NILE VALLEY REGIONAL PROGRAM
PHASE II

Resource Management Series

Volume 17

MULTIDISCIPLINARY SURVEYS

New Lands of Egypt

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Volume 17

Resource Management in the New 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
CA = Cultivated Area
EU = European Union
HCU = Human Consumptive Unit
HLU = Human Labor Unit
ICARDA = International Center for Agricultural Research in the Dry Areas
LU = Livestock Unit
NVRP = Nile Valley Regional Program

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.

Results of the Multidisciplinary Survey in the New Lands: El Bustan Area

Ali Ibn Abi Taleb Village

Summary

Cropping Patterns and Rotations

Winter

- Wheat is the major crop (50% of the cultivated area).
- Peas and berseem are the two other major winter crops. Berseem is slowly expanding at the expense of faba bean and other minor winter crops.

Summer

- Groundnut is occupying at least 75% of the farmers' fields each summer.
- No perceived trend of a decrease in groundnut importance.
- Lack of viable alternatives to groundnut.

Rotations

- Groundnut every summer is the most common rotation.
- Legume crop every two to three years is the most common in winter.
- Nematode problems related to groundnut monocropping are plaguing the whole area.

Fertility Management

Evolution of crop yields

- Yields increased for only half of the crops (highest increases for faba bean, fenugreek, onion).
- Yields decreased over 5 years for groundnut, maize and watermelon.
- Fertility build-up seems to be very slow.

Manure and fertilizers

- Farmers increased the use of both but more markedly for manure than for chemical fertilizers.
- Manure is applied more or less equally to all crops; P is given priority to summer crops, N goes also in much larger quantities to vegetables.
- N fertilization of legume crops is far above the recommendations.
- N fertilization for cereals is less than recommended.

- P fertilization is not reduced after maize and berseem although they are given large quantities of phosphorus.

Legume crops

- Crops following legume crops usually receive more N fertilizer than after non-legume crops or at least the same. Nitrogen-fixing effect of legumes is not taken into account by farmers.
- Legume crops are the majority in the rotation (in average one legume crop on the same plot every 11 months, from seeding to seeding); however, the effect on fertility build-up is not evident.

Water Management and Soil Degradation

Trend in water supply

- The water quantity available each year is not decreasing.
- Water supply problems come from water distribution infrastructure (sprinkler system).

Soil salinization

- Appears at high levels in low-lying areas.
- Large pieces of land are fallowed due to excessive salinity.
- Sub-surface water table is also common in depressions.

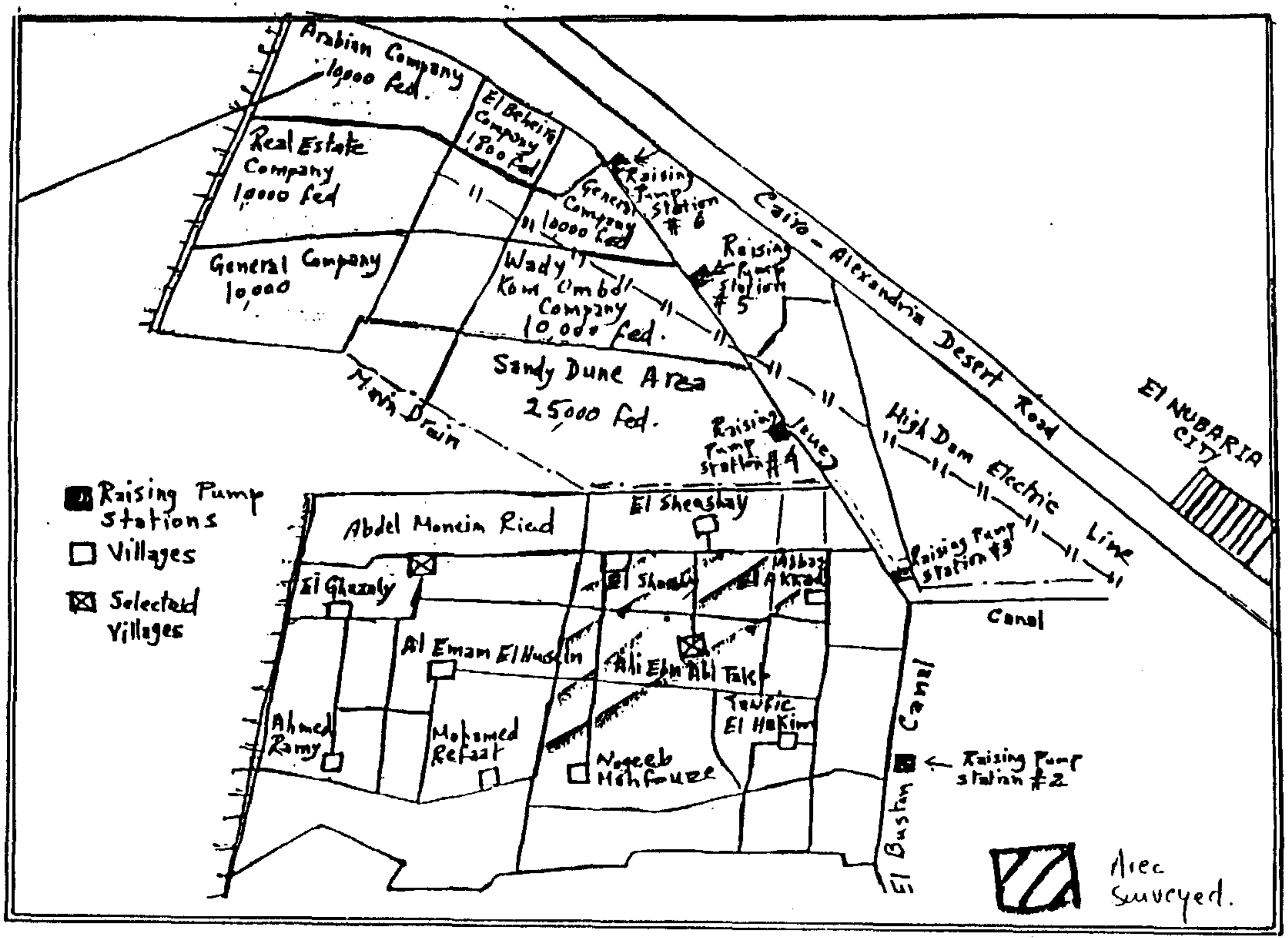
Introduction

The survey was conducted in Ali Ibn Abi Taleb village, located about 40 km east of the Alexandria Desert Road and south of Nubaria canal (see Map 1).

Thirty farmers were interviewed (11% of the total farmers' population in the village), spatially distributed as follows:

- 23% in depressions (low-lying areas).
- 53% on slopes.
- 24% on flat tops.

Superimposed on this spatial stratification, 50% of the sample is made up of graduates and the other 50% of beneficiaries. We also worked on three separate irrigation lines, surveying farmers from the head to the end of irrigation canals, to have a third criterion of differentiation afterwards, based on water supply.



Map 1. Location of the survey area in El Bustan region.

Structural Data on the Sampled Population

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

Table 1. Average values of structural descriptors for the surveyed sample (El Bustan area).

Criterion	Beneficiaries	Graduates	Whole sample
Age (median)	40	37	37
Year of settlement	1986	1987	1987
Family size (HCU)†	4.8	3.9	4.3
Family workforce (HLU)‡	2.7	2.9	2.8
Total farm area (fed)	4.5	10	7.25
Farmland use (share of different treatments):			
fallow	48%	9%	28%
	(80% fallow 60% of their farm)	(27% fallow 32% of their farm)	(54% fallow 53% of their farm)
trees	3%	18	11%
	(7% grow trees on 50% of their farm)	(50% grow trees on 39% of their farm)	(29% grow trees on 40% of their farm)
crops	49%	73%	61%
	(80% of farmers)	(all farmers)	(90% cultivate crops)
% of animal holders	80	60	70
Average livestock holding (in LU)§	2.5	3	2.7
Structural ratios			
CA/HCU	0.57	3.8	2.19
HLU/CA¶	1.03	0.30	0.63

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

Year of Settlement

Beneficiaries and graduates settled in the area approximately at the same time, 1986/87. The earliest arrival is 1986 and the latest 1990.

Family Size and Workforce

Beneficiaries have larger families than graduates (+23%) but slightly smaller family workforces, or say, equal. In fact, this is due to the high variability of family size and family workforce among the graduates, which distorts somewhat the average. Some of the graduates—mostly those coming from rural families—settled in the village with their parents, sometimes brothers and sisters, recreating that way the large undivided family common in the Delta. These ones enjoy quite large family workforces (up to 11 human labor units or HLU). Others are not resident and keep their family in their original city, and the only family workforce they can dispose of is themselves.

Farm Area

Graduates own approximately the same area as beneficiaries (4.5 to 5 fed), but all of them in our sample were renting an additional 5 fed from beneficiaries or graduates who preferred to return to their original place, although they are still legally tied to their land.

Livestock Holding

Seventy percent of farmers in our sample have animals, the other 30% being usually absent or not interested in animals. Absentee graduates who have animals usually lend them to beneficiaries under the sharing system: the animal and half of the offspring belongs to the owner, the other farmer is totally responsible for feeding the animals, tending them and receives in exchange the animal products and the other half of the offspring. Graduates have slightly larger livestock holdings, but variability in our sample is high, therefore, we will not consider this difference as really significant.

Structural Ratios

The average land size available per family member (cultivated area by human consumptive unit, or CA/HCU) is of course higher for graduates (3.8 fed) than for beneficiaries (0.57 fed). This means theoretically that graduates should reach higher food self-sufficiency levels than the beneficiaries and be more inclined to allocate a large part of their land to cash crops.

On the other hand, the average family labor available per feddan (HLU/CA) is lower for graduates and therefore the need for hired labor is higher for them.

Cropping Patterns and Rotations

The cropping patterns and rotations practiced in the surveyed area have been derived from the crop sequences recorded by the multidisciplinary survey team. The whole farmland was comprehensively surveyed with each farmer and therefore the data obtained represent the cropping patterns and rotations practiced on 178.5 fed of the village (equal to 11% of the village farmland).

Evolution of Cropping Patterns

Past trends

The crop sequences 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. However, we based our description of the cropping patterns and the trends affecting them on the past and present years only, since many farmers were still quite unsure of what their next year's cropping pattern would be.

The dynamics in the local cropping patterns are presented in Figs 1, 2 and 3. Each figure contains three distinct criteria used to better discern and explain the actual trends. These three criteria are:

- % of farmers cultivating the crop: This gives an idea of whether the crop is widespread or limited to specialized farmers.
- % of farmland allocated to each crop on an "average" farm: This gives an idea of how the distribution of crops on an average model farm in this area has evolved over three years.
- % of the total cultivated area of our sample population allocated to each crop: This should represent the trend in the crop shares at the village territory level.

Each criterion was studied each time, first separately for the graduates and the beneficiaries, and then for the whole sample.

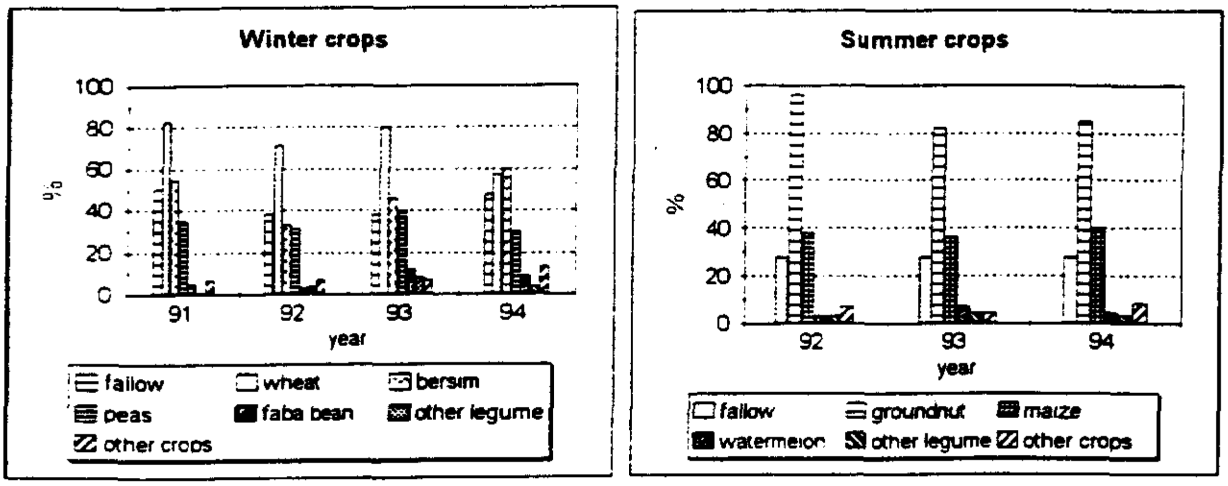
The main results of this cropping pattern study for each crop are[1]:

Winter crops

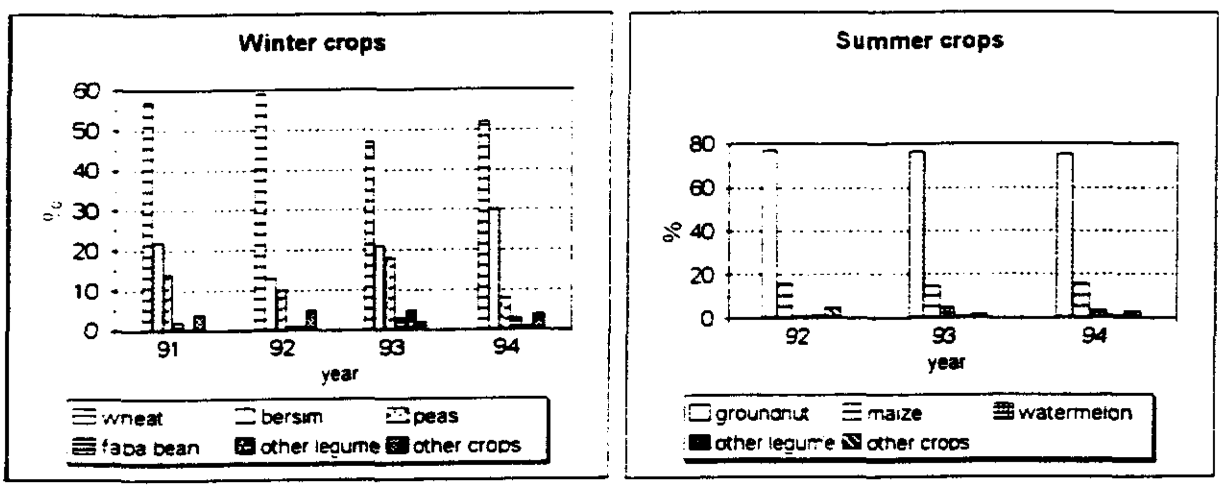
Wheat: The position of wheat as the dominant winter crops is more and more challenged by berseem. The percentage of farmers cultivating wheat is not regular year after year and shows some signs of decrease, although the total wheat area looks stable.

[1] Differences between beneficiaries and graduates are stated only when they seem significant.

1. Percentage of farmers cultivating the crop:



2. Crop shares on an average farm:



3. Crop shares for the total surveyed area:

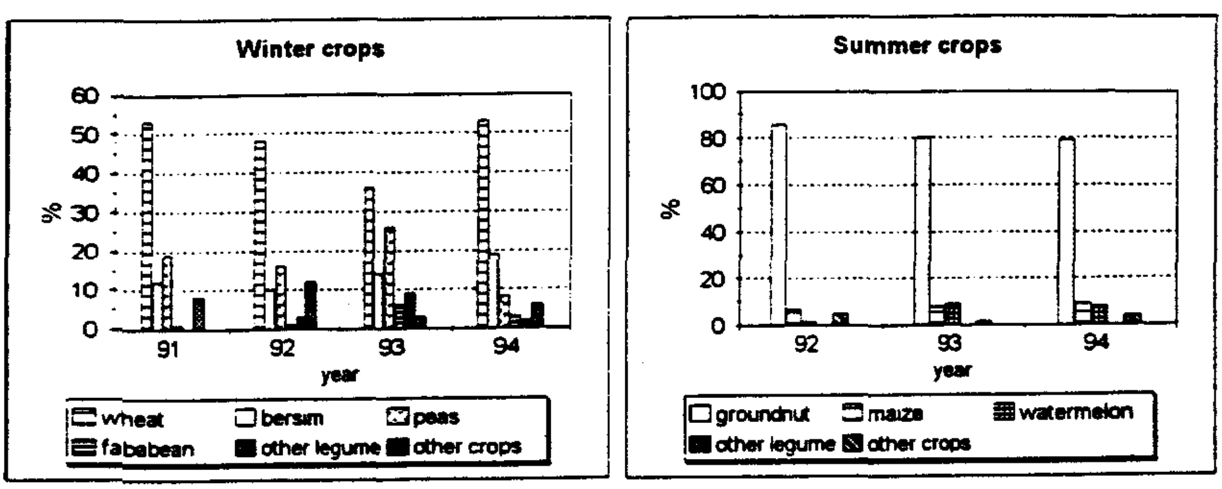
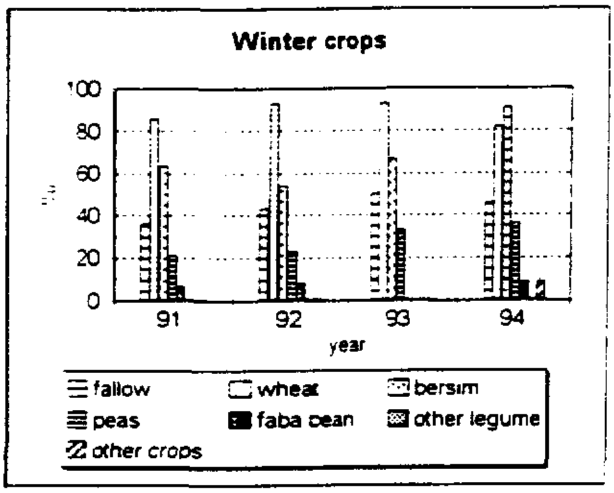
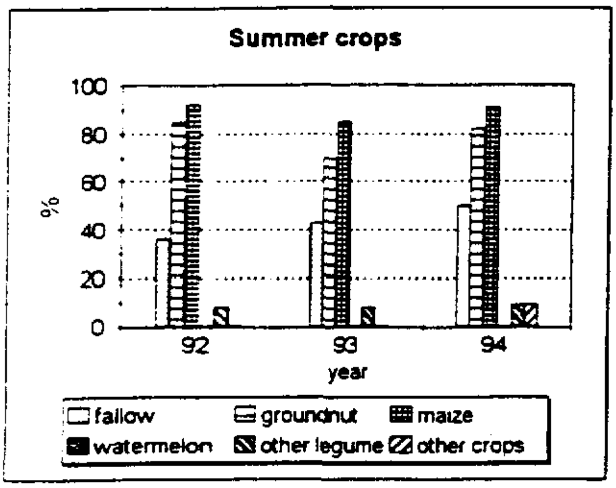


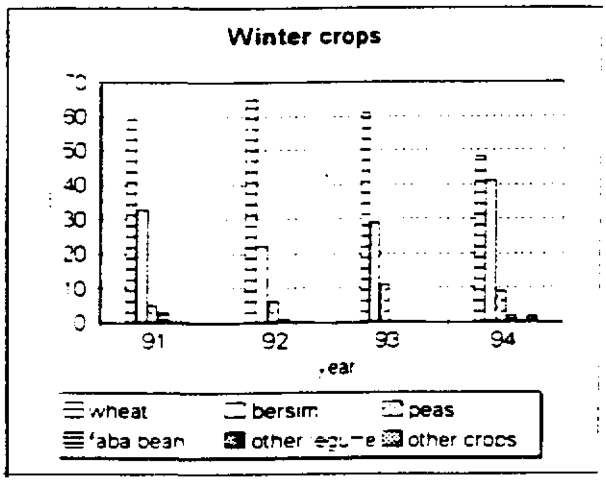
Fig. 1. Cropping pattern trends in Ali Ibn Abi Taleb village (El Bustan area) for whole sample.

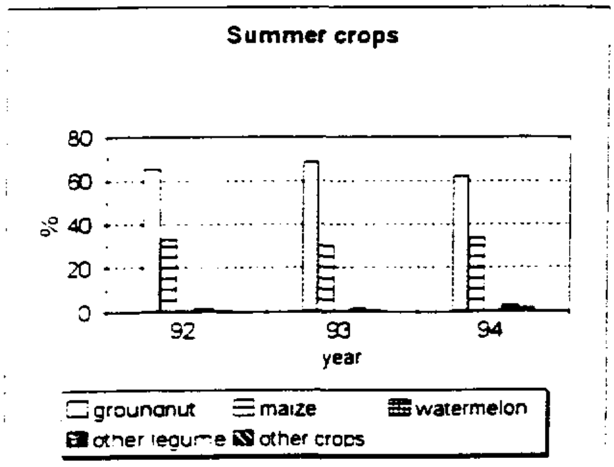
1.Percentage of farmers cultivating the crop:



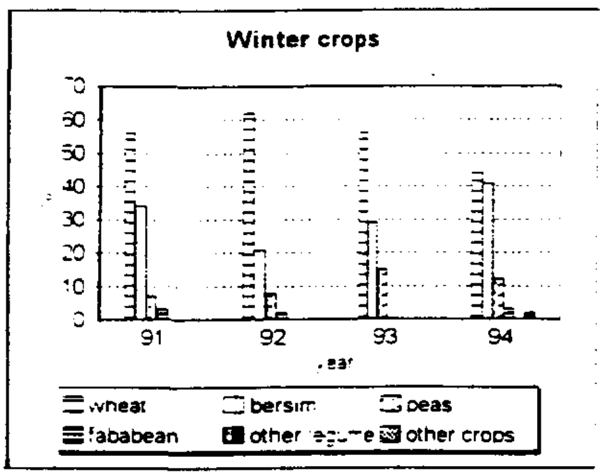


2. Crop shares on an average farm:





3. Crop shares for the total surveyed area:



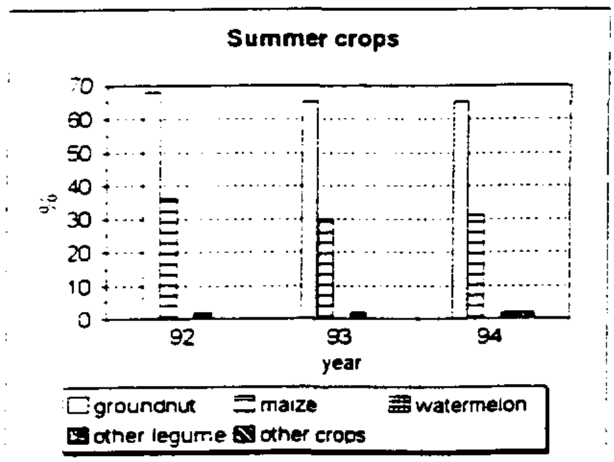
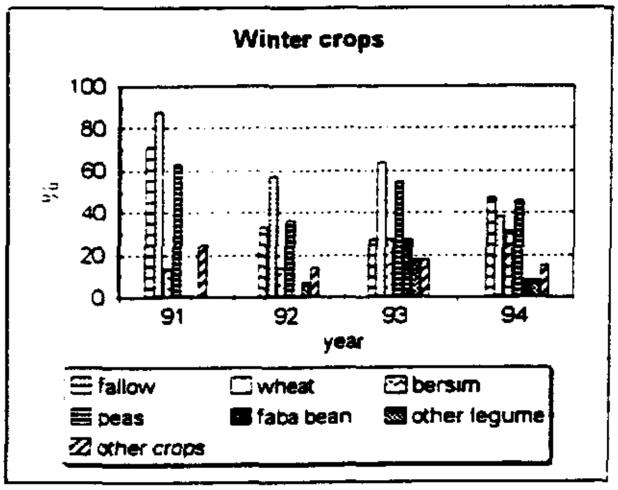
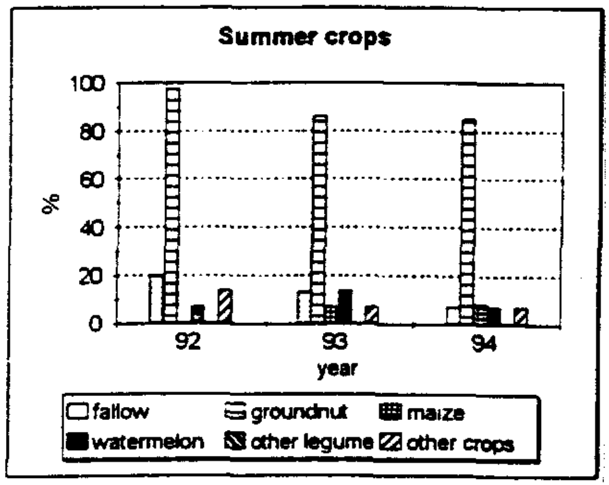


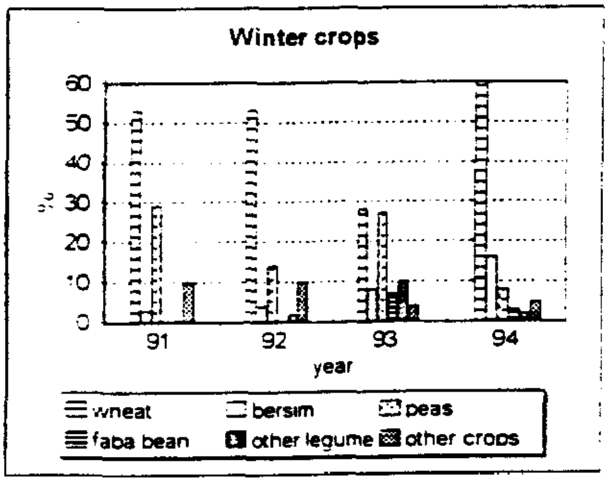
Fig. 2. Cropping pattern trends in Ali Ibn Abi Taleb village (El Bustan area) for beneficiaries.

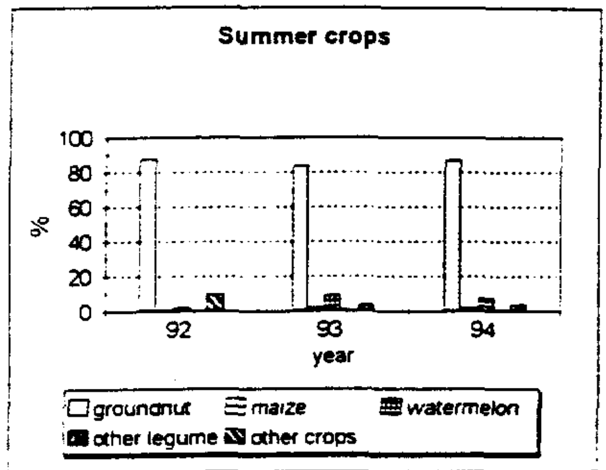
1. Percentage of farmers cultivating the crop:



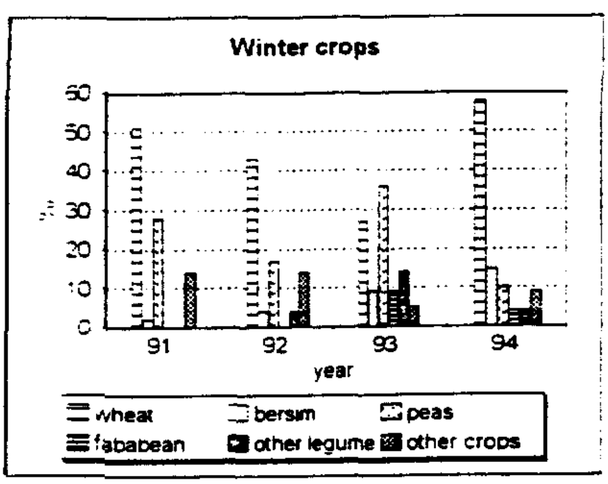


2. Crop shares on an average farm:





3. Crop shares for the total surveyed area:



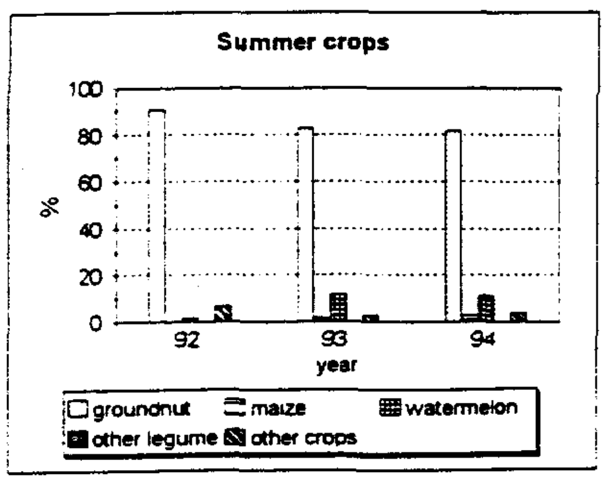


Fig. 3. Cropping pattern trends in Ali Ibn Abi Taleb village (El Bustan area) for graduates.

Berseem: On all levels, berseem is gaining importance in the local cropping pattern. Still, it occupies a modest share of the winter cropland (19%), much lower than in other areas of the New Lands (32% in the Sugar Beet area). Berseem was less important than peas until last winter, but it seems that the contrary is now true, with berseem overtaking peas by a large margin this winter. Graduates have always been much less involved in berseem cultivation than beneficiaries. This is due to the fact that they usually do not feed their own animals but leave this task to be done by the beneficiaries under the sharing system. The increase of berseem cultivation among the beneficiaries is also due to the gradual salinization of the land of some of them. This rising salinity reduces the range of cultivable crops in winter, and in El Bustan, berseem is one of the most salt-tolerant crops.

Peas: The total area cultivated with peas has experienced a large decrease over the last 4 years (–58%), although the number of farmers cultivating it is rather stable. The average farm share devoted to peas has therefore been reduced mainly in favor of berseem. Pea was mainly a graduates' crop until last winter, but is now cultivated on a equal basis by both groups. As a typical market crop, pea is anyway susceptible to large year-to-year variations according to the market prospects.

Faba bean: Faba bean is a minor winter crop in El Bustan area. The total land share never went over 6%, and this last winter's high was due to a sudden graduates' surge on faba bean, which does not seem to have persisted in 1994.

Other legume crops: The only other legume crop is helba (fenugreek). Its importance is still very minor and it remains a crop cultivated by a small number of farmers. Graduates are the only ones interested in this crop, but it could have been just a trial over two winters since, already this season, the number of beneficiaries cultivating helba has dropped from 18 to 8%.

Other winter crops: Principally, eggplant and, in a few cases, tomato, barley, onion, garlic and potato. Although the number of farmers diversifying their cropping system is on the rise (almost +50% in 4 years), the total area occupied by other winter crops is still low and does not seem to go up very much. As for fenugreek, it has more to do with a trial attitude than a real sustainable development of non-traditional crops, and it is related mainly to the fact that graduates tend to always look for new crops and are not tied by high needs for food crops as beneficiaries.

Summer crops

Groundnut: groundnut is overwhelmingly the dominant summer crop in El Bustan, and its position as a leader crop is not yet threatened by any other major crops, although a certain trend downwards has been noticeable for the last 3 years. Its is also a crop more favored by graduates who allocate it up to 87% of their farmland in summer. The situation is very close to a summer monocropping, and lots of nematode problems are surfacing more and more due to this.

Maize: As the second crop in 1994 (area-wise and frequency-wise), maize is still far behind groundnut, on less than 10% of the surveyed area. Actually, maize is a more important crop with beneficiaries than with graduates. The former plant it on a third of their land in summer, whereas less than 10% of the graduates cultivate it on 25% of their farm. Graduates are definitely not interested in cultivating maize in summer, although it might be beneficial for their land's fertility.

Watermelon: As much as maize is a beneficiary crop, watermelon is a graduate crop. Only these latter cultivate it, and even among themselves, watermelon cultivation is practiced by a small number of graduates, sometimes allocating it up to 100% of their land in summer. Watermelon has increased in total land share among graduates but not by the number of graduates who cultivate it. It requires a lot of labor (watermelon is cultivated in deep ditches) and lots of inputs. It might be the reason why no beneficiaries cultivate it since their resources are usually scarcer than the graduates' (larger families, less land).

Other summer legume crops: These are mainly lubia (dry bean). Its share at the village level is negligible (less than 1%), and it is grown only by beneficiaries. No upward trend is noticed for this crop.

Other summer crops: These are mainly vegetables (eggplant, tomato, watermelon for seeds, green pepper) and fodder maize. These other minor crops keep a stable place in the cropping pattern and are cultivated by less than 10% of the farmers. They are also cultivated mainly by graduates who consider these crops the same way they do with marginal winter crops.

