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PHASE II

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Volume 1

INVENTORY STUDIES

Old Irrigated Lands of Egypt
Agronomy

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Volume 1

Resource Management in the Old Irrigated Lands of Egypt: Agronomy

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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

AMV = Alfalfa Mosaic Virus
ARC = Agricultural Research Center
BBWV = Broad Bean Wilt Virus
BLRV = Bean Leaf Roll Virus
BRDP = Beheira Rural Development Project
BYDV = Barley Yellow Dwarf Virus
CLFF = Central Lab for Food and Feed
CMV = Cucumber Mosaic Virus
DP = Digestible Protein
EC = European Commission
EMV = Early Maturing Varieties
FBNYV = Faba Bean Necrotic Yellow Virus
FCRI = Field Crops Research Institute
FLRP = Food Legumes Research Program
GY = Grain Yield
ICARDA = International Center for Agricultural Research in the Dry Areas
IPM = Integrated Pest Management
MALR = Ministry of Agriculture and Land Reclamation
NRC = National Research Center
NVRP = Nile Valley Regional Program
PM = Powdery Mildew
SDV = Short Duration Varieties
SWERI = Soil, Water and Environment Research Institute
TDN = Total Digestible Nutrition
WUE = Water-use Efficiency

Executive Summary

Egypt is located between 21° 55' and 32° N latitude, and between 24° and 37° E longitude. The total area of the country is 1,001,450 km^2. The Old Lands (Nile Valley and Delta) comprise 35,000 km^2, equivalent to only 3.5 percent of the total area of Egypt. The Nile Valley (Middle and Upper Egypt) is about 12,000 km^2 and the Nile Delta (Lower Egypt) area is about 23,000 km^2.

The climate in the North Delta is typically Mediterranean, with dry mild summers and fair cool wet winters. Due to the proximity to the Mediterranean and the northern lakes, as well as to prevailing northeasterly winds, the summer heat, so typical of the rest of Egypt, is temperate and the summer is most agreeable. In the rest of the Delta, the climate resembles that of the great desert area of northeastern Africa, with minimal rainfall, occurring mostly as occasional thunderstorms. In Cairo, 10 or 12 rainy days a year is probably the average, decreasing rapidly to the south. The influence of the sea may extend southwards as far as the apex of the Delta, but the air is warmer in summer after its passage over the heated Delta, and colder when the south wind blows in winter.

The average maximum temperature of the Delta is about 34°C (in July or August), while the minimum is about 6.4°C (in December and January), and the mean annual temperature is around 20°C. All the Nile Delta soils are thus in the thermic temperature regime. Relative humidity is rather low in summer and high in winter: 65 percent in May and 82 percent in January.

Evaporation is relatively high, especially during the summer, and reaches about 8 mm/day in June and 2 mm/day in December. The annual mean evaporation is about 5 mm/day or about 1.825 meters/year.

The climate of Upper Egypt is generally like that of the great desert area of northeast Africa; rainfall is extremely low, occurring as occasional thunderstorms. The rainfall in Cairo is about 24 mm/year, falling mostly in winter from November through March. From Cairo to Aswan the rainfall decreases, with a mean annual rainfall between 1 and 7 mm/year making this zone virtually rainless.

Summers are very hot (but cool at night) and winter is mild and windy. The mean maximum and minimum summer temperatures are 36.6° and 19.6°C, respectively, while the mean maximum and minimum winter temperatures are 23° and 7.5°C, respectively. The mean annual temperature in Upper Egypt is more than 22°C, which places the soils in the hyperthermic temperature regime. Relative humidity is low (ranging from 39 to 70 percent). Evaporation exceeds 2 m annually and dust storms are frequent.

The world population is increasing at a rate far exceeding any other period in history. Therefore, increasing crop production is a worldwide necessity, particularly in developing countries such as Egypt, where people are gradually losing the ability to feed themselves. The population of Egypt has increased from 37 million in 1975 to 45 million in 1982 to about 58 million in 1993. By the year 2000, if the population growth rate stays the same, it is estimated that 70 million people will be living on the Old Lands, with a population density of over 1,000 persons/1 km^2.

