# NILE VALLEY REGIONAL PROGRAM
# PHASE II

## Resource Management Series

### Volume 16

## MULTIDISCIPLINARY SURVEYS

## Old Lands of Egypt

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Volume 16

# Resource Management in the Old Lands of Egypt: Multidisciplinary Surveys

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# Foreword

Limited soil and water resources and threatened sustainability of agricultural production call for an effective resource management strategy and farming systems approach in agricultural research. Implementing a long-term research program where more emphasis would be on systems-oriented rather than commodity-oriented agricultural research would represent such a strategy. Therefore, the Resource Management Component of the Nile Valley Regional Program (NVRP) of the International Center for Agricultural Research in the Dry Areas (ICARDA) was developed. The Component, which started in 1994 in one of the Nile Valley countries, Egypt, and is expected to be extended to the others, aims at achieving sustainable production at a high level, based upon the need to protect the resource base (land and water) through good management. This would be achieved through basic intensive technical research (long-term on-station trials) and on-farm extensive monitoring of resources in farmers' fields and farmers' decision making logic.

Preparatory studies were carried out prior to conducting the trials and monitoring activities. The objectives of these studies were to define and characterize the major farming systems of the main agroecological environments; to identify and prioritize—with respect to the natural resources—the constraints to optimum utilization and the threats to sustainable production; and to provide an outline for the strategy, design and implementation of the long-term research activities.

The preparatory studies involved three procedures for information collection: **Inventory Studies**, in which existing information and details of the ongoing research and development, related to soil and water management, agronomy and cropping systems, and socioeconomics were collected; **Rapid Rural Appraisals**, which included qualitative sampling of farmers and extension views concerning current limitations, constraints, dangers, and opportunities in the utilization of soil, water, and inputs; and **Multidisciplinary Surveys**, which employed short-focused questionnaires to fill some important information gaps. In general, information collected in the preparatory studies dealt with resource description, resource utilization and management, productivity, and threats to sustainability. This knowledge was used in planning the long-term research activities at selected locations by identifying high-priority researchable resource management problems, in the context of realistic cropping sequences and farm level economics.

The outcome of these studies is hence presented in what is called the **Resource Management** Series. The series includes a total of 18 volumes on Inventory Studies, Rapid Rural Appraisals, and Multidisciplinary Surveys in the Old Irrigated Lands, New Lands, and Rainfed Areas. In the Inventory Studies, five volumes on the research and development activities and findings in each of the Old and New Lands were compiled. These volumes were on Agronomy, Soil Fertility and Management, Water Management, Socioeconomic Studies, and a Synthesis of all the latter. The Inventory Studies of the Rainfed Areas included two volumes, one on the Northwest Coast and the other on North Sinai.

These studies were conducted in Egypt with the involvement of the Agricultural Research Center (ARC), Desert Research Center (DRC), National Water Research Center (NWRC), National Research Center (NRC), Ain Shams University and ICARDA within the NVRP with financial support from the European Commission. Appreciation is expressed to all those who contributed to these important reviews and studies.

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## Weights and Measures

1 feddan (fed) = 0.42 hectare = 1.037 acres
1 hectare (ha) = 2.38 feddans
1 qentar (cotton) = 150 kg

## Acronyms

ARC = Agricultural Research Center
EC = Electrical Conductivity
ET = Evapotranspiration
EU = European Union
ICARDA = International Center for Agricultural Research in the Dry Areas
TSS = Total Soluble Salts

# Results of the Multidisciplinary Survey in the Old Lands: Beni Suef Area

## Qemn El Arous Village

# Methodology Used in the Multidisciplinary Surveys

## Conducting the Surveys

A specific questionnaire was designed for each site surveyed, each questionnaire comprising four parts:

(i) Structural information (description of the household, land area, livestock, etc.).

(ii) Crop rotations recorded by plot over four to five years. In Beni Suef and North Sinai, the whole farm was not recorded systematically if the farmers had too many plots. In these two sites, the first plots to be recorded were those located in the area of interest, according to the sampling method.

(iii) Crop-related information. For at least four crops/farmers, all relevant information on cropping practices and yields was recorded on standard "crop sheets." All this detailed information always referred to the previous season (summer or winter) and to a specific plot so as to record the exact data in relation to the preceding crop.

(iv) Soil and water management aspects. All questions related to fertility, soil degradation, and water availability were recorded.

In each site, a different sampling strategy was devised according to the local specificities and available information. Sampling was always done with the help of a local informant. Farmers' names were randomly selected within each defined category, usually according to the position of their plot. In the New Lands, farmers were selected from detailed maps where all plots were recorded. In Beni Suef, selection was done by visiting each selected area and randomly selecting plots or farmers.

All surveys were conducted in the farmers' fields.

## Method of Analysis

### *Structural information*

Family size was measured by using the human consumption unit (HCU) concept, with the following scale:

Adult man 15–60 = 1 HCU

Adult woman 15–60 = 0.8 HCU

Child less than 15 = 0.5 HCU

Old person over 60 = 0.5 HCU

Only family members who permanently resided with the farmer were recorded.

Available family labor was measured using the human labor unit (HLU) concept, which was calculated using the same scale as for HCU but multiplying by the rate of presence of the person, as given by the farmer. For example, an adult farmer spending all his time on his farm = 1 HLU; his adult wife who would spend only half of her time on farm work = 0.8 × 50% = 0.4 HLU.

Livestock holding was measure in livestock units (LU). 1 LU = one cow of 250 kg. The value in LU of other animals is as follows:

Young cow = 0.7

Adult buffalo = 1.2; Young = 0.8

Adult sheep or goat = 0.2; Young = 0.15

Donkey = 0.4

Horse = 1.2

Camel = 2

Poultry was not included in this livestock inventory.

Structural ratios were calculated. The cultivated area divided by family size (CA/HCU) gives the average land area available to the farmer to sustain one member of his family (in HCU). The family labor by cultivated area (HLU/CA) gives the area that each labor unit in the family has to work on.

### *Cropping patterns and rotations*

All the crop sequences were recorded with the specific area for each crop each year. This allowed calculating the percentage of land cultivated by each crop on each farm (or field, in the case of Beni Suef and North Sinai) and to recreate the trend at the farm level. By adding all the crop areas for each farmer and dividing the result by the total cultivated area in our sample, we obtained the estimated share of land devoted to each crop on the same total sampled area.

### *Fertility management and soil degradation*

All information included in this analysis came from two sources:

- General information (qualitative data) obtained from the farmer at the end of the survey.
- Crop-specific information recorded on the crop sheets.

The two were combined in the synthesis and were almost always in agreement.

Values for yield and fertilizer application were always recorded for at least two dates: the previous season and five years ago (or less if the farmer started cultivating less than five years ago, as found in the New Lands).

All the information reported in the synthesis came from the farmers' interviews. No modifications were made to what the farmers told us, whether we agreed with it or not.

# Summary

## Cropping Patterns and Rotations

### *Winter*

- Berseem is slightly decreasing in favor of wheat.
- Faba bean is also decreasing and remains a minor winter crop.

### *Summer*

- Maize is the major crop.
- Cotton is decreasing in favor of maize.

### *Rotations*

- Cotton every three years and cotton every two years are the most common rotations.
- Berseem–wheat and berseem–berseem–wheat are the prevailing winter rotations.
- Traditional fixed rotations are disappearing to the benefit of more opportunistic rotations (especially with the increasing role of tomato).

## Fertility Management

### *Evolution of crop yields*

- Yields increased for cotton, wheat, and fenugreek and decreased for onion, tomato, and faba bean (pest-related problems).

### *Manure and fertilizers*

- Most farmers use more manure than before and usually more fertilizers also.
- Summer crops have more priority in receiving manure and legume crops are usually not manured.
- P is given more priority for berseem and vegetables. It is also becoming more frequent on cotton. For almost all crops, P rates correspond to recommendations (but for wheat, few farmers add it).
- N is applied in excess to legumes and cotton.

### *Legume crops*

- N fertilization is not substantially reduced after berseem (even increased in the case of tomato).

- Legume crops are coming on average every 1 year and 7 months on the same plot (from seeding to seeding). Their importance is decreasing in the local cropping pattern.

## Water Management and Soil Degradation

### *Trend in water supply*

- The water quantity presently available is usually more than before in winter but is still insufficient in summer.
- Drainage water is used at different rates depending on the plot location (head, tail end, far from/close to drain). The rates recorded go from 0 to 100%.

### *Irrigation levels*

- Irrigation is applied in excess for all crops, especially berseem, wheat, cotton, and tomato.

### *Water quality*

- Most farmers testified that canal water quality has changed to the worse.