Summary

In winter, wheat occupies about half of the farmers' fields, the other half being split between peas and berseem. Berseem seems to be slowly gaining ground at the expense of peas and wheat. However, the winter cropping pattern can be classified as rather stable over the last 5 years.

In summer, groundnut is occupying almost all the land and the rest is occupied by maize for beneficiaries, and a mixture of watermelon plus various vegetables for graduates. As for winter, the situation is almost unchanged during the last 4 years.

Looking at graduates separately from beneficiaries, they are definitely more involved in vegetables and other cash crops. They try many different crops on small areas and change their cropping pattern from year to year. Some of them also tend to specialize in specific cash crops (watermelon for example). Beneficiaries generally diversify their cropping systems more and keep them more stable. They also respect a certain balance between crops, especially in summer.

Future expected trends

We can expect that the present situation will not change, except for a possible continuation of the rise of berseem as a main winter crop. Farmers in El Bustan regret having to practice a quasi-monocropping of groundnut in summer, but express that their choice is limited, due to the need for a drought-resistant crop in summer in these very quickly dried-up sandy soils. No promising new crops seem to be available yet to challenge the place of groundnut.

When asked about which crops they would increase and which they would decrease, farmers of our sample answered as shown in Table 2.

Table 2. Percentage of farmers willing to increase or decrease specific crops in the near future.

Trend	Berseem	Maize	Potato	Groundnut	Wheat	Pea	Tree crops	Eggplant	Onion
Up	56	28	20	16	16	16	16	8	8
Down	0	5	0	73	23	14	0	0	0
Balance	+56	23	+20	–58	–7	+2	+16	+8	+8

This data can give us a complementary look at what could be the future trend in the local cropping pattern and shows clearly that berseem, maize and potato (now only cultivated by a handful of graduates) should be increased over the next years. Groundnut is threatened as a dominant summer crop, but as long as an appropriate alternative is found, its importance will not diminish. An interesting point also is the desire of many graduates to plant more of their land to tree crops. Some already did it on half of their farm and, especially if they are not resident in the village, they wish to plant it on the other half as well.

To finish with, we also asked the farmers which new crops they would like to introduce in their rotations. The answers are as follows:

Crop	Potato	Tomato	Other vegetables
% of farmers citing it	56	40	22

Potato comes largely ahead, and the main constraint for farmers in El Bustan is still the high input cost of this crop. However, since sandy soils are quite suitable for potato, there is a good chance that this crop becomes in the medium-term, a major winter crop, competing with wheat and berseem. Tomato and other vegetables in summer would be the other favored new crops, but water and drought stress in summer make these hardly strong challengers to groundnut.

Prevailing Crop Rotations

The crop rotations have been studied on a sample of 78 crop sequences over 5 years (10 seasons). The total area concerned is 141.58 fed (equivalent to 7 % of the village land).

The complexity and great variety of crop sequences encountered do not permit defining broad rotation categories if we adhere to taking each crop separately and studying its position in the crop sequence. Therefore, we grouped some of the cultivated crops in two categories:

- Legumes = Berseem, faba bean, pea, lubia.
- Vegetables.

We used as a classification criterion, the occurrence of groundnut as a summer crop, since the monocropping of groundnut is rather frequent and against all principles of balanced rotations. Then, the number and kind of other summer crops was taken as a second stage criterion (summer crops divided between maize and vegetables) and then, winter crop rotation was the last stage criterion. There are a few strictly defined and fixed rotations (as berseem/groundnut monocropping for example), but most of them seem actually rather unstructured.

The complete results of this rotation classification are presented in Table 3.

Table 3. Tentative classification of prevailing crop rotations in Ali Ibn Abi Taleb village (El Bustan area).

Groundnut occurrence in summer	A	No.	Other summer crops	A	No.	Number of winter crops	A	No.	Winter crop rotation	A	No.	Example	Rotation years
Groundnut every summer	52	40	no	52	40	(1) Wheat	3	3	W–W–W...	3	3	Wheat/Groundnut–...	1
						(2) Wheat/Legume/Vegetables	31	27	W–V	1	1	Wheat/G–Wm seeds/G	1
									W–L–L or W–W–L	16	13	Wheat/G–Wheat/G–Peas/G	3
									W–L	10	9	Wheat/G–Berseem/G	2
									W–L–L–L	4	4	Faba bean/G–P/G–Ber/G–W/G	4
						(3) Wheat/Legume/Veg/Fallow	18	10	not fixed ex: W–L–V–Sesame	18	10	Eggplant/G–Wheat/G–Helba/G–Wheat/G...	
Groundnut 3/4 and 2/3	19	18	Maize G–G–(G)–M	12	14	(1) Leg or Wheat	4	5	W–W–W...	2	2	Wheat/G–Wheat/G–W/Maize	3
									L–L–L...	2	3	Berseem/G–Ber/G–Peas/Maize	3
						(2) Legume + Wheat	8	9	L–W	8	9	Berseem/G–W/G–Ber/Maize–W/G–Ber/G–W/Maize	6
			Vegetables G–G–(G)–V	7	4	(2) Legume + Wheat (Barley)	7	4	W–L–L	7	4	Wheat/G–Peas/G–Ber/Wm	3
Groundnut every two years	13	19	Maize	11	16	(2) Legume + Wheat	11	16	L–W	11	16	Wheat/Maize–Berseem/G	2
			Vegetables	2	3	(2) Legume + Wheat	2	3	L–W	2	3	Berseem/Wm–Wheat/G	2
Groundnut 1/3 and 1/4	7	14	Maize M–M–(M)–G	2	6	(2) Wheat + Legume	2	6	W–L	2	6	Wheat/Maize–Ber/Maize–W/G–Ber/M–W/Maize–Ber/G	6
			Vegetables V–V–(V)–G	3	5	(3) Wheat + Leg + Veg	3	5	not fixed	3	5	Peas/Tomato–Ber/Tom–W/G	
			Maize/Veg M–V–G	1	2	(2) Wheat + Legume	1	2	W–L	1	2	Wheat/Maize–Faba bean/Wm–Wheat/G...	
No Groundnut	7	1	Watermelon	7	10	(1) Fallow (wheat)	7	10	Fallow–Fallow–Fallow–(W)	7	10	Fallow/Watermelon–...	1

A = Area = % of the total sample area which is subject to the described rotation.
No. = % of the total sample crop sequences which corresponds to the described rotation.
G = groundnut; L= legume winter crop; W = wheat; Veg = V = vegetable; M = maize; FB = faba bean; Tom = tomato; Ber = berseem; Wm = watermelon.
(1) = One type of summer crop only; (2) = Two types of summer crops.

Based on this classification, the three more frequent rotations—called hereafter prevailing rotations—are:

1. Groundnut Every Summer

Area = 52% Number = 40%

Type = Wheat/G—Wheat/G—Leg/Groundnut

This rotation is based on the summer monocropping of groundnut combined with a three-year winter rotation where wheat comes into the rotation two years out of three.

Example: Wheat/Groundnut–Wheat/Groundnut–Berseem/Groundnut

2. Groundnut 3/4 to 2/3

Area = 19% Number = 18%

Type = Legume/Wheat × Groundnut/Groundnut/Maize

This rotation is the combination of a 2-year winter rotation and a three-year summer rotation. It is therefore, in theory, a 6-year rotation and one of the most complex and diversified rotation, but in practice, few farmers would complete it strictly as such.

Example: Berseem/Groundnut–Wheat/Groundnut–Berseem/Maize–Wheat/Groundnut –Peas/Groundnut–Wheat/Maize

3. Groundnut Every Two Years

Area = 13% Number = 19%

Type = Legume/Groundnut–Wheat/Maize

This is a two-year rotation with good crop diversification, but, however, there is concentration of two legumes in the same year.

Example = Berseem/Groundnut–Wheat/Maize

Table 4 gives additional information on crop successions). The percentages expressed in that table tell us, for such particular crop, what the percentage of cases is (throughout our sample) in which it is succeeded by the following crop. This exercise has been done for winter to summer successions, as well as for winter-to-winter and summer-to-summer.

Table 4. Crop successions in Ali Ibn Abi Taleb village, El Bustan area (expressed in % of total number of cases).

Winter/summer and summer/winter successions

Following / Preceding	Berseem	Wheat	Pea	Faba bean	Onion	Helba	Barley	Potato	Groundnut	Tomato	Maize	Watermelon & watermelon seed	Lubia	Pepper & eggplant	Fallow	Total
Berseem									55	1	31	1	7	1	3	100
Wheat									71	1	23	2	1	1	2	100
Pea									80	2	11	4		2	2	100
Faba bean									75		17	8				100
Onion									100							100
Helba									100							100
Barley									100							100
Potato																
Groundnut	22	38	20	6	1	2	2	0		0		0		1	7	100
Tomato	50	25							25							100
Maize	33	38	19	3								2		2	3	100
Watermelon & watermelon seed		50					10		20						20	100
Lubia	20	80														100
Pepper & eggplant			14						29		29	14		14		100
Fallow			5	5		5			67			14	5			100

Winter to winter succession

Following / Preceding	Berseem	Wheat	Pea	Faba bean	Onion	Helba	Barley	Potato	Groundnut	Tomato	Maize	Watermelon & watermelon seed	Lubia	Pepper & eggplant	Fallow	Total
Berseem	9	75	5				2					2		2	5	100
Wheat	35	20	25	5	2	2	2			1		1		2	5	100
Pea	17	48	19	4	2	2	2	2							6	100
Faba bean	8	50	25	17												100
Onion															100	100
Helba		75													25	100
Barley		50	25	25												100
Potato																
Groundnut																
Tomato						100										100
Maize																
Watermelon & watermelon seed	50	50														100
Lubia																
Pepper & eggplant		50	25											25		100
Fallow	10	43		10		5	5							5	24	100

Table 4. (Cont'd)

Summer to summer successions

Following / Preceding	Berseem	Wheat	Pea	Faba bean	Onion	Helba	Barley	Potato	Groundnut	Tomato	Maize	Watermelon & watermelon seed	Lubia	Pepper & eggplant	Fallow	Total
Berseem																
Wheat																
Pea																
Faba bean																
Onion																
Helba																
Barley																
Potato																
Groundnut									68		24	2	4	1	2	100
Tomato									67	33						100
Maize									72		18	2	4		4	100
Watermelon & watermelon seed									57			29			14	100
Lubia									50		25		25			100
Pepper & eggplant									33	33	33					100
Fallow									75		25					100

Fertility Management

Evolution of Soil Characteristics

Farmers were asked in the survey to describe the main changes they perceived in the soil quality of their farm. The results of this opinion poll are as follows:

Category	Changes	% of farmers
Beneficiaries	. Increase of salinity	45
	. Color	45
	. Structure	27
	. No change	23
Graduates	. Improvement (no details)	33
	. No change	67
Total	. Salinity increase	23
	. Color	23
	. Improvement	16
	. Structure	13
	. No change	35

These qualitative data clearly show that the farmers' impression on soil changes varies a lot with the position of their plot. Indeed, a good half of the interviewed beneficiaries were in depressions and most of them suffered from high salinity in part of their fields. The surveyed graduates are usually better placed and mentioned only positive changes. The change in color refers to organic matter build-up, but it was mentioned by only a quarter of the farmers, where in the Sugar Beet area it was 36%. Also, 35% of the farmers mentioned no change at all, although the average duration of cultivation in this village is 9 years (by comparison, in the Sugar Beet area, only 9% of the farmers did not notice changes and the average farm age there is 5 years). This confirms that fertility build-up in El Bustan (sandy soil) is slower than in the Sugar Beet area (calcareous soil).

Beneficiaries in our sample have been cultivating their land for, on average, 19 seasons and graduates for 17 seasons.

To continue with this effect of age of cultivation, we looked at the correlation between the number of seasons cultivated and the yields obtained for various crops. However, even more than in the Sugar Beet area, we highly suspect that most of the farmers understated their yield records to us and, therefore, the correlation did not give satisfactory results. The results are shown in Table 5.

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Table 5. Coefficient of correlation between age of cultivation and yield for various crops (Ali Ibn Abi Taleb village).

Crop	All
Berseem	–0.35
Faba bean	----
Groundnut	0.04
Pea	–0.63
Maize	–0.56
Eggplant	0.50

If we look at the yield increase for the same crops[2], over a five-year period (see Table 6), the picture is mixed. There is a clear trend upwards (more than 5%) for 4 crops out of 13, and two of them are legume crops. Then, for another 4 crops, the trend is obviously downwards, with a maximum drop for watermelon seeds and sesame. Groundnut yield has also steadily decreased over the last 5 years, mainly as a consequence of the frequent monocropping and the pest problems associated with it. For the remaining 5 crops, there is no clear indication that the trend was up or down because the rate of variation is too low (less than 10%) to be really significant.

Anyway, this shows that cultivation in these sandy soils does not bring rapid increase in yields like in the Sugar Beet area, for example, and that solutions have to be quickly devised to stop the yield decline of a major crop like groundnut, or to boost the yield increase of another major crop like wheat.

Soil Improvement Work

A small proportion of farmers (24%) carried out soil improvement work on their land after starting its cultivation. The details are given in Table 7.

Leveling and the addition of clay are the most common types of soil improvement practiced in sandy soils in this village. Rates of clay reported by the farmers (150 m^3) are enormous compared to what farmers in the Sugar Beet area use (15 m^3). Graduates are keener on carrying out land improvement work, maybe because of their more comfortable financial resources, but also due to their usual desire for practicing a modern and technology-intensive agriculture.

[2] The yield increase between absolute values is less likely to be far from reality than the absolute yield value.

Table 6. Evolution of crop yields (kg/fed) over 5 years, Ali Ibn Abi Taleb village (El Bustan area).

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	
Berseem	3253	1500–5000	3209	2500–4000	3220	2500–4000	+2
Faba bean	726	500–1500	513	300–620	552	200–775	+31
Helba	333	150–500	150	150	200	150–250	+67
Lubia	367	300–500	?	?	450	400–500	–18
Pea	1972	500–4000	1796	500–4000	2000	500–5000	–1
Groundnut	647	300–1350	689	450–1125	782	375–1350	–17
Wheat	935	300–1350	1050	750–1350	903	450–1200	+3
Barley	630	540–720	?	?	540	540	+15
Maize	879	420–1600	984	700–1400	942	700–1400	–7
Sesame	110	70–150	150	100–200	200	150–250	–45
Watermelon seed	140	100–200	210	180–250	275	250–300	–50
Potato	8000	4000–12000	NA	NA	NA	NA	NA
Onion	2500	1000–4000	2167	1500–3000	2000	2000	+25
Eggplant	10750	3000–15000	?	?	12333	12000–25000	–13

Table 7. Soil improvement work carried out by farmers in Ali Ibn Abi Taleb village.

Type of soil improvement	Beneficiaries (%)	Graduates (%)	Whole sample (%)
- Addition of sulfur (75 kg/fed)	7	0	4
- Addition of clay (150 m^3/fed)	7	13	10
- Leveling	0	20	10
% of farmers who carried out at least one type of soil improvement	14	33	24

Fertility Management Methods

We will first look at the farmers' opinions concerning the best fertility management methods. The question was not restrictive in terms of soil fertility, but was referring more to the land quality as a cultivation stratum. Therefore, some of the farmers' answers obviously deal with problems which are not related to what is considered as fertility management *stricto sensu*, yet these answers point out some problems which, in the farmers' views, surpass in importance the strictly speaking fertility build-up issues. The question also focused on methods with long-term effects.

The results are shown in Table 8.

Table 8. Farmers' best methods to increase soil quality (expressed in % of farmers mentioning the method), Ali Ibn Abi Taleb village.

Beneficiaries		Graduates		Whole sample	
Drainage	80	Manuring	100	Manuring	90
Manuring	74	Fertilizers	53	Fertilizers	43
Fertilizers	33	Legume cropping	20	Drainage	43
Legume cropping	20	Drainage	7	Legume cropping	20
Crop rotation	7			Crop rotation	7

The results show that:

- Manuring is overwhelmingly the farmers' preferred method to improve their land quality, especially in this sandy soil which is very poor in organic matter.
- Drainage comes as a surprise for farmers cultivating sandy soils, but we found that there is a real problem of waterlogging and salinity increase in the depression zones close to the canals, certainly due to water seepage from the canals down to the groundwater table. However, this would do no harm if there was not a kind of hard soil layer close to the surface which prevents this excess water from draining out.
- Other traditional, and often thought-of, methods come in the last position, such as legume cropping and crop rotations. However, legume cropping is much more mentioned than in the Sugar Beet area for example (7% of the farmers there).

We will now review, one by one, all the methods dealing *stricto sensu* with fertility management and detail all relevant survey results regarding each of them.

Use of manure

General data on the use of manure

All farmers use manure in Ali Ibn Abi Taleb village, on all or some of their crops (see later). The most interesting points taken from Table 9 are:

- The general trend is towards increasing the quantity of manure applied in the fields, and this applies to both classes of farmers. The majority of beneficiaries even recognize that they use more manure than they would on their Old Lands farms, although the rates there are already high. In the Sugar Beet area, the proportion is the opposite. This again shows the difficulty to build-up a fertile soil layer in these sandy soils, even after almost 10 years of cultivation.

- Farmers mention all crops as a priority when it comes to the use of manure, meaning that the soil is so poor that manure is seen as a prerequisite to getting decent yields and not a kind of luxury fertilization. It is surprising to see that only 7% of the farmers mentioned specifically groundnut, which shows again that farmers are far from appreciating this crop.

Table 9. Various general data on the use of manure in Ali Ibn Abi Taleb village.

Criterion	Beneficiaries		Graduates		Whole sample	
Number of seasons during which land was manured	16		14		15	
Average time gap between first cropping season and first manuring season	1 season		3 seasons		2 seasons	
Trend in the use of manure (quantity)[3]	Up	67%	Up	73%	Up	70%
	Equal	17%	Equal	20%	Equal	19%
	Down	17%	Down	7%	Down	11%
Rate applied compared to Old Lands practice (beneficiaries only)	More	75%	NA		NA	
	Equal	8%				
	Less	17%				
Priority crops manured (% of farmers mentioning the crop)	All	67%	All	62%	All	64%
	Maize	23%	Trees	14%	Wheat	19%
	Wheat	23%	Wheat	14%	Maize	15%
	Berseem	15%	Vegetables	14%	Berseem	11%
	Groundnut	15%	Berseem	7%	Vegetables	11%
	Faba bean	8%	Maize	7%	Faba bean	7%
	Vegetables	8%	Faba bean	7%	Groundnut	7%
					Trees	7%

NA = Not applicable.

We also tried to relate the trend of manure use to the trend of chemical fertilizers use and found that:

- 4% of the farmers said they had increased manure and reduced fertilizers at the same time
- 8% did not change manure but increased fertilizers
- 7% decreased manure and increased fertilizers.

Altogether, for only 19% of the farmers could we detect a clear antagonist relation between the trend in manure application and the trend in fertilizer application. However, 50% of the farmers said they had increased manure application but maintained the fertilizer doses at the same level as 5 years ago. This would mean that farmers expect more pronounced fertility build-up effects from manure than from fertilizers.

[3] Based on farmers' appreciation and not on crop data (see later).

Use of manure by crops

Percentage of farmers using manure by crop:

Table 10 shows that the highest percentage is reached for vegetables. Winter crops are markedly less manured than summer crops, especially berseem and faba bean.

Rate applied per crop:

If we put aside potato, which is always manured and fertilized to excess, there is no big difference in the manure rates applied to the various crops.

The trend in rate is positive for 8 crops out of 10. The highest increases took place not for vegetable cash crops, but surprisingly for winter legumes.

Effect of preceding crop: (see Fig. 4, 5 and 6)

The quantity of manure applied varies with the preceding crop, but it is not clear from the data collected (see Fig. 6) whether there are common rules for certain preceding crops. It seems that after wheat, manure rate is usually less than the average rate[4]. For the other preceding crops, we lack data to draw any conclusions.

Use of manure according to farmers' origin

The first obvious difference between beneficiaries and graduates concerning crop manuring appears in the percentage of farmers from each group who apply manure (Table 11). For example, graduates add, in general, manure to berseem, whereas beneficiaries are less prone to do it. On the opposite side, most beneficiaries will do it with peas when graduates rarely give manure to this crop. If we look at the applied rates, for 4 crops out of 5, beneficiaries add more manure than graduates (up to twice more for groundnut and maize) do. Only for berseem do graduates add more than beneficiaries, showing that this crop is more and more favored by graduates (high increase in rate also for the graduates concerning berseem). Both graduates and beneficiaries increased manuring rates within the last 5 years, except for maize concerning graduates (which also confirms the minor importance given by graduates to this crop).

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[4] Average rate means here the average of the rates of manure applied to a certain crop for different preceding crops. It differs from the rates presented in Table 9, which are average rates on the whole sample, where the various preceding crops are not represented equally.

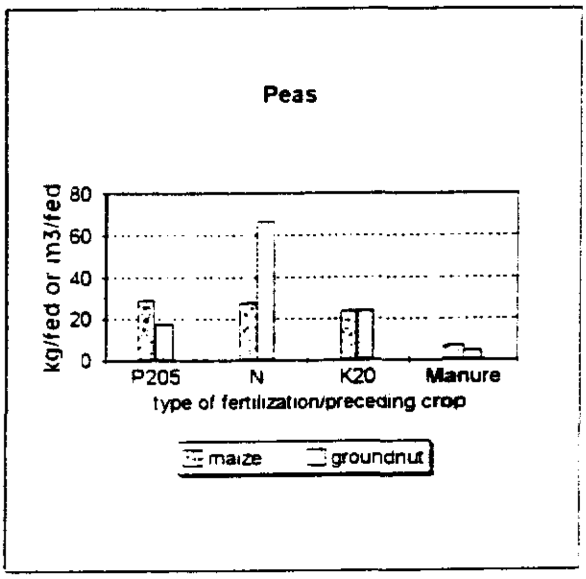
Table 10. Fertilization practices by crop in Ali Ibn Abi Taleb village, El Bustan area.

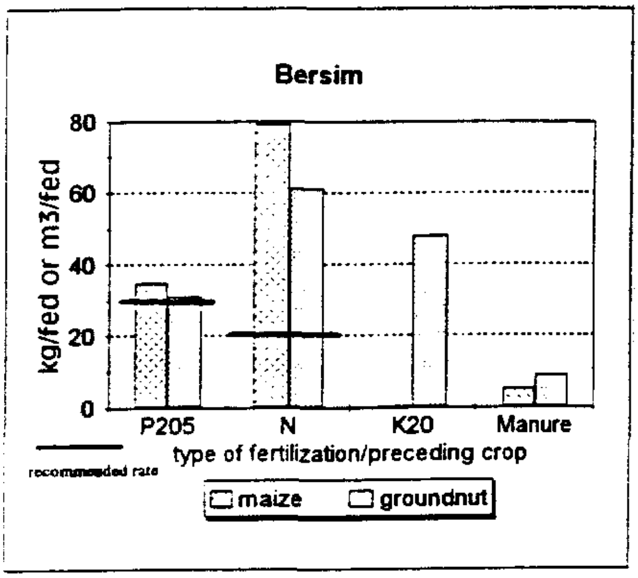
Crop	P_2O_5				Manure				Total N				K_2O			
	% farmers applying	Rate (kg/fed)	Range	Rate trend (5 years)	% farmers applying	Rate (m^3/fed)	Range	Rate trend (5 years)	% farmers applying	Rate (kg/fed)	Range	Rate trend (5 years)	% farmers applying	Rate (kg/fed)	Range	Rate trend (5 years)
Berseem	94	31	8–39	0%	44	8	4–20	+66%	100	66	21–116	+5%	6	48	48	+50%
[illegible]sa	93	21	8–39	0%	38	6	3–8	+20%	100	56	21–119	+2%	38	22	12–24	–8%
Faba bean	100	22	16–39	+22%	44	6	4–8	+50%	100	50	21–119	0%	11	48	48	0%
Lubia	67	35	23–47	?	67	7	5–8	?	100	59	50–66	+5%	33	48	48	0%
Helba	100	16	16	0%	33	4	4	?	100	41	41	+15%	0	–	–	–
Groundnut	92	27	16–39	0%	88	7	2–15	+16%	100	92	65–165	+6%	60	25	12–48	+9%
Wheat	96	25	8–39	0%	75	6	3–15	+20%	100	92	66–198	+12%	44	26	24–48	+8%
Maize	100	29.5	8–47	+3%	100	9.9	3–15	+18%	100	86	66–165	+16%	85	26	24–48	+7%
Barley	100	12	8–16		0		–	–	100	88	76–99	?	0	–	–	–
Sesame	50	16	16	+100%	0		–	–	100	41	33–50	–18%	50	24	24	+100%
Water-melon seed	75	26	16–31	+13%	100	6	3–7	–14%	100	66	33–99	–4%	100	21	12–24	+5%
Potato	100	74	31–116	+89%	100	24	2–45	+11%	100	274	153–395	+38%	50	48	48	?
Onion	100	16	16	+14%	100	3	2–4	0%	100	66	66	0%	50	24	24	+33%
Eggplant	100	31	16–39	+20%	100	9	4–12	+33%	100	259	83–790	+50%	50	96	48–144	–

Table 11. Fertilization according to farmers' origin in Ali Ibn Abi Taleb village, El Bustan area.

Crop	P_2O_5						Manure						Total N						K_2O					
	% farmers applying		Rate (kg/fed)		Trend over 5 years (%)		% farmers applying		Rate (m^3/fed)		Trend over 5 years (%)		% farmers applying		Rate (kg/fed)		Trend over 5 years (%)		% farmers applying		Rate (kg/fed)		Trend over 5 years (%)	
	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G
Berseem	100	85	34	25	+4	+8	27	71	6	9	+20	+30	90	100	73	58	+13	0	0	14	–	48	–	+100
Groundnut	100	82	30	23	+8	+7	93	82	9	4	+22	+2	100	100	95	89	+8	+6	92	36	24	28	0	+100
Maize	100	100	30	26	+5	0	100	100	11	6	+25	0	100	100	81	108	+12	0	92	67	24	36	0	0
Pea	100	91	26	18	+5	+27	80	18	7	4	+40	+25	100	100	37	64	0	+6	60	27	24	20	0	0
Wheat	100	93	33	17	+11	–3	93	57	7	5	+24	+23	100	100	93	91	+13	+4	64	23	24	32	0	0

B = Beneficiaries; G = Graduates.





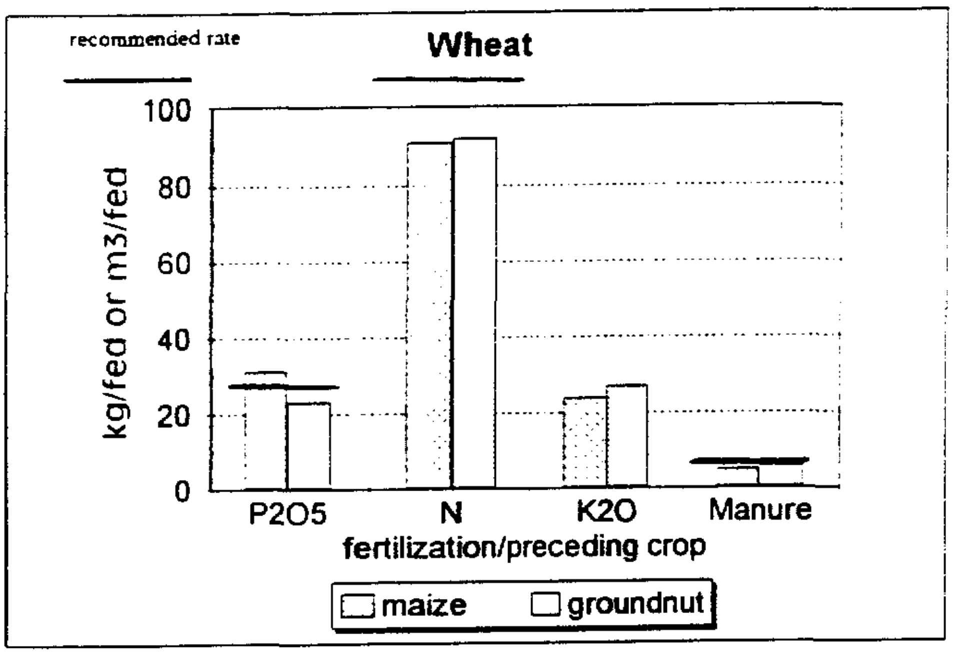
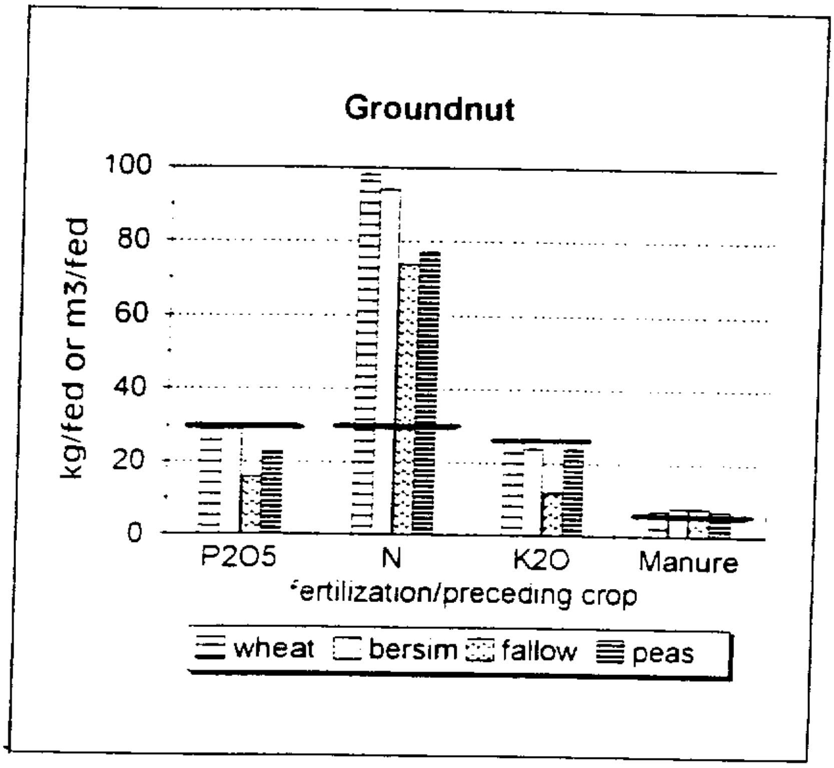


Fig. 4. Fertilization package by crop (according to the preceding crop), Ali Ibn Abi Taleb village, El Bustan (winter crops).