Introduction

Cool-season food legumes (faba bean, lentil, and chickpea) are among those important crops that have the potential to cover Egypt's increasing demand for food. These crops are generally included in the crop rotation and have succeeded in keeping the Egyptian soil fertile and productive, as they fix atmospheric nitrogen. The area cropped to food legumes ranges from 150,000 to 168,000 ha annually, of which faba bean occupies about 80 percent. Faba bean acreage has increased from 115,080 ha in 1982 to 160,440 ha in 1992 (Table 1). During the same period, the average seed yield per ha (productivity) gradually increased from 2,254 kg in 1982 to 2,944 kg in 1990, then declined to 2,305 kg in 1991 and 1,313 kg in 1992. This decline in average yield and total production during 1991 and 1992 resulted in reduction in self-sufficiency from 100 percent in 1990 to 75 percent in 1991 and only 60 percent in 1992. The deficit was made up through importation. Yield losses were mainly due to a viral disease epidemic that occurred in Middle Egypt, which is considered the main faba bean production area, affecting faba bean acreage in 1991 and 1992.

Although average lentil seed yield has increased by 52 percent and total production by 80 percent during the past decade, Egypt is still dependent on imports because of limited acreage (6,300 ha annually) (Table 2).

Table 1. Faba bean area and average seed yield (1982–1993).

Year	Area (1000 ha)	Seed yield (t/ha)
1982	115	2.25
1983	122	2.40
1984	114	2.40
1985	120	2.53
1986	113	2.48
1987	120	2.69
1988	152	2.38
1989	138	2.94
1990	127	2.94
1991	123	2.36
1992	160	1.61
1993	97	2.61

Source: Ministry of Agriculture, Central Administration for Agricultural Economics.

Table 2. Lentil area and average seed yield in Egypt, 1982–1992.

Year	Area (1000 ha)	Seed yield (t/ha)
1982	5.1	1.13
1983	6.3	1.18
1984	7.5	1.41
1985	8.4	1.60
1986	8.4	1.60
1987	10.1	1.79
1988	8.0	1.87
1989	7.1	1.87
1990	6.7	1.98
1991	6.7	1.79
1992	6.3	1.71

Source: Ministry of Agriculture, Central Administration for Agricultural Economics.

Fluctuations in chickpea area (5,500–6,300 ha) and production (11–12 million tons) are relatively small. Egypt is considered self-sufficient in the crop.

Wheat and barley production could be increased using irrigation where favorable climatic and soil conditions exist. Rainfed barley is grown on a large area (63,000–105,000 ha) along the Northwest Coast and North Sinai. This area is potentially a very important barley area. Where yields are quite low there is room for additional improvement. An increase of about 15–20 percent can be expected to result from use of improved germplasm alone, and there is room for greater increases through the application of improved packages of cultural practices.

Wheat is the main staple food in urban, suburban, and rural areas in Egypt. Blended with maize flour, it is used widely in rural areas for breadmaking. Wheat straw is a source of fodder for animals, for which reason the price of straw sometimes exceeds that of grain. Intensive efforts are being made to increase local production. One of the most important goals in the wheat program is to increase wheat production to narrow the gap between production and local consumption. National wheat consumption in 1984 reached about 8 million tons (80 percent imported) and is projected to reach 12.5 million tons by the year 2000. This reflects the size of the problem and the need for every effort to be made to increase national production on the limited wheat area in Egypt.

According to the official information from the Egyptian Ministry of Agriculture, the total area cultivated with wheat in 1992/93 in the Old Lands was about 761,950 ha, and 65,895 ha in the New Lands. Average grain yield was 5.8 and 4.15 t/ha, respectively (Table 3).

