THE FUTURE OF MECHANIZATION IN LIBYA

By

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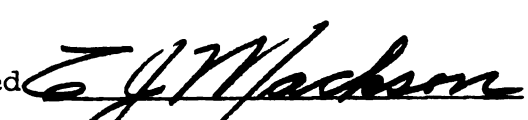
To all those who have been trying to contribute to the mechanization of Libyan agriculture this report is dedicated.

Approved 

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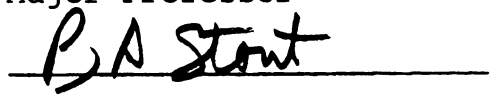
Approved 

Department Chairman

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INTRODUCTION

Agriculture is the mainstay of the Libyan economy and is likely to remain so for a long time to come. Agriculture once produced 30 percent of Libya's domestic production and also employed 70 percent of the labor force [18]. But like most of the developing nations, mechanization was introduced too slowly and with insufficient encouragement of farmers and too complicated an administration; it was little utilized to replace the lack of manpower, to increase their income, and provide enough incentive for the farmers to stay in their lands [20]. In addition, farming was inefficient, largely as a result of poor methods of cultivation and traditional land tenure practice; the country suffered less from a feudal system of land ownership than from fragmentation of holdings, which resulted in many plots being too small for efficiency. The migration of the rural population to the cities, oil fields, and construction sites in search of higher wages has also created a problem.

Libya depends on importation for tractors and machinery. Importers have seldom considered the needs

of agriculture, and the main criteria has been the initiative of dealers and distributors.

Research in the agriculture mechanization of Libya is essential to decide which type of machinery to import and how to use it. The research in agricultural mechanization has been meager. The study presented here makes an evaluation and proposal for agriculture mechanization research in Libya as essential for the success of the process of mechanizing Libyan agriculture.

The University of Libya is the only vocational institution in the country which can proceed in research in agriculture mechanization. It can improve the curriculum of higher education and technical institutes of agriculture. Training programs and seminars for extension people are very important. Cooperation between the Ministry of Agriculture and Land Reclamation, the University of Libya, and the Agriculture Bank is essential to improve the quality of mechanization in the country.

The objectives of this study are as follows:

1. To review the situation of agriculture mechanization in Libya
2. To survey the needs of mechanization in the short and the long run
3. To analyze the real needs for mechanization for the most important crops grown in Libya

4. Manpower available for agriculture and to what extent power machinery should be used to replace it
5. Government support to agriculture sector
6. To prepare a proposal for agricultural mechanization research

Goals of the proposal are:

a. To present guidelines for types of necessary research to be done
b. To prepare guidelines for the experimental procedure for the research in agricultural mechanization
c. To establish short and long term goals according to government plans

Importance of the Research Project

The organization of a research project in agriculture mechanization is very important for Libyan agriculture for these reasons:

1. The government is putting very much emphasis on the development of agriculture.
2. Government agencies, cooperatives, and farmers have great interest in the use of machinery.

3. All of the machinery is imported and for this reason the selection of machinery must avoid the wasting of money. Research is essential to decide which equipment can be used most efficiently under the Libyan conditions.

4. The research done so far in agriculture mechanization is very limited. No exact information is available about the most suitable machinery under Libyan conditions and maintenance.

5. Increase yield per hectar through better methods of tillage, weed control, and the use of better tools.

6. Good possibilities exist for improving hand tools.

I. GENERAL CONDITIONS

1.1 Location and Topography

Libyan Arab Republic (Libya) is located in North Africa and extends in latitude from slightly below 20° North at the southern border deep in the Sahara, to nearly 33° North, the desert coastline of the Mediterranean Sea. In longitude Libya ranges from 9° East to 26° East [5]. On the west Libya is bounded by Tunisia and Southern Algeria, on the east by EAR (Egypt) and the Northern tip of Sudan, the south by Niger and Chad, and the Northern part is bordered by the Mediterranean Sea. The Mediterranean coastline of Libya is nearly 1,140 miles long and is deeply indented by the Gulf of Sirte [12].

Libya consists largely of vast areas of desert. Covering approximately 679,378 square miles (1,760,000 sq. kilometers) [5], Libya is Africa's fourth largest state. The general elevation is approximately 2,000 feet above sea level [5]. There are no perennially running rivers or any true mountains, but there are

several highland ranges south of the narrow coastal plain. Over 95 percent of the country is classified as either pre-desert or desert.

The geographic regions are shown in Figure 1-1.

1.2 Climate

Libya is located between two enormous geographical features, the sea and the desert. The sea climate is characterized by mild temperatures and humidity, where as the desert is dry and hot. The result is the formation of quite a number of zones; in fact, five zones are distinguishable: the Mediterranean Zone (coastal belt) the Steppe Zone, the Jebel Zone (mountain zone), the Pre-desert Zone, and the Desert Zone. It should be pointed out that there are also transitional or intermediate zones where the climatic conditions are a mixture resulting from the conformation of two zones [27].

a. The Mediterranean Zone (coastal zone) stretches from the Tunisian to the Egyptian border and ranges from 8 to 15 kms. in width. This is a very important area for agriculture in Libya because the average rainfall is 100-600 mms. per annum. The rainy period averages around 45 days extending from October to March. The temperature is moderate with a maximum of about 30°C recorded in July. In winter the lowest temperature may fall to 7 or 8°C. The relative humidity in this zone

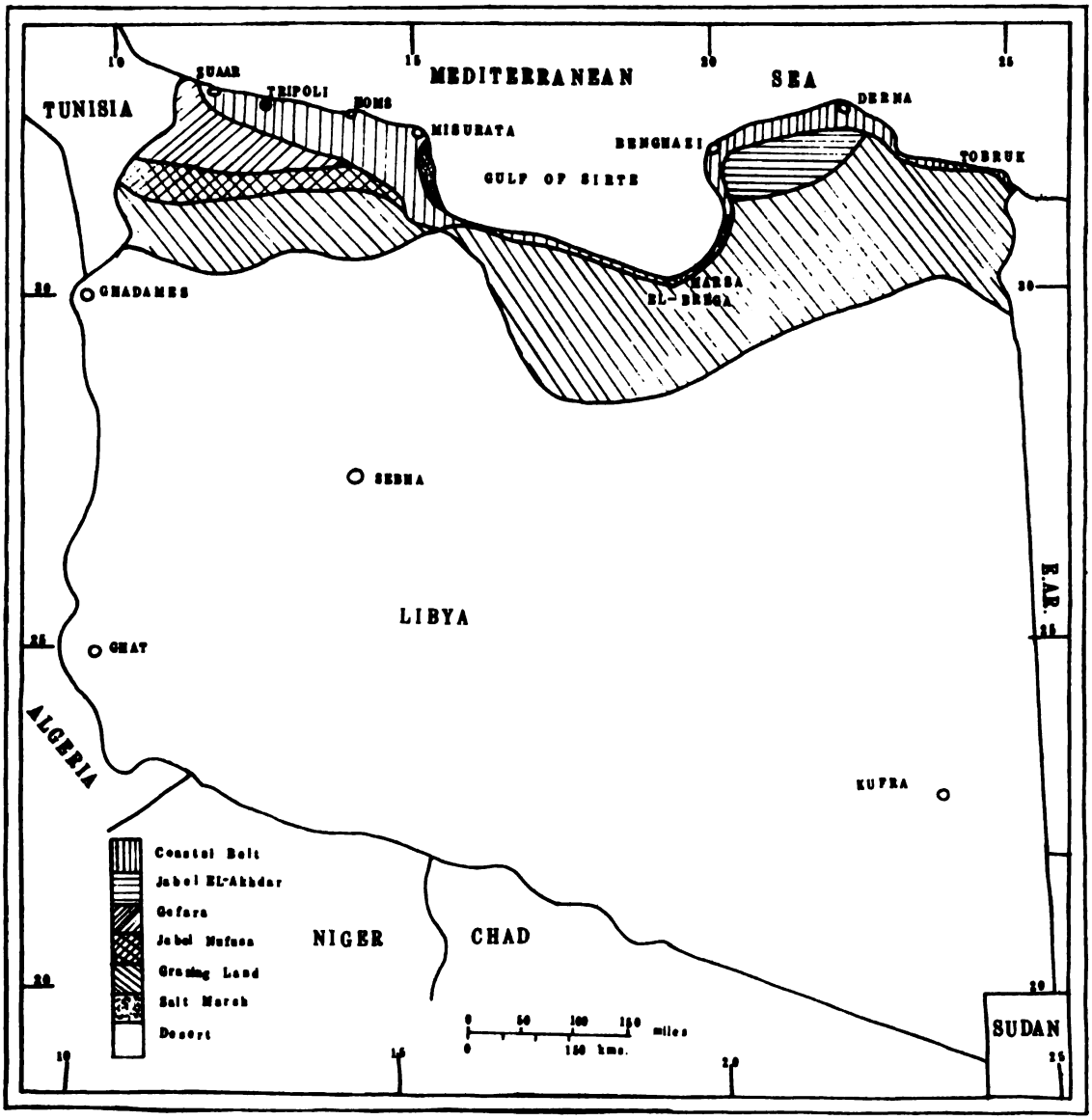

Fig 1-1 The geographic regions

is very high in the summer. The main products are wheat and horticulture production.

b. The Steppe Zone, in the western regions, occupies Gefara and forms a belt 20 kms. wide. The rain averages from 200 to 250 mms. and the temperature varies from 40°C to 45°C in the summertime and falls to 2-3°C in the wintertime and sometimes below zero (0°C) during January and February. Main products are olives and cereals .

c. The Jebel Zone includes the chain of Nefusa Mountains from the Tunisian border to Homes and the Jebel Akhdar (Green Mountains) in the eastern region. The rainfall in this zone varies from 100 to 260 mms. in the Nufusa Mountains. The Jebel Akhdar's altitude varies from 200 to 870 m. and its rainfall ranges from 200-700 mms. with lower humidity. The average temperatures are mainly lower than those in the coastal regions. The maximum in the west reaches 25°C and the minimum 10°C. Main products are cereals (wheat), olives, and figs.

d. The Pre-desert and the Desert Zones lie south of the Jebel which are typical desert zone, rainfall is approximately 70 mms. on a yearly average and relative humidity oscillates between 30 percent in summer and 15 percent in winter. The temperature difference

between day and night are great (average), 50°C during the day and 10°C at night. From the agricultural point of view production is limited in the wadis and on the oases. The main products are palms, cereals, and vegetables for local use.

The annual rainfall in selected stations throughout the country is shown in Table 1-1.

1.3 Soil Resources

The soil quality in Libya differs because of its different geological origins and climatic influences. The following are some of the common characteristics: the soil is mainly alkaline, and more or less calcareous; the content of organic substance is very low particularly in the western section.