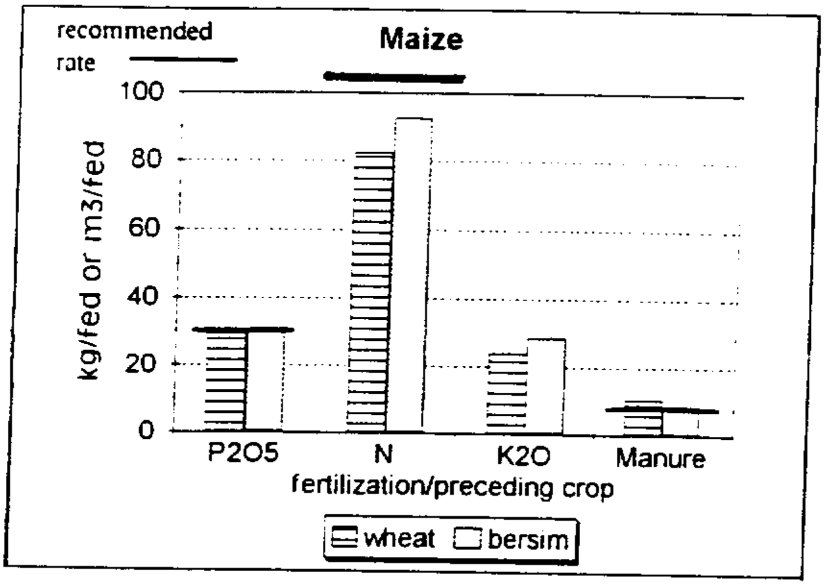
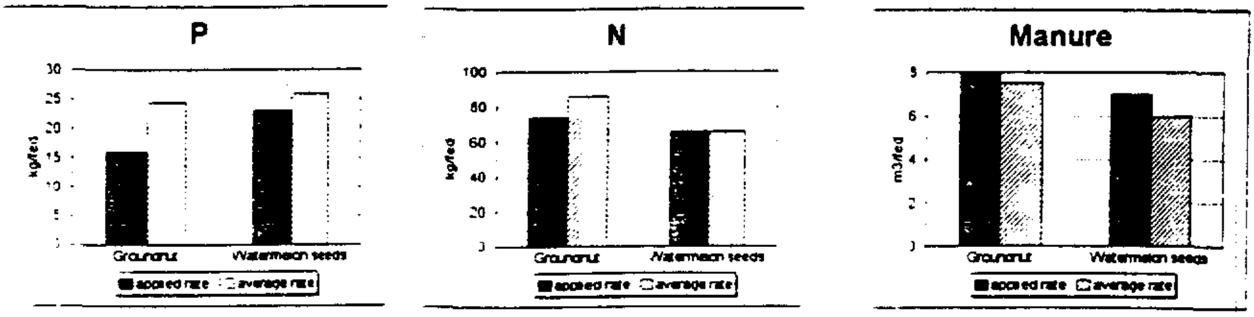
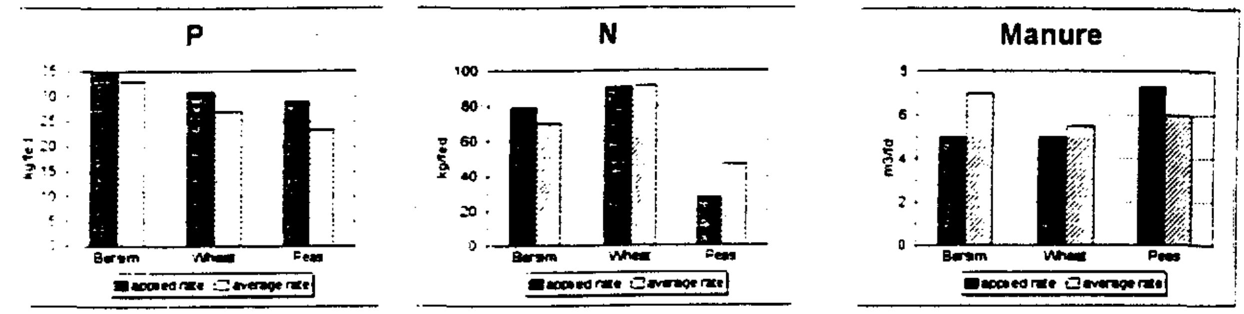


Fig. 5. Fertilization package by crop (according to the preceding crop), Ali Ibn Abi Taleb village, El Bustan (summer crops).

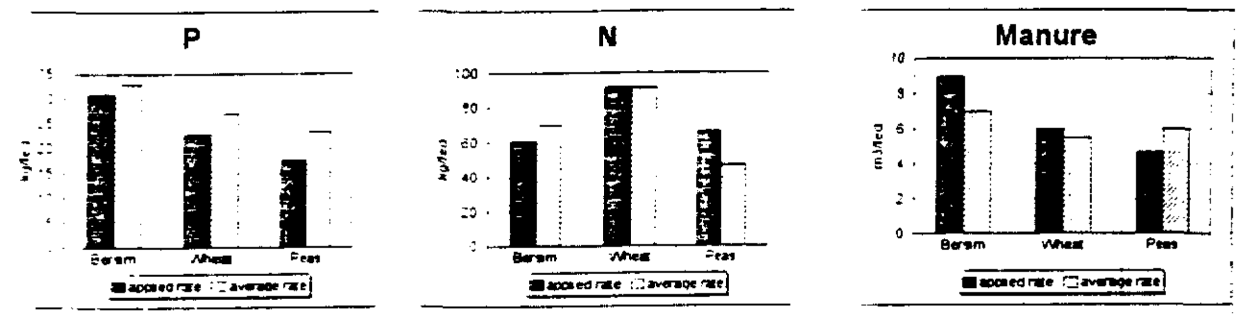
A- After FALLOW :



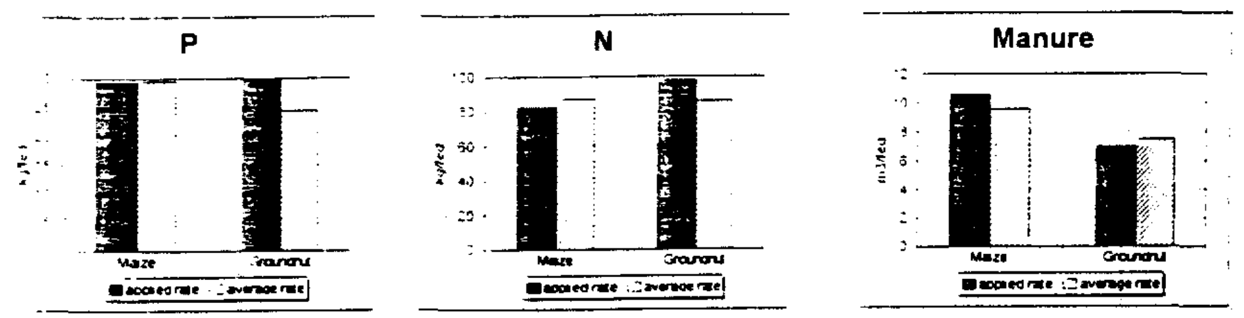
B- After MAIZE



C- After GROUNDNUT



D- After WHEAT



E- After BERSIM

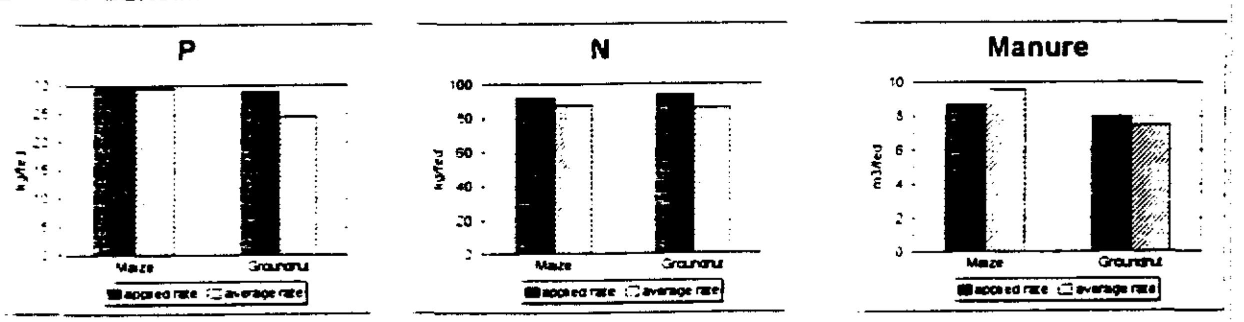


Fig. 6. Effect of the preceding crop on the fertilization rates, Ali Ibn Abi Taleb village (El Bustan area).

Correlation to yield

There seems to be a correlation at least for 5 crops (berseem, pea, wheat, maize and eggplant) (Table 12). The higher coefficients of correlation for maize and eggplant are certainly due to the fact that these two crops receive the highest manure rates, and therefore the effect on yields are more likely to appear.

Table 12. Coefficients of correlation between manure application and crop yields (Ali Ibn Abi Taleb village).

	Berseem	Faba bean	Groundnut	Pea	Wheat	Maize	Eggplant
Graduates[5]	0.76	–0.03	0.03	-0.05	0.30	0.43	0.98
All	0.09	–0.03	0.03	0.40	0.52	0.58	0.80

Use of chemical fertilizers

General data on the use of fertilizers

All farmers use phosphorus (superphosphate 15.5%) and nitrogen fertilizers (urea 46%, ammonium sulfate 20.6%, ammonium nitrate 33%), and 90% use potassium fertilizers (potassium sulfate 48%) (Table 13).

Table 13. General data on the use of fertilizers in Ali Ibn Abi Taleb village.

Criterion	Beneficiaries	Graduates	Whole sample
Trend in the use of fertilizers[6]	Up 29% Equal 64% Down 7%	Up 33% Equal 60% Down 7%	Up 31% Equal 62% Down 7%
Reaction to fertilizer price increase:			
1. Reduce rate/fed	20% (berseem, peas)	33% (winter crops)	27% (berseem, winter crops)
2. Change rotations	0%	0%	0%
3. Decrease crop area	0%	20% (wheat, groundnut)	10% (wheat, groundnut)
4. No change	80%	40%	60%
Rate applied compared to Old Lands (beneficiaries only)	More 92% Less 8%	NA	NA

NA = Not applicable.

[5] The correlations were run on the whole sample first, giving rather disappointing results. It was run again on the graduate sample only. Indeed, we suspect that beneficiaries usually understate their yields when questioned by outsiders. Throughout the survey results, all yield data therefore had to be treated carefully and the error margin could be as high as 30% (on absolute values). Graduates are less expected to give false information on their yield values for various reasons, and this is why usually the correlations to yields give more significant results with them.

[6] Based on farmers' appreciation and not on crop data.

The main comments on Table 13 are:

- The majority of farmers are maintaining their fertilizer rates at the same level as 5 years ago. This attitude would mean that farmers in El Bustan did not get convincing results from the marginal increase of fertilizer rates. This is to be expected in sandy soils where chemical fertilizers are rapidly leached away into the soil profile making fertilizer efficiency low.
- Most farmers are not reacting to fertilizer price increases by changing their fertilization practices. Especially beneficiaries are not eager to reduce the rates or the area cultivated with fertilizer-consuming crops. However, if rates have to be reduced on some crops, it will be first on winter crops, especially berseem and wheat, whereas summer crops and especially vegetables will remain untouched.
- As mentioned earlier, there is no clear relation between the trend in use of fertilizers and the trend in use of manure from what the farmers expressed. However, if we look at the correlation between manure rates and respectively phosphate and nitrogen rates, we find the results as in Table 14.

Table 14. Coefficients of correlation for various crops between manure rates and fertilizer rates.

Crop	Berseem	Eggplant	Faba bean	Groundnut	Maize	Pea	Wheat	Watermelon seeds
Manure x phosphate	0.03	0.83	0.58	0.53	0.60	0.58	0.59	0.98
Manure x nitrogen	0.33	0.68	0.29	0.24	0.04	–0.45	0.41	0.55

Except for peas (negative correlation between applied rate of manure and N fertilizer), there is a clear positive relation for all crops between manure and chemical fertilizers. This means that farmers in El Bustan do not see the two as being competitive but supplementary. Farmers want to add more of the two, although, as seen before, manure has been increased to a larger extent than fertilizers. Farmers add according to their means, and if they can afford large quantities of manure they can also afford higher fertilizer rates. The traditional thinking that the increase of one of the two is usually done at the expense of the other one does not apply here.

Use of fertilizers detailed by crop (cf. Table 10)

Percentage of farmers using fertilizers by crop:

Phosphorus

Practically all farmers use superphosphate on all the crops.

Nitrogen

All farmers use nitrogen fertilizer on all crops.

Potassium

Potassium is applied to 12 out of 14 crops, but by only a small number of farmers on berseem. Groundnut, maize and vegetables are given potassium by at least half of the farmers. Potassium utilization is however much higher here than in the Sugar Beet area, for example, or in Middle Egypt where no farmers were found using it.

Rate applied per crop:

Phosphorus

There are no marked differences in rates applied to the various crop types (legumes, cereals, vegetables) if we consider potato as a separate case. The average rate for winter crops is 21 kg P_2O_5/fed, whereas it is 27.4 kg for summer crops, showing again that farmers do not balance their fertilizer application over the year, but tend to concentrate it in summer.

Rates have been increased mainly for summer vegetables and for sesame.

Finally, rates applied are usually equal or just under the recommendations (when they were found) given by the Extension Services for the use of phosphate in the New Lands.

Nitrogen

Potato and eggplant receive huge amounts of nitrogen as would be expected for high gross-margin cash crops. Apart from these two crops, cereals receive the highest amounts of nitrogen, whereas sesame and faba bean are the least favored in that respect. There is no significant difference between winter and summer crops here (65.6 kg N/fed against 68.8 kg).

The rates applied are much over the recommended rates for winter legume crops (+200% for groundnut and +230% for berseem), but below the recommendations for cereals. This would mean that, in fact, legume crops are better treated than cereals, if we assume that farmers are aware of what the recommended rates of nitrogen fertilizer are (see Figs 4 and 5).

Regarding the increase rate within the past 5 years (increases under ±5% are considered equal to nil), these rates were augmented for 5 crops out of 13 (and 2 of them are considered as atypical, namely eggplant and potato), decreased for one (sesame, but it is a marginal crop in El Bustan), and unchanged for the rest.

Potassium

Among the 12 crops that are given potassium, vegetables and winter legume crops receive the highest rates, with a maximum recorded dose for eggplant (96 kg K_2O/fed).

The increases recorded are only significant for berseem, sesame and eggplant. Once again, berseem is one of the most favored crops in terms of fertilization trend over the last 5 years.

Effect of preceding crop:

For all the crops for which we have at least three different following crops with specific fertilization packages recorded, we compared the rates applied to these crops to what would be the average rate. The results are shown in Fig 6.

Phosphorus

Farmers clearly reduce the P rate after a period of fallow and, to a lesser extent, after groundnut. On the contrary, it is always higher after maize, although maize receives a high P_2O_5 rate among all crops (30 kg/fed when the average rate calculated on the major crops would be 26 kg/fed). Surprisingly also, P rates are not reduced after berseem, although it receives one of the highest P rates across all crops.

Nitrogen

Farmers somehow reduce N fertilization after fallow, but otherwise (like in the Sugar Beet area) they increase it after berseem. For groundnut and wheat, which receive the highest N rates among the 5 crops present in Fig. 6, there is no effect on N fertilization of the succeeding crop, which shows that farmers might take into account that the residual effect of N fertilizer from one crop to the other is very low, especially in sandy soils. However, they do not consider at all the N-fixing effect of berseem. Like in the Sugar Beet area, this is certainly a priority issue to be studied through closer monitoring and, possibly, in some of the trials.

Use of fertilizers according to farmers' origin

Phosphorus

Beneficiaries add, in all cases, more P_2O_5 than graduates do, maybe because—at least in our sample—their fields were located in poorer soil-quality areas than the graduates' ones (Table 11).

Nitrogen

For nitrogen, there is no significant separation between the two groups. For berseem and groundnut, beneficiaries clearly give more nitrogen than graduates, whereas it is the opposite for maize and peas. Beneficiaries have been more prone to increasing N fertilization than graduates.

Potassium

Potassium is more often added by beneficiaries than by graduates.

Correlation to yield

The correlations are obviously positive for some crops like berseem, eggplant, and, to a lesser extent, for wheat (Table 15). On the other hand, they are rather negative for faba bean and groundnut. However, due to the uncertainty around the yield values, we will not go into further analysis on these correlation coefficients.

Table 15. Coefficients of correlation between P, N and K application and crop yields (Ali Ibn Abi Taleb village).

		Berseem	Faba bean	Groundnut	Pea	Wheat	Maize	Eggplant
P	G	0.25	−0.24	−0.18	0.26	0.44	−0.1	1
	All	0.52	−0.24	−0.40	0.57	0.74	0.06	1
N	G	0.89	0.01	−0.27	0.11	0.30	0.24	0.81
	All	0.65	0.01	−0.29	−0.42	0.18	−0.04	0.50
K	G	0.91	−0.17	0	0.28	0.31	−0.22	0.83
	All	0.46	−0.17	−0.15	0.62	0.56	−0.15	0.50

Legume crops

The use of legume crops as a fertility management method has been cited by only 20% of the farmers. However, farmers in El Bustan cultivate a major share of their land with legume crops and the land ratio allocated to legume crops is quite high (see later). Given the relatively high rates of fertilizers added to legume crops, the enriching effect of legumes could be shadowed by this excess of N fertilization. In addition to this, crops that follow berseem are also fertilized with nitrogen at higher levels than after other preceding crops, which clearly contradicts the expected improving effect of legumes.

Still, when farmers were asked which crops have a positive effect on the succeeding crops, the answers were as follows:

Crop	Berseem	Pea	Faba bean	Helba
% of farmers	93%	45%	29%	7%

This seems contradictory to the data collected on fertilization according to the preceding crops. But berseem can also be seen as an improving crop because it greatly reduces the amount of weeds for the following crop, provides rich residues which are plowed in the soil before the following crop, and is heavily irrigated and therefore the soil is well leached and salinity is reduced before the summer crop also. The N-fixation effect is probably not the first benefit of berseem that farmers think of when they mention it in the first position.

Trend in legume cultivation

Eighty-one percent of the farmers said that they increased (and will continue to) the importance of legume crops in their rotations. This is mostly true for berseem since faba bean is rather on the decline. Groundnut will still occupy the major part of the summer cropped area although farmers wish they could reduce its cultivation.

If we use the cropping pattern data and add up all the legume crops, we obtain the results in Table 16.

Table 16. Trend of importance of the position of legume crops in the cropping pattern.

Year	Average farm share			Total area share		
	1992	1993	1994	1992	1993	1994
Winter legumes	25%	45%	45%	30%	54%	32%
Summer legumes	78%	77%	76%	86%	80%	79%

Table 16 shows that, on the whole, the importance of legumes in the land-use patterns did not vary much over the last 4 years. It remains very high in summer but since in that season, it concerns only groundnut, the potential positive effects of N-fixation are overridden by the negative consequences of groundnut monocropping.

Place of legumes in the rotations

In the three prevailing types of rotations, legume crops occupy a major place in summer and are usually grown every two to three years in winter.

Using the crop sequence data per plot, the average duration between two legume crops (winter and summer) on a piece of land were statistically calculated (Table 17).

Table 17. Average time lapse between two legume crops in Ali Ibn Abi Taleb village.

Category	Average time lapse	Range
Beneficiaries	11 months	(7m, 1y 5m)
Graduates	10 months	(7m, 1y 2m)
Total	11 months	(7m, 1y 5m)

The time lapses are from seeding date to seeding date. These time lapses are very short and, without any doubt, among the shortest that could be found in any cropping system in Egypt. However, these intensive legume-cropping rotations do not show much fertility build-up effect in these sandy soils.

Use of inoculants

No farmer is using or has ever used inoculants in the sample we surveyed. This could be a reason why the N-fixing effect of legume crops does not appear in this survey in El Bustan area.

Crop residues

We tried to classify crops in three groups, according to the effect of crop-residue management practiced by the farmers. The following results were obtained:

1. Total export (of nutrients) means that the residues are all removed from the field, then burnt, sold or used in any way which is not farm animal feed.

2. Partial restitution means that the residues are given to animals whose manure will be applied on the field later on.

3. Complete restitution means that the residues are left to decay on the field and then plowed in the soil at the time the land is prepared for the following crop.

The survey results go as follows (Table 18):

Table 18. Crop residue management in Ali Ibn Abi Taleb village.

Total export	Partial restitution	Complete restitution
Maize (fuel)	Barley (straw–AF)	Berseem (P)
Eggplant	Lubia (AF)	Barley (stem base–P)
	Wheat (AF)	Pea (P)
	Sesame (M)	Wheat (stem base–P)
	Groundnut (AF)	Watermelon (P)
	Faba bean (AF)	Onion (P)
		Groundnut (P)
		Faba bean (P)

AF= Animal feed, M = Mixed with manure, P = Plowed-in.

Faba bean and groundnut are mentioned in two categories because most of the farmers are actually using their residues both as animal feed and as mulch.

Table 18 shows that most of the crop residues are contributing indirectly or directly to fertility maintenance. However, farmers' awareness of the need to recycle as much as possible of the crop residues on the field itself is rather low (crop residues as a fertility management method not cited by the farmers). Green manuring and zero-tillage are also totally unknown.

Water Management and Soil Degradation

Water Supply

To investigate whether there were variations in El Bustan regarding water supply among farmers depending on the distance of their field from the main canal, we surveyed farms situated at increasing distances from the line head on three irrigation lines (each line being connected to the main canal of the area). In our sample, the maximum distance on the line is 2 km and the minimum 5 m. We studied water availability by taking into account various factors as days, hours, and pressure problems. The farmers were grouped into three classes based on the distances from the line head: 0 to 300 m, 400 to 800 m, and 900 to 2000 m, each class including 10 farmers, to see if there is any difference in water supply due to the increasing distance. Results are presented in Table 19.

The table shows that there is really no significant difference in water supply between farmers at the head and at the end of the irrigation line. Low-pressure problems can be more common at the end of the line, especially if there is a slope between the head and the tail. On the whole, we can say that water supply is not really a criterion for differentiation between farmers, especially regarding the cropping pattern and rotations they follow.

During the past 5 years, the situation in terms of water supply has not deteriorated.

Irrigation at Field Level

All farmers use moving sprinklers and none of them changed the irrigation system that he found in his field at the time he settled in this village. However, farmers are not really enthusiastic about this irrigation system. Eighty-three percent mentioned facing serious problems with it (leakage 45%, blocked pipes and emitters 30%, cost of labor 25%, theft 5%).

Finally, 57% of the farmers practice night irrigation, independently from the location of their field (head or tail end).

We calculated from the collected data (number of irrigations and hours/irrigation for each crop), the total water applied by farmers[7] and compared it to the crop water requirement[8] These data are presented in Table 20.

Excessive irrigation is highest for vegetables (peas and eggplant). In terms of water waste, over-irrigation of wheat and groundnut are however more detrimental to the whole area since these are the two major crops locally.

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[7] Based on the average water discharge of a moving sprinkler set-up on a 1 fed field = 30.2 mm/hour.

[8] ETP × 0.6 (K factor for all crops) / 0.75 (system efficiency).

Table 19. Water availability during winter and summer seasons in Ali Ibn Abi Taleb village

Position	Winter						Summer					
	Now				Five years ago			Now			Five years ago	
	No. of days	No. of hours/day	Supply adequacy	Low pressure problems	No. of days	No. of hours	No. of days	No. of hours	Adequacy	Low pressure problems	No. of days	No of hours
Class 1 (0–300 m)	all	6.3	Y 100%	Y 11%	all	6.5	all	7.6	Y 100%	33%	all	8
Class 2 (400–800 m)	all	6.5	Y 90%	Y 0%	all	7	all	8.7	Y 90%	40%	all	8.7
Class 3 (900–2000 m)	all	7	Y 83%	Y 17%	all	8	all	8	Y 75%	42%	all	9
Whole sample	all	6.6	Y 89%	Y 10%	all	7.2	all	8.2	Y 83%	39%	all	8.7

Table 20. Irrigation practices by crop.

Crop	Berseem	Wheat	Pea	Faba bean	Maize	Groundnut	Eggplant
No. of irrigations	24	21	15	17	16	23	21
No. of hours/ irrigation	3	4	5	4	5	5	5
Total hours	72	84	75	68	80	115	105
Applied irrigation (mm)	972	1134	1012	918	1080	1552	1418
Required irrigation (mm)	516	485	212	484	718	1021	545
Excess amount (mm)	456	649	800	434	362	531	873
% excess	+88	+134	+377	+90	+50	+52	+160

Drainage and Soil Salinization

There is no drainage system in El Bustan area, whether open or subsurface. Although it should not be a problem in sandy soils, we found that the absence of drainage and the commonly-related consequences (high water table, waterlogging, salinity) is a major issue for all farmers having their fields in depressions, and even more if they are close to big canals. The relation between these various factors is detailed in Table 21.

Table 21. Drainage-related problems in Ali Ibn Abi Taleb village.

Field position	Drainage problems (% farmers)	Water table in winter (m)	Water table in summer (m)	% of land affected by waterlogging	Salinity level (farmers' appreciation)	% of land permanently fallowed
Depressions	100	0.3	0.25	72	low 13% medium 25% high 62%	64
Gentle slope	40	0.95	1.3	8	no	14
Flat top	14	1	1.4	0	no	0

From this table we can see that salinity issues are tightly related to the topography, and come from the presence of a high water table in the low-lying areas. This high water table might come from seepage from adjacent canals but is also favored by the suspected presence of a hard soil layer in the profile. It has dramatic consequences for farmers having their fields in these areas; waterlogging affects, for example, 72% of their land in winter (as an average). In these areas, farmers usually have no solution but to permanently fallow the salinity-stricken patches of their land, which tend to increase in size year after year.

Results of the Multidisciplinary Survey in the New Lands: Sugar Beet Area

Village No. 1

Summary

Cropping Patterns and Rotations

Winter

- Wheat is the major crop (50% of the cultivated area).
- Berseem is expanding at the expense of faba bean and, to a lesser extent, of wheat.

Summer

- Maize is decreasing in importance in favor of vegetable crops (mainly tomato), which now occupy 75% of the summer cultivated area.

Rotations

- Winter crops mostly follow a traditional legume/cereal rotation.
- Summer crops are less subjected to fixed rotations. Monocropping of vegetables in summer is on the rise.

Fertility Management

Evolution of crop yields

- Yields increased for all main crops during the last 5 years. The highest increases are reported for maize, wheat and berseem.

Manure and fertilizers

- Summer vegetables are more fertilized than other crops.
- The use of manure and fertilizers has increased for all crops compared to 5 years ago. No negative correlation between the two has been detected.
- Legume crops are given N-fertilizer far above the recommendations.
- Farmers adapt their fertilization package for each crop according to the preceding crop.
- P fertilization is not reduced after vegetables although they receive some of the highest rates.

Legume crops

- Crops succeeding legume crops usually receive more N fertilizer than after non-legume crops. The nitrogen-fixing effect of legumes is not taken into account by farmers.

- Legume crops are the minority in the rotation (on average one legume crop on the same plot every 2 years and 8 months, from seeding to seeding).

Water Management and Soil Degradation

Trend in water supply

- The water quantity available each year is declining.
- Tail-end problems are becoming more acute, especially in summer.

Irrigation methods

- All farmers are now using surface irrigation. Water needs are therefore over the needs planned at the time of land reclamation (part of the land was supposed to be under localized irrigation).

Soil salinization

- Appears mainly in the areas not equipped with subsurface drainage.
- No land is fallowed yet for high salinity reasons.

Introduction

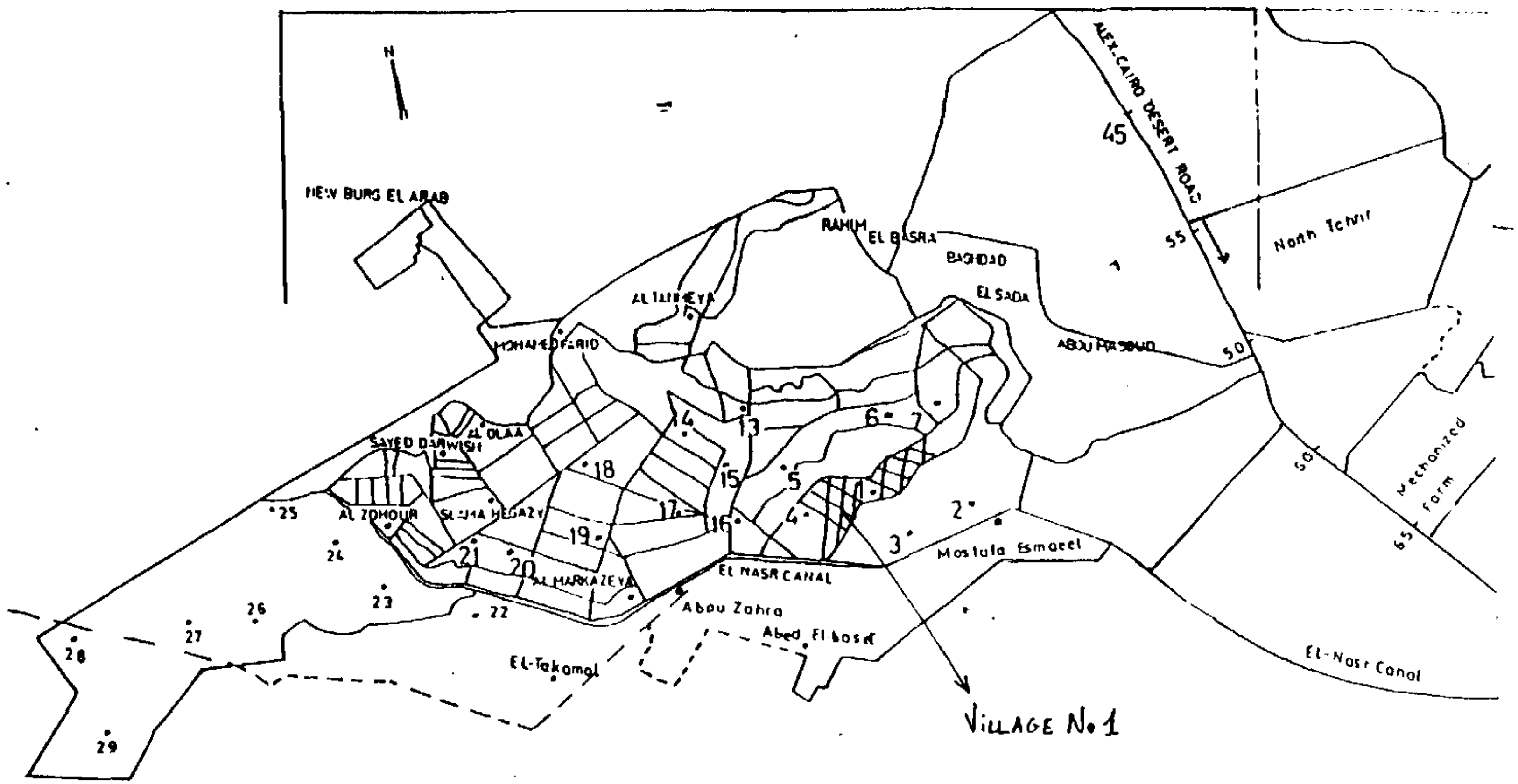
The survey was conducted in Village No. 1, located about 20 km west of the Alexandria Desert Road. Village No. 1 is irrigated from El Nasr Canal (see Map 2).

Thirty-three farmers were interviewed (11% of the farmers in Village No. 1), geographically distributed as follows:

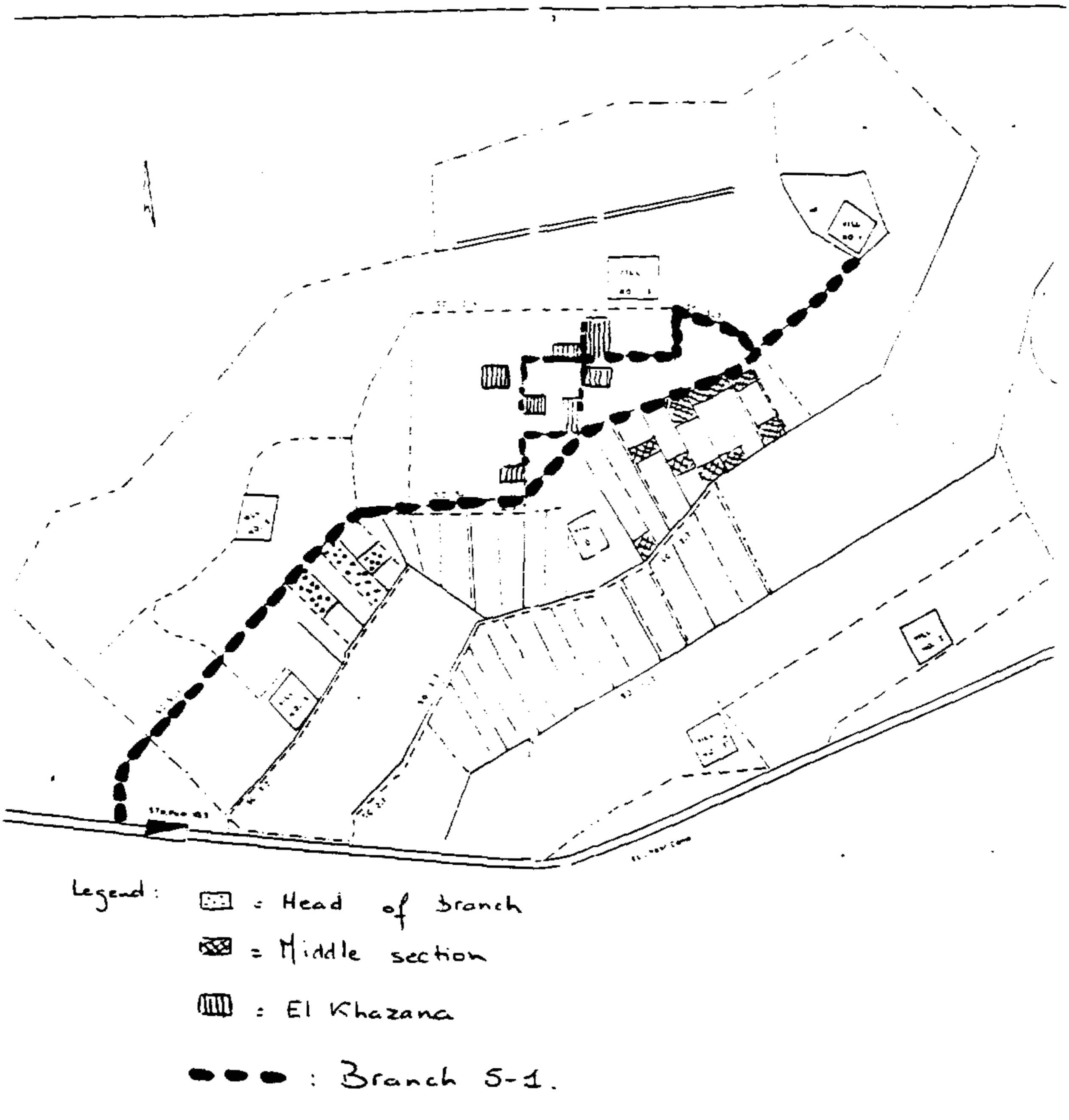
- about one-third (10 farmers) selected at the head of the canal crossing the village (branch 5-1, see Map 3),
- another third at the middle section, and
- the remaining third in the area called El Khazana, which is not physically at the tail end of the canal, but in fact it faces serious water supply shortages and was therefore considered as an example of a tail-end situation.