Table 3. Wheat area and yield (1980–1993)

Year	Nile Valley		Beyond the Nile Valley	
	Area (ha)	Grain yield (kg/ha)	Area (ha)	Grain yield (kg/ha)
1980	557,218	3,224		
1981	587,853	3,295		
1982	577,148	3,495		
1983	554,640	3,598		
1984	495,114	3,666		
1985	498,287	3,759		
1986	506,868	3,806		
1987	576,894	4,719		
1988	597,360	4,752		
1989	642,798	4,951		
1990	702,873	5,480	69,667	2,135
1991	822,783	5,087	107,919	2,742
1992	751,462	5,662	127,384	2,859
1993	762,254	5,962	132,078	2,285

Source: Ministry of Agriculture, Central Administration for Agricultural Economics.

Increasing wheat production at the national level can be achieved through vertical and horizontal expansion. Cultivating saline soils (about 30 percent of the total area) could effectively increase the limited area grown to wheat. Maximizing the yield per unit area is of great importance as well. Therefore, applying improved cultural practices to tolerant cultivars is being seriously investigated.

The area under wheat production in Upper Egypt and the New Valley is about 143,000 ha, which represents about 17 percent of the total wheat growing area under irrigation. Constraints to wheat production in Upper Egypt are: high temperatures during grain filling, aphid infestation and disease, planting old poor local varieties, late planting, little access to advanced production technology, and inadequate irrigation. Therefore, grain yield in Upper Egypt is one of the lowest in the country.

Fayoum is one of the most important wheat producing governorates in Middle Egypt (Ghanem *et al.* 1993). Wheat is grown on an area of about 21,370 ha (36 percent of the total wheat area in the region). Though grown in a number of different environments, suffering problems of salinity, poor drainage, multiple soil types, etc., it gives an average production comparable to that of Beni Sueif and Minya, the major wheat producing governorates of Middle Egypt. Demonstration fields during the last four years found a high grain yield potential, about 28 percent, by using the recommended cultivars Sakha 69 and Giza 164 as well as applying the appropriate cultural practices. The drilling method of sowing added about 0.35–0.38 t/ha. Both dry and wet methods are equally common on farmers' fields. Although the dry method yields more, the wet method of sowing may ensure better results when application is under control.

Barley (*Hordeum vulgare* L.) is the main crop grown on a large scale in the north coast of Egypt. It long ago adapted to adverse local conditions. It is considered one of the most suitable crops for a wide range of soil types and adverse conditions such as heat stress, drought stress, low soil fertility, salinity, etc.

In the Old Lands, barley is mostly used for livestock feed and the malting industry, which consumes about 20,000 tons annually. The barley area in the Valley is small (Table 4), especially where the soil is suitable for other strategic crops such as wheat. The main barley producing areas are in the rainfed coastal region and New Lands with some irrigation facilities and/or with enough precipitation to grow barley.

Table 4. Barley area and yield (1980–1993).

Year	In Nile Valley		Rainfed areas	
	Area (ha)	Grain yield (kg/ha)	Area (ha)	Grain yield (kg/ha)
1980	40,138	2,665		
1981	38,325	2,696		
1982	45,516	2,653		
1983	50,836	2,590		
1984	53,092	2,722		
1985	52,353	2,776		
1986	54,668	2,804		
1987	47,163	2,884		
1988	37,270	2,936		
1989	49,679	3,576		
1990	53,437	3,050	17,000	1,000
1991	46,689	3,116	34,000	500
1992	41,000	2,460	63,000	1,250
1993	48,400	2,860	18,600	880

Source: Ministry of Agriculture, Central Administration for Agricultural Economics.

The objectives of the barley program in the Old Lands are: i) to maintain barley productivity and stability of production in marginal areas; ii) to develop cultural practices that can improve water-use efficiency and consequently increase barley production; iii) to develop the best management methods for other biotic and abiotic stresses, especially nutrient deficiency, drought, salinity, disease and insects; and iv) to transfer the new technology to the extensionists and farmers in order to build research extension linkages.