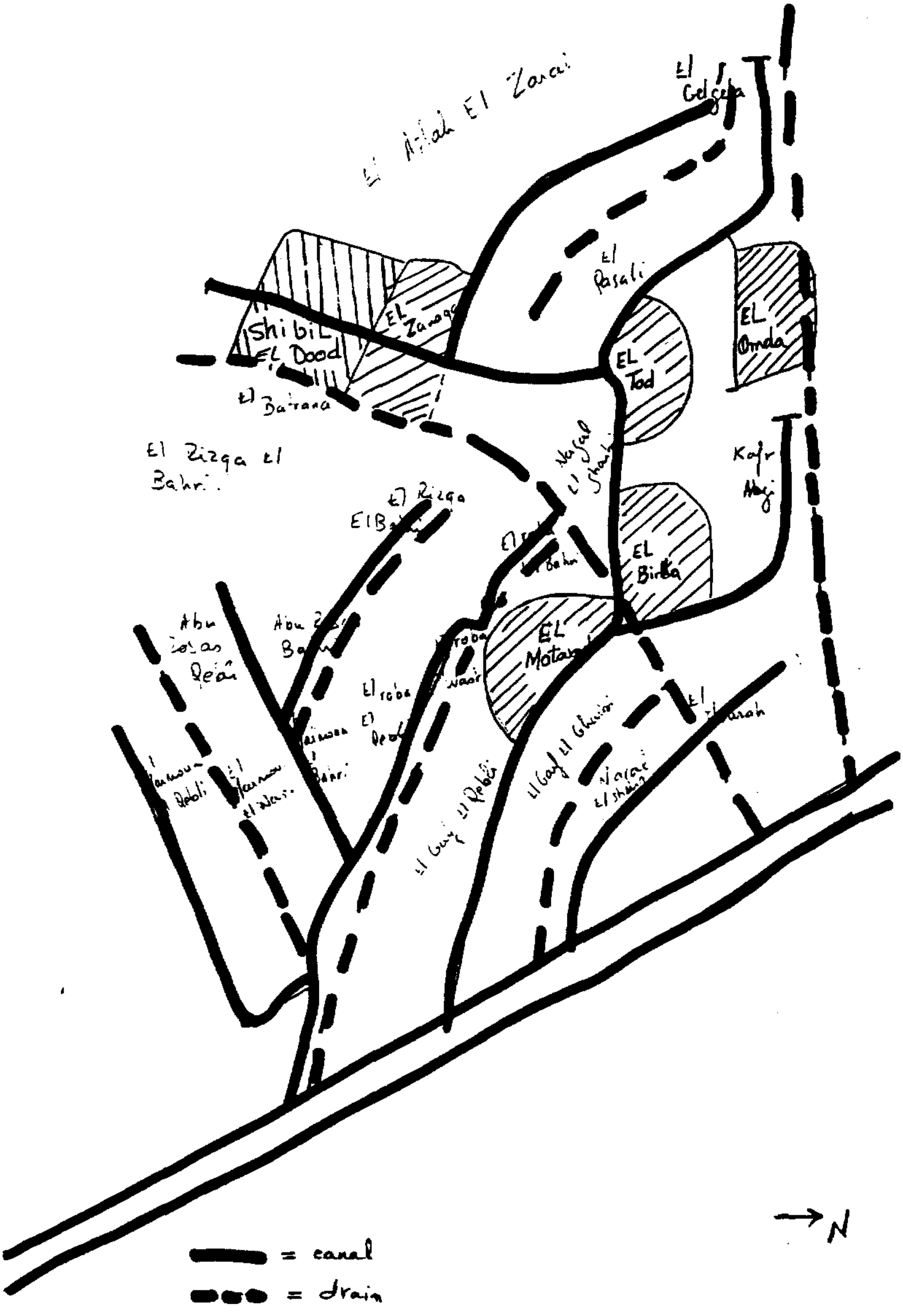
### *Soil salinization*

- The use of drainage water has less negative effects on soil salinity than a drainage system that does not work well.

## Introduction

The survey was conducted in the village of Qemn El Arous, located 35 km north of Beni Suef in Middle Egypt. The population of the village is around 50,000, the total area is about 6,540 fed, and the total cultivated area is around 6,000 fed. Six different basins (or groups of plots) were selected from the village map, representing different irrigation and water supply situations. The names of the basins are: El Birka, El Matared, El Omda, Shibil El Dood, El Tod, and El Zanqa. The survey team then visited these basins and randomly selected 4 to 6 farmers who had plots in these areas. Altogether 29 farmers were surveyed, distributed among the 6 basins, as shown in Map 1.

The surveys were always conducted in farmers' fields, and soil samples were collected from the fields at the end of the survey.




**Map 1. Location of the selected basins in Qemn El Arous.**

## Structural Data on the Surveyed Farmers

Table 1 gives an overview of the main descriptors used in characterizing the sample. The main points are:

**Table 1. Average value and range of structural variables of the surveyed farmers in Qemn El Arous.**

| Criterion | Average value | Range |
|---|---|---|
| Age (median) | 41 | 20–70 |
| Family size (HCU)† | 6.6 | 1.7–13.2 |
| Family workforce (HLU)‡ | 3.4 | 0.5–8.8 |
| Total cultivated area (TCA) | 3.8 fed | 0.75–17 fed |
| % farmers not owning land | 19 (average TCA = 2.19 fed) | |
| % farmers owning and renting land | 44 (average TCA = 4.73 fed) | |
| % farmers not renting land | 37 (average TCA = 3.50 fed) | |
| Average number of fields | 2.3 | 1–6 |
| Average field size | 1.7 fed | 0.47–3.17 fed |
| % of animal holders | 97 | |
| Average livestock size (in LU)§ | 4.2 | 0.4–11 |
| Structural ratio | | |
| TCA/HCU | 0.61 fed | 0.17–2.5 fed |
| HLU/TCA | 1.33 | 0.21–3.52 |

† HCU = Human consumptive unit.
‡ HLU = Human labor unit.
§ LU = Livestock unit.
1 fed = 0.42 ha.

### Family Size and Workforce

Families are usually large (6.6. adults on average) and about 50% of the family members work full-time on the farm (women usually spend 50% of their time). Variability in family size is not negligible (42%) and even more so in family labor (56%).

### Total Cultivated Area

The average size of the cultivated area (3.8 fed) in the sample is higher than the village average since a few large farmers (9–17 fed) were surveyed, which are much less represented at the whole village level than in this sample. Data from the Rapid Rural Appraisals study gave an average size of 1.70 fed, which is certainly closer to reality.

### Land Tenure Pattern

Most of the farmers own and rent land at the same time. It is also in this class of farmers that the average holding is the highest. Landless farmers are only 19% and have limited farms. Also, farmers who do not rent land have smaller holdings, meaning that they might be constrained by limited means to rent more land. This data also shows that farm expansion is almost possible only by renting land (land price being prohibitive for the farmers).

### Livestock Data

Virtually all farmers have animals, but livestock size is highly variable (59%). An average herd would be one buffalo, two cows and one calf.

### Structural Ratios

The ratio of total cultivated area by human consumptive unit (TCA/HCU) gives the average land size available per family member (counted as adult men). It is low in Beni Suef compared to the New Lands for example (1–2 fed). But it is also very different from one farmer to another (85% variation). This shows that the socioeconomic ladder in this village—and certainly in the rest of the Old Lands—is quite spread and therefore farm management will not be uniform.

The same applies to the average labor force per cultivated feddan (HLU/TCA). It varies from 0.21 to 3.52 (in that case, most of the family members would work as daily laborers).

## Cropping Patterns and Rotations

The cropping patterns and rotations practiced in the village have been derived from the crop sequences recorded by the multidisciplinary survey team. At least one field (which can contain more than one plot) was surveyed for each farmer, sometimes more. For half of the farmers, this allowed us to survey their whole farm. For the rest, who had more than two fields, only part of their farm was surveyed. Altogether, the data obtained represents the cropping patterns and rotations practiced on 67 fed of the village (1% of village cultivated area).

### Evolution of Cropping Patterns

#### *Past trend*

The crop sequences by plot were recorded for the last three years and for the present year. Farmers were also questioned on their plans for next year in terms of plot allocation to various crops. Yet, we based our cropping pattern description on the past and present years only.

The dynamics of the local cropping patterns are presented in Table 2 and Fig. 1.