Western Section.--The soil is either of eol, alluvial, or deluvial origin. In most areas the soil is deposited by wind and it is usually located on the coastal belt. The alluvial soils are found in river valleys and formed by soil sedimentation. They are carried by water from the spacious flows and are mainly deep and fertile (Wadi Ben Ulid, Wadi Meger, Wadi Soffegin). The resistance to wind erosion is low because of the lack of humus. The deluvial soils are also deep and located at the base of the hills or in river deltas, also carried by water (Wadi Meginin, Wadi Hira, and

TABLE 1-1 Annual Rainfall in Selected Stations (1969)

	Station	Latitude North	Longitude East	Annual Precipitation (mms.)	
				'70	'69
1.	Sub Humid (500-650 mms.)				
	Shahat	32°49'	29°51'	482.2	697.2
2.	Semi-Arid (250-500 mms.)				
	Sidi Mesri	32°52'	13°13'	85.3	352.5
	Tripoli	32°54'	13°11'	98.4	342.6
	Zuara	32°56'	12°07'	132.8	220.0
	Tripoli Airport	32°41'	13°10'	49.1	186.3
	Komes	32°39'	14°16'	113.5	215.5
	Misurata	32°23'	15°05'	77.1	172.5
	Benghazi	32°06'	20°04'	110.5	335.5
	Derna	32°46'	22°39'	139.2	339.7
3.	Arid (under 250 mms.)				
	Tarhuna	32°26'	13°38'	55.2	314.3
	Yefren	32°04'	12°31'	50.3	123.4
	Azizia	32°32'	13°01'	64.0	209.0
	Sirte	31°13'	16°35'	68.2	92.5
	Hun	29°08'	15°57'	14.2	25.5
	Gadames	30°08'	9°30'	4.3	11.4
	Sebha	27°01'	14°25'	0.0	16.5
	Kufra	24°00'	23°20'	0.0	8.4

Source: Some Agricultural Statistics 1961-1970 (Ministry of Agriculture) [26].

Wadi Gadu). The soil content in organic matter is about one percent. It is poor in phosphate but contains a higher percentage of potassium. Because of the slope of the land, soil is exposed to water erosion and it contains more silt, thus it is less liable to wind erosion. The saline (sebkhas) in the Touorga Springs is a problem. The Jebel is composed of cretaceous rocks surmounted by layers of limestone [27].

Eastern Section.--The soil is formed from rock decomposition through the influence of atmospheric phenomenon. It has a high clay content, and is poor in mineral elements except for potassium. The soil is exposed to water erosion. A great part has a loamy clay soil, and some regions have dark loamy soil (the Green Mountains).

Southern Section.--The soil is generally light and sandy, and also very poor in humus and the heavier soils. The desert has a high salt content (gypsum saline crust). Irrigation is vital for growing palm trees, which are grown near water sources.

1.4 Water Resources

Libya is a vast country and has a relatively small amount of rainfall and no permanently flowing rivers. During the rainy season a considerable amount of water is lost by either evaporation or by run off to

the sea, and only a small quantity penetrates through the soil. The water which flows to the sea not only impoverishes the water capital, but carries with it an enormous quantity of soil. Most of the wadis are no more than dry gullies except during the rainy season. Table 1-2 shows the water resources:

TABLE 1-2 Water Resources

Total Holdings	Wells	Springs	Cisterns
145,518	87,882	2,977	41,492

Source: Census of Agriculture 1960 [35].

In some places underground water comes to the surface and forms a spring, this is a very important factor in Libya. About 2,977 springs have been recorded in the 1960 census of Agriculture, of which Touarga is the largest one (3,000 liters per second) [27]. Besides these springs about 87,882 wells have been recorded (1960 Census of Agriculture) and these are used for irrigation purposes.

The depth of water varies from place to place; in some places it can be reached by hand, but in others it is 100 m. or deeper (Bir El Ghnem 110 M). In general the underground table in the western regions has an average depth of 15-35 m.; and in the eastern part it is 40-400 m. (an artesian well in Sokna is 800 m. deep).

As of the 1960 Census of Agriculture, Libya was irrigating 120,590 hectors of land. At the present time an area of 1.4 hectors can be irrigated from one well or spring. The traditional well with its animal operated irrigation device usually is no deeper than 50 to 100 feet [27].

The plan is to reclaim 25,000 acres of land, which would make Kufra the most important agricultural area in Libya by 1980.

1.5 Soil Erosion

Water and wind are the two main causes for erosion and the changes of conditions of the soil. Water washes away the soil and wind brings in sand and covers the agriculture land. The devastation made by man and animal also adds to the damage. Goats are generally known to be the greatest enemies of the forest and this is especially true in Libya where afforestiation is so badly needed. Unskilled farmers usually employ the wrong methods of cultivation and tilling with the improper use of the wrong implements and tools which may lead to plowing too deep thus adding to soil erosion [27]. The introduction of mechanization in the recent years contributed much to progressively increasing erosion. Up and down plowing on slopes and the uprooting of esparto grass for shifting cultivation of cereals unfortunately has caused such erosion.

1.6 Human Resources

The total population in 1954 was 1,088,889 and in 1964 it was 1,564,369. The population increases at a rate of 3.7 percent annually and with that rate the estimated population at the end of July, 1969, was 1,875,000 [29]. The actual rate as of July, 1969, was 3.6 percent per year. Most of the people are concentrated in the coastal belt. The composition of the population by age makes Libya a country in which more than 75 percent of the population is less than 40 years of age. Table 1-3 shows the structure of population by age 1968.

TABLE 1-3 Structure of the Population by Age 1968

	Total	% From Total Population
0 under 5	327,500	18.10
5 under 9	273,200	15.19
10 under 15	186,900	10.38
15 under 20	140,400	7.81
20 under 25	142,000	7.87
25 under 30	147,800	8.29
30 under 40	216,100	11.95
40 under 55	195,400	10.80
55 under 65	80,400	4.45
65 and over	93,300	5.16
Total	1,803,000	100

Source: Statistical Abstract 1968 [29]

During the decade since the discovery of oil, the population has become increasingly urbanized as a result

of large scale movement of rural elements towards the cities and towns. Agricultural reclamation programs have been initiated by the government to arrest rural to urban migration. The overall population density as of 1969 was approximately 2.7 persons per sq. mile (1 person per sq. km.) [29].

The overwhelming majority of the people (99.9%) are Moslem and the language is Arabic [5]. Just prior to the proclamation of independence it had been shown that about 90 percent of the people were illiterate. Table 1-4 shows the main occupations of the working population, 1954-1964.

1.7 Economy

The discovery of petroleum in 1959 completely transformed the economy and by 1968 Libya had become the world's fifth ranking exporter of crude oil.

The per capita income has risen from less than L.D. 14 (L.D. = U.S. $2.8, thus $39.2) in 1951 to almost L.D. 180 in 1966 (U.S. $504). In 1951 the total budget was L.D. 7 million, but in 1970 it was L.D. 200 million or in U.S. it would be $560 million [5].

The market economy acts as a powerful magnet to the rural population, thousands of Libyans have left the desert of the interior for shanty towns which have sprung up around Tripoli and Benghazi. It has

TABLE 1-4 Composition of the Working Population by Occupation

Occupation	1954	%	1964	%
Agriculture, Fishing, and Forestry	199,568	49.5	144,853	35.74
Mining and Quarrying	470	0.11	14,259	3.52
Manufacturing	34,600	8.6	29,377	7.25
Construction	7,048	1.74	31,434	7.76
Electricity, Gas, Water and Sanitary Services	641	0.16	6,064	1.50
Commerce	16,659	4.12	26,735	6.6
Transportation	7,048	1.74	22,748	5.61
Services	30,756	7.61	82,531	20.36
Others	106,364	26.42	47,257	11.66
Total	403,154	100	405,258	100

Source: Figures from General Population Census 1964, 1954 [35, 16]

been estimated that while Libya's population in 1956 was 80 percent rural, it had become 80 percent urban by 1968 [5].

Before the discovery of oil: agriculture provided 30 percent of Libyan Gross National Income; 75 percent of the population directly depended on agriculture for a living; the per capita annual income was under $56 in rural areas and over $112 in the cities [5].

II. AGRICULTURE IN LIBYA

2.1 Agricultural Zones

The agricultural physiognomy of Libya varies greatly from north to south and from east to west. A number of classifications based on physiographic, climatic, and ecological conditions must supplement classifications based on production.

The country has been divided into five forage areas according to differences in climate and ecological conditions.

The country was divided into five zones based primarily on their rainfall and climate. These zones are:

Zone I Mediterranean-coastal belt: annual precipitation from 100-600 mm.; temperature range is from 76°F-45°F (19°C-8°C); relative humidity is high in the summer. Rainy days average about 45 per year (October-March).

Zone II Stepped: annual precipitation from 200-250 mm.; temperature range is from 104°F

in summer to 38°F in winter (45°C in summer to 2°C in winter); the relative humidity is low.

Zone III Jebel: annual precipitation from 300-700 mm.; temperature range is from 77°F to 50°F (25°C to 10°C); the relative humidity is usually lower than the coast.

Zones IV and V Pre-desert and Desert: annual precipitation from 0-70 mm.; temperature range varies between daytime and night, 122°F-50°F (50°C-10°C); the relative humidity oscilates between 30 percent in summer and 15 percent in winter.

2.2 Land Capability

The agricultural land represents the physical source of agriculture production. More than 90 percent of the country's vast land area is desert. Out of 450 million acres [5] only 9.6 million acres or 2 percent of the total are fit for agricultural use. Table 2-1 shows the usage of agriculture land.

The usage of arable land gives a general picture of intensity of production, as shown in Table 2-2 and 2-3.

Table 2-4 shows the distribution of land in the country.

TABLE 2-1 The Usage of Agriculture Land

	000 ha	%
Land area	3,868	100
Agriculture land	3,645	94.2
Arable land	2,263	
Land under permanent crop	134	
Permanent meadows and pasture	1,246	
Wood and forest land	63	1.6
All other lands	160	4.2

Source: Calculation based on 1960 Census of Agriculture [35]

TABLE 2-2 Distribution of Arable Land

	000 ha	%
Under temporary crops	883	39.0
Under vegetables and flowers	26	1.2
Under temporary meadows	78	3.4
Temporarily fallow	1,278	56.4
Total arable land	2,265	100.0

Source: Agricultural Statistic 1970 [26]

TABLE 2-3 The Utilization of Land Under Cultivation

	000 ha	%
Cereals	945	95.6
Vegetables	26	2.6
Industrial crops	12	1.2
Temporary fodder crops	5	0.6
Total cultivated land	988	100.0

Source: Ministry of Planning and Development [27]

TABLE 2-4 Distribution of Land in the Country

	000 ha	%
1. Land under temporary crops	664	.368
2. Land under temporary meadows	78	.043
3. Land under market and kitchen market	18	.010
4. Land under temporary fallow	1,638	.897
Total Arable Land	2,375	1.218
5. Land under crops	142	.079
6. Land under permanent meadows and pastures	1,128	.710
Agriculture Area Including Arable Land	3,645	2.007
7. Forest and wood land	532	.297
8. Other land	160	.089
9. Unused land	175,663	97.607
Total Area	180,000	100.000

Source: Agriculture Statistics [26]

2.3 Land Distribution

The poor distribution of land remains one of the main problems of Libyan agriculture. In 1963, 2,873 holdings, or 2.7 percent of the total, were without land; and 4.7 percent of the total owned less than 0.5 hectares.

Table 2.5 gives the distribution of the holdings by size. The overall goal of the Agrarian Reform and Land Reclamation Corporation (ARLRC) is to reclaim land from the desert and to improve and distribute land presently owned by the government. Funds have been secured and studies made to enable these projects to be carried out. Twelve hundred hectars at Wadi Shatti and Wadi Ajal (both in the south), 12,500 hectares at Jable El Akhder (in the east), 3,000 in Musrata (in the west) are to be given to about 2,500 rural families composed of landless workers. In the future, land may also be given to the owners of small farms to help them support their families and thereby reduce the migration of farmers to the city.

