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FEEDGRAIN PRODUCTION AND POTENTIAL IN TUNISIA

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I. RECOMMENDATIONS

1. That the government take further steps to stimulate barley production in marginal wheat areas by raising the price of barley relative to wheat. This effort should be concentrated in areas where rainfall is between 300 and 450 mm per annum. State-owned farms should be directed to initiate this effort in order that they may be used as a model for other growers.

2. Further extension effort is required to promote wheat production in the northern sector. Wheat production can be increased by convincing farmers to adopt better rotations, improved varieties, herbicide use, and heavier fertilizer application. This is basically an extension job but if farmer risk aversion is such that farmers will not adopt these techniques then the Government should consider assuming some of the risk for some years until farmers are more willing to withstand the risk.

3. Bottlenecks occurring in obtaining farm inputs from the Office of Cereals be removed. Better management on behalf of the Office is required to make sure that seed is of good quality and available at the right time, that fertilizer is available when needed, and that credit applications are processed in a timely manner. The Kansas State University report mentioned these as problems three years ago. They continue to be problems today.

4. Maize and sorghum extension specialists need to be trained in field production techniques with emphasis on farm experience with production methods, machinery, and irrigation. This experience should be gained from an area where similar production techniques are now employed, for example, Arizona or California.

5. If the Government intends to increase maize production it must obtain equipment to level land for furrow irrigation. Currently very little land is adequately prepared resulting in inefficient use of water and low productivity in maize fields.

6. On perimeters where furrow irrigation is not allowed, the possibility of growing sorghum under sprinklers rather than attempting to grow maize should be investigated and trial areas established.

7. Currently there are large unirrigated areas within irrigation perimeters. This appears to be due to the fact that farmers operating this land have a history of dryland farming and have only recently been exposed to irrigated agriculture. These farmers need to be encouraged through extension techniques to more fully utilize the available water. This could include the possibility of irrigating cereals now grown within the perimeters on dry land.

8. Before the Government embarks on a program of producing maize on irrigated areas it should examine the possibility of expanding production of higher value vegetable, fruit, and oilseed crops. Not until the returns for these crops fall to that received for maize can maize production be economically justified.

9. Further research efforts (in terms of funding) and closer interaction of researchers with extension agents is required for the development and adoption of new cropping systems. Initial research emphasis should be on regional varietal adaptation. Specifically, early barley varieties adapted to low rainfall areas need to be developed.

10. With the adoption of maize as a crop, a natural evolution is to doublecropping maize. This is not a technique that should be attempted at the outset but one which might be implemented after a higher expertise in maize production has developed.

11. Continue research efforts on cotton and soybeans. Special emphasis should be directed towards the feasibility of double cropping soybeans after wheat or barley.

12. Intensify the extension agents knowledge of agribusiness and how it relates to field crop production and the grower's interest.

II. INTRODUCTION

1. Reason for the Study

In 1976, a project to develop livestock feed production and utilization in Tunisia was initiated by the U.S. Agency for International Development in conjunction with Canadian and Swedish foreign aid organizations, and the Government of Tunisia. The project commenced in 1977 and is scheduled to end in 1980, and is part of the USAID assisted Integrated Livestock Project which was begun in 1971. During the course of that project, it became apparent that forage and feed production and its correct utilization were the binding constraints to improved livestock production. While Tunisian farmers have a long history of livestock raising they have limited experience in the use of feedstuffs to supplement and substitute for grazed forage. Feedgrains per se are produced in small quantities, much of the ingredients for the formula feed industry being imported. Since Tunisia wishes to minimize its imports of agricultural products it appears logical to explore the possibility of domestic production of feedgrains. It is this question which is addressed by this report.

2. Scope of Work

The terms of reference given to the consultants regarding the feedgrains study were to survey all phases of barley, oats, corn, and grain sorghum production and utilization in Tunisia. Specifically included were the following items:

(1) An assessment of the adequacy of feedgrain production to meet current and future needs;

(2) An evaluation of the feedgrain extension program in the Office of Cereals with respect to its impact on meat and milk production;

(3) The impact of current feedgrain availability on the Livestock Feed Production and Utilization Project, taking account of current production, exports, imports, marketing channels, and use in preparation of formula feeds; and

(4) An analysis of the trade-off between feed/forage production and production of cereals.

3. Method of Analysis

The two-member team visited Tunisia for four weeks beginning in mid July, 1977. Both members are familiar with a variety of agricultural systems throughout the world and with grain production and prices. Information used to write the report came from three major sources:

(1) Interview with 24 separate individuals associated with various Government of Tunisia offices, U.S. Agency for International Development, Ford Foundation, and the National Bank of Tunisia (see Appendix);

(2) Trips to farms and interviews with 14 farmers, farm managers, and farm owners in the north and central agricultural regions of Tunisia; and

(3) Official public documents, AID reports, and other papers on Tunisia (see Bibliography).

It is clear that the conclusions and recommendations presented here are only as good as the data and accuracy of the interviews given to the team. Further, the team did not feel constrained to present only "politically acceptable" recommendations. It is not within the team's task or ability to judge political acceptability. Acceptability changes over time with changing conditions thus a current politically unacceptable alternative may be quite acceptable in the future.

4. An Outline of Agriculture in Tunisia

As in most developing countries, agriculture in Tunisia plays a major role in the economy, directly accounting for approximately 20 percent of her Gross Domestic Product in recent years and employing 53 percent of the labor force.

For purposes of description the country is usually divided into three regions - the Southern region consisting of 60 percent of the country's area where rainfall is below 100 mm per year and production is limited to extensive grazing (except along the coastal fringes), the Central region where annual rainfall varies from 200 mm in the interior and south to 400 mm along the coast and the north, and the Northern region where annual precipitation ranges from 400 mm to above 700 mm and where most of the cereals are produced.

It is only the latter two regions that are of concern here. The Central region is basically used for livestock grazing (cattle, sheep and goats) except in the valleys where dryland farming (durum wheat, barley) is practiced and along the coast where olives, fruit trees, and vegetables are grown.

The Northern region contains the country's only non-seasonal river, the Medjerda, and in this area much of Tunisia's 133,000 irrigated hectares are found. On this area, more than half of the nation's vegetables, almost all of its grapes and citrus production and about a third of livestock production are found. On the dryland areas, approximately 70 percent of the national cereal output (durum and bread wheats) is grown. In addition, barley, oats, beans, peas, forage crops, and other crops are produced. This region is clearly the most productive and most developed agricultural region in the country.

III. THE TUNISIAN GRAIN SITUATION

1. Current Grain Production, Trade and Prices

The structure of the foodgrain/feedgrain industry in Tunisia is such that it cannot be separated into two distinct activities as is the case in many developed countries. Barley, the principle feedgrain, is also used for human consumption and poorer quality wheat and wheat by-products are often fed to livestock. Accordingly we will review the total grain sector.

Wheat is grown in the north and central regions under dryland conditions. Two types of wheat are grown - durum wheat which is used in pastas and couscous, and bread wheat which is used in breads. Of the two, durum is the most important covering an area of 1.27 million hectares in 1976 and producing 940 thousand metric tons. Bread wheats are grown on 126 thousand hectares and yielded 210 thousand metric tons.

Barley and oats are also grown in significant quantities covering an area of 576 thousand hectares and 39 thousand hectares, respectively, in 1976. Including other miscellaneous grains total production in 1976 was 450 thousand tons.