Altogether, the canal considered (branch 5-1, see Map 3) is 7 km long.

The sample was split equally between graduates and beneficiaries (17 beneficiaries and 16 graduates).



Map 2. Location of Village No. 1 in the Sugar Beet area.



Map 3. Location of the surveyed areas in Village No. 1.

Structural Data on the Sampled Population

Table 22 gives an overview of the main descriptors used in characterizing our sample. The main points are given below.

Table 22. Average values of structural descriptors for the surveyed sample.

Criterion	Beneficiaries	Graduates	Total sample
Age (median)	45	33	35
Year of settlement	1986	1990	1989
Family size (HCU)†	5.9	3.0	4.5
Family workforce (HLU)‡	3.0	1.7	2.4
Total farm land (feddan)	5.9	4.9	5.4
Farm land use:			
fallow	2%	7%	5%
	(11% fallow 14% of their farm)	(25% fallow 30% of their farm)	(18% fallow 25% of their farm)
trees	0%	3%	1%
		(7% grow trees on 40% of their farm)	
crops	98%	90%	94%
	(all farmers)	(all farmers)	
% of animal holders	100	85	93
Average livestock holding (in LU)§	2.6	5.3	3.8
Structural ratios			
CA/HCU	1.05	1.86	1.44
HLU/CA¶	0.53	0.38	0.46

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

Year of Settlement

Beneficiaries settled in the area about 4 years before the graduates. The earliest arrival was in 1985 and the latest in 1992 (graduates).

Family Size and Workforce

Beneficiaries have families twice larger than those of graduates and, consequently, a family workforce also two times higher.

Farm Area and Total Cultivated Area

Beneficiaries usually have farms that are larger by one feddan (1 fed = 0.42 ha) than graduates, and fallow is seldom practiced by them (11%), whereas for graduates, fallowing the land is more usual (25 % do it) due to various reasons such as the unreliable supply of water to their field, the non-residence of the graduates in the village, and the lack of interest.

Livestock Holding

All the beneficiaries have animals (poultry not counted) against 85% for the graduates; however, the average livestock holding is remarkably higher for graduates. This is explained by the fact that several graduates in Village No. 1 turned to veal fattening after they failed in making any benefits from cropping (especially in the water-deprived sections of the village land). However, the livestock holdings of the beneficiaries could also be substantially higher knowing that these traditional farmers tend to "underestimate" their wealth in livestock and crop yields when questioned by strangers or government-affiliated persons.

Structural Ratios

The average land size available by family member (CA/HCU) is of course higher for graduates (1.86 fed) than for beneficiaries (1.05 fed). This means theoretically that graduates should reach higher food self-sufficiency levels than the beneficiaries and devote less of their land to food crops.

On the contrary, family labor available by feddan (HLU/CA) is lower for graduates and therefore the need for hired labor is higher for them.

Cropping Patterns and Rotations

The cropping patterns and rotations practiced in the surveyed area have been derived from the crop sequences recorded by the multidisciplinary survey team. The whole farmland was comprehensively surveyed with each farmer and therefore the data obtained represent the cropping patterns and rotations practiced on 178.5 fed of the village (equivalent to 11% of the village total farmland).

Evolution of Cropping Patterns

Past trends

The crop sequences by plot were recorded for the last two years and the present year, and farmers were also questioned on their plans for next year in terms of land allocation to various crops. However, we based our description of the cropping patterns and the trends affecting them on the past and present years only, since many farmers were still quite unsure of what their next year's cropping pattern would be.

The dynamics in the local cropping patterns are presented in Figs 7, 8 and 9, which represent three distinct criteria used to better discern and explain the actual trends. These three criteria are:

- % of farmers cultivating the crop: This gives an idea of whether the crop is widespread or cultivated by specialized farmers.
- % of farmland allocated to each crop on an "average" farm: This gives an idea of how the distribution of crops on an average model farm in this area has evolved over three years.
- % of the total area cultivated by the sample population allocated to each crop: This should represent (by extrapolation) the trend in crop shares at the village territory level.

Each criterion was studied each time first separately for the graduates and the beneficiaries and then for the whole sample.

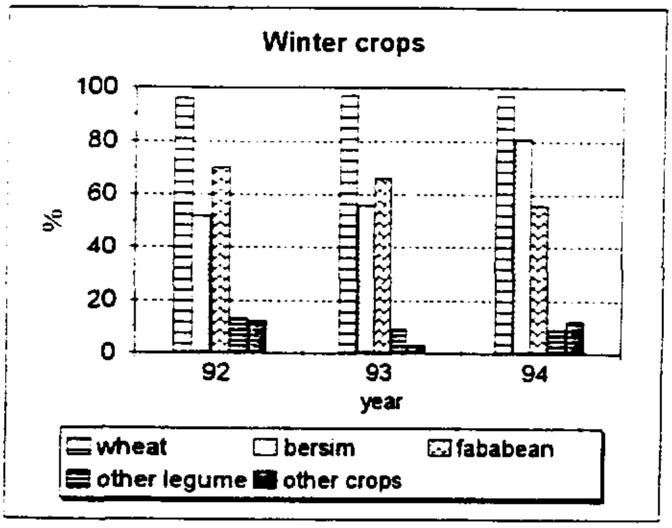
The main results of this cropping pattern study for each crop are[9]:

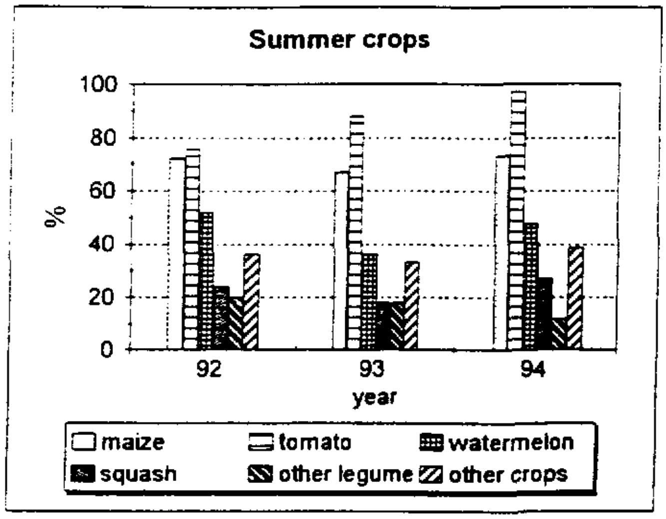
Winter crops

Wheat: The place of wheat as the dominant winter crop has remained quite stable over the last three years at all levels (% farmers, share at farm and village levels). Practically all farmers cultivate wheat in winter on about half of their farm. Graduates tend to allocate a larger share of their farm to wheat (about two-thirds); maybe because it is for them the easiest crop to start with when they first settle as farmers (in our sample, the years of records for the cropping patterns correspond to the second, third, and fourth years of farming for most of the graduates). However, wheat land-share tends to diminish with time and this might be a sign that diversification of winter cropping is gaining ground among graduates.

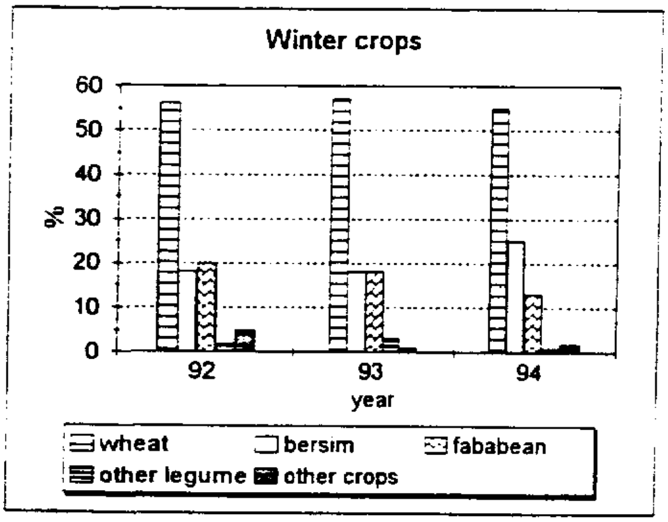
[9] Differences between beneficiaries and graduates are stated only when they seem significant.

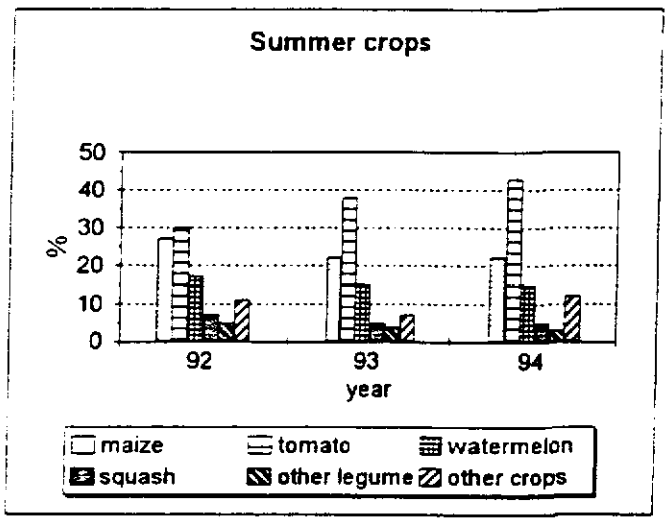
1.Percentage of farmers cultivating specific crops



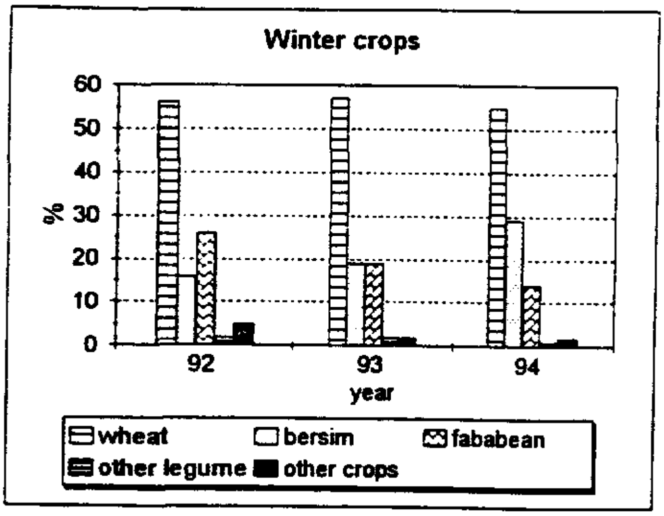


2. Crop shares on an average farm:





3. Crop shares for the total surveyed area:



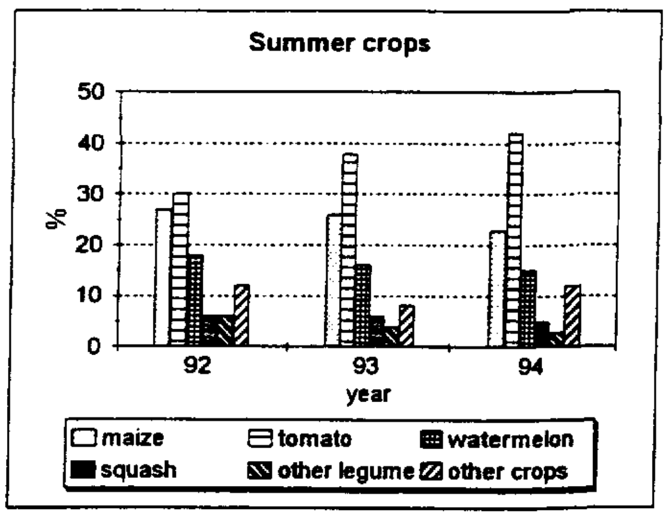
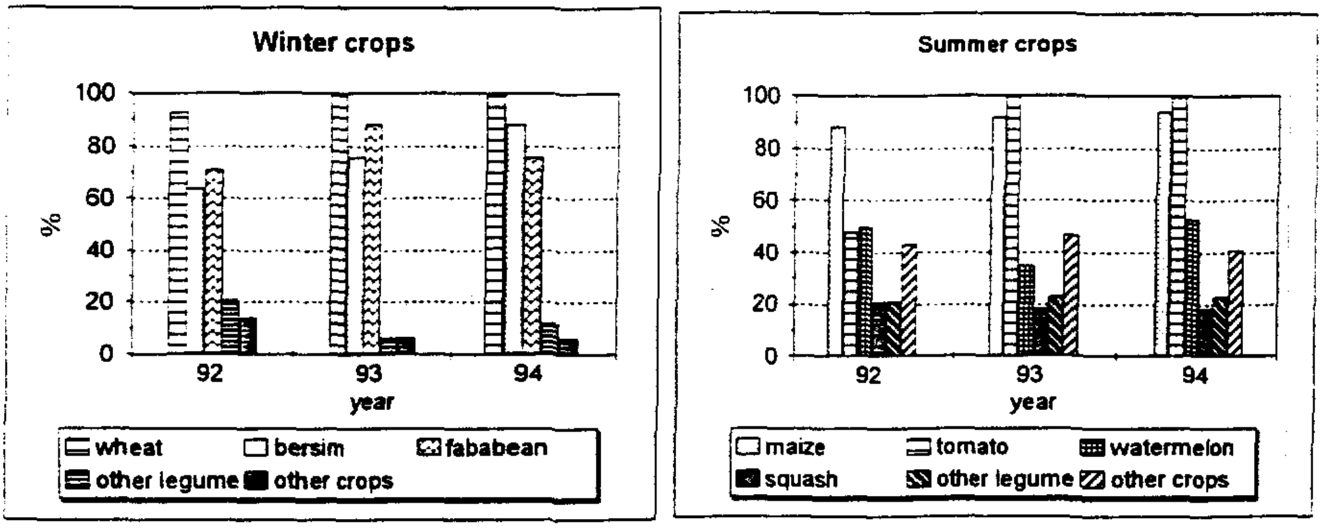
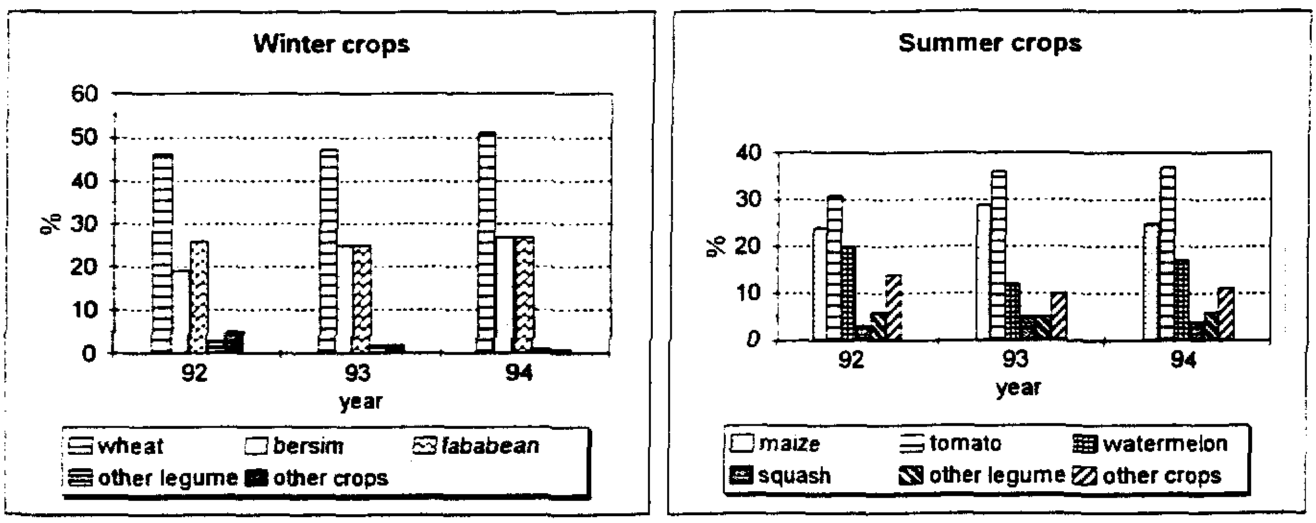


Fig. 7. Cropping pattern trends in Village No. 1 in the Sugar Beet area (graduates): Percentage of farmers cultivating specific crops.

1.Percentage of farmers cultivating specific crops



2. Crop shares on an average farm:



3. Crop shares for the total surveyed area:

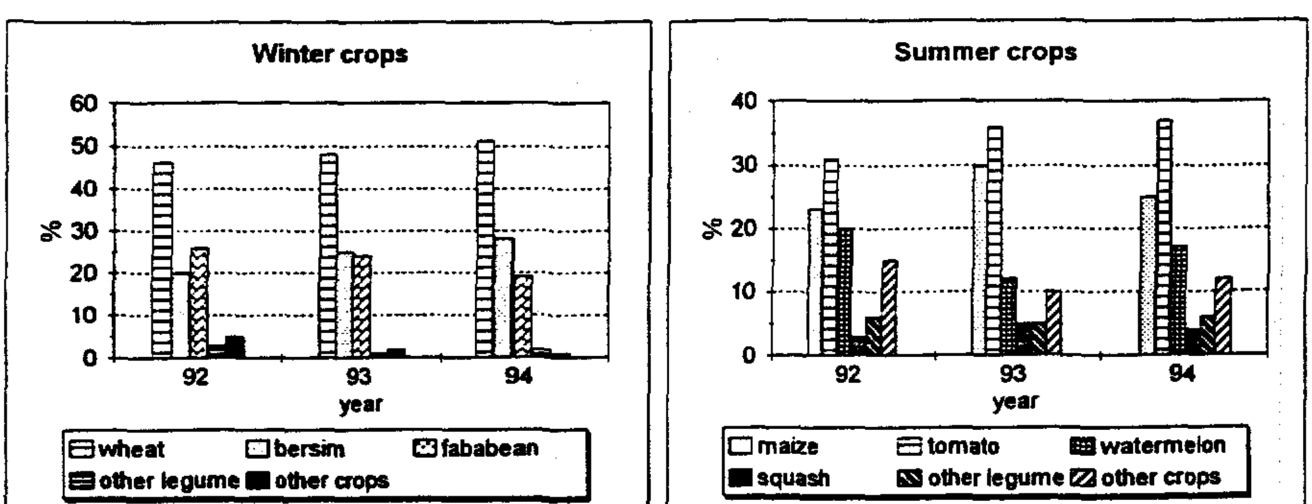
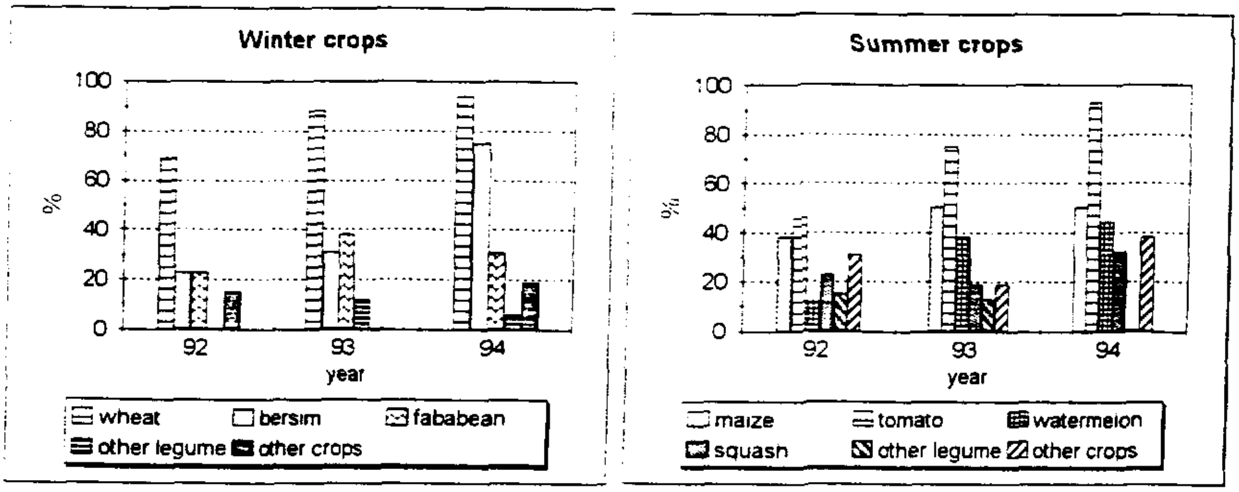
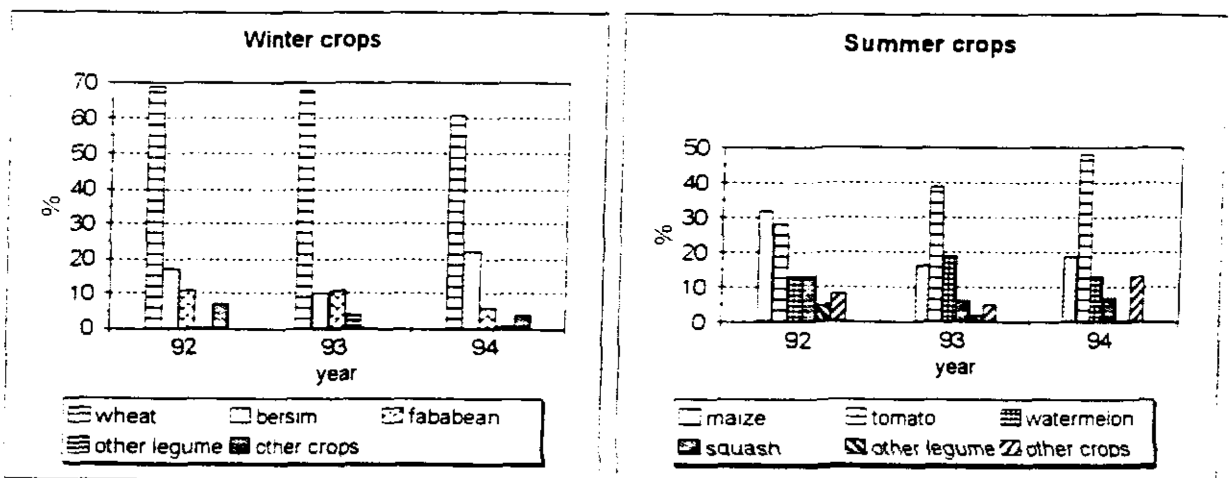


Fig. 8. Cropping pattern trends in Village No. 1 in the Sugar Beet area (graduates): Crop shares on an average farm.

1. Percentage of farmers cultivating specific crops



2. Crop shares on an average farm:



3. Crop shares for the total surveyed area:

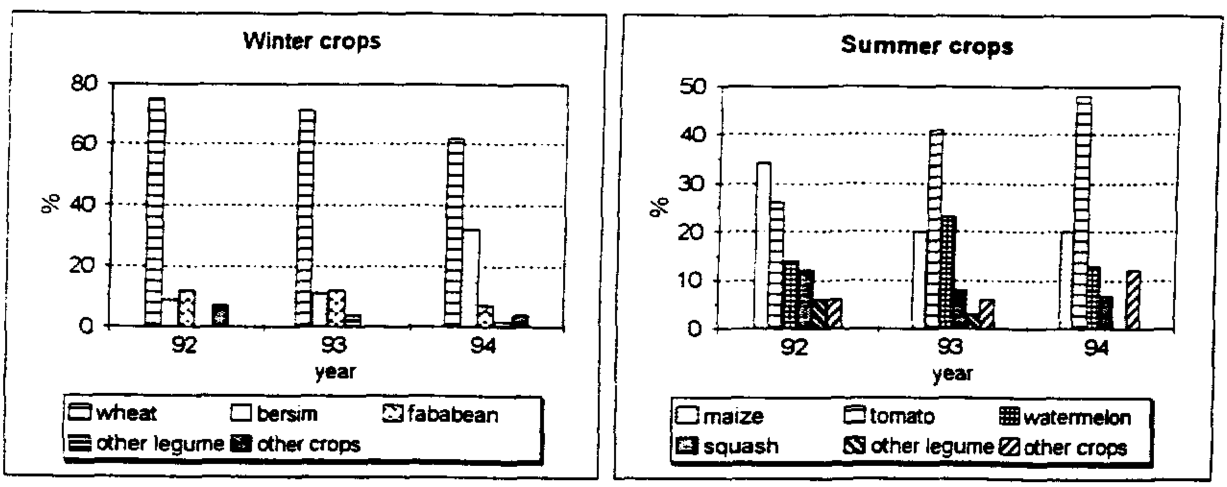


Fig. 9. Cropping pattern trends in Village No. 1 in the Sugar Beet area (graduates): Crop shares for the total surveyed area.

Berseem: On all levels, berseem has seen a tremendous increase in the winter cropping pattern. The proportion of farmers cultivating berseem has soared by 56%, the average share of berseem on the farm by 40%, and the share of berseem at the village level by 81%. Nowadays, berseem is occupying about half of the area cultivated with wheat but with a steady trend upwards; it could reach two-thirds of the wheat area within a few years. This increase in berseem has to be related to the growing livestock number in the village. Usually farmers, when they settle, have a small number of heads and then try to increase it with time either by purchasing or by sharing with other farmers. Graduates in Village No. 1 also recently invested a lot in livestock raising, which boosted their berseem area.

Faba bean: Faba bean has known a steady decrease both in area and in number of farmers cultivating it. However, this decline is much more pronounced for graduates, and faba bean can now be seen as mainly a beneficiaries crop.

Other legume crops: The other legume crops are mainly peas and, secondarily, chickpeas. These are minor winter crops in the Sugar Beet area, and the number of farmers cultivating them has slightly decreased. It seems also to be more favored by beneficiaries. At the same time, these crops are mainly market crops and, therefore, the extent of their cultivation from year to year is mainly subject to price prospects.

Other winter crops: These are principally sugar beet and marginally vegetables such as lettuce, onion, cabbage, carrot, potato, radish, karawia (medicinal plant). Although the number of farmers cultivating these crops is rather unstable (mainly graduates) and does not show a trend, the area devoted to these crops at the farm and village levels is decreasing. But for this kind of market-oriented crops, this decrease is more of an opportunistic nature rather than a strategic one (as for faba bean, for example). Also, these non-traditional crops are still limited to a small percentage of farmers who specialize in them and usually devote 30% of their land to their cultivation.

Summer crops

Maize: Although the number of farmers growing corn seems unstable, it still remains high especially with beneficiaries. Graduates devote less land to maize than beneficiaries (family food requirements are less pressing for them than for beneficiaries, see *CA/HCU in the* previous chapter). There is, however, a possible indication that maize is being threatened by other summer crops (all vegetables, see later) and this is clear with graduates in the total area cropped with maize (50% decrease in three years).

Tomato: Like berseem, tomato is a crop which has seen a tremendous increase recently (+28% in number of farmers, +43% in farmland area, + 40% in village land share). Although almost all farmers grow tomato now in summer, still the graduates allocate to it a larger share of their land than beneficiaries and the upward trend is more pronounced among them also.

Watermelon: Watermelon is the third summer crop by area and importance in Village No. 1. It is grown almost equally by beneficiaries and graduates and there is no clear trend in the extent of its cultivation. This is also a typical market-led crop and it knows more fluctuations than tomato. Also, fluctuations are more pronounced with graduates, showing again that these latter are more sensitive to market forces than beneficiaries.

Squash: Same comments as watermelon.

Other summer legume crops: The main summer legume crop is Phaseolus (green beans). A small number of farmers now grow it and it is more popular with beneficiaries. Farmers who grow Phaseolus tend to specialize in it and usually allocate a third of their farm to it. The sharp decline in the number of graduates growing the crop should not be seen as a definite trend since Phaseolus is a market crop.

Other summer crops: These are mainly mixed cropping of eggplant with green pepper and, marginally, sesame, sweet maize, sunflower and cantaloupe. These other vegetable crops are grown by a substantial proportion of farmers (40%) and occupy about 10% of the summer cropland. No clear trend is perceptible although it tends to be upwards. For some farmers, intercropping of eggplant and pepper can occupy up to 30% of their farm in summer.

Summary

In winter, wheat remains by far the major crop for all farmers. Berseem is on a steady rise at the expense of faba bean and, to a lesser extent, at the expense of other minor vegetable crops.

In summer, maize has now become less important than all vegetables put together (average share of farmland = 78%). This should have important consequences in terms of fertility management since vegetables are commonly fertilized at higher levels than any other crops. Finally, the predominance of vegetables in summer crops will bring more instability to crop rotations.

Looking at graduates separately from beneficiaries, it is clear that their cropping patterns are not fixed, and, by consequence, the rotations they follow are not either. If they now follow a more traditional system in winter, they still show high volatility in their crop choice in summer. They also generally give less importance to food crops compared to cash crops and tend to grow a smaller number of crops than beneficiaries. These latter still replicate their multi-crop system of the Old Lands, aimed at answering both domestic food and cash needs. It also diminishes the risk of losses, especially in the harsh marketing environment that prevails in the New Lands and which still plays an important role in disfavor of the farmer.

Future expected trends

We can expect that the present upward trends for berseem and tomato will remain valid for some years until stabilization and balance with wheat in winter and maize in summer, respectively, is reached. When it comes to other vegetables in summer, their share is already important—and is not expected to decrease—but it is difficult to predict what will be the trend for each vegetable crop separately since market forces are the most influencing factor.

When asked about which crops they would increase and which they would decrease, farmers of our sample answered as shown in Table 23.

Table 23. % of farmers willing to increase or decrease specific crops in the near future

Trend	Berseem	Tomato	Wheat	Water-melon	Pepper	Maize	Faba bean	Squash	Egg-plant
Up	58	48	48	30	30	24	15	0	15
Down	12	27	27	9	3	42	36	21	3
Balance	+46	+21	+21	+21	+27	–18	–21	–21	+12

This data can give us a complementary look at the future trend in the local cropping pattern and shows clearly that berseem, tomato and wheat are expected to continue dominating as major crops. Maize apparently would still lose more ground in favor of vegetables, as well as faba bean in favor of wheat and berseem. Among vegetables, squash is the least likely to be increased, whereas watermelon, pepper and eggplant are expected to keep a good place in the summer cropping pattern.

To finish with, we also asked the farmers which new crops they would like to introduce in their rotations. The answers are as follows:

Crop	Potato	Sugar beet	Pepper, cotton	Barley, strawberry, cantaloupe, lentil, medicinal plants
% of farmers citing it	67	18	6	3

Potato comes largely ahead, and the main constraint for farmers in Village No. 1 is still the high input cost of this crop. Also, calcareous soils are not really appropriate for potato. Therefore, we should consider that sugar beet has a higher potential as a new large-scale crop in this region than potato. The main constraint for sugar beet is still the absence of the proper transformation facilities in the vicinity of the so-called Sugar Beet area.

Prevailing Crop Rotations

The crop rotations have been studied on a sample of 80 crop sequences over 4 years (8 seasons). The total area concerned is 111.75 fed (equivalent to 9 % of the village land).

The complexity and great variety of crop sequences encountered does not permit defining broad rotation categories if we stick to taking each crop separately and studying its position in the crop sequence. Therefore, we grouped the cultivated crops in three categories:

- Winter legumes = Berseem, faba bean, pea.
- Cereals = Wheat, maize.
- Vegetables.

We used as a classification criterion, the occurrence of legumes as winter crops, since after a first review of the crop sequences, it was obvious that there were no strictly fixed winter–summer rotations. Actually, farmers tend to stick to traditional or fixed rotations from winter to winter but the summer season is left open for any crop combination mainly according to market prospects. We did not differentiate between the various winter legumes since our main concern was the fertility build-up effect of various rotations and, therefore, the place of legumes in them becomes an essential criterion. However, a winter legume has a probability of being berseem in 68% of the cases, faba bean in 29% and pea in 3%

Likewise, we considered all vegetables in the same class, knowing that the two major ones are tomato and watermelon then squash and pepper.