2.4 Rural People

In 1964 the total rural population was 1,179,130 or 75 percent of the total population. But the distribution of population remains a major problem with increasing urbanization. More than 68 percent of the population now lives on 250 sq. km. [27], which is a population density of 413 people per sq. km. In the

TABLE 2-5 Distribution of Agriculture Property by Size of Holding

Size of Holding	Number of Holding	% of Numbers	Land Area in ha	% of Area in ha	Average ha Holding
Without land	2,873	2.7			
Under 0.5	5,100	4.7	1,243	0.04	0.24
0.5 - 1.0	4,361	4.0	2,554	.08	.58
1.0 - 2.0	7,203	6.7	8,164	.27	1.13
2.0 - 3.0	6,095	5.6	12,635	.42	2.07
3.0 under 4	5,799	5.4	17,727	.59	3.06
4 under 5	4,500	4.2	18,184	0.6	4.04
5 under 10	16,079	14.9	106,296	3.51	6.61
10 under 20	19,858	18.4	257,316	8.5	12.95
20 under 50	21,693	20.1	618,518	20.46	28.51
50 under 100	7,672	7.1	482,244	15.94	62.85
100 under 200	3,944	3.7	491,533	16.26	124.63
200 and over	2,744	2.5	1,007,996	33.33	367.34
Total	107,921	100.0	3,024,430	100.0	100.00

Source: Agricultural Census 1960.

east the population density is only 53 people per sq. km. and in the south it is 12 people per sq. km. [28].

Many people have left rural areas looking for better lives in the cities and this has created problems in all sectors of the economy. The discovery of oil brought about a serious scarcity of labor in the agricultural section of the economy. The state has been making increasing use of mechanization to help make up for the lack of production due to the labor shortage.

Mechanization is used because it is cheaper than importing farm labor from neighboring countries. The cost of production in agriculture is increasing with the exception of the marketing phase. The farmer that wants to stay on his land is learning that he has to adjust to the new technology. The illiteracy rate is about 70 percent, but is still higher in the countryside.

In 1960 the average per-capita income was nineteen Libyan Dinars.

Of the Libyan work force, 2.5 percent was engaged in the production of oil.

A field study done in 1964 estimated that in the rural areas 85 percent of the working population was engaged in agriculture and about 15 percent was in secondary and tertiary production. Of the working population in the country as a whole, 65 percent was

engaged in agriculture and 35-40 percent was in service industries. In urban areas 20-25 percent of the working population is engaged in agriculture [5].

The First Annual Report for Development Activities in Libya for the year ending March 31, 1964, noted that farmers leaving nonviable agricultural districts could not compete for skilled jobs and were relegated to unskilled, low income, or part time employment.

2.5 Agricultural Production

In the last few years great attempts have been made in the development of agriculture. Two visable results obtained from the first five-year plan are the establishing of the Agrarian Reform and Land Reclamation Corporation and the Agricultural Bank. After the discovery of oil, the resultant increase in the national income has made a great difference in the comparative standards of living between the rural and urban population.

Prices have increased thus raising the cost of living.

The income of Libyan farmers depends primarily on crop and livestock production. Drought is a constant and serious hazard for dry farming. There was a serious lack of planning in the growing of cereals and vegetables till the last few years when the government took dramatic action. Because almost every farmer was growing tomatoes

and thereby glutting the market, the government bought the entire tomato production and tossed it into the sea. Because of the limited capacity of industry, it would not even have been possible to process all of that year's harvest.

The production of cereals is, after livestock, the largest source of income to the agricultural inhabitants of Libya.

Barley is best suited to the climate, for it is tough and quick growing thereby able to take advantage of the short growing seasons. It matures before it is burned by the hot weather and lack of moisture.

In the low mountain areas wheat is grown with some supplemental irrigation as a dry land crop. Table 2-6 indicates the production of wheat and barley.

Olive production comes after wheat and barley in its importance to Libyan agriculture. There are 3,338,000 olive trees in the country and the average yield per tree in 1965 was 50 Kg./tree and 21 Kg./tree in 1970 [26]. The reason for this drop in production of the olives was due to a lack of manpower during a harvesting season to collect the fruit from the trees.

TABLE 2-6 Production of Wheat and Barley in Libya Between 1965-70

Year	Wheat			Barley		
	Tons	Yield Kg/ha	Area (ha.)	Kg/ha.	Tons	Area
1965	56,914	316	179,946	352	95,982	272,112
1966	57,788	296	194,935	329	99,058	300,788
1967	62,221	271	229,556	301	109,964	364,752
1968	52,041	228	227,790	246	98,421	400,218
1969	78,421	291	269,237	247	123,955	357,270
1970	21,112	129	165,735	244	52,808	215,892

Source: Agricultural Statistics 1970 [26]

III. AGRICULTURE MECHANIZATION IN LIBYA

3.1 Historical Development

Agricultural machinery in Libya has only recently been introduced and has proved to be popular with the farmers. The import of agricultural machinery by years and its value is shown in Table 3.1.

TABLE 3-1 Import of Agricultural Machinery

Year	Libyan Dinars
1954	58,200
1955	95,756
1956	178,959
1957	269,464
1958	363,976
1959	181,265
1960	194,114
1961	271,703
1962	498,285
1963	832,903
1964	1,434,863
1969[a]	3,228,208

[a]L.A.R. Ministry of Planning, External Trade Statistics 1969 [28]

Source: Agricultural Statistics, 1963 (1 L.D. = 2.8$) [27]

The Table 3-2 indicates the import of tractors in the country during the latest years:

TABLE 3-2 Import of Tractors

Year	Number of Import
1964	665
1965	1,240
1966	1,253
1967	1,018
1968	2,417
1969	1,999

Source: Agricultural Statistics, 1970 [26]

Agricultural education is an important factor according to the structure of the economy of the country in which agriculture absorbs about 75 percent of the population. The high agricultural institute was established in Tripoli in 1952 for the technical education of farmers. Another school was established in 1952 in Oalia with the aim of educating the farmers' children to become well-trained farmers. The University of Libya established a new agricultural college in 1965. One course is being taught in power machinery but there is a proposal to increase the number of courses in the future. Courses in irrigation and drainage, farm structures, electrification, hydraulics, engines, and processing (food technology) are not available but will be offered this year.

3.2 Extent of Machinery

The start of mechanization in Libyan agriculture gave encouraging results. For the future, the cooperative with the help of the government should have to carry the responsibility of agriculture mechanization. But lack of skilled operators, mechanics, and maintenance shops are the problem. Table 3-3 shows the resources of power on the farm.

TABLE 3-3 Power Available in the Libyan Farms

	Number
Wheel tractor	2,040
Stationary threshers	470
Combine	1,061
Seed Drills	135
Track laying tractors	468
Camels	263,008
Horses	32,492
Cattle	118,309
Plows	

Source: Agriculture Census 1960 [35]

3.3 Importation

As indicated in 3.1, the agricultural machinery is largely of foreign origin. This has represented about 1.3 percent in 1969, 1.0 percent in 1968, and 0.7 percent in 1967 of the total value of all imports into the country [28].

All the farm power machinery is imported and there is no production locally except for some hand tools

and old wooden plows. In the country there are about twelve dealers for importation, twelve different kinds of machines from various countries.

3.4 Mechanization

As a result of the fact that modernization is coming to the country through the towns, agriculture has remained largely primitive. The gap between the rural and urban population became wide, which led to the migration of the rural population to towns. A new policy came out, the Libyan National Agriculture Bank was born in 1958 to help the farmer buy machines to mechanize farm production and to level land for use in agriculture.

> Mechanization was introduced too slowly and with insufficient encouragement of farmer and too complicated administration. It was little utilized to replace the lack of manpower, to increase their income, and thus in turn, to attract farmers to stay on their lands [20].

The problem facing agriculture in this time for mechanizing the farm in Libya needs some changes in the training center in Garabuli for training trainers on the operation of machines. The second problem is that the Agriculture Bank, which is helping the farmer with loans (free from interest), must have some control on the kind of machines farmers want to buy, and should take into consideration the type that can be repaired locally depending on the availability of spare parts and workshops.

The human, animal, and mechanical power used in farming is shown in Table 3-4.

3.5 Agriculture Bank

It was established in 1957 with a capital of one million Libyan dinars and increased in 1971 to 7,200,000 Libyan dinars. The capital will increase at the end of this year (1971) to 10 million Libyan dinars.

The main purpose of the bank is to give loans without any interest and government support to the farmers through 20 branches all over the country [3]:

A. To give 50 percent help from the government to the farmer when he purchases chemical and organic fertilizers, when he uses it for agriculture land (does not matter if he rents or owns the land).

B. To give 50 percent help from the government for the cost of pesticides, for the protection of the plants and their production.

C. To give 50 percent toward the purchase of fodder and hay by dairy farmers for milk and meat production, and for concentrated food for poultry production.

TABLE 3-4 The Use of Power in Agricultural Holding by Districts

District	Number and Percentage of Holdings Use									
	Total Holding	%	H Power	%	H + M Power	%	H + A Power	%	H + M + A Power	%
Tripoli	17,918	100	4,921	27.4	10,028	55.9	1,709	9.5	1,260	7.2
Zavia	18,859	100	7,706	40.9	9,493	50.3	991	5.2	669	3.6
Misurata	21,118	100	4,653	22.0	15,731	74.5	101	0.6	633	2.9
Westmountia	27,092	100	2,854	10.5	22,837	84.3	162	0.6	1,239	4.6
Homes	22,934	100	3,337	14.5	19,190	83.7	175	0.8	232	1.0
Benghaz	12,067	100	2,046	16.9	9,958	82.5	21	0.2	42	0.4
Derna	6,472	100	293	4.5	6,168	95.3		--	11	0.2
Green Mountain	11,180	100	909	8.1	10,080	90.2	127	1.1	64	0.6
Sebha	4,549	100	2,813	61.9	1,607	35.3	69	1.5	54	1.3
Ubari	3,329	100	1,369	41.1	1,607	57.4	41	1.2	8	0.3
Libya	145,518		30,907		107,003		3,396		4,212	

Note: H = Human; A = Animal; M = Machinery

Source: Adapted from Agricultural Census 1960 [35]

D. To give 25 percent from the cost of purchasing farm machinery; and if he owns and/or rents 10 ha. of irrigated land and 15 ha. of non-irrigated land to buy a tractor of more than 50 h.p.

E. To give 50 percent from the initial cost of power farm machinery to the cooperative for using the machines in the farming business.

F. Give loans to farmers to use it in:

1. Seasonal loans (crop loans)--Loans in this category are used for small farmers to support themselves until the farm production is ready; the period is for one year and the range of the loan is from 0-3000 LD. (This is facing the problem of spending money on seeds, pesticides, and fertilizer at the beginning of planting and preparing land for agriculture and the time of harvesting.)

2. Medium-term loans--For 75 percent from the cost of the power machinery and will be paid in a period of 4 years. The range of the loan is from 3,000 to 4,000 L.D. (For purchasing farm machinery-sprinkler irrigation system, pumps, tractors, plowing, and harvesting equipment.)

3. Loans for cooperatives--Loans to cooperatives for use in purchasing machines, fertilizer, and improved seeds. The loans will be paid in a period of between 3-5 years.

4. Long-term loans (more than 15 years)--This kind of loan is for constructing or to reclaim or build new farms (leveling of land) or to make it better. It will be given to the farmer at intervals of time depending on the kind of farm or project. The loans range from less than 1,000 and up. (For land reclamation, digging wells, and construction of farms.)

G. Commercial Section

1. Farmers' Supplies Section: Import fertilizer, pesticides, improved seeds, sprinkler systems for irrigation, pumps, and motors and sell them to the farmer and/or the cooperative to keep their prices low.

2. Marketing Section: Buying the production of olive oil, wheat, barley, peanuts, and almonds from the farmer in the harvesting season with higher prices than the market price; and then the bank markets the products in the country

or they export them. The bank also imports hay, fodder, and grains used as feed for animals to the government. Table 3-5 gives the values and the number of loans given by Agriculture Bank in 1971.