Tunisia cereal farms are very variable in size. Of the 123 thousand cereal farmers roughly half have farms of 5 to 20 hectares and occupy approximately 33 percent of the cereal land. On the other hand, there are 310 cereal farms (0.25 percent of cereal farmers) which are larger than 500 hectares. These farms account for over 5 percent of the cereal area.

The cultural practices used depend on whether the farm is dryland or irrigated. Dryland farms have numerous rotations but the traditional one in the north was cereal-cereal-fallow-fallow grazed (grazing of the weeds in the 4th year rotation). However, since the advent of better varieties and a successful cereal extension program sponsored by the Office des Cereales the typical rotation at this time is generally cereal-legume or sugar beet and occasionally oat-vetch or sunflower following cereal. The practice of farming cereals for two consecutive years has been discouraged. In the dryer or center part of the country, a typical dryland rotation is cereal-fallow. In recent years, medic has been introduced in rotation with cereal and has met with success on a limited area.

Where irrigation is available, farmers will grow a variety of vegetable crops with various rotations which include cereals, but it appears that the cereal fields are never irrigated.

The grain producers appear to be well equipped with modern tractors and grain combines. At the time of harvest the grain is sacked in the combine and transported to collection centers. From these centers it is shipped via truck or rail to the nearest cooperative grain elevators or to some storage areas in Tunis. Once the grain has reached its destination it is unsacked and stored as bulk grain.

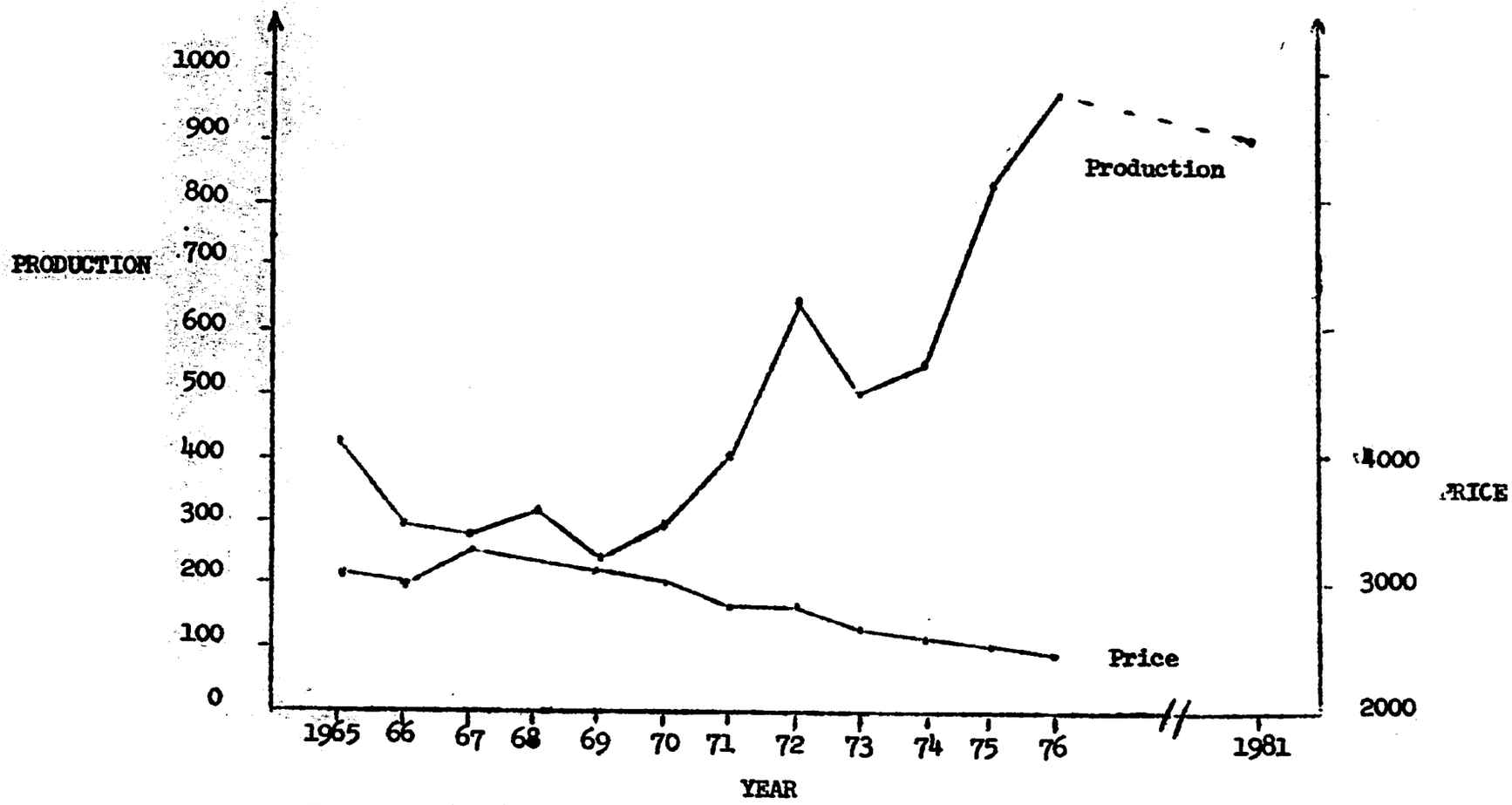
Grain produced under adequate rainfall condition exhibited good quality. However, some grain produced under marginal environmental conditions was of inferior quality due to lack of moisture towards the end of the maturation process.

Corn production at this time is limited to small areas within various irrigated districts. Yields have varied from 10 quintals per hectare to 60 quintals per hectare. Most yields have been disappointing due to a number of production factors. Mainly, poor stand establishment, improper irrigation methods, inadequate weed control and lack of technical corn production knowledge contributed to low corn yields. At this time, less than 2000 hectares are currently in production. During our travel to various irrigated districts we did not observe any area planted to grain sorghum production.

Durum wheat production has increased dramatically since 1969 when a government policy change allowed for increased private ownership of land. Production increased from 245 thousand tons in 1969 to 940 thousand tons in 1976. This increased production has occurred despite the fact that real net farm prices (after tax) for durum wheat have shown a secular decline over that period (figure 1).

The Tunisian government has adopted a policy of administered prices for cereals at the producer, intermediate, and retail levels. Some wheat is sold outside government channels in the "parallel market" at prices slightly higher than government levels. Until the steep increase in world wheat prices during the 1972-74 period, the domestic price of Tunisian wheat was substantially higher than that prevailing on the world market. While it is very difficult to compare producer prices across countries because of quality differences, artificial exchange rates, transportation costs, and different price support programs, it does appear that producer prices in Tunisia are typically higher - as much as 80 percent higher - than those

FIGURE 1. DURUM WHEAT PRODUCTION (THOUSAND TONS) AND REAL NET FARM PRICE (MILLIMES PER QUINTAL, 1962 PRICES)



SOURCE: 1, 8, 14.

