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PROJECT TECHNICAL REPORT No. 25

PROBLEM IDENTIFICATION REPORT FOR EL-MINYA

By:

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EGYPT WATER USE AND MANAGEMENT PROJECT

22 El Galaa St., Bulak, Cairo, Egypt

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ABSTRACT

The Egypt Water Use and Management Project team selected the Abyuha area, in Middle Egypt, to conduct irrigation management studies. The maize-cotton-sugarcane cropping pattern, typical in this area, is representative of much of Middle Egypt. The team characterized the major physical, hydrologic, bilogical and socio-economic factors operating in the system under study; then they analyzed the data and identified major factors that were acting as contstraints or problems of the system. The results of the study were used to develop a research program designed to assist both governmental organizations and the farmer in removing, where possible, irrigation management constraints in the system. This process is called "problem identification."

ARABIC ABSTRACT

نبذة

أختيرت منطقة أبيوها فى منطقة مصر الوسطى لتكون منطقة أبحاث الرى بمعرفة فريق البحث التابع لمعهد بحوث المياة.

إن التركيب المحصولى فى هذة المنطقة يتكون من الذرة والذرة الرفيعة والقطن وتمثل هذة الحاصيل التركيب المحصولى لمنطقة مصر الوسطى.

وقد قام فريق الباحثين بتحديد العوامل البيولوجية والاجتماعية الاقتصادية والتى تمثل العوامل الأساسية للنظام الذى يدرس ويبحث ثم تمت بعد ذلك دراسة البيانات وتم تحديد المعوقات الأساسية فى النظام.

وأستخدمت نتائج هذة البحوث لتصميم برنامج التطوير وذلك لمساعدة المؤسسات الحكومية والمزارعين للتعرف على مشكلات الرى الأساسية وأين تتواجد فى النظام.

وسمى هذا البرنامج ببرنامج التعرف على المشكلة.

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I. INTRODUCTION

El-Minya Governorate was one of three agricultural areas selected for applied irrigation research by the Egypt Water Use and Management Project (EWUP). EWUP's main objective is to improve the social and economic well-being of small Egyptian farmers by improving the management of water, soil, capital, and human resources used in agricultural production. EWUP's special concern is on-farm water management. The areas were chosen to represent different agronomic, social and economic conditions in Egypt. The Governorates selected for study were Giza (Southern Delta), Kafr El-Sheikh (Northwestern Delta) and El-Minya (Middle Egypt). This report deals with the identification of production problems at the Project's field site in El-Minya Governorate.*

A description of EWUP's organization and working methods can be found in Mansuriya Problem Identification Report (PTR No. 1) and will not be repeated here. EWUP's first task was to identify and quantify problems, to develop appropriate solutions through field testing and demonstrations and then to design and test pilot programs which could be implemented throughout Egypt.

The purpose of this report is to describe those problems which were identified in a small segment of an irrigation district in Middle Egypt. The EWUP team has attempted to identify and characterize the major physical, hydrologic, agronomic and social-economic factors that may act as constraints in Egyptian irrigated agriculture for this part of Egypt. EWUP's objective is to remove these constraints wherever possible, thereby increasing crop production and improving the social and economic well-being of the Egyptian farmer.

The identification of problems is an on-going process as is the development and implementation of solutions to these problems. EWUP can only hope to initiate a process for pinpointing those major problems which seem capable of solution. This report gives a broad overview of the characteristics of the Abyuha agricultural area in El-Minya Governorate, and summarizes the EWUP process of problem identification.

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* For Problem Identification Reports for Mansuriya and Kafr El-Sheikh Study Areas, see EWUP Technical Reports No. 1 and 6 respectively.

II. PROBLEM IDENTIFICATION PROCEDURE

An orderly procedure for identification of problems (constraints) is best illustrated by the "flow chart" shown in Figure 1.

The procedure begins by stating the goal. The goal may be broad or narrow, e.g., the basis of the entire project, or a direction for problem identification only. Once established, each succeeding step must lead toward a decision to proceed, to re-evaluate, or to reject the proposed hypotheses.

Preliminary field surveys as well as farmer interviews begin early in problem identification work. These surveys are performed with a minimum of equipment and often consist of "windshield tours," i.e. cursory observation, to obtain a picture of the whole. The observations, coupled with initial farmer interviews, allow researchers to pose certain hypotheses, which form the foundation for further investigation. In some cases, preliminary investigation may be sufficient to reject the hypothesis and decide that the problem is not real or is of little significance. In other cases, the problem may be sufficiently well defined to proceed with problem solution research or in exceptional situations to make recommendations for implementation. If the preliminary investigation indicates that the problem that hinders the achievement of the goal is complex, then a detailed study may be required to fully measure the magnitude of the problem and obtain a basis for appropriate solutions. Again, additional analysis may indicate the following actions: a) proceed with problem solution research; b) more study is needed, or c) reject the hypothesis (Figure 1).

The problem identification procedure, thus outlined, is followed to present the report for the El-Minya area.

III. GENERAL DESCRIPTION OF PROJECT AREA

A general description of the project area was obtained from reports and publications located in key local and regional agricultural extension and Ministry of Irrigation offices.

A. El-Minya Governorate

The city of El-Minya, capital of El-Minya Governorate, lies south of Cairo some 200 km, in a narrow part of the Nile Valley, in Middle Egypt. The Governorate itself is bounded on the north by Beni Suef Governorate and on

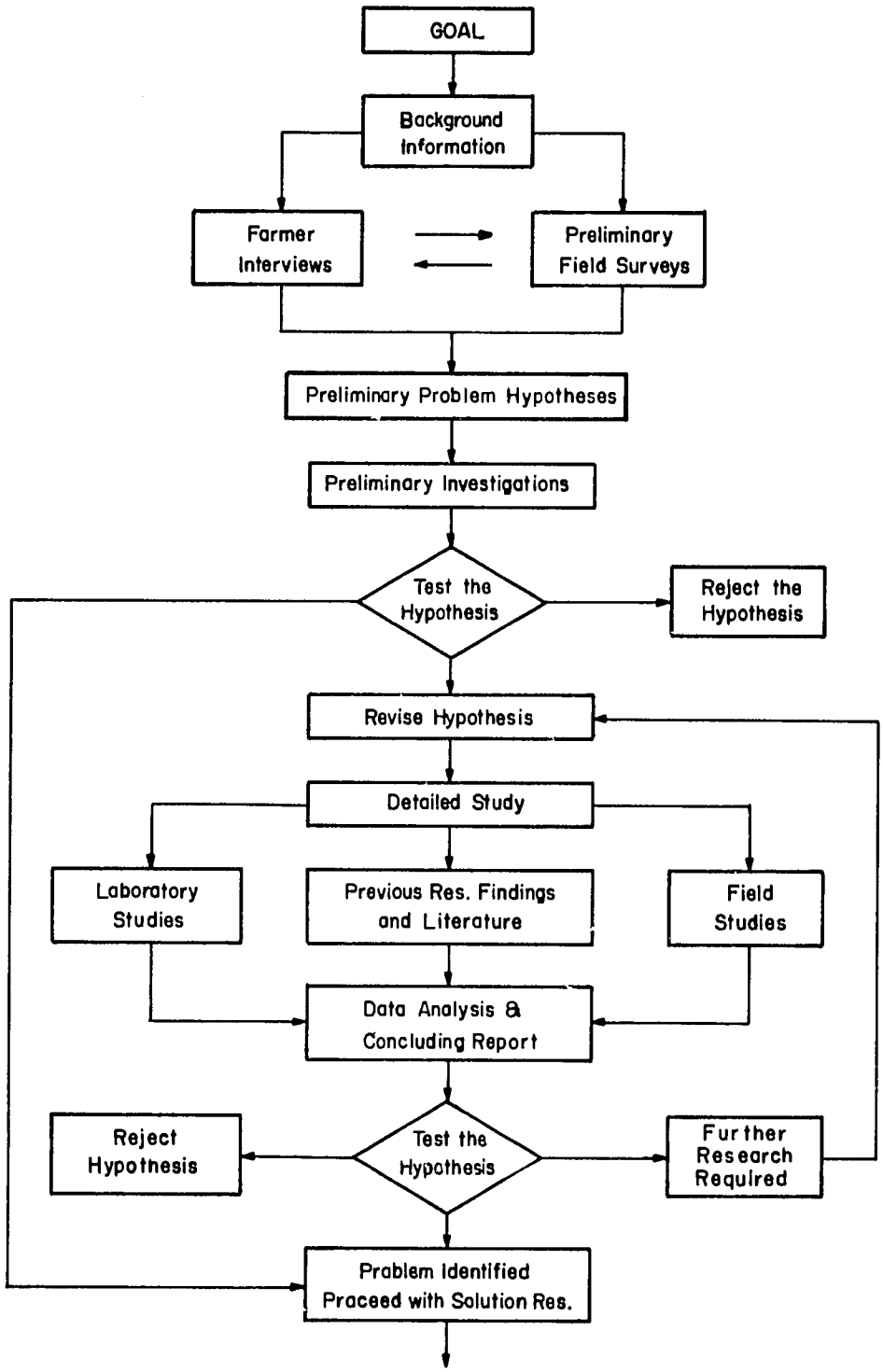

Figure 1. Diagram of the EWUP Problem Identification Procedure

the south by the Governorate of Asyut; on the east and west the deserts confine its width to about 35 km. The north-south length of the Governorate is about 150 km.

El-Minya Governorate is divided into 9 administrative districts. There are 57 village councils that serve 337 villages. According to the 1976 census, there were 2,055,739 persons in the Governorate. About 21% live in villages and 79% in urban areas, primarily in El-Minya city.

The total area of the Governorate is 432,176 feddans of which 82% is under cultivation by private farmers. The total annual value of agricultural production by private farmers is LE 150 million, of which LE 110 million is derived from crops and LE 40 million from livestock. Table 1 gives data on major field crops, fruits, vegetables, and livestock in El-Minya Governorate for 1978.

The water management project area in El-Minya Governorate was selected one year after the work had begun in Mansuriya and Kafr El-Sheikh. The site chosen is in the east irrigation district of Abu Qurqas and specifically included the Abyuha area.

B. Abu Qurqas East Irrigation District

Abu Qurqas East District is centered about 35 km south of El-Minya city and is about 34 km long and 8 to 10 km wide. It is bounded on the east by the Eastern Desert, on the west by El-Moheit Drain, on the north by Maqusa Drain and on the south by the road from El Roda Village to the Serri Canal. (see Figure 2).

The source of irrigation water for the east district is the Ibrahimiya Canal, the largest and longest in Egypt and possibly in the world. Water is diverted from the Nile into the Ibrahimiya Canal at the Asyut barrage. At Dairut it divides into five main canals, the largest of which continues as the Ibrahimiya. From there it distributes water to branch canals all the way to the Giza Governorate, a distance of nearly 400 km. The Abu Qurqas East Irrigation District takes its water from the Ibrahimiya Canal between kilometers 88.3 and 122.4. The Hafiz Barrage on the Ibrahimiya at kilometer 93.0 assists in the regulation of flow to upstream canals.

Abu Qurqas East District has 13 first class branch canals which take their water directly from the Ibrahimiya, and 26 second class canals fed by the first class canals. Table 2 gives data on each of the canals. The agricultural area of the district is 51,000 feddans. This area can be divided into three sub-districts:

TABLE 1 CROP PRODUCTION AND LIVESTOCK NUMBERS IN EL-MINYA GOVERNORATE - 1978

CROPS

Crop	Area-Feddans	Yield Per Feddan		Percent of National Total Production
		No.	Units	
Wheat	80,000	10.3	ardab	---
Broad bean	65,000	6.6	ardab	32
Cotton	130,000	4.5	qintar	---
Sugarcane	35,000	38.0	ton	---
Berseem	24,000	1.0	ardab	---
Maize	200,000	11.0	ardab	---
Potato	6,000	6.0	ton	---
Tomato	1,100	6.5	ton	---
Watermelon	20,000	15.0	ton	---
Cucumber	1,500	5.0	ton	---
Garlic	12,000	9.0	ton	50
Onion	8,000	5.5	ton	50
Coriander	8,000	0.8	ton	---
Soybean	25,000	0.7	ton	33
Grape	15,000	8.0	ton	27
Citrus	2,000	5.0	ton	---
Fig	155	5.0	ton	---
Banana	120	8.5	ton	---
Mango	260	4.5	ton	---

LIVESTOCK

Cattle			Buffalo		
2 yrs. & Older	Less Than 2 yrs. Old	Total	2 yrs. & Older	Less Than 2 yrs. Old	Total
149,220	15,200	164,420	145,870	7,850	153,720

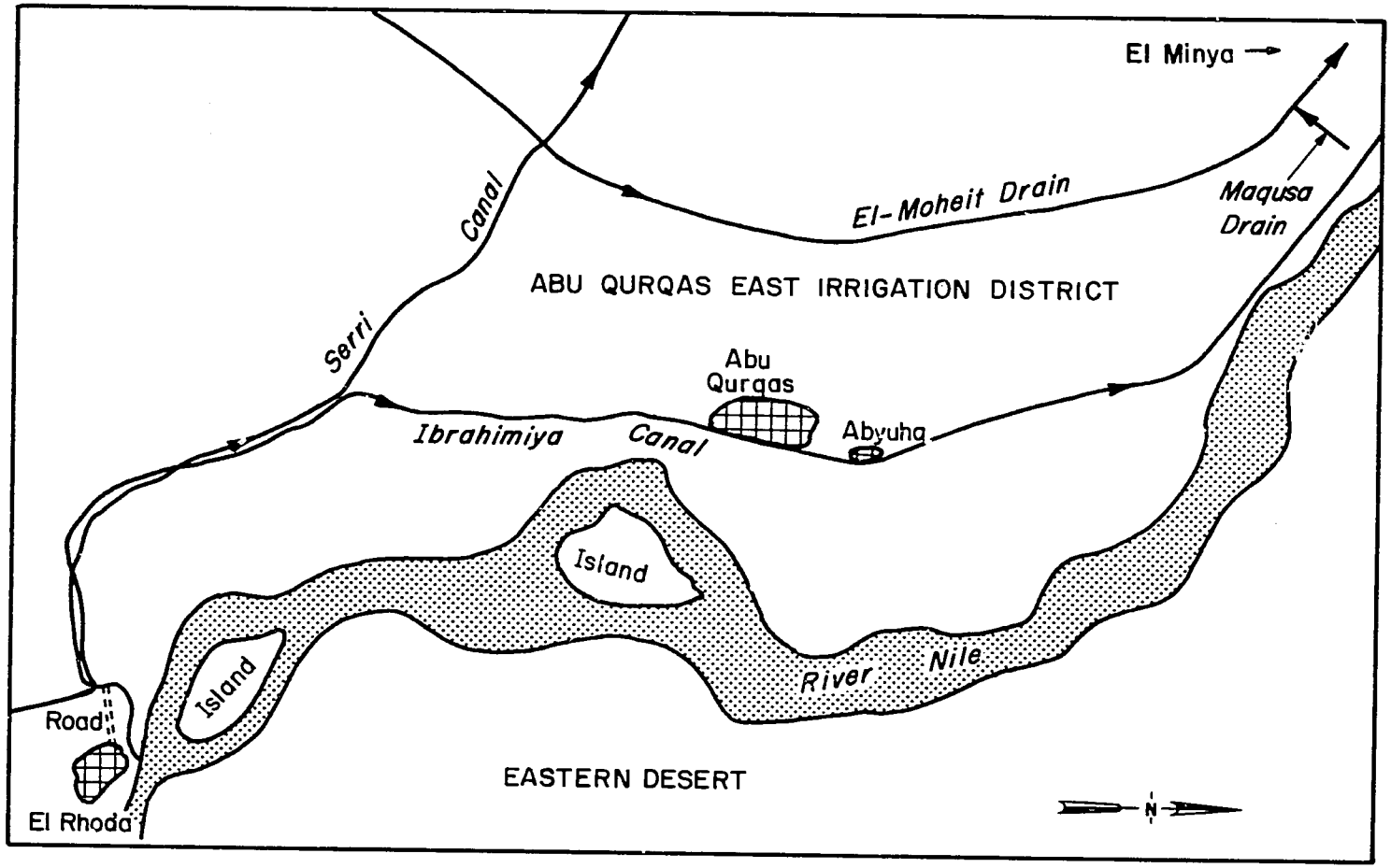

Figure 2. Map of the Abu Qurqas East Irrigation District

TABLE 2 THE IBRAHIMIYA FIRST CLASS AND PRINCIPAL SECOND CLASS BRANCH CANALS SERVING ABU QURQAS EAST DISTRICT

Class	Canal	Length	Area	Gravity Irrigation			Lift Irrigation		
		km	fed	Area	From - To		Area	From - To	
				fed	km	km	fed	km	km
First	Sahliya	10.43	3,750		Intake	4.60		4.60	10.43
	Makin	2.90	500					Intake	2.90
First	Hafiz el-Sharqiya	27.70	11,500	3,000	Intake	7.90		7.90	27.70
	Abu Qurqas el-Gharby	2.40	1,100					Intake	2.40
	Abu Qurqas el-Sharqy	1.60	150					Intake	1.60
	Abu Qurqas el-Bahary	1.50	500					Intake	1.50
	Manhary	3.10	850					Intake	3.10
	Abyuha el-Sharqy	2.00	730					Intake	2.00
	El-Sahala	5.05	1,200					Intake	5.05
	Faraa el-Sahala	0.84						Intake	0.83
	El-Hawasliya el-Gedida	1.63	200					Intake	1.63
First	Hafiz el-Gharbiya	14.70	11,600	2,500	Intake	5.00		5.00	14.70
	Itlidem	12.18	2,700	550	Intake	3.00		3.00	12.18
	Diyab	11.20	2,900	600	Intake	3.00		3.00	11.20
	El-Gahasha	1.74	650					Intake	1.74
	Dairutiya el-Aysar	6.10	2,000	700	Intake	2.00		2.00	6.10
	Dairutiya el-Ayman	1.70	750					Intake	1.70
First	Dairutiya el-Ibr.	1.81	600					Intake	1.70
	Dairutiya el-Ibr.el-Gedid	1.11	200					Intake	1.81
First	Abyuha el-Gharby	4.08	1,500	900	Intake	2.70		2.70	4.08
First	Kom el-Zoheir el-Aysar	7.76	1,900	1,900	Intake	7.76			
First	Kom el-Zoheir el-Ayman	4.60	1,275					Intake	4.60
First	Hawasliya el-Qadima	1.50	300	300	Intake	1.50			
First	Hawasliya el-Qebliya	1.17	500	500	Intake	1.17			
First	Waslet Kom el-Zoheir	5.08	900					Intake	5.08
First	Hawasliya el-Wosta	1.34	440	440	Intake	1.34			
First	Hawasliya el-Bahariya	2.00	875					Intake	2.60
First	Abu-Magdy	3.26	1,400					Intake	3.26

(1) One area, east of the Ibrahimiya, consists of 17,000 feddans, and takes its water from the Sahliya, Hafiz el-Sharqiya, and Abu-Magdy Canals.

(2) Another area to the west of the Ibrahimiya Canal consists of about 30,000 feddans. This area is fed by the remaining branch canals in the district and contains the EWUP worksite.

(3) The third area consists of islands and beaches, first cultivated after construction of the High Aswan Dam when flooding no longer occurred along the Nile. The area is about 4,000 feddans and takes its water directly from the Nile by various lift systems.

As noted in Table 2, irrigation water is applied to land either by gravity or lift, depending upon the design and maintenance of the delivery system and the elevation of the land. Gravity flow irrigation is possible predominantly along the upper reaches of many canals. Intakes for large canals use sluice gates of the Fahmi Henein type for water control, while smaller canals use wooden stop logs.

The quantity of water taken through the inlets of canals is not known. Previously calibrated gates have generally lost their calibrations, and discharge measurements by current meter have not been taken by irrigation officials. Marble staff gauges are, however, used to measure water elevations. Downstream water levels in canals are generally maintained at certain elevations during specified on-periods.

Private mesqas (ditches) constructed at fairly regular intervals along the branch canals take water to the farms through vents (intake pipes) in the canal banks. The vent size has been selected to deliver a pre-determined rate of flow of water when the invert (bottom inside surface of vent) has a head of 25 cm. Mesqas range in length from 500 to 1,800 m. The initial mesqa design was for bed widths of 50 cm and side slopes of 1/2 to 1. These private ditches are supposed to be maintained by farmers either individually or in cooperation with each other. Use of water from the mesqas is by mutual agreement among farmers. In general, no gates are on the mesqa intake pipes, and when water is "on" in the canal, it flows freely through all of the vents at the same time. If water is not used, it flows through into drains constructed at the lower end of the mesqas.

- Drainage System at Abu Qurqas

A system of branch drains covers the district. These drains empty into El-Moheit el-Gaharbi Drain, except for two which return their water directly to the Nile. Table 3 presents data on the second and third class branch drains in Abu Qurqas District.

El-Moheit Drain begins at Dairut, 50 km south of Abu Qurqas and runs northwest past Giza City. There it joins the El-Rahawi Drain which spills into the Rosetta Branch of the Nile below the Delta Barrage. The Rosetta Branch is essentially a drain to the sea.

The portion of the drain lying in Abu Qurqas District is from km 99.5 to km 13.5. At various points south of Abu Qurqas District are cross-channels carrying water eastward to the Nile.

C. Abyuha Project Site-Description

In November and December, 1978, a Project site selection team visited areas in the El-Minya Governorate between El-Minya City and Mallawi, and on January 9, 1979, selected the Abyuha area as a suitable site for conducting Project activities. The area is served by a single source of water and may be described as a separate and complete hydrological unit. Both gravity and lift irrigation systems are used. All of the major crops of Upper Egypt are under cultivation there, and the farmers were reported to be cooperative with governmental programs. Farming units range in size from less than 1/2 feddan to more than 30 feddans, with most units about one feddan. The area is readily accessible from the main north-south road linking the governorates in Upper Egypt to the Delta.

The farmers live in two villages, Abyuha and Kom el-Zoheir. The major village, Abyuha, lies in the southwest corner of the site adjacent to the Ibrahimiya Canal. It is 17 km south of El-Minya City and 5 km north of the town of Abu Qurqas. Kom el-Zoheir is at the northwest corner of the site.

Abyuha Village has a population of 6648 with 42% men, 40% women and 18% children. There are about an equal number of people in each 15-year age group, spanning to 75 years. Only 13 persons are over 75 years of age. One is reported to be over 100.

The village Umdah is Abdel Hakim El-Shabenny. He is 54 years of age and has been the Umdah since 1964. He is an influential leader and has the respect of the community, who follows his leadership. He owns 31 feddans in Abyuha and has five sons.

TABLE 3 BRANCH DRAINS SERVING ABU QURQAS EAST DISTRICT

Class	Branch Drain	Length km	Area fed	Outlet
Second	Maqusa	36.46	9300	Nile
	El-Serw	6.90	1650	Nile
	Kom el-Zoheir el-Qadim	3.20	2500	El-Moheit
	El-Dayra el-Bahary	3.30	9500	El-Moheit
	Itlidem	13.00	6700	El-Moheit
	Waslet-Maqusa	2.48		El-Moheit
Third	Mansafis el-Bahary	3.68		Waslet-Maqusa
	Kom el-Zoheir el-Mostaged	5.88	1700	Kom el-Zoheir
	Mansafis el-Qebly	1.90	1000	Kom el-Zoheir
	El-Dayra el-Bahary	6.69		Itlidem

Abyuha Village has a community center which also serves six other villages, including Kom el-Zoheir, just outside the northwest corner of the Abyuha site area. This center contains a small health center, a primary school, and a social center. There are several activities aimed at agricultural development funded by the village. They include small projects for animal breeding, the acquisition and operation of farm machinery, carpet weaving by handicapped children, and poultry production. Several villages from the area take part in these projects.