TABLE 3-5 The Values and Number of Loans Given by Agriculture Bank in 1971

		Values	%	Number	%
A.	Seasonal				
	Less 100 L.D.	331,490	15	3,886	29
	Between 100, 300	1,623,145	72	8,646	66
	Over 300	313,840	13	668	5
		2,268,480	100	13,200	100
B.	Medium term	2,083,330	100	3,966	100
C.	Long term				
	Less than 1,000	1,089,250		1,202	
	More than 1,000	1,065,000		753	
		2,154,250		1,955	

Source: Annual Report Number 13 and 14 1971 [2]

The intermediate loans are important in this study because most of the loans go for purchasing power and machinery for better and increasing production, and to use more land for agriculture. The farmers were helped in the budget year 1969-1970 to purchase was given in power machinery as given in Table 3-6.

Table 3-7 shows the values and the number of loans from the time when the bank started in 1961.

TABLE 3-6 Purchasing Farm Machinery Through the Agriculture Bank

Items	Number
Tractors	236
Plows	303
Planters	5
Harvesting combines	72
Stationary combines	1
Balers	20

Source: Annual Report 13 1970 [2]

TABLE 3-7 Values and Number of Loans Given by Agriculture Bank

Budget Year	Number	Value in Libyan Dinars
1961-62	281	93,360
1962-63	1,376	429,400
1963-64	1,203	447,473
1964-65	1,417	405,600
1965-66	2,337	928,120
1966-67	3,484	1,813,706
1967-68	2,273	676,379
1968-69	2,500	1,014,385
1969-70	2,571	938,224
1970-71	3,966	2,083,330

Source: Agriculture Bank, Annual Report No. 14 [3]

More people are trying to get the advantages of these loans to stay on the farm and to increase production by using new technology.

3.6 The Agrarian Reform and Land Reclamation Corporation (ARLRC)

The Agrarian Reform and Land Reclamation Corporation (ARLRC) was set up in 1963 with an annual budget of about one million Libyan Dinars. In 1965 it started reclaiming 15,000 hectars of scrubland in the Geble El-Akhdar, and it was planned to plant 5 million vines, fruits, and almond trees. Now it is running about 10 projects all over the country [1]:

1. Jabel El-Akhder (Green Mountain).--The aim is to reclaim 1,200 hectars of very rich soil. It will be irrigated by rain water and springs in the mountain. The area will be divided among 2,000 farmers (6 ha. each) for settlement by those who are interested in farming to keep them in the rural area. Imported to plant in the project area were 1,988,000 fruit trees (cost 5.745 M.L.D).

2. Wadi Shatti and Wadi El Ajal (South).--Studies are being made through experiment stations of the 20,000 ha. in the area of Wadi Shatti, Wadi Ajal, and Tragen to check the soil, test for underground water, springs, and to determine the best crops to grow. The estimated cost of the project is 2,300,000 L.D. ($6.9 million) [1].

3. Tourga.--The water in the springs (Q = 3.45 m^3/sec.) in the area is used for agriculture instead of going to the sea to get it. An annual water yield of 78 million m^3 is used to reclaim 3,000 ha. which will be divided into 300 farms. The soil is also being washed to decrease the salt concentration in it. This project has an estimated cost of 7 million L.D. ($19.6 million) [1].

4. Jafar.--Here 1,100 ha. is being reclaimed by using government water wells in the Azizia area, and this land will be divided among 110 farmers. The project will cost 1.676 million L.D. ($5.01 million) [1].

5. Hadba El-Kadra (Green Hill).--The purpose of this project is to use sanitary water for irrigation. There is a water source of 6 million gallons a day, after filtration, and it will be used to irrigate 600 ha. which will be divided among 100 farmers (6 ha. each). There are studies for increasing this by 400 ha. The estimated cost of this project is 1 million L.D. ($2.8 million) [1].

6. Wadies Projects.--

a. Wadi Meginen--The main purpose is the building of main and secondary dams to store rain water, instead of going to the sea to get it. This artificial lake that will be made will have a capacity of 60 million m^3. The water source of

13.5 million m^3/year will be used to reclaim 38 ha. for agriculture. The cost of the project is 7 million L.D. ($19.6 million) [1].

b. Wadi Catara--They are building dams to protect Bengazi from floods from the water resources of 20 million m^3 annually, and to use the water to increase the underground water level. The cost of this project is 4.15 million L.D. [1].

c. Wade Ain Kyam--The aims of this project are to protect the Zleaten from floods and to use the water to increase the underground water level, also to protect the area from soil erosion and to decrease the salt concentration in the water in the area.

The ARLRC is running some projects to distribute and thus replenish the land that was left after the Italian colonial farmers left the country shown in Table 3-8.

The use of machinery in the ARLRC project is important but they face the problem of the need for some trained people to take care of the machines and to operate them; and they have:

tractors	33
plows	65
planters	13
combines	3

TABLE 3-8 Projects Under Supervision of (ARLRC)

A.	Land Returning From Italian	
	No. of projects	16
	No. of farms	325
	Area of land (hectars)	32,677
	Olive trees	491,491
	Oranges	251,427
	Vines (grapes)	1,752,000
	Other (trees)	309,000
B.	Old Government Land	
	No. of farms	3,056
	Area of land (ha.)	76,676

Source: ARLRC Summary 1971 [1]

Oases.--Libya had long been believed to be a waterless desert, but lately definite evidence came to light that there is a lot of underground water under her surface. Scientists are using various types of radio-active isotopes to determine the quantity of underground water. The quantity of water found ranges from very shallow wells near the coast, to wells over 1,000 meters. Wadiel Shatti, Elajal, Kufra, and Ghat Oases were established and the water was found fit for all purposes, both for irrigation and for drinking. Which led to the start of the Kufra Agriculture Project. The project started in 1968, and now the aim is to reclaim 10,000 ha. from the desert. Table 3-9 Future of reclaiming the desert.

The use of new technology in irrigation needs highly trained people to carry out the jobs. Many

TABLE 3-9 Reclaiming of Desert

Year	Area (ha.)	Wells
68	100	12
69	200	12
70	250	12
71	520[a]	12
72[b]	10,000	100

[a]Under cultivation in the summer 1971.

[b]Estimated at the end of 1972 (by the director of the project).

Source: Estimation was given by the director of the project.

problems are facing the project, such as the lack of technical, skilled manpower to operate the machines. The main idea of the project is the raising of sheep and for that reason most of the production is alfalfa, which is used to feed the sheep. The yield of alfalfa is 200 Kg/ha. Sudangrass, which is currently under experimentation, is harvested 4 times a year.

Pumping.--Using a 6-stage pump for raising the pressure and pump water to the sprinkler systems. The depth of the wells is 120 meters and the discharge rate is 150 liters/sec.

Pivot for irrigation.--It has a radius of 420 m. and has 3 speeds to complete the cycle in 18, 24, 36 hours to irrigate 52 hectars. The cost of the machines and

TABLE 3-10 Equipment in Use in the Project

Equipment	Number
Tractors	15
Disc sub soiling	3
Moldboards	3
Combines	2
Balers	2
Choppers	1
Rakes	2

Source: Collected by the author during his visit to the project during the summer of 1971.

the irrigation system in Kufra, Jalo, and Ojla oases is 4.474 million L.D. [1].

3.7 Ministry of Agriculture

The Ministry of Agriculture has under its responsibility the agricultural movement in the country. To strengthen the agriculture cooperative movement: research is being done on water and soil, and the experiment stations are making tests for improving seeds and using fertilizers under the Libyan climatic conditions. Power machinery is a section of plant production. The main objective is having services for the farmers at low prices. Table 3-11 shows the workshops owned by the government.

There are three main workshops out of twenty throughout the country; five out of twenty have storage to store spare parts and they can perform maintenance work (with about 200 mechanics[manpower]) to carry out

TABLE 3-11 Government Workshops

	Workshop	Main	Store and Workshop
Tripoli	1	1	1
Benghaze	1		1
Zavia	1		
Homes	1		
Gerian	3		
Musratia	4		1
Derna	3		1
Green Mountain	2	1	
Sebha	4	1	1

Source: Collected from the Ministry of Agriculture workshop main office in Tripoli during my visit in summer 1971

the maintenance required for the machines. Table 3-12 shows the machinery owned by the government workshops. Three combines broke down during the first weeks of operation. Before 1967 hiring services hired machines to the farmers through the agriculture cooperative. Some of the machines were sold to the agriculture cooperative in 1967, thus trying to keep the hiring price low if compared to the price charged by the individual owners who hire their machines to the farmers. Table 3-13 shows the prices of leveling land through the government hiring station and owners.

Table 3-14 shows the cost of operation of farm and power machinery throughout cooperative.

The two main objectives of the establishing of the workshops were:

TABLE 3-12 Machines Owned by the Government Workshop

		In[a] Field	Under Maintenance	Total
Caterpillars		9	19	28
D-8, D-7, D-6, D-4	Maraj	83	18	101
HI D-T-9	Green Hill	10	-	10
	Total	102	37	139
Tractors	Tripoli	54	42	96
165, 65, 135 HP.	Maraj	20	-	20
	Total	74	42	116
Planters	Tripoli	26	-	26
	Maraj	16	-	16
	Total	42	-	42
Stationary Thresher	Tripoli	1	14	15
Combines	Tripoli	2	27	29
	Maraj	-	3	3
	Total	2	30	32
Balers	Tripoli	14	28	42
Wagons	Tripoli	13	-	13
Plows	Tripoli	-	-	93

Source: Collected by the author during a visit to the Ministry of Agriculture Workshop main office in Tripoli, Summer of 1971

[a]Still in good condition

TABLE 3-13 Comparison of Prices for Leveling Land[a]

Caterpillars	Hiring Station L.D./hr.[a]	Owners L.D./hr.
D-4	1.20	3.00
D-6	1.50	4.00
D-7	2.00	5.00
D-8	3.00	7.00

[a]Transportation of the Machines is at the expense of the government.

Source: The prices were obtained from the hiring station in Tripoli.

TABLE 3-14 Cooperative Cost of the Operation of Farm Machinery

		L.D.	
Tractor	per hr.	1.50--2.00	
Planter	per hr.	2.00	
Combine (Self-propelled)		1.00	L.D./100 Kg of grain
Baler		0.2	L.D./Unite Unite = 20 Kg
Stationary Combines		0.65	L.D./100 Kg of grain

Source: Based on the estimation from the power and machinery department Ministry of Agriculture in Tripoli

1. Repairing and maintenance of farm machinery in the area where the workshop is located, to serve the government, and to help the farmers (private or cooperative).
2. The location of the workshop must be established where there is no private workshop, then it can serve the farmers.

Problems of the government workshop:

1. The complicated routine of obtaining spare parts for quick repair of the machines.
2. Spare parts are not available from the dealers.

The problem in one of the cooperatives I visited was that they have three combines but no housing for or maintenance of the machines. Three years without lubrication or greasing has made the machines in terrible shape and falling apart. The lack of the trainer-operator is the cause of the problem of taking care of the machines. There are some experiments on machines in operation in the field:

1. Testing the tractor draw bar on an inclined plane.
2. Testing a drill planter with fertilizer attachments.

Only these two experiments are available and they were done in April, 1962, and were tested again in 1963.

3.8 Distributors of Agriculture Machinery

The main source of machines is importation. There are about twelve types of machines being sold by eleven dealers. Some of them do not have any stock of spare parts or a workshop; and they are concentrated in the same area and town in Tripoli. They do not train or help in training some people to run workshops. One of them ran out of business and thus most of the International Harvester tractors become useless if any part of it breaks down because no spare parts are available and it is very difficult to manufacture them in the country.