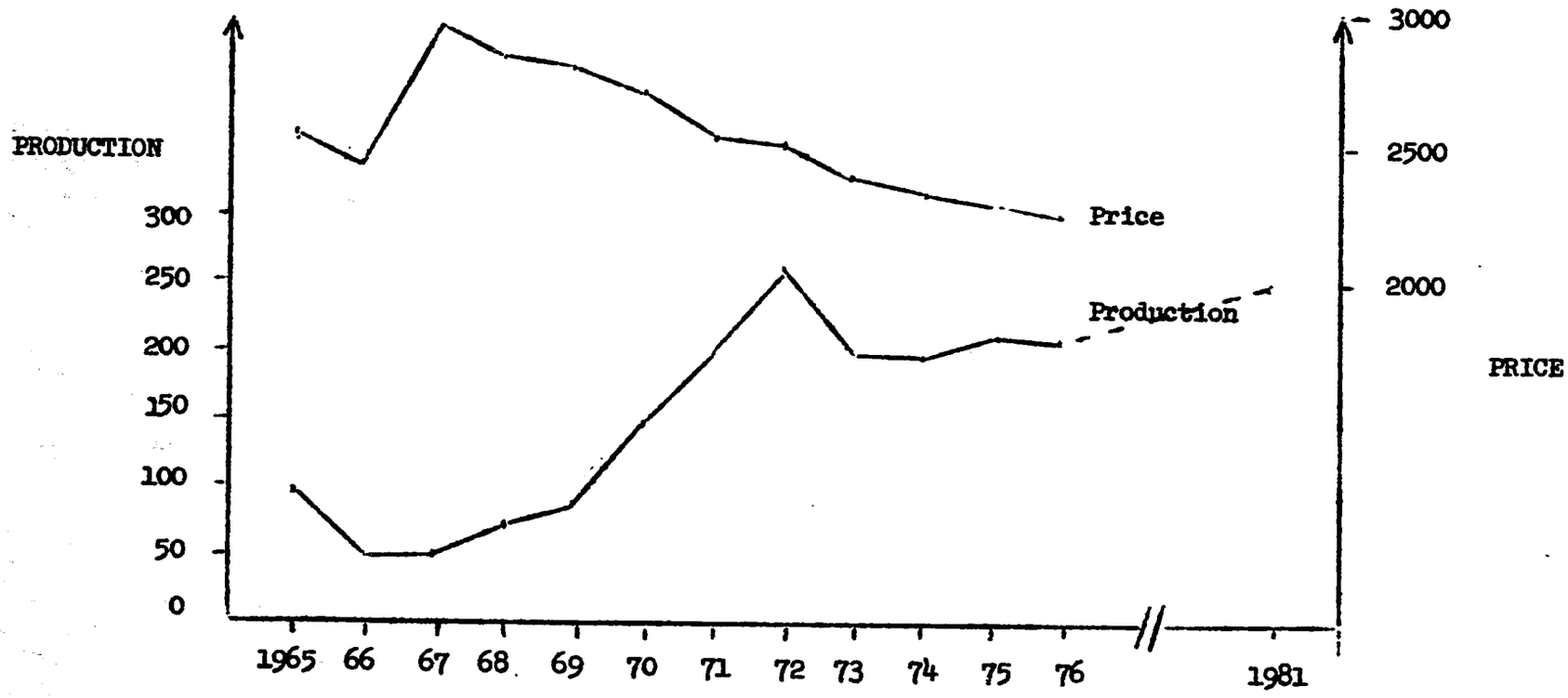
existing in the major wheat exporting nations (8).

Tunisia was a traditional exporter of durum until the early 1970's. At this time increased domestic consumption eliminated the export surplus. In the last year, increased production has again moved Tunisia into a net export position. The Fifth Plan of the Ministry of Agriculture (14) calls for durum wheat production of 900 thousand tons by 1981. Since this figure was exceeded in 1976 the goal may have already been met.

The bread wheat production in Tunisia has also increased since the late 1960's although in the last four seasons production has leveled off at around 200 thousand tons. While the Government wants to produce enough bread wheat to fill its domestic needs, imports have been running around 300 thousand tons in recent years. It is unlikely that this situation will change greatly in the future given a continuation of falling real farm prices for bread wheat (figure 2) and the relatively high durum to bread wheat price ratio. The Fifth Plan calls for bread wheat production of 250 thousand tons by 1981.

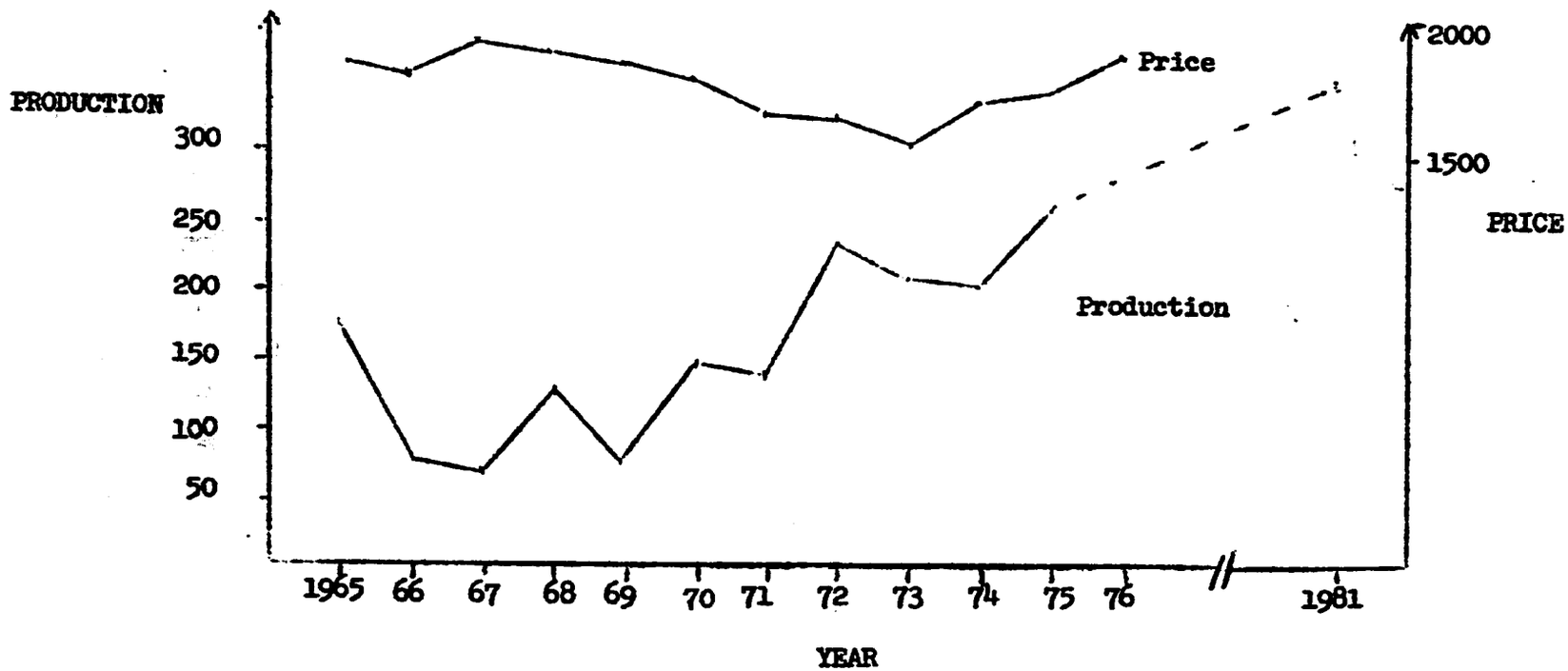
Production of barley and other grains, while being more variable because of climatic variability, has increased since 1969. This is due in part to the fact that the real barley price has trended upward in recent years compared to the downward trend in wheat prices (figure 3). The 1975 barley production was 260 thousand tons with 350 thousand tons being planned for 1981.