Key institutions of the village include the Agricultural Cooperative, Village Bank, Agricultural Department and Irrigation Department. The purpose of the Cooperative, which is government-operated (not farmer-operated in the same sense as the U. S.), is fourfold: (1) to increase agricultural yields, (2) assist small farmers, (3) administer the national agricultural policy, (e.g., cotton allocations), and (4) provide the extension services. Of the 1111 farmers farming the project site at Abyuha, 784 belong to the Abyuha Cooperative and the rest belong to other Cooperatives.

The Cooperative owns relatively few pieces of equipment for farm use. However, equipment available in the area, owned either by private farmers or by the Cooperative includes: 6 tractors, 6 hand sprayers, 7 plows, 9 diesel pumps, and 4 threshing machines. These numbers change each year as more equipment becomes available.

Many farmers, especially those farming the area served by the lower reach of Abyuha Canal, live in Kom el-Zoheir village. The area immediately surrounding this village is served by several sources of irrigation water and was therefore excluded from the project site.

Of the land included in the project site, approximately 60% is farmed by residents of Abyuha village and 40% by farmers from Kom el-Zoheir village.

The study site is served exclusively by the Abyuha Canal, which is the east boundary. The west boundary is Kom el-Zoheir el-Mostaged Drain. The boundary to the north is Kom el-Zoheir el-Qadim Drain, and to the south Mesqa 4 (See Figure 3). The total area is 1,126 feddans. There are 909 farm units for an average of 1.24 feddans per unit. Sixty-two percent of the area is cultivated as rented farms. Of 291 farm management units of various sizes owned by farmers in the area, 2% of the farmers with farms greater than 10 feddans own 30% of the area. Table 4 shows the distribution of owned and rented farms in relation to farm size.

TABLE 4 OWNED AND RENTED FARMS BY FARM SIZE (Abdalla Saber, 1979)

Farm Size Feddans	Owned Farms			Rented Farm Units			Owned Farm Units		Rented Farm Units		Owned and Rented Farm Units				
	Farm Units	Area		Farm Units	Area		Farms %	Area %	Farms %	Area %	Farm Units	Area		Farms %	Area %
		Fed	Qir		Fed	Qir						Fed	Qir		
< 1	172	77	4	344	188	---	60	18	56	27	516	265	4	57	24
1- 2	67	86	21	172	200	10	23	21	28	28	239	287	7	26	25
2- 5	41	107	10	91	237	19	14	25	14	34	132	345	5	15	31
5- 10	4	26	20	11	75	3	1	6	2	11	15	101	23	2	9
> 10	7	126	17	---	---	---	2	30	0	0	7	126	17	1	11
TOTAL	291	425	---	618	701	8	100	100	100	100	909	1126	8	100	100

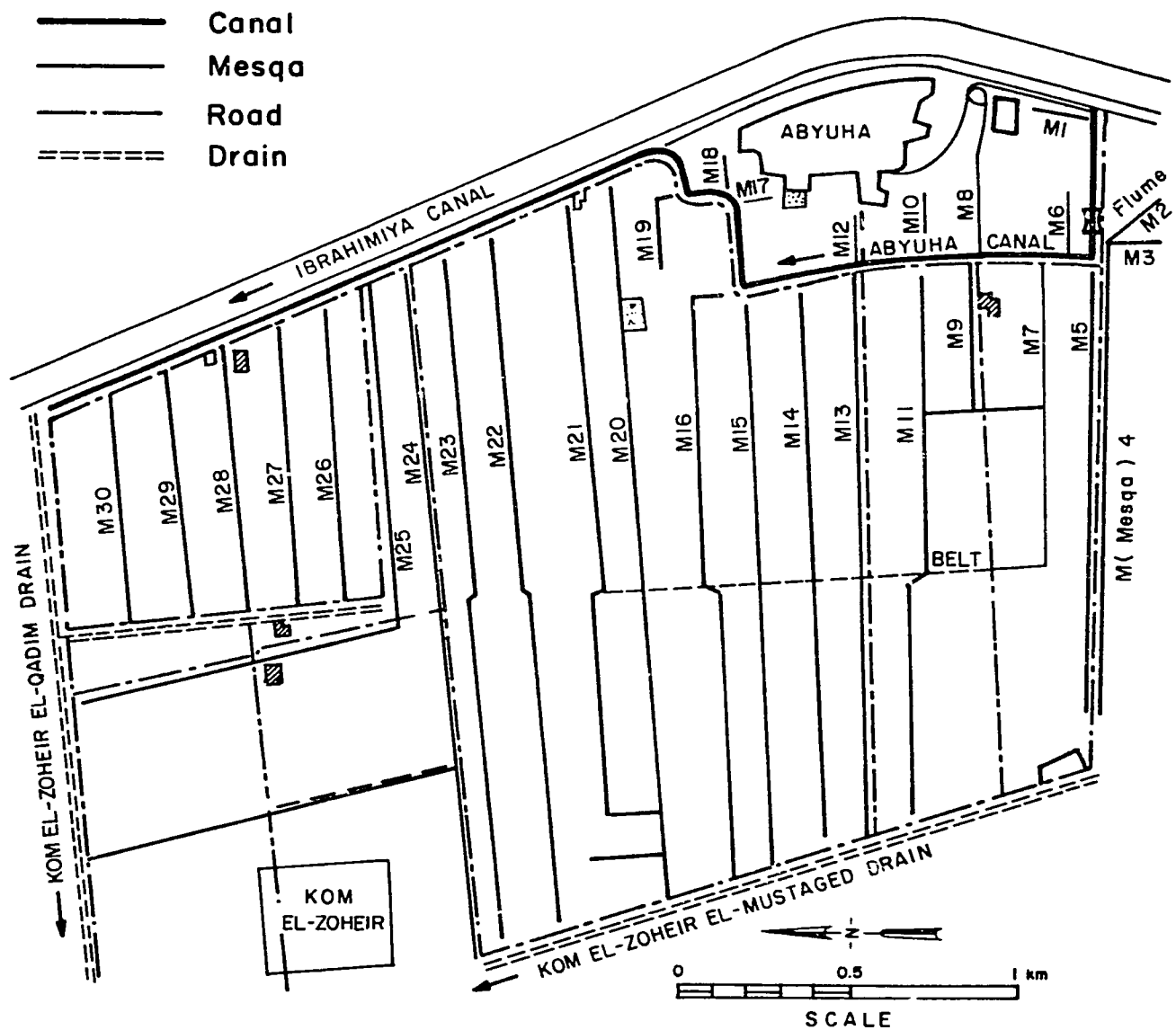

Figure 3. The Abyuha Study Site served by the Abyuha Canal showing each of the 30 Mesqas and the location of the Abyuha flume. Approximate scale is 1:25,000.

The major field crops grown are broad beans, maize, cotton, berseem, wheat and sugarcane. Maize and cotton are planted in the spring, while broad beans, wheat and berseem are planted in the fall. Minor winter crops include onion, garlic, fenugreek, potatoes, and carrots, while the minor summer crops are soybeans, sunflowers, tomatoes, and grapes. Sugarcane, a perennial crop and a heavy water user, is grown on about 1/8 of the land area. Table 5 shows the area cultivated and Figure 4 the cropping patterns for these crops. The cropping intensity is 1.9, i.e. an average of 1.9 crops per feddan per year.

Since the area has no internal roads suitable for wheeled vehicles, farmers rely on pack-animals for transportation. Donkeys are principally used for this purpose. Camels are often used to carry sugarcane, cotton, broad beans and wheat for threshing or storage at harvest time. A summary of the livestock population in Abyuha and Kom el-Zoheir villages is given in Table 6.

The Abyuha Cooperative owns one rubber-tired tractor which is available on a rental basis. Approximately 5 other tractors are available in the area. Farm land generally is plowed once each year by tractor using a chisel plow. Furrows for seedbeds usually are made by hand, or by wooden plow pulled by two milk cows--then finished by hand. All planting, cultivating, fertilizing, insect control, and harvesting is done by hand, but cotton is sprayed by airplane after the season advances. The tractor does not return to the fields until the end of the season, when it is used to power the flat-belt-drive threshing machine/straw chopper. Winnowing is accomplished by hand. Other than for plowing and threshing, tractors are utilized to pull wagons on the existing roads.

Cotton is the only government-controlled crop in Abyuha. The area receives its allotment of required feddans from the government cooperative. Farmers are assigned to cultivate cotton once every three years. Allotments are based upon the national supply, export demand, the need for cotton in local mills, and the need to generate foreign earnings.

The climatological data in Table 7 are from the Mallawi Research Station 35 km to the south of Abyuha. The mean daily temperature ranges from 11.9° C in January to 28.5° C in July, with an annual mean of 21.2° C. The diurnal temperature range is 15 to 17 ° C, and there is occasional night frost. Rainfall is negligible (4.1mm annually), and occurs in very light showers during the fall/winter seasons. The mean daily relative humidity ranges from 36% in May to 62% in December.

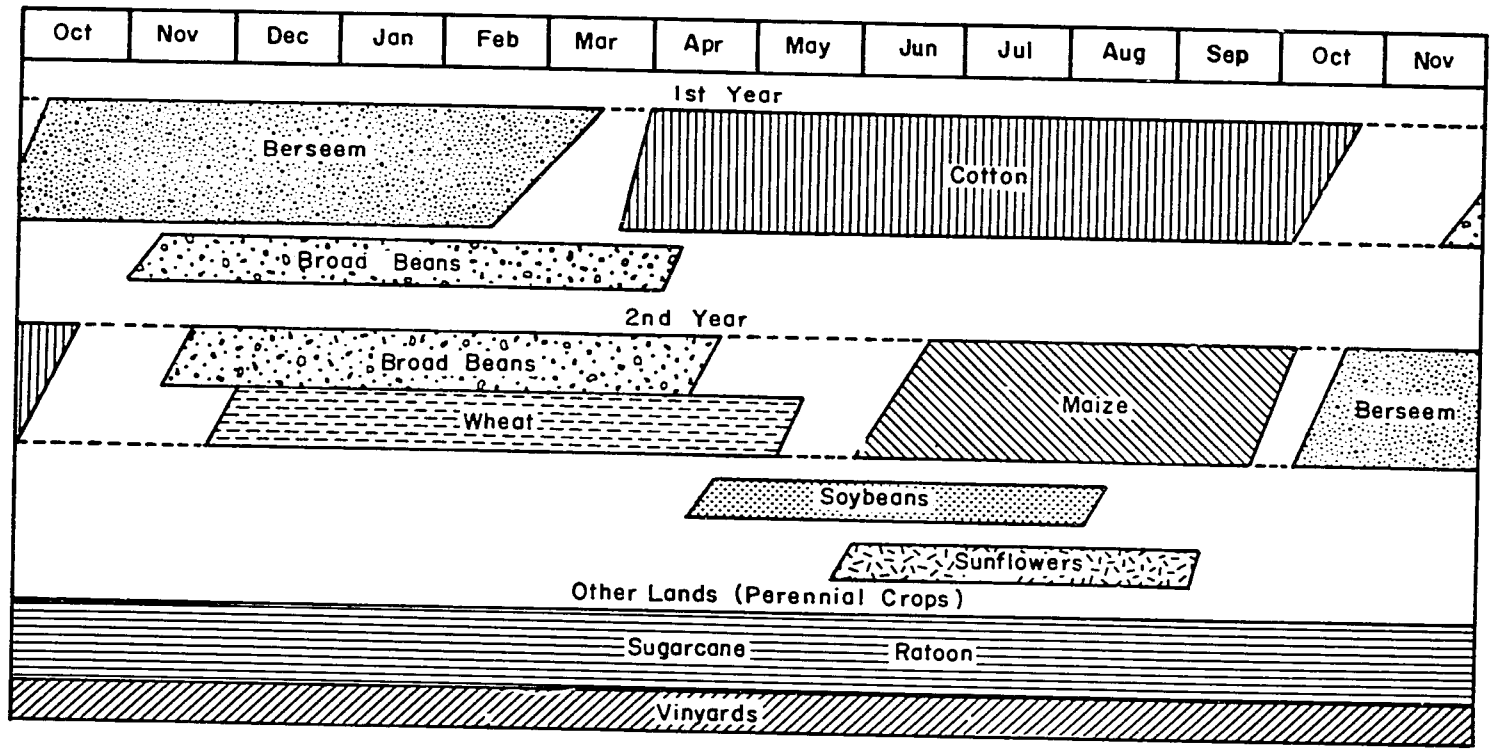

Figure 4. Typical cropping pattern in the Abyuha Study Site

TABLE 5 FEDDANS OF VARIOUS CROPS IN THE ABYUHA CANAL COMMAND AREA EACH MONTH, 1979

Crop	Month											
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Corn	—	—	—	—	—	630	630	630	630	—	—	—
Cotton	—	—	—	267	267	267	267	267	267	—	—	—
Wheat	206	206	206	206	206	—	—	—	—	—	—	206
Berseem	322	322	322	—	—	—	—	—	—	322	322	322
Broad beans	314	314	314	314	—	—	—	—	—	—	314	314
Sugarcane	145	145	145	145	145	145	145	145	145	145	145	145
Minor Crops Winter 1/	163	163	163	218	—	—	—	—	—	163	163	163
Minor Crops Summer 2/	—	—	—	—	—	108	108	108	108	—	—	—
Fallow	—	—	—	—	532	—	—	—	—	520	206	—

1/ Includes onions, garlic, fenugreek, potatoes, carrots.

2/ Includes soybeans, sunflowers, tomatoes, and grapes.

TABLE 6 LIVESTOCK POPULATION IN THE ABYUHA & KOM EL-ZOHEIR VILLAGES

Type	Livestock Population			
	Abyuha		Kom El-Zoheir	
	Young	Mature	Young	Mature
Cattle	60	286	22	212
Buffalo	70	449	40	491
Donkeys	56	35	648	340
Camels	2	21	--	2
Goats	125	237	10	150
Sheep	210	505	264	486
Poultry	672	7,210	100	300

TABLE 7 CLIMATOLOGICAL DATA, MALLAWI, 1979

Month	Monthly Mean					
	Temp. °C	Max. Temp. °C	Min. Temp. °C	Day Time Rel. Humid. %	Evap. mm/day	Precip. mm
Jan.	11.9	20.7	4.0	58	4.5	0.0
Feb.	13.3	22.4	5.2	53	5.8	1.2
Mar.	16.6	25.8	7.9	48	7.7	0.3
Apr.	21.2	30.6	11.9	41	10.2	0.4
May	25.7	34.9	16.4	36	14.0	0.6
Jun.	27.8	36.4	19.0	40	15.0	0.0
Jul.	28.5	36.7	20.3	45	13.6	0.0
Aug.	28.3	36.4	20.5	50	11.7	0.0
Sep.	25.6	33.4	18.6	55	9.1	0.1
Oct.	23.2	31.4	15.6	55	7.9	0.6
Nov.	18.4	26.8	11.5	60	6.0	0.2
Dec.	13.7	22.0	6.9	62	4.6	0.7

Water Distribution System and Irrigation Methods

The Abyuha Canal takes its water from the left side (with respect to the downstream direction) of the Ibrahimiya Canal at km 111. The inlet consists of an arch-type masonry structure with a 2 m wide gate. The structure is arched to act as a bridge for the main north-south road in Egypt that parallels the Nile River. The gate has a bed level of 39.7 m and is fitted with wooden stop logs for controlling the flow. The gate is not capable of totally stopping the flow since it is in a poor state of repair.

As shown in Figure 3, water flows around 5 bends in the Canal before coming to the tail escape, 4.085 km from the head gate. Table 8 gives the essential design features of the canal.

The canal is served from the Ibrahimiya on a rotation basis -- 7 days "on" and 7 days "off" in summer, and 5 "on" with 10 "off" in winter. Because the wooden stop-logs in the head gate at the inlet to the Abyuha Canal do not completely close, the canal always has some water intake during the "off" period. There is often enough water for farmers in the lower reach to irrigate by lifting the water with a mechanical pump. The leakage between the logs is often adjusted to satisfy the needs.

Nearly two-thirds of the entire area irrigates by gravity, but the gravity head ranges from more than adequate to zero. The remaining area is irrigated by lifting by tambour or by diesel-powered pump. Farmers also construct mud dams in the mesqas to raise the water level in front of their farms.

Thirty mesqas take water from the Abyuha through vents that were sized to deliver adequate water provided the water surface elevations in the canal and the mesqas maintain a 25 cm head difference. Farmers have altered most of the vents in an attempt to get adequate water with less than 25 cm head loss, which means less pumping and more gravity flow to the fields.

Water application to the field is similar to that described in the Mansuriya Problem Identification Report. Water is first diverted from the mesqa into a marwa (field ditch) and then into small basins. The basins are usually 5m x7m, but may vary because of the shape and topography of the field and irrigation stream size. The basins may be smooth or contain furrows. A typical field layout is shown in Figure 5 with dimensions of the furrows and marwas.

TABLE 8 ABYUHA CANAL DESIGN

Location	Bed Surface			Side Slope	Water Surface		Area Served
	Width	Elev.	Slope		Elev.	Slope	
km	m	m	cm/km	ratio	m	cm/km	Feddans
0.00		39.70			40.90		
	2.0		0.0	1:1		11.0	450
2.30		39.70			40.65		
	1.0		5.3	1:1		13.0	700
4.08		39.51			40.42		

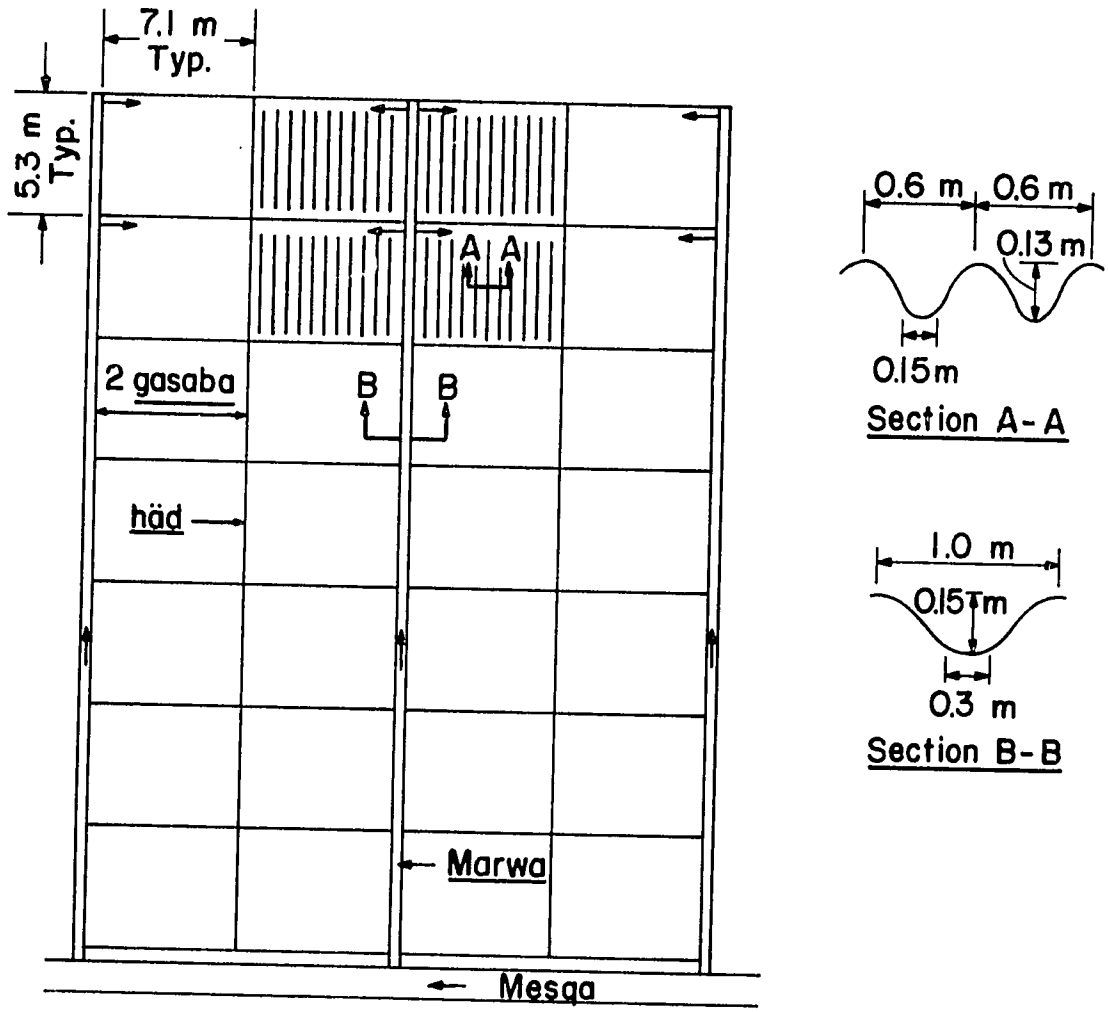

Figure 5. Typical field layout for irrigation in Abyuha

NOTE: Egyptian farmers measure their fields by gasaba (Egyptian pole), which is a distance of 3.55 m. A field will typically be divided by marwas placed 4 gasabas apart with a hod (border) half-way between. Each basin is then 2 gasabas x 1.5 gasabas, or 7.1x5.3 m. Furrows are typically 60 cm apart, with 11 furrows betwen the marwa and hod.

IV. FARMER INTERVIEWS AND PRELIMINARY FIELD SURVEYS

After getting a general description of the project area from secondary information sources, preliminary farmer interviews and observations were begun. The purpose of these early-on activities is to obtain an overview of the irrigated farming system as soon as possible. The data then are analyzed and used to develop preliminary problem hypotheses (see Figure 1).

A. Socio-Economic Information From Farmer Interviews

For this activity in the problem identification, the senior EWUP sociologists and the EWUP-Abyuha field team launched a series of farmer interviews beginning May 9, 1979. The interview questions used to guide the discussions with farmers are given in Table 9.

The farmers' responses to these questions are summarized briefly in the approximate order that the questions appeared on the interview schedule.

- Most farmers believe they are not getting enough fertilizer for cotton and corn; they buy approximately 100 kg of nitrogen fertilizer per feddan at about twice the official price. Co-op officials corroborated this need and supply situation. The farmers suggested that they be allowed to buy their extra needs from the Co-op/Village Bank for cash. (This provision is acceptable by law, but cannot be honored because of limited fertilizer availability through official channels.)

- Most farmers feel they do not get sufficient dry animal food concentrate during the summer season. They can obtain only about 25-30 kg per head of livestock through official channels during the summer season whereas the rest of their requirement from the free market is several times the official price. They demand that the amount be increased, or provision for growing forage during this period be made.

- One group of farmers complained of imprecise aerial spraying of cotton for insects, wherein substantial portions of their crop become infested. They first recommended returning to hand-spraying, but then agreed that adequate aerial spraying would be satisfactory.