Egypt has a large livestock population that plays a major role in the farming system. The livestock holding is almost 2.4 animals per ha. According to the census carried out by the Ministry of Agriculture and Land Reclamation in 1982, the total number of cattle and buffalo was 5.28 million head, while there are about 6.0 million sheep and goats (Table 5). A survey conducted by MALR in 1988 shows that there has been some change in the buffalo and cattle numbers, with the buffalo population increasing by 20 percent, and cattle population decreasing by 7 percent.

Table 5. Livestock population (MALR census 1982 and 1988).

Kind	Number	
	1982	1988
Cattle	2,906,207	2,694,279
Buffalo	2,378,561	2,856,479
Sheep	3,370,672	
Goat	2,747,558	
Camel	134,514	
Horse and Donkey	2,345,549	
Pig	53,390	

Agriculture in the Nile Valley and Delta is completely dependent on irrigation from the Nile River. Water is available year-round and continuous cropping is the common practice. The agricultural year starts with sowing of the winter crops and ends with the harvest of the summer crops. Winter crops, including wheat, barley, Egyptian clover (berseem), food legumes (faba bean, lentil, and chickpea), winter onion, flax, and winter vegetables, are sown starting in October and continuing through November and December. Harvesting usually begins in April and continues through May and June.

Summer crops, including cotton, cereals (maize, rice, and sorghum), sugarcane, onion, oil crops (peanut, sesame, sunflower, and soybean), and summer vegetables, are usually sown from March to June and harvested from August to November.

The dominant rotation is a three-year cotton rotation in which the area is divided into three blocks. The first block is planted in winter to a temporary cash crop such as clover, from which one or two cuttings are taken. This is followed by cotton in March as the summer crop. The second block is planted in winter to berseem and/or food legumes. The third block is planted to wheat and/or barley. Both the second and third blocks are followed by rice, maize, sorghum, and/or oil crops (peanut, sesame, sunflower, and soybean) as summer crops, depending on the locality. This sequence is rotated among the three blocks during the second and third year.

Another dominant rotation is a two-year cotton rotation in which the area is divided into two blocks. The first block is planted in winter to temporary berseem followed by cotton as the summer crop. The second block is split into two parts, one for berseem or other winter legumes, and the other for wheat or barley; both are followed by rice, maize, sorghum, and/or oil crops as summer crops. This sequence is rotated in the two blocks in the second year.

This inventory study includes four sections: i) cool-season food legumes production; ii) cereal production; iii) animal production and animal feed sources; and iv) cropping patterns and crop rotations. The principal objective of the study was to review results from national research programs on cropping systems and rotations, tillage systems, productivity (farmer and researcher data), livestock number and kind, animal feed sources, and animal product yield. The study also explains the common problems facing crop and animal production in Egypt. It outlines management practices to control or minimize the constraints that limit the production of both crops and animals which are so important to human nutrition and to the agricultural systems of Egypt.

Cool-Season Food Legume Production

Cultural Practices

Tillage systems and sowing methods

Cotton, maize, and rice are the country's major summer crops. They are harvested in October–November. There is usually a limited time to get land prepared for the winter crops. One solution to this problem is to use zero or minimum tillage. Therefore, intensive work has been carried out on faba bean (NVRP 1979–1988) and on faba bean, lentil, and chickpea in governorates representing the Nile Delta and the Nile Valley (NVRP 1989–1992).

Faba bean

The effect of tillage (conventional vs. no-tillage) on faba bean following different summer crops has been the subject of several studies. The overall effect of land preparation (plowing and ridging) on seed and straw yield was negligible after cotton or corn in Minya (Middle Egypt). However, in Kafr El Sheikh (North Delta) after rice, soil tilling slightly improved seed and straw yield/ha (Nassib *et al.* 1983). Similar results were obtained by Hussein *et al.* (1991b) in Minya. Moreover, results of a series of researcher-managed trials conducted in Minya and Kafr El Sheikh (1985-88) show that zero tillage produces slightly higher seed yield compared to other tillage systems (chisel/chisel or moldboard/chisel plowing). In addition, total N and P uptake is higher with untilled soil. Weeding, either twice by hand (40 and 70 days after sowing) or by using Igran (post-sowing) combined with an application of 36 kg N and 72 kg P_2O_5/ha under zero tillage, would sustain higher faba bean yields.