FIGURE 2. BREAD WHEAT PRODUCTION (THOUSAND TONS) AND REAL NET FARM PRICES (MILLIMES PER QUINTAL, 1962 PRICES)



SOURCE: 1, 8, 14.

FIGURE 3. BARLEY PRODUCTION (THOUSAND TONS) AND REAL NET FARM PRICE (MILLIMES PER QUINTAL, 1962 PRICES)



SOURCE: 1, 8, 14.

Because of the growing livestock industry increased quantities of feedgrains have been imported during the 1970's. Barley and other grain imports grew from less than 12 thousand tons in 1970 to over 72 thousand tons in 1974. Preliminary import figures for 1976 indicate that 64 thousand tons of corn alone was imported. By 1981, the Fifth Plan projects that this figure will rise to 130 thousand tons.

In addition to corn, 15 thousand tons of soybean cake was imported in 1976 and this is projected to rise to 60 thousand tons by 1981.

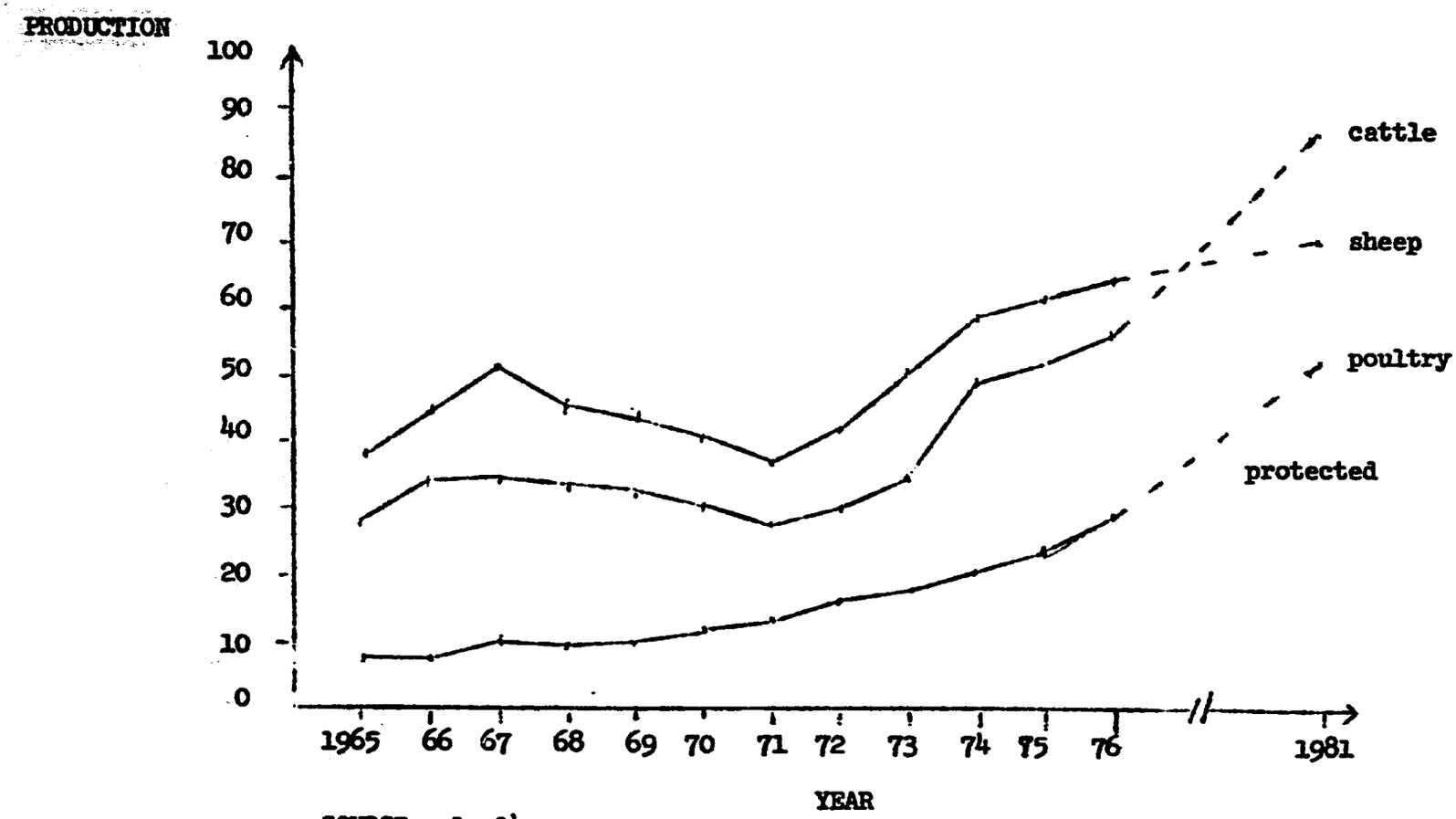
2. Current Meat Production

While the scope of this study was not intended to specifically examine the livestock industry, from the standpoint of analyzing the feedgrain industry and production some form of reference points had to be established with respect to the livestock production in Tunisia.

Meat production in terms of live weight produced by cattle, sheep, and poultry is one such indicator used as a reference point. The total number of sheep and cattle imported into Tunisia also plays a significant role in feed consumption, but is difficult to assess in terms of meat production. We purposely omitted meat production from goat, camel and pork, since these sources account for a relatively minor amount of total meat production (Figure 4).

In 1976, meat produced from cattle, sheep, and poultry represented 90 percent of the total live weight produced in Tunisia. It is projected that by 1981 cattle, sheep, and poultry will account for approximately the same percentage but not necessarily in the same ratio as in 1976 (table 1).

FIGURE 4. MEAT PRODUCTION BY TYPES (THOUSAND TONS)
LIVE WEIGHT



SOURCE: 1, 14.

Table 1

Meat Production by Types and Percent of Total
(Thousand tons live weight)

	1976		1981	
	Live Weight	% of Total	Live Weight	% of Total
Cattle	55.9	33.8	76.3	34.6
Sheep	65.8	39.9	70.9	32.2
Poultry	29.3	17.7	52.3	23.7
Other	13.9	8.6	20.5	9.3
TOTAL	164.9		220.0	

According to the projected 1981 production figures, meat produced from sheep will decline by 7 percent. However, the biggest percentage of meat increase will be coming from the poultry sector. An increase of approximately 6 percent in poultry meat production is expected to take place by 1981. In terms of feedgrain consumption the poultry sector will consume more feedgrain than that reduced as a result of a decrease in sheep production. Total meat production is projected to increase 34 percent above that of 1976 meat production - an increase from 164 thousand tons in 1976 to a projected 220 thousand tons in 1981.

Meat production from cattle and sheep has shown a steady increase from 1965 to 1976 with the exception of a slight downward trend from 1967 to 1971. All other years have recorded an increase in production.

