per thousand. The very high percentage of the population under 15 (45%) insures a continued high growth rate, even if the birth rate was to drop sharply. This is unlikely. The young population also means a low death rate. If age distributions were standardized, the death rate would be higher. This point is made to suggest that the death rate is likely to remain low in the future and tend to offset any reductions in fertility.

The strong possibility exists that the population of Morocco is likely to be over 36 million by the turn of the century. This prospect makes expansion of Morocco's food production essential on a crisis basis. At the same time the very rapid population growth will put increasing pressure on all other resources such as on money for education and development, on land which is currently over extended, on people, especially the poor who have rising expectations and falling realities.

10th Constraint: Slowness of the evolutionary process of removing constraints. Evolutionary methods will take generations to remove and/or minimize the major constraints to small farmers' risking change in farming methods and family patterns of living. This is not fast enough. The population-food relationship is so very tenuous that reducing population pressures on resources is urgent. The reforms needed to modernize small farm agriculture must be made within a generation, say twenty-five years, if Morocco is to avoid major social and economic problems.

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Annex J. A FARMER-TO-FARMER PROGRAM - UNITED STATES AND MOROCCO

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Annex J. A FARMER-TO-FARMER PROGRAM - UNITED STATES & MOROCCO

The primary goal of a farmer-to-farmer program is to increase the technical agricultural skills and, thus, the agricultural production of the farmers involved in one or both countries, Morocco and the United States. Since Morocco is a net food importing country, increasing agricultural production assumes major importance. A secondary goal is to increase understanding of conditions affecting farming practices in other cultures. This is especially important for United States farmers who are called upon (1) to provide food for export, and (2), along with all other citizens, to give support to other countries in the form of services and other resources such as money. Farmers in the United States must understand farming conditions in developing countries intimately as they are asked to share the technical expertise available to them with LDC farmers.

A number of options exist as to how farmer-to-farmer programs might be developed. One option which frequently is discussed is to exchange farmers for a period of time, perhaps a year to two in length. This option is rejected for the Moroccan dryland area for the following reasons: The dryland farmers of the United States are characterized for the most part as large scale, highly capitalized, mechanized, technically oriented, willing to take risks and otherwise viewing farming as a business. The average Moroccan dryland farmer is, in contrast, small, very marginal in capital, non-mechanized, traditionally oriented, conservative, and viewing farming as a means of subsistence. Other major cultural differences exist in addition to these disparate characteristics. Morocco is an Arab-Moslem nation with the language of the small farmers being either Arabic or Berber. The United States is an Occidental Christian English-speaking nation. Thus, commercial farmers of the United States would have difficulty relating on a continuing basis to the small dryland farmers of Morocco as would be required in long-term exchanges. The converse is also true.

This logic should not be taken as a reason to preclude all types of exchanges. It would seem to reduce the feasibility of long-term exchanges. If short-term exchanges will accomplish some of the desired purposes, then the following options may be considered:

<u>Option 1</u>: Moroccan Farmers to the United States

The world horizons of the small subsistence farmers in any culture are usually limited to the immediate time, the immediate problems and the local area. Frequently one of the best motivational devices to bring about change in individuals is to broaden such horizons by exposing them to alternatives, to show them that there are different ways to approach problems. One very effective way to do this is through exchange programs where highly selected small groups of farmers are brought into contact with other cultures. Such exchange programs must be structured to insure exposure to the right types of experiences.

The number of individuals involved should be limited to those who can travel as a small unit, perhaps six to twelve individuals. The time spent in the United States should be between two and three weeks. Such a duration would permit the visitation of several farms in various areas and several research stations. The visits should be timed to provide exposure to farming activities. While early harvest time would be the most desirable, it might be difficult to arrange such timeing because of farming commitments of the participants. The next best time would be slightly earlier, perhaps during April or early May.

The participation in the exchange program could be coupled with participation in other programs. For example, the participants might be those individuals who had cooperated with extension workers to serve as demonstration farmers by using agricultural innovations on their farms. Care should be used to select farmers who are trusted leaders, but who are still recognized by local farmers as ones who use techniques that they can also use. Care must be taken to insure that such a program does not become a "junket" for large farmers.

Option 2: United States Farmers to Morocco

This is the parallel to Option one. The primary objectives of such a program would be to educate the participants and others from the resulting publicity about conditions in Morocco and thus to build citizen awareness and support for U.S. activities in these areas.

The selection of farmers to participate in such a program should be on a basis that will insure a wide representation of types of farmers and not just large scale commercial farmers. Small, bottom-of-the-agricultural-ladder, and young farmers should be included. The dryland farmers of the Great Plains and Southwestern United States should have a closer appreciation for Moroccan conditions than farmers in the cornbelt or other relatively high rainfall areas.

Since almost none of the Moroccan farmers speak English and the same proportion of American farmers speak Arabic, the program would be limited to tours, visiting selected farms, and meeting with Moroccan and United States researchers. The farmers could learn of the techniques of research, the types of research underway and hopefully could make suggestions as to further directions in research.

Option 3: A Farmer Corps

The Peace Corps experiences have shown that under certain carefully controlled conditions, American citizens can be effective as teachers and in other roles. Two age groups have shown willingness and ableness in such activities. These have been people just out of college and/or those near or after the age of retirement.

The Moroccan systems have two points where such individuals could effectively function. These are in the secondary school systems or in the Extension Service (Direction de la Mise en Valeur Agricole) at the Work Center level where individuals would be in direct contact with farmers.

As another possibility, USAID could support a small number of agricultural educational workers. As a start it is proposed that three "agro-agents" would be placed in secondary schools in the dryland farming areas. Three other agro-agents would be placed to work with Work Center extension personnel for a total of six agents.

One important characteristic of persons to be selected for participation in such a program is that they be well trained in intermediate agriculture and not just in highly technical commercial agriculture. The terms 'intermediate agriculture' are taken here to mean small scale and labor intensive agriculture which is suitable for use by small, frequently marginal farmers. In addition these people should have experience in dryland farming and livestock husbandry. These agents must have or be given training in Arabic language and customs.

It is highly desirable that the workers have had practical experience in farming, especially small scale farming. The length of assignment would be for two years. A careful orientation would have to be established to acquaint the individuals with the following:

1. the culture and customs of the Moroccan rural areas,
2. the research program and results of the dryland farming,
3. the agricultural programs of the Government of Morocco, and
4. feasible alternatives for small dryland farmers in Morocco.

A Farmer-to-Farmer Program

1st year and each year thereafter

Option 1: A group of 12 Moroccan farmers to United States plus one interpreter and one guide for 3 weeks.

$1500 each travel costs		$21,000
35 per diem expenses		10,290
400 each miscellaneous costs		5,600
	Annual costs	$36,890
	5 year costs	$184,450

Option 2: A group of 12 United States farmers to Morocco plus one interpreter and one guide for 3 weeks.

$1500 each travel costs		$21,000
35 per diem expenses		10,290
400 each miscellaneous costs		5,600
	Annual costs	$36,890
	5 year costs	$184,450

Total Options 1 and 2: 5-year costs $368,900

Option 3: 3 Agro-Agents $10,000 each per year including expenses $ 30,000

Total 5 years $150,000