Results of another set of on-farm trials in Beheira (northwest Delta) and Minya comparing different land preparation and sowing methods during 1985–1988 show that planting faba bean in hills on the old ridges of the preceding crop (either cotton or corn) results in stand establishment equal to minimum tillage (broadcast/rotovator) and better than full tillage (chiseling twice/broadcast). However, seed yield was better with the no-till hill planting on old ridges. Faba bean genotypes differed in their response to tillage systems after rice or corn. The breeding line 123A/45/76 seemed to be more adapted to untilled soil after rice and corn.

Lentil

In a series of on-farm trials conducted in Kafr El Sheikh and Sharkia governorates under zero tillage after rice, it was found that a pre-sowing irrigation (wet sowing method), a seeding rate of 95 kg/ha, and covering the seed with a rotovator was superior to the traditional method of sowing using a chisel plow for seed covering (Rizk and Hassan 1990). The same seeding rate was optimal for lentil preceded by either cotton or maize with the use of a rotovator and the wet sowing method (Rizk and Hassan 1990).

Soil tillage had no obvious effect on foliar disease incidence, but is expected to affect root and seedling diseases to a great extent. Further study is needed on the effect of soil tillage systems on soil-borne diseases, which have been very damaging to faba bean in recent years, especially in Middle and Upper Egypt.

Chickpea

The improved dry method of sowing, where a pre-sowing irrigation is used, has proved more suitable for chickpea than the traditional dry or wet methods. Planting in hills spaced 10 cm apart on both sides of 60 cm ridges under the improved dry method of sowing outyields the other two methods (Khattab *et al.* 1993).

Sowing date

Faba bean

Damage caused by chocolate spot and rust diseases in the North Delta can increase if the crop is sown early in October, as pathogen spread and development are enhanced by vigorous vegetative growth (Mohamed and El Rafei 1983). Planting faba bean in the Delta during the first half of November was found to be optimal for higher yields and lower rates of infection with foliar diseases (Nassib *et al.* 1983; Amer and El Sorady 1992).

In Middle and Upper Egypt, planting faba bean on 1 November was superior to other dates. On the other hand, planting on 15 October or on 1 December decreased seed yield by 17.6 and 55.3 percent, respectively (Ibrahim *et al.* 1983).

Lentil and chickpea

The optimum sowing period for lentil is the first half of November in Middle Egypt and the second half of November in the Delta. The delayed sowing in the Delta results in a lower rate of downy mildew infection and higher yield (Rizk *et al.* 1993).

The first half of November is also recommended for sowing chickpea both in the Delta and Upper Egypt.

Seeding rate and plant population density

Faba bean

Moisture condensation occurring around faba bean plants in dense stands usually encourages foliar diseases, resulting in lower yields. A seeding rate of 185 kg/ha to achieve a plant population density of 25–27 plants/m^2 is optimum to increase yield and reduce disease incidence (Mohamed and El Rafei 1983; Ibrahim *et al.* 1983; Amer and El Sorady 1992).

Lentil

Plant population studies recommend a seeding rate of 95 kg/ha to achieve a population density of about 300 plants/m^2 for higher seed yield in both the Delta and Middle Egypt (Rizk *et al.* 1990).

Chickpea

A seeding rate of 120 kg/ha is recommended to achieve an optimum plant population (33 plants/m^2) for higher seed yield in both the Delta and Upper Egypt (Khattab *et al.* 1993).

Fertilization

Faba bean

Faba bean responded to N and P in several on-farm trials conducted in different locations in the Delta and Middle Egypt (Ibrahim *et al.* 1983). However, the increase in yield was much higher when both nutrients were added together. A rate of 36 kg N + 72 kg P_2O_5/ha along with *Rhizobium* inoculation is recommended. N fertilizers should be applied early for better growth and yield.