TABLE 9 FARMER INTERVIEW QUESTION SCHEDULE FOR THE PRELIMINARY PROBLEM IDENTIFICATION STUDY

1. What are the important problems you face in your farm operation?

2. For each of these, how do you think it might best (or possibly) be solved?

3. We are interested in your ideas of how certain government services and policies could be improved.

   A. How might the irrigation system design and operation be improved?

   B. How might government policies on crop allocation and agricultural services (chemicals, machines, etc.) be improved?

   C. How might the services of: (a) the local cooperatives, (b) the village bank, and (c) the agricultural extension service be improved?

4. How adequate is the information you get (formally or informally) about the policies and practices of the:

   A. Irrigation System

      Entirely adequate _____
      Sometimes a problem _____
      Inadequate _____

   B. Other government agricultural services

      Entirely adequate _____
      Sometimes a problem _____
      Inadequate _____

   C. General Comments:

5. How much cooperation and coordination do you think occurs now among individual farmers around Abyuha in their crop choices, irrigation activities, and other agricultural practices?

   A. Very much cooperation and coordination occurs. _____

   B. Some cooperation/coordination occurs, but only a moderate amount. _____

   C. Additional comments on cooperation among farmers.

- Several farmers complained of their soil. They said it was "weaker" than when the annual floods continually brought additional sediment to them. They have tried to remedy the problem by adding organic fertilizers and residues, but they believe this is not sufficient. They would appreciate help in determining the nutrient soil deficiencies and in finding possible solutions.

- Many of the farmers complained of the untimely availability, insufficient head, and inadequate supply of water to the farms. Some have great difficulty getting the water when they need it, even though it seems generally in adequate supply. Pumping is often necessary in areas where the farmers believe there should be enough head available for gravity flow. Weeds prevent water from reaching the middle and lower reaches. At the same time, farmers nearer the intake believe that the slope of the mesqa favors those at the lower end. The land has high and low areas, allowing some farmers to irrigate rather easily while others are always forced to wait for a period of higher head - usually at night or at the end of the "on" period. Farmers' recommendations included having the co-op clean the mesqa when the farmers did not, and assess a charge against the farm production to pay for it, enlarging the mesqa inlet pipes, and to change from winter to summer schedule (5 "on" - 10 "off" to 7 "on" - 7 "off") in May rather than in June.

- On improvement of agricultural policy and services, several factors in addition to those already noted were advocated. They include the following: (1) A 3-year crop rotation plan, i.e. the "government" crop (cotton) every third, rather than every second year as has been the practice (this practice was being implemented at the time of the survey); and (2) Having improved access to agricultural machinery.

- It is noteworthy that farmers did not indicate a shortage of agricultural labor.

- Regarding improvement of the co-op's service: (1) Farmers recommended that registration rights on transferred lands take place promptly when the transaction is finalized rather than at the beginning of a new year, because all operating rights must be done through the previous owner (operator) until registration transfer is official. (2) There is also a rather great tendency to want a change in membership of the cooperative council (in coordination with Presidents' reorganization of national political posts). The reason is that present cooperative council members are entrenched, and favor their friends and relatives in services supplied by the cooperative. It is important for EWUP's work that no factionalism develop in the Abyuha community, and we must be particularly frank and fair in our dealings with all community members. Presently, the co-op does the field survey for the village bank, supplies machinery and pesticides, and serves inspection/enforcement tasks.

- Concerning relations with the new village bank, feelings are ambivalent. There is considerable sentiment in favor of shifting banking and agriculture input supply functions back to the co-op (i.e., the old system). There is a general belief that co-op personnel know the farmers' problems better, and so can give closer attention to them. Some farmers feel that certain bank personnel are not seriously interested in serving their interests or needs. Some farmers, likewise, feel the bank's policy of expecting regular repayment of loans throughout the two cropping seasons instead of at harvest time is an unwelcome change from the old co-op credit system. Some resentment has been incurred when the village bank has "cut off" credit for fertilizers after the planting of cotton because payments on the accounts were not made during the previous season(s). In contrast, some farmers - especially those working through a "branch bank" in a cooperative outside of Abyuha (served by the "main bank") - find the present service as handy, or even more so, than before.

- Concerning the question on how well they were served by the extension service, the standard answer was, "there isn't any." They get some help from the agronomy staff of the co-op, but, in fact, there is no regular extension service program which serves them. Most of the farmers anticipated that they would obtain extension advice and assistance from EWUP.

- In response to the question of whether they got sufficient information on the irrigation system and agricultural policies and operations, the universal answer was "yes." They believe they know what is happening, and that the information they get (even concerning the time when seeds, fertilizers, etc. will be available) is highly accurate. Formal and informal communication links with the Umdah and other officials apparently work well. This will benefit of the Project as long as we minimize errors and treat people well. Thus, we should be particularly careful about what we say and do to avoid concerns that will slow development efforts.

- The final question raised had to do with the present levels of cooperation and coordination among neighboring farmers. To this, we got an ambiguous answer. All agreed there were good cooperative relations in some aspects as in the choice of voluntary crops, etc. Some farmers indicated that they arranged with their neighbors to grow the same crops (e.g. broad beans) when irrigation and other conditions suggested this was wise. Others said they informed their neighbors of their intentions enough in advance so they could take this into account while planning their crops. Still others said that they take their neighbors' feelings and intentions seriously so as not to harm their farming activities in any way.

Yet several instances of inadequate cooperation have been noted, particularly concerning mesqa maintenance and access to machines for harvesting, etc. It is probable that cooperation among them is good on most issues, but not on symbolically important ones that involve differential access to privileges resulting from contacts with officials and others in the local power structure.

- Conversations with the co-op personnel generally were supportive of the farmers' positions except on the matter of machinery management policy and maintenance. The co-op position seemed rather objective and emphasized that what the farmers sometimes wanted wasn't really practical, although they could understand how they came to feel as they did.

- The village bank manager indicated that only a few farmers were dissatisfied with the new bank system, and they would have to get used to its somewhat different style and rules of operation. He emphasized that their frustrations would be minimized if they would be content to go through proper channels rather than want to handle things personally, uniquely, or informally.

He further indicated that many people were able to save money in the Abyuha area, but that some fell behind in their payment schedule and had to be prodded by officials. He also added that quite a few of the farmers do not understand the banking institution and its policies, which causes some misunderstandings. Their previous experience with the co-op credit system was not really comparable.

- In our discussion with the Umdah, he wanted to know what specific progress to expect in response to the listing of problems and challenges faced by the village council which were brought to our attention at a previous meeting. He reiterated some of these concerns, and testified to the legitimacy of most issues reported to us by the farmers who were interviewed.

B. Observations

- Farmers show only slight inclination to accept a physical or social system when it does not function effectively to serve their interests. In contrast, they feel justified - perhaps even compelled - to modify or circumvent it to better fit their conceptions of how it should be. For instance, we saw several additional (illegal) intakes to supplement water in the mesqas. When inquiring about this, the farmers spoke frankly and rather proudly about the need for some relief which was not being met by the system, so they confidently took matters into their own hands. This spirit has some distinct advantages and disadvantages. The farmers seem self-motivated and creative, unlikely to be intimidated by authority, and determined to use whatever means--formal or informal, legal or illegal--that are available to them to make their farm operations more manageable and profitable.

- We found the farmers frank, friendly, and cooperative people, who seemed genuinely anxious to have the Project there to help them as long as we were sincere and did not intend to "push them around" or interfere with them. Most of them offered their personal future cooperation and assistance.

- The farmers gave every appearance of being hard working and conscientious. In summer, they work until noon, then promptly go home and usually return to their fields in the evening.

V. PRELIMINARY PROBLEM HYPOTHESES

In November, 1979, after collecting background information, observing farmer practices, and conducting farmer interviews, an EWUP seminar, attended by the Minya field team and the Cairo staff, was held to develop a set of problem hypotheses (see Figure 1). The concensus of that seminar resulted in a staff memorandum which detailed the "working" hypotheses for El-Minya. These working hypotheses became the basis for developing a work plan for the "preliminary investigations".

The following hypotheses were proposed as the primary causes for the relatively low crop yields and family income of the Abyuha farmer:

A. Water is not applied with proper frequency or in proper quantities.

- The distribution of water for the Abyuha Canal is on rotation basis and the system does not promote optimum use of water. This is the result of Ministry of Irrigation Policy.

- Water is not as readily available to farms located near the lower reaches of a canal or mesqa, perhaps because: (1) Farmers on mesqas located near an intake frequently take more than their share; (2) Weeds and silt restrict the flow to the end of a canal or mesqa; and (3) Seepage from a mesqa reduces the flow in the lower reaches.

- Fields are not properly leveled and thus excessive quantities of water must be applied to cover the higher locations in the field because farmers do not have the proper equipment to make the needed changes in field topography.

- Farmers are accustomed to applying large quantities of water to inundate the field as was usually the case during flooding of the Nile. This practice is by way of tradition. The farmer does not know of alternative methods to use or apply irrigation water.

B. Excessive quantities of water flow from the mesqas to the drains.

- The excessive flow to the drains causes high water levels in the drains and results in high water tables in fields near the drain. The high water levels in the drains are maintained by luxuriant weed growth and by deposition of silt in the drains, the silt resulting from construction of mud dams in the mesqas for irrigation. The drains are poorly maintained because the irrigation district lacks resources.

C. Interactions among crop growth and soil and water resources are not well understood and by the farmer.

- Farmers do not apply micronutrients either to the soil or to the foliage.

- Farmers are supplied with and use only high-analysis nitrogen and phosphorus fertilizers. The government does not recognize the need to supplement soils with micronutrient fertilizer.

- Farmers do not consider soil salinity or sodicity in their present water management practices, even though these factors apparently do affect crop yields.

D. Farmers use poor crop management practices.

- Few improved weed nor pest control practices are followed, possibly because of lack of knowledge.

- Poor seedbed preparation is common and results in poor germination and poor stands.

- Seeding rates are not sufficient to give the proper density of plants; tradition and/or the lack of knowledge may be reasons for the low rates.

- Farmers do not plant cotton at the proper time of the year because the price of cotton is so low net income is greater when another crop (broad beans) is grown before cotton.

- Sugarcane production is low, possible causes being associated with poor soil aeration, poor soil physical properties, lack of proper pest control, or lack of capital to use recommended crop management practices.

E. Farmers' fields adjacent to mesqas are subjected to high water table conditions and the spread of weeds.

- Seepage from the mesqa may cause a high water table resulting in poor soil aeration and reduced root penetration.

- Seepage may cause excessive movement of nutrients into the groundwater.

- Weeds may have spread from the bank of the mesqa into the fields.

F. The farmers' economic and socio-cultural environments may be major management-decision factors.

- Economic/financial factors involved in farmers' decisions include: government agricultural pricing policies; lack of available credit for farmers; adverse farmer reaction to risk and uncertainty, including uncertainty of government action; the high cost of lifting water by present methods, for example, why saqias are not used as a common

method of water lifting instead of tambours; the high cost of producing crops and livestock using traditional recommended practices; cropping patterns maybe dictated by traditional methods for lifting water; the lack of poultry, honey production or other diverse family or farm enterprises.

- Socio-cultural factors that strongly affect irrigation management practices include: rural life, traditions and labor conditions in Abyuha; inadequate extension support; their own limited voluntary farmer organizations.

VI. PRELIMINARY INVESTIGATIONS

After developing the working hypotheses (Section V), work plans were formulated by the El-Minya team in cooperation with the main-office EWUP staff to conduct preliminary investigations in the Abyuha area. The purpose of these preliminary investigations was to gain a better understanding of the socio-economic, agronomic and hydrologic characteristics of the area so as to confirm or reject the various proposed hypotheses and to identify potential problems needing researched. These activities began in November, 1979. Some were completed within a year, other activities continued into the search-for-solutions phase.

A. Farm Records

Data obtained from farm records, concerning the farm family and their activities related to the farm enterprises, are used to assist in identifying socio-economic as well as physical and biological problems. This type of data also helps acquaint the team with the farming system, and begins to provide quantitative values on the magnitude of the problems faced by the farmers.

It was recognized early-on that a clear distinction should be made between a "farm" or "field" and a "farm management unit". A farmer may have "fields" at different locations -- all of which make up one "farm management unit."

Beginning in November, 1979, a group of 9 farmers interested in cooperating were selected to participate in developing farm records for their production and home enterprises. The farmers were chosen to represent small, medium and large units located at the head, middle, and tail of the mesqas

dispersed along the Abyuha Canal. Since it was not a random sample, caution must be exercised in making too many inferences--especially in terms of applying collective averages to the area as a whole.

The farmers were visited approximately every two weeks to record activities that had taken place. Included were not only purchases and sales, but all operations performed on each field with a recording of human labor, animals, machinery and materials. Figure 6 indicates the approximate location of each of the nine farm management units for the farm record study.

1. Farm Size and Tenure

The area operated by individual farmers varied from 0.5 to more the 14 feddans, with a collective total of 55 feddans, making this group's average considerably larger than that of the Abyuha area as a whole.

Of the nine farmers, two owned no land and one farmer owned all of the land in his management unit. The remaining farmers both owned and rented their land.

2. Family Size

The number of persons living in the farm-operator's household varied from three to twelve, with two-thirds of the households having seven or more members. There appeared to be little relationship between farm size and size of household, resulting in an extremely wide variation in the household members per feddan. At the extremes, one household had eight family members per feddan, while three farms had less than one person per feddan.

3. Gross Income and Expenses

The total gross annual income per farm management unit varied from less than LE 800 to more than LE 9000 with an average of more than LE 4000. About one-third of this income was received from the sale of crop and livestock products. The remainder was used in the household, fed to livestock or was reflected in an increase in value of assets which were not converted to cash during the accounting years.

Gross annual expenses per farm ranged from about LE 300 to more than LE 3000 and averaging about LE 1700. Net income per farm varied from LE 430 to more than LE 6000, averaging about LE 2700 when the estimated increase in value of land owned was included. Omitting land appreciation reduced net income per farm management unit to less than LE 2000.

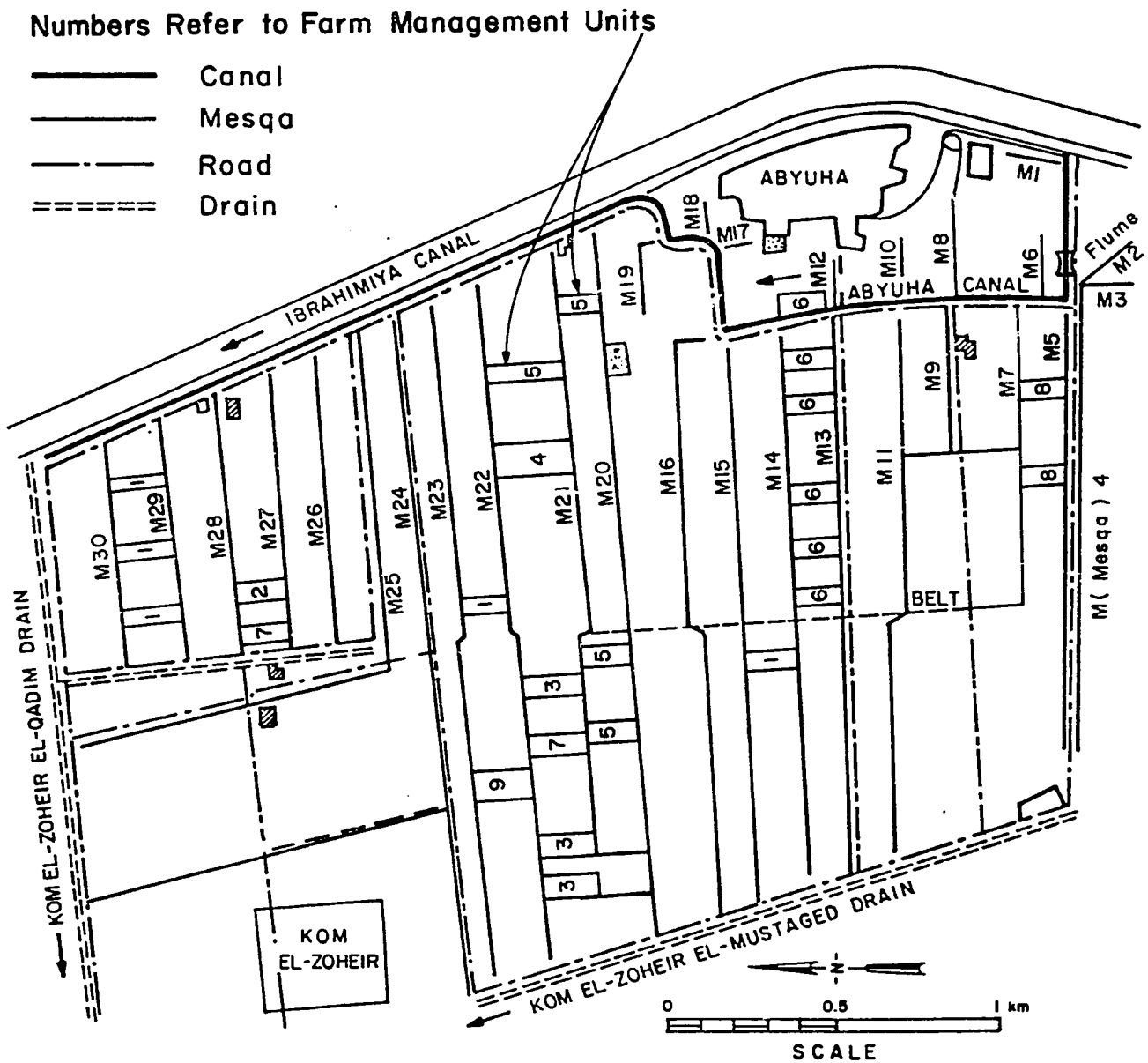

Figure 6. Location of the nine farm management units for the Farm Record Study

Gross income, gross expenses and net income varied according to the farm size but were not directly proportional. When placed on a per feddan basis, both income and expenses decreased as farm size increased. In order to support a family, farmers with a small land base must farm the land more carefully and more intensively. As the size of the farm increased, gross income, gross expenses and net farm income on a per feddan basis all tended to decrease.

4. Farm Management Data:

- Land Rental Rates

As previously indicated, the typical farm in the Abyuha area consisted of both owned and rented land. Parcels could be rented for an entire year, for a single crop, or for combinations of crops. Most of the land was rented on an annual basis with the annual rent per feddan per year varying from LE 52 to LE 90 and averaging LE 70. Three observations of summer crop rentals for a summer maize crop averaged LE 60 per feddan. One payment of LE 150 was made for a winter berseem crop.

The annual legal rental rates are based on land taxes. According to the agrarian-reform law which was passed in 1953, rates are fixed at 7 times the taxes due. The land tax rates differ from one site to the other. Even in the same site it differs from one basin to the other according to land fertility.

The legal rental rate did not change for 25 years although the agricultural product prices were increasing. Land owners who rented their land at the legal rental rates started to complain. Beginning with the Agricultural year 1978-79, the land tax rates were raised and government policy during the last three years has been to increase the annual legal rental rate. This was done to improve relationships between landlords and the tenants.

- Irrigation by Tambour

Although not an integral part of the record keeping system, notations on the crop records of 2 of the 9 farmers make it possible to compile information not readily available elsewhere on the cost and time for irrigation by tambour. Where tambour operators were hired, the number of operators, hours operated and cash costs were recorded.

Individual irrigations on farm management unit number 1 revealed a wide variation in the time required for one operator to irrigate a feddan; this

ranged from 3 to 40 hours, averaging 8.7. The cost of tambour operators, per feddan per irrigation, however, varied less and ranged from LE 0.96 to LE 2.10, averaging LE 1.41. The time required to irrigate one feddan, with several tambours operating, averaged 4.2 hours.

Farm management unit number 7, with but 8 irrigations from which complete data were available, showed higher costs and labor requirements, averaging 13.4 man hours and LE 1.84 per feddan per irrigation. The time required to irrigate one feddan averaged 5 hours.

- Pump Rental Rates

Some farmers rented diesel pumps alternative to renting tambour operators. Six cases were found where complete data were available on pump rental rates.

The cost per hour for renting a pump varied from LE 0.25 to LE 0.63, averaging LE 0.39. The time required to irrigate one feddan varied from 2.3 to 6 hours, averaging 4.0 hours. Pumping rental costs per feddan ranged from LE 1.33 to LE 2.33, averaging LE 1.58.

Crop Production

Maize and cotton are the two main summer crops grown in the Abyuha area. Together, they account for about 80 percent of the planted land with the area of maize more than double that of cotton. (Cotton is required every third year.)

Berseem, broad beans and wheat are the major winter crops. Berseem and broad beans occupied more than half of the area, and wheat about 20 percent. Beans and wheat were also interplanted with sugarcane when cane was being established. Sugarcane, the major perennial crop in the area was grown on about one-eighth of the land. A summary of the crop production data is shown in Table 10. Long season berseem produced the greatest gross income per feddan. Broad beans and early planted cotton were the second highest income-producers after berseem (Table 10). However, on the average, each of the 9 farmers produced berseem on only 18 girats (3/4 feddan). It is also interesting to note that, of the 9 record farmers, only one grew short-season berseem before cotton. The usual practice was broad beans before cotton.

The area served by the Abyuha Cooperative has an annual cotton allotment of 575 feddans. The government recommends that cotton be planted before March 31. Those who comply with this requirement usually raise

TABLE 10 SELECTED CROP PRODUCTION DATA FROM FARM RECORDS

Crop	Average Area Cultivated Per Farmer Fed.	Qir.	Planting Dates	Harvest Dates	No. of Irrig. Per Crop	Average Fert. Used kg/Fed.	Prior Crop	Average Yields Per Fed.	Gross Average Income/Fed. LE
Maize	2	3	May-June	Sep.-Oct.	8	90 - N	Wheat Berseem Beans	9.4 Ard.	174
Cotton	1	12	April	Sep.-Oct.	10	96 - N	Beans Berseem	6.0 Qir.	234
Short Season Berseem		16	Sep.-Nov.	Nov.-Mar.	4-8	------		60 Qir. Cuts	135
Long Season Berseem		18	Sep.-Oct.	June	10-13	30 - P		106 Qir. Cuts	388
Beans	2	22	Nov.	Apr.	4	68 - P 32 - N	Maize Cotton	6.2 Ard.	139
Wheat	1	9	Nov.-Dec.	May	7	70 - N	Maize Cotton	8.5 Ard.	209

berseem as a short season winter crop. They take two cuttings in February and prepare the land for planting cotton before March 31. However, as noted above, many farmers plant broad beans -- often intercropped with fenugreek, instead of berseem. Broad beans mature in early April consequently delaying the planting of cotton until late April or nearly one month past the recommended planting date. It is generally accepted by government researchers that the cotton yield is reduced if its planting date is delayed past March 31. The site studies show that planting cotton in April reduces the yield as much as 33 percent. Farmers at Abyuha do not believe that late planting affects their yields.

Crop Enterprise Budgets

Preliminary crop enterprise budgets for two cropping patterns were estimated from production cost data reported by farmers at Abyuha. For budgeting purposes, cotton yields were reduced from 6 qintars per feddan (following berseem) to 4.9 qintars per feddan when cotton followed broad beans/fenugreek (Table 11). Likely, the yield reduction is the result of later planting.

The costs represent the amount paid by the farmers for machines, materials, and labor. Inputs supplied by a farmer such as his own labor, management, and land were charged at their estimated opportunity cost rate. Therefore, the income available to a farmer for either cropping scheme may exceed "return above all costs" if a farmer supplies his own labor, management and capital.