Our classification is based on the application of the following succession of criteria:

1. Importance of legume crops in the winter rotation.
2. Other winter crops between legume crops.
3. Number of summer crops (two classes = maize, vegetables).
4. Summer crop rotations.

The complete results of this rotation classification are presented in Table 24.

Table 24. Tentative classification of prevailing crop rotations in Village No. 1 (Sugar Beet area).

Legume occurrence in winter	A	No.	Other winter crops	A	No.	Number of summer crops	A	No.	Summer crop rotation	A	No.	Example	Rotation years
Legume every winter	7	10	No	7	10	(1) Vegetables	2	3	V-V-V	2	3	FB/Tom–Pea/Tom–Ber/Pep	1
						(2) Maize + Vegetables	5	7	M-V	2	3	Ber/Maize–Berseem/Pepper	2
									M-V-V or M-M-V	3	4	Ber/Maize–Ber/Watermelon–Pea/Tomato	3
Legume 2/3	15	14	Wheat (s. beet) L-L-W	15	14	(1) Vegetable	6	5	V-V-V.....	6	5	FB/Waterm.–Ber/Tom–Wheat/Tomato	3
						(2) Veg + maize	9	9	M-V	4	4	Ber/Tom–Ber/Maize–Wheat/Tom–Ber/Maize	6
									M-V-V or M-M-V	5	5	Ber/Pepper–FB/Squash–Wheat/Maize	3
Legume 1/2	33	36	Wheat L-W	33	36	(1) Vegetable or maize	19	19	V-V-V...	16	15	Wheat/Tomato–Berseem/Tom	2
									M-M-M...	3	4	Wheat/Maize–Berseem/Maize	2
						(2) Veg + Maize	14	17	M-V	5	4	Wheat/Tomato–Ber/Maize	2
									M-M-V or M-V-V	9	13	Wheat/Eggplant–FB/Egg–Wheat/Maize	6
Legume 1/3	16	15	Wheat, Veg L-W-V	2	3	(2) Maize + vegetable	2	3	Not fixed	2	3	Ber/Squash–Wheat/Maize–Lettuce/Tomato	
			Wheat L-W-W	14	12	(1) Vegetable	2	1	V-V-V...	2	1	Ber/Waterm–Wheat/Sq–Wheat/Tomato	3
						(2) Maize + vegetable	12	11	M-V-V or M-M-V	12	11	Ber/Squash–Wheat/Tom–Wheat/Maize	3/6
Legume 1/4 and less	21	18	Wheat (s.beet) W-W-...	21	18	(1) Vegetable	3	4	V-V-V...			Wheat/Squash–Wheat/Tom–Wheat/Tomato–Ber/Squash	
						(2) Maize + Vegetable	18	14	M in majority			Wheat/Maize–W/M–W/Tom	
									V in majority			Wheat/Waterm–Wheat/Tom–Wheat/Tom–Ber/Maize	

A = area = % of the total sample area which is subject to the described rotation.
No. = % of the total sample of crop sequences which correspond to the described rotation.
L = legume winter crop; W = wheat; Veg = V = vegetable; M = maize; FB = faba bean; Tom = tomato; Ber = berseem; Pep = pepper; Sq = squash; Egg = eggplant.
(1) = One type of summer crop only; (2) = Two types of summer crops.

Based on this classification, the three more frequent rotations—called hereafter prevailing rotations—are:

1. Legume Winter Crop Every Two Years

Type = Leg/Maize–Wheat/Veg–Leg/Veg–Wheat/M–Leg/Veg–Wheat/Veg

Strictly speaking, this is not a fixed rotation, but if crops are grouped in three classes (wheat, legumes, vegetables), then it becomes a 6-year rotation. It is in fact the combination of a classical two-year winter rotation (legume/wheat) with a three-year summer rotation (maize/veg/veg or maize/maize/veg). It is the most complex and diversified rotation in the area.

Example: Berseem/Maize–Wheat/Tomato–Berseem/Watermelon–Wheat/Maize–Berseem/Tomato–Wheat/Squash

2. Legume Winter Crop Every Four Years or Less

Type = Wheat/Veg–Wheat/Veg–Wheat/Veg–Leg/Maize

It is not really a fixed rotation since apparently the frequency of legume crops is not well established. It concerns more farmers who have small or no livestock and therefore do not have to grow berseem. Vegetables are the main summer crop and maize comes usually every three to four years, depending on the market prospects for other crops as vegetables. In terms of resource management, this rotation shows no concern on the part of the farmers for fertility maintenance and pest and weed control.

Example: Wheat/Watermelon–Wheat/Tomato–Wheat/Tomato–Berseem/Maize, etc.

3. Legume Winter Crop Every Three Years:

Type = Leg/Maize–Wheat/Veg–Wheat/Veg

This is *largo sensu* a three-year rotation, made up by the combination of a three-year winter sequence (legume–wheat–wheat) with a three year summer rotation also (maize–vegetable–vegetable).

Example = Berseem/Maize–Wheat/Squash–Wheat/Tomato

Table 25 gives additional information on crop successions. The percentages expressed in this table tell us for such particular crop, what the percentage of cases (throughout our sample) is in which it is succeeded by such following crop. This exercise has been done for winter to summer successions, as well as winter-to-winter and summer-to-summer.

Table 25. Winter/summer and summer/winter successions in Village No. 1, Sugar Beet area (expressed in % of total number of cases).

Following / Preceding	Berseem	Faba bean	Pea	Wheat	Sugar beet	Chickpea	Carrot/ lettuce	Phaseolus	Tomato	Squash	Maize	Water-melon	Pepper/ eggplant	Fallow	Total
Berseem								4	24	14	26	19	13		100
Faba bean								18	33	7	15	18	9		100
Wheat								1	46	5	31	7	7	2	100
Sugar beet											20	60	20		100
Pea									57	14	14	14			100
Chickpea										67	33				100
Carrot/lettuce									100						100
Phaseolus	8	17		75											100
Tomato	24	26	1	45	1									2	100
Squash	13	25		56		6									100
Maize	31	20	1	41		1	1							3	100
Watermelon	29	14	9	27	3		3							6	100
Pepper/eggplant	27	14		59											100
Fallow				16					26	5	16	21	11	5	100

Winter/winter succession

Following / Preceding	Berseem	Faba bean	Pea	Wheat	Sugar beet	Chickpea	Carrot/lettuce	Total
Berseem	20	20	3	74	3			100
Faba bean	18	20	3	6				100
Wheat	34	24	3	35	1	1	2	100
Sugar beet	25			75				100
Pea	40			60				100
Chickpea				50		50		100
Carrot/lettuce	100							100

Summer/summer succession

Following / Preceding	Phaseolus	Tomato	Squash	Maize	Watermelon/ watermelon seed	Pepper/ eggplant	Total
Phaseolus		47	7	27		19	100
Tomato	7	38	9	24	14	8	100
Squash		50	15	15	5	15	100
Maize	8	29	8	32	13	9	100
Watermelon		59	9	6	24	3	100
Pepper/eggplant		33	14	38	5	10	100

Fertility Management

Evolution of Soil Characteristics

Farmers were asked in the survey to describe the main changes they perceived in the soil quality of their land. The results of this opinion poll are as follows:

Category	Changes	% of farmers
Beneficiaries	. structure	82
	. color	41
	. decrease of salinity	6
	. no change	6
Graduates	. structure	69
	. color	31
	. decrease of salinity	19
	. increase of nematodes	12
	. increase water holding capacity	6
	. no change	12
Total	. structure	76
	. color	36
	. decrease of salinity	12
	. no change	9

This qualitative data clearly shows that soil structure has noticeably changed with cultivation and that soil-borne salinity has been successfully leached. Soil color became browner, which certainly denotes an increase in organic matter content.

Beneficiaries in our sample have been cultivating this land for. on average, 14 seasons and graduates for 7 seasons. This could explain the slightly different perceptions they have, especially of structure and color, which are more often mentioned by the beneficiaries.

To better understand the effect of age of cultivation, we looked at the correlation between the number of seasons cultivated and the yields obtained for various crops. The results are shown in Table 26. The correlation factors show some clear effect of the age of cultivation on crop yields for a minority of crops (Phaseolus, eggplant, watermelon), but for most of them the correlation does not appear or is negative, which comes certainly from the unreliability of the absolute yield data.

If we look at the yield increase for the same crops[10] over a five-year period (see Table 27 and fig. 10), there is an unquestionable upward trend for 9 crops out of 11. Of course, yield increase is also due to the use of new varieties and to higher fertilization rates (see below), but

[10] The yield increase between absolute values is less likely to be farther from reality than the absolute yield value.

still, these unanimous yield increases certainly testify that soil characteristics in this area have improved with time, which reflects positively on crop yields.

Table 26. Coefficient of correlation between age of cultivation and yield for various crops (Village No. 1).

Crop	Category	
	Graduates[11]	All
Berseem	0.14	–0.33
Faba bean	–0.61	0.09
Phaseolus	1.00	0.67
Wheat	0.08	0.07
Maize	–0.46	–0.21
Squash	NA†	–0.60
Tomato	0.40	0.28
Eggplant	NA	0.48
Pepper	NA	0.33
Watermelon	0.96	–0.12

† NA: There were no graduates growing this crop in our sample to run a correlation with the years of cultivation.

Table 27. Crop yields (kg/fed) in 1994 and 5 years ago in Village No. 1.

Crop	Yield last season (Y1)		Yield 5 years ago (Y2)		% variation between Y1 & Y2
	Value	Range	Value	Range	
Berseem	7083/cut	5000–10000	5364/cut	4000–7000	+32
Faba bean	795	500–1550	635	500–900	+25
Pea	2875	2000–4000	2500	2500	+15
Phaseolus	1767	450–3000	1870	450–3000	–6
Wheat	1451	375–1800	923	532–1500	+57
Maize	2122	1120–2800	1328	840–1800	+60
Sugar beet	21667	20000–25000	NA		NA
Eggplant	15000	12000–18000	11667	10000–15000	+29
Tomato	8286	4000–10000	7177	5000–10000	+15
Squash	3500	2500–5000	3167	2500–4000	+11
Pepper	4500	2500–7000	4750	2500–7000	–5
Watermelon	8572	6000–12000	6250	4000–8000	+31
Watermelon seed	NA		283	200–350	NA

[11] The correlations were run on the whole sample first, but due to contradictory results, they were run again on the graduate sample only. This is because it is highly suspected that beneficiaries usually understate their yields when questioned by outsiders, even more so by government-affiliated persons. Throughout the survey results, all yield data had to be treated carefully and the error margin could be as high as 30% if beneficiaries supplied erroneous yield figures. Graduates are much less expected to act this way for various reasons, and this is why usually the correlations to yields give more positive results when the sample population is limited to them only.

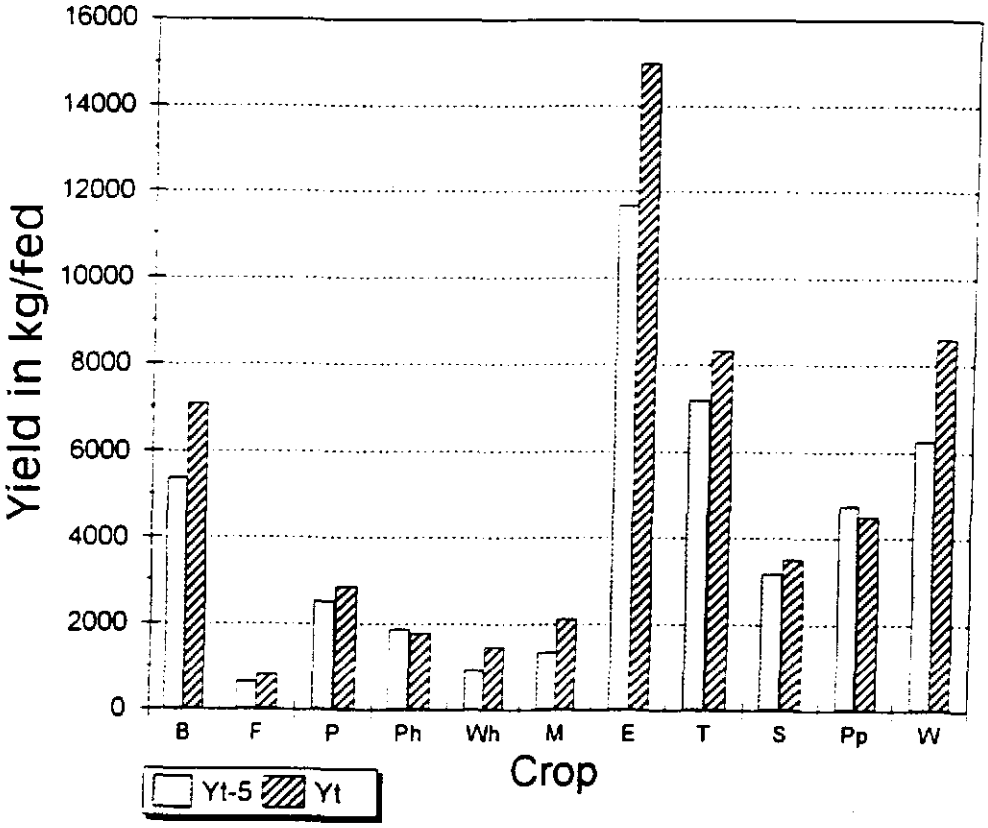


Fig. 10. Yield evolution in Village No. 1, Sugar Beet area (5 years ago and now).

Soil Improvement Work

A large proportion of farmers (66%) carried out soil improvement work on their land after starting its cultivation. The details are given in Table 28.

Table 28. Soil Improvement work carried out by farmers in Village No. 1.

	Beneficiaries	Graduates	Whole sample
Type of soil improvement			
- Subsoiling (60 cm)	76%	25%	51%
- Addition of sulfur (75 kg/fed)	0%	19%	9%
- Addition of clay (15 m^3/fed)	6%	6%	6%
% of farmers who carried out at least one type of soil improvement	82%	50%	66%

Subsoiling remains the most common form of soil improvement and became popular in this area five years ago. Sulfur addition is still unusual and practiced only by graduates who are better informed than beneficiaries about soil reclamation techniques. They are also more eager to invest in land improvement (when they are definitely settled in the village). They recently started carrying out subsoiling, because up until one to two years ago, most of them had their land still equipped with drip or sprinkler irrigation networks and soil permeability was not a major concern. Now that all of them have reverted to surface irrigation, they face drainage problems and wish to fight this issue by carrying out subsoiling.

Fertility Management Methods

We will first look at the farmers' opinions concerning the best fertility management methods. The question was not restrictive in terms of soil fertility but was referring more to the land quality. Therefore, some of the farmers' answers obviously deal with problems which are not related to what is considered as fertility management *stricto sensu*, yet these answers point out some problems which, in the farmers' views, surpass in importance the strictly speaking fertility build-up issues. The question was also focusing on methods with long-term effects. The results are shown in Table 29.

The results show that:

- Manuring and subsoiling are by far the preferred methods by the farmers to improve their land quality.
- Fertilizers are not mentioned in all cases which indicates a rather surprising understanding by the farmers that fertilizers do not have a real soil improvement effect in the long run.
- Irrigation and drainage come in the third position for graduates because in Village No. 1 most of them turned to flood irrigation whereas the water supply system of their area (all graduates located in the same basin) was designed for sprinkler and drip systems. Water is often short in quantity and there is no drainage system, which now leads to some slight but visible salinity increase.

- Other biological and environment-friendly methods, such as rotations, crop residues and legume crops, come in the last position. This is with beneficiaries as well as with graduates.

Table 29. Farmers' best methods to increase soil quality (expressed in % of farmers mentioning the method) in Village No. 1.

Beneficiaries		Graduates		Whole sample	
Manuring	88	Manuring	100	Manuring	94
Subsoiling	88	Subsoiling	63	Subsoiling	76
Fertilizers	76	Irrigation	31	Fertilizers	51
Sulfur application	18	Drainage	31	Irrigation	21
Irrigation†	12	Fertilizers	25	Sulfur application	18
Crop Rotation	6	Sulfur application	19	Drainage	15
Crop residues	6	Crop rotation	19	Crop rotation	13
		Leaching	13	Crop residues	6
		Crop residues	6	Leaching	6
		Legume crops	6	Legume crops	3
		Leveling	6	Leveling	3

† Irrigation here means having a reliable water supply and not irrigation for leaching.

We will now review, one by one, all the methods dealing directly with fertility management and detail all relevant survey results regarding each of them.

Use of manure

General data on the use of manure

All farmers use manure in Village No. 1 on all or some of their crops (see below). The most interesting points taken from Table 30 are:

- In most cases, graduates started using manure more rapidly after they settled than beneficiaries. Although they do not have animals when they arrive, they can more easily afford buying manure from other farmers than beneficiaries.
- The general trend is towards increasing the quantity of manure applied in the fields and this is for both classes of farmers. However, the majority of beneficiaries use less manure than they did in their Old Lands farms. This is mainly due to the relatively smaller livestock holding they own in the New Lands.
- The priority crops when using manure—especially when it is in short supply—are vegetables, and, in general, all summer crops. Winter crops usually receive much less manure (see Table 31).
- The large majority of farmers are not self-sufficient in manure from their own livestock. Actually, only the graduates who started fattening projects and do not cultivate all of their land are really self-sufficient and even sell some manure.

Table 30. Various general data on the use of manure in Village No. 1.

Criterion	Beneficiaries		Graduates		Whole sample	
Number of seasons during which land was manured	10		6		8	
% of farmers who used manure from first season	29		38		23	
Average time gap between first cropping season and first manuring season	3 seasons		1 season		2 seasons	
Trend in the use of manure (quantity)†	up equal down	60% 18% 22%	up equal down	47% 33% 20%	up equal down	54% 25% 21%
Rate applied compared to Old Lands practices (beneficiaries only)	more less	29% 71%	NA		NA	
Priority crops manured (% of farmers mentioning the crop)	Tomato Watermelon Squash/Maize Phaseolus	67% 40% 20% 13%	Tomato Maize Watermelon Pepper Squash	76% 59% 41% 29% 12%	Tomato Watermelon Maize Pepper Squash	72% 41% 38% 19% 16%
Farm self-sufficiency in manure	No farms self-sufficient		25% of farms self-sufficient		12% of farms self-sufficient	

† Based on farmers' appreciation and not on crop data (see below).

We also tried to relate the trend in the use of manure to the trend in the use of chemical fertilizers and found that:

- 3% of the farmers said they had increased manure and reduced fertilizers at the same time.
- 13% did not change manure but increased fertilizers.
- 9% decreased manure and increased fertilizers.

Altogether, therefore, for 25% of the farmers only could we detect an antagonist relation between the trend in manure application and the trend in fertilizer application. This is low compared to the 38% of farmers who acknowledged having increased both manure and fertilizers during the last 5 years.

Use of manure by crops

<u>Percentage of farmers using manure per crop</u>

Table 31 shows that the highest percentage of farmers using manure is for vegetables (watermelon seed is in fact now cultivated by a very small number of farmers). Phaseolus and peas were put in the legume crop section, but these data clearly show that they are considered by farmers simply as vegetables, therefore receiving higher fertilization packages. Winter crops, especially berseem and faba bean, are markedly less manured than summer crops.

Compared to 5 years ago, there is a notable change only for wheat and some vegetables.

Table 31. Fertilization practices by crop in Village No. 1, Sugar Beet area.

Crop	P_2O_5					Manure					Total N					K_2O				
	% farmers applying now	% farmers 5 yrs ago	Rate (kg/fed)	Range	Rate trend (5 yrs ago)	% farmers applying now	% farmers 5 yrs ago	Rate (kg/fed)	Range	Rate trend (5 yrs ago)	% farmers applying now	% farmer 5 yrs ago	Rate (kg/fed)	Range	Rate trend (5 yrs ago)	% farmers applying now	% farmers 5 yrs ago	Rate (kg/fed)	Range	Rate trend (5 yrs ago)
Berseem	100	90	36	31–47	+3%	8	0	5	5	NA	100	92	60	17–66	–1%	0	0	/	/	NA
Faba bean	100	100	31	8–47	+19%	6	6	10	10	0%	100	100	36	31–66	+2%	0	0	/	/	NA
Pea	100	?	31	31	?	100	100	18	10–25	0%	100	100	26	21–33	+28%	100	100	24	24	0%
Phaseolus	100	100	43	31–62	+29%	100	100	17	10–20	+13%	100	100	82	82–83	+9%	100	100	62	48–72	0%
Wheat	96	90	31	23–38	+8%	54	30	10	4–15	+15%	100	100	125	66–144	+15%	0	0	/	/	NA
Maize	100	100	29	23–31	+15%	100	93	14	3–20	+15%	100	100	120	96–132	+22%	50	50	24	24	0%
Sugar beet	100	?	44	39–47	?	0	0	0	/	0%	100	?	165	165	?	75	?	24	24	?
Eggplant	100	?	33	31–39	?	50	?	10	10	?	100	100	91	82–116	+26%	0	0	/		NA
Tomato	100	100	53	39–116	+11%	100	94	19	3–30	+15%	100	100	101	50–371	+22%	90	90	50	24–72	+5%
Squash	100	100	54	39–78	+20%	100	75	10	5–15	+11%	100	100	143	132–165	–1%	20	0	48	48	NA
Pepper	100	?	29	16–78	?	100	100	11	10–15	+61%	100	100	103	72–198	+28%	0	0	/	/	NA
Watermelon	100	100	49	39–78	+26%	100	75	9	5–20	+6%	100	100	111	99–152	–5%	0	0	/	/	NA
Watermelon seed	100	?	41	31–47	?	67	?	10	10	?	100	?	78	62–99	?	0	0	/	/	NA

? = Data not available; NA = Not applicable.

Rate applied per crop

If we consider peas and Phaseolus as vegetables more than as legume crops, then the average rate applied to vegetables is 13%, and for cereals, 12%. The ranges also show that the highest values are for vegetables (tomato, pea).

The trend in rate is positive for 7 crops out of 10, and nil for the other 3. Once again, the highest increases took place for vegetable cash crops.

Effect of preceding crop (see Fig. 11)

The quantity of manure applied varies with the preceding crop, but it is not clear from the data whether there are common rules for certain preceding crops. It seems that after wheat, manure rate is usually less than the average rate[12]. For the other preceding crops, we lack data to draw any conclusions.

Use of manure according to farmers' origin

There are only slight differences in the use pattern of manure between beneficiaries and graduates (Table 32). This concerns specific crops like berseem (no graduates add manure), squash (rate for graduates markedly higher), and watermelon (rates for beneficiaries markedly higher). Usually, however, the beneficiaries increased their manure application more than the graduates did. For some crops as wheat and Phaseolus, since beneficiaries and graduates now use approximately the same rates, it means that 5 years ago the beneficiaries were using less manure than graduates.

These data are rather contradictory with the general opinion that beneficiaries always add more manure than graduates. In fact, both follow—at least in Village No. 1—the same use patterns and have increased their manure application over the years along with the increase of their livestock holding. They both tend to favor vegetables although, surprisingly enough, graduates show more concern for manuring winter food crops than beneficiaries.

Correlation to yield

There seems to be a correlation, at least for 5 crops (faba bean, maize for graduates, squash, eggplant, pepper), although these are not the most heavily manured in the whole lot (Table 33). However, we cannot rely enough on the yield figures given by farmers to go into further analysis of these correlation data.

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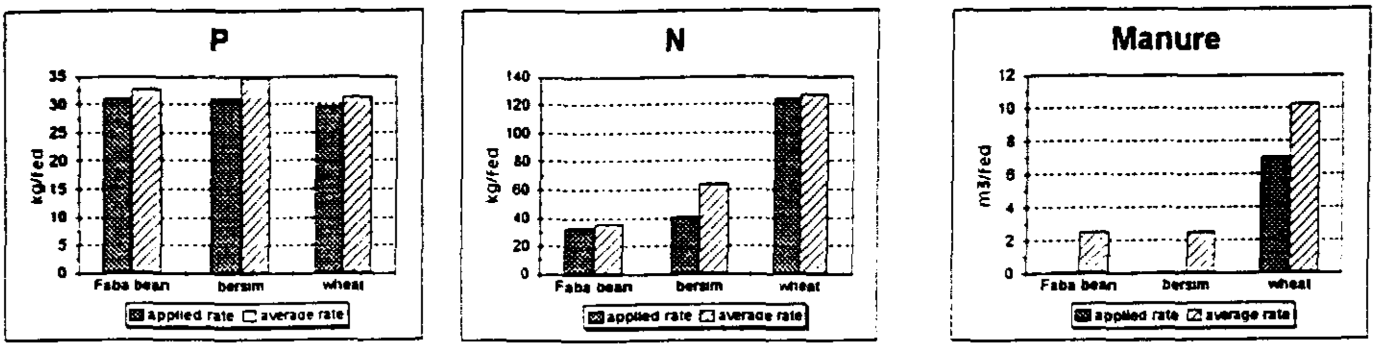
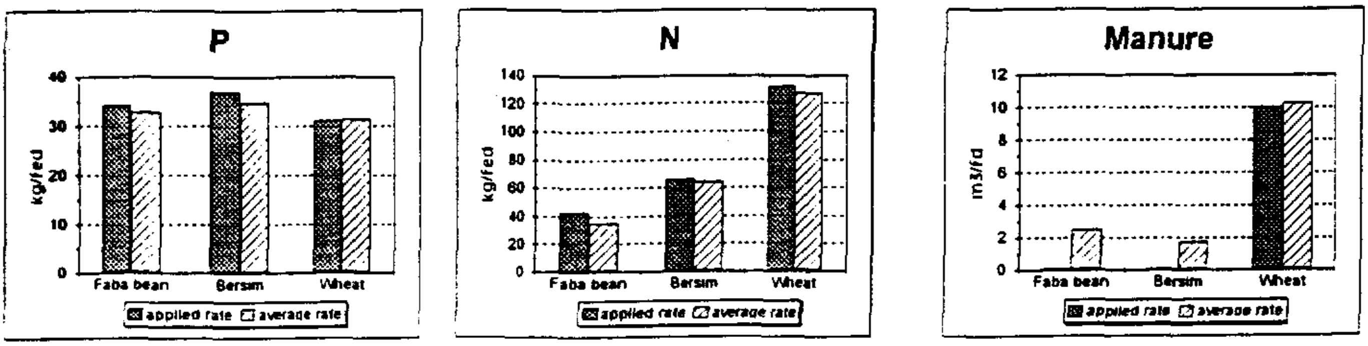
[12] Average rate indicates here the average of the rates of manure applied to a certain crop after various preceding crops. It differs from the rates presented in Table 30 which are average rates from the whole sample, where the various preceding crops are not represented equally.

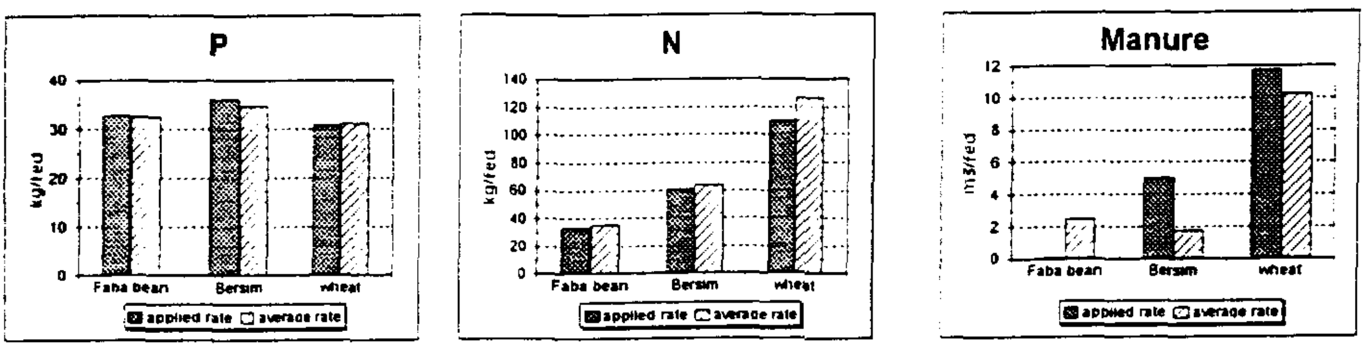
A- After FALLOW :



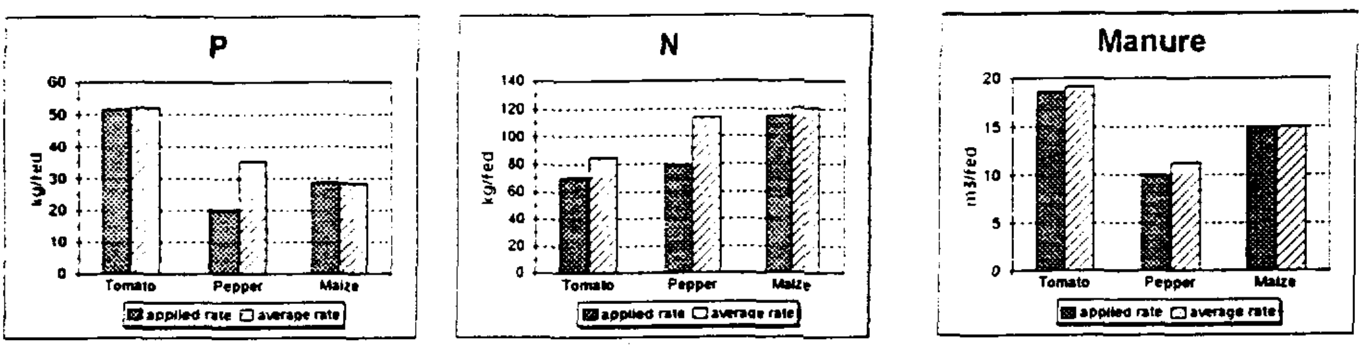
B- After MAIZE



C- After TOMATO



D- After WHEAT



E- After BERSIM

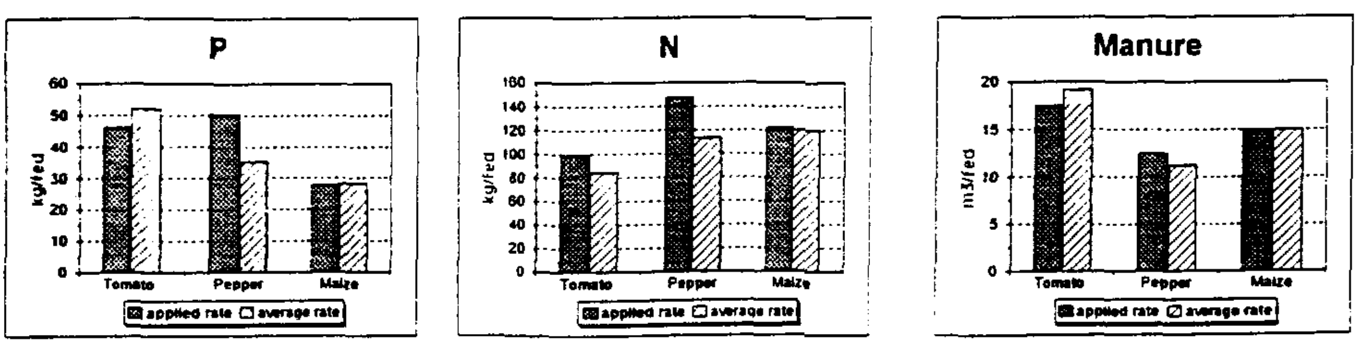


Fig. 11. Effect of preced[illegible] (Sugar Beet [illegible]).

Table 32. Fertilization according to farmers' origin in Village No. 1 (Sugar Beet area).

Crop	P_2O_5						Manure						Total N						K_2O					
	% farmers applying		Rate (kg/fed)		Trend over 5 years (%)		% farmers applying		Rate (m^3/fed)		Trend over 5 years (%)		% farmers applying		Rate (kg/fed)		Trend over 5 years (%)		% farmers applying		Rate (kg/fed)		Trend over 5 years (%)	
	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G
Berseem	100	100	33.2	39.0	+5	+10	16	0	5.0	–	–	–	100	100	61.3	57.8	–6	0	0	0	–	–	–	–
Faba bean	100	100	29.6	33.6	+14	+11	0	16	–	10.0	–	0	100	100	34.5	38.2	+5	0	0	0	–	–	–	–
Phaseolus	100	100	44.6	39.0	+25	0	100	100	17.5	15.0	+25	+13	100	100	82.4	82.4	+8	+30	100	100	60	72	0	0
Maize	100	100	28.9	25.0	+18	0	100	100	13.0	15.0	+29	+27	100	100	118.5	123.2	+25	+20	60	33	24	24	0	0
Wheat	92	100	32.3	29.6	+39	+8	50	55	10.0	10.0	+75	+17	100	100	130.0	120.0	+16	+20	0	0	–	–	–	–
Squash	100	100	59.4	49.0	+32	+20	100	100	8.3	11.7	0	+17	100	100	143.0	143.0	0	0	33	0	48	–	–	–
Tomato	100	100	56.2	48.0	+13	+38	100	100	19.8	17.7	+40	+28	100	100	105.0	96.0	+26	+26	92	90	48	53	+5	+6
Watermelon	100	100	44.6	54.3	0	–	100	100	12.5	5.0	0	0	100	100	116.0	105.0	–5	+20	0	0	–	–	–	–

B = Beneficiaries; G = Graduates.