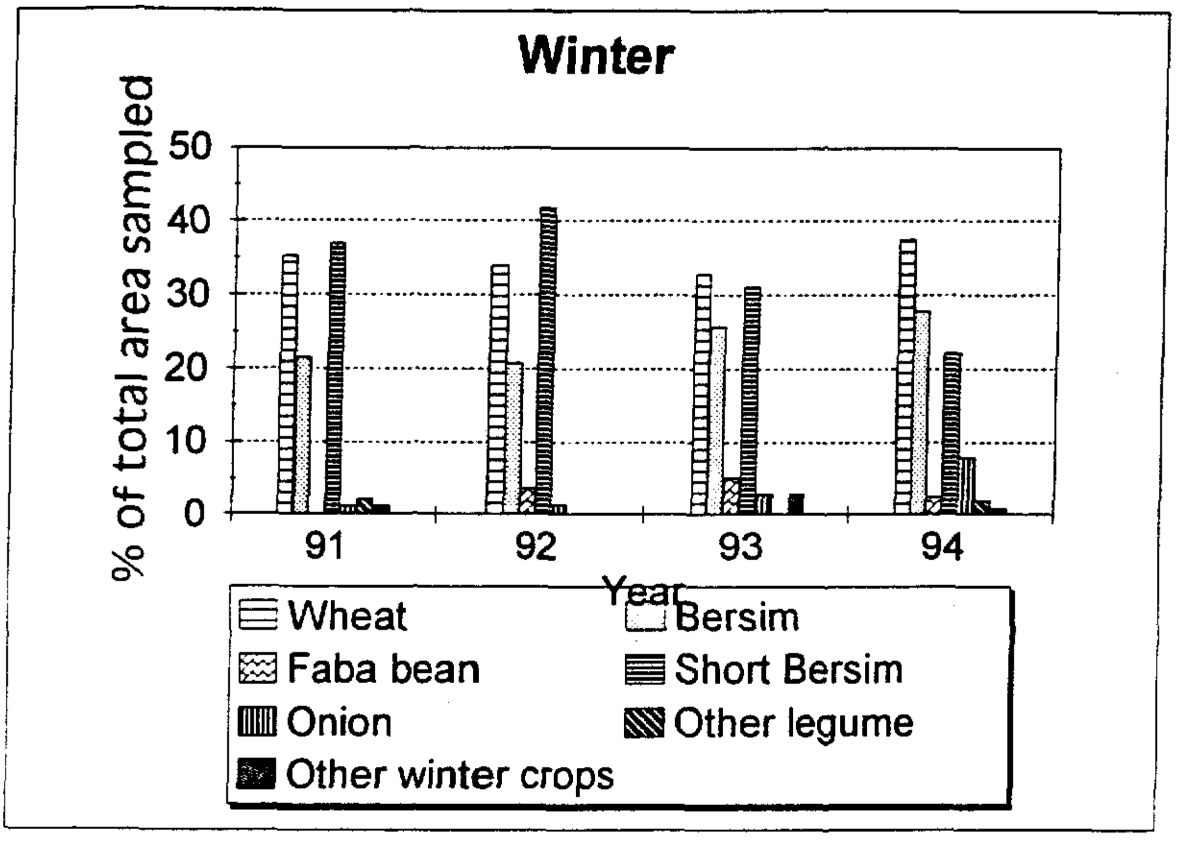
**Table 2. *Percentages of total cultivated area of winter and summer crops.***

| Winter crops | | | | | Summer crops | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Year** | **91** | **92** | **93** | **94** | **Year** | **92** | **93** | **94** | **95** |
| Wheat | 35 | 34 | 33 | 37 | Maize | 45 | 44 | 42 | 46 |
| Short berseem | 37 | 42 | 31 | 22 | Cotton | 35 | 28 | 32 | 26 |
| Berseem | 21 | 21 | 26 | 28 | Tomato | 15 | 11 | 18 | 20 |
| Onion | 1 | 1 | 3 | 8 | Other legumes (*lubia*) | 0 | 2 | 1 | 1 |
| Faba bean | 0 | 4 | 5 | 5 | Other summer crops (sesame) | 0 | 3 | 0 | 1 |
| Other legumes (termes, helba) | 2 | 0 | 0 | 2 | | | | | |
| Other winter crops | 1 | 0 | 3 | 1 | | | | | |

In winter, the wheat area tends to increase at the expense of short berseem (i.e., at the expense of cotton, since short berseem is a catch crop always followed by cotton) and faba bean. The same applies to berseem and, to a lesser extent, to onion (becoming more and more spread as a preceding crop for cotton under a relay-cropping system).

In summer, maize remains the major crop, whereas cotton is on the decline and tomato on the rise.

In addition to these data, only 28% of the farmers said that they had introduced new crops to their cropping system, while 62% abandoned one or more (faba bean, sesame and watermelon). In particular, 51% of the farmers said that they had stopped cultivating faba bean over the last four years due to insect pest control issues.



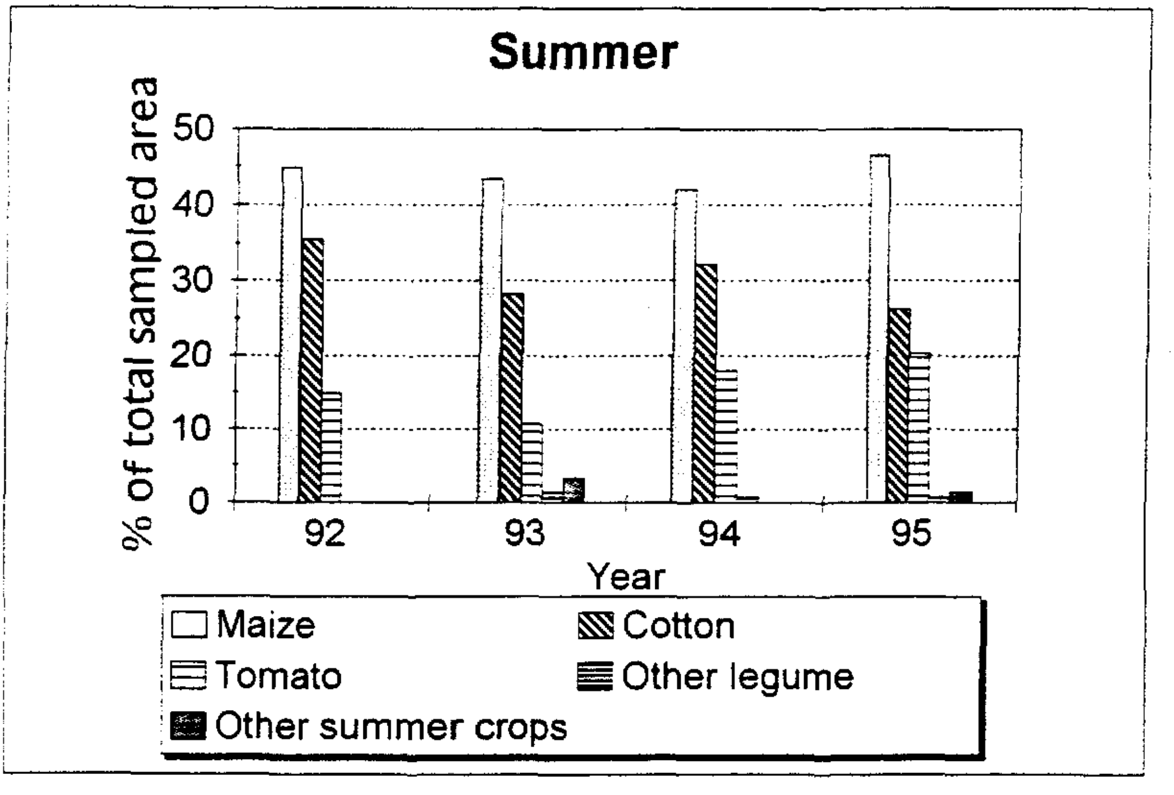




**Fig. 1. Cropping pattern trends in Qemn El Arous (Beni Suef area).**

### *Future expected trends*

Table 3 shows that the wheat share of the winter cropped area should continue to increase, whereas maize might expand more at the expense of cotton. Tomato might have reached its peak level (growing pest build-up issues) as well as berseem.

**Table 3. Future expected trend in crop areas (according to farmers' views) in Qemn El Arous.**

| Crop | Berseem | Wheat | Maize | Tomato | Cotton | Faba bean | Onion |
|---|---|---|---|---|---|---|---|
| Up | 39 | 72 | 77 | 22 | 17 | 0 | 6 |
| Down | 54 | 8 | 8 | 23 | 23 | 23 | 31 |
| Balance | –15 | +64 | +69 | –1 | –6 | –23 | –25 |

## Crop Rotations

Rotations were classified according to the occurrence of cotton as a summer crop, since local cropping systems are still very much influenced by cotton (for example, planting short berseem or wheat in a plot in winter will depend on whether the same plot will be planted with cotton the following summer).

The various rotation classes are summarized in Table 4.

It was found that the most common rotations are:

**A. Cotton every 2 years with maize or tomato as other summer crops:**

Wheat and berseem are the main winter crops.

Example: Short Berseem/Cotton–Wheat/Maize

Short Berseem/Cotton–Berseem/Maize

Short Berseem/Cotton–Wheat/Tomato

Thirty-eight percent of the surveyed cultivated area follows this rotation and 39% of the inventoried crop sequences. Maize is the most common summer crop in alternation with cotton in this rotation.

Although the government is now trying to enforce three-year cotton rotations instead of this traditional two-year one, the latter seems to be still dominant in this region.