The distributors can play an important factor in the future of agriculture mechanization in Libya by: helping in the training programs, establishing their workshops in agricultural areas, and by supplying spare parts. They can give assistance to the farmers by demonstrating the best use of machinery, and they can support research by linking the kinds of machinery they import to the agricultural conditions of Libya.

3.9 Local Production

There is a plan to build an assembly factory for tractors and trucks, with a capacity of:

tractors	2,000
trucks	3,000-4,000

The main objective of the plan is production of as many parts as possible for tractors and trucks, with the aim of creating technical knowhow and development of local talents and industry.

1. One type of tractor and truck.
2. Three different types may be considered for the assembly.

But the problem is the choice of:

1. The particular type and model of tractor and its range of power and tonnage that will suit the local requirements.
2. Availability of labor at all levels in sufficient numbers and quality.
3. General alignment with national, pan-arab, and international economic policies.

Favorable and Unfavorable Conditions

a. Favorable

In Libya there are many favorable factors for the mechanization of agriculture, such as:

1. The climate in general is favorable for mechanization. The dry land which depending on rain and the cultivation time is limited for growing the main diet of the country, which is wheat and barley.

2. Varieties of crops which allow a better distribution of the work throughout the year or the experiment station can develop a new variety.

3. Mechanization can improve the social level of farm workers if they receive training for jobs with modern machinery.

4. Mechanization can improve the quality of the farm work because the country is facing a lack of labor in the agriculture sector.

b. Unfavorable

1. Land distribution is a problem because 66.6 percent have under 20 ha. This can be solved by improving the quality of the cooperative system of hiring machinery.

2. The cost of machines, but it can be solved by credit from the Agriculture Bank.

3. Lack of spare parts in the country makes the farmer and/or the cooperative buy more machines.

4. Primitive way of agriculture.

5. Government control of the distribution of production.

Serious Problems

1. Lack of trained people (such as technicians, mechanics, and operators) to carry on agriculture mechanization.
2. Lack of experiments and testing in agriculture mechanization.
3. Lack of extention work in agriculture mechanization.
4. Insufficient use of agriculture.
5. No control from the Agriculture Bank on the farmer as to the size of the machinery and its use.

The government is trying a new approach to face the progressing of the agriculture by establishing a new "The General Agricultural Company" to run a commercial business of the government owned farms and to increase production and marketing. A new law has been made for organizing a new agricultural cooperative for the whole country to avoid interaction of responsibility and to organize the work on a village basis, which before was under the Ministry of Labor and Social Welfare.

IV. FUTURE OF MECHANIZATION RESEARCH

4.1 Needs of Research

In fact, the country's real problem is the lack of professional people to lead agriculture and trained personnel to carry out the programs. Officials and technical personnel, as well as, the farmer recognize the importance of mechanization for the success of the development of agriculture. The government supports the farmer to a high degree, but this is without the research programs to back them up which could provide the solutions to the problems in the agriculture sector. Because without planning when and what crops should be mechanized and (how) which way is better to increase the production and prevent losses in the Libyan agriculture, no matter how much money the government puts into agriculture the crop production will not be advanced.

Two factors appear as evidence:

a. Research in agriculture mechanization
b. Agriculture education program to produce the trained personnel

The feedback information for long-range and short-range research is the basis on which agriculture education will take steps of progress. The necessity of the research programs in agriculture mechanization is evident, since information in all aspects must be obtained to successfully implement the mechanization process.

Many experts have insisted that each country has to develop its own research. There have been many failures in the use of imported machinery in developing countries because different conditions exist than those for which the machinery was originally designed. Obviously researchers will need a solid knowledge of the basic findings already available in developed countries, and they have to keep up to date in related publications. In this way more advanced research can be adapted to local conditions. This adaptation should be the main goal in the research in agriculture mechanization in Libya for the first five or ten years.

The coordination of the research is very important to avoid having different institutions do their own research separately, and thus solve only their own immediate problems. Cooperation between the Ministry of Agriculture and Land Reform and the University of Libya can be coordinated. The University of Libya in this time is trying to gather its specialist people in

agriculture mechanization, and the facilities and equipment which will best serve the country as a whole.

4.2 Success of the Research Programs in Agriculture Mechanization

The following points can be considered as essentials for the success of the projects in agriculture mechanization in Libya:

1. Developing programs for teaching in the University of Libya concerning farm power, machinery, and soil and water engineering to build a background for the leaders in agriculture.
2. The active collaboration between all governmental and private institutions, dealers, and distributors of machinery.
3. Technical assistance to organize or develop specific types of research should be encouraged especially until a coordination team of researchers and leaders is organized.
4. Technical exchange between specialists of different institutions with specialists of all Arab countries and those countries carrying out similar projects are also important.
5. The establishment of an agriculture engineering or agriculture mechanization curriculum is an

urgent necessity in Libya because the plant production department cannot prepare specialists for all aspects of agriculture engineering.

6. Extension work in the aspects of agriculture mechanization has to be increased. Here again the necessity of an agriculture engineering curriculum is felt, because the lack of trained personnel can be a major obstacle to the application of new techniques on machinery as recommended by research.

4.3 Needs of Education

Libya badly needs many agriculture professional staff to meet the demand of improving agriculture.

The High Agriculture Institute of Tripoli was established, in 1952, for the technical education of farmers, teaching programs and organization, and also training extension service agents. The school can educate more students now than before. In 1964-65 there were only 79 students and then in 1965-66 there were about 120 students [27].

The lack of sufficient cooperation between the school and the Ministry of Agriculture. Since the Ministry of Agriculture is responsible for the improvement of Libyan agriculture it would be quite logical and natural if the closest collaboration between the Ministry and the school should exist.

The real problem facing the Institute is the shortage of books and scripts, which renders learning and improvement of teaching programs more difficult.

The problem of practical seasonal work for students has not been attempted.

The equipment for practical training and the existing laboratory with some additional equipment will be able to satisfy the needs of the teaching program.

The need for a middle technical school of agriculture is important to meet the demand of the country in the field of agriculture, for people to work in the field as extension workers.

Cooperation with other institutions and experts from abroad who can be invited for improving curriculum and research program to gain more experience in the field of mechanization.

The University of Libya is the only source of graduate professionals in the country. The stress is for good quality professors to teach and develop a new curriculum with Libyan experts. They are given aid for progressing and stressing field trips and laboratory exercises for the students, and building a Libyan agriculture library as a goal.

V. PROPOSAL

5.1 Society of Agriculture Engineers

The first step is to establish a society for agriculture engineers, which would accept as a member all those who graduate in the field of agriculture. This can serve the country by getting all the leaders in this field in the country together in one spot.

Then seminars can be organized in agriculture mechanization research and education to keep all the leaders up to date on what is going on in the research in agriculture mechanization, news of any findings of problems created upon application, and the result of the research done.

The society can be coordinated on this basis:

1. Presentation and discussion of research and studies being done;
2. Panel on the future needs of research in agriculture mechanization.
3. Election of a working committee on study and coordination for agriculture mechanization research.

5.2 Agriculture Mechanization Research Committee

This committee should have the following responsibilities:

1. To prepare a study of the present stage of research in agriculture mechanization;
2. To coordinate all research in agricultural mechanization in the country and exchanging programs with neighboring countries and/or countries with the same conditions;
3. To organize courses and seminars at national and international levels on aspects related to research in agriculture mechanization.

At least five specialists should constitute this committee:

1. A representative from the University of Libya;
2. A representative from the Agriculture Engineering Society;
3. A representative from the Ministry of Agriculture;
4. A representative from the distributors;
5. A representative from the Agriculture Land Reform.

At least three of them are directly involved in agriculture mechanization research and the committee must meet at least once a month. The same committee should operate

between three to five years to give them time to finish the work involved in Figure 5-1 which shows the flow chart of the organizing of research agriculture mechanization.

5.3 The Goals

5.3.1 Immediate Goals:

a. To determine the state of agriculture mechanization research to date;

b. To evaluate the future needs of research in agriculture mechanization;

c. To run preliminary experiments in areas where no information is available;

d. To secure financing of, technical assistance for, and training of the research personnel;

e. Planning for field experiments and economical studies for the next few years;

f. Best methods of using machinery;

g. Best machinery type and power that can be employed under Libyan conditions;

h. Most economical and efficient use of machinery; as in the flow chart in Figure 5-2.