Table 33. Coefficients of correlation between manure application and crop yields (Village No. 1).

	Faba bean	Phaseolus	Wheat	Maize	Squash	Tomato	Egg-plant	Pepper	Water-melon
Graduates	0.44	−0.35	0.21	0.55	*	0.55	*	*	*
All	0.15	−0.49	0.20	−0.04	0.53	0.37	0.71	0.44	0.11

* = Not enough data available to run the correlation.

Use of chemical fertilizers

General data on the use of fertilizers

All farmers use phosphorus (superphosphate 15.5%) and nitrogen fertilizers (urea 46%, ammonium sulfate 20.6%, ammonium nitrate 33%) and 75% use potassium fertilizers (potassium sulfate 48%).

The main comments on Table 34 are:

- The majority of farmers have been increasing or at least maintaining the rate of fertilizers for the past 5 years. This attitude is even stronger with beneficiaries than with graduates. Even in the context of frequent fertilizer price hikes, half of the farmer will not modify their fertilization habits nor reduce the area cultivated by fertilizer-demanding crops. The other half will reduce rates principally on maize, wheat and tomato (maize and wheat receive some of the highest nitrogen rates and the same for tomato with respect to phosphorus).

Table 34. General data on the use of fertilizers in Village No. 1.

Criterion	Beneficiaries		Graduates		Whole sample	
Trend in the use of fertilizers† (compared to 5 years ago)	up	70%	up	44%	up	57%
	equal	6%	equal	38%	equal	21%
	down	24%	down	19%	down	22%
Reaction to fertilizer price increase:						
1. Reduce rate/fed	47% (maize, watermelon, wheat, tomato)		44% (maize, wheat, tomato)		46% (maize, wheat, tomato)	
2. Change rotations	0%		13%		6%	
3. Decrease crop area	18% (tomato)		0%		9%	
4. No change	53%		50%		52%	
Rate applied compared to Old Lands (beneficiaries only)	more	53%	NA		NA	
	less	47%				

† Based on farmers' appreciation and not on crop data.

- As mentioned before, there is no clear relation between the trend in the use of fertilizers and the trend in the use of manure from what the farmers expressed. However, if we look at the correlation between manure rates and each of phosphate and nitrogen rates, we find the following (Table 35):

Table 35. Coefficients of correlation for various crops between manure rates and fertilizer rates.

Crop	Berseem	Faba bean	Maize	Phaseolus	Pepper	Wheat	Squash	Tomato	Water-melon
Manure x Phosphate	–0.27		–0.26	0.71	0.99	–0.02	–0.71	–0.12	–0.25
Manure x Nitrogen	–0.5	–0.14	0.06	0.16	0.98	0.21	–0.61	–0.16	–0.03

We can broadly define three classes of crops out of these correlations:

1. Crops where manure and N or P fertilizers are competitive: berseem and squash. This means that on these crops, farmers tend to reduce P and sometimes N if they increase manure.

2. Crops where manure and N or P fertilizers are supplementary: Phaseolus and pepper. For these crops, farmers try to increase fertilization packages. These crops might be those for which economic return is the highest, meaning that farmers are assured of getting a good profit before harvesting and therefore will try by all means to increase the yields, whatever the cost.

3. Crops for which there is no clear relation between manure and fertilizers: tomato, wheat, faba bean and watermelon.

These differences between crops would explain that there is no negative relation between the use of fertilizers and manure at the farm level, although it might happen at specific crop levels, depending on their role (food or cash), and gross margin.

Use of fertilizers detailed by crops (cf. Table 31)

<u>Percentage of farmers using fertilizers per crop</u>

Phosphorus

Practically all farmers use superphosphate on all the crops. The situation 5 years ago was practically similar (slight increase for wheat and berseem).

Nitrogen

All farmers use nitrogen fertilizer on all crops, and this was the same 5 years ago (only slight increase for berseem also).

Potassium

Potassium is applied to only half of the crops recorded, and among these, two-thirds are vegetables. Potassium is not seen as a must in the fertilization package except for peas, Phaseolus and tomato. The situation was almost identical 5 years ago (increase only for squash).

Rate applied per crop

Phosphorus

Application of phosphorus is markedly higher for vegetables and sugar beet than for all other crops. Once again, summer crops receive quite larger amounts of fertilization than winter crops (if we except sugar beet which is still a marginal crop in this village). The average rate for vegetables is 42 kg P_2O_5/fed (peas and Phaseolus included), whereas it is 33 kg for winter legume crops and 30 kg for cereal crops.

Rates have been increased for all crops (for which we have data) and with higher percentages for vegetables.

Finally, rates applied are usually equal or very close to the recommendations (when they were found) given by the Extension Services for the use of phosphate in the New Lands (see Figs 12 and 13).

Nitrogen

The picture is not so clear-cut with nitrogen as with phosphorus. The highest average is found for sugar beet followed by squash, the highest rate is given for tomato (371 kg/fed), but on the whole, cereals receive more nitrogen than vegetables (123 kg N/fed against 105 kg/fed). Peas and Phaseolus seem to be treated like other legume crops and not so much as vegetables. This indicates that farmers are managing their fertilization by crop differently according to the type of fertilizers.

The rates applied are much over the recommended rates for winter legume crops (+80% for faba bean, +200% for berseem) and equal to the recommendations for cereal crops (see Figs 12 and 13).

Regarding the rate increase over the last 5 years, if we consider the increases under ±5% as equal to nil, then rates were increased for 7 crops out of 11 and unchanged for the rest. Usually increases are higher for vegetables but not so far above the other crops as in the case of P or manure.

Potassium

Among the 6 crops that are given potassium, vegetables receive the highest rates, with maximum recorded rates for Phaseolus and tomato.

The increases recorded are not significant. Potassium is not a fertilizer that farmers consider as giving profitable marginal increases in yields.

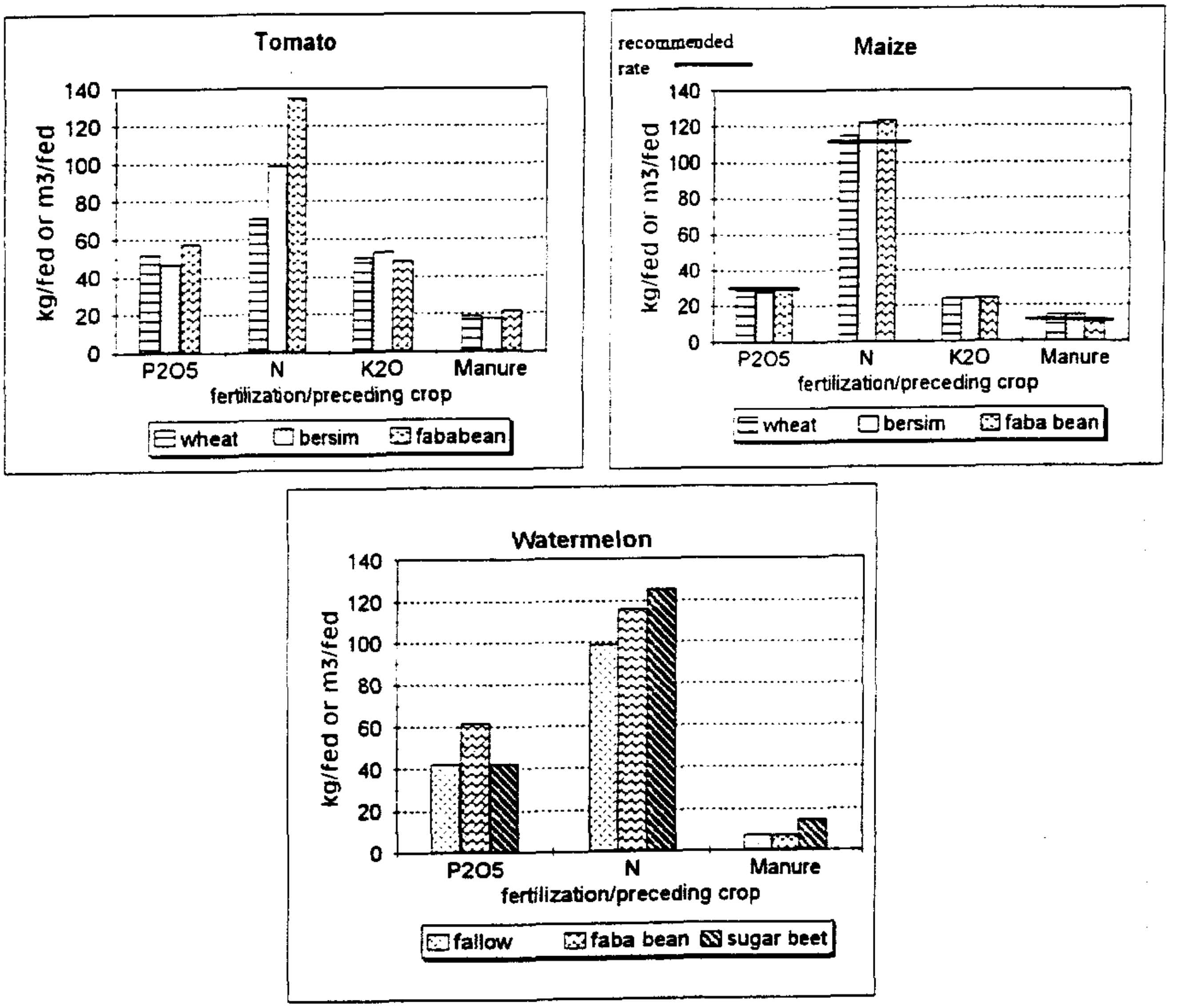
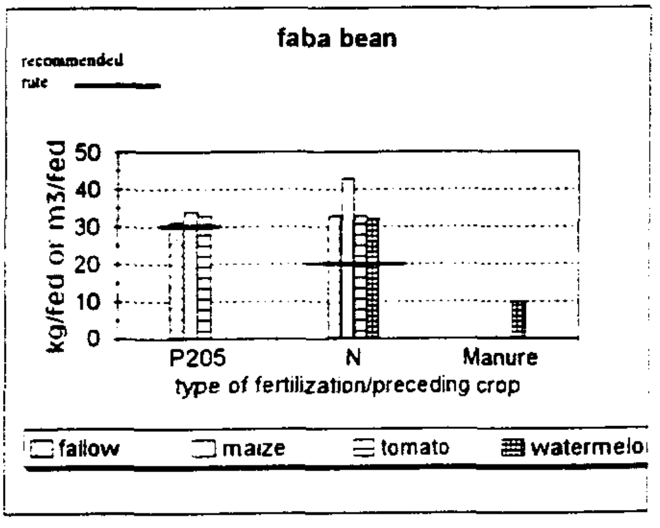
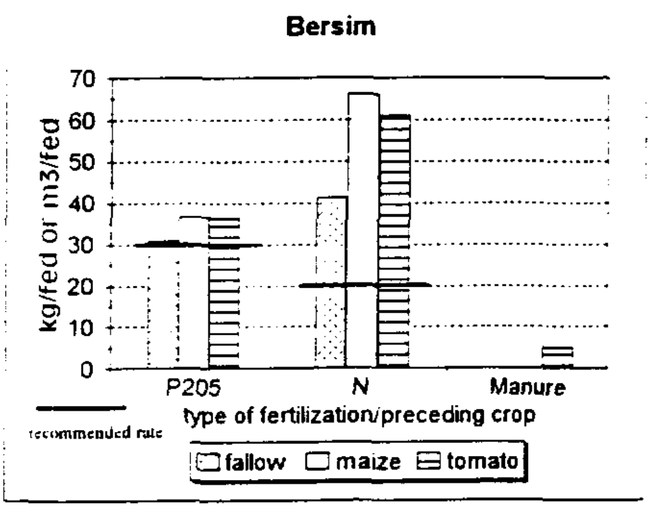


Fig. 12. Fertilization package by crop (summer crops) according to the preceding crop in Village No. 1, Sugar Beet area.





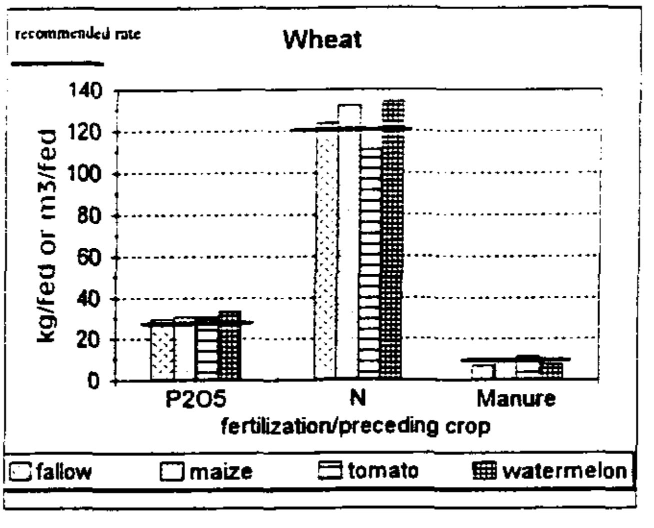


Fig. 13. Fertilization package by crop (winter crops) according to the preceding crop in Village No. 1, Sugar Beet area.

Effect of the preceding crop

For all the crops for which we have at least three different following crops with specific fertilization packages recorded, we compared the rates applied to these crops to the estimated average rate. The results are shown in Fig. 11.

Phosphorus

Farmers clearly reduce the P rate after a period of fallow and less markedly after berseem. On the other hand, it is always higher after faba bean. Surprisingly, P rates are not substantially reduced after tomato although it receives one of the highest P rates across all the crops.

Nitrogen

Farmers reduce N application after a fallow period, tomato and wheat (both of them receive high N rates). But surprisingly, they always add more after berseem than after other crops. Here the farmer does not seem to take into account that the remnant effect of N fertilizers from one crop to the other is very low and that legume crops like berseem are supposed to enrich the soil in nitrogen. This is certainly a priority issue to be studied through closer monitoring and possibly in some of the trials.

Potassium

No clear difference in rates according to the preceding crop is detectable.

Use of fertilizers according to farmers' origin (see Table 32)

Phosphorus

No clear-cut difference appears in the rates applied by each class of farmers. Graduates add slightly more to winter legume crops than beneficiaries do and beneficiaries tend to add more to cereals and some of the vegetables.

On the whole, over the past 5 years, beneficiaries also increased P rates more than graduates.

Nitrogen

For nitrogen, even more than for phosphorus, there is no significant separation between the two groups. By opposition to what happens with phosphorus, graduates have been more keen on increasing nitrogen fertilizers than beneficiaries.

Potassium

Potassium is more often added by beneficiaries than by graduates, but usually in lower rates.

Correlation to yield

As for manure, we will not consider these results as reliable enough to draw any conclusions. A real correlation seems to appear for N fertilization on tomato, pepper, watermelon (graduates only) and wheat (Table 35). It may be more apparent with these crops because they receive more nitrogen than the others do and the range of fertilization recorded is also wider (correlation more likely to appear).

For P, the only positive correlation appears for wheat, pepper and watermelon.

Table 35. Coefficients of correlation between P, N and K application and crop yields (Village No. 1).

		Berseem	Faba bean	Phaseolus	Wheat	Maize	Squash	Tomato	Egg-plant	Pepper	Water-melon
P	Grad.	−0.65	0.44	−0.35	0.84	−0.45		0.54			0.94
	All	−0.42	−0.68	−0.38	0.42	−0.51	−0.81	0.37	0	0.45	0.86
N	Grad.	−0.88	0.41	−0.99	0.6	−0.38		0.85			0.87
	All	−0.70	0.11	−0.71	0.49	−0.28	−0.65	0.66	0	0.57	−0.35
K	Grad.	NA	NA	1	NA	0.45		0.53	NA	NA	NA
	All	NA	NA	0.07	NA	0.08	−0.23	−0.41	NA	NA	NA

Legume crops

The use of legume crops as a fertility management method has been cited only by 3% of the farmers. Given the relatively high rates of fertilizers added to legume crops, the enriching effect of legumes could be shadowed by this excessive N fertilization. However, crops that follow berseem are also fertilized with nitrogen at higher levels than after other preceding crops, which goes against the expected improving effect of legumes.

Still, when farmers were asked which crops had a positive effect on the following crops, the answers were as follows:

Crop	Berseem	Faba bean	Tomato	Watermelon	Squash
% of farmers	82	55	40	9	9

This looks contradictory to the data collected on fertilization according to the preceding crops. But berseem can also be seen as an improving crop because it greatly reduces the amount of weeds for the following crop, it provides rich residues which are plowed in the soil before the following crop, and it is heavily irrigated and therefore the soil is well leached and salinity is reduced before the summer crop. The N-fixation effect is perhaps not the first benefit of berseem that farmers think of when they mention it in the first position. Faba bean comes in second position but this is not in contradiction with the N fertilization after faba bean which is not significantly higher than after other crops.

Trend in legume cultivation

Ninety-four percent of the farmers said that they increased (and will continue to) the importance of legume crops in their rotations. This is mostly true for berseem since faba bean is rather on the decline.

If we use the cropping pattern data and add up all legume crops, we obtain the results in Table 36.

Table 36. Trend in the place of legume crops in the cropping pattern (Village No. 1).

	Average farm share			Total area share		
Year	1992	1993	1994	1992	1993	1994
Winter legume	40%	39%	39%	41%	40%	44%
Summer legume	5%	4%	3%	6%	4%	3%

This shows that, on the whole, the importance of legumes in the land-use patterns did not vary much over the last 4 years, since berseem just filled the place left empty after faba bean was reduced.

Place of legumes in the rotations

From Table 24 we can extract the percent of rotations and farmland falling into the three following classes:

1. Legume winter crop at least two years out of three:
   - % of area = 22
   - % of rotations = 24
2. Legume winter crop every two years:
   - % of area = 33
   - % of rotations = 36
3. Legume winter crop every three years or less:
   - % of area = 37
   - % of rotations = 33

The distribution between these three classes is rather balanced and shows that farmers are practicing, in a more or less similar way, these three groups of rotations. This also means that the importance of legume crops in the rotation is not seen as a decisive choice factor for the farmer.

We calculated statistically, using the crop sequence data per plot, the average duration between two legume crops (winter and summer) on a piece of land. The results are given in Table 37.

Table 37. Average time lapse between two legume crops in Village No. 1.

Category	Average time lapse	Range
Beneficiaries	2y 7m	(1y 2m, 5y 7m)
Graduates	2y 10m	(1y 7m, 5y 7m)
Total	2 y 8m	(1y 2m, 5y 7m)

These time lapses are from seeding date to seeding date.

In addition, 16% of the graduates did not grow any legume crop over 4 years whereas this never happened among beneficiaries. However, the difference between the two is not large (3 months).

This time lapse is rather important compared to other places surveyed in Egypt (1y 6m in Beni Suef, 11m in El Bustan) and shows that legume crops might not yet be playing a major role in fertility build-up in the Sugar Beet area.

Use of inoculants

Only 6% of the farmers reported having used inoculants with legume crops (faba bean, Phaseolus) and half of these noticed an increase in production. However, nowadays, nobody uses inoculants in Village No. 1 mainly because they are not readily available at the cooperative stores nor on the market.

Other improving crops (non-legume)

Farmers also mentioned crops other than legumes as good preceding crops. Tomato, watermelon and squash were often cited. The main reason for this is, of course, the high amount of fertilizers which is applied to them, but also the intensive care given to these crops (weeding, fine soil surface work, pesticides) which undoubtedly reflects positively on the following crop.

Crop residues

We tried to classify crops in three groups according to the effect of the type of crop-residue management practiced by the farmers:

1. Total export (of nutrients) means that the residues are all removed from the field, then burnt or sold or used in any way which is not farm animal feed or mixing with manure.

2. Partial restitution means that the residues are given to animals whose manure will be applied on the field later on.

3. Complete restitution means that the residues are left to decay on the field and then plowed in the soil at the time the land is prepared for the following crop.

The survey results are given in Table 38.

Table 38. Crop residue management in Village No. 1.

Total export	Partial restitution	Complete restitution
Eggplant	Watermelon (AF)	Berseem (P)
Tomato	Chickpea (M)	Squash (P)
Pepper	Maize (AF, M)	Phaseolus (P)
	Sugar beet (AF)	Wheat (stem base–P)
	Wheat (straw–AF)	
	Peas (AF, M)	
	Faba bean (AF)	

AF = Animal feed; M = Mixed with manure; P = Plowed-in.

This table shows that most of the crop residues are contributing indirectly or directly to fertility maintenance. However, farmers' awareness of the need to recycle as much as possible of the crop residues on the field itself is rather low (crop residues as a fertility management method cited by only 6% of the farmers). Green manuring and zero-tillage are also totally unknown.

Water Management and Soil Degradation

Water Supply

The sample of farmers interviewed can be divided into three groups representing the head and middle of the canal and a separate area (El Khazana) which is not physically at the end of the canal but can be assimilated to a tail-end situation due to the serious water supply problems affecting this zone (see Map 3). This zone was in fact designed to be served under localized irrigation and therefore the water conveyance system has been designed to accommodate a moderate water demand. Now that all the farmers in this area (mostly graduates) have turned to surface irrigation, the water supply structure there cannot accommodate the accrued demand.

The water availability pattern over the year and its trend for the last 5 years has been tentatively studied, in particular by asking the farmers how full the secondary canal (branch 5-1, see Map 3) from which their field gets water is in different seasons. Although this methodology does not give precise enough results and is in a way too dependent on the subjectivity of the farmer (it was changed for other sites), we obtained the results presented in Table 39.

Table 39. Water availability during winter and summer seasons in Village No. 1 (Sugar Beet area).

Position	Winter				Summer			Water supply trend†	
	Water level in canal (on-days)	Regularity of winter closure	Regularity of water supply‡	Irrigation from the drain (% of farmers)	Water level in canal during on-days	Regularity of water supply	Irrigation from drain		
Head	81%	Y 90%	Y 90%	0%	66%	Y 90%	0%	up	10%
		N 10%	N 10%			N 10%		stable	60%
								down	30%
Middle	66%	Y 36%	Y 91%	15%	49%	Y 18%	15%	up	18%
		N 64%	N 9%			N 82%		stable	18%
								down	64%
End (El Khazana)	56%	Y 50%	Y 57%	0%	48%	Y 50%	0%	up	30%
		N 50%	N 43%			Y 50%		down	70%

† Trend here is intended as a continuous phenomenon over 5 years, not a situation in which water supply is highly variable, for the better or the worse, each year.

‡ Regularity of water rotation.

This table shows a difference in water supply parameters (quantity, regularity and trend) between the head and middle–end situations. However, the difference between the middle and end situations here is not convincing, partly because the problems affecting El Khazana area are more complex than just being at the tail end of the canal. In some ways water supply is more advanced there (all farmers have pumps and there are several small raising stations within the perimeter itself), but water quantity is usually not up to the needs.

In all cases, there is also a marked difference between the winter and summer seasons, whether in terms of the quantity of water available or the regularity of the water rotation. Irrigation from drains is rare in Village No. 1 mostly because, for many farmers, the water available is enough, although not plentiful, and for others, such as the graduates in El Khazana area, there are no open drains within a reachable distance.

Over the last 5 years, the water supply situation did not really improve, since a majority of farmers are complaining of a trend downwards regarding the water available. And this decrease is felt more by farmers at the end than at the head of the canal.

Irrigation Methods and Water Consumption

The irrigation methods employed are described in Table 40.

Table 40. Irrigation methods now and in the past in Village No. 1.

Position	Irrigation method now		Irrigation method in the past	
Head	Gravity	60%	Gravity	60%
	Surface with pump	40%	Surface with pump	10%
			Sprinklers	30%
Middle	Gravity	83%	Gravity	100%
	Surface with pump	17%		
El Khazana	Gravity	8%	Drip system	100%
	Surface with pump	92%		

As mentioned before, all of the farmers in El Khazana gave up the drip irrigation system and had to equip themselves with pumps because of the low level of water in the canals which impedes irrigating by gravity. In the middle-canal section, there is also a trend towards surface irrigation assisted by a pump instead of a pure gravity system, also because the water level in the canals is getting too low to practice gravity all-year-round.

From the data collected on the number of irrigations and hours/irrigation of each crop, we calculated the actual amount of water applied to each crop[13] and compared it with the theoretical plant requirement[14] (Table 41).

Peas and squash are the most excessively irrigated crops. Berseem and wheat in winter are also over-irrigated, and since they are cultivated on large areas, this means that to reduce water waste, efforts should first be devoted to rationalizing irrigation practices for these two crops. On the other hand, some crops are notably under-irrigated (sugar beet, watermelon, pepper). For sugar beet, it could be due to the lack of experience in this area for this new crop. These results should however be taken carefully since no specific crop coefficients were used nor was the actual pump discharge checked. Also, the applied irrigation data would not apply to farmers irrigating by gravity, who make up the majority of farmers there.

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[13] For a pump of 150 m^3 discharge (concerns graduates in El Khazana only).

[14] Based on actual ETP with K factor = 0.6 for all crops and system efficiency = 60%.

Table 41. Irrigation practices by crop.

Crop	Berseem	Faba bean	Wheat	Pea	Sugar beet	Egg-plant	Water-melon	Maize	Tomato	Squash	Phaseolus	Pepper
No. of irrigations	9	5	7	6	7	6	5	7	6	7	4	5
No. of hours/ irrigation	5	4.5	4.5	4	4	4	4	4	4	4	4	4
Total hours	45	22.5	31.5	24	28	24	20	28	24	28	16	20
Irrigation applied (mm)	1607	804	1125	857	1000	857	714	1000	857	1000	571	714
Irrigation required (mm)	1220	731	850	308	1381		916	956	890	598	513	1037
Excess amount (mm)	387	73	275	549	–381		–202	44	–33	402	58	–323
% of excess	31%	10%	32%	178%	–27%		–22%	5%	–4%	67%	11%	–31%

We also asked farmers whether their choice of crops grown in each season is seriously influenced by water supply constraints or not. The results are presented in Table 42.

Table 42. Relation between choice of crops and water availability in Village No. 1.

Position	Winter season	Summer season
Head of canal	Y 0%	Y 90%
	N 100%	N 10%
Middle of canal	Y 8%	Y 92% (reduce T/Wm/M)
	N 92%	N 8%
El Khazana	Y 64% (reduce B, Wh)	Y 75% (reduce M)
	N 36%	N 25%

B = Berseem; Wh = Wheat; T = Tomato; Wm = Watermelon; M = Maize.

Only graduates in El Khazana are really influenced in their crop choice during the winter season, which shows that this area is actually suffering more from water shortage than the rest of Village No. 1. In summer, almost all the farmers are adapting their cropping pattern according to the water supply conditions. Beneficiaries (middle-canal section) are more prone to reducing the vegetable area, whereas graduates will first reduce the maize area, showing again the different importance of these two types of crops for each group.

Drainage and Soil Salinization

The last kind of data collected on water-related aspects concerned drainage and soil salinity. The results are presented in Table 43.

Table 43. Drainage and salinity issues in Village No. 1.

Drain type	Drain efficiency	Salinity level (farmers' appreciation)	
No drain	NA	low	14%
		medium	43%
		high	43%
Tile drain	good	low	37%
		medium	67%

From this table we can see that salinity issues are tightly related to the absence of a drainage system. Salinity-stricken plots are mostly confined to El Khazana area where no tile drainage network was installed since it was meant to be a localized irrigation area. However, salinity problems started to appear as soon as graduates reverted to surface irrigation. Still, no farmer mentioned that there was a close-to-surface water table. This would mean that salinity problems come only from slow drainage in these rather heavy calcareous soils and not from water stagnation at subsurface level.

Results of the Multidisciplinary Survey in the New Lands: North Delta Region

Village No. 42 and Khalid Ibn El-Waleed Village

Introduction

The survey was conducted in villages No. 42 and Khalid Ibn El-Waleed, located in El Hamoul area, about 75 km to the north of Sakha in Kafr El-Sheikh governorate.

Twenty-six farmers were interviewed, geographically distributed as follows:

- 23% were selected in Village No. 42 to represent a head of canal situation,
- 62% were selected in Khalid Ibn El-Waleed village and its closest neighbor to represent the middle of the canal situation, and
- 15% were selected in Khalid Ibn El-Waleed village to represent the end of canal situation.

In addition to this stratification, 42% of the farmers were graduates and the remaining 56%, beneficiaries.

Structural Data on the Sampled Population

The detailed results of the main variables used in characterizing the sample are presented in Table 44.

Table 44. Average values of structural descriptors for the surveyed sample (Khalid Ibn El-Waleed village).

Criterion	Beneficiaries	Graduates	Total sample
Age (median)	49	30	40
Year of settlement	1987	1990	1990
Family size (HCU)†	6.1	2.0	4.3
Family workforce (HLU)‡	3.6	1.0	2.5
Total farm land (feddan)	7.7	4.9	6.5
Farm land use:			
fallow	7% (20% fallow 36% of their land)	45% (64% fallow 70% of their land)	23% (38% on 60% of their land)
crops	93% (100% cultivate 93% of their land)	55% (70% cultivate 79% of their land)	77% (92% on 84% of their land)
% of animal holders	93	30	68
Average livestock holding (LU)§	4.1	0.4	2.7
Structural ratios			
CA/HCU	1.26	1.54	1.38
HCU/CA¶	0.55	0.39	0.49
Motorized equipment			
Irrigation pumps	100%	91%	96%
Tractors	7%	0%	4%

† HCU = Human consumptive unit.
‡ HLU = Human labor unit.
§ LU = Livestock unit.
¶ CA = Cultivated area.

1 fed = 0.42 ha.

The main points are:

Year of Settlement

Beneficiaries settled in the area about 3 years before the graduates. The earliest arrival was in 1964 and the latest in 1993 (graduates).

Family Size and Labor Workforce

Beneficiaries have families 3 times larger than graduates and the family workforce is 3.5 times higher.

Farm Area and Total Cultivated Area

Beneficiaries usually have farms that are larger by about 2.5 feddans than the graduates and usually cultivate it all. Graduates are more prone to fallow part of their land because of the frequent water shortages in their area and the frequent absenteeism among them.

Livestock Holding

The results showed that about 93% of the beneficiaries have animals while only 30% of the graduates own animals. Average livestock size is also insignificant for graduates compared to beneficiaries. This difference is explained by the fact that several of the graduates are not full-time residents in the village and therefore cannot keep animals.

Structural Ratios

The average land size available per family member (CA/HCU) is slightly higher for the graduates (1.54 fed) than for beneficiaries (1.26 fed). On the other hand, family labor available per feddan (HLU/CA) is lower for graduates (0.39) than for beneficiaries (0.55) and therefore the need to hire labor is higher for the former.

Motorized Equipment

The results revealed that all beneficiaries and most graduates own irrigation pumps, while 7% of the beneficiaries own tractors.

Cropping Patterns and Rotations

The data obtained represent the cropping patterns and rotations practiced on 53.5 feddans (about 4% of the total area) in Khalid Ibn El-Waleed village (graduates) and on 116 feddans (about 7% of the total area) in Village No. 42 (beneficiaries).

Evolution of Cropping Patterns

Past trends

The dynamics of cropping patterns for the beneficiaries, graduates, and the whole sample during 1991 through 1995 are presented in Figs 14, 15 and 16 which represent:

- % of farmers cultivating the crop,
- % of farmland allocated to each crop on an average farm, and
- % of total cultivated area of the sample population allocated to each crop.

The main results of the cropping pattern study for each crop are given below.

Winter crops

Wheat: It is the major winter crop, cultivated in the area by both beneficiaries and graduates. About 73% of the farmers grew wheat on 42% of the total cultivated area over the last four seasons. There is a sharp decrease in the number of graduates cultivating the crop. In terms of total area, wheat has declined during the last 2 years after a peak in 1992, and this in favor of berseem.