**Table 4. Tentative classification of prevailing crop rotations in Qemn El Arous (Beni Suef area).**

| Cotton occurrence in summer | A | No. | No. of other summer crops | A | No. | Summer crops rotation | A | No. | Winter crops rotation | A | No. | Example | Rotation years |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cotton every 2 years | 38 | 32 | 1 crop | 31 | 30 | Cotton–Maize | 23 | 21 | Berseem as sole winter crop | 9 | 9 | Berseem/Cotton–Ber/Maize | 2 |
| | | | | | | | | | Berseem–Wheat | 14 | 12 | Ber/Cotton–Wheat/Maize | 2 |
| | | | | | | Cotton–Tomato | 8 | 9 | Berseem–Wheat | 5 | 4 | Ber/Cotton–Wheat/Tomato | 2 |
| | | | | | | | | | not fixed (W, B, onion) | 3 | 5 | Onion/Cotton–W/T–B/T | 2 |
| | | | 2 crops | 7 | 9 | Cotton–Maize–Cotton–Tomato | 7 | 9 | Berseem only | 3 | 3 | B/Cotton–B/M–B/Ct–B/T | 4 |
| | | | | | | | | | not fixed (onion, B, W) | 4 | 6 | Onion/Ct–B/M–B/Ct–B/T | |
| Cotton every 3 years | 35 | 32 | 1 crop | 23 | 18 | Cotton–Maize–Maize | 22 | 17 | Berseem–Berseem–Wheat | 22 | 17 | Berseem/Ct–B/Maize–B/M | 3 |
| | | | | | | Cotton–Tomato–Tomato | 1 | 1 | Berseem only | 1 | 1 | Ber/Ct–B/Tom–B/Tom | 3 |
| | | | 2 crops | 12 | 13 | Cotton–Maize–Tomato or Cotton–Tom–Maize | 12 | 13 | Berseem–B–Wheat or Berseem–Wheat–Wheat | 12 | 13 | Berseem/Cotton–Wheat/M–Wheat/Tomato | 3 |
| Cotton 2 years in a row | 9 | 6 | 1 crop | 2 | 3 | Cotton–Cotton–Maize–Maize | 2 | 3 | Berseem–B–Wheat–W | 2 | 3 | Berseem/Cotton–B/Ct–Wheat/Maize–W/M | 4 |
| | | | 2 crops | 7 | 3 | Cotton–Cotton–Maize–Tomato | 7 | 3 | not fixed (B, W, Faba bean) | 7 | 3 | Berseem/Ct–Berseem/Ct–Wheat/Maize–Wheat/Maize | |
| Cotton every 4 years or less | 15 | 17 | 2 to 3 crops | 15 | 17 | not fixed (Maize, Cotton, Tomato, Lubia, ...) | 15 | 17 | not fixed (Wheat, Berseem, Onion, Faba bean) | 15 | 17 | Berseem/Cotton–W/Maize–Berseem/Maize–Wheat/M–Berseem/Tomato ... | |

Crop codes: B = Ber = Berseem; W = Wheat; Ct = Cotton; M = Maize; Tom = T = Tomato.

A = Area.

**B. Cotton every 3 years with maize and/or tomato as other summer crops.**

The most common is to have maize two years in a row after cotton. However, rotations including maize and tomato after cotton are gaining importance also.

Examples: Short Berseem/Cotton–Berseem/Maize–Wheat/Maize

Short Berseem/Cotton–Berseem/Maize–Wheat/Tomato

Short Berseem/Cotton–Wheat/Maize–Berseem/Tomato

These rotations make up 32 % of all the rotations inventoried by the multidisciplinary survey team (and 35% of the total sampled area).

**C. Cotton every 4 years**

This type of rotation represents 17% of the recorded crop sequences and occupies 15% of the surveyed area.

Table 5 gives additional information on crop successions. The percentages expressed in that table tell us for such crop, what the percentage is in the cases (throughout our sample) in which it is followed by such crop. This exercise has been done for winter-to-summer successions, as well as for winter-to-winter and summer-to-summer.

**Table 5. Crop successions in Qemn El Arous, Middle Egypt (expressed in % of recorded cases).**

| Following / Preceding | Wheat | Berseem | Short berseem | Faba bean | Onion | Helba | Termis | Lubia | Maize | Tomato | Cotton | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Winter/summer and summer/winter** | | | | | | | | | | | | |
| Wheat | | | | | | | | 1 | 63 | 36 | | 100 |
| Berseem | | | | | | | | 1 | 48 | 25 | | 100 |
| Short berseem | | | | | | | | | | | 100 | 100 |
| Faba bean | | | | | | | | 33 | 33 | 33 | | 100 |
| Onion | | | | | | | | | 6 | | 94 | 100 |
| Helba | | | | | | | | | 50 | 50 | | 100 |
| Termis | | | | | | | | | | | | |
| Lubia | 25 | 25 | 25 | | | | | | 25 | | | 100 |
| Maize | 30 | 17 | 44 | 1 | 5 | 1 | | | | 1 | | 100 |
| Tomato | 23 | 13 | 47 | | 17 | | | | | | | 100 |
| Cotton | 41 | 47 | 5 | 5 | | 1 | | | | | | 100 |
| **Winter/winter** | | | | | | | | | | | | |
| Wheat | 17 | 21 | 55 | 1 | 6 | | | | | | | 100 |
| Berseem | 43 | 12 | 33 | | 9 | 1 | 1 | | | | | 100 |
| Short berseem | 43 | 44 | 6 | 6 | | | | | | | | 100 |
| Faba bean | 22 | 56 | 11 | | 11 | | | | | | | 100 |
| Onion | 25 | 63 | | | | 13 | | | | | | 100 |
| Helba | | | | | | | | | | | | |
| Termis | 100 | | | | | | | | | | | 100 |
| Lubia | | | | | | | | | | | | |
| Maize | | | | | | | | | | | | |
| Tomato | | | | | | | | | | | | |
| Cotton | | | | | | | | | | | | |
| **Summer/summer** | | | | | | | | | | | | |
| Wheat | | | | | | | | | | | | |
| Berseem | | | | | | | | | | | | |
| Short berseem | | | | | | | | | | | | |
| Faba bean | | | | | | | | | | | | |
| Onion | | | | | | | | | | | | |
| Helba | | | | | | | | | | | | |
| Termis | | | | | | | | | | | | |
| Lubia | | | | | | | | | 75 | | 25 | 100 |
| Maize | | | | | | | | | 36 | 12 | 52 | 100 |
| Tomato | | | | | | | | | 29 | 7 | 64 | 100 |
| Cotton | | | | | | | | 3 | 62 | 29 | 7 | 100 |

## Fertility Management

### Evolution of Soil Characteristics

Farmers were asked to describe the main changes they perceived in the soil quality of their field (the one that was surveyed) during the last 10 years. The answers go as follows:

| Change | Salinity increase | Salinity decrease | Improvement | Waterlogging |
|---|---|---|---|---|
| % farmers | 57 | 13 | 22 | 4 |

Most of the farmers viewed the changes in their soils as negative, with an increase of salinity. Improvements usually refer to better drainage and higher fertility.

We also tried to relate the farmers' perceptions to the position of their field. Results are given in Table 6.

**Table 6. Soil changes according to field position (expressed in % of farmers).**

| | Salinity level (from soil analysis) | | | | | |
|---|---|---|---|---|---|---|
| | High | | Medium | | Low | |
| Basin | Birka | Matared | Omda | Shibil | Tod | Zanqa |
| Salinity trend | | | | | | |
| Up | 80 | 75 | 100 | 0 | 25 | 66 |
| Equal | 0 | 0 | 0 | 100 | 50 | 0 |
| Down | 20 | 25 | 0 | 0 | 25 | 34 |

These data show that, in general, the highest proportions of farmers mentioning salinity increase are reached for the basins already severely touched by salinity build-up.

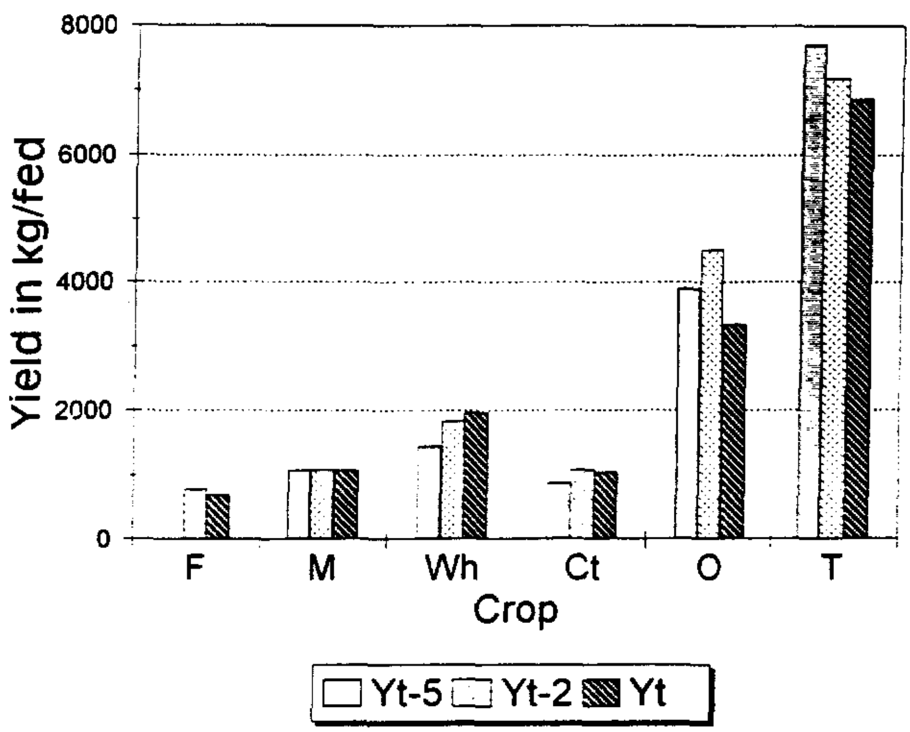
### Evolution of Crop Yields

Although there was an increase in yield for some crops over the last 3 years (wheat, cotton, helba), the yield of some others has declined (Table 7 and Fig. 2). For example, yield of wheat increased by 35% due to new varieties and new agricultural policies which encouraged farmers to produce wheat, while yield of faba bean decreased by 10% due to viral diseases.