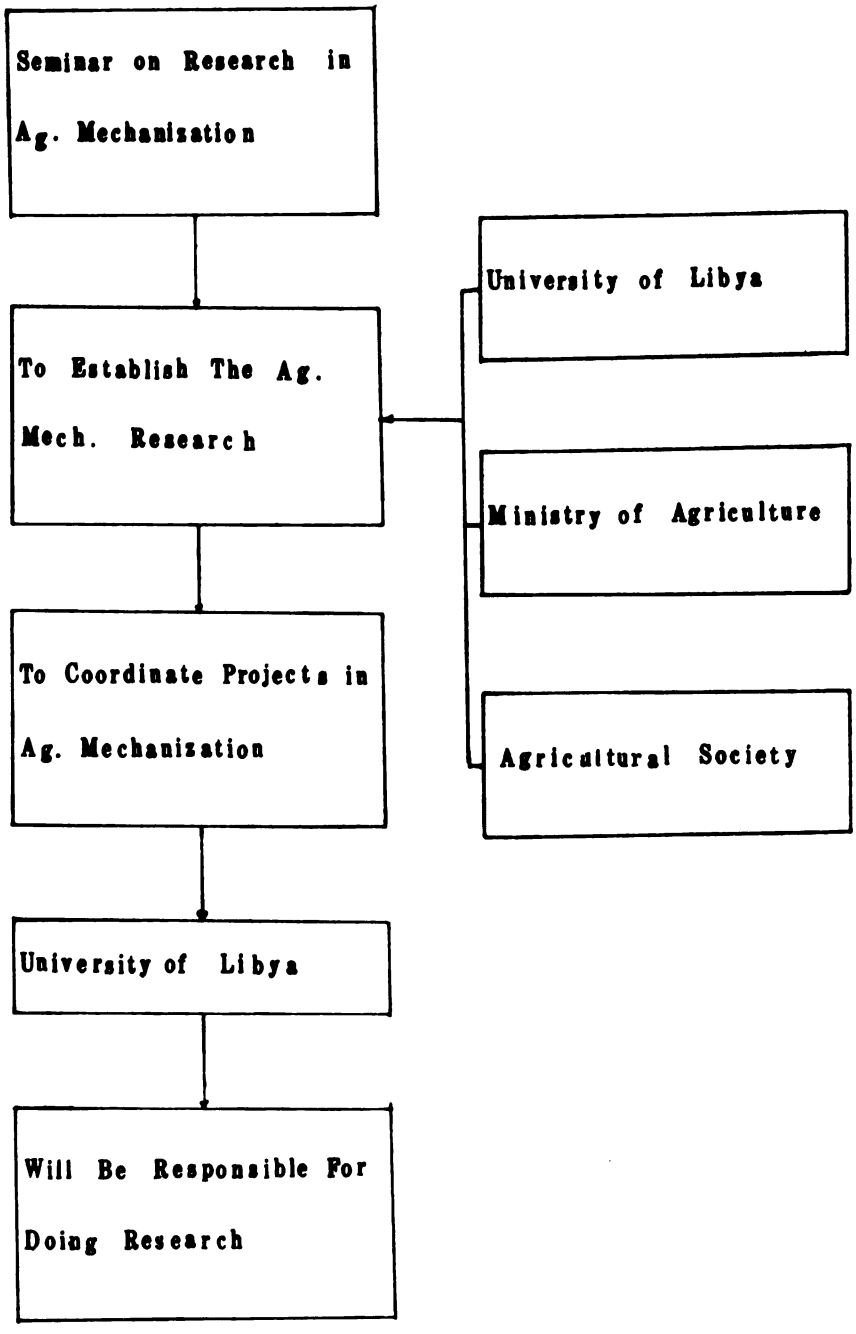

Fig 5-1 Flow Chart For The Research in Agricultural Mechanization

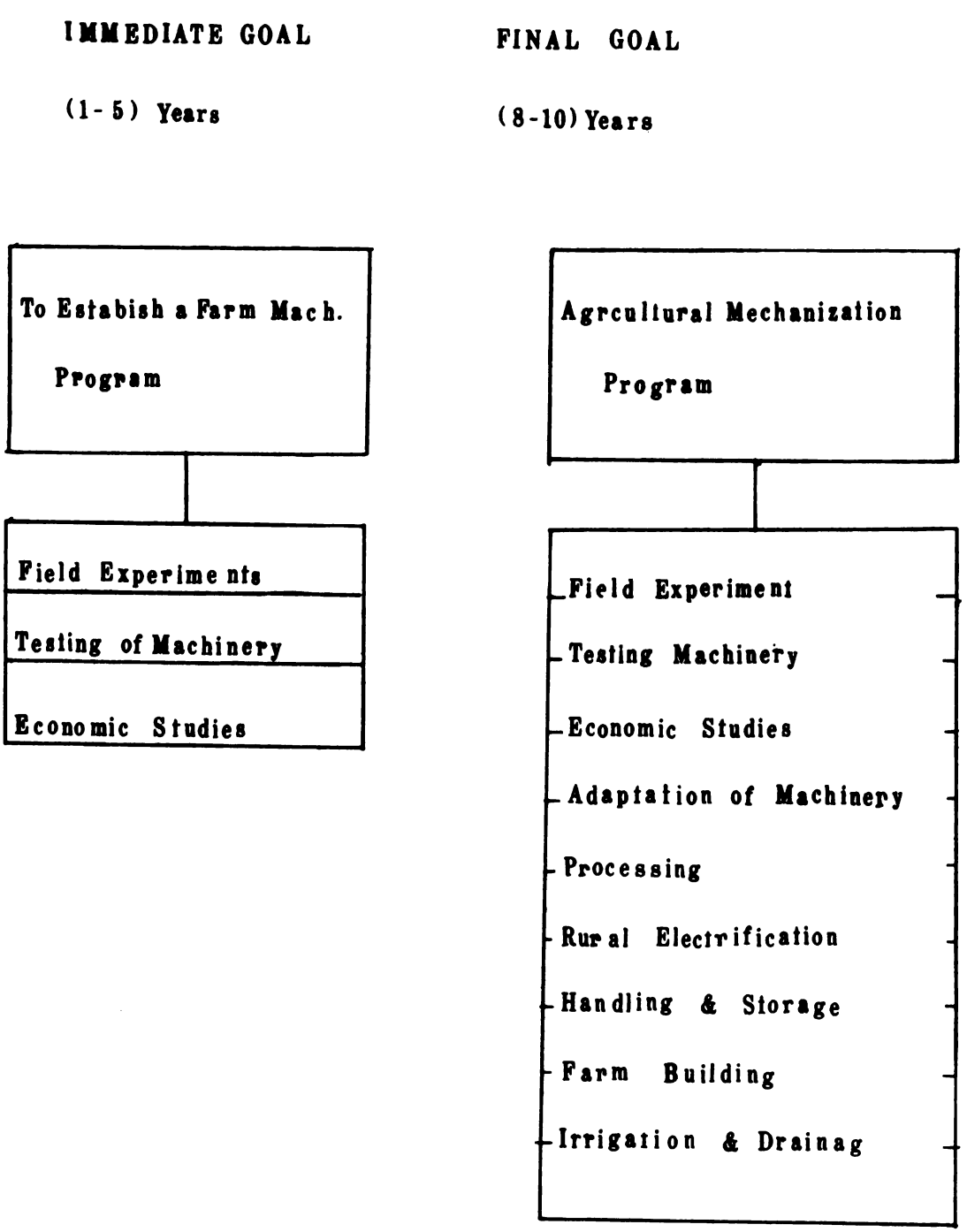

Fig 5-2 Goals of Agricultural Mechanization

5.3.2 Long-Term Goals

After eight or ten years of having operated the research project full information should be available on all the most important aspects of agriculture mechanization studies and the recommendations made. The University of Libya can develop most of the courses required in the future for building a background for research. By that time this data must be available:

a. Most appropriate methods for using machinery;

b. Types of machinery and equipment suitable to Libyan conditions for different crops and climatic conditions;

c. Economic aspects involved in the use of machinery;

d. Developing of hand tools used in Libyan agriculture;

e. Adequate information on methods and equipment for processing, rural electrification, handling and storage equipment.

Follow-Up Project

At the end of eight or ten years this project will require plans to be made to reorganize the research by establishing a new project called an agriculture mechanization research, to consider separately the areas of power and machinery processing and handling, electric

power, farm structure, irrigation and drainage as shown in Figure 5-2. Advanced studies should be initiated at this point and establishing a diploma for graduate studies in the University of Libya for graduates in the other fields of engineering interests in agriculture.

5.4 Types of Research to be Done

The research projects presented here will concentrate mainly on power and machinery, but most of the guidelines presented can be applied to the rest of the areas of agriculture mechanization.

Types of research in agriculture mechanization that have to be considered are:

5.4.1 Field experiment

5.4.2 Testing of machinery

5.4.3 Economic studies

5.4.4 Design and adaptation of machinery

5.4.5 Basic research

This classification is considered suitable for the following reasons:

1. It gives an idea of the different types of experiments and tests that could be done in the area of power and machinery.
2. It could make the establishment of priorities of future research easier if some aspects of

information are delayed and will continue to be recorded to start that type of experiment later on a better basis.

3. Future needs of equipment and facilities, and types of training required for the personnel can be better visualized.

4. Work can be coordinated to introduce mechanization in the country to avoid repetition of the research in the same area.

Many experiments will fall into more than one category especially in the first few years of work. For example, the field experiments will consider both economic aspects and testing of equipment.

Figure 5-3 shows a general picture of the aspects of agricultural mechanization that should be considered now or in the future in Libya.

5.4.1 Field Experiment

The field experiment must have first priority during the first four or five years of research projects because they are designed to solve the immediate problems of the farmers, and because the lack of information in this area is delaying more extensive and efficient use of machinery. The experiment should be directed to finding better methods of using machinery more efficiently and economically. The main crops, types of soil,

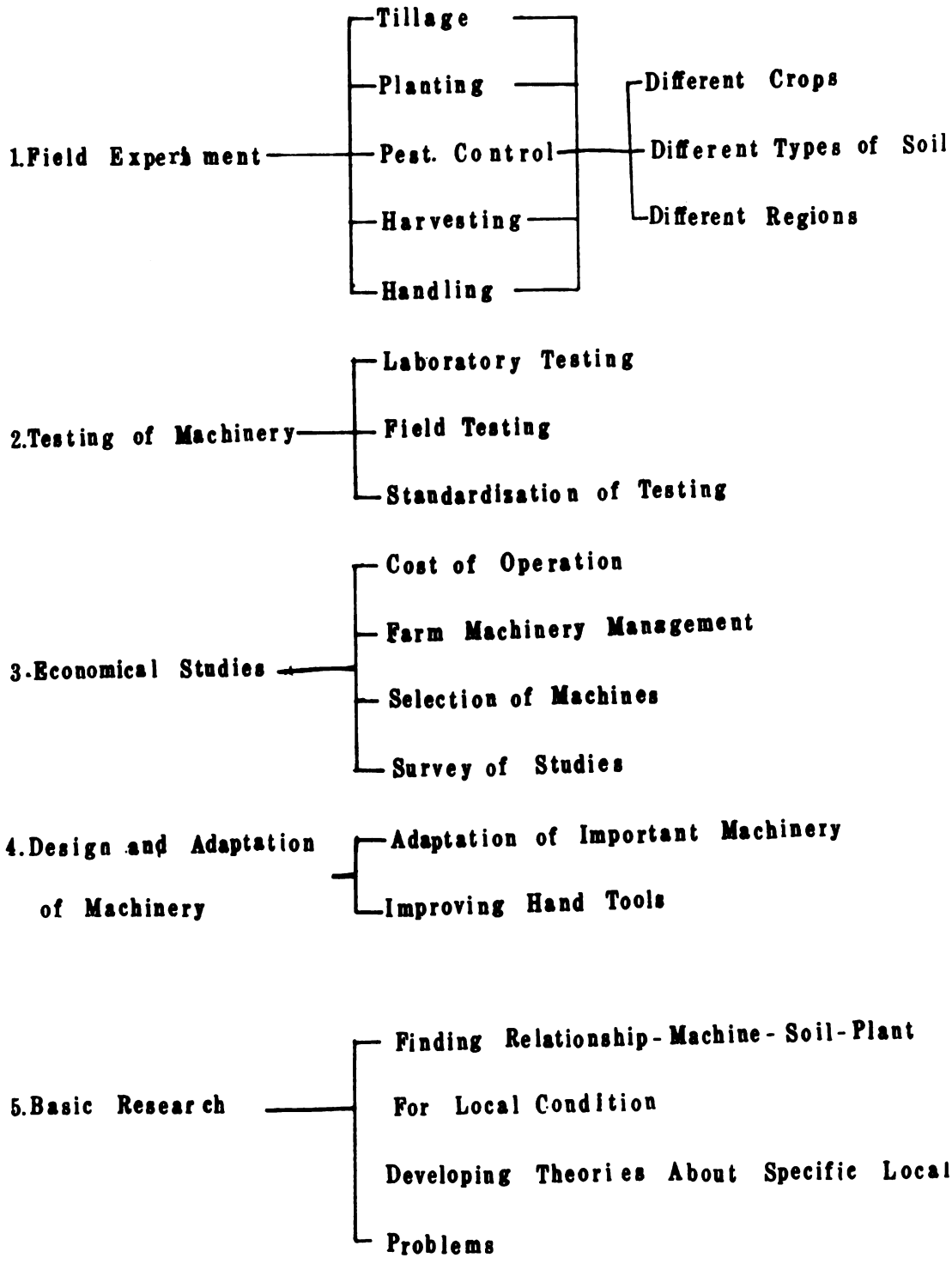

Fig 5-3 Types of Research in Agricultural Mechanization

topography, climate, and cropping systems used in different regions of the country have to be analyzed before planning specific programs.

Three types of experiments can be considered:

1. Preliminary experiments--These experiments should be done when no previous information about agriculture problems is available, and the methods and types of machinery used or usable in Libya is large. For example, if tillage is studied, there is a large variety of machinery, and possible combinations of machinery and tillage methods are many. The preliminary experiments can compare all possible treatments without a specific design, and with no replications. The other possibility is to use an experimental design and to make a statistical analysis using a low power to find significant difference. These experiments can be especially useful in agricultural mechanization research because large plots are used, the cost of the machinery is expensive, and thus the experiment may be too large to handle. But the preliminary experiments would identify the most promising factors and thus allow the reduction of the experiments to a workable size.