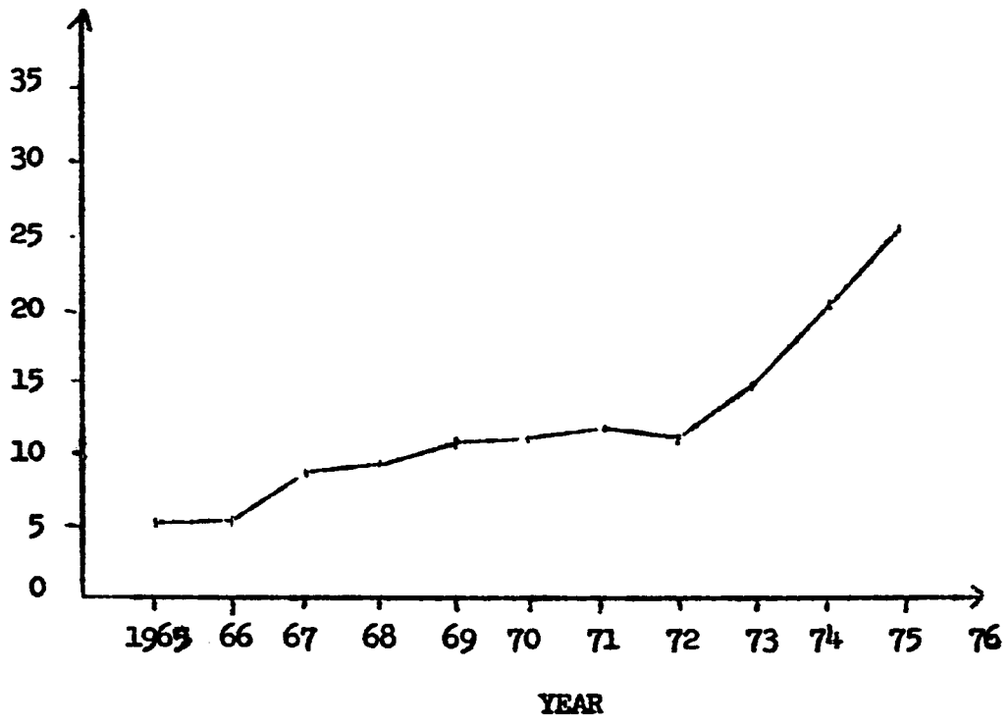
The poultry industry has shown, from 1965, a steady increase and is projected to attain the greatest percentage increase by 1981. Since more than 50 percent of the contents in the present poultry feed concentrate formulated in Tunisia contain corn, it is apparent that maize consumption will continue to rise sharply in the years ahead.

The tonnage of cattle and sheep slaughter meat imported in Tunisia is an important figure to take into consideration in regard to planning for total livestock feedgrain consumption in the years to come. In 1965, Tunisia imported 5,900 tons of slaughter meat, in 1975 a total of 26,200 tons were imported representing an increase of over 400 percent for that same period (figure 5).

Other factors that indirectly affect the livestock/feedgrain program is the production of eggs and milk. Although we have not graphically illustrated the egg and milk production from 1968 to 1975, it should be emphasized that production from these two products have increased moderately over the years. Milk and eggs have increased in production 53 percent and 47 percent, respectively, over an eight-year period. Since both of these products are produced from animals requiring some form of formulated feed, it is imperative that this additional feed requirement be assessed carefully.

The above comments pertain to a small segment of the livestock industry. We have merely attempted to emphasize the major components that have a direct influence on the future of the livestock feedgrain program in Tunisia.

FIGURE 5. CATTLE-SHEEP MEAT IMPORTS
(SLAUGHTER WEIGHT, THOUSAND TONS)



SOURCE: 1, 14.

IV. CURRENT CONSTRAINTS TO INCREASING FEEDGRAIN PRODUCTION

During the course of this study it became apparent that there are many obstacles retarding agricultural production in Tunisia. Some are specific to the feedgrain sector while others are quite general. We now detail what we see as the major inhibiting factors. The order in which we present them does not necessarily imply their order of importance. Also, recognition of the problem does not imply that the problem can be easily addressed. Some problems are structural and traditional for which there is no "quick fix".

1. Land Tenure

There are two aspects to the land tenure problem - the problem of absentee landlords and the problem of family division of a parcel of land into many small plots.

Considerable tracts of land (unquantified, as far as we know) are owned by individuals to whom the agricultural output is a secondary or unimportant source of income. We heard many cases of landowners who lived in the city visiting their farm only at planting and harvest time. Rather than leasing their land under a method that allowed incentives for production by the tenant many such owners merely hire workers and a foreman on a wage basis where no incentive exists for performance. These farms are being operated inefficiently and appear to be producing at levels well below better managed farms.

Even on land where owners have renters operating the farm the landlord/tenant lease is often one of a flat payment by the tenant

for the right to use the land. Since the landlord will get this payment regardless of the level of output, there is no incentive for him to invest in capital improvements such as farm buildings, irrigation systems, land leveling, etc. Further, since the lease is often an annual one the tenant has no security and will not invest in any interannual activities.

The second aspect of the land tenure problem is the custom of a landowner dividing his land between his sons. Over the generations this has led to a very small farm size in some areas and in many cases efficiency problems associated with non-contiguity of parcels of land exist. A farmer may own several small tracts of land separated by several other farms. This type of farm structure is inefficient. Parcels of land are so small that it is not profitable for the farmers to employ modern production techniques. Some effort to consolidate land holdings has occurred when irrigation perimeters have been created. Currently Tunisia has a law imposing a maximum farm size that an individual may own in public irrigated perimeters. While we do not necessarily recommend controls on farm size we observe that laws placing a minimum size on farm land ownership make as much sense as those that place a maximum size limit on land ownership.

2. Extension and New Technology

It is difficult to assess the effectiveness of the extension program since extension agents are attached to various offices in the Ministry of Agriculture. While extension agents working in the Office of Cereals are technically well trained and render a

satisfactory service to cereal growers, there are serious deficiencies in the extension service. All of our contacts have been with agents who specialized in cereal production and freely admitted that maize or sorghum was a totally new crop to them. Agents located in the countryside cannot be expected to be proficient in new technology if they are not given direction and training from the specialist in the home office.

Individuals who were familiar with maize production did not have experience with any irrigation schemes and cannot be expected to train field agents. There are between 1000 and 2000 hectares of maize planted and most of these farmers rely largely on their own intuition for guidance. Agents and farmers are learning together. This is not an ideal situation and does not add to the growers' confidence in the Extension Service.

We have noticed that there is a lack of communication between the national research organization and extension. Very little exchange of information appears to flow between these organizations. A free exchange of ideas should be encouraged between all organizations charged with promoting agriculture at all levels of production.

In the irrigation perimeters developed by the Government, farmers have not traditionally used irrigation. They know very little about irrigation systems, alternative crop choices, rotations, possibilities of double cropping, optimal fertilizer use, etc. In many areas where water is available dryland farming is still practiced on part of the land because of farmer inexperience with irrigation and with new crops such as corn.

Extension agents appear to be spread too thinly and they are not knowledgeable in many matters pertaining to production or extension techniques. Until recently extension publications were written in French - a language not read by a large proportion of small farmers who may even have a low level of literacy in Arabic. Under such conditions frequent farm visits, demonstrations, and close contact with farmers by extension agents is critical if farmers are to adopt new crops and improved production methods.

We understand that the national farm extension budget has been reduced recently. It appears to us that a greatly expanded extension program would have a very high rate of return and we question the wisdom of decreasing the farm extension budget. A larger part of the budget should also be allocated to training extension specialists. Unless the extension agents are well trained and knowledgeable they cannot be expected to perform effectively.