In the analysis, the items listed under "variable costs" reflected the technology employed in producing each crop. They also reflected the market rate for labor at the season during which they were employed. The labor cost for picking early cotton in September, for example, is lower than that for late cotton which is picked in October. Peak labor demands occur in October leading to an increase in market wage rate.

The results of this enterprise cost study showed that the difference in "return above all costs" was LE 23 in favor of broad beans/fenugreek-cotton over short season berseem-cotton. If the budget yields are not correct and yields on late cotton are as good as early planted cotton, then the difference in income would be more than LE 23 per feddan in favor of broad beans/fenugreek-cotton. Based upon water requirement studies at the Mallawi Research Station, 33 km south of Abyuha, it seems that the most profitable cropping pattern crop was also the least demanding of water.

TABLE 11 CROP COST AND RETURN ESTIMATES FOR TWO CROPPING PATTERNS AT ABYUHA, PER FEDDAN

Cost/Return Item	Cropping Pattern			
	Berseem-Cotton		Broad beans/Fenugreek-Cotton	
	Production	Value	Production	Value
RETURNS:		(LE)		(LE)
Berseem	48 Qir.	108.00	--	--
Cotton (Plus Stalks)	6 Qin.	234.00	4.9 Qin.	229.18
Broad beans	--	--	6.5 Ardab	146.00
Fenugreek	--	--	0.5 Ardab	12.00
TOTAL VALUE OF OUTPUT	--	342.00	--	387.18
COSTS:				
Variable Costs				
Machine & Animal	--	13.60	--	23.41
Materials	--	65.73	--	69.05
Labor	--	54.18	--	63.16
Fixed Costs	--	79.56	--	79.56
RETURN ABOVE ALL COSTS	--	128.93	--	152.00

- Management of On-Farm Irrigation

Of the 55 feddans, 23 feddans 7 girats were irrigated by tambour during 1978-1980 at an average cost of L.E 1.84 per feddan and an average period of 5 hours spent irrigating each feddan. In addition, 10.46 feddans were irrigated by diesel pump at a slightly lower cost and less time (LE 1.58 and 4 hours respectively) for each feddan. Most of these irrigations took place on fields which were located on the lower reach of the canal or mesqa.

Obviously, the irrigation system as presently managed discriminates against the downstream user and raises operating costs. The problem lies with the distribution system and cannot be controlled by the individual farmer. The farmer must pump to exist. Improving the delivery system and creating a farmer-controlled management unit to schedule and operate the system would provide each farmer with the opportunity to irrigate by gravity and thereby reduce the costs of irrigation for downstream users.

B. Water Distribution and Control Investigations

Of major concern to the Egypt Water Use and Management Project is the control and management of irrigation water and its distribution at the three selected field sites.

In order to quantify the flow of water in the Abyuha Canal during the "on" and "off" periods, a cutthroat flume was installed in the canal during the general irrigation closure period in January, 1980, using local materials of brick and concrete. Automatic upstream and downstream water elevation recorders were installed. The overall length of the flume was 3.36 m, the throat was 1.42 m wide, and the elevation of the floor was set at 40.38 m. The flume was constructed at the end of the first straight reach from the inlet (see Figure 3).

On March 14, when nearly every feddan in Abyuha site required water, the farmers became angry and upset with EWUP because they were not getting sufficient water. They believed that the newly constructed flume was restricting the flow, and threatened to break it unless immediate corrective action was taken by EWUP. On March 15, a by-pass channel was constructed on the side of the flume to allow additional water to flow. On March 30, the

floor of the flume was lowered to an elevation of 40.13 m. The by-pass was closed thereafter as the reduced floor level satisfied the farmers' demand for water. After reconsideration of the floor level design together with operating experiences of the flume, the floor was set at its final elevation of 40.29 m on October 16, 1980. A similar experience was recorded in Kafr El-Sheikh. Obviously, water measuring devices that have excessive head losses are not acceptable where head and flow rate are critical.

Table 12 presents the water budget for the Abyuha site between April and December, 1980. It should be noted that more than 50 percent of the flow into the site passes to the drains. The passage of this additional unneeded water through the system adds considerable cost and maintenance not only to the irrigation system but to the drainage system as well.

- Observations

The preliminary water distribution and control survey showed poor water distribution into the mesqas. For all mesqas after the second bend in the Abyuha Canal (see Figure 3, Mesqas 16-30), water must be lifted for irrigating the areas close to the canal. There usually was adequate head for gravity flow into the mesqa for the middle and end users. When there was insufficient head in the canal, a diesel pump was used to lift water into the mesqa where irrigation by gravity was then possible through cuts made in the mesqa bank. Most of the farmers made their own arrangement for hiring portable diesel pumps. The Umdah preferred to irrigation with water coming through the head gate of the Abyuha Canal during the off-periods when no one else was using the mesqa. He then could place mud dams without interfering with the other farmers.

Mesqas upstream from the fourth bend in the canal (Mesqas 1-18) received an adequate supply of water by gravity from the canal. However, the head available in the mesqas was variable and relatively small, and consequently irrigation required more time than necessary because of the resulting small stream size.

Table 13 gives the discharge rates through the Abyuha Canal flume from April to December 1980. Most of the flow during the off-period was not used for irrigation because of the low head and went directly to the drain or was lost by seepage and evaporation. The off-period flow averaged about 18% as much as the flow during the on-period. It should also be noted that the ratio of "on" to "off" (1.3) was much higher than the 1.0 for summer and 0.5 for winter that was established by the irrigation district. Since farmers do not

TABLE 12 PRELIMINARY ESTIMATE OF ABUYHA WATER BUDGET FOR APRIL THROUGH DECEMBER, 1980 (GATES)

Water Budget Component	Volume (m^3)
Inflow	
Inflow from Abyuha Canal	14,719,100
Inflow from adjacent areas	110,600
Inflow by subsurface horizontal flow 1/	~0
Inflow from precipitation	0
Total Inflow	14,829,700
Outflow	
Outflow by surface to drains 2/	8,250,600
Outflow to adjacent areas	411,100
Outflow to subsurface horizontal flow 1/	~0
Outflow by deep percolation	2,890,500
Outflow by consumptive use 3/	4,153,400
Outflow by evaporation	14,300
Total Outflow	15,719,900
Storage Change	
Storage change in surface water	0
Storage change in subsurface water 1/	~0
Total Storage Change	0
Unaccounted	890,200

1/ Not computed but assumed negligible.

2/ Computed daytime (6:00-18:00) flow from current meter data and assumed night time (18:00-6:00) flow approximately equal to inflow from Abyuha Canal less 7% seepage loss.

3/ Computations based upon data for middle Egypt reported in Water Master Plan Report, Comsumptive Use of Water by Major Field Crops in Egypt (1981).

TABLE 13 DISCHARGE THROUGH ABYUHA CANAL FLUME FROM APRIL THROUGH DECEMBER, 1980 (GATES)

Month	Delivery Schedule Days			Average Discharge rate	
	On	Off	Ratio On/Off	On-Period m^3/s	Off-Period m^3/s
April	17	13	1.3	1.17	0.22
May	17	14	1.2	1.09	0.33
June	15	15	1.0	1.32	0.15
July	19	12	1.6	0.99	0.21
August	19	12	1.6	1.22	0.19
September	18	12	1.5	1.02	0.24
October	15	16	0.9	0.93	0.14
November	14	16	0.9	0.75	0.10
December	19	12	1.6	0.61	0.03
Average	17	14	1.3	1.01	0.18

irrigate at night, and because of the low irrigation delivery efficiency, it becomes apparent that extra time must be made available for irrigation at the Abyuha site. The delivery efficiency for the Abyuha site based upon the preliminary data of Table 12 is shown by the equation to be:

$$Eff_{Del} = \frac{\text{Consumptive Use + Deep Percolation}}{\text{Water Delivered to Area}} \times 100 = \frac{7.04 \text{ mil} \times 100}{14.83 \text{ mil}}$$

$$Eff_{Del} = 47.5\%$$

In Figure 7, the upstream level (USL) elevation for the Abyuha flume is plotted as a function of time for on "on" and "off" period in the month of August. The water surface elevation in Kom el-Zoheir E.M. Drain at D-2 near the outflow boundary of the Abyuha site is plotted for the same period.

The "peaks" of the USL for the flow through the flume occur during daylight hours. During the night the gatekeeper is obliged to reduce the flow to prevent flooding of the land adjacent to the drain. It should be noted that the drain is basically for surface water, and that the drain curve is out of phase with the flume curve. During the daytime, the drain water surface level decreases steadily until about the time farmers stop irrigating. Even though the level of water in the canal is decreased at that time, the water builds up in the drain until it peaks in the early morning. Assuming a time lag for water movement through the system, it indicates that little water enters the drain during daylight hours. On the other hand, during the two "extra" days in the middle of the "off" period the level in the drain continued to rise, even though the canal level was lower on the second day.

Due to the presence of a large number of mesqas in the Abyuha site, it is possible that seepage from these channels may affect the delivery efficiency to a certain extent. Some preliminary measurements were taken to determine whether a detailed study would be necessary to further quantify seepage as a potential problem. The results of this study are represented in Figure 8, where the seepage rate per 1000 m of mesqa is plotted as a function of time. Time is measured from the moment the mesqa is first filled with water.

The results show that seepage decreased quickly (in less than 24 hours) to less than 2 l/s for each 1000 m of mesqa. Mesqa seepage does not, in all likelihood, contribute significantly to the water table and thus no further study is proposed for this concern.

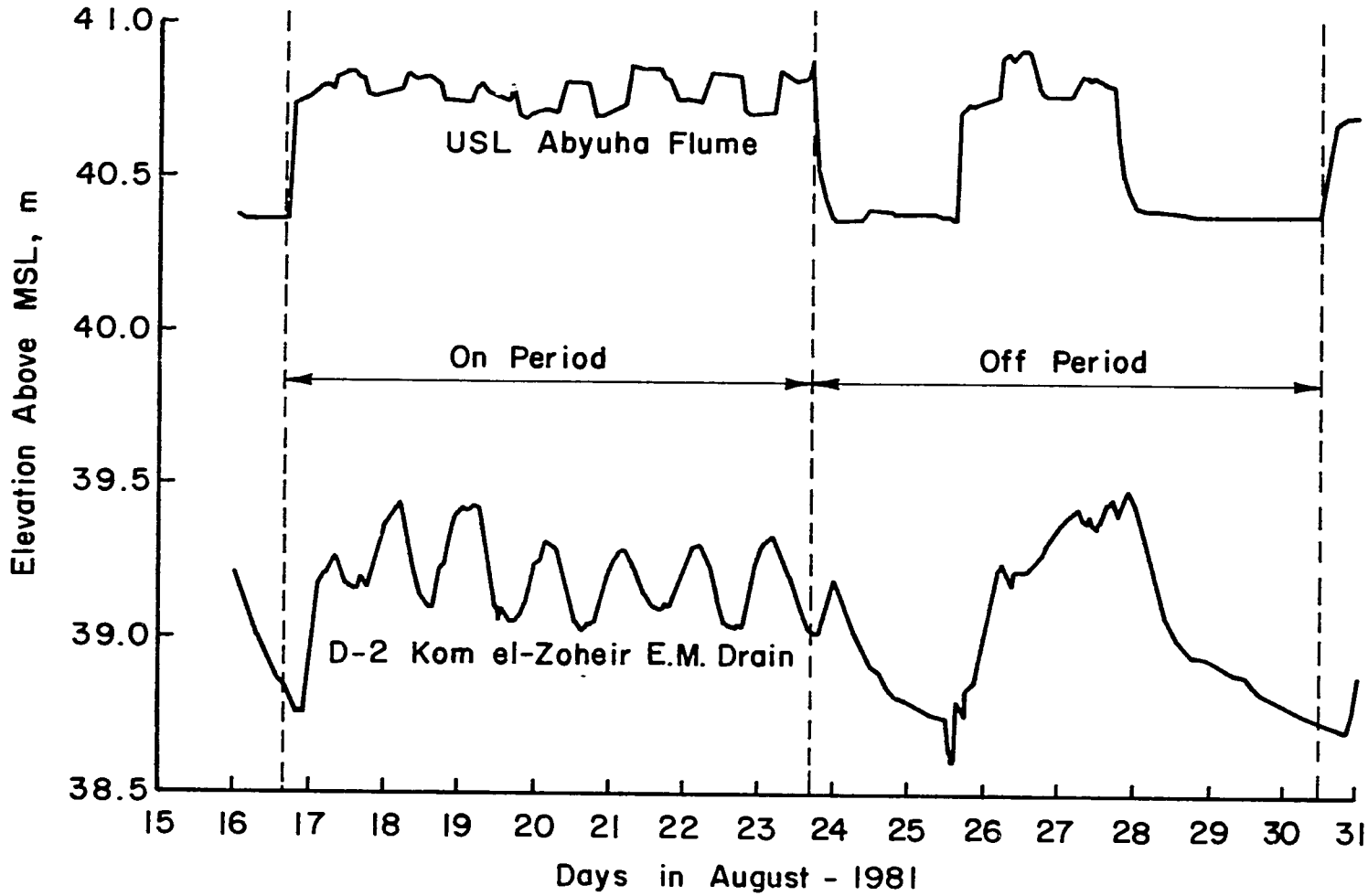

Figure 7. Water levels in the Abyuha Canal and Kom el-Zoheir Drain for the on-off cycle

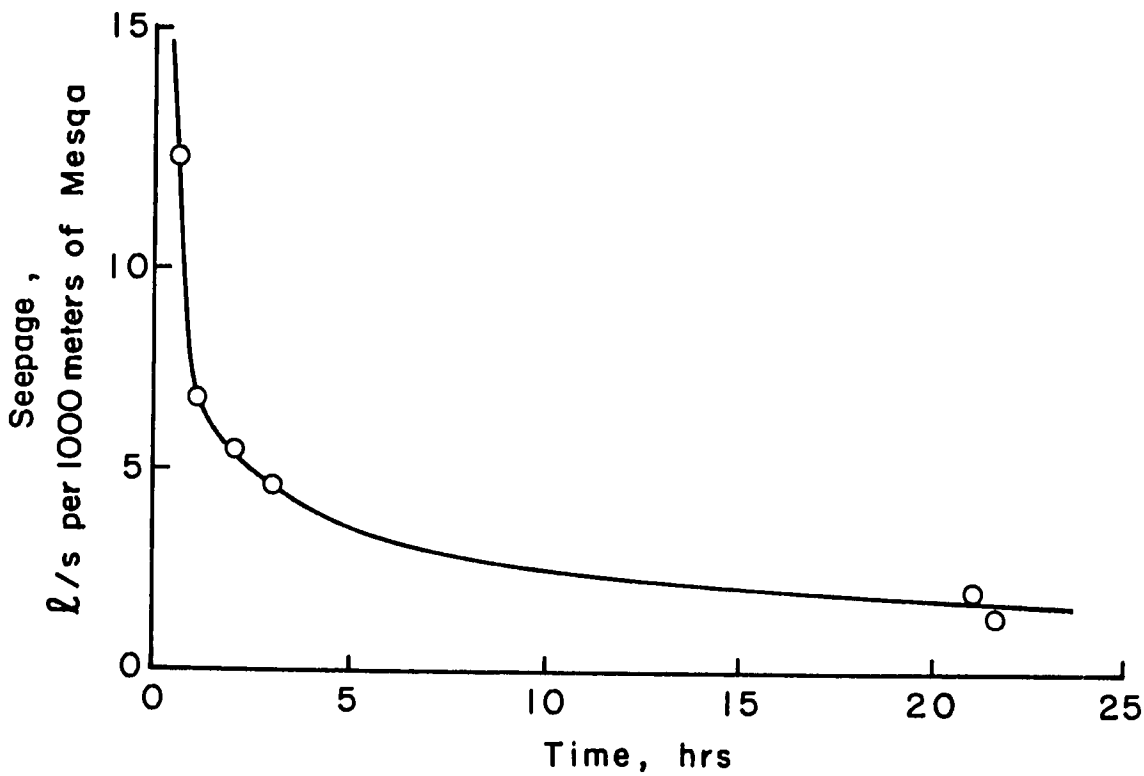

Figure 8. Seepage test on Mesqa 7, September 1981

C. Irrigation Practices

A cursory view of irrigation practices in the Abyuha area led the field team to suspect that Abyuha farmers may apply water too frequently and in excessive amounts. The rationale being that the rotation system promotes neither optimum use of water nor high application efficiencies, and that fields are not sufficiently level for uniform water distribution on the field.

Preliminary data on irrigation practices were obtained by selecting several farms planted to different crops. Soil moisture samples were taken to a depth of 90 cm below the soil surface one day before irrigation and 3 days after irrigation. Bulk density was also measured at corresponding depths. Samples were taken over the entire growing period before and after each irrigation and at harvest.

The results for wheat are shown in Figure 9 where soil-water content expressed as percent saturation is plotted as a function of depth below the soil surface. Curve 1 is the water content distribution in the profile one day before the planting irrigation. Three days after irrigation, the soil-water content distribution curve for the profile is shown by a vertical straight line that represents saturation (100 percent). Curve 2 represents the water content distribution one day before the second irrigation and curves 3 to 6, represented by the shaded area, show the range in water content in the profile one day before the 3rd, 4th, 5th and 6th irrigations. After each irrigation, the water content throughout the profile was brought to complete saturation. Curve H represents the water content in the profile at the time of harvest.

The soil profile apparently remained nearly saturated below 40 cm to the water table after the third irrigation. The level of the water table was not measured during this data collection. Other data show that it was 1.5 to 2 m below the surface.

The soil moisture characteristic curve for a 0-30 cm composite sample typical of this profile is shown in Figure 10. Assuming that the curve is valid for this profile, then the farmer is keeping the average soil moisture tension (capillary pressure head) in the surface soil layer (0-30 cm) below 0.7 bars (700 cm H_2O) after the third irrigation. This was assumed to be an indication of over-irrigation. The data in Table 14 show that an average of only 3.6 cm of water are required to fill the profile for the third to sixth irrigations.

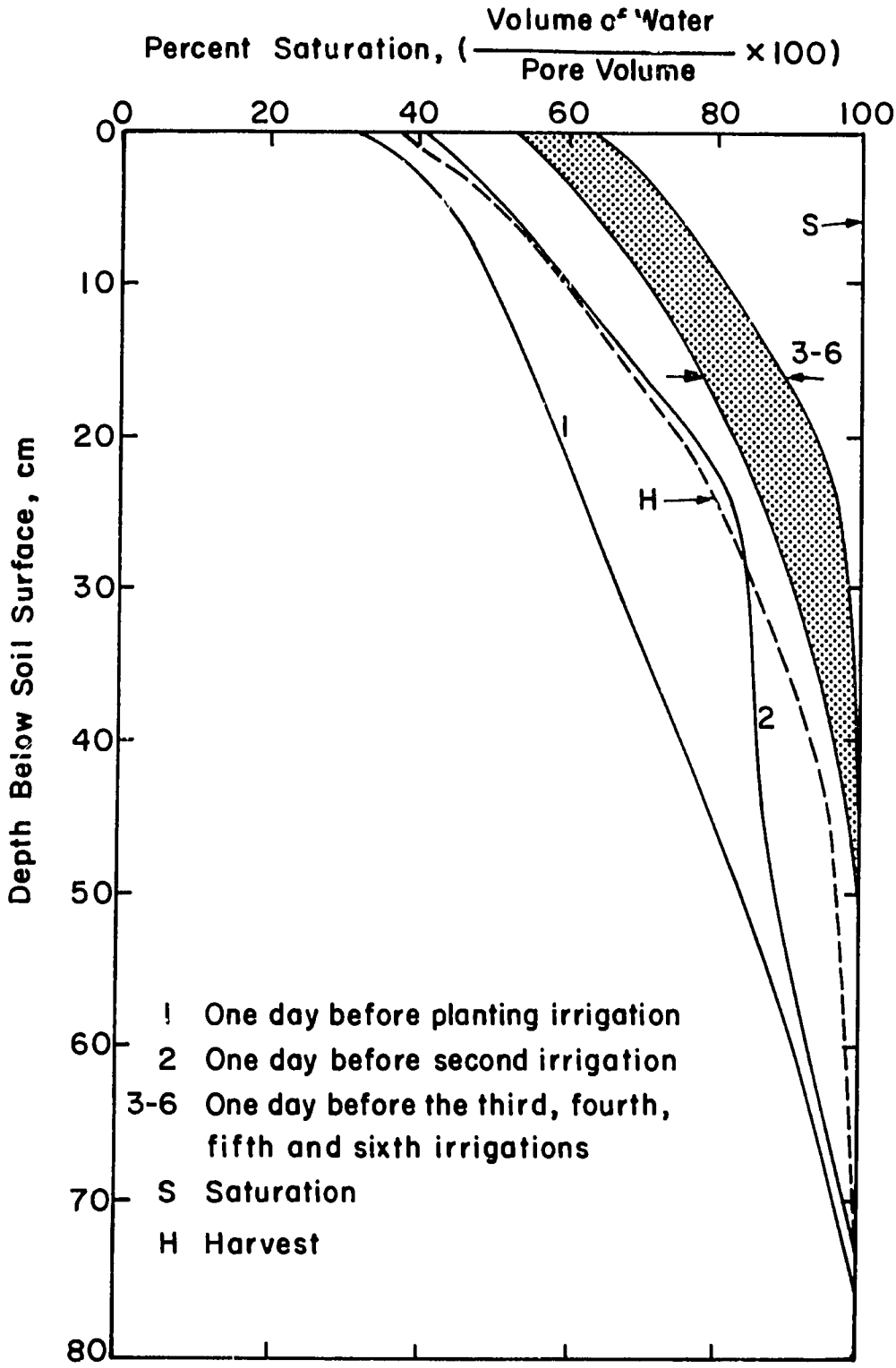

Figure 9. Soil-water content expressed as percent of saturation, before consecutive irrigations and at harvest of wheat

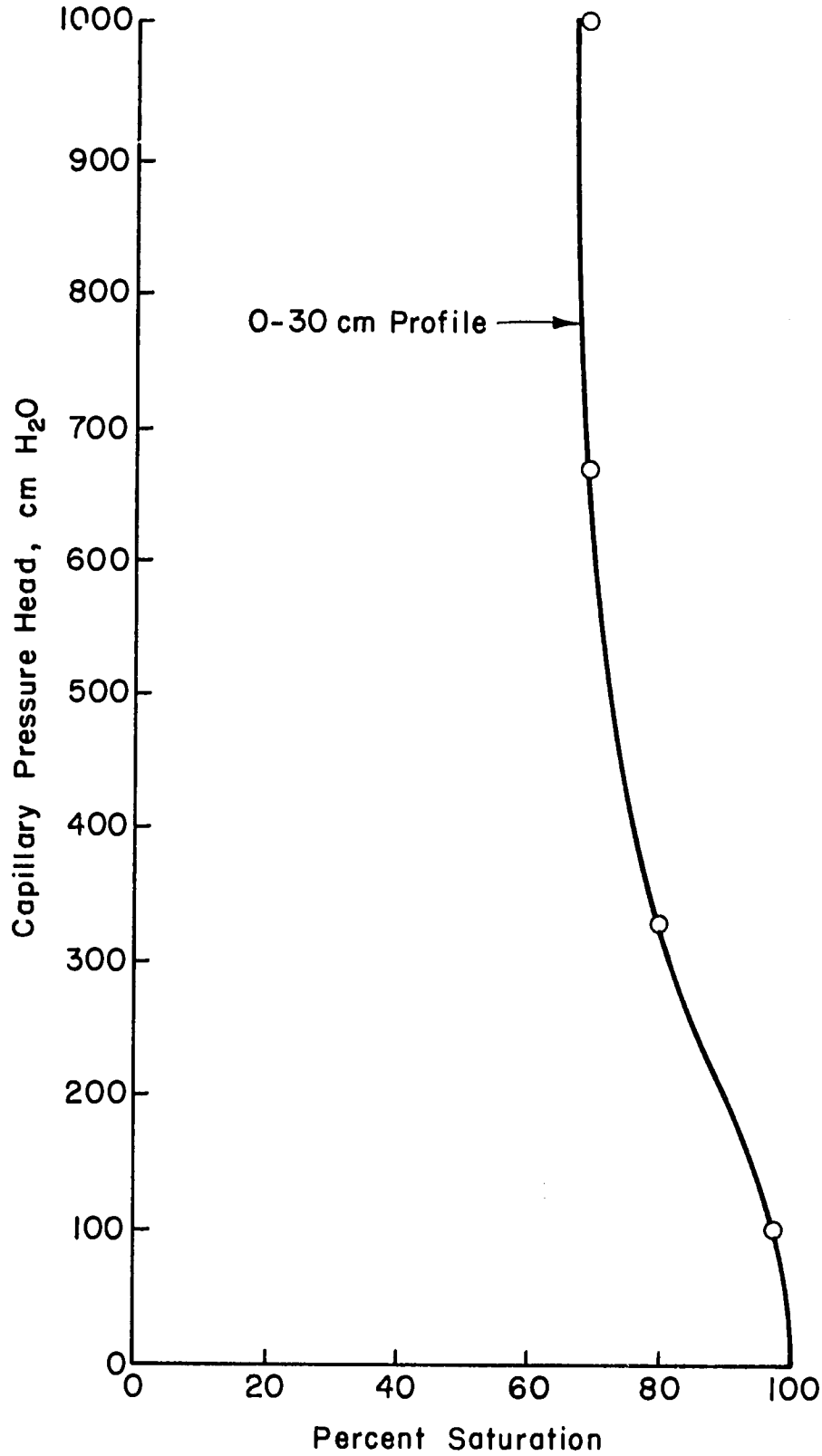

Figure 10. Soil-moisture curve for a 0-30 cm composite from the Abyuha Site

TABLE 14 IRRIGATION AND SOIL WATER DEPLETION SUMMARY FOR WHEAT, ABYUHA, 1979-80

Irrigation Number	Date	Days Between Irrigations	Water Applied cm	Water Depletion** Between Irrigations cm	Application Efficiency %
1	12-14-79	---	11.7	11.0	94
2	12-28-79	14	7.0	7.8	100
3	2-03-80	37	7.7	4.5	58
4	2-29-80	26	(9.9)*	3.1	31
5	3-19-80	19	13.6	3.7	27
6	4-04-80	15	9.6	3.2	33
Harvested	5-12-80		---	6.9	---
TOTAL			59.5	33.3	57 (ave.)