2. Specific experiments--These experiments would be designed for testing particular crops, work methods, and machinery prior to any specific recommendations to farmers and the agriculture bank. An experimental design adequate to the purposes of the project must be used and a statistical analysis for the results is necessary. These experiments should be repeated over at least three years to counteract any effect of climatic variations through the years. The standardization of the experimental design conducted in all of the research institutions is essential. Electronic computation can be used for the statistical analysis.

3. Demonstration experiments--These experiments should be done mainly on farms that are central to the agricultural production areas where farmers can observe the processes and compare the results of the different treatments. It would be best to delay these experiments until results are obtained in the earlier specific experiments. In these cases only two or three of the most promising treatments can be compared with the traditional method. The different operations, crops, and other conditions that should be studied in the field experiments are

shown in Figure 5-4. Farm weeks are important aspects to show the farmers new machines that can be used in the field and for them to get an idea about different tools that can be employed in the field. These tools which can be used by himself or by hiring it through the agriculture cooperative in his area which may have a great effect for introducing agriculture mechanization to the farmers.

Projects Outline

Project title	Tillage Methods and Machinery
Subject	Wheat or barley
Departments	Agriculture Engineering Soil and Water Conservation Plant Production
Date of revision	November (each year)
Probable duration	Five years (for irrigated and non-irrigated area)
Personnel	One farm machinery specialist One soil and water conservation specialist One plant production (wheat or barley) specialist
Leaders	To be selected from the three specialists in charge in each one of the three main experimental stations
Cooperators	Agriculture economics specialists Weed control specialists
Location	Libya (in the faculty of agriculture farms)

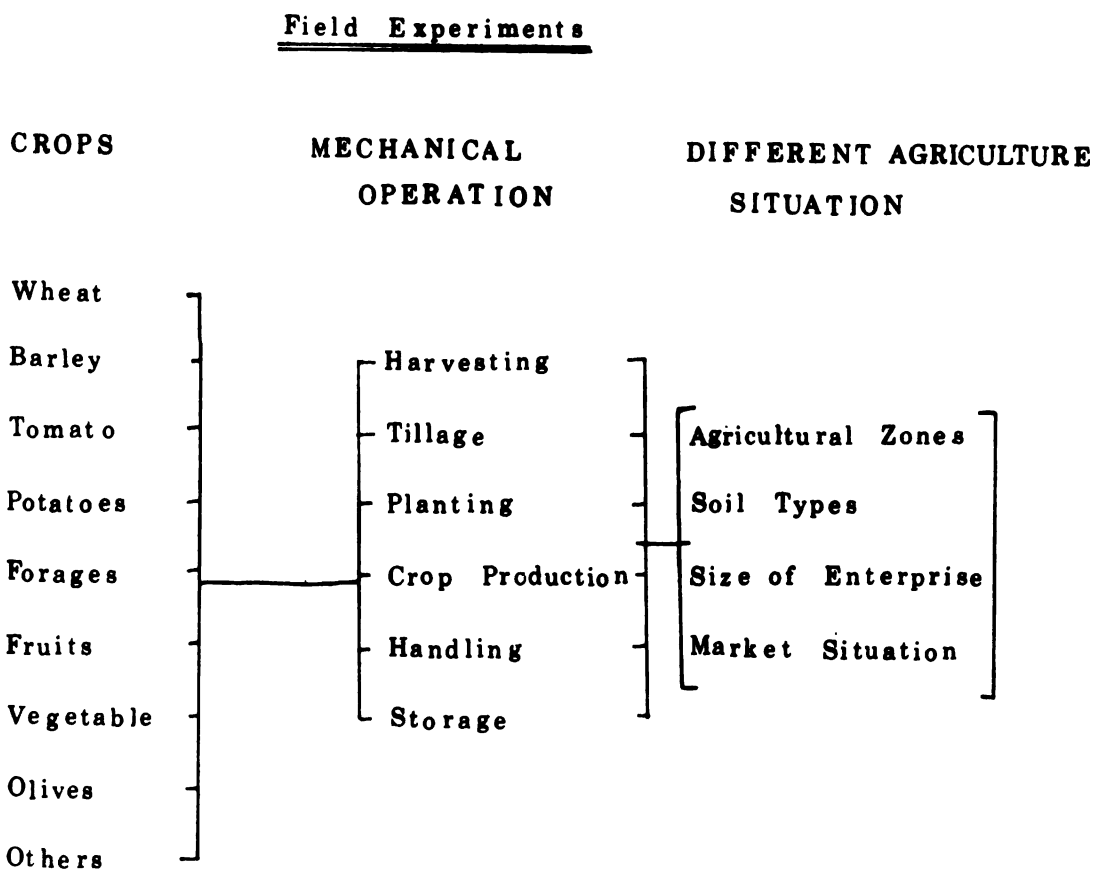

Fig 5-4 Aspects To Be Studied By Field Experiments

Importance

1. Wheat and barley are the most important crops in Libya.
2. Tillage is one of the basic operations for wheat and barley production.
3. There is not enough information about tillage methods, machinery, efficiency, and cost of different tillage operations.
4. Most of the farmers use methods of tillage based on their own experience. In many cases this implies excessive tillage with severe damage to the soil and high waste of power, money, and time.
5. There is very much interest on the part of extensionists, cooperatives, governmental agencies, and farmers to know the adequate methods of tillage and machinery for their conditions.

Objectives

1. To find the most adequate methods of tillage for wheat and barley in the main regions where it is grown.
2. To be able to select the most adequate tillage machinery for wheat and barley production.

3. To find the most economic tillage methods.

4. To obtain guidelines for governmental and private agencies about what kind of equipment to import or to improve to meet the Libyan conditions.

5. To standardize the experimental procedure.

Resume of Previous Investigation

In general, some experiments especially at the university level can help the country by building a national library in research through its experiment station it can give an answer in the best concepts of tillage for wheat and barley in the point of view of the best methods of tillage, the cost of operation, and types of machinery.

1. Experimental Design

a. Randomize Complete Design--This will be the most common design to compare various tillage methods. The plot size depends upon the size of the tillage implements. In general the plots will be fifteen meters (45 ft.) in width by twenty-five meters (75 ft.). Sufficient headland for free movement of equipment is necessary, four replications should be the minimum.

b. Split Plot Design--This design could be used when studying more than one factor, as for example:

1. Tillage methods and date to initiate the operation
2. Tillage methods and types of weed control
3. Tillage methods, weed control, and fertilization.

c. Incomplete Blocks or Incomplete Blocks with fractional replication could be used when comparing two or more factors at various levels and the number of treatment combinations is too big. This type of design could be used after having collected information on which to base the decision about the treatment combinations and what interaction could be neglected.

2. Tillage Machinery

The machinery owned by the farmer should be used first, and what machinery is used will depend upon the number owned by the farmer and the availability of special kinds in the country. Other types can be used to know their effect under Libyan conditions in order that recommendations can be made in the future to the farmer or other organizations.

At least some of the following tillage equipment should be used in many areas:

a. Moldboard plows

1. One-way plows

2. Two-way plows

b. Disc plows

c. Sub soil

d. Disc tiller plows

e. Rotary tiller

f. Chisel plows

g. Offset disc harrow

h. Field cultivators

i. Spring tooth harrow

j. Spike tooth harrow

k. Rollers, packers, mulchers

l. Double action disc harrow

3. Treatment

Farmers used many kinds of tillage implements and tillage methods. Since no experimentation has been done before, it will be convenient to start the first year with a preliminary experiment comparing all possible tillage methods or combination methods. This could include the utmost possible combinations of treatments that could be handled in the country which depends on the types that are available in the country without any replications. This will permit the work of each implement to be watched, to define what measurements are

more convenient, to prepare the personnel, to observe the effect of soil moisture, date to initiate the plowing, velocity of the equipment, etc.

The definite design will be established after knowing the results of the first year. These results will help the country in many ways, as through the extension workers who will be able to explain methods to the farmers, thus avoiding most of the wrong ways that had been done before.

Here are the examples of some treatments that can be compared and held in Libya:

1. Disc plow and secondary tillage
2. Disc plow and plant
3. Moldboard plow and secondary tillage and plant
4. Moldboard plow and plant
5. Plow plant (moldboard plow with drill, one operation)
6. Offset harrow and moldboard plow and secondary tillage and plant
7. Offset harrow and moldboard plow and plant
8. Offset harrow and plant
9. Offset harrow and plant (one operation)
10. Rotary tiller and plowing and secondary tillage and plant

11. Rotary tiller and plowing and plant

12. Rotary tiller and plant

13. Rotary tiller and plant (one operation)

14. Chisel plow and secondary tillage and plant

15. Chisel plow and plant

16. Chisel plow and plant (one operation)

17. Field cultivator and secondary tillage and plant

18. Field cultivator and plant

19. Field cultivator and plant (one operation)

And many other combinations can be used in different parts of the country and in different climatic conditions. Numerous different results could be obtained in various methods of using tillage operations.

4. Measurements

Soil measurements:

Mechanical analysis
Fertility level
Bulk density
Permeability
Agregate size
Soil moisture
Photographs

Implement measurements:

Depth and width of work
Forward speed
Draft
PTO requirements
Turning time
Cost of operation

5. Reports of the Results

The most common type of statistical analysis will be analysis of variance to the yield of the crops to find if there exists a significant difference between the treatments. Simple negration and multiple negration analysis between any factors that could effect the yield can also be done. The results can be analyzed by computer, at either the computer facilities of the Faculty of Science or in the Faculty of Engineering. Studies of the correlation between the different factors affecting the yields could also be done.

5.4.2 Testing of Machinery

Testing of machinery is important in the country because then it will be possible to determine which machines are suitable to the local conditions. This will be of great advantage instead of just importing any kind of machine into the country without knowing whether it is suitable to the conditions or if their is a difficulty in its operation or adjustments that would make it harder for the farmers to handle.

The University of Libya can do something in this field by establishing a testing center for machinery in the country. For many reasons the university is the only place that one can find: (1) the most equipment available for testing, (2) it will have trained personnel in the future in this field and can concentrate on

gaining some graduate students who are interested to work in this field, (3) it is in an agriculture area, (4) it is not far away from all machinery distributors which can help.

The University of Libya can also help by inviting professors from abroad for exchange programs with universities who are interested in the same programs. Information can also be exchanged with foreign testing centers, which can result in the building of a Libyan scientific library. The main aspects to be studied in this center will be concentrated on the mechanical characteristics of the machinery, such as: simplicity of design, size, mechanical efficiency, material used, field efficiency, facility in use and maintenance, power requirement under different agricultural situations, etc. [22].

The personnel that should be involved in this center are: an agricultural engineer, an agricultural mechanization specialist, a mechanical engineer, and a technician, mechanics, and operators.

Sample Projects Outline

Project	Testing of Machinery--combines (small grains)
Cooperating agencies	University of Libya and distributors of machinery

Date to start	1972
Duration	
Leaders	One agriculture engineer One agriculture mechanization specialist
Collaborators	Agricultural economists Agronomists Farmers

Objectives:

1. Using approved testing procedures for combines
2. To compare functional, mechanical, and structural characteristics of combines
3. To know power consumption under local conditions:
   a. Tractor drawn by PTO
   b. Tractor drawn with combine driven by its own engine
   c. Self-propelled with combine pulled and driven by its own engine
4. The rate of work (capacity)
5. Field losses
6. To encourage importers to sell suitable machinery for Libyan agricultural conditions

The results of the tests should be available to the farmer in as simple a form as possible so he will be able to use it. Literature from abroad about this special subject should be carefully reviewed, especially that from the United States, Europe, and Australia.

Procedure:

The testing procedures for combines should be established first. This has to be obtained from the literature and then adapted to fit the local conditions, facilities, and personnel available.