3. Land Title

In many parts of the country, farm owners do not have clear title to their farm thus making it impossible for them to obtain long-term credit. Before irrigation perimeters were developed land ownership was such that a farmer might own several small pieces of land. Property boundaries were rather unimportant because of the extensive nature of production. When the irrigation system was installed the Government attempted to consolidate the fractured landholdings by reallocating land to give each farmer a single tract. However, the issuance of ownership titles for the land has been very slow and the process of obtaining title is a long and tedious one. Yet title or

"Certificate of Possession" is a prerequisite for long-term credit. Thus for many farmers it is not possible for them to finance capital improvements such as land leveling, permanent irrigation ditches, deep wells, farm ponds, etc.

4. Competition with Other Crops

In Tunisia, maize must be grown under irrigation. Currently crops grown under irrigation are relatively high-value, labor intensive crops such as vegetables, melons, tobacco, fruit, etc. Small areas of alfalfa and maize are grown but these areas are not large. If maize production is to be increased it will be on land where these higher value crops can be grown. A recent government study (unavailable to us as it has yet to be released) has shown what is intuitively obvious - that the net returns from a variety of vegetable and fruit crops is considerably higher than that from maize production where the price is set by the government at TD 7 per quintal. Relatively few large tracts of irrigated land on which a modern maize production industry could be developed are available. Tunisia has approximately 133,000 hectares of land under irrigation. Thus under the current structure it is unlikely that a significant increase in maize production will occur unless it can be fitted into a crop rotation with vegetables.

5. Government Decisions

Without an explicit decision and action by the Government to increase feedgrain production in Tunisia, levels of output are likely to remain small. In the absence of considerable incentives to prospective feedgrain producers, farmers are unlikely to adopt the technology required for maize production because it is more profitable and less risky for them to raise high value vegetable crops. Farmers are familiar with these crops, they know the production methods, they have a subjective idea of the returns they will obtain, and they see little reason to experiment with an unknown crop. Risk aversion, reluctance to change, and the strength of tradition and habits, especially among those whose standard of living is barely above subsistence levels, all enter into the farmer's decision to avoid new crops or cropping systems.

For farmers producing wheat under marginal dryland conditions in the central region, wheat is produced in preference to barley because of the greater return it yields under a system of administered prices. The wheat/barley price ratio is high relative to the world price ratio. Currently Tunisian farmers receive TD 7.135, 6.555 and 5.35 per quintal for durum wheat, bread wheat, and barley respectively. This gives a durum wheat to barley price ratio of 1.333 and a bread wheat to barley price ratio of 1.207. These compare to ratios of 1.180 and 1.105 respectively for similar grains on the U.S. market. The relatively low barley price must certainly be a major factor inhibiting barley production in areas where rainfall is such that the land is better suited to barley than wheat production.

Accordingly if the Government wishes to increase feedgrain production it will need to raise the price of barley. It will also need to make maize production attractive to producers by removing the barriers which now exist. Higher prices, free or subsidized inputs, frequent agronomic advice by knowledgeable extension agents, etc. are steps that could facilitate maize production.

Before the Government undertakes such action, however, it should consider other alternatives available to it. Alternative wheat rotations, discussed later in this report, further encouragement of heavier fertilizer application on wheat land, and the timely availability of fertilizer and high quality seed wheat could dramatically increase wheat production. This would allow an exportable surplus of production and/or the switching of marginal wheat land to barley production. An alternative to attempting to introduce maize production on irrigated areas is to increase fruit and vegetable production. The possibility of expanding markets for these products should be investigated, together with an investigation of the adequacy of ancillary marketing and transportation systems to handle the increased volume. If feasible this alternative is likely to yield greater returns to farmers than growing maize and could generate export revenue with which maize could be purchased on the world market.

6. Technical Agronomic Limitations

(a) Land Preparation

During our brief stay we spent time visiting different public irrigated perimeters in as many regions as time allowed. It was highly noticeable that lack of land preparation was a limiting factor in crop production. Many fields were not properly prepared for furrow irrigation and consequently a considerable amount of labor was being used to spread water evenly across fields. In all these instances the land was not leveled prior to planting due to lack of land leveling equipment. In other instances land was not level because it looked or appeared to the grower that the land was level and no further measurements were made. In some cases furrow irrigation was being used on highly irregular surface areas, resulting in a considerable amount of water loss. Many small areas scattered throughout these production fields were not irrigated and were not expected to produce anything. We did observe one maize production field in the Sbikha area that was properly leveled and was being irrigated in the correct manner. It was by far the best production field in any of the irrigated perimeters we visited and should be used as a model and a teaching aid to managers of other irrigated perimeters. In most cases managers were well aware of the problem of land leveling but due to lack of equipment very little was done about the situation. Investment in proper land leveling equipment is a must if a furrow irrigation system is to be used properly. Properly graded land conserves water. Land leveling is an expensive outlay and should be studied carefully in light of water availability and types of crops that are anticipated to be grown in the region.

(b) Irrigation Methods

The furrow or sprinkler irrigated methods of applying water were the most commonly observed systems used. Fields utilizing the furrow method were, for the most part, not properly leveled. As a result, poor water management and loss of crop productivity were encountered. Any fields set up to use the furrow method of irrigation must be graded accordingly otherwise an alternate method of irrigation must be used. In many irrigated perimeters the lack of water pressure prohibited the use of furrow irrigation, thus forcing all growers to use the expensive sprinkler system regardless of cropping pattern. The laborers who worked with the furrow irrigated method were not aware of the use of syphon tubes and instead were using a series of small dikes and canals to direct water and trying to compensate for the unlevel land.

Principles of applied irrigation techniques should be taught by individuals who have had some experience in row cropping. See accompanying remarks under crop technology. Sprinkler systems currently used on maize were not adequate and caused some leaf and mechanical injury to plants that are near risers and nozzles. The damage was particularly evident in fields where they were using short risers above the water pipe. There are some definite advantages to using a sprinkler system, mainly that it conserves water and the land does not have to be level. However, sprinkler systems are expensive and/out of reach for most small growers. In addition, they can create some crop management problem such as finding enough labor to irrigate at night in order to avoid leaf burn and cut down on water evaporation loss. In addition, short maize varieties would

have to be developed to complement the sprinkler system. Lack of available pressure dictates the use of sprinkler systems, consequently the choice of suitable crops should be determined on that basis. It may be that until an adequate water supply is available maize should not be grown in perimeters utilizing sprinkler systems.

Due to the high cost of a sprinkler system and other related problems it would seem wise to expand the vegetable production and concentrate maize production in perimeters where the furrow irrigated system can be used to its full advantage.

(c) Crop Technology

Producing a high-yielding crop regardless if it is maize, sorghum or other feedgrains requires a high degree of input from all parties concerned with production. It is evident at this time that if maize production is to be encouraged, technicians will have to be trained in the methods. During our farm visits we encountered very few individuals who were knowledgeable about maize production under an irrigation system. The whole concept of maize production should be taught to all individuals who are going to be responsible for production. The technology at this time is known but to only a very few. There are many areas in the United States where this type of training can be obtained in a relatively short period of time. Emphasis should be placed on actual farm production experience. Especially valuable would be experience with equipment maintenance, cultivator setups, calibration of seed planter and sprayer. In addition, training in proper irrigation techniques under similar environmental conditions is a must. All training phases should be based on actual field experience with maximum exposure to as many varied conditions as possible.