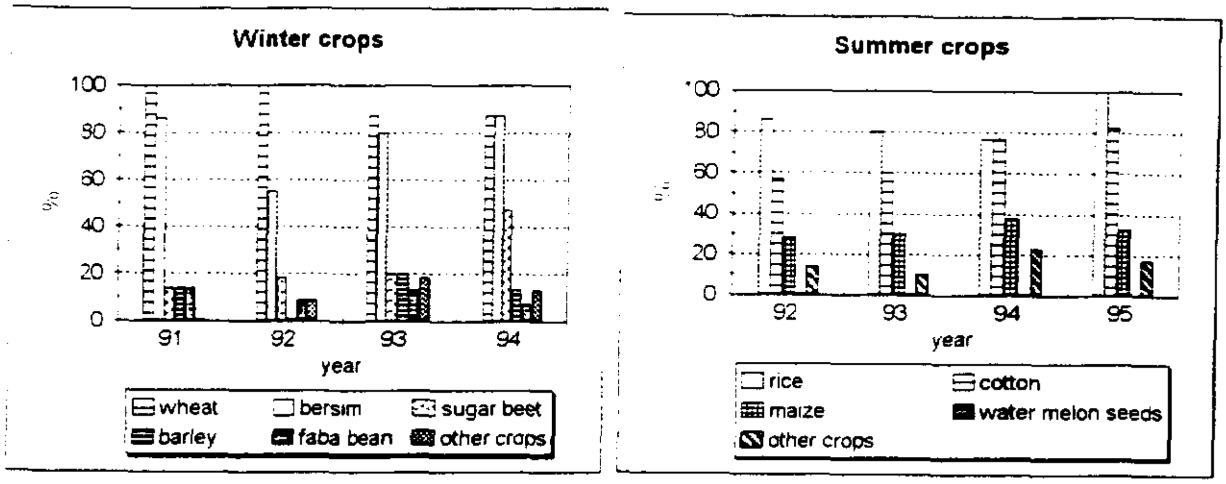
Berseem: Berseem is now as important as wheat. There is an increasing trend in the number of graduates cultivating the crops, while no such increase was noticed with beneficiaries. All in all, berseem area is increasing in the village, coming back to the high level recorded in 1991. However, this increase is provoked mainly by an increase of cotton cultivation (mostly preceded by short berseem). It is therefore an increase of short berseem rather than long berseem (lesser effect on fertility build-up).

Sugar beet: There has been an increasing trend in the number of farmers (54%) and in the area devoted to the crop (16%) over the last four seasons at the expense of faba bean and other winter crops.

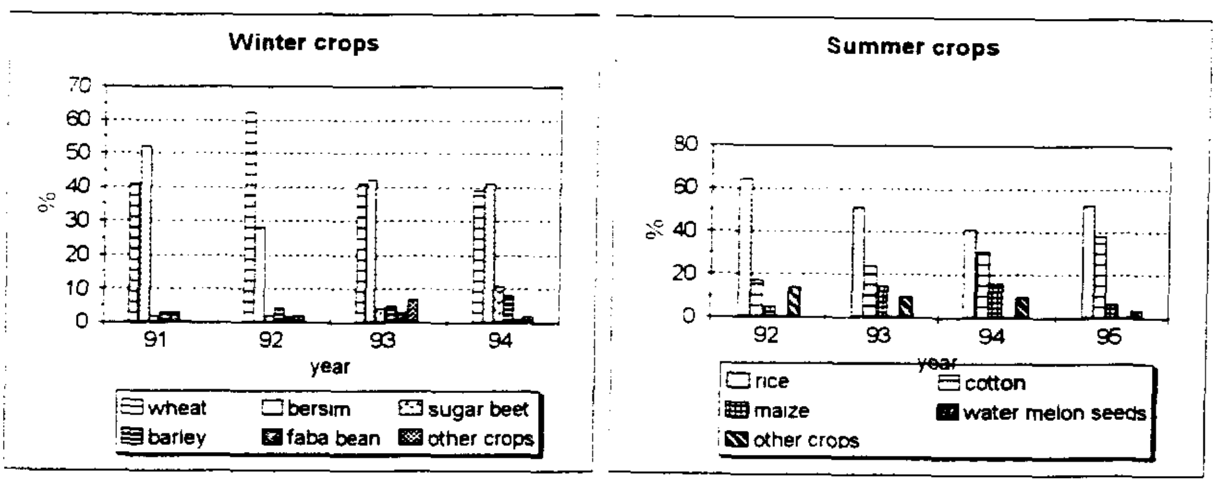
Faba bean: Faba bean is one of the minor crops cultivated in the area. Only 14% of the farmers grow it on about 4% of the total cultivated area. The results showed that more graduates cultivate faba bean than beneficiaries. Faba bean was on the rise until 1993 but was sharply reduced this year.

Barley: Barely is a minor crop in the area, cultivated in about 6% of the total area by about 14% of the farmers. Graduates tend to decrease the area cultivated with the crop (only 1% this season), but altogether its share remains stable at the village area level.

1. Percentage of farmers cultivating the crop:



2. Crop shares on an average farm:



3. Crop shares for the total surveyed area:

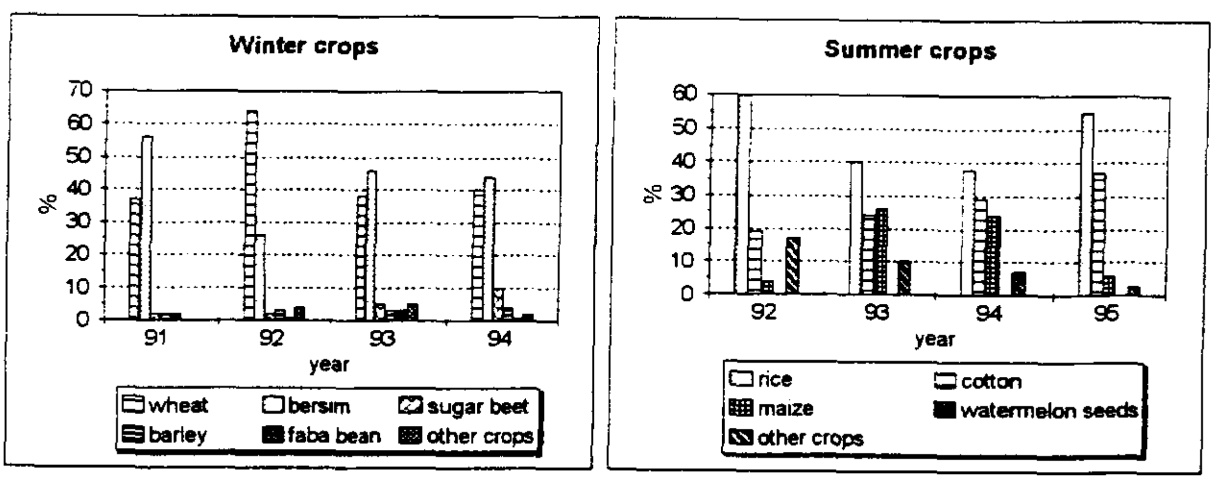
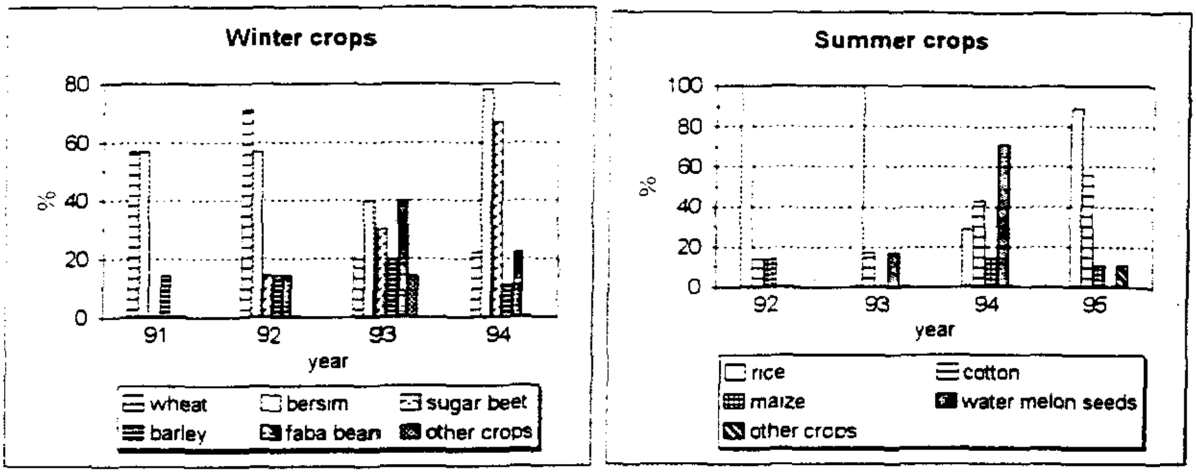
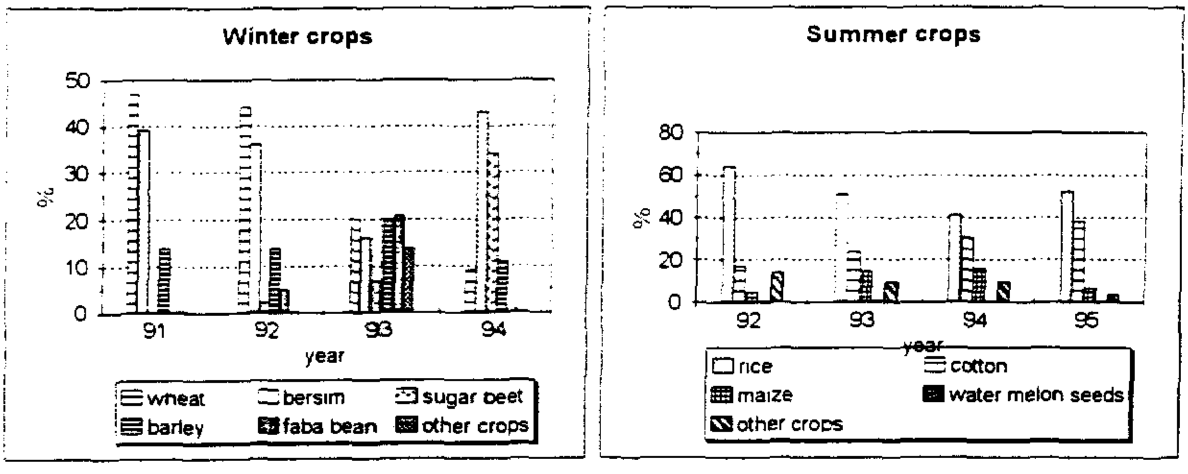


Fig. 14. Cropping pattern trends in Khalid Ibn El-Waleed village, North Delta area (beneficiaries).

1.Percentage of farmers cultivating the crop:



2. Crop shares on an average farm:



3. Crop shares for the total surveyed area:

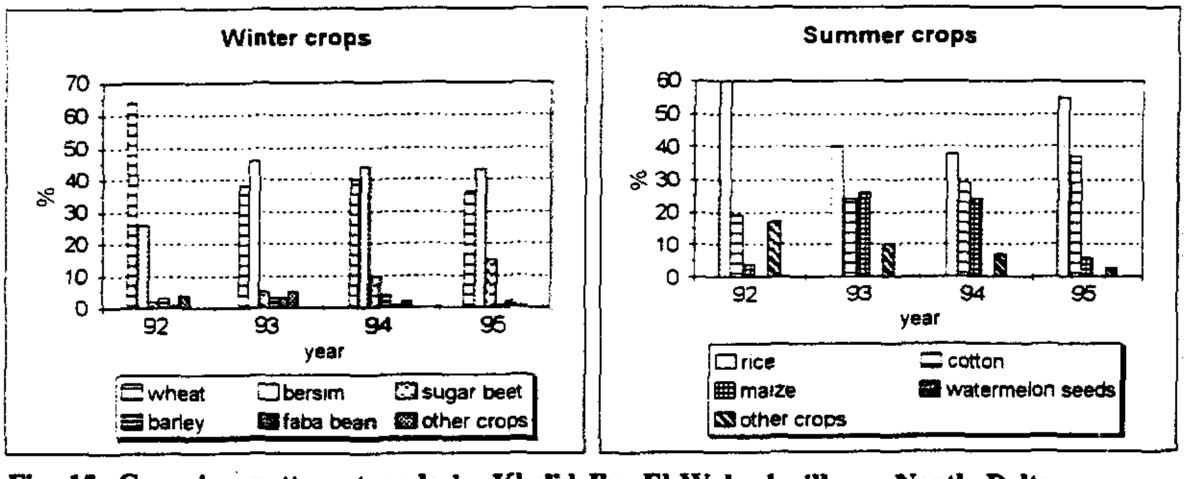
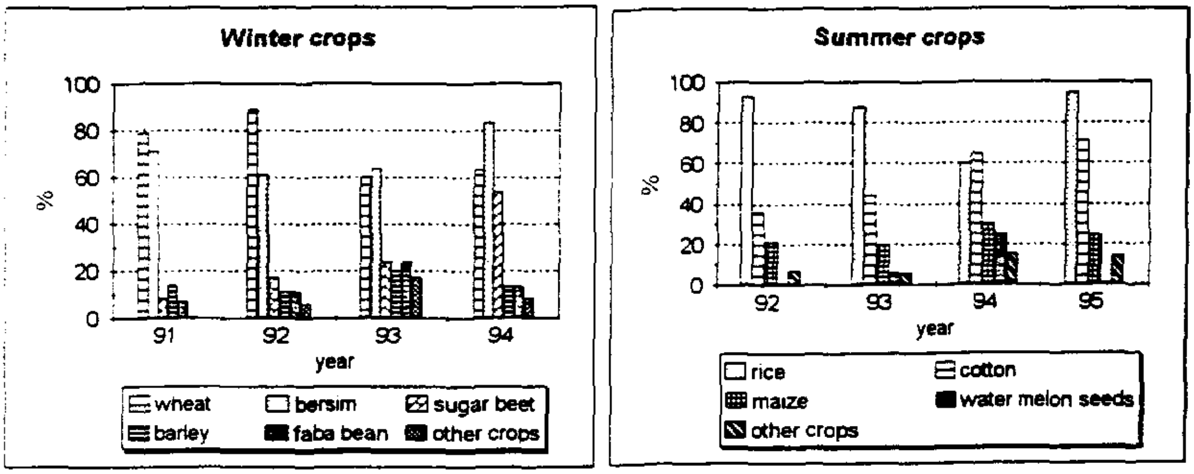
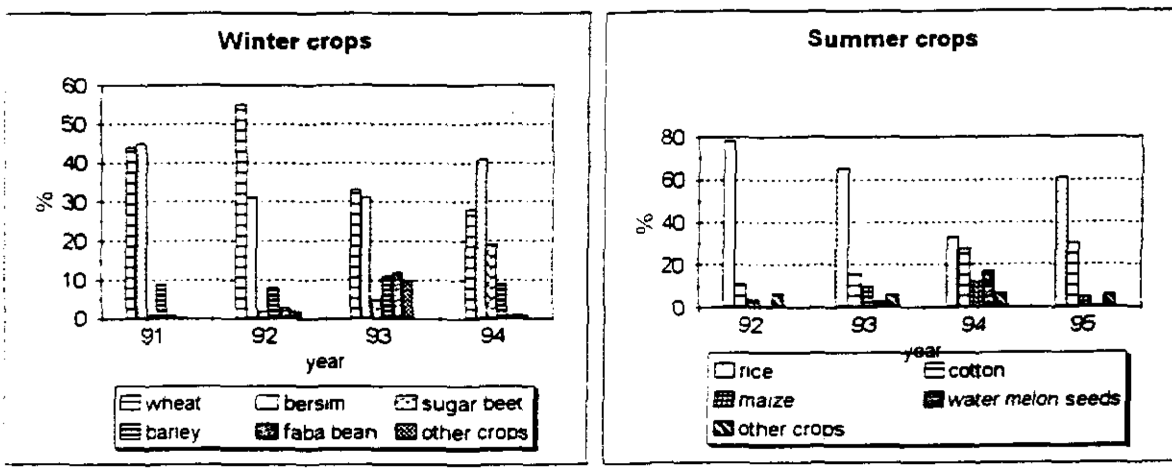


Fig. 15. Cropping pattern trends in Khalid Ibn El-Waleed village, North Delta area (graduates).

1. Percentage of farmers cultivating the crop:



2. Crop shares on an average farm:



3. Crop shares for the total surveyed area:

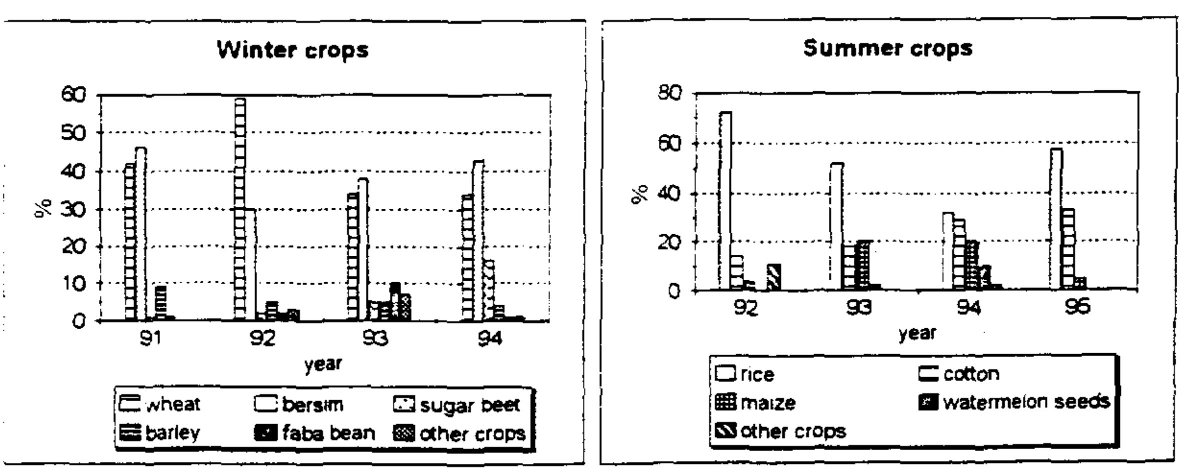


Fig. 16. Cropping pattern trends in Khalid Ibn El-Waleed village, North Delta area (whole sample).

Other winter crops: These are mainly potatoes and onions, cultivated by both beneficiaries and graduates in about 3% of their land. Graduates did not grow any other winter crop in the last season.

Summer crops

Rice: Rice is the major summer crop cultivated in the area. Eighty-four percent of the farmers grew rice on 54% of the total cultivated area in the last four seasons. However, rice cultivation has experienced a major drop from 1991 to 1993 (due to water shortage). The figure for summer 1995 is only prospective and depends on the water amount that will be available in that season. Generally, graduates devote a larger area to rice than beneficiaries, mainly because their farms are younger and need more leaching.

Cotton: Cotton is cultivated by about 54% of the farmers on about 24% of the total area. There is an increasing trend in both the number of farmers growing cotton and the area devoted to the crop.

Maize: The crop is cultivated by about 24% of the farmers on about 12% of the area. The average number of beneficiaries growing maize is three times that of the graduates (beneficiaries have higher domestic food requirements). The results show that there could be a sharp decrease in the number of farmers and area devoted to the crop in 1995, but this will happen of course only if the water supply is good enough to grow rice.

Watermelon for seed: This is a minor crop grown only by the graduates. About 8% of the graduates cultivate this crop on about 3% of the total area. There were large variations in the area cultivated with the crop over the last four seasons (market crop). In 1995, no farmers intend to cultivate it.

Other summer crops: There are mainly tomatoes and fodder maize, which represent 8% of the total cultivated area by 11% of the beneficiaries. The graduates will start growing such crops in summer 1995.

Summary

In winter, wheat and berseem are the main crops cultivated by the farmers and have now reached identical levels. There is an increase in the area devoted to sugar beet by all farmers at the expense of faba bean and the other minor winter crops.

In summer, rice is the major crop cultivated by all farmers as long as water is enough. Maize area depends mainly on the rice area and, therefore, also on the water supply. Cotton, on the other hand, is definitely on the rise at the expense of all other summer crops. However, this trend is still fragile especially in the light of the very bad 1994 harvest (pest control failure).

Future expected trends

Table 45 presents the farmers' answers when asked which crops they expect to increase or decrease in the future.

Table 45. Percentage of farmers willing to increase or decrease specific crops in the future (Khalid Ibn El-Waleed village).

Trend	Rice	Berseem	Sugar beet	Faba bean	Maize	Wheat	Watermelon seeds	Cotton
Up	63	63	42	21	16	11	5	65
Down	18	24	6	0	18	18	24	60
Balance (up–down)	+45	+39	+36	+21	–2	–7	–19	5

The results indicate that farmers are willing to cultivate more berseem, sugar beet and faba bean and grow less wheat. For summer, rice will continue to be the dominating summer crop since more farmers are willing to cultivate it. The trend towards more cotton is not quite obvious here but this is mainly due to the pest problems last season. This situation should be seen as temporary.

To finish with, farmers were asked about the new crops they would like to introduce in their rotations. Their answers are as presented in Table 46.

Table 46. New crops to be introduced in crop rotations.

Crop	Vegetables	Rice	Cotton, berseem, faba bean
% of farmers citing it	68%	23%	14%

Vegetables came as the majority choice and the main constraint for farmers to cultivate them is water availability and quality.

Prevailing Crop Rotations

Crop rotations have been studied on a sample of 54 crop sequences over 5 years (10 seasons). The total concerned area is 118.5 feddans.

In El Hamoul area, we used the occurrence of rice crop, which is the main summer crop, as a classification criterion. Rice is also a major crop for soil improvement in these highly saline areas.

Our classification was based on the following succession of criteria:

1. Importance of rice crop in the summer rotation.

2. Importance of legume crops in the winter rotation.

Winter legumes were not differentiated when classified so as to level down the complexity of our sample. Our first concern was the fertility build-up potential of the various rotations based on rice occurrence (leaching effect) and legume crop frequency. Also, all vegetables were treated under one category.

The complete results of this rotation classification are presented in Table 47.

Table 47. Tentative classification of prevailing crop rotations in Khalid Ibn El-Waleed village, North Delta.

Rice occurrence as summer crop	A	No.	Rice as summer crop	A	No.	Other summer crops	A	No.	Winter crop rotation	A	No.	Example	Summer rotation (years)
Rice every year to 4/5	11	13	Rice 1/1 or 4/5	11	13	Rice 1/1 or 4/5	11	13	Wheat monocropping	5	6	Berseem/Rice …	1
									Legume monocropping	2	2	Wheat/Rice …	1
									Fixed rotation L-Wh (SB)	6	5	Berseem/Rice- Wheat/Rice	2
Rice 3/4 to 2/3	19	24	Rice 3/4	7	6	R-R-R-Ct	7	6	Not fixed (Wh, L, SB)	7	6	Wh/R-Wh/R-Berseem/R-SB/Ct	4
			Rice 2/3	12	18	R-R-R-Maize	4	8	Not fixed (SB, Wh, L, Barley)	4	8	Berseem/Rice-Wh/R-FB/Maize	3
						R-R-R-Cotton	5	4	Not fixed (Wh, L, SB, Veg)	5	4	Berseem/Rice-Ber/Rice-Onion/Cotton	3
						R-R-R-Watermelon	5	7	Not fixed (L, Wh, Barley)	5	7	Ber/R-Wh/R-FB/Watermelon	3
Rice 1/2 or 2/4	16	20	Rice 1/2	4	7	Cotton, Maize R-Ct or R-Ct-R-M	3	6	Not fixed (L, Wh, Barley)	3	6	Ber/Maize-Ber/R-Ber/Cotton-Wheat/Rice	2 to 4
			Rice 2/4	12	13	Maize R-R-M-M	3	2	Not fixed	3	2	Ber/Maize-Ber/Maize-Ber/Rice-Ber/Rice	4
						Cotton R-R-Ct-Ct	10	12	Not fixed	10	12	Wheat/Rice-Berseem/Rice-Onion/Cotton-SB/Cotton	4
Rice 1/3 to 1/4	9	11	Rice 1/3	5	6	R-Cotton-Cotton R-Cotton-Vegetable	5	6	Wheat-Leg-Leg	5	6	Wheat/Rice-Berseem/Cotton-Berseem/Cotton	3
			Rice 1/4	4	6	Not fixed Maize, Cotton, Vegetable	4	6	Not fixed	4	6	Wheat/Rice-Ber/Cotton-Ber/Ct-Ber/Tomato	
Rice 1/5 to no Rice	16	18	Crop alternation in summer	8	11	Not fixed M, Fodder M, Ct, Veg	8	11	Not fixed	8	11	Wheat/Fodder M-Wh/M-Wh/Cotton-SB/Cotton	
			Summer monocropping	8	9	Cotton	5	7	Fixed Leg-Leg-…	5	7	Berseem/Cotton	1
						Fallow (leaching only)	3	2	Fixed Wheat-Wheat…	3	2	Wheat/Fallow	1

A = area = % of the total sample area which is subject to the described rotation.

No. = % of the total sample of crop sequences which correspond to the described rotation.

R = rice, Ct = cotton, M = maize, Fodder M = fodder maize, Ber = berseem, SB = sugar beet, Wh = wheat, Leg = L = legume crop.

Based on this classification, the three more frequent rotations are:

1. Rice Every Two Years out of Three

Area = 12% Number = 18%

Type: This is a 3-year summer rotation. Farmers do not seem to follow any fixed scheme for winter crop rotation. It is a mixture mainly of wheat, legumes and sugar beet, in alternation or by blocks (two years wheat, two years berseem, etc.). The most common summer crop after two years of rice is maize.

Example: Berseem/Rice–Wheat/Rice–Faba bean/Maize

2. Rice Crop Two Years in a Row Followed by Two Years without Rice

Area = 12% Number = 13%

Type: This is a 4-year summer rotation where alternation is practiced by blocks (two years of the same crop followed by two years of another crop). In winter, there is no fixed rotation. The most common summer crop in this kind of rotation is cotton.

Example: Wheat/Rice–Sugar Beet/Rice–Onion/Cotton–Berseem/Cotton

3. Rice Less Than One Year out of Five

Area = 8% Number = 10%

In this type of rotation, rice is not any longer a major summer crop. It can actually not appear at all for 5 years or more. This rotation is rather a sequence of summer crops in alternation, coupled with a non-fixed sequence of winter crops also. It could be called a 100% open rotation.

Example: Wheat/Fodder Maize–Wheat/Maize–Wheat/Cotton–Sugar Beet/Cotton

Table 48 gives more information on crop successions as obtained from the surveyed sample. This exercise has been done for *winter–summer successions, winter–winter* and *summer–summer*. The percentages expressed in this table tell us for a crop, what the percentage of cases is in which it is succeeded by such following crop. For example, in the winter-to-summer successions, cotton follows berseem in 40% of the cases. Also, rice comes after berseem in 47 % of the cases studied.

Table 48. Winter/summer and summer winter successions in Khalid Ibn El-Waleed village, North Delta (expressed in % of total number of cases).

Following / Preceding	Berseem	Barley	Faba bean	Onion	Potato	Wheat	Sugar beet	Cotton	Maize	Rice	Tomato	Watermelon seed	Fallow	Total
Berseem								40	4	47	2	4	2	100
Barley									50	29			21	100
Faba bean								24	18	24	6	29		100
Faba bean								67			33			100
Potato									33	67				100
Wheat								7	10	71	1		11	100
Sugar beet								45	18	30	3	3		100
Cotton	45		9	2	2	23	19							100
Maize	35	9	4			26	26							100
Rice	34	5	10	2	1	28	11							100
Tomato	25				2	25	25							100
Watermelon seed	50		13				38							100
Fallow	6	11				28	6			33			17	100

Winter to winter successions

Following / Preceding	Berseem	Barley	Faba bean	Onion	Potato	Wheat	Sugar beet	Cotton	Maize	Rice	Tomato	Watermelon seed	Fallow	Total
Berseem	54		1	1	3	30	10							100
Barley	8	50				8	25						8	100
Faba bean	31		23			15	31							100
Faba bean	33					33	33							100
Potato	100													100
Wheat	22	4	14	3	1	40	13						3	100
Sugar beet	24	5	5			38	29							100
Cotton														
Maize														
Rice														
Tomato														
Watermelon seed														
Fallow	22	11	11			44	11							100

Table 48. (Cont'd)

Summer to summer successions

Following / Preceding	Berseem	Barley	Faba bean	Onion	Potato	Wheat	Sugar beet	Cotton	Maize	Rice	Tomato	Watermelon seed	Fallow	Total
Berseem														
Barley														
Faba bean														
Faba bean														
Potato														
Wheat														
Sugar beet														
Cotton								56	6	25	13			100
Maize								23	27	50				100
Rice								20	9	61	1	8	1	100
Tomato								40	20	40				100
Watermelon seed								13		75		13		100
Fallow								8	17	17			58	100

Fertility Management

Evolution of Soil Characteristics

Farmers were asked in the survey to describe the main changes they observed in the soil quality of their farm. The results are presented in Table 49.

Table 49. The observed changes in soil quality (Khalid Ibn El-Waleed village).

Changes	Beneficiaries (%)	Graduates (%)	Total (%)
Structure	33	27	31
Color	13	–	8
Decrease in salinity	60	45	54
Improved	33	36	35
Structure	–	9	4
+ F	7	–	4
– F	–	18	8

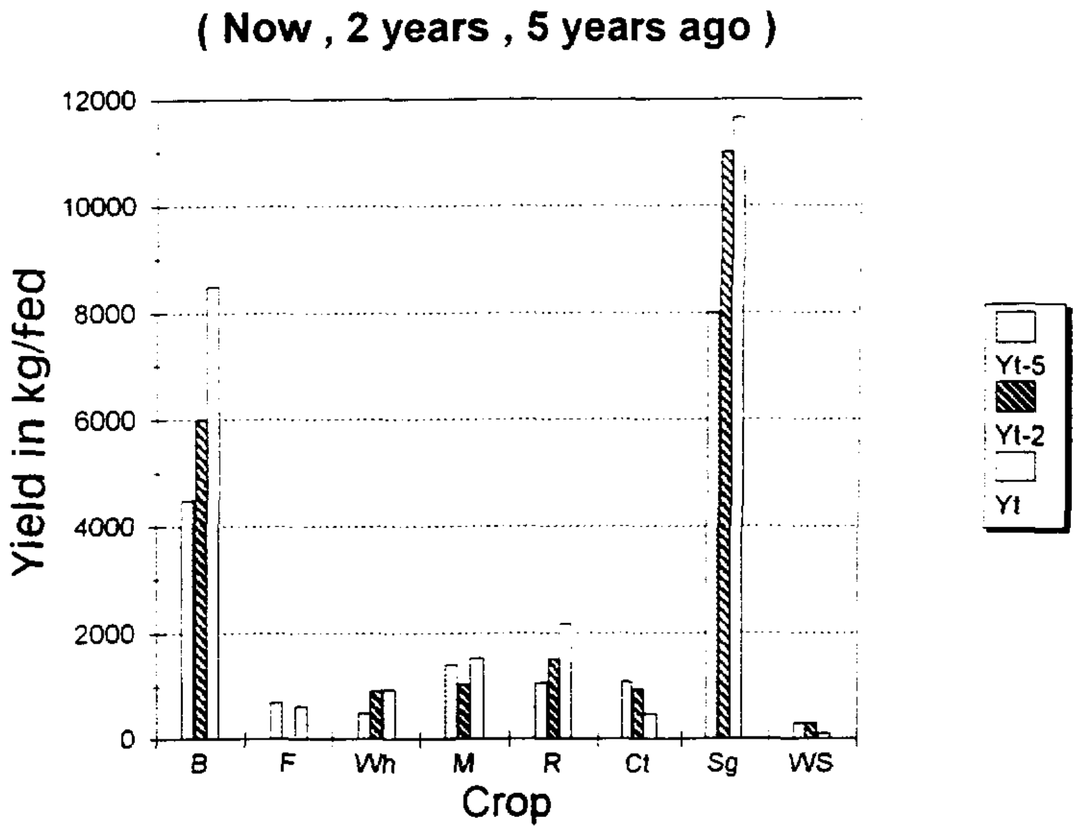
+ F = More fertility; – F = Less fertility.

These results clearly indicate that soil salinity has significantly decreased. Also, soil structure has changed with continuing cultivation of the soil (more aggregated). More generally, 35% of the farmers observed some improvement in their soil. Beneficiaries in this sample have been cultivating their land for an average of 19 seasons, and graduates for 9 seasons. This can explain the differences in their perceptions, especially for salinity decrease and texture improvement.

The effect of age of cultivation on crop yield is presented in Table 50 and Fig. 17. The results show that there is a yield increase for 5 crops, varying between 10% for maize and 103% for rice. This yield increase could be due to the improvement in soil characteristics with time as well as to the use of new varieties and higher fertilizer application.