Table 7. Yield evolution by crop (kg/fed).

| Crop | Yield last season (Y1) | | Yield 2 years ago (Y2) | | Yield 5 years ago (Y3) | | % variation between Y1 and Y3 |
|---|---|---|---|---|---|---|---|
| | Value | Range | Value | Range | Value | Range | |
| Maize | 1080 | (350–1630) | 1086 | (560–2000) | 1081 | (420–2100) | 0 |
| Cotton | 6.7 qentar | (5–10) | 6.9 q | (4–10) | 5.9 q | (3–10) | +14 |
| Onion | 3333 | (2500–4500) | 4500 | (4500) | 3900 | (2000–5500) | –14 |
| Wheat | 1971 | (1200–2700) | 1846 | (1200–2700) | 1456 | (750–2250) | +35 |
| Tomato | 6869 | (1200–14000) | 7200 | (2000–12000) | 7708 | (3000–15000) | –11 |
| Faba bean | 698 | (465–930) | 775 | (775) | NA | NA | –10 |
| Helba (fenugreek) | 50 | (50–60) | NA | NA | 45 | (30–60) | +11 |

NA = Not available.




Legend: F = Faba bean, M = Maize, Wh = Wheat, Ct = Cotton, O = Onion, T = Tomato

**Fig. 2. Trend of crop yields over a period of five years in Qemn El Arous (Beni Suef area), 5 years ago (Yt–5), 2 years ago (Yt–2) and now (Yt).**

## Methods of Fertility Management

With respect to the farmers' opinions concerning the best fertility management methods, the question was not restrictive in terms of soil fertility only, but referred more to the land quality. Therefore, some of the answers obviously dealt with problems which are not related to what is considered as fertility management. This question also focused on methods having long-term effects.

Cultural practices refer to repeated ploughing, weeding, furrowing, pest control, etc. The most surprising in this opinion poll is the absence of legume crop cultivation as a fertility maintenance method (Table 8).

**Table 8. Farmers' best methods to maintain soil quality (expressed in % of farmers mentioning the method), Qemn El Arous (Beni Suef area).**

| Method | % of farmers |
|---|---|
| Intensive cultural practices | 71 |
| Manuring | 61 |
| Improving drainage | 43 |
| Irrigation | 25 |
| Fertilizers | 18 |
| Weeding | 14 |
| Crop rotation | 11 |
| Addition of clay | 11 |
| Leveling | 4 |
| Nematode control | 4 |

We will now concentrate on the methods dealing strictly with soil fertility.

### *Use of manure*

#### *General data on the use of manure*

All farmers used cattle manure mixed with soil in their fields and a small majority had increased the rates applied. It is obvious that summer crops are favorites for manure application, whereas wheat is not even mentioned (Table 9). We also tried to relate the trend in manure use to the trend in fertilizer use. The results are:

- 15% of the farmers said they had increased manure and reduced fertilizers.
- 11% had not changed manure but increased fertilizers.
- 14% decreased manure and increased fertilizers.

**Table 9. Various data on the use of manure in Qemn El Arous.**

| Criterion | | % of farmers | |
|---|---|---|---|
| Trend in manure use (over 5 years): | | | |
| | more | 56 | |
| | same | 26 | |
| | less | 18 | |
| Type of manure used | | 100% use cattle manure mixed with earth | |
| Manure self-sufficiency | | 52% are self-sufficient | |
| | | 33% are 50–90% self-sufficient | |
| | | 15% are less than 50% self-sufficient | |
| Priority crop for manure application | | Cotton | 78 |
| | | Maize | 41 |
| | | Berseem | 4 |
| | | All crops | 4 |

Altogether, for 40% of the farmers, an antagonist relation could be detected between the use of manure and the use of fertilizers. This does not seem enough to assume that there was a general trend by which farmers had to choose between one of the two fertilization systems, due to financial constraints. For 60% of the farmers, there was no choice as they increased both manure and chemicals or maintained both or decreased both at the same time.

*Use of manure by crops*

From the detailed information collected for each crop, more precise figures concerning the use of manure in this village were obtained (Table 10 and Figs 3 and 4).

*Percentage of farmers using manure*

Only maize and cotton are systematically manured. Some crops like short berseem and faba bean never receive manure and, more generally, winter crops are manured by a minority of farmers (this confirms the qualitative data presented in Table 9). It is also surprising that tomato is not manured in most of the cases.

*Rate applied per crop*

Onion receives the highest rates but it is still a minor crop in the local cropping system. Among the major crops, summer crops are favored, especially cotton.

*Effect of preceding crop (see Fig. 5)*

Although maize and cotton are given high doses of manure, farmers sometimes still increase manure application after these crops, as in the case when they add manure to the following winter crops (wheat or berseem), which is done by a minority of farmers only.

**Table 10. Fertilization practices by crop in Qemn El Arous, Beni Suef.**

| Crop | $P_2O_5$ | | | | Manure | | | | Total N | | | | $K_2O$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % farmers applying | Rate (kg/fed) | Range | Rate trend (5 years) | % farmers applying | Rate ($m^3$/fed) | Range | Rate trend (5 years) | % farmers applying | Rate (kg/fed) | Range | Rate trend (5 years) | % farmers applying | Rate (kg/fed) | Range | Rate trend (5 years) |
| Berseem | 100 | 27.2 | 16–62 | +24% | 36 | 10.9 | 8–16 | +4% | 58 | 42.7 | 17–99 | +39% | 0 | | | |
| Short berseem | 50 | 15.5 | 16 | +20% | 0 | – | – | – | 25 | 23 | 23 | –30% | 0 | | | |
| Faba bean | 50 | 23.3 | 23 | 0% | 0 | – | – | – | 100 | 39.5 | 33–46 | 0% | 0 | | | |
| Wheat | 29 | 20 | 12–31 | –11% | 26 | 13.6 | 8–16 | +26% | 100 | 82 | 33–138 | +17% | 0 | | | |
| Maize | 50 | 23.3 | 16–31 | +14% | 100 | 15 | 8–25 | +3% | 100 | 95.8 | 46–188 | +15% | 0 | | | |
| Cotton | 41 | 31 | 16–47 | +38% | 95 | 17.3 | 2–35 | +7% | 100 | 79 | 46–191 | +10% | 0 | | | |
| Tomato | 91 | 65.8 | 31–124 | +37% | 15 | 12.8 | 8–16 | +7% | 100 | 331.8 | 102–626 | +18% | 0 | | | |
| Onion | 90 | 31 | 16–47 | 0% | 60 | 22.7 | 16–32 | –6% | 100 | 65.8 | 46–99 | +8% | 0 | | | |