* Estimated - No measurement

** Calculated - Method described in text

Grain yield - 13.3 Ard/Fed

Straw Yield - 5.8 Ton/Fed

The actual amount of water applied for each irrigation is shown in column four of Table 14. The soil depletion between irrigations was calculated by assuming straight line variations in moisture content between mean depths. The irrigation application efficiencies, as computed from the above analysis, tend to decrease with the increase in the number of irrigations. However, the farmer irrigated at irregular intervals and with varying amounts. This tended to lower irrigation efficiency over the growing period. No runoff occurred from this field so that all water applied may be accounted for either as evapotranspiration or as deep percolation.

The data for broad beans (Figure 11) is similar to those for wheat (Figure 9). The total number of irrigations to produce the broad beans was four. As shown in Table 15, the farmer in this case allowed the amount of soil-water depletion (4.9 cm) to be about the same for the last three irrigations as did the farmer for wheat. However, data on the amount of water applied per irrigation (Table 15) indicated that the farmer not only added uniform amounts to correspond with the uniform soil-water depletion, but also added the correct amount, thus obtaining a very high irrigation application efficiency. Two irrigation measurements were missed, so the data may be too optimistic with respect to overall irrigation efficiency.

These preliminary data, though subject to error, indicate a need for collection of information from a large number of farms so that a detailed analysis of the farmers irrigation practices might be conducted. This is part of the detailed studies (Section VIII).

The lack of level fields needed for high irrigation efficiency may be a constraint in agricultural production on Abyuha farms. Two fields located along Mesqa 22 selected at random were surveyed to obtain information on their topography. One field was in wheat, the other in sugarcane. Spot levels for the field in wheat are shown in Figure 12. Several profiles across the field are also shown. Farmers irrigate with small basins under these topographic conditions to increase the degree of irrigation application efficiency. Considerable attention (labor input) must be given to such a field to obtain uniform water application. Soil moisture sampling over the entire field area is needed to determine the uniformity of this method of application.

A different shaped field (sugarcane) is shown in Figure 13. The rod readings are shown on the plan view and typical cross-sections are shown at right angles to each other. Notice that the profile normal to the mesqa has an adverse slope, making it difficult to obtain uniform applications of water.

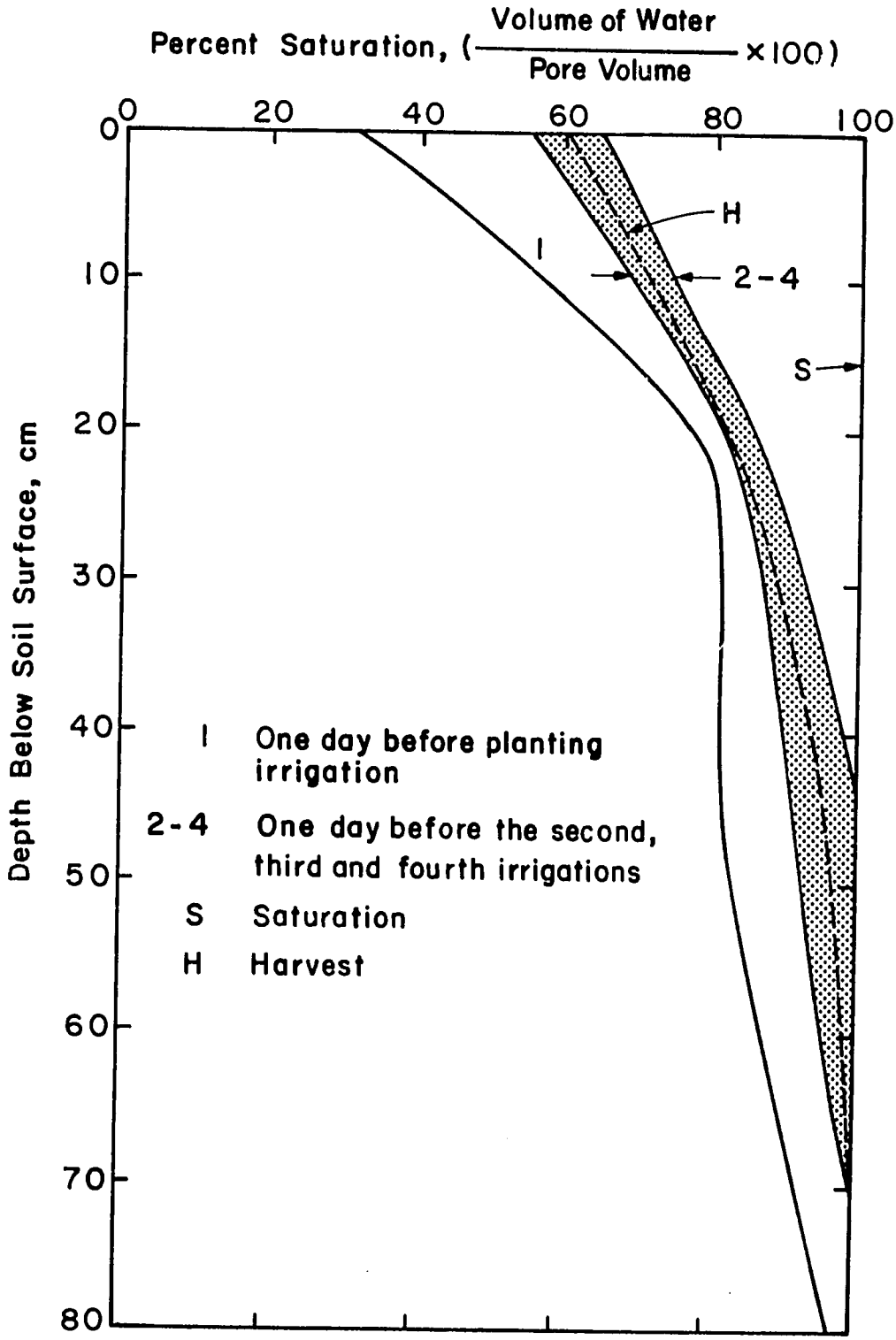

Figure 11. Soil water content, expressed as per cent saturation, before consecutive irrigations and at harvest of broad beans

TABLE 15 IRRIGATION WATER APPLICATION AND DEPLETION SUMMARY FOR BROAD BEANS, ABYUHA, 1979-80

Irrigation Number	Date	Days Between Irrigations	Water Applied cm	Water Depletion** Between Irrigations cm	Application Efficiency %
1	11-9-79	50	10.5*	10.5	100
2	12-29-79	48	5.6	5.3	95
3	2-15-80	34	5.4	4.6	85
4	3-20-80	28	5.5*	4.8	87
Harvested	4-18-80		--	5.1	--
Total		160	27.0	25.2	93

* Estimated - no measurement

** Calculated-method described in text

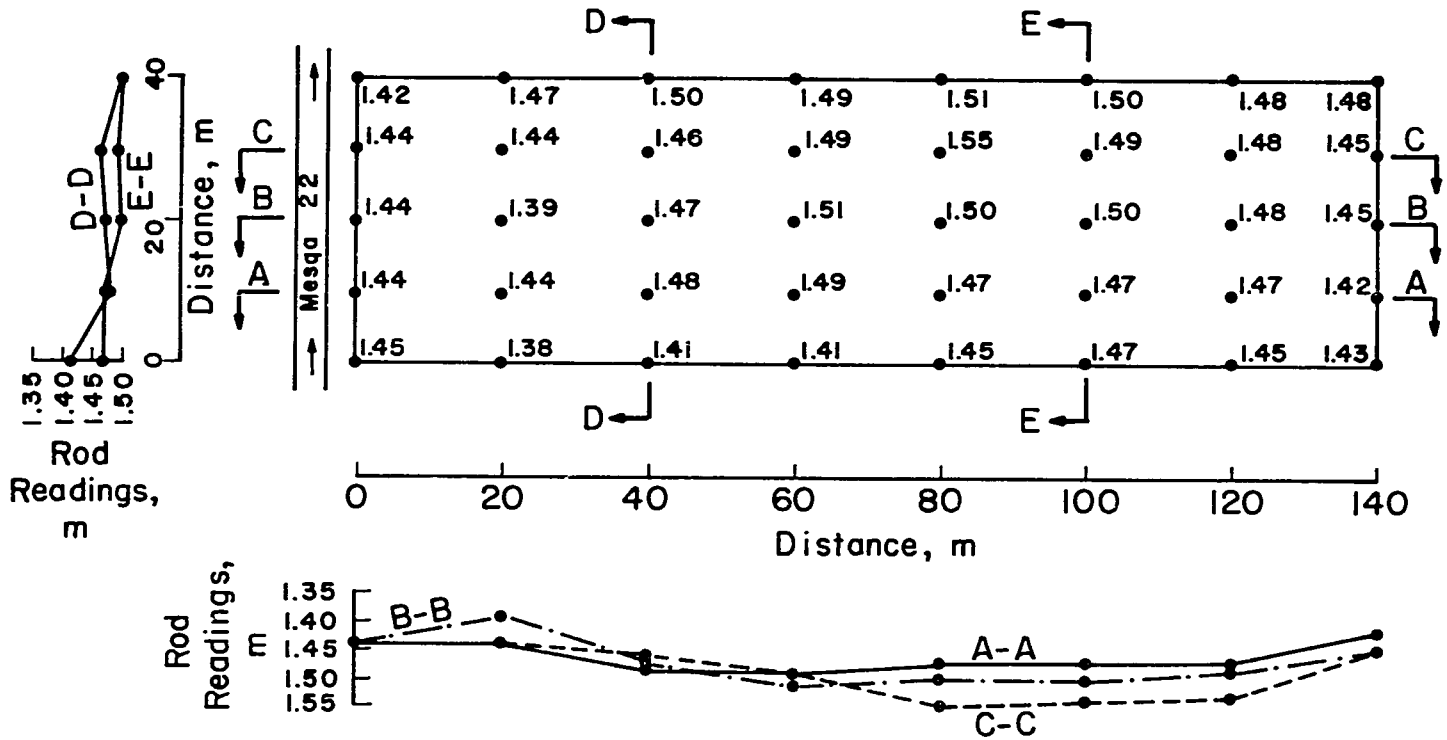

Figure 12. Spot elevations in a wheat field supplied by Mesqa 22 at elevation 1.45 m.

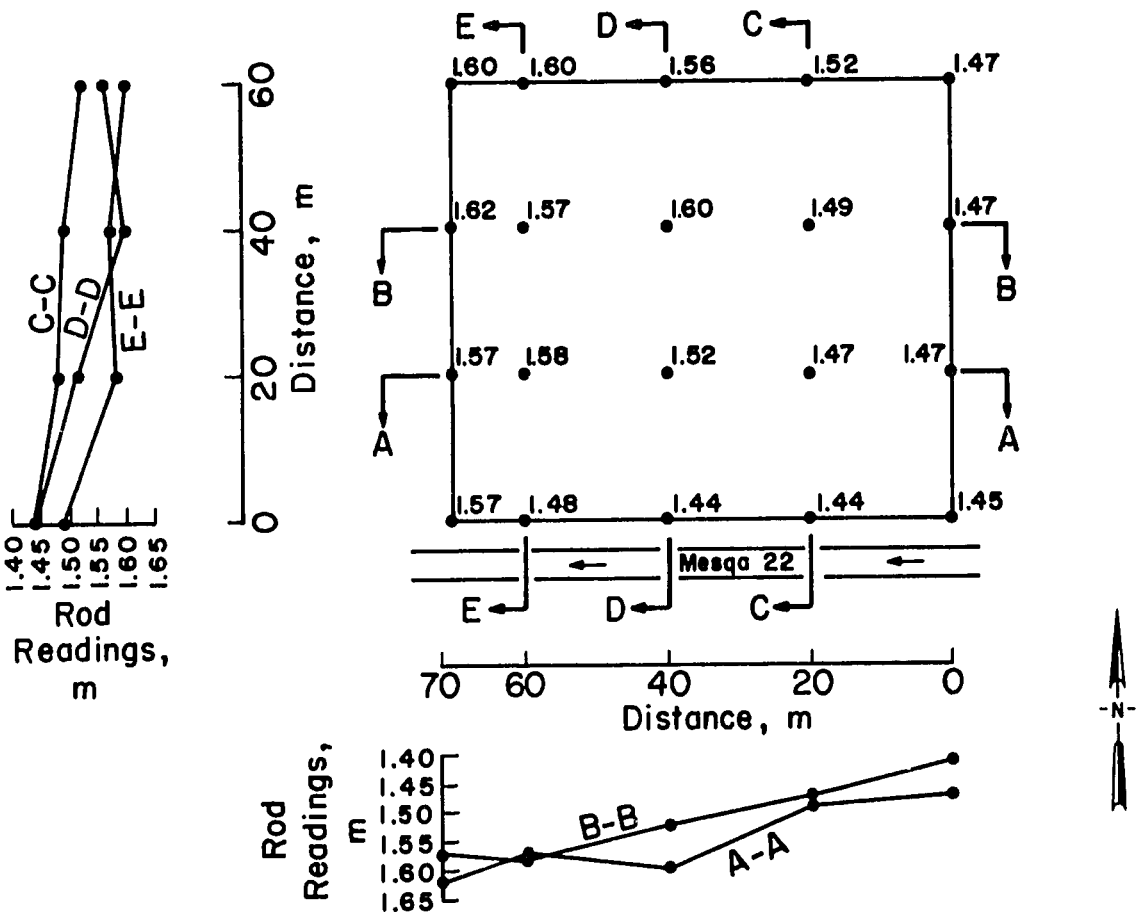

Figure 13. Spot elevations in a sugarcane field supplied by Mesqa 22 at elevation 1.45 m

These two fields are examples of situations that do not permit good on-farm water management, and crop production on these fields may be reduced because over-irrigation may result in loss of nitrates and/or poor soil areation.

D. Water Table Investigations

To determine the depth to the water table in time and space, a series of 46 observation wells were installed in Abyuha. Figure 15 shows contours drawn from the elevation data taken at the soil surface of the observation wells.

Figure 16 shows the water table elevation contours on August 24, 1981. This date, being the end of an irrigation on-period, should therefore reflect the "worst conditions" for the water table. In general, the water table was below 1 m except for areas close to the drain. Several water table mounds are noted from Figures 16 and 17. In Figure 17, profiles of the soil surface and water table elevations are shown by sections taken in the west-east and north-south directions at the end of an "on-period."

The water table does not seem to be a threat to the management of soils in Abyuha. An examination of water table records outside the area for similar hydrologic units indicates that the water table has remained relatively stable over a long period of time. Water table elevations will continue to be monitored during the life of the project since these data will serve as a basis for observing groundwater change occurring due to interventions of technology. The water table data also serve as an important input to the water budget studies in the Abyuha site.

E. Soil Fertility Survey

The preliminary farmer interviews and field observations indicated the need for a better understanding of the soil fertility status and salinity-sodicity characteristics of the Abyuha soils. Thus, in response to early team discussions, a soil fertility survey was begun in September, 1979, and continued through the fall. The soils were sampled by hod and were analyzed in 1980. A summary of the survey is presented here. The detailed report is given in PTR #10.

The Abyuha cooperative consists of 14 hods. Ten fields were selected at random in each hod and two surface (0-20 cm) samples were obtained from each farm. Two fields in each hod were sampled to a depth of 60 cm in 20 cm increments.

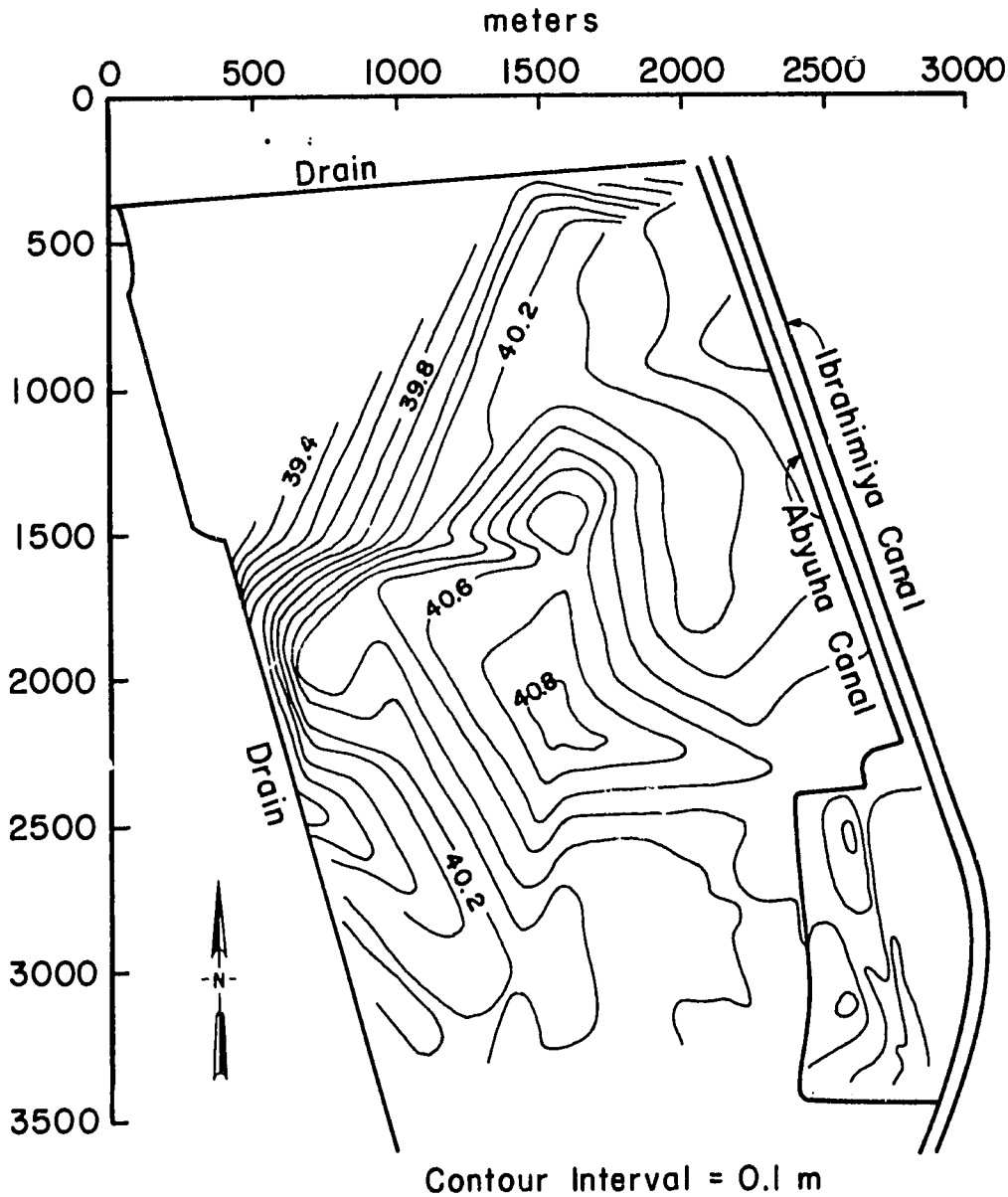

Figure 14. Soil surface contours in elevation above mean sea level, Abyuha Site

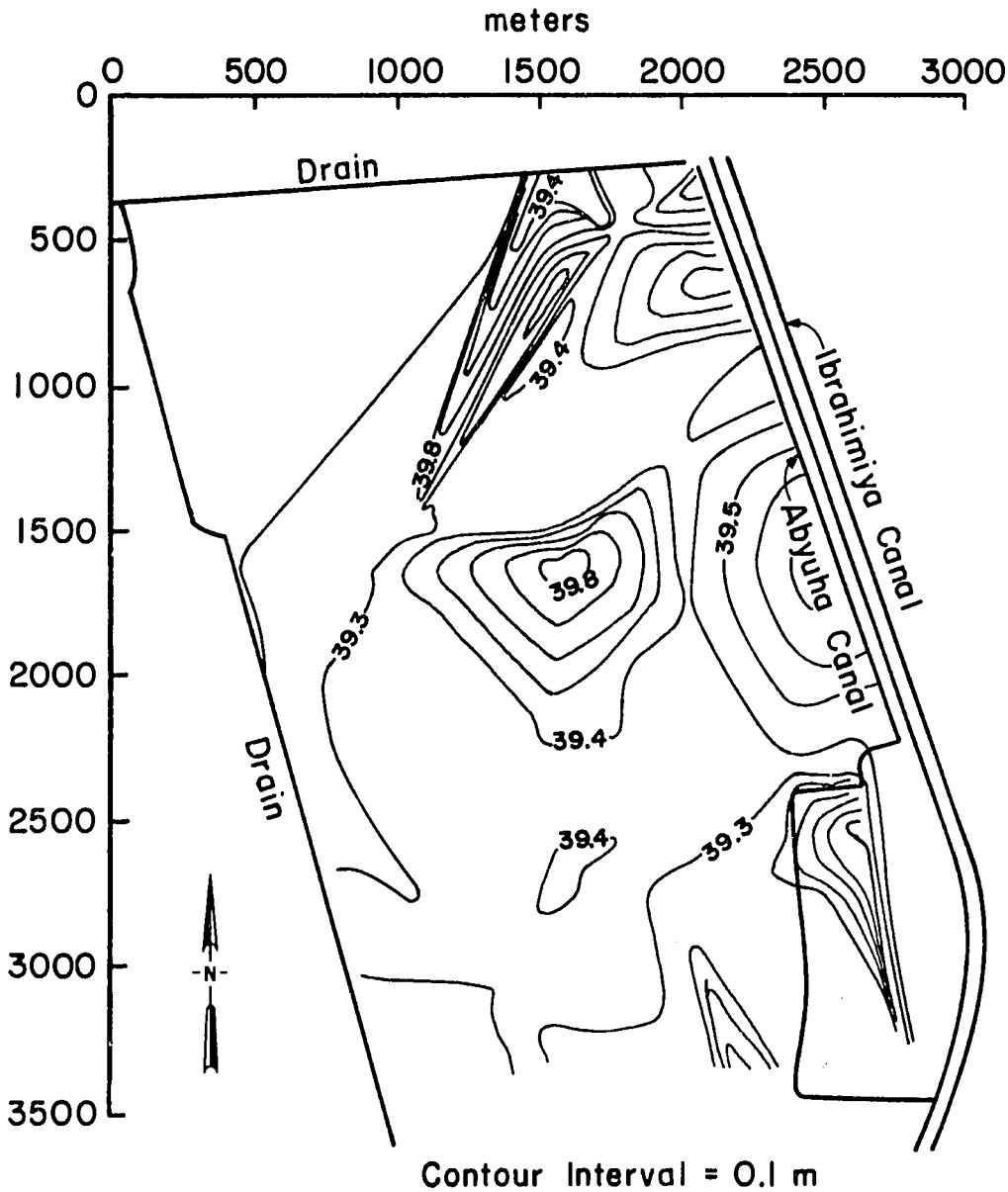

Figure 15. Water table elevation contours in elevation above mean sea level, Abyuha Site, August 24, 1981