(d) Research

As part of our investigation we visited the National Institute for Agronomic Research of Tunisia (INRAT) facilities and found that, because of lack of funds, good scientists were curtailing their research activities. If a new technology is to be adopted by growers, necessary research support funds must be committed towards that end. It is not in the scope of this survey to outline the many research projects that should be carried out by INRAT. Scientists at INRAT are well aware of what needs to be done and are keenly interested at the prospect of working on problems related to feedgrain production. If the Government is committed to increasing feedgrain production then adequate funding for feedgrain research must be available.

V. INCREASING FEEDGRAIN PRODUCTION

Prior to introducing a new concept regardless of difficulty of adoption one must approach the new program with caution and at the same time with tenacity. In the eyes of the grower a new concept of system of cropping means difficulty, suspicion and above all a higher element of risk on his part. Any new system introduced to growers should be thoroughly tested beforehand on a small scale on various state-owned farms on as many soil types and climatic conditions as possible. The intent of a testing program on local farms is primarily done to find out how varieties respond to various soil types, dates of planting, irrigation scheduling, and other related cultural practices. During the testing phase research personnel and extension agents can become familiar with the program and at the same time it gives participants an opportunity to learn the technology without risking costly mistakes on large planted acreage.

Individuals assigned to this project should be highly motivated, have a high degree of mechanical aptitude and be adaptable to new situations. In an economy such as Tunisia the key to successful adaptation of new technology by farmers depends largely on the ability of the extension agents to gain confidence of the growers. If growers are going to launch into a new cropping system, extension agents and research personnel are going to have to be ready to back them up with proven research and practical know-how learned from previous years of testing.

We are well aware that resistance to change is a very difficult situation to overcome with farmers who have followed traditional methods for decades. However, we feel confident that given a reasonable period of time these obstacles will slowly be overcome providing we can avoid costly unnecessary mistakes during the initial state of introduction.

The following suggestions to increase feedgrain production are based on sound technical basis and are feasible to implement providing a carefully thought-out approach has been made. Admittedly some of these methods require a higher degree of farming ability, others are quite simple and require very little change in current cultural practices. Needless to say that some of those methods are only adaptable to certain areas under a given set of conditions. We have not attempted to present a system that can be used informly throughout the country. We assume at this point that all major constraints have been removed prior to establishing the following cropping systems.

1. Single Crop per Year - Maize-Sorghum

(Irrigated Perimeter) Furrow Irrigation

This is a relatively simple approach to maize-sorghum production because the time element is in favor of the grower. Land preparation can begin in the fall after the last harvest or after the winter rains have subsided in the spring. Land preparation consists of discing, harrowing, floating and listing of beds every 70 to 90 cm apart. Fertilizer should be applied prior to bed shaping or at the same time depending on equipment. The amount applied initially will depend on

soil type and leaching potential. A second application of fertilizer can be applied as side dress at the time of the last cultivation. Following land preparation one pre-irrigation is applied in sufficient amount to saturate the soil profile 1.2 m to 1.8 m. Final bed shaping and the use of herbicide may be applied at this time if the conditions warrant its use. Seed planters should be adjusted to match the bed spacing and calibrated to drop the required amount of seed suggested by the seed producer. Depending on the varieties, maize is seeded at 50,000 to 70,000 seeds per hectare. Sorghum can be seeded at 9.0 kg to 13.5 kg per hectare without any appreciable yield differences. Seeds should be planted in soil moisture and firmly packed. Following stand establishment one or two cultivations may be necessary depending on weed infestation.

Irrigation scheduling should follow recommended practices for the soil type and area. Generally, maize should be irrigated every 8 to 12 days or may be less frequent if it is planted on heavy clay soils, sorghum is irrigated less frequently than maize. Irrigation scheduling for sorghum or maize can be determined during the initial testing stages along with choice of varieties, fertilizer requirement and time of planting. Irrigation of maize is generally stopped at the black layer formation stage which can be seen at the bottom of the kernel if it is cut transversely during the hard dough stage. Harvest can commence when grain moisture is less than 20%, however, grain cannot be safely stored at moisture exceeding 10-11%.

Prior to planting a soil analysis should be conducted to determine the fertilizer requirement, the EC_e level (Electrical Conductivity of soil extract) and other tests than can be helpful in making

crop management decisions.

The choice between sorghum or maize, if the financial inputs are not limiting, will depend on the soil type and availability of water. Sorghum will tolerate a higher level of salt, require less water and managerial skills and is generally more drought resistant than maize.

The above scenario is a broad example how maize is produced under arid conditions using furrow irrigation. We did not mention diseases, insect control, seed quality, choice of herbicides and others because they have to be researched on location. The above system under comparable climatic conditions of the San Joaquim Valley in California yields up to 11 MT/hectare of maize . Sorghum will yield less than maize under comparable management conditions and more prone to bird damage. However, recent development of sorghum varieties that are bird resistant are currently commercially available.

The above system can be used on irrigated perimeters with furrow irrigation providing good crop management is practiced. In the event furrow irrigation cannot be used, sorghum production would be recommended under a sprinkler irrigation method.

2. Double Cropping - Maize-Sorghum

(Irrigated Perimeter) Furrow and Sprinkler Irrigation

In comparison, this is a more sophisticated system than the previous one. It requires good timing, more labor and equipment inputs and the willingness to work long hours. Generally, this cropping sequence follows either a winter forage crop or a barley or wheat

crop depending on the traditional rainfall condition in the months of October and November. If winter rains are delayed until November or December a short-season maize or sorghum variety can be planted following a grain crop of barley or wheat. Double cropping behind wheat is somewhat riskier because of the late maturing nature of wheat which is later than barley by 10 to 14 days. In any event, the objective is to plant the following crop by the first week of July.

Double cropping behind a winter forage usually gives the grower more time to prepare and plant his next crop. Winter forage can be harvested in April or early May thus allowing ample time for land preparation. Growers chosing to double crop have an additional option to harvest maize or sorghum as grain or silage depending on their requirements. The key to using this system successfully is the selection of early maturing varieties. Maize and sorghum varieties maturing in less than 90 days are commercially available from many U.S. seed producers.

If sorghum is double cropped a grower can have the option of using furrow or sprinkler irrigation systems.

Under the double cropping method the same crop management practice is used as in the single crop system with some minor modifications in fertilizer requirements, variety selection, and plant population. In general, less fertilizer is used, an early variety is chosen and a high plant population is established. Double cropping is not limited to following cereals, it can also follow a winter vegetable crop. The potential to increase feedgrain by this method is substantial and will require careful planning and execution.

We do not envision this system to be practical until growers have learned to use irrigation on cereals and realize themselves the potential of maximum utilization of available water. Under good management this system has commonly produced 87 MT of maize silage per hectare per crop year (32 MT of winter forage and 55 MT of maize silage), or 14.3 MT of grain per hectare per crop year (5.5 MT of cereal grain and 8.8 MT of maize grain).

3. Barley in Northern Sector (Dryland)

At the present, barley is not too commonly planted in the rotation in the northern sector of the country. Generally this is the traditional wheat belt of Tunisia where high yields can be expected under normal environmental conditions. At this time there is not any price incentive to plant barley in the rotation, and if this is to change the pricing differential between barley and wheat will need to be reduced. The potential total production from this system will depend on how many growers are willing to convert from wheat to barley production.