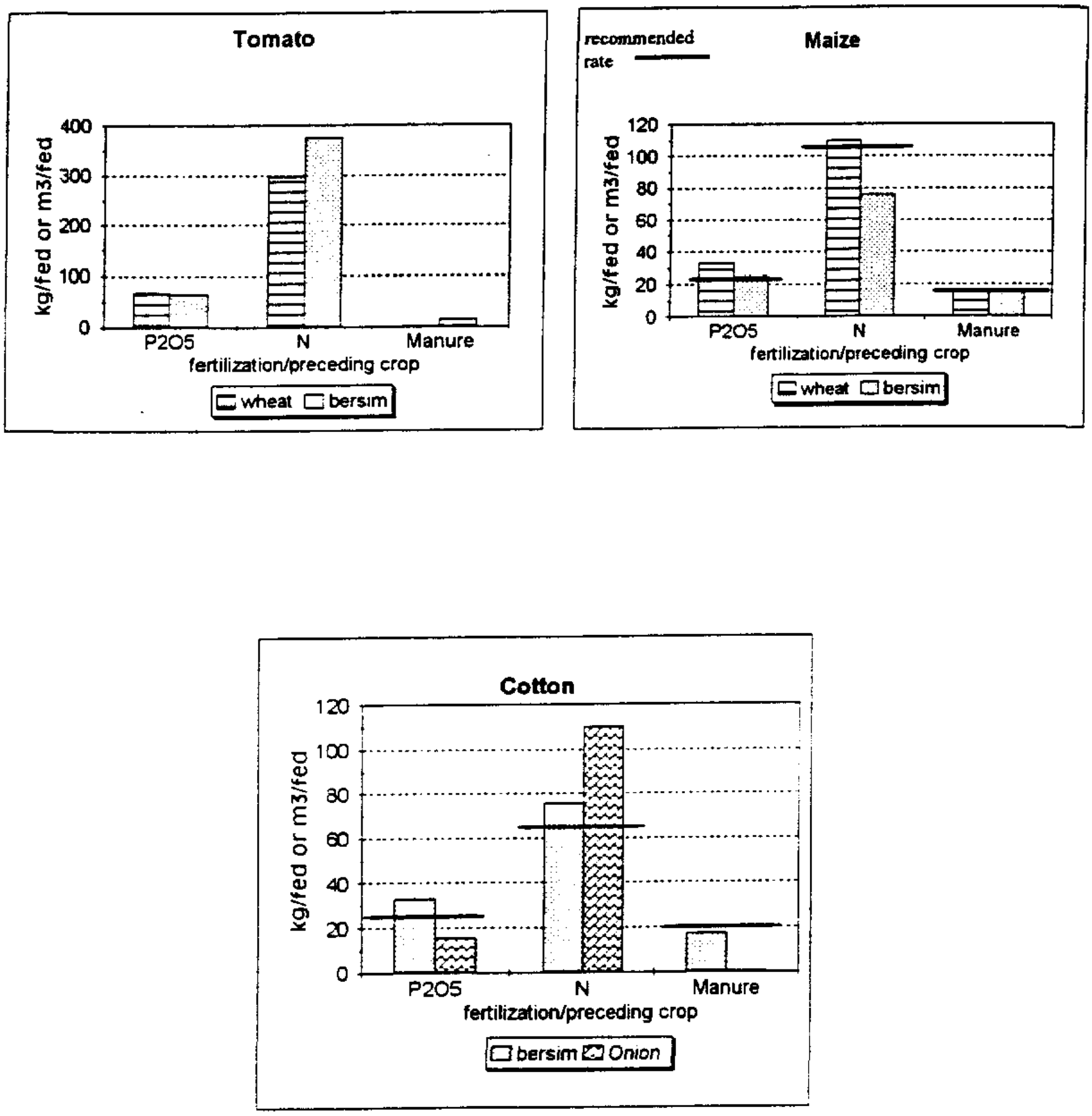
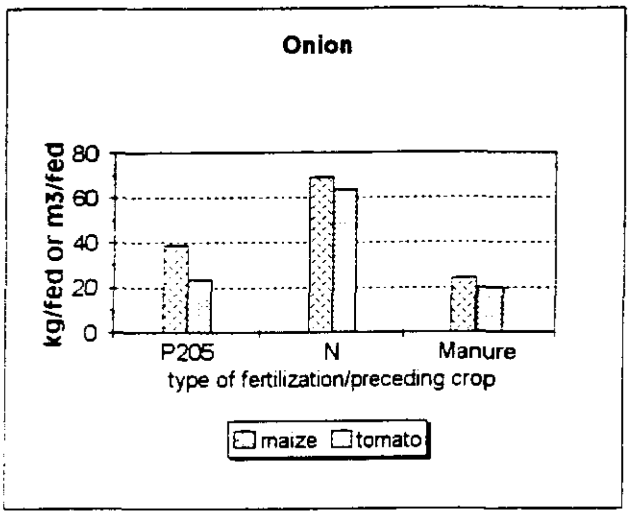
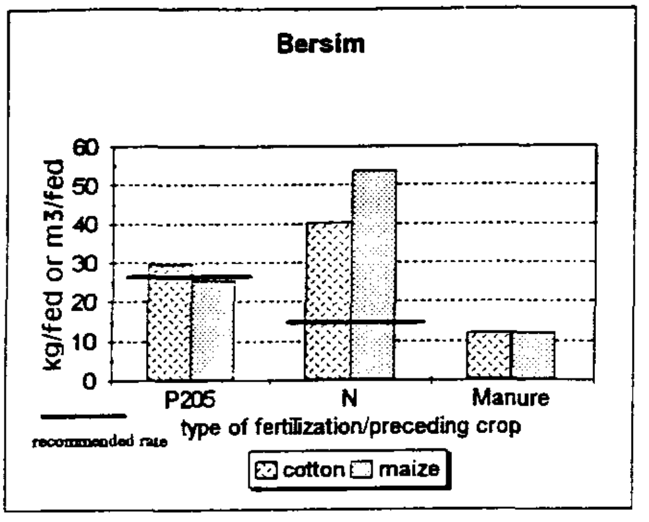



**Fig. 3. Fertilization package by crop (summer crops) according to the preceding crop, Qemn El Arous (Middle Egypt).**



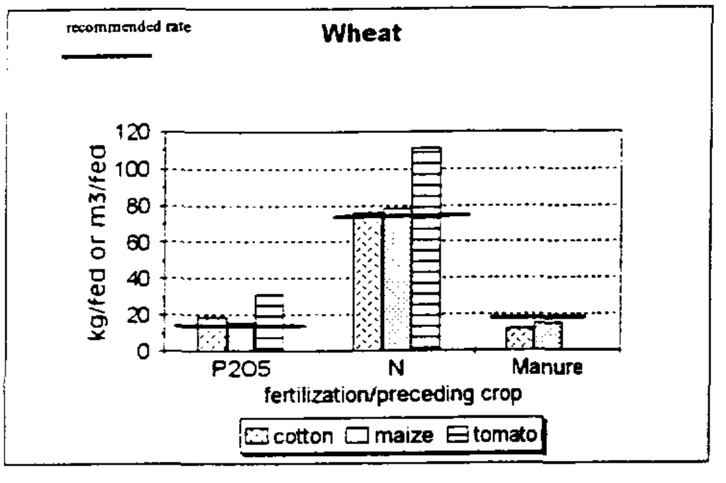
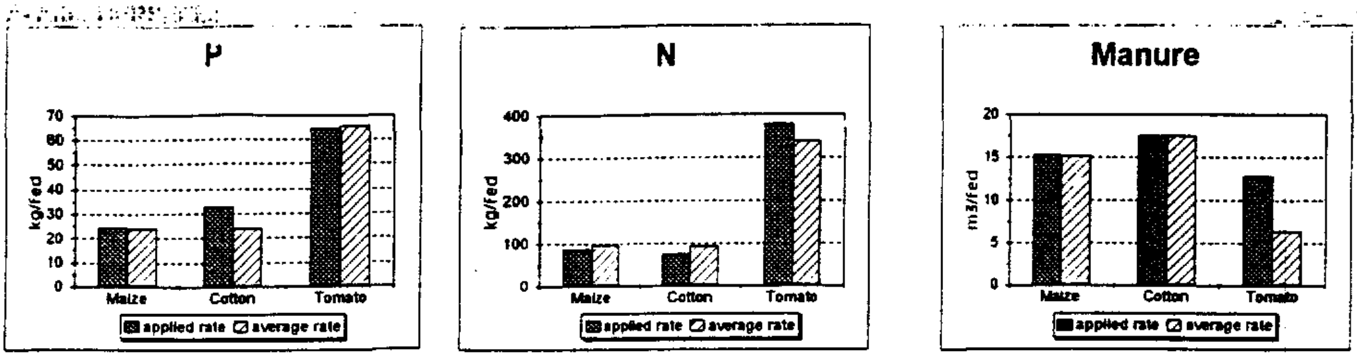
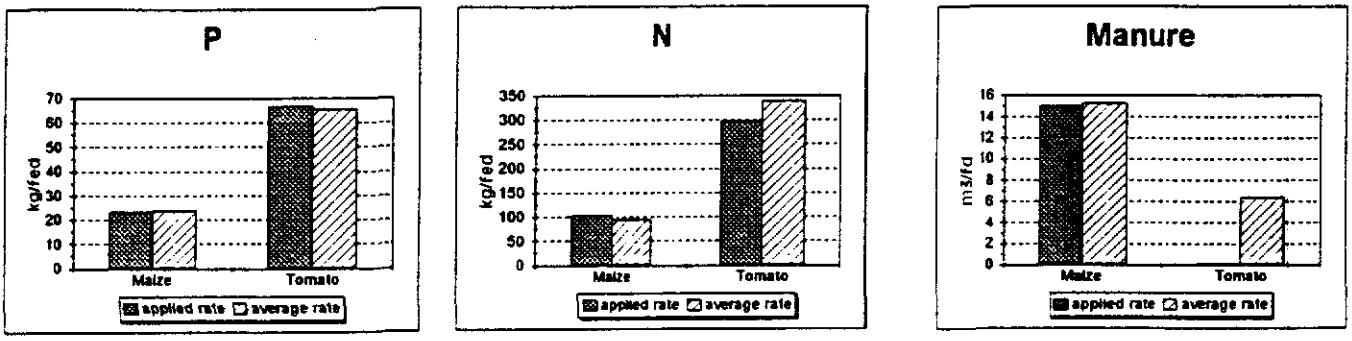