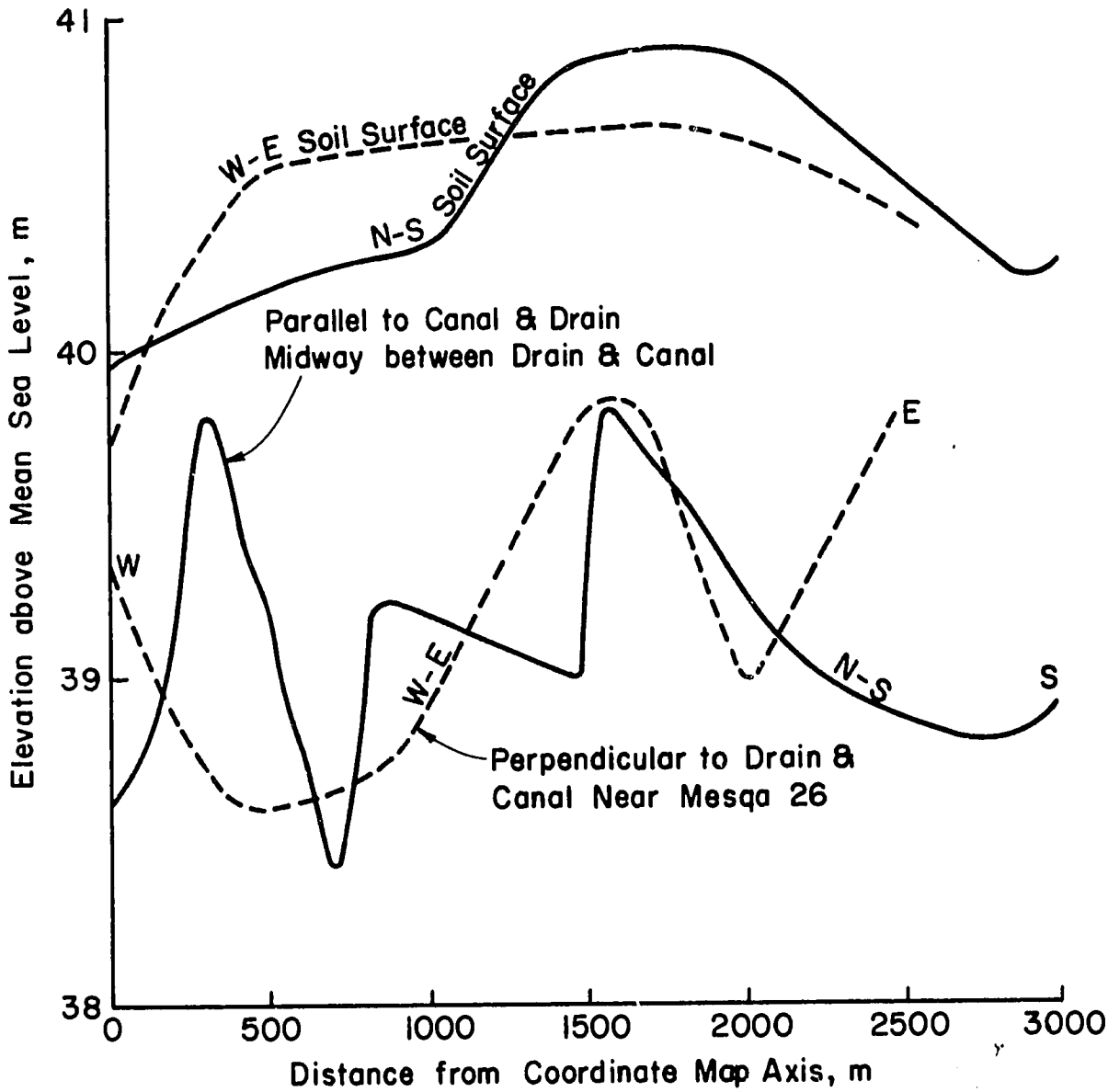

Figure 16. Water table and soil surface elevations for north-south and east-west sections at Abyuha Site on August 24, 1981

The distribution and variation of pH, electrical conductivity and fertility index values of soil samples were determined. Soil salinity and fertility are interpreted in terms of moderately sensitive and sensitive crops, respectively. These interpretations will change for different crops species and varieties having different physiological characteristics.

The pH values ranged from 7.7 to 9.5 with a mean of 8.3. A few surface samples and some of the deep samples had pH values over 8.9 which could be attributed to sodicity. In this case, SAR values should be determined and, if found to be greater than 12, the gypsum requirement of the soils should be determined.

Most of the soils were non-saline at the time of sampling. Of the surface soil samples 28% and 56% tested "very low" and "low" in phosphorus availability, respectively. The phosphorus fertility index did not change with depth.

Eighty-one percent of samples tested low and 14% tested marginal in zinc availability. Iron, manganese and copper levels were not found at deficient levels for crops grown in the Abyuha area.

Abyuha soils apparently are quite uniform in fertility, and for sampling purposes one may sample at the hod level. Taking 30 soil cores per hod will result in a 95% confidence interval of ± 14% for P and ± 12% for EC evaluation. Sampling soils on a large area basis and taking 30 cores from all Abyuha area will result in a ± 23% confidence interval for the geometric mean of zinc. These data provide guidelines for developing a soil fertility sampling program in Abyuha.

For making of general recommendations, Abyuha soils should be considered deficient in phosphorus and zinc, and in a very few cases in iron. Mineral nitrogen was not determined and no statement can be made about its distribution. Responses to nitrogen fertilizers were reported by farmers. These soils are however, very low in organic matter, and responses to the application of nitrogen fertilizer would be expected. Field testing is needed to verify its need.

F. Crop management practices

Plans were developed for conducting preliminary investigations to test the following hypotheses related to crop management practices:

- The plant populations seemed low as evidenced particularly by the wide spacing of corn plants.

- Although most soils in Abyuha were low in zinc and phosphorus, as revealed by the soil fertility survey, many farmers were not aware of possible yield responses to the application of these fertilizers.
- Insecticides were used only sparingly to control infestations of aphids noted on most crops. Insect control for cotton was, however, regularly practiced by the government.
- Sufficient quantities of fertilizers were often not available, or not available at the correct time for application. The field team observed that fertilizers may be applied to crops other than those for which they were distributed.
- Uneven distribution and improper placement may be reducing the effectiveness of fertilizer now being used.

Improving the above-mentioned crop management practices, when combined with proper on-farm water management, would most likely have a great impact upon crop production in Abyuha and help achieve an improved economic status for the farmer. Other possible improvements, such as using improved seed varieties and better seedbed preparation, were noted but were considered of lower priority when the work plans were developed. The following subsections report the results of field research conducted to assess the magnitude of the problems noted above.

1. Plant populations.

A preliminary investigation of three different crops, (corn, cotton and broad beans) showed that the plant densities were considerably below those recommended by the Ministry of Agriculture (MOA). The data from randomly selected fields are shown in Table 16.

During the soil fertility survey, 24 farmers were selected for measuring broad bean plant population and yield. A linear regression analysis was made from the data, and the correlation between yield and plant density was found to be,

$$Y = -0.01 + 0.08D \qquad (1)$$

where Y is the yield in ardabs per feddan and D is the plant density in 1000 plants per feddan. The regression coefficient was $r^2=0.65$. An approximately linear relationship for plant population can be expected to

TABLE 16 PLANT POPULATIONS MEASURED ON RANDOMLY SELECTED FARMERS FIELDS

Farmer	Crop	Plants Per Feddan	Yields Per Feddan	MOA Recommended Plant Population
1	Corn	10,100	8.9 ardab	24,000
2	Corn	16,100	12.5 ardab	24,000
3	Cotton	38,000	2.9 qintar	70,000
4	Cotton	46,000	4.5 qintar	70,000
5	Broad Beans	52,000	915 kg	170,000
6	Broad Beans	140,000	2040 kg	170,000

about 90% of the recommended stands. Thus if 90% of the MOA recommended density (153,000) is used in equation 1, the expected yield would be,

$$Y = -0.01 + 0.08\ (153)$$

$$= 12.2 \text{ ardabs/feddan or } 1.9 \text{ tons/feddan}$$

The average yield of beans among the 9 farm record keepers of Table 10 was 6.2 ardabs/feddan. The calculation suggests considerable potential for increasing yields with higher plant populations. The highest plant density recorded by the 24 farmers in the above-mentioned survey was 140,000 plants per feddan with a yield of 13.2 ardabs/feddan.

2. Application of zinc fertilizer.

Since early results of the soil fertility survey revealed that the Abyuha soils were frequently low in available zinc, field trials were conducted to test this nutrient on wheat in the 1979-80 winter season. Zinc fertilizer was applied as a foliar spray. The field trial consisted of four treatments: (1) control, (2) one foliar application at tillering, (3) one foliar application at shooting, and (4) two foliar applications, one at tillering and one at shooting stage. Each treatment was replicated 4 times.

The results showed that 0.4% $ZnSO_4$ sprayed at 400 ℓ/fed at tillering stage increased the grain yields by 28%, and seed size (weight per 100 seeds) was increased by 7.4% over the control.

Water application efficiencies were determined for each treatment by measuring the water applied and the soil moisture content before and after each irrigation. The treatments received nearly the same amounts of water with application irrigation efficiencies of 70-75%. Soil water depletion in cm/day was also quite similar. However, the crop water production index (kg grain/m^3 of depleted water) was 1.07 and 0.68 kgs for the treated and untreated wheat, respectively.

Sprayers are required to adopt this technology, and $ZnSO_4$ must be readily available to the farmers. Nonetheless, the trials indicate that the farmers in Abyuha may substantially increase wheat production by using foliar applications of zine fertilizer.

In a similar study on corn, significant increases were also experienced. A cost enterprise study of one foliar application of $ZnSO_4$ on corn showed that returns above costs were LE 21.2 per feddan over the control.

No further field trials with zinc are being considered. These preliminary data are sufficient to confirm the significance of the problem. Intervention of this technology into a pilot study is proposed in conjunction with optimum use and control of on-farm water.

3. Application of nitrogen and phosphate fertilizers.

In their interviews with EWUP staff, farmers often contended that fertilizers were not available in sufficient quantities and that more fertilizers should be available at government prices. The field team selected, at random, 5 farmers to survey for detailed data on their fertilizer use for several 1979-80 winter crops. A summary of their data for broad beans, wheat and berseem is shown in Table 17, together with recommendations from the MOA. In general, these farmers applied more fertilizer than that recommended by the MOA.

A field study with corn and wheat was conducted on a randomly selected farm management unit. One field was used as a control to observe the farmer's fertilizer practices and another field was used to impose the fertilizer practices recommended by the EWUP team.

The results of this study are shown in Table 18. For both crops, the farmer applied more fertilizer than recommended. The timing of fertilizer application may also have had an effect upon yield but, in general, the lack of fertilizer does not appear to limit production. The increase in corn production on the field following EWUP practices was attributed, primarily, to an increase in plant density. It should be noted, however, that the farmer applied sufficient nitrogenous fertilizer for the recommended plant density of 24,000 plants/feddan. This does not lend credence to the often-heard hypothesis that plant stand densities are established according to fertilizer availability.

Based upon these preliminary findings, there will be no further investigation into farmers' practices concerning the testing of nitrogen and phosphorus fertilizer materials.

TABLE 17 UNITS* OF N AND P FERTILIZER APPLIED PER FEDDAN ON 1979 WINTER CROPS AT ABYUHA

Farm No.	Farmer's Name	Broad Beans N	Broad Beans P	Wheat N	Wheat P	Berseem N	Berseem P
1	Mohamed A. Saber	30.0	22.5	70.0	22.5	----	----
2	Fathy Hamouda	----	22.0	----	----	----	----
3	Shahat Farag	16.0	27.0	92.0	----	----	15.2
4	Saad Youssef	----	14.7	75.0	17.4	----	----
5	Ahmed A. Youssef	----	----	92.0	31.0	----	----
	Units/Feddan Recommended by MOA	7.5	22.5	60.0	15.0	7.5	15.5

* One unit equals one kilogram total N or available P_2O_5

TABLE 18. COMPARISON OF FARMERS' PRACTICE WITH EWUP RECOMMENDED PRACTICES ON YIELDS OF CORN AND WHEAT

a. FARMERS' PRACTICES

Crop	Fertilizer Applied kg/Fed	Timing of Application	Source of Supply	Plant Population plants/Fed	Yield Ard/Fed
Corn	110 N	3 times during maturing stages	60 kg from Village Co-op 50 kg from Free Market	13,000	9.5
Wheat	80 N $30P_2O_5$	4 times beginning with first irrigation before first irrigation	15 kg from Village Co-op 15 kg from Free Market	----	9.6 (grain) 4.3 T/Fed (straw)

b. EWUP RECOMMENDED PRACTICES

Crop	Fertilizer Applied kg/Fed*	Timing of Application	Source of Supply	Plant Population plants/Fed	Yield Ard/Fed
Corn	80 N	2 applications (1/2 each time) 21 days after planting 36 days after planting	Village Co-op	24,000	16.0
Wheat	70 N $15P_2O_5$	2 applications (1/2 each time) 21 days after planting 51 days after planting Before Maturity	Village Co-op Village Co-op	-----	11.3 (grain) 4.6 T/Fed (straw)

* MOA recommended rate.

4. Use of Insecticides in Abyuha:

Preliminary surveys of Abyuha farms frequently revealed large populations of aphids on corn, broad beans, wheat and other winter and summer crops. Apparently the Village Cooperative (Government) has not recognized aphid or other infestations as a problem. Neither sprayers nor chemicals are available within the Cooperative to treat insect problems.

One field on Mesqa 9 and another on Mesqa 22 were selected to test possible benefits of insect control or crop yields. When wheat was sprayed for aphids, the average grain yield increased from 9.6 to 11.3 ardabs/feddan, an increase of 18%. Larger increases were measured with corn, but since, other factors were involved, the total increase should not be attributed to aphid control alone. Nonetheless, field testing has shown that chemical control of insects on infested fields is important and does improve yields.

These preliminary observations indicate that there are insect control problems. No further action or detailed studies in insect control are anticipated, but the data show that aphid control is among several management practices that should be recommended to increase crop production.

VII. REVISED HYPOTHESES

Following completion of the preliminary investigations, another workshop was held to re-examine the problem hypotheses stated in Section V, using the primary data collected from the investigations reported in Section VI.

Where the investigations were conclusive and hypotheses were accepted, no further analysis or verification of the problem was needed and technical interventions were proposed for field testing. However, some investigations were still inconclusive. Hypotheses A, B and C in Section V were rewritten to be more specific and a more detailed problem identification study was initiated. Listed below are restatements of these hypotheses developed for the more detailed studies.

A. The farmer does not understand on-farm water management.

The farmer applies too much water resulting in low irrigation application efficiency. The primary reasons for these low application

efficiencies are: 1) Fields are not level and, therefore, water cannot be uniformly applied to all areas of the field, and 2) The mesqa, or canal, delivers water at low heads. For farmers who can divert water from the mesqa by gravity, the head usually is small, requiring an excessive amount of time for irrigation. For those who must lift water, the additional costs are high, reducing net income. Low heads are the result of deliberate design by the government and also inadequate maintenance of mesqas and canals.

B. The Abu Qurqas Irrigation District does not provide adequate water control on the Abyuha Canal.

The Irrigation District delivers water to the farmers at a low delivery efficiency. This occurs because: 1) The head gate to the Abyuha Canal is an inadequate closure device, 2) No head gates are used on the mesqa; all farmers take water at the same time from the canal, and 3) Because of the lack of water control, much water flows directly to the drains. This over-loads the system resulting in flooding of adjacent lands and increased costs of operation and maintenance.

C. The farmer does not understand the complex soil/water interactions involved in managing the heavy Abyuha Vertisols.

The revision of hypotheses A, B and C, and the need for continued clarification of hypothesis statement F were the basis for implementing detailed studies to more clearly identify problems that act as constraints to soil and water management for improved crop production in Abyuha. Obviously, these hypotheses are interrelated with the other hypotheses stated in Section V.

Problem solution research proceeds as the team obtains a clearer understanding of the high priority problems, their interrelations and causes. The detailed studies that follow in Section VIII were designed to improve the causal understanding of the constraints and to provide the basic information needed to design and plan the problem solution research.

VIII. DETAILED PROBLEM IDENTIFICATION STUDIES

The detailed studies were conducted, in general, during the period from January, 1980 to September, 1981. There was, however, no abrupt change in Project activities, and some investigations initiated as preliminary activities continued into the detailed study stage.

A. Detailed Water Management Studies in Abyuha:

Detailed water management studies were conducted to investigate hypotheses A and B as revised in Section VII. Results of the preliminary investigations noted earlier in Section VI regarding irrigation practices at Abyuha were inconclusive. For example, does the Abyuha farmer over-irrigate? If so, why? Does location of the field with respect to the water source affect application efficiency? These and other questions pertaining to irrigation practices in Abyuha were asked to guide the detailed studies.

The following questions were posed to clarify hypothesis statements A and B in Section VII:

1. When comparing fields near the head of the Abyuha Canal and/or near the head of any mesqa with those farther down, are there observable differences in:
   a. The length of time required to irrigate?
   b. The head of water available for irrigation?
   c. The size of stream used for irrigation?
   d. The quantity of water applied at each irrigation or for the season?
   e. The application efficiency?
   f. The interrelationships among the above variables?

2. What are the differences between the fields irrigated by gravity and those where lifting is required?

3. At what intervals do the farmers irrigate?

4. What is the daily and seasonal consumptive use?

5. Can a farmer distribute water evenly within and among small basins?

6. What are differences in elevation within a small basin, and among the small basins in a field?

Many of these questions can be answered by measuring and observing the irrigation practices on various farms. The study reported below has been extracted from a report by the EWUP El-Minya team and Cairo office staff.

- Sites Selected For Study

Three mesqas were chosen initially to represent various distances from the Abyuha canal intake: Mesqa 13 near the head, Mesqa 22 near the middle, and Mesqa 26 near the tail. Later Mesqa 7 was chosen, even closer to the head end, for land leveling trials.

To represent varying distances along the mesqa, either two or three fields were selected along each of the four mesqas. They were located near the head, the middle, or the tail of their respective mesqas. The location of these fields is shown on the map (Figure 17).

Wheat fields identified for study were located in the middle, and the tail of Mesqas 13, 22 and 26. Broad bean fields were near the head of Mesqas 22 and 26. The two fields chosen on Mesqa 7 were both located near the head, one planted to wheat and the other to broad beans. The identification of the crops grown on each farm is also shown in Figure 18.

A study of these sites revealed that the gradient in each mesqa was about 36 cm/km. The fields on Mesqa 7 and Mesqa 13 were always irrigated by gravity. On Mesqa 22, the irrigation was sometimes by gravity and sometimes by lifting. The gradient of this mesqa was sufficient to make gravity diversion possible, especially toward the lower end. Sufficient water, however, was not always available to provide the option of irrigating by gravity or by lifting. These farmers often delayed irrigation until the others above them had finished.

Irrigation from Mesqa 26 was similar to that of Mesqa 22, except that 26 is less than 1/2 as long. After it was re-constructed during the 1980-81 winter closure, all farms along Mesqa 26 then had water supplied by gravity.