4. Increase Wheat Yields in the Northern Sector (Dryland)

It appears to us that the northern sector has a tremendous potential to increase yields. We are aware of the additional inputs required to increase yield and the reluctance on the part of the grower to take that risk. We would recommend that more efficient and timely use of fertilizer be continued to be recommended to growers. In addition to advocating using proven varieties from good seed source, the effectiveness and the economic benefit from using timely application of herbicides should also be encouraged.

Special emphasis should be placed on educating the grower on the business aspects of cereal production.

Currently many farmers operate in a very traditional manner. Especially on smaller landholdings farmers operate in a modified subsistence manner producing agricultural goods for their own household consumption and selling any residual that they may have. Under such conditions farmers tend to be very risk averse. This means that farmers endeavor to minimize their input costs in order to minimize their losses if, in any one year, the crop fails. Consequently, farmers frequently underfertilize. We were told that even if the probability of crop failure due to drought was 0.1 farmers would still underfertilize. Studies need to be conducted to ascertain optimal applications of fertilizer under conditions of uncertainty. If it is then demonstrated that farmers are indeed underfertilizing then steps should be taken to rectify this situation. If explaining to the farmer is insufficient to convince him that he is fertilizing at an incorrect rate then the government should consider assuming the risk for the farmer. It could do this by forgiving loans on fertilizer in years where there are crop failures, by offering farmers a certain minimum return per hectare on their crop land and making up the difference between this and what the farmer actually realizes in years of drought, or a variety of other devices. These devices could eventually be phased out as the farmer becomes more willing to assume some risk.

Along this same line we observe that very few extension agents are capable of advising farmers on farm management/agribusiness matters. They know little about input costs, returns for alternative

crops, farm record keeping systems, credit availability, etc. The reason for this is that there is a lack of data and research at the national level on economic matters. Because of this, agribusiness is not emphasized during the training of extension agents.

Technically it is possible to increase yields in the northern sector to a point where production in excess of domestic human needs could be produced. From an economic point of view, we suspect that the case is equally true. With better management, optimum fertilizer applications, closer advice from farm management extension specialists, and some removal of farmer risk by the government, increased yields should occur.

5. Barley in Rotation - Center Sector (Dryland)

It is felt that the greatest potential for increasing feedgrain production in the immediate future is by introducing barley in rotation with medic in the center of the country. The basis for our reasoning is as follows: Barley generally reaches maturity before wheat and the evapotranspiration for barley is less than wheat. Therefore, it would appear that barley could be grown in this area more successfully than wheat.

We are specifically concerned in creas where annual rainfall is between 300 mm and 450 mm per year.

It would appear to us that wheat production is a greater risk in this area unless late rain can be depended on to carry the crop to maturity. We have observed that the quality of wheat from this area is not as good (pinched kernels, small seeds and yellow berries) as in the North. We believe, due to the maturity differences

between barley and wheat, that barley could be grown more successfully over a period of years than wheat.

In years when marginal condition for wheat production is encountered the chances are that barley production will be higher and with better grain quality than wheat. In many areas of the world the input for growing wheat is higher than barley, and if the price offered to growers were closer for both cereals the incentive for growing barley would exist. Usually less fertilizer and seed are required for barley production, and typically barley is a better competitor with weeds than wheat.

By raising the barley price closer to the world wheat:barley price ratio we would expect greater quantities of barley to be forthcoming in this area. Such a shift would need to be taken hand in hand with increasing wheat yields in other areas in order to compensate for the smaller wheat area.

6. Increase Barley-Maize-Sorghum Research

Special efforts should be made to develop barley varieties adaptable to various areas of the country. Varieties that are drought-resistant need to be developed along with characteristics of earliness and salt tolerance. Early maturing barley would especially fit into the low rainfall area in the center of the country. A relatively large area could be planted with this type of barley along with medic in rotation.

Plant breeders who are familiar with local conditions should devote some time to develop varieties that are adaptable to the southern region. At the present local barley varieties in the

Southern region are not known to most cereal specialists.

If an effort is to be made to increase feedgrain production an equal effort must be made to develop an effective barley plant breeding program.

Equally important is the development of a maize and sorghum variety screening program located throughout various field crop producing regions.

Emphasis should be placed on searching for maize and sorghum varieties adapted to long season and double cropping situations. Efforts should be made to identify salt tolerant sorghum varieties which can be grown under sprinkler irrigation in areas that have excessive level of salt in water or soil for maize production.

Screening for local diseases, insects and area adaptability should also be an integral part of the objective of the region-wide varietal screening program.

7. Cereal and Fodder Crop Production on Irrigated Perimeters

We propose that work be done on exploring the possibility of producing cereals and fodder crops on the land within the irrigated perimeters which is currently being left idle. This means that agricultural economists need to examine why irrigable land is now being left fallow. Alternative cropping rotations that allow for the introduction of cereals and fodder crops into a farmer's production without conflicting with his labor constraints of equipment availability should be budgetted. Demonstration plots showing how this can be achieved and showing how profitable it can be should be developed.

Plans to produce cereals as part of a rotation on irrigated land may not require much extra machinery except for perhaps extending the farmer's sprinkler irrigation system. Since it also does not require much labor, it may fit into his rotation. The overall idea is simply to move the idle area within irrigation perimeters into production without conflicting too radically with the farmer's existing system. Grain yields obtainable from this type of culture often exceed 7 MT per hectare.

8. Possibilities of "Self-Sufficiency" in Feedgrain Production

Given the resources that are presently available in the cereal sector and the developed land found in the various irrigated perimeters, it is feasible to produce feedgrain in relatively large quantities. However, there are many obstacles to overcome which have already been discussed. The situation could be summarized as follows: (1) Maize production could be started on a small scale on irrigated perimeters providing the major constraints were removed and trained technologists were available to supervise the operation. (2) Barley production could be increased dramatically if it were encouraged and promoted in the center of the country; (3) Dramatic yield increases could be realized with barley or wheat if they were grown under an irrigated system; (4) The political climate must be sympathetic towards the idea of feedgrain production and the proper incentive given to producers; (5) Intensify the practical farm training of all extension agents involved in feedgrain production.

9. Fiber and Oil Crops

It is not within the scope of this study to report on the status of the fiber and oil crops. However, since both of these crops are heavily used in the livestock industry a brief comment on what we have observed in the field is justified. We visited two areas where cotton and soybeans were grown in small experimental plots. It is encouraging to see this type of venture on the part of the managers and research personnel. Based on the limited area that was observed it appears that cotton and soybeans deserved further investigation. Both soybean and cotton plants were healthy and vigourously growing, no diseases or insect pests were noticed at the time. Soybean plants looked exceptionally vigourous and had a good fruit set on most of the varieties. Both of these crops can be grown under sprinkler irrigated system. In addition, soybeans can be grown in a single season or can be easily double cropped after a winter forage crop or after barley or wheat. An added benefit obtained from soybean production is the amount of nitrogen it places in the soil for the benefit of the following crop.

Needless to say that both crops are extensively used in livestock feed supplement. Cotton seed and soybean products produced in this country would greatly benefit the local livestock sector and at the same time reduce imports. Further research and experimental plantings are recommended and should be encouraged at the highest managerial level.

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