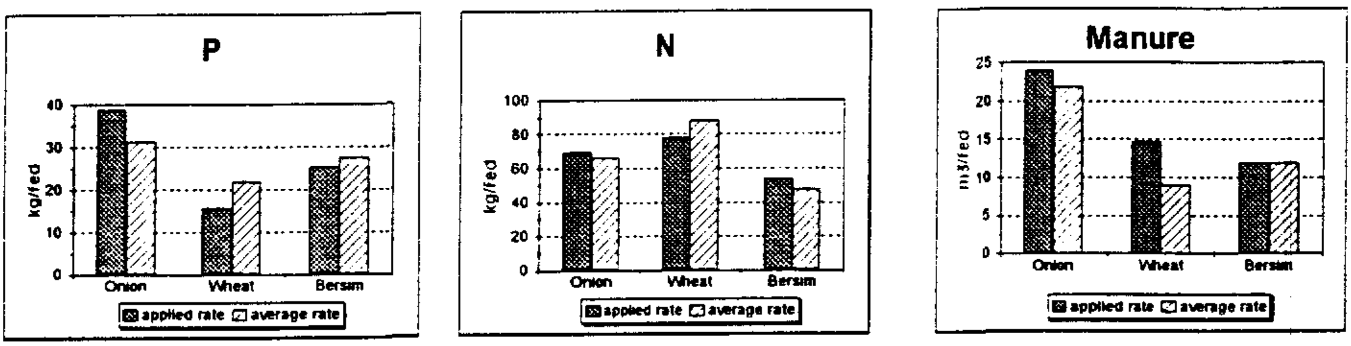

**Fig. 4. Fertilization package by crop (winter crops) according to the preceding crop, Qemn El Arous (Middle Egypt).**



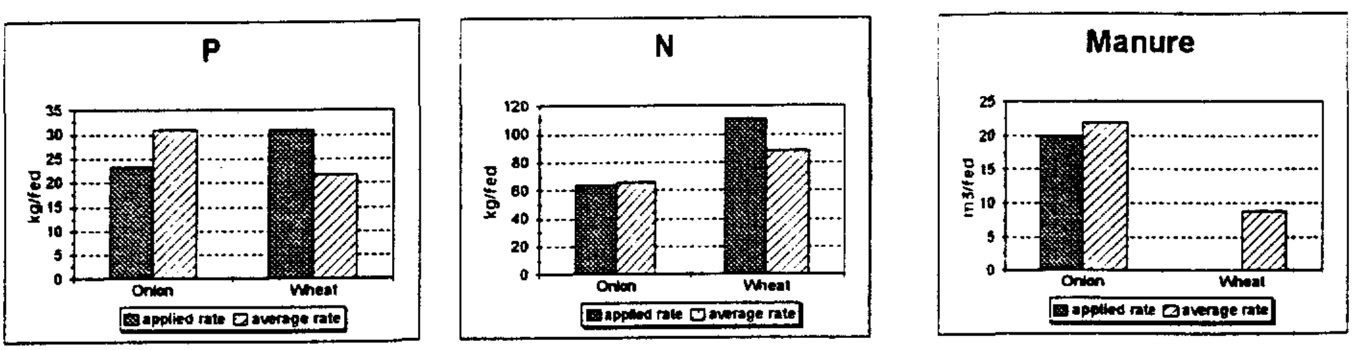

## B- After WHEAT:




## C- After MAIZE :




## D- After TOMATO:




## E- After COTTON:

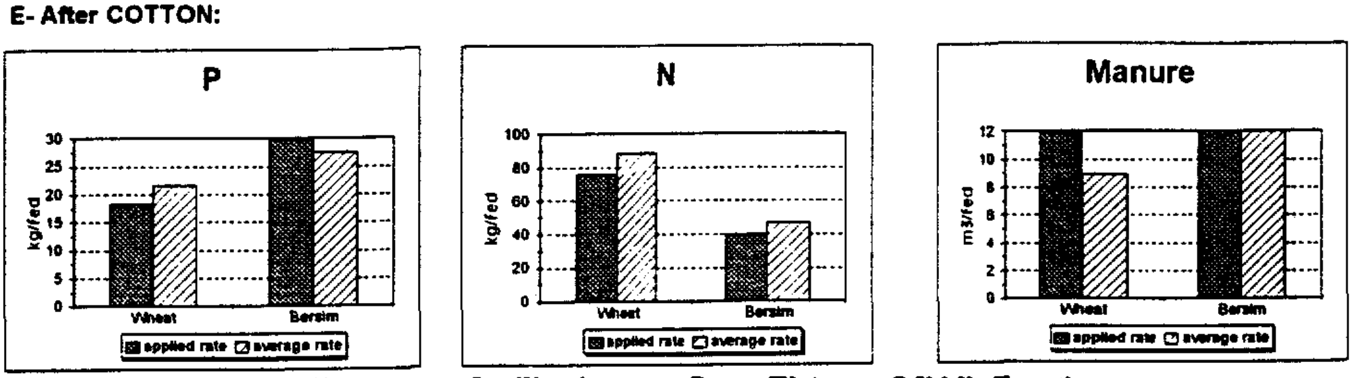



**Fig. 5. Effect of the preceding crop on fertilization rate, Qemn El Arous (Middle Egypt).**

## *Use of chemical fertilizers*

### *General data on fertilizer use*

Fertilizer price increases have not yet really produced the expected effect of reduction in quantities applied (Table 11). On the contrary, the majority of farmers acknowledged having increased their use of fertilizers during the last 5 years and most of them are not sensitive to price increases.

**Table 11. Trend of fertilizer use in Qemn El Arous.**

| Criterion | | % of farmers |
|---|---|---|
| Trend in rate applied | | |
| | more | 54 |
| | equal | 30 |
| | less | 16 |
| Reaction to fertilizer price increase: | | |
| 1) Rates reduced | | 29 |
| 2) New crop rotation | | 0 |
| 3) Reduction of fertilizer-consuming crop area | | 0 |
| 4) No change in rate nor area | | 71 |

### *Use of fertilizers detailed by crop (cf. Table 10, Figs 3, 4 and 5)*

P-fertilizers:

Phosphorus is not yet a fertilizer that is systematically applied to all crops. Even for a major cash crop as cotton, it is added by only 40% of the farmers. Surprisingly, berseem is always fertilized with P and at high rates (if we exclude tomato). Wheat is definitely the least favored crop concerning P.

Farmers tend to apply more P-fertilizers now than before to all summer crops and berseem. Only in the case of wheat, the rate of application has been decreased. Compared with the recommended rate of P-fertilizer, farmers apply less than needed to both cotton and maize, while they apply more to wheat and berseem.

Finally, the preceding crop does not clearly affect the P rate applied to the following crop (see Fig. 5).

N-fertilizers:

Nitrogen fertilizers are used by all farmers. Results indicate that urea is the most common N-fertilizer used by the farmers, while ammonium nitrate is used in higher percentages by farmers in case of berseem.

For all crops, there is an increase in the rate of N-fertilization now as compared with that of 5 years ago. The highest increase was attained for berseem. Tomato receives incredibly high rates, and since tomato is a summer crop of growing importance, this over-fertilization can only bring about water pollution concerns. Also, usually summer crops are more fertilized than winter crops (as for manure).

Compared to the recommended rates of N-fertilization, farmers apply more nitrogen than needed to cotton and, above all, to berseem. Rates applied to maize and wheat correspond more or less to the recommendations.

Finally, the effect of the preceding crop on N fertilization is shown in Fig. 5. Farmers tend to reduce N fertilization after cotton but not so clearly after berseem and, surprisingly, after maize, although it is the most N-fertilized crops of all the field crops.

K-fertilizers:

Not a single farmer of our sample was using potassium fertilizers. It is not available at the village cooperative nor with the local private traders.

### *Fertility-improving crops (non-legumes)*

When farmers were questioned about their opinion of the crops which improve the soil and increase the yield of the succeeding crop, it was found that cotton followed by berseem (52 and 44%) were considered as improving crops, while tomato and wheat (15 and 11%) had the lowest priority. Yet, most of the farmers are using the same crop pattern without increasing the area cultivated with those improving crops (74%); only 19% tend to increase it. In fact, a crop is increased or decreased according to its profitability and/or the family need, but not due to its potential fertility-improving effect.

### *Legume crops*

The most common legume crop in the area under survey was berseem (and short berseem before cotton), while faba bean occupied a low percentage of the cultivated area (Table 12).

**Table 12. Percentage of the surveyed cultivated area occupied by legumes.**

| Crop | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|
| Berseem | 21 | 21 | 26 | 28 |
| Short berseem | 37 | 42 | 31 | 22 |
| Faba bean | 0 | 4 | 5 | 3 |
| Other legumes | 2 | 0 | 0 | 2 |
| Total | 60 | 67 | 62 | 55 |

Table 12 shows that an area ranging between 55 and 60% was cultivated with legumes over the last 4 years. This area tended to have the lowest value last year (1994) due to the increase in area cultivated with wheat. Altogether, there is no marked trend affecting the total area cultivated with legume crops within the last 4 years.

We also calculated what is statistically the average time lapse between two legume crops on the same plot (from seeding date to seeding date). The average value found for Qemn El Arous is 1 year and 7 months.

As shown in Fig. 3, farmers tend to apply less N fertilizers to maize cultivated after berseem, while they apply more N to tomato after berseem. This means that the N-enriching effect of berseem is not really taken into account by farmers when they decide on fertilizer amounts for the following crops.

In fact, it is clear that farmers cultivate berseem (the main legume crop) for the reason of feeding their livestock more than for maintaining soil fertility.

Use of inoculants: All the farmers reported that they never used inoculants with legume crops.

### *Crop residues*

According to the way farmers manage their crop residues, we separated crops into three categories:

1. Total export of nutrients: All residues removed from the field, then burnt or not recycled on the farm.

   This is the case for tomato and cotton.

2. Partial restitution: Residues are given to animals whose manure will be applied to the field.

   This is the case for maize, wheat (straw), and faba bean.

3. Complete restitution: Residues are left to decay on the field and then ploughed in.

   This is the case for berseem and the stem base of wheat.

### *Rotations*

The quantity of chemical fertilizers applied over a long period of time varies according to the rotation. Table 13 presents 3- and 2-year cotton rotations and the equivalent N and P fertilization for the whole period.

**Table 13. Rotation and fertilizer use.**

| Rotation | Kg/feddan | |
|---|---|---|
| | Total N | Total $P_2O_5$ |
| Short Berseem/Cotton–Berseem/Maize–Wheat/Maize | 408 | 141 |
| Short Berseem/Cotton–Berseem/Maize–Wheat/Tomato | 602 | 184 |
| Short Berseem/Cotton–Wheat/Maize–Berseem/Tomato | 693 | 186 |
| Short Berseem/Cotton–Wheat/Maize | 277 | 90 |
| Short Berseem/Cotton–Berseem/Maize | 228 | 102 |
| Short Berseem/Cotton–Wheat/Tomato | 473 | 133 |

## Water Management

Although the area surveyed was divided into different basins according to the distance from the head of the main canal, it was found that the water supply patterns are much more complex than a clear-cut head–tail reasoning. In fact, water sources were different in each basin and the most disadvantaged are not always the ones at the tail end. The proximity of an open drain is also quite appreciated by farmers as well as the possibility to use shallow groundwater. Most of the area used freshwater from the canal for irrigation, some of the farmers used drain water, and others used wells.