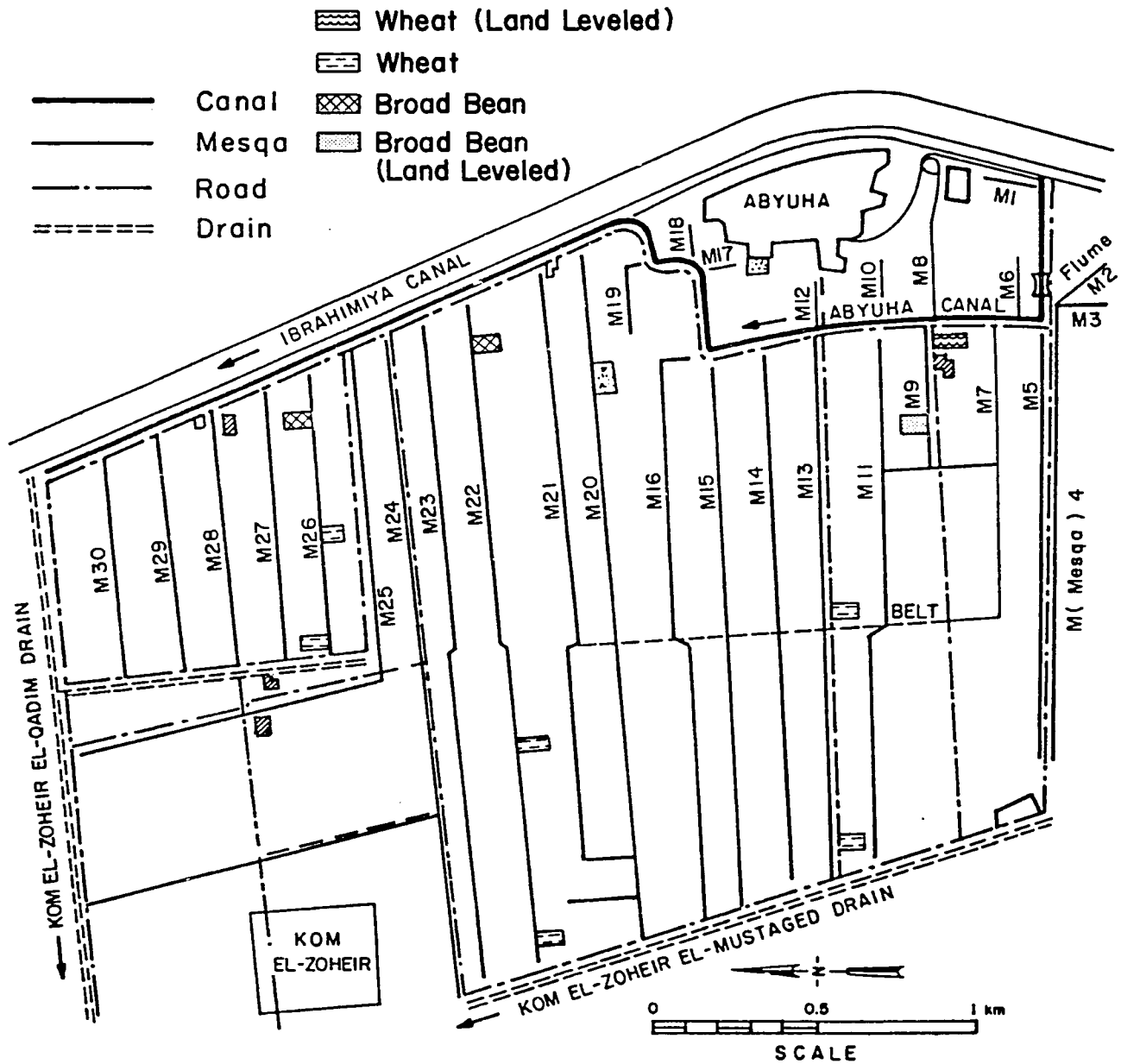

Figure 17. Location of Mesqas and fields selected for the detailed water management studies

- Procedure

Observations of farm irrigation practices consisted mainly of measuring water application during irrigation and soil moisture depletion between irrigations. The farmers cooperated by notifying the project people of each irrigation in advance, giving the team sufficient time to set the measuring flumes. Farmers were willing to permit entry to their land, even though some crop damage was inevitable. Other observable farm characteristics and all special events, such as date of planting, date of harvest, the field layout (e.g. basins or borders) were also recorded. At the end of the season, yields were measured from selected sites.

Measurements of water applied were all made with portable 20 x 90 cm cutthroat flumes fabricated in Egypt from galvanized sheet steel. In a typical installation, the floor of the flume was placed in a marwa 2 or 3 cm below the ground surface elevation. (A marwa is a small field ditch carrying water from the mesqa to small basins in the field). Both H_a and H_b water levels in the flume were measured manually at intervals ranging from 2 to 15 minutes, the more frequent readings were required when the flow rate was changing rapidly. From these readings, the rate of flow (q) in liters per second (ℓ/s) was calculated from standard discharge tables. The flumes were frequently submerged, sometimes even to the point of reduced accuracy. By multiplying the rate of flow with the time interval between readings, the volume (m^3) of water in the period was obtained. The volume applied during one complete irrigation then was divided by the area irrigated to obtain the average depth (cm) of water applied (W_a) to the field. The assumed average rate of flow for the entire irrigation was the total volume applied divided by the total time required.

Another set of data derived from the flume readings was the head of water (H) available at the beginning of the field. It was obtained by adjusting the downstream flume reading (H_b) by the 2 or 3 cm difference between the floor of the flume and ground surface elevations.

An additional set of data obtained was the time (T) required to complete an irrigation, reported as hours per feddan (h/f). This figure may be used to estimate desirable flow rates, deep percolation, labor requirements, etc.

Soil moisture content data were obtained by the gravimetric method. Samples were taken at depths of 0 to 15, 15 to 30, 30 to 60 and 60 to 90 cm. One sampling was made immediately before irrigation, and the next, three

days after irrigation. The samples were oven-dried to obtain the percentage of water by weight, which was then converted to a volume percentage by applying previously measured values of the soil's bulk density, and recorded as cm of depth.

The difference in soil moisture contents between samplings after any irrigation and before the next gives the cm of water depleted for that period. It was calculated as mm/day depletion rate. The same rate of depletion was assumed for the three-day period from the day of irrigation to the time of sampling three days later. Thus, with this overall depletion rate, the consumptive use (CU) for the entire period was calculated. The CU was expressed both as cm depth and mm/day. It is recognized that the calculated soil moisture depletion differs from true CU by the quantity of water transfer between the water table and the root zone by capillary action.

Water application efficiency (E_a, expressed in percent), was calculated by dividing the depth of water stored (W_s) in the 90 cm root zone by the depth of water applied (W_a) during the irrigation.

The data were assembled in tables. Some trends in the results were readily apparent from visual observations. Regression analyses were run to further analyze the data.

- Results and Discussion

Tables 19 through 22 contain data assembled during these detailed studies. The analysis of these data gave the conclusions presented here. An explanation of the column headings in the tables is given below:

H	-	head
q	-	rate of flow
ℓ/s	-	liters per second
T	-	time
h/f	-	hours per feddan
W_a	-	water applied
W_s	-	water stored
E_a	-	water application efficiency
Depl'n rate	-	depletion rate
I	-	interval in days between consecutive irrigations
CU	-	consumptive use
Lift or Gravity	-	method of obtaining water from the mesqa

Field Size	Area irrigated (variations were caused by differences in where water entered and left the field, farmers' decisions as to which small basins received water from which marwa, etc.).

Answers to Question 1:

The data summarized in Tables 19 through 22 were examined to seek answers to questions posed when the detailed studies were initiated. Pertinent portions were re-assembled in Tables 23 through 27 to assist in answering the first question.

From Table 23, it is evident that the time required to irrigate one feddan of wheat for the season increased with distance along the Abyuha Canal, as well as down the mesqa. This conclusion could be drawn by examining the mean values along the canal in the last column on the right and across the bottom for the three mesqas. Both sets of means increased with distance from the intakes. The mean of all six is at the lower right corner of the table. The set of data from Mesqas 13 and 22 is, however, too small from which to draw firm conclusions, especially since there was little difference in irrigation time toward the lower end of the mesqa. However, the nearly 40% increase from Mesqa 13 to Mesqa 22 should be a real effect. Broad beans showed the same trend for increased irrigation time with distance down the canal.

Table 24 suggests that nearly all of the extra time spent on irrigating wheat on Mesqa 22 resulted in the additional application of water, whereas Table 25 suggests that at least half of the difference in the amount applied on Mesqa 22 could be due to a larger stream size. However, these arguments are all rendered pointless when one notes in Table 27 that the application efficiencies were higher on Mesqa 22 than those on Mesqa 13 in spite of the larger applications of water. This was due to the fact that soil moisture depletion was greater on Mesqa 22, as shown in Tables 19 and 20 by the columns headed "CU" (consumptive use). The farmers on Mesqa 22 were aware that the soil moisture depletion was greater and, therefore, more water was required.

Thus Tables 23, 24, 25 fail to produce convincing evidence that each increment of distance down a watercourse causes the farmer to spend more time irrigating. The farmer may spend more time awaiting his turn, but this possibility was not considered in the present study.

TABLE 19 IRRIGATION OF TWO WHEAT FIELDS ON MESQA 13

FIELD NO. 1

Irrig. Date	H cm	q ℓ/s	T h/f	W_a cm	W_s cm	E_a %	I days	Dep'l Rate mm/d	CU cm	Lift or Gravity	Field Size mxm
Dec. 6	10	11.4	6.7	6.6	3.2	49	--	--	--	G	29x10.75
Dec. 23	10	7.2	7.0	4.3	2.4	55	17	0.8	1.4	G	29x10.75
Feb. 7	11	15.9	11.2	15.3	7.3	48	46	0.9	4.4	G	29x10.75
Mar. 10	6	6.1	12.4	6.5	3.0	46	31	0.9	2.8	G	29x10.75
Mar. 28	9	13.6	6.7	7.8	3.3	42	18	2.5	4.5	G	29x10.75
Apr. 12	8	9.3	9.0	7.1	4.5	63	15	3.8	5.7	G	29x10.75
Harvest	--	--	--	--	--	--	28	2.7	7.5	--	
Total or Average	9	10.6	53.0	47.6	23.7	50*	155	1.7*	26.0		
FIELD NO. 2											
Dec. 4	9	12.0	11.0	11.3	4.0	35	--	--	--	G	28.7x12.2
Dec. 27	7	8.2	7.6	5.3	2.4	45	23	0.6	1.4	G	54x12
Feb. 11	11.5	16.4	8.7	12.2	9.4	77	46	1.6	7.4	G	54x12
Feb. 27	6	6.2	10.4	5.6	2.8	50	16	3.8	6.0	G	14x12
Mar. 14	10	15.5	4.5	6.0	3.5	58	15	1.7	2.5	G	54x12
Mar. 29	8.5	9.5	11.9	9.7	7.7	79	15	3.4	5.1	G	54x12
Apr. 13	10	15.3	5.6	7.4	4.9	66	14	5.7	8.0	G	54x12
Harvest	--	--	--	--	--	--	27	3.2	8.5		
Total or Average	8.9	11.9	59.7	57.5	34.7	60*	156	2.5*	38.9		

*Weighted Average

TABLE 20 IRRIGATION OF TWO WHEAT FIELDS ON MESQA 22

Irrig. Date	H cm	q ℓ/s	T h/f	W_a cm	W_s cm	F_a %	I days	Dep'l Rate mm/d	CU cm	Lift or Gravity	Field Size mxm
FIELD NO. 2											
Dec. 3	5	4.2	19.3	7.1	4.4	62	--	--	--	G	22.7x12.75
Dec. 25	9	14.0	6.1	7.3	5.2	71	22	0.5	1.1	G	12.7x12.75
Feb. 8	20	35.0	7.0	20.9	6.0	77	45	1.6	7.4	G	78x25
Feb. 25	8	13.6	7.3	8.5	6.0	71	17	6.5	11.1	G	72x12.75
Mar. 14	6	7.4	13.6	8.6	7.4	86	17	4.2	7.1	L	14.1x12.75
Mar. 29	5	3.4	26.9	7.7	6.4	83	15	6.0	9.0	L	10.2x12.75
Apr. 11	11	16.0	5.6	7.7	5.7	74	13	4.1	5.4	L	72x26
Harvest	--	--	--	--	--	--	27	2.7	7.3		
Total or Average	9.1	13.4	85.8	67.8	51.1	75*	156	3.1*	48.4		
FIELD NO. 3											
Dec. 3	6	5.5	15.3	7.2	5.2	73	--	--	--	G	28.5x11.25
Dec. 28	12	15.1	6.8	8.8	6.1	69	25	1.8	4.5	G	79.5x11
Feb. 9	10	12.0	19.7	20.2	11.7	58	43	2.3	9.7	G	68x11.5
Feb. 28	14	19.2	6.7	11.0	6.5	59	19	5.0	9.4	G	58x11.5
Mar. 14	8	9.5	9.4	7.7	4.5	58	14	1.1	1.6	G	45.2x11.5
Mar. 29	12	15.9	7.6	10.4	7.6	73	15	5.3	7.9	L	79.8x11.5
Apr. 12	10	21.4	5.7	10.5	7.1	67	14	5.4	7.6	L	79.8x11.5
Harvest	--	--	--	--	--	--	30	2.7	8.0		
Total or Average	10.3	14.1	71.2	75.8	48.7	64*	160	3.0*	48.7		

*Weighted Average

TABLE 21 IRRIGATION OF TWO WHEAT FIELDS ON MESQA 26*

FIELD NO. 2

Irrig. Date	H cm	q ℓ/s	T h/f	W_a cm	W_s cm	E_a %	I days	Dep'l Rate mm/d	CU cm	Lift or Gravity	Field Size mxm
Dec. 4	12	21.7	8.9	16.5	5.7	35	--	--	--	L	35.5x10
Dec. 28	15	17.1	3.6	5.3	4.0	75	24	0.8	1.9	L	123x10
Feb. 10	13	15.4	15.9	21.0	8.3	40	44	1.6	7.1	G	123x10
Mar. 12	13	15.7	8.8	11.8	4.9	42	30	1.6	4.7	G	123x10
Mar. 26	10	12.3	7.6	8.1	3.7	46	14	3.9	5.4	G	123x10
Apr. 10	9	8.6	10.5	7.8	2.6	33	15	0.9	1.3	G	123x10
Harvest	--	--	--	--	--	--	32	1.7	5.4		
Total or Average	12	15.1	55.3	70.5	29.2	4.**	159	1.6**	25.9		

FIELD NO. 3

Dec. 4	5	5.3	29.0	13.2	7.8	59	--	--	--	L	41.1x9.8
Dec. 28	8	9.7	7.2	6.0	4.6	77	24	0.6	1.3	L	71.5x9.8-31.4
Feb. 13	7	6.8	22.5	13.2	11.4	86	47	2.5	11.8	G	71.5x9.8
Mar. 10	7	9.8	10.2	8.6	6.0	70	25	3.8	9.5	G	71.5x11.1
Mar. 27	4	2.9	25.3	6.4	5.5	86	17	3.2	5.4	G	71.5x11.0
Apr. 9	6	7.0	11.6	7.0	5.7	81	13	4.7	6.2	G	71.5x11.0
Harvest	--	--	--	--	--	--	31	1.7	5.2		
Total or Average	6.2	6.9	105.8	54.3	40.9	75**	157	2.5**	39.4		

* Mesqa was modified in January winter closure period to provide gravity flow to all farms. Water was lifted into mesqa by diesel pump.

** Weighted Average

TABLE 22 IRRIGATION OF BROAD BEANS ON MESQAS 22 and 26

FIELD NO. 1 MESQA 22

Irrig. Date	H cm	q ℓ/s	T h/f	W_a cm	W_s cm	E_a %	I days	Dep'l Rate mm/d	CU cm	Lift or Gravity	Field Size mxm
Dec. 31	7	9.8	8.8	7.4	4.6	62	53	0.8*	4.2*	L	53.3x11.2
Feb. 13	7	12.6	7.3	7.8	6.5	83	44	1.6	7.1	L	37x12
Mar. 11	12	18.7	7.0	11.2	7.7	69	26	2.6	6.7	L	44x12
Mar. 29	7	11.7	7.2	7.2	5.0	69	18	3.4	6.1	L	121x12
Harvest	--	--	--	--	--	--	10	4.4	4.4		
Total or Average	8.3	13.2	30.3*	33.6*	23.8*	71**	151	1.9**	28.5		

FIELD NO. 1 MESQA 26

Dec. 23	15	26.7	6.9	15.7	8.5	54	45	0.8*	3.6*	L	68.1x19.4
Feb. 8	14	13.0	16.4	18.3	11.4	62	47	2.5	11.8	G	68.1x19.4
Mar. 13	14	26.0	5.2	11.5	7.2	63	33	2.6	8.7	G	68.1x19.4
Mar. 29	10	10.2	6.8	6.0	3.3	55	16	3.4	5.4	G	68.1x19.4
Harvest	--	--	--	--	--	--	17	2.7	4.5		
Total or Average	13.3	19.0	35.3*	51.5*	30.4*	59**	158	2.2**	34.0		

Note:

* First irrigation (at planting) was not measured at either farm. Planting date was Nov. 8 for both farms. The consumptive use (CU) rate for the period between planting and the first recorded irrigation was assumed to be the average of the three measured values on Mesqa 7 during the same period and has been added to the total. However, the figures for the total hours per feddan, total water applied, and total water stored reflect only the four irrigations measured and recorded, and do not include the planting irrigation.

** Weighted Average

TABLE 23 HOURS/FEDDAN/SEASON REQUIRED TO IRRIGATE RELATIVE TO DISTANCE FROM THE INTAKE

No.	Mesqa		Field			
	Total Length	Canal Position	Position Along Mesqa			
			Beginning	Middle	End	Mean
	m	m	h/f/s	h/f/s	h/f/s	h/f/s
Wheat						
13	1,600	1,100	--	53.0	59.7	56.4
22	2,100	2,565	--	85.8	71.2	78.5
26	840	3,195	--	55.3	105.8	80.6
End	-------	4,080	--	--	--	--
Mean Mesqas 13, 23, 26			--	64.7	78.9	71.8
Mean Mesqas 13, 22			--	69.4	65.5	--
Broad Beans						
13	1,600	1,100	--	--	--	--
22	2,100	2,565	37.8*	--	--	37.8
26	840	3,195	44.1*	--	--	44.1
Mean			41.0	--	--	41.0

* The first irrigation was not measured. The figures shown were calculated by multiplying the remaining four irrigations in Table 22 by 5/4ths.

TABLE 24 CENTIMETERS OF TOTAL WATER APPLIED PER SEASON IN RELATION TO DISTANCE FROM THE INTAKE

No.	Mesqa		Field			
	Total Length	Canal Position	Position Along Mesqa			
			Beginning	Middle	End	Mean
	m	m	cm	cm	cm	cm
Wheat						
13	1,600	1,100	--	47.6	57.4	52.5
22	2,100	2,565	--	67.8	75.8	71.8
26	840	3,195	--	70.4	54.3	62.4
Mean Mesqas 13, 22, 26			--	61.9	62.5	62.2
Mean Mesqas 13, 22			--	57.7	66.6	--
Broad Beans						
13	1,600	1,100	--	--	--	--
22	2,100	2,565	41.9*	--	--	41.9
26	840	3,295	64.4*	--	--	64.4
Mean			--	--	--	53.2

* The first irrigation was not measured. The figures shown were calculated by multiplying the remaining four irrigations in Table 22 by 5/4ths.

TABLE 25 LITERS PER SECOND OF STREAM SIZE IN RELATION TO DISTANCE FROM THE INTAKE

No.	Mesqa		Field			
	Total Length	Canal Position	Position Along Mesqa			
			Beginning	Middle	End	Mean
	m	m	ℓ/s	ℓ/s	ℓ/s	ℓ/s
Wheat						
13	1,600	1,100	--	10.6	11.9	11.2
22	2,100	2,565	--	13.4	14.1	13.7
26	840	3,195	--	15.1	6.9	11.0
Mean Mesqas 13, 22, 26			--	13.0	11.0	12.0
Mean Mesqas 13, 22			--	12.0	13.0	--
Broad Beans						
13	1,600	1,100	--	--	--	--
22	2,100	2,565	13.2	--	--	13.2
26	840	3,295	19.0	--	--	19.0
Mean			--	--	--	16.1

TABLE 26 CENTIMETERS OF HEAD, FOR IRRIGATION OF BOTH WHEAT AND BROAD BEANS IN RELATION TO DISTANCE FROM THE INTAKE

No.	Mesqa		Field			
	Total Length	Canal Position	Position Along Mesqa			
			Beginning	Middle	End	Mean
	m	m	cm	cm	cm	cm
Wheat (gravity only)						
13	1,600	1,100	--	9.0	8.9	9.0
22	2,100	2,565	--	10.5	10.0	10.3
26	840	3,195	12.7	11.3	6.0	10.0
Mean Mesqas 13, 22, 26			--	10.3	8.3	9.8
Mean Mesqas 13, 22			--	9.8	9.5	--
Broad Beans (all farms)						
13	1,600	1,100	--	9.0	10.3	9.7
22	2,100	2,565	8.3	9.1	10.3	9.2
26	840	3,295	13.2	12.0	6.2	10.5
Mean Mesqas 13, 22, 26			--	10.0	8.9	9.8
Mean Without Mesqas 13, 22			--	9.1	10.3	9.5

TABLE 27 WATER APPLICATION EFFICIENCY (PERCENT), RELATIVE TO DISTANCE FROM THE INTLET

No.	Mesqa		Field			
	Total Length	Canal Position	Position Along Mesqa			
			Beginning	Middle	End	Mean
	m	m	%	%	%	%
Wheat						
13	1,600	1,100	--	50	60	55
22	2,100	2,565	--	75	64	70
26	840	3,195	--	41	75	58
Mean Mesqas 13, 22, 26			--	55	66	61
Mean Mesqas 13, 22			--	62.5	62	--
Broad Beans						
13	1,600	1,100	--	--	--	--
22	2,100	2,565	71	--	--	71
26	840	3,295	59	--	--	59
Mean			--	--	--	65

Table 26 shows the head available to push water down the field after it has passed the measuring flume. Perhaps the most significant observation from this table is that, when Mesqa 26 is not included, the average available head was greater at the two ends of the mesqa than at the center. The field team explained that, the head is higher at the intake of the mesqa, because the available head in Abyuha has not yet been lost to friction in the mesqa. At the lower end, the gradient in the mesqa permits the build-up of head by damming the mesqa, and waiting until the preceding farmers terminate their irrigation.

Mesqa 26 deserves additional explanation. Raising the mesqa represented such a change for the farmers, that one season was apparently insufficient for them to learn all of the advantages available to them. The most striking example was the small stream size used at the lower end of the mesqa, averaging only about 7 ℓ/s (Table 25). As result, 60% more time was required to irrigated wheat than that the average for Mesqas 13 and 22, even though less total water was applied. If fewer farms were irrigated at one time, less labor would be required from each farmer. Also, Table 27 shows that the season application efficiency measured for both wheat and broad beans was as low or lower on Mesqa 26 than on Mesqas 13 and 22. One might believe that these low efficiencies were the result of water being readily available by gravity, but close examination of the data in Tables 21 and 22 does not confirm this belief. In each case, there was an irrigation by lifting that gave about as low an efficiency as the lowest obtained by gravity. Thus, there must be other reasons for the excessive applications.

In response to question 1f., a multiple regression analysis was used to express application efficiency (E_a) as a function of the available head (H), the size of stream (q), and the time required to irrigate (T). The result showed that application efficiency did not seem to depend on any of these factors. The multiple correlation coefficient was only 0.03. Another regression was then calculated to relate application efficiency to water applied (W_a). One would expect these two to be correlated since W_a was one of two factors used to calculate E_a. However, although the regression coefficient was significant, the correlation coefficient was still only 0.05. Probably the most significant finding from the multiple regression analysis was that, within the range of sizes of streams measured in this study, the farmer could irrigate small basins as well with a small stream as with a large one. The primary problem with the small stream is that it takes more time. From studies

conducted in other countries, we know that larger streams are important for efficient irrigation, especially for long borders and long furrows, but apparently even the smaller streams used here can cover the small basin quickly enough to avoid excessive deep percolation.

Answers to Questions 2 through 6:

The average application efficiency on wheat fields irrigated by lifting was slightly higher than that by gravity but with broad bean fields, a slightly higher efficiency was obtained with gravity irrigation. The means and standard deviations of the efficiencies measured at each irrigation were calculated for irrigation of wheat and broad beans by both gravity and lifting . The results were as follows:

Wheat		Broad Beans	
Gravity	Lifting	Gravity	Lifting
63.8 ± 15.7	69.9± 15.3	69.9 ± 11.4	68.0 ± 11.1

These figures show that the average efficiency was about 6% higher for lifting than for gravity irrigation on wheat fields, but about 2% lower for lifting on broad beans. In each case, the standard deviation was much greater than the difference between the means, indicating that these probably were chance variations. If real differences do in fact exist, they apparently are not large. Additional data is needed to determine if real differences do exist.