Table 50. Evolution of crop yields (kg/fed) over 5 years, Khalid Ibn El-Waleed village (North Delta).

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	
Berseem	8500	6000–10000	6000	4000–8000	4500	4000–5000	+89
Faba bean	*620*	*310–930*			698	698	–11
Barley	1080	1080	720	720	360	360	+200
Wheat	943	150–1800	908	225–1800	483	150–1200	+95
Maize	1540	1400–1680	1050	700–1400	1400	1400	+10
Rice	2178	1000–3550	1500	1000–2000	1075	500–2000	+103
Sugar beet	11643	5000–15000	11000	10000–13000	8000	5000–11000	+45
Potato	11500	8000–15000					
Watermelon seed	92	50–125	300	300	300	300	–69
Cotton	*3 qentar*	*0.5–7*	*6 qent.*	*3–7*	*7 qent.*	*4.5–9*	*–57*



Legend: B = berseem, F = faba bean, M = maize, R = rice, Ct = cotton, Sg = sugar beet, Wh = wheat, Ws = Watermelon for seed.

Fig. 17. Evolution of crop yields over 5 years in Khalid Ibn El-Waleed village, North Delta area.

Fertility Management Methods

Table 51 presents the farmers' opinions concerning the best fertility management methods.

The results show that:

- Legume crops came as the first method for fertility management and improving soil quality for both beneficiaries and graduates.
- Availability of irrigation water for leaching, water quality, and improving the existing drainage system all refer to salinity control. This emphasizes the importance of a reliable and better quality water supply for farmers so as to maintain salt at an acceptable level.
- Fertilizers and manure are not often mentioned. In fact, fertility is not a major problem in these black soils and, actually, most farmers do not add manure at all.

Table 51. Farmers' best methods to increase soil quality (% of farmers citing the method).

Beneficiaries		Graduates		Whole sample	
Legume cropping	67	Legume cropping	45	Legume cropping	58
Leaching	60	Drainage	36	Leaching	46
Improving water quality	40	Phosphorus	36	Drainage	38
Drainage	40	Manure	36	Water quality	35
Crop rotation	33	Leaching	27	Crop rotation	31
Gypsum	27	Water quality	27	Phosphorus	27
Phosphorus	20	Crop rotation	27	Gypsum	19
Leveling	13	Leveling	18	Manure	19
Manure	7	Subsoiling	18	Leveling	15
Repeated plowing	7	Gypsum	9	Subsoiling	9
		Cultivation	9	Plowing	4
				Cultivation	4

The methods dealing with fertility management *stricto sensu* will be discussed in the following sections.

Use of manure

The survey results indicated that most farmers do not use manure in their fields because they consider it as a source of salinity and would damage their crops[15]. In fact, most of the manure produced in this area is sold to the desert New Lands farmers where manure is in short supply.

In our sample, 11% of the farmers used it and all were beneficiaries. It is used primarily for vegetables like potato and tomato. It is never applied to rice (except in the nursery) nor to cotton (see Table 52 and Figs 18, 19 and 20).

[15] This could be explained by the fact that farmers mix animal manure with the clay which is under the animals in the stables. This clay usually has a high salt content (not cultivated) which in turn makes the manure also saline.

Table 52. Fertilization practices by crop in Khalid Ibn El-Waleed village, North Delta.

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	83	26.4	16–31	−15%	17	27	27	–	100	36.3	21–56	+25%	0	–	–	–
Faba bean	100	27.0	23–31	−19%	0	–	–	–	75	35.2	33–40	−15%	0	–	–	–
Wheat	89	20.2	2–31	−13%	17	20	27–50	+28%	94	39.0	17–86	−11%	0	–	–	–
Barley	100	21.6	10–39	−20%	0	–	–	–	100	21.1	17–25	−16%	0	–	–	–
Rice	43	20.7	8–39	+59%	0	–	–	–	100	47.0	23–90	+9%	0	–	–	–
Maize	75	20.7	16–23	−20%	25	27	27	+100%	100	40.3	31–64	−8%	0	–	–	–
Cotton	89	25.2	16–31	−5%	0	–	–	–	100	58.0	33–86	−2%	0	–	–	–
Potato	100	54.3	31–78	–	100	12	10–13	–	100	330.0	330	–	0	–	–	–
Sugar beet	88	23.6	10–31	−17%	0	–	–	–	100	63.0	33–129	+16%	0	–	–	–
Water-melon seed	100	27.0	23–31	−12%	0	–	–	–	100	41.2	33–50	−18%	0	–	–	–

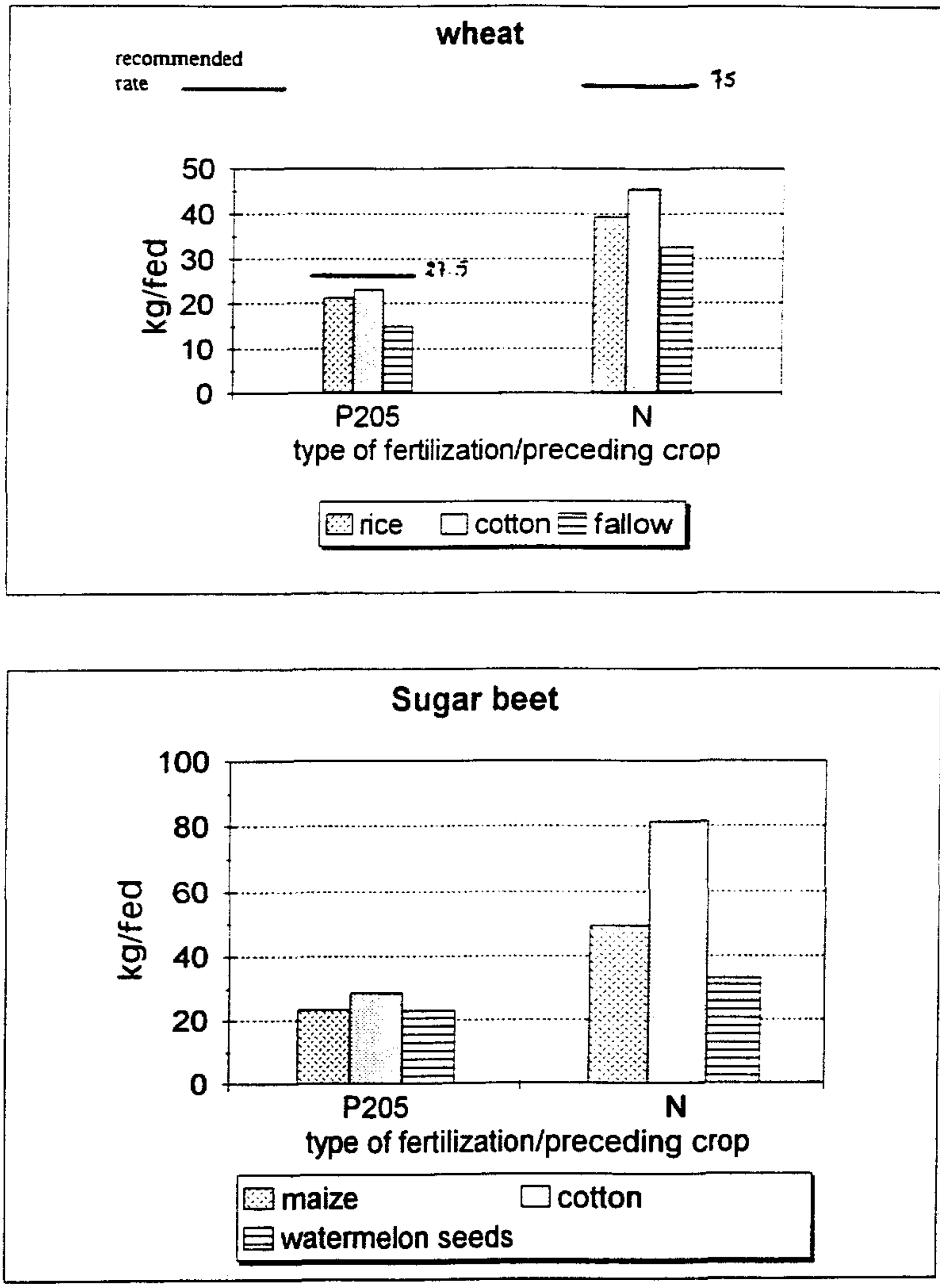


Fig. 18. Fertilization packages by crop for winter crops (according to the preceding crop) in Khalid Ibn El-Waleed village, North Delta area.

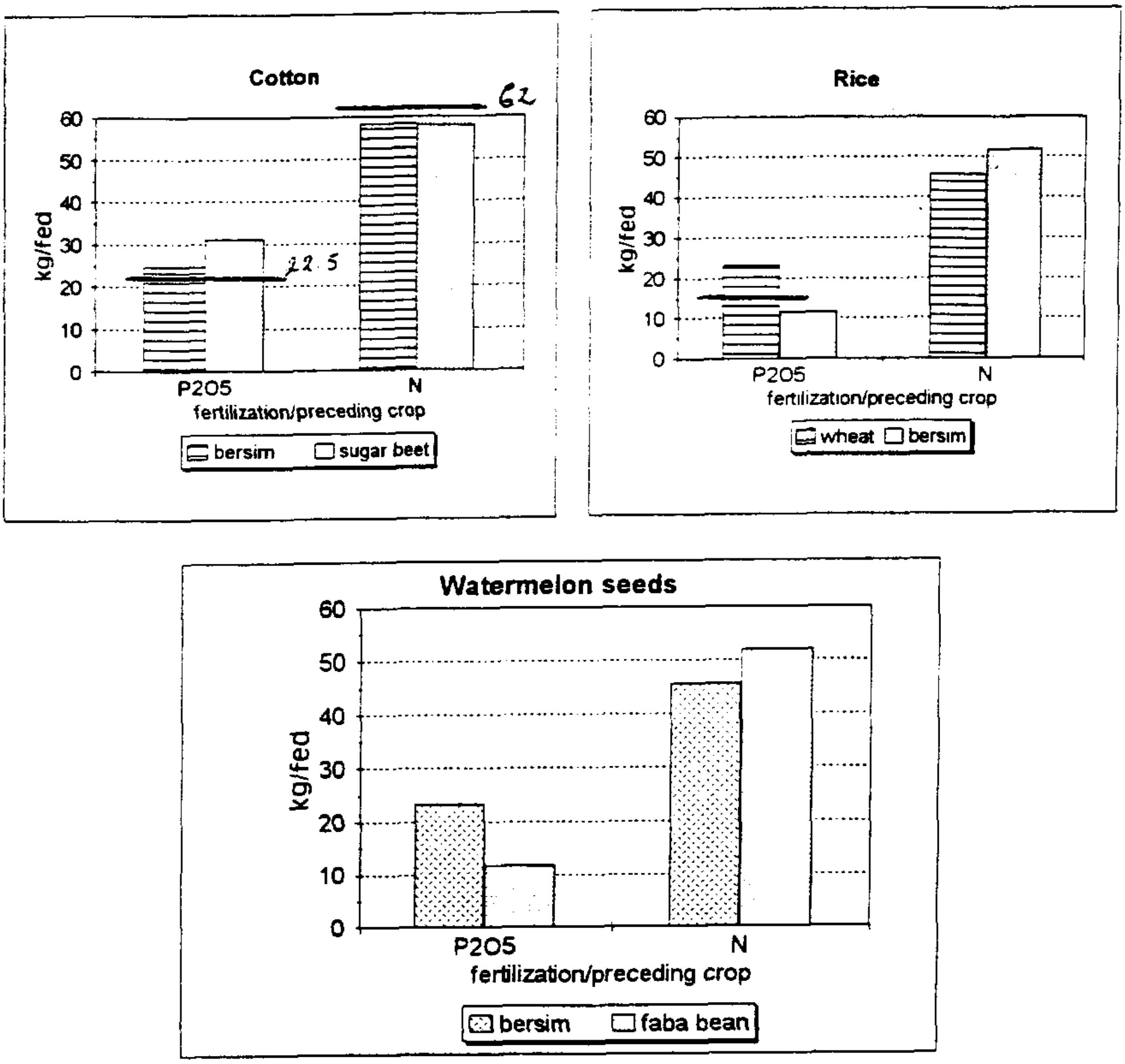
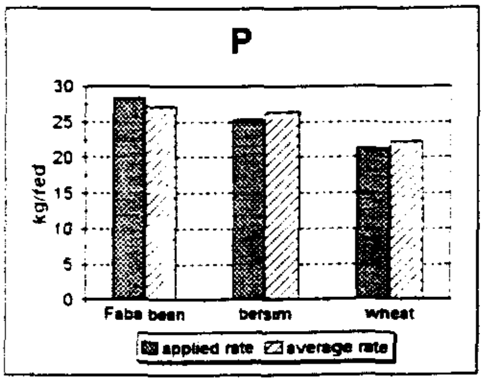
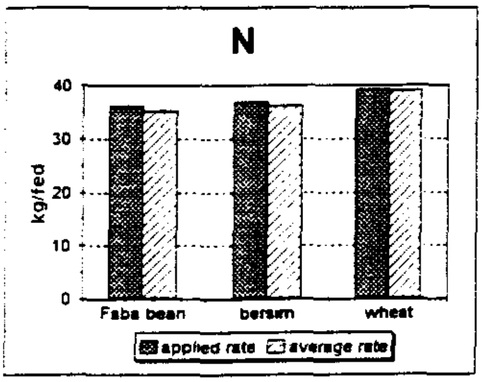


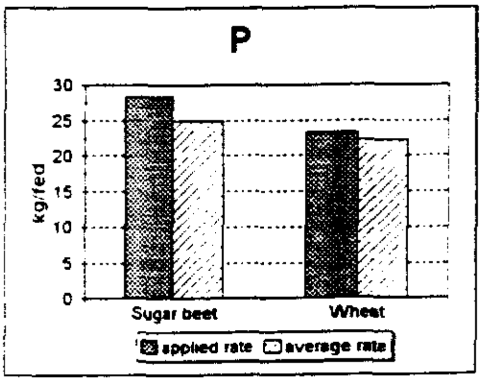
Fig. 19. Fertilization packages by crop for summer crops (according to the preceding crop) in Khalid Ibn El-Waleed village, North Delta area.

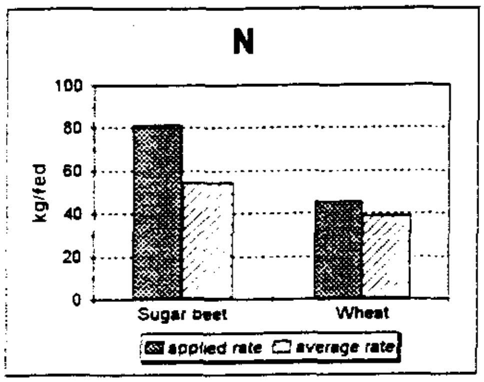
A- After RICE:



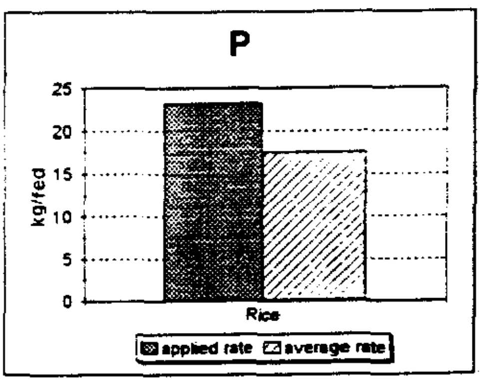


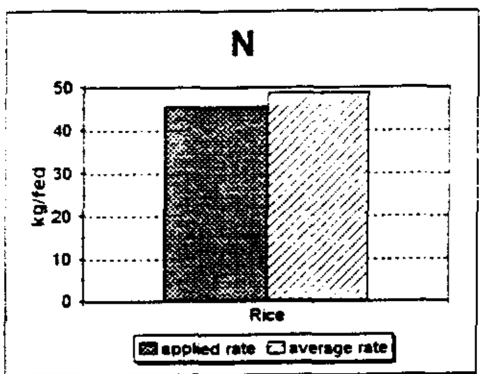
B- After COTTON



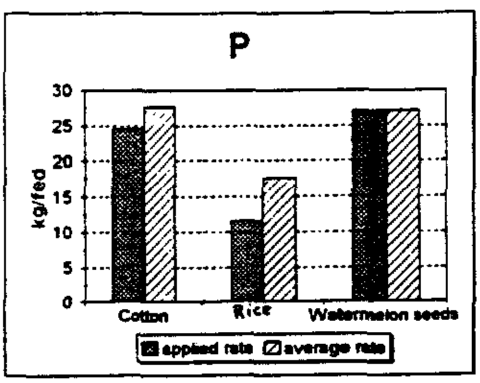


D- After WHEAT





E- After BERSIM



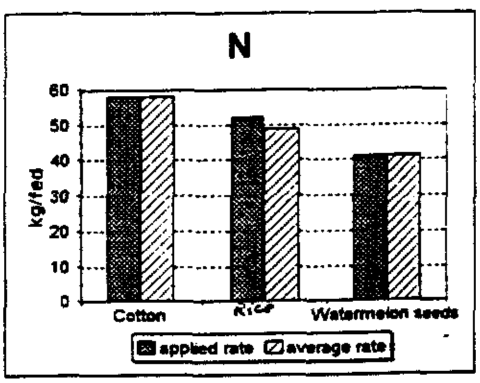


Fig. 20. Effect of the preceding crop on fertilization rates in Khalid Ibn El-Waleed village, North Delta area.

Use of fertilizers

Table 53 presents a qualitative description of the use of fertilizer by the surveyed sample of farmers. The results indicate that half of the farmers are still applying the same rate of fertilizers as they did five years ago, while the other half have increased their application rates. In response to the increase in the prices, 36% of the farmers will continue applying the same rates of fertilizer they are adding now, while 36% will reduce the rates applied to wheat. Also, 24% of the sampled farmers will follow a crop rotation with more legume crops (especially berseem) in it. The minority (12%) will reduce the area of wheat.

Also, the results indicated that the majority of beneficiaries add less fertilizer than they used to apply in the Old Lands.

Table 53. Use of fertilizer in Khalid Ibn El-Waleed village.

Criterion	Beneficiaries	Graduates	Total
% of users	100	100	100
Trend in fertilizer use during the past 5 years			
up	40%	45%	42%
equal	47%	55%	50%
down	13%	0%	8%
Farmers' reaction to price increase (% farmers):†			
1. Reduce the rate of application	40%	30%	36%
2. Follow another crop rotation	20%	30%	24%
3. Reduce the area cultivated with certain crops	7%	20%	12%
4. Continue with the present rates	40%	30%	36%
Fertilizer use compared to the Old Lands (beneficiaries only)			
more	34%	NA	NA
equal	8%	NA	NA
less	58%	NA	NA

† More than one choice was possible.

Use of fertilizers detailed by crops

The detailed fertilizer use for each crop is presented in Table 52 and Figs 18, 19 and 20.

Percentage of farmers using fertilizers/crop:

Phosphorus

Only rice is not given P by the majority of farmers, while for all other crops, P fertilization is the common rule.

Nitrogen

All farmers use nitrogen fertilizer on almost all crops. For faba bean only, a minority of farmers seem to be taking into account the N-fixing ability of legumes.

Potassium

Potassium is not applied at all in Khalid Ibn El-Waleed area.

Rate applied/crop:

Phosphorus

The highest rates are applied to vegetables and legume crops. Cereals are markedly less fertilized with P than other crops.

Rates have been increased only for rice and decreased for all other crops during the last 5 years.

Finally, from Table 54 and Figs 18 and 19, we can see that P rates applied to legumes are slightly over the recommendations whereas they are below the recommended rates in the case of cereals (except rice).

Table 54. Comparison between the recommended and actual fertilizer rates used by farmers in Khalid Ibn El-Waleed village.

Crop	P_2O_5			N		
	Actual rate	Recommended	% variation	Actual	Recommended	% variation
Berseem	26.4	22.5	+17	36.3	15	+142
Faba bean	27.1	22.5	+20	35.3	15	+135
Wheat	20.2	27.5	−27	39.0	75	−48
Barley	21.6	30	−28	21.1	45	−53
Rice	20.7	15	+33	47	40–60	−6
Maize	20.7	30	−31	40.3	112.5	−64
Cotton	25.2	22.5	+12	58.0	62	−7

Nitrogen

If we exclude potato that is always fertilized with huge rates of N, we can see from Table 52 that summer crops are, on average, more fertilized with N than winter crops (47 kg N/fed against 39 kg N/fed, respectively). Only sugar beet receives more than any summer crops. Actually, farmers usually favor cash crops and most of these crops are grown in summer.

The rates applied are much over the recommended rates for winter legume crops (+142% for faba bean, + 135% for berseem) and well below the recommendations for cereal crops. These gaps are more pronounced than for P fertilization.

Regarding the rate increase in 5 years, if we consider the increases under ±5% as equal to nil, then the rates were increased for 3 crops out of 9 and decreased for 5 crops. Once again, it is surprising that the highest increase occurred for a legume crop, berseem.

Effect of the preceding crop:

For all the crops for which we have at least three different succeeding crops with specific fertilization packages recorded, we compared the rates applied to these crops to what the average rate would be[16]. The results are shown in Fig 20.

Phosphorus

Farmers clearly reduce P rate after berseem (logical since berseem receives one of the highest P doses). On the other hand, it is always higher after cotton although cotton also gets a fair amount of P (25 kg/fed).

Nitrogen

No effect of wheat and rice as preceding crops is visible on fertilization of the following crop. By opposition, N is always increased after cotton and less markedly after berseem. The farmers do not seem to take into account that a legume crop like berseem is supposed to enrich the soil with nitrogen. This is certainly a priority issue to be studied through closer monitoring and possibly in some of the trials.

Use of fertilizers according to farmers' origin (see Table 55)

Phosphorus

No clear-cut difference appears in the rates applied by each class of farmers, except for cotton where graduates tend to fertilize more than beneficiaries with P.

On the whole, over the past 5 years, beneficiaries decreased or maintained their P application and only graduates increased it for wheat.

Nitrogen

Beneficiaries apply more N for wheat and sugar beet than graduates and have also increased N fertilization for sugar beet over the past 5 years. Apart from this, no significant difference appears between the two groups.

Correlation to yield

Although we should consider the data in Table 56 with care (due to doubts on yield data reliability), it seems that:

- Berseem responds well to nitrogen fertilization but not to phosphorus.
- Wheat responds well to P and N.
- Maize shows good correlation to P and less clearly to N.
- Rice seems to respond only to N.
- Cotton does not show any clear results.
- Sugar beet seems to respond well to N.

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[16] Average rate here means the average of the rates of fertilizers applied to a certain crop for different preceding crops. It differs from the rates presented in Table 52 that are average rates calculated from the whole sample in which the various preceding crops are not represented equally.

Table 55. Fertilization according to farmers' origin in Khalid Ibn El-Waleed village, North Delta.

Crop	P_2O_5						Manure						Total N						K_2O					
	% farmers applying		Rate (kg/fed)		Trend over 5 years (%)		% farmers applying		Rate (m^3/fed)		Trend over 5 years (%)		% farmers applying		Rate (kg/fed)		Trend over 5 years (%)		% farmers applying		Rate (kg/fed)		Trend over 5 years (%)	
	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G
Cotton	100	67	24.5	27.1	–3	0	0	0	0	0	–	–	100	100	58	57	–1	0	16	0	15	–	–	–
Wheat	91	86	20.9	19.0	–9	+25	18	0	30	–	0	–	100	100	41	35	–1	0	9	0	24	–	–	–
Rice	50	33	19.3	18.6	0	?	0	0	0	–	–	–	100	100	45	49	–7	0	0	0	0	0	–	–
Sugar beet	100	80	23.2	23.9	–8	–7	0	0	0	0	–	–	100	100	82	52	+10	0	0	0	0	0	–	–

B = Beneficiaries; G = Graduates.

Table 56. Coefficients of correlation between P, N and K application and crop yields (Khalid Ibn El-Waleed village).

		Berseem	Wheat	Maize	Rice	Cotton	Sugar beet
P	Graduates†	?	0.94	?	−0.27	0.80	−0.32
	All	−0.52	0.52	0.88	−0.28	0.23	0.26
N	Graduates	?	0.62	?	0.82	−0.69	0.72
	All	0.61	0.55	0.41	0.45	0.13	0.62

† The correlations were run on the whole sample and on the graduates only. This is because we suspect that beneficiaries usually understate their yields when questioned by outsiders. This attitude is assumed to be less prevailing among educated graduates.

Improving crops

Table 57 presents the farmers' opinions on the field crops which have a positive effect on the succeeding crops.

Table 57. Improving crops.

Crop	Beneficiaries (%)	Graduates (%)	Total (%)
Non-legume crops			
Rice	7	20	12
Cotton	0	10	4
Legume crops			
Berseem	100	100	100
Faba bean	60	80	68

The results indicate that farmers are aware of the role of legume crops in improving soil quality. However, since N fertilization is not reduced after legume crops, this improving effect could refer more to the leaching factor, to the weed reduction after berseem, to the abundant crop residues left by legume crops, and to the improving effect on soil structure (deep rooting).

For the non-legume crops, the graduates tend to choose both rice and cotton crops as soil improving crops since rice helps in decreasing soil salinity by leaching and cotton will enhance soil texture because it needs many cultural practices.

Trend in legume cultivation

Seventy-two percent of the farmers said they increased (and will continue to) the importance of legume crops in their rotations.

If we use the cropping pattern data and add up all legume crops, we obtain the results in Table 58.

Table 58. Trend in legume cultivation.

Category	Average farm share (%)				Total area share (%)			
	1991	1992	1993	1994	1991	1992	1993	1994
Beneficiaries	55	30	45	44	58	27	49	45
Graduates	39	41	37	45	27	49	45	45
Whole sample	46	34	45	42	47	32	48	44

From these data, we can only say that, over the last 4 years, there is no obvious trend towards an increase of the place of legumes in the rotation. If 72% of the farmers say they have increased the importance of legumes, they in fact refer to the drop in 1992 which was followed by a an increase back to the level of before 1992 (this drop was due to a large reduction in berseem cultivation in favor of wheat during that winter).

From the crop sequences recorded on each farmer's field, we statistically calculated the average time lapse (seeding date to seeding date) between two legume crops on the same field. The results are as follows:

Beneficiaries: 2 years and 2 months.

Graduates: 1 year and 10 months.

Whole sample: 2 years.

Crop residues

Crops were classified in three groups according to the effect on fertility maintenance of the type of crop residue management practiced by the farmers. These groups are:

- Total export (no nutrients added to the soil), which means that all the residues are removed from the field, then burnt or sold or used in any way which prevents return of nutrients to the field.
- Partial restitution, which means that the residues are given to animals whose manure will be applied on the field later on.
- Complete restitution, which means that residues are left to decompose or plowed directly in the soil.

The survey results are presented in Table 59.

Table 59. Crop residue treatment in Khalid Ibn El-Waleed village.

Total export	Partial restitution	Complete restitution
Maize	Maize (AF,M)	Berseem (P)
Cotton	Rice (AF)	Sugar beet (P)
	Water melon seed (AF)	Wheat (P)
	Faba bean (AF)	Barley (P)
	Wheat (AF)	
	Barley (AF)	

AF = Animal feed; M = Mix with manure; P = Plowed in soil.

The results show that most of the crop residues contribute indirectly or directly to fertility maintenance.

Soil Improvement Work

Table 60 presents the soil improvement work that was carried out by the farmers.

Table 60. Soil improvement methods practiced in Khalid Ibn El-Waleed village.

Method	Beneficiaries	Graduates	Total
Subsoiling	60%	82%	69%
Gypsum (3 t/fed)	13%	27%	19%
Leveling	0%	9%	4%
% of farmers who carried out at least one type of soil improvement	67%	91%	77%

The majority of farmers carried out at least one type of soil improvement, in addition to what was carried out by the Land Improvement Authority before delivering the land to the farmers (this can date back to 20 years in some cases). Subsoiling (down to 45 cm) has the best effect on improving soil permeability and water movement which enhances the leaching process and decreases soil salinity.

Water Management and Soil Degradation

Water Supply

The responses of the farmers, representing the head, middle and end of canal situations, to questions concerning water availability during winter and summer seasons are presented in Table 61.

In winter

There are no changes in water rotation except for farmers at the end of the canal who are one day short of the on-days. Irrigation water is available 4 out of 5 days for 24 hrs/day for the farmers at the head and middle of the canal, while at the end of the canal, farmers have water for 2 days out of 5 and for 13 hrs/day. Also, the results indicated that the majority of farmers at the head and middle of the canal have adequate amounts of irrigation water in winter, but half of the farmers at the end of the canal do not have adequate amounts. All farmers do not irrigate from the drain in winter.

In summer

There have been no changes in water rotation during the last five years. The only change was observed for farmers at the tail end. Concerning water availability, both farmers at the head and middle have water 3 out of 5 days for 24 hrs/day. Water shortage is also experienced more acutely in summer by farmers at the tail end. During summer about 14% of the farmers at the head and end of the canal use drain water for irrigation. More farmers would use drain water if it was easily accessible. Indeed, in many cases, main drain embankments are too high for farmers to be able to pump water from them with a regular pump.

All farmers indicated that soil salinity had decreased since they started cultivating their lands. When they were asked about the method they use to reduce salinity level in their fields we got the answers in Table 62.

Table 61. Water availability during winter and summer seasons (Khalid Ibn El-Waleed village).

Position	Winter								Summer							
	Water rotation				Water availability				Water rotation				Water availability			
	5 years ago		Now		No. days (during on-days)	No. hours	Water adequacy	Irrigation from drain	5 years ago		Now		No. days	No. hours	Adequacy	Irrigation from drain
	On	Off	On	Off					On	Off	On	Off				
Head	5	6	5	6	4	24	Y = 67% N = 33%	no	5	5	5	5	3	24	Y = 50% N = 50%	14%
Middle	5	6	5	6	4	24	Y = 100%	no	5	5	5	5	3	24	Y = 36% N = 64%	0%
End	5	6	4	6	2	18	Y = 50% N = 50%	no	4	6	4	5	1	13	Y = 12% N = 88%	13%

Salinity Control and Water Quality

Table 62. Farmer's methods for salinity control.

Position	Leaching	Continuous cultivation	Irrigation	Efficient drainage system	Cropping pattern	Plowing
Head	83%	67%	33%	33%	33%	–
Middle	60%	60%	50%	30%	10%	10%
End	83%	83%	–	50%	17%	–

The majority of the farmers indicated that leaching the soil and continuing cultivation will help in reducing soil salinity (in fact both can be assimilated since rotations comprise a large share of rice and berseem, the two main leached crops). Also, they mentioned that an efficient drainage system (tile drainage) and following certain cropping pattern (crops more tolerant to salinity) will help in reducing soil salinity.

All farmers indicated that salinity is an important factor in crop choice for cultivation. They also mentioned that the poor quality of irrigation water is the main reason for soil salinity. Farmers' opinions on the change in water quality since they first came to their farms are given in Table 63.

Table 63. Change in water quality in Khalid Ibn El-Waleed village.

Position	Water quality		
	Improved	Worsened	The same
Head	20%	60%	20%
Middle	–	67%	33%
End	–	100%	–

The results indicated that only 20% of the farmers at the head of the canal had noticed some improvement in water quality.

Irrigation Practices

The data in Table 64 present the number of irrigations given to each crop and number of hours per irrigation as indicated by the surveyed sample of farmers. Also, the total applied water and the recommended amount of irrigation are presented[17].

Table 64. Irrigation practices in Khalid Ibn El-Waleed village.

Crop	No. of irrigations	No. of hrs/ irrigation	Amount of applied water (m^3)	Recommended amount of water requirements (m^3)	Excess amount (m^3)	% excess water
Berseem	11	3.0	7590	3333	4257	+128
Barley	5	3.0	3450	1942	1508	+78
Wheat	5	3.0	3450	2450	1000	+41
Faba bean	3	2.5	1725	2030	−305	−15
Sugar beet	5	3.0	3450	3112	338	+11
Cotton	8	3.5	6440	3570	2870	+80
Maize	7	3.0	4830	4050	780	+19
Rice	11					
Watermelon seed	5	2.0	2300	–		

The results showed that farmers over-irrigate all crops (except faba bean), especially the major winter (berseem and wheat) and summer (cotton) crops. To some extent, this additional water could be the reason for decreasing soil salinity as indicated previously by all farmers.

[17] Applied water amount is based on a 230m3/hour discharge of the locally utilized pumps. Required water amounts are based on ET values for the North Delta and for an irrigation efficiency of 60%.