Surface irrigation using irrigation pumps is the only method of irrigation used. It was estimated that there are 620 irrigation pumps in the village according to the Rapid Rural Appraisal study conducted there. The irrigation rotation in this area is 10 days off and 5 days on, but the water availability in those "on" days varies according to the distance from the head of the canal. In summer, water availability is always less than in winter. Farmers use drain water and wells to meet their need for irrigation water mainly in summer. The quantity of the "additional" water varies form basin to another. All the farmers in Matared and Omda basins mentioned that they use drain water at different times, while in Tod the percentage was 75%. In Shibil and Zanqa, the percentages were 40 and 22 only.

However, 91% stated that water quality did not affect their choice of crops.

Farmers were asked about the number of irrigations for each crop and number of hours per irrigation. This information along with the value of irrigation pump discharge (230 $m^3$/hour) enabled us to estimate the total quantity of water applied to each crop. Table 14 presents the water amount applied as compared with irrigation requirement calculated based on seasonal ET (evapotranspiration) for each crop. Tomato, cotton and berseem were found to consume more water than the other crops. In all cases, farmers tended to use excessive amounts of irrigation water than the actual water requirements, which reflects very poor irrigation management.

**Table 14. Water consumption by crop in Beni Suef.**

| Crop | No. of Irrig. | No. of hours/irr. | Total water applied ($m^3$/fed) | Irrigation requirement $ET_o$ ($m^3$/fed) | Excess amount of water ($m^3$/fed) | Excess water (%) |
|---|---|---|---|---|---|---|
| **Winter** | | | | | | |
| Berseem | 10 | 3 | 6900 | 3920 | 2980 | + 76 |
| Wheat | 7 | 3 | 4830 | 2835 | 1995 | +70 |
| Onion | 5 | 2.6 | 2990 | 2355 | 635 | +27 |
| Faba bean | 5 | 3 | 3450 | 2450 | 1000 | +71 |
| Fenugreek | 3 | 4 | 2760 | 2412 | 348 | +14 |
| Short berseem | 4 | 3.5 | 3220 | 1948 | 1272 | +64 |
| **Summer** | | | | | | |
| Cotton | 10 | 3.4 | 7820 | 4620 | 3200 | +70 |
| Maize | 7 | 3.2 | 5152 | 4353 | 799 | +18 |
| Tomato | 13 | 3 | 8970 | 3623 | 5347 | +148 |
| Dry bean (lubia) | 9 | 3 | 6210 | 3290 | 2920 | +88 |

# Soil Degradation

## Soil Analysis

Soil samples were collected from the field of each farmer included in the survey. Samples were analyzed for pH, EC, available nitrate ($NO_3$-N), available phosphorus (P-Olsen), organic matter, exchangeable potassium, and sodium (Tables 15 and 16).

**Table 15. Average, maximum and minimum values for soil analysis.**

| | Average | SD | Max | Min |
|---|---|---|---|---|
| pH (1:2.5) | 8.0 | 0.22 | 8.44 | 7.75 |
| EC (1:5) | 3.16 | 2.65 | 8.5 | 0.33 |
| TSS (ppm) | 2025 | 1692.6 | 5440 | 211 |
| $NO_3$-N (ppm) | 56.6 | 39.7 | 105 | 5 |
| P-Olsen (ppm) | 19.4 | 17.23 | 73.12 | 2.75 |
| Av. K (ppm) | 1276.7 | 1228.4 | 5499 | 482 |
| Ex. K (meg/100g) | 0.66 | 1.18 | 6.183 | 0.09 |
| Ex. Na (meg/100g) | 8.61 | 9.36 | 34.21 | 0.70 |
| Organic matter (%) | 1.78 | | 2.5 | 1.09 |

**Table 16. Average values for soil analysis by basin.**

| | Birka | Matared | Omda | Shibil | Tod | Zanqa |
|---|---|---|---|---|---|---|
| pH | 7.8 | 7.9 | 8.1 | 8.2 | 7.8 | 8.1 |
| TSS (ppm) | 3725 | 2832 | 1153 | 755 | 392 | 1637 |
| $NO_3$-N (ppm) | 68 | 46 | 68 | 45 | 38 | 52 |
| P-Olsen (ppm) | 18 | 27 | 7 | 16 | 16 | 31 |
| Ex. Na (meg/100g) | 18 | 8 | 4 | 5 | 0.9 | 10 |
| Organic matter (%) | 1.9 | 1.8 | 1.5 | 1.6 | 2.0 | 1.7 |

## Salinity Build-up

*Results in Table 17 show the following:*

**Salinity levels**: The highest levels as assessed by the farmers correspond to the values given by the soil analyses. Also, salinity trends are more pronounced towards an increase in the basins suffering from high salinity.

**Table 17. Basins and salinity interaction.**

| | Birka | Matared | Omda | Shibil | Tod | Zanqa |
|---|---|---|---|---|---|---|
| Salinity | 50% M | 20% H | 40% H | 0% | 50% No | 55% M |
| | 50% L | 20% M | 60% M | | 50% L | 45% L |
| | | 60% L | | | | |
| Use of drain water | 0% No | 100% (few times in summer) | 100% (few times in summer) | 60% No | 25% No | 78% No |
| | | | | 40% Yes | 75% Yes | 22% Yes |
| | | | | (permanent) | (perm.) | (perm.) |
| Use of well water | 0% No | 0% No | 40% Yes | 0% No | 0% No | 44% Yes |
| | | | 60% No | | | 56% No |
| Total salt (ppm) | 3725 | 2832 | 1153 | 755 | 392 | 1637 |
| Range | | | | | | |
| Max | 5310 | 3456 | 2624 | 1280 | 608 | 5440 |
| Min | 2176 | 2176 | 326 | 230 | 230 | 211 |
| Drain efficiency | 100% No | 20% Yes | 20% Yes | 100% Yes | 50% Yes | 50% No |
| | | 80% No | 80% No | | 50% No | 50% Yes |
| Water table (W) | 70 cm | 120 cm | 116 cm | 100 cm | 111 cm | 138 cm |
| Average (S) | 125 cm | 165 cm | 145 cm | 150 cm | 130 cm | 220 cm |
| Salinity trend | 80% (+) | 75% (+) | 100% (+) | 100 (=) | 25% (+) | 66% (+) |
| | 0% (=) | 0% (=) | | | 50% (+) | 0% (=) |
| | 20% (-) | 25% (-) | | | 25% (-) | 34% (-) |

H = High salinity; M = Moderate salinity; L = Low salinity.

**Cause of salinity:** 70% of the farmers believe that inefficient drainage systems cause the salinity, while 45% related that to the bad water quality. This is also confirmed by the results of the soil analyses since the highest salinity levels are reached in the basins where the drainage system is obviously not functioning.

**Drainage system:** All the farmers are using tile drain system in their field; most of them (83%) implemented it in 1988. In spite of being relatively new, the efficiency of the tile drain system is low. Around 65% of the farmers believed that the system is not efficient; they mentioned that the main effect of the inefficient drain system was to cause more salinity (64%), while 36% believed that it caused higher water table.

**Water table:** Average water table in winter was estimated by the farmers to be 114 cm (max 300 and min 15 cm), while the average in summer is 155 cm (max 300 and min 30 cm). Water table is usually higher in the basins where the drainage system is blocked.

**Effect of water quality:** About 65% of the farmers surveyed believed that low water quality led to more salinity in their land, while 56% mentioned the direct impact of low water quality on decreasing yield. Yet most of them (91%) did not consider water quality as a factor for choosing their crops. The soil analyses also show that the intensive use of drainage water or well water is not a main cause of salinity build-up.

**Salinity × choice of crops:** Few farmers indicated that high salinity in their field affects their choice of crops. About 75% mentioned that their choice of winter crops was not affected by salinity, while this value was 62% for summer crops.

**Salinity × basin:** Information about salinity, use of drainage water, use of well water, drain efficiency, average water table, salinity trend along with total salt (ppm) is summarized in Table 17 on basin base. It is clear that in Birka basin, where drain efficiency is very low and water table is high, the soil analysis shows higher salt content (average 3725 ppm, max 5312 and min 2176 ppm). The cause of salinity is related more to inefficient drain systems than to the use of drain water for irrigation. In Shibil and Tod basins, where the drain system is effective with low use of drain water for irrigation, most of the farmers mentioned that there was no increase in the salinity in their fields. The soil analysis also confirmed that trend, where total salts in Shibil averaged 755 ppm (max 1280 and min 230), while in Tod, the average salinity was 392 ppm (max 608 and min 230).

**Salinity effect on yields:** We measured the correlation between the yield recorded for the main crops and the salinity of the corresponding basin. The results are as follows:

| Crop | Maize | Wheat | Cotton | Onion | Tomato |
|---|---|---|---|---|---|
| Correlation factor | –0.31 | –0.33 | –0.08 | 1 | –0.15 |

These data are not considered as non-significant, mainly because of the unreliability of the yield values as reported by the farmers.