Irrigation intervals are shown in Tables 19 through 22. For wheat, the second irrigation averaged 23 days after the planting irrigation. This was followed by a period of about 45 days for winter closure. The next interval averaged about 23 days, then about 16, and finally the last interval about 15 days. The period between the last irrigation and harvest ranged from 27 to 32 days. Fields with only 6 irrigations have slightly longer intervals, and those with 7 irrigations slightly shorter.

For broad beans, the first interval averaged 49 days, and the second about 46. The interval was reduced to about 29 days for the next irrigation, and finally to about 17 days for the last. Harvest was about 14 days later. It is apparent that for both crops the farmer is aware of the need for more frequent irrigations as the crop grows larger and the weather becomes warmer.

Figures 18 and 19 show the average measured soil moisture depletion rate for wheat and broad beans, respectively. Although there were variations among plots, the averages permit rather smooth curves to be drawn. The rate for wheat appears to peak slightly above 4 mm per day, and for beans slightly below. These curves may be the best estimate available in Egypt for the consumptive use rate of these two crops.

The measured application efficiencies averaged well above 60% is adequate testimony that farmers can distribute water evenly within and among small basins. Some fields averaged about 70% for the entire season. Not many gravity-irrigated areas in the World attain this level of efficiency. Of course, there is room for improvement among those farmers that are lower than the average. Some application efficiencies were in the 40 to 50% category. Reducing excessively heavy irrigations would increase application efficiency.

- Summary of water management studies.

No strong evidence was found among the data gathered from this study to indicate that farms located nearer to the head of the Abyuha Canal or of a mesqa are better situated than others with respect to available head (H) or available size of stream (q), except for Mesqas 13 and 22 where the head is a bit lower in the middle.

Application efficiency (E_a) was found to be independent of the available head (H), size of stream (q), or time spent in irrigation. Only a very weak, negative correlation was found between application efficiency (E_a) and water applied (W_a), even though W_a is used in the calculation of E_a.

The data can only suggest the possibility that irrigation time increases with distance from the intake of a canal or mesqa. Insufficient data are available to make a positive identification.

Relatively high average application efficiencies were obtained by farmers when irrigating by gravity as well as by lifting, with only slight differences between gravity and lifting.

The average soil moisture depletion rates peaked at about 4.5 mm per day for wheat and slightly below 4 mm for broad beans. This is assumed to be a reasonable estimate of consumptive use.

The average irrigation intervals practices by farmers, and the resulting average quantities of soil moisture replaced at each irrigation, appear satisfactory for the crops and soils involved.

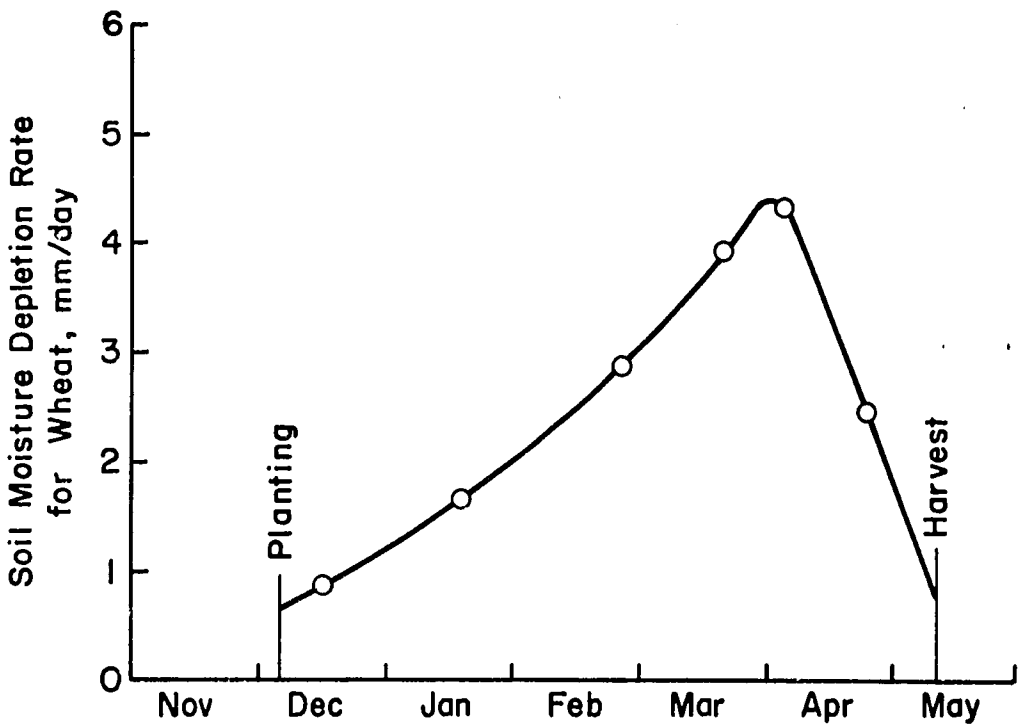

Figure 18. Soil moisture depletion rate for wheat, Abyuha Site, 1980-81

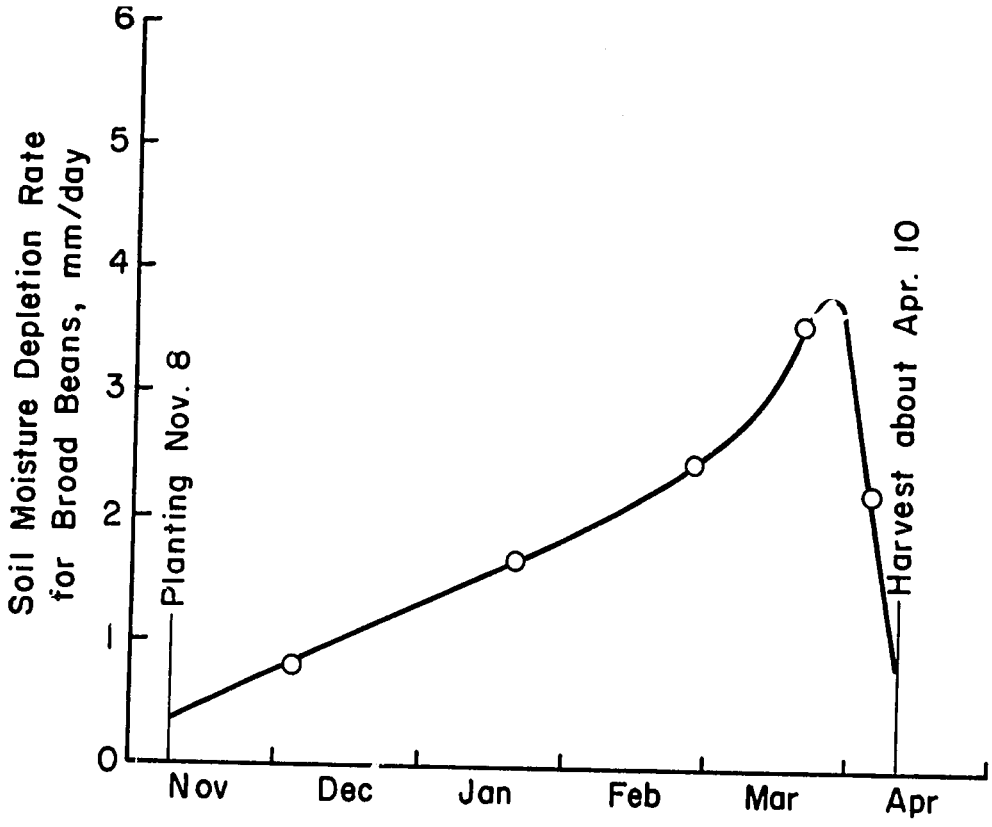

Figure 19. Soil moisture depletion rate for broad beans, Abyuha Site, 1980-81

B. Detailed Soils Studies

Management of water for crops grown on the heavy Abyuha soils is very complex. It was stated in hypotheses C, in Section III, that farmers do not understand these relationships. To help the field team understand how farmers currently manage their crops and soils, and to assist the field team in the design of appropriate intervention alternatives, detailed studies of the physical-chemical properties of the soils were conducted. These studies included a soil taxonomic survey and a root penetration study.

- Soil taxonomic survey

Abdel Wahed Salim, of the MOA, conducted a soil taxonomic survey by examining 87 soil profiles in the Abyuha area. The field and laboratory studies show that the area is quite uniform in soil morphological, salinity and physical characteristics. The soil texture is clayey throughout the profile but tends to be more clayey in the subsoil. Particle size distribution analysis of the representative samples shows that the clay content in the surface ranges from slightly less than 40% to more than 67%. In the subsoil, the clay content is only slightly higher, ranging between 42% and 69% (PTR# 33).

The soil has a weak subangular blocky structure in the surface and becomes more developed at the lower depths to give a strong, fine-angular, blocky structure. The soil has a firm, sticky and plastic consistency. Slickensides are quite evident in the subsoil. The soils of the area are generally non-saline and non-sodic, but both properties increase slightly with increasing depth. The soil cation exchange capacity ranges from 40 to 50 meq/100g, indicating that the clay fraction (<2μ) has a cation exchange capacity of more than 80 meq/100g. Since the soil is low in soil organic matter, this high cation exchange capacity is evidence that the dominant mineral in the clay fraction probably is montmorillonite.

All the soils of the area have been classified as Typic-Torrert without series or phase subdivisions. Typic-Torrerts belong to the Vertisol soil order.

These soils are characterized by deep cracks that develop upon drying during extended periods between crops. Loose soil falls into these cracks, and upon rewetting results in substantial vertical movement that may produce an uneven soil microrelief (gilgai) in the field. Research is needed to determine irrigation practices best suited to these heavy, cracking soils.

- Root penetration in Abyuha soils

Root penetration studies conducted by the on-site team in the Abyuha area have shown little root development below about 30 or 40 cm for maize, cotton and berseem or below 50 cm for sugarcane. Similar limited root penetration has been reported for Vertisols throughout the World under other cropping conditions. Thus, with the limited root penetration that has been observed, more frequent, lighter irrigations may be preferred. Light irrigations, however, may be less than the farmer is able to apply easily with the present management system. These root penetration studies data provide additional information that will assist in developing appropriate irrigation practices for farmers in the Abyuha area.

C. Detailed Economic Studies

Farm records begun on the nine farms (farm management units) for the 1979-80 cropping season were extended into the detailed studies to continue testing hypothesis statement F (Section V). These studies were designed to give a better understanding of the Abyuha irrigated farming system. All but of the record-keeping farms were owned by the farmers who work them.

Sizable differences existed in the number of livestock per farm and per feddan of land. Intensity of cropping, defined as the number of feddans planted to crops per year divided by the total number of feddans available, ranged from 2.6 feddans for the smallest farm to 0.88 for the largest farm. In general, the more intensive cropping practices were associated with the smaller farms.

Farms which had the most roughage-consuming livestock also tended to have the greatest amount of berseem. On most farms, about one half of the total value of crop production was fed to livestock or consumed in the home. The two large farms had a much higher proportion of marketable surplus from crops. Home use also claimed an important part of the value of livestock production on nearly all farms.

On a relative basis, livestock was a small contributor to farm income on farms in the Abyuha area. In addition to their contribution to food for the home consumption, livestock also contributed many hours for transportation. Livestock's contribution as draft power for field operations and lifting water was not as important in Abyuha as in the other Project sites, but their services as means of transport were relatively more important. The value of this

service added significantly to the gross value of livestock production. In several cases, the cost of feed, both purchased and home grown, exceeded the value of the livestock.

Crop enterprises were the largest single source of income, although animal product sales and live animal (capital) sales taken together averaged almost 25% of total gross income. The Abyuha farms accumulated significant increases in inventories during the 1979-80 crop year. The larger farms tended to provide more income per person, but the smaller farms were farmed more intensively and produced more income per feddan.

D. Socio-cultural Investigations

To investigate the hypothesis that socio-cultural factors affect irrigation practices (Hypothesis F, Section V), a survey of farmers was conducted to determine how the farmers irrigate and their perceptions of how the irrigation system is serving them.

The findings of the survey revealed that the Abyuha farmers, themselves, do most of the irrigation. This is in contrast to Mansuriya and Kafr El-Sheikh where there is much greater participation by other members of the family in irrigation activities.

With respect to critical times to irrigate, the farmers believed that the planting and germination irrigations were the most important. Most of the farmers did not perform a pre-irrigation before plowing. Slightly less than half of the farmers (44%) reported that they irrigate at night. Reasons given for night irrigation was varied, but the lack of sufficient water during the day was the most frequent response.

The number of irrigations for a crop of cotton or maize generally ranged from 9 to 11 and from 12 to 14 for sugarcane. Seventy-three percent of the farmers reported that their decision to irrigate was determined largely by the time interval (number of days) since the last irrigation. Plant or top-soil appearances as criterion for irrigation were given by only 15 and 7 percent of the farmers, respectively. Most farmers (84%) decided to stop irrigating a field when the ground was covered with water. Neither depth of water on the field nor a specific time period for irrigation were important factors used to decide when to stop an irrigation.

Most of the Abyuha farmers (78%) believed that the supply of irrigation water was adequate for cotton and maize, but was often limiting for sugarcane. The timing of the delivery of irrigation water was considered satisfactory by 94% of the farmers.

About 35% of the farmers believed that drainage was inadequate. Maintenance of either public or private ditches and drains was poor in the minds of most farmers. Slightly more than half of the farmers (56%) considered their fields to be sufficiently level for good irrigation.

IX. SUMMARY AND CONCLUSIONS

Problem identification is the first step in developing an on-farm research program. Its purpose, in the EWUP context at Abyuha, was to describe the irrigated farming system, to identify the primary constraints in the system, then use this information to design and test farm management alternatives that have a high probability of being integrated into the system.

The problem indentification step consists of several activities conducted in sequence. It begins with the collection and analysis of significant background information, then conducting farmer interviews and making preliminary field surveys. The information collected to this point in time is analyzed for an early statement of problems.

Next in sequence are the preliminary field investigations, and an analysis of the data to revise and restate the problem hypotheses. Those problem areas that still elude definition are studied in detail. Some problems, and their causes, may be identified early in the project, others may require longer periods of time. The problem identification step is not complete on a certain date, but instead, continues over time, with continuous feedback to better describe the system as new information is obtained. The time required for the description of an irrigated farming system usually takes longer than for the similar activity in a rainfed farming system. The Abyuha problem identification report covers the activities needed to obtain a description of one years' management of the irrigated farming system. The findings and conclusions are summarized in the following sections.

A. Summary of Problem Identification Findings

No strong evidence was found among the data gathered in the problem identification to indicate that fields located closer to the head of the Abyuha Canal or of a mesqa were better situated than other fields regarding available head (H) or available size of stream (q). Application efficiency (E_a) was found to be independent of the available head (H), size of stream (q), and time spent in irrigation.

Relatively high average application efficiencies were attained by farmers when irrigating either by gravity or by lifting, with only slight differences between the two.

The average soil moisture depletion rates peaked about 4.5 mm per day for wheat and slightly below 4 mm per day for broad beans. This was assumed to be a reasonable estimate of consumptive use for these crops.

The average irrigation interval practiced by farmers, and the resulting average quantities of soil moisture replaced at each irrigation appeared satisfactory for the crops and soils involved.

The soils of the area generally were non-saline. The electrical conductively of the saturation extract from the surface soil was very low, being about 1.5 mmhos per cm in most samples and slightly above 2 mmhos in only a few samples. The electrical conductivity increased slightly in the subsoil reaching 8 mmhos for only a few fields. The sodium absorption ratio (SAR) generally was low at the surface and increased gradually with depth but remained below 13 in most profiles.

A soil fertility survey was conducted in the fall, 1979, to determine available phosphorus, potassium, zinc, manganese, iron and copper. Soils were sampled to depths of 0-20, 20-40 and 40-60 cm. The analysis of these data indicates that, in addition to nitrogen, phosphorus and zinc were the plant nutrients that generally should be added for most crops to improve production under irrigation at Abyuha.

Based upon the soil classification survey, the clay soils found in the Abyuha are of the order Vertisol. They have the following characteristics: 1) steady-state infiltration of water was very slow and approached zero as soil swelling increased. When there was modest drying of the soil, cracks formed and water often reached the subsoil layers rapidly through the cracks rather than through usual infiltration mechanisms. During irrigation, once the clays in the surface layer were totally rewetted, infiltration was very slow. The

additional ponded water from irrigation may have to be drained away as soon as possible to obtain adequate aeration in the root zone; 2)root penetration was limited largely to the top 30 to 50 cm of soil; and 3) since considerable swelling occurred in these soils when wetted, considerable cracking also occurred upon drying. As the cracking increased, the roots across these cracks become stretched and some may even be pruned.

Some of the agricultural products are produced for household consumption; other products are fed to livestock which, in turn, supply food for the household. At the same time, the household provided an important amount of the labor used on the farm.

From 14 to 34 percent of the value of crop production was fed to livestock, and between 6 and 27 percent was consumed directly by the household. On the average, a much higher percentage of the value of livestock than crop production products were consumed by the household.

The irrigation system was shown to interact with the household through the labor supply, the cropping pattern and the soil resource to define the irrigation requirements. Farm records were used to reveal the pattern of irrigation practices during specific (two-week) periods of the year. Then, these irrigation practices, when compared with canal deliveries and the water requirements as defined by the stage of plant growth, provided information about the functioning of the irrigation system in relation to demands placed upon it.

The household labor supply, land available to the farmer, management alternatives as affected by expected profits, the resource base and Government policies all interacted to form the farmers' management plan each year. The relative profitability of crops varied, depending upon which resource was considered by the farmer to be most limiting. Generally, berseem provided the greatest return per unit of land. While returns per cubic meter (m^3) of water applied generally were favorable with berseem, other crops often gave equivalent or better return per m^3 of water.

Not only were significant amounts of farmer and farm family labor used on the farm, hired labor was the largest source of cash expenditure for purchased inputs. Thus, as labor becomes increasingly more expensive, the selection of crops based on returns per hour of labor may become of greater importance since a different order in the profitability of crops may result when returns per hour of labor become the profitability criterion.

Perhaps an overriding influence on technical and advances on Egyptian farms is Government policy. Both irrigation policies and agricultural price procurement policies are important.

Because farm incomes are so low, farmers appear to have limited ability to adopt improved technologies such as more efficient water management, mechanization or other output-increasing packages. Since water is supplied to the farmer as a free input, there is little financial incentive to use it more efficiently. The lack of financial incentive for farmers to increase water-use efficiency makes achieving Government goals for greater water-use efficiency more difficult. Farmers are the primary water users and unless their stake in the Government goals can be increased, improvements in on-farm water management practices will be slow. The leadership network among farmers in the Abyuha Canal area is not clearly defined and needs further study.

A survey of the farmers perceptions of the Abyuha irrigation system revealed that they believe they receive adequate water for their crops, except possibly for sugarcane. They did not believe that the location of the outlet along the mesqa (i.e. head, middle, tail) had much effect on the supply of water delivered to a field. In their opinion, neither government nor private ditches and drains were properly maintained. They also believed that their fields generally were as level as they need be for irrigation purposes.

The socio-political constraints which govern specific irrigation practices in Abyuha were not determined during the problem identification. These constraints should be documented.

B. Conclusions and Proposed Future Activities

The primary constraints were identified in this early-on study of the Abyuha irrigated farming system. Symptoms of other problems were noted and additional studies will be required to better define their importance in the system.

The EWUP team will now conduct a planning seminar to design, research and test the proposed solutions to the identified problems. Potential solutions for testing include technical interventions (such as precision land leveling, irrigation scheduling, improved field layout of the irrigation system), formation of water users associations, more effective use of the farmers resources, and adjusting the irrigation delivery system to fit the soil and crop management practices more effectively, as well as the reverse relationship. As the Project progresses, additional site-specific research may be required to

assist in designing the appropriate irrigation interventions, for example, (1) a better characterization of the unique soil-physical system in Abyuha as it relates to water movement, root penetration and soil aeration, (2) delineation of the leadership network among the farmers in the Abyuha Canal area, and documentation of the specific irrigation practices of farmers in Abyuha emphasizing the socio-political constraints governing such practices, and (3) benefit-cost analyses of the proposed technical and socio-cultural interventions.

AMERICAN EQUIVALENTS OF EGYPTIAN ARABIC TERMS AND MEASURES COMMONLY USED IN IRRIGATION WORK

LAND AREA	IN SQ METERS	IN ACRES	IN FEDDANS	IN HECTARES
1 acre	4,046.856	1.000	0.963	0.405
1 feddan	4,200.833	1.038	1.000	0.420
1 hectare (ha)	10,000.000	2.471	2.380	1.000
1 sq. kilometer	100×10^4	247.105	238.048	100.000
1 sq. mile	259×10^6	640.000	616.400	259.000

WATER MEASUREMENTS	FEDDAN-CM	ACRE-FEET	ACRE-INCHES
1 billion m^3	23,809,000.000	810,710.000	
1,000 m^3	23.809	0.811	9.728
1,000 m^3 /Feddan (= 238 mm rainfall)	23.809	0.781	9.372
420 m^3 /Feddan (= 100 mm rainfall)	10.00	0.328	3.936

OTHER CONVERSION		METRIC	U.S.
1 ardab	=	198 liters	5.62 bushels
1 ardab/feddan	=		5.41 bushels/acre
1 kg/feddan	=		2.12 lb/acre
1 donkey load	=	100 kg	
1 camel load	=	250 kg	
1 donkey load of manure	=	0.1 m^3	
1 camel load of manure	=	0.25 m^3	

EGYPTIAN UNITS OF FIELD CROPS

CROP	EG. UNIT	IN KG	IN LBS	IN BUSHELS
Lentils	ardab	160.0	352.42	5.87
Clover	ardab	157.0	345.81	5.76
Broad beans	ardab	155.0	341.41	6.10
Wheat	ardab	150.0	330.40	5.51
Maize, Sorghum	ardab	140.0	308.37	5.51
Barley	ardab	120.0	264.32	5.51
Cottonseed	ardab	120.0	264.32	8.26
Sesame	ardab	120.0	264.32	
Groundnut	ardab	75.0	165.20	7.51
Rice	dariba	945.0	2081.50	46.26
Chick-peas	ardab	150.0	330.40	
Lupine	ardab	150.0	330.40	
Linseed	ardab	122.0	268.72	
Fenugreek	ardab	155.0	341.41	
Cotton (unginned)	metric qintar	157.5	346.92	
Cotton (lint or ginned)	metric qintar	50.0	110.13	

EGYPTIAN FARMING AND IRRIGATION TERMS

fara = branch
marwa = small distributer, irrigation ditch
masraf = field drain
mesqa = small canal feeding from 10 to 40 farms
qirat = cf. English "karat", A land measure of 1/24 feddan, 175.03 m^2
qaria = village
sahm = 1/24th of a qirat, 7.29 m^2
saqia = animal powered water wheel
sarf = drain (vb.), or drainage. See also masraf, (n.)

EGYPT WATER USE AND MANAGEMENT PROJECT

PROJECT TECHNICAL REPORTS

NO.	TITLE	AUTHOR
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PTR#3	Preliminary Evaluation of Mansuriya Canal System, Giza Governorate, Egypt.	American and Egyptian Field Teams.
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