Tests must be carried out in the field on different types of combines and can be classified in three ways:

a. according to use

b. according to power

c. according to design

Determining the characteristic and performance of combines based on field studies will help to find the sources of field losses due to the overall functioning of the machine (ground speed, cylinder speed, r.p.m., height of cut, etc.).

The aspects of structural characteristics, quality of material, simplicity of design, and adjustment, care, and maintenance required should be recorded.

Report and Results:

The results of tests must be published and made available to specialists in machinery, extension personnel, and farmers. Preferably these results should be published in both Arabic and English.

5.4.3 Economic Studies

This study should also have priority because the economic aspects are extremely decisive for the present and the future development of agriculture mechanization in Libya. The fact that mechanization replaces labor should be taken into consideration as a social problem, because it may start to grow in the future because now the Libyan agriculture needs labor.

Some of the aspects to be studied are as follows:

1. Cost of farm machinery
2. Capacity and efficiency of machinery
3. Optimum mechanization level for a given size farm
4. Government and cooperative hired station machinery
5. Rural labor situation and its implications for the mechanization process
6. Cost studies of mechanizing a given crop for different regions of the country

7. Comparative cost studies for using hand power, animal power, and tractor power for a given operation

8. Market situation for various kinds of machinery, etc.

5.4.4 Adaptation of Machinery

In the adaptation of machinery to local conditions it is important for the machinery owned by the farmer and/or cooperative to be used to its fullest capacity.

For improving the machinery under Libyan conditions there will be the establishment of a curriculum in the university which can serve the growth of agriculture production and to solve its problems.

Another important task is the improving of the animal drawn machinery and the manual implements (hand tools).

5.4.5 Basic Research

The basic research is for a long run after eight or ten years.

After collecting most of the information that can be obtained relating to the basic research, aspects should be considered so that this information could be the basis for initiating definite research later on.

The fact that this research can be kept up to date by exchanging information with other research

institutions should be enforced and the participation of researchers in international meetings should be encouraged. These exchanges and keeping up to date will be valuable to initiate basic research probably at the agriculture engineering department as these future students get their professional degree as agriculture engineers.

5.5 Equipment and Facilities

Agriculture machinery will be necessary for any type of research. Some important equipment and facilities to start with are:

1. Field experiments
   Manual implements
   Animal drawn implements
   All kinds of tractor machinery that is available in the country
   Tractors, fuel, and lubrication
   Self-propelled machinery
   Auxiliary of tractors
   Arable land
   Fertilizer, seeds, pesticides, etc.
   Laboratory instrumental
   Plot equipment
   Photographic equipment
   Recording equipment
   Transportation facilities

Shop facilities

Electronic computing facilities

Some of the equipment and workshops can be shared or other university's laboratories and workshops could be used.

2. Testing of machinery

All kinds of machinery sold in the country should be tested. The needs are:

-- All kinds of testing instrumental

-- Reports from other testing centers

-- Electronic computing facilities

3. Design and adaptation of machinery

Design and adaptation of machinery will require laboratory and experimentation shop facilities, obtaining most of the lists of instruments, equipment, and material have to be prepared according to the needs of the country in projects for the future.

4. The basic research

This will require more sophisticated instruments for measuring and laboratory facilities. Most of these instruments can be collected for a long-term program of research and can build for the long run.

5. The economic studies

Economic studies mainly needs transportation, survey personnel, and computing facilities. Most of it should be planned to meet the requirements of the future needs of the country.

5.6 Personnel Requirements

Many personnel are required for the accomplishment of the complete research project. It will start with the personnel already available. The involvement of the graduates of the university is important to carry out many of the field experiments.

The University of Libya has the facilities and the personnel in most of the technical fields. A technicians' training program for the personnel outside the country is important in establishing in the country who is advanced in mechanization.

It is believed necessary for cooperation to exist between the University of Libya and the departments of the Ministry of Agriculture and Land Reclamation in order to achieve all of the goals of the projects in full coordination and collaboration.

Another factor that must exist so that the goals for the proposed projects may be achieved is the training for dealers, mechanics, drivers, operators, etc.

The financing of the projects can be out of the budget for research grants of the five-year plan. The University can finance the laboratory facilities to complete the facilities they have to continue the research programs. The FAO can play an important factor in supporting such a program by some facilities and support for trained personnel.

CONCLUSIONS

1. The agricultural mechanization in Libya was badly introduced because of the lack of skilled technical personnel, training programs, and industrial material aids. It is very important that new approaches be considered in order to create a situation based on scientific methods.

2. The research for the mechanization of agriculture has been very limited and scattered, there has only been a few years of demonstrating in the area of field experiments and testing machinery that was done by the FAO in the early sixties.

3. Organizing research in agricultural mechanization for the coming ten years is necessary because much information is needed in the aspects of agricultural mechanization to fully implement the National Agriculture Development Plans.

4. The low yield per hectar and the low production per animal is due to the bad techniques and technology applied in agriculture production, such as the lack of using proper: tillage

methods, chemical fertilizers, or improved varieties of seeds; also some of the bad techniques come from the continuing use of traditional methods.

5. The farmer has been supported too much which has made him a parasite of the government. This has made the whole plan for developing the agriculture fail because no feedback information or statistical data has come from the extension people.

6. Changing the structure of agriculture production primarily to make a better balance between crop planting in specific areas. These plans can save the fertility of the soil and control water conservation.

7. Encouraging a processing industry in order to improve and increase the production of raw materials and industrial products.

8. Training programs must be carried out by the University because it has more facilities for education than the Ministry of Agriculture does.

9. Seminars and training programs from time to time for extension personnel are very important to keep them up to date with improvements so they are able to carry out the planning program for the future of the Green Revolution.

10. Improving the educational curriculum through the high school of agriculture, middle technical school, and improving some and making available new courses at the University level.

11. Organize research services which should study and investigate different types of machinery for short and long runs which are appropriate under the Libyan conditions, as well as to study different methods of using machines with more efficiency and economically.

12. Farm weeks are for giving seminars and demonstrating farm machinery and equipment to the farmers, which will help to introduce mechanization into the country with the dealers' cooperation.

13. Demonstrating dry land farming techniques and equipment in the rural area, especially for wheat and barley throughout the cooperative.

14. To make the advantages of modern power agriculture equipment on a self-supporting basis to the farmers whose financial status does not permit them to possess such equipment.

15. To introduce improved tillage and seeding practices for crop production under the semi-arid conditions existing in Libya.

BIBLIOGRAPHICAL REFERENCES

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1. The Agrarian Reform and Land Reclamation Corporation. Summary of the Projects Under Process, July 27, 1971.

2. Agriculture Bank LAR. Annual Report No. 13. March 31, 1970.

3. Agriculture Bank LAR. Annual Report No. 14. March 31, 1971.

4. Allan, W. The African Hasbandman. New York: Barnes & Nobel, 1965.

5. Area Handbook for Libya. Prepared for the American University by Stanford Research Institute, completed on June, 1969. Washington, D.C.: Government Printing Office, December, 1969.

6. Bank of Libya. Annual Report No. 14. March 31, 1970.

7. Blunsum, Terence. Libya, The Country and Its People. London: The Queen Anne Press Ltd., 1968.

8. Brown, Leon Carl, ed. State and Society in Independent North Africa Middle East Institute. Washington, D.C., 1966.

9. Chang, C. W. "Agricultural Research, An Example of Practical Approach." Selected Reading to Accompany, Getting Agriculture Moving. Edited by R. E. Boton. New York: The Agriculture Development Council, 1966.

10. _____. "Research Planning and Coordination." Selected Reading to Accompany Getting Agriculture Moving. Edited by R. E. Brotor. New York: The Agriculture Development Council, 1966.

11. Esmay, M. L. AE 804 Agriculture Mechanization in Developing Countries. Notes from class. East Lansing, Mich.: Michigan State University, 1971.

12. Farley, F. Planning for Development of Libya. The Exceptional Economy in the Developing World. New York: Praeger Publisher, 1971.

13. FAO. Food and Agriculture Organization of the United Nation. Agricultural Economics Bulletin for Africa, No. 7, September, 1965. "Group Farming and Tractor Use." S. M. Makings.

14. Giles, G. W. Towards a More Powerful Agriculture. Government of West Pakistan, Lahore: The Planning Cell Agriculture Department, November, 1967.

15. Jain, S. D. Agricultural Planning in Developing Countries, Vol. I: Agricultural Development of African Nations. India, 1965.

16. Kingdom of Libya. Ministry of Economy and Trade. Tripoli: General Population Census 1964, 1966.

17. Libyan Arab Republic. Press section. Washington, D.C.: Embassy of Libya, Vol. VI, No. 12 (May, 1970).

18. _____. Press section, Vol. VII, No. 2 (July, 1970).

19. _____. Press section, Vol. VII, No. 3 (August, 1970).

20. _____. Press section, Vol. VII, No. 4 (September, 1970).

21. Mackson, C. J. A Basic Tractor Operator's Training Program. A cooperative project between Michigan State University, Agricultural Engineering Department, East Lansing, and John Deer and Company, Moline, Illinois, September, 1970.

22. McColly, H. F., and Martin, J. W. Introduction to Agriculture Engineering. New York: McGraw--Hill, 1955.

23. McLoughlin, Peter, ed. African Food Production Systems Cases and Theory. London: The John Hopkins Press, 1970.

24. Ministry of Agriculture and Agrarian Reform. Agricultural Statistics 1967-68. Planning and Agricultural Economics Department. Agricultural Statistics and Marketing Division.

25. Ministry of Agriculture and Agrarian Reform. Some Agriculture Statistical Data, 68/69, 69/70. Planning and Agricultural Economics Department. Agricultural Statistics.

26. _____. Some Agriculture Statistics--Libya, 1961-1970. Planning and Agricultural Economics Department. Agricultural Statistics.

27. Ministry of Planning and Development. Agriculture in Libya and a Plan for Development. Tripoli: Government Printing Press, 1966.

28. Ministry of Planning, LAR. External Trade Statistics, 1969. Census and Statistical Department, Press, June, 1970.

29. _____. Statistical Abstract 1968. Census and Statistical Department Press, July, 1969.

30. Mosher, A. T. Training Manual for Group Study of Getting Agriculture Moving. New York: The Agricultural Developing Council, 1966.

31. Nina, Epton. Oasis Kingdom. New York: Roy Publisher, 1953.

32. Nuttonson, M. Y. The Physical Environment and Agriculture of Libya and Egypt with Special Reference to Their Regions Containing Areas Climatically and Latitudinally Analogous to Israel. Washington, D.C. American Institute of Crop Ecology, 1961.

33. Paddock, William, and Paddock, P. "How to Alter the Hand of God." Selected Reading to Accompany Getting Agriculture Moving. Edited by R. E. Borton. New York: The Agriculture Development Council, 1966.

34. Ulloa, Omar. "Evaluation and Proposal for Agricultural Mechanization Research in Chile." Unpublished An AE-811 Technical Problem Report (M.S.) East Lansing: Michigan State University, 1969.

35. United Kingdom of Libya. 1960 Census of Agriculture Report and Tables. Tripoli: Ministry of Agriculture, February, 1962.

36. United Kingdom of Libya. General Population Census 1954 Report and Tables. Tripoli: Ministry of National Economy, 1959.

37. Villard, H. S. Libya, The New Arab Kingdom of North Africa. Ithaca, N.Y.: Cornell University Press, 1956.

38. Wright, John. Nation of the Modern World--Libya. New York: Frederick A. Praeg, Inc., 1969.

39. Wylie, G. M. Agriculture Mechanization. FAO Report to the Government of Libya, Report No. 2060, Rome, 1965.