Lentil and chickpea

As with faba bean, 36 kg N + 72 kg P_2O_5/ha along with inoculation with the specific rhizobia is recommended.

Irrigation regimes

Faba bean

Farmers are used to delaying the first post-sowing (life) irrigation until 50–55 days after sowing, therefore they are usually unable to irrigate before the winter canal closure late December. Nassib *et al.* (1983) show that this is detrimental to seed yield. They recommend giving life irrigation 4–5 weeks after sowing, followed by 3–4 irrigations at 30-day intervals. Recent studies (El Sherbeeny *et al.* 1993) show that faba bean yield is greatly affected by irrigation timing and frequency. Three irrigations, one before canal closure (5 weeks after the seeding irrigation) and two thereafter during pod setting and pod filling, are the most economical.

Lentil

Two waterings at the onset of flowering and at mid-pod filling are recommended for higher yield.

Chickpea

Three waterings, 5 weeks after sowing, at the beginning of flowering, and at mid-pod filling are recommended.

Biotic and Abiotic Stresses

Productivity of faba bean (*Vicia faba*), lentil (*Lens culinaris*), and chickpea (*Cicer arietinum*) is constrained by various biotic and abiotic stresses in different farming systems. Yield potential is seldom achieved due to poor seed quality, unsuitable cultivars, and inadequate crop management.

Major biotic stresses include disease, insect pests, and weeds (parasitic and non-parasitic), while major abiotic stresses include extremes of soil moisture, high temperatures during the reproductive stage, and soil fertility imbalances (nutrient deficiency, toxicity, and salinity). The seriousness of these stresses is often associated with particular farming systems characterized by specific agro-climatic conditions.

Farming System Stresses

Given the irrigated farming systems (mostly flood and furrow irrigation) and relatively hot dry environment in Egypt, foliar diseases are usually less important than soil-borne diseases in cool-season food legumes, except in areas of high relative humidity and wetness, such as the North Delta. In this hot environment, aphids, leaf miner (*Liriomyza* spp.), white flies, and seed beetles become important production constraints. Viruses are of major concern because of high aphid activity. Broomrape (*Orobanche* spp.) is also a serious parasitic weed of faba bean, lentil, and to a lesser extent chickpea. The most common species is *O. crenata*, which attacks most cool-season food legumes, but is most serious in faba bean, especially in Middle and Upper Egypt where yield losses of 100 percent are commonly observed in heavily infested areas.

Abiotic stresses are strongly associated with agro-climatic conditions. High temperatures during the reproductive stage, high water table in Middle and Upper Egypt, and salinity in the North Delta are the major production constraints.

Achievements with Stress Management

Foliar diseases in the Delta

Faba bean

Chocolate spot (*Botrytis fabae*) and rust (*Uromyces fabae*) are among the most serious yield-limiting biotic stresses of faba bean in the Delta. Losses can be devastating when a virulent *Botrytis* pathogen and a susceptible host are brought together in an environment that favors disease development (Hanounik and Bisri 1991). Faba bean is grown under irrigation in the Delta with little rainfall, however, yield losses as high as 50 percent have been reported in faba bean due to chocolate spot epiphytotic. Annual yield losses are estimated at 5–20 percent (Mohamed and El Rafei 1983). This is mainly due to the high relative humidity (80–90 percent) and favorable daily temperature (15– 20 C) in the Delta in winter and early spring. In addition, late rains in certain seasons increase relative humidity and wetness, which leads to epiphytotic conditions. With the increase in temperature in spring and high relative humidity, rust also flourishes, causing tremendous losses (Mohamed and El-Rafei 1983). Because of such conditions in 1987/88 and 1990/91, chocolate spot and rust epiphytotics reduced faba bean production in the Delta by 50 percent. Recently, Mohamed *et al.* (1993) evaluated the efficiency of different fungicides in controlling chocolate spot and rust diseases in the North Delta. They conclude that Dithane M45 is still an effective fungicide to control both diseases. They add that Ronilan fungicide can also control both diseases effectively. Amer (1992) came up with similar results, showing that Dithane M45 sprayed three times at three week intervals reduced the rate of infection by 53–58 percent in the North Delta.

Sowing date, as it affects the timing and duration of the vegetative and reproductive stages, greatly affects seed and straw yield. The damage caused by chocolate spot and rust in the North Delta is increased if the crop is sown early in October, when pathogen spread and development is enhanced by vigorous vegetative growth. Planting during the first half of November is recommended in this area for higher yield and lower rate of infection with foliar diseases (Nassib *et al.* 1983; Amer and El Sorady 1992).

Moisture condensation occurring around faba bean plants in heavy stands encourages foliar diseases. An optimum plant stand is thus recommended for low disease incidence and high yield (Mohamed and El Rafei 1983). A plant population density of 25–27 plants/m^2 is optimum (Nassib *et al.* 1983; Amer and El Sorady 1992).

The integrated disease control package demonstrated to farmers since 1990/91 includes resistant cultivars (e.g. Giza 461), an effective fungicide (Dithane M45 sprayed at a rate of 250 g/100 L of water), an appropriate planting date (around mid November), and a reasonable plant stand (25–27 plants/m^2). This was found to increase seed yield by 20–41 percent and more than 50 percent in certain locations (Nassib *et al.* 1991). Currently this practice is being adopted by most farmers in the Delta as a standard practice because of its effectiveness.

Lentil

Downy mildew (*Peronospora* spp.) is now considered the limiting factor for lentil production in north Egypt. Redomil Mz 58 percent was effective in controlling the disease when sprayed at 250 g/100 L water (Mohamed *et al.* 1993). Planting lentil in the Delta during the second half of November at a seeding rate of 95 kg/ha resulted in higher yields and lower rate of downy mildew infection (Rizk *et al.* 1990, 1993).

Chickpea

Chickpea cultivation is concentrated in Upper Egypt, mainly in Assiut Governorate (75 percent of the total area), with only 25 percent in the Delta. However, foliar diseases (Botrytis gray mold, rust, and to a much lesser extent, ascochyta blight) are constraints to high production in the Delta in certain seasons. Seedling and root-rot diseases are important because of the damage they cause, particularly in Middle and Upper Egypt (Mohamed and El Rafei 1983). Recent studies (Omar *et al.* 1992; El Gantiry *et al.* 1993) show that chickpea seed treated with Quinolate, Topsin M, Rhizolex T, or Vitavax/Captan fungicides at a rate of 3 g/L kg seed or Benlate fungicide at a rate of 2 g/1 kg seed receives sufficient protection against pre- and post-emergence damping-off, root-rot and *Sclerotinia* stem-rot diseases.

Similarly, faba bean and lentil seed can be treated with one of the above-mentioned fungicides at the same rate to control seedling damping-off and root-rot disease complex (Mohamed and El-Rafei 1983).

Broomrape (Orobanche spp.)

Broomrape (mostly *Orobanche crenata*) is the most serious biotic stress of faba bean in Egypt. After a long history of concentrated efforts, an integrated control package has been developed and transferred to farmers in Middle and Upper Egypt, where *O. crenata* is most serious. The package includes:

- A cultivar tolerant to *Orobanche*, Giza 402.
- Sowing date in the first half of November.
- Fertilization with 36 kg N/ha (starter dose) + 71 kg P_2O_5/ha.
- Chemical control using glyphosate (Lancer) at 64 g a.i. in 500 L water/ha.

- Seeding rate of 184.5 kg/ha to achieve 25–27 plants/m^2.

As a result of the adoption of this package over a five-year period (1985–1989), *Orobanche* infestation was reduced considerably (up to 96 percent in some fields) and faba bean yield increased as much as 292 percent in 1988/89 (Nassib *et al.* 1989). The integrated package was recently modified, and the high rate of glyphosate replaced with a reduced rate of 34 g a.i./ha combined with NPK (1:1:2), resulting in yield increases up to 182 percent (Nassib *et al.* 1990, 1991).

Recent studies show that a new chemical (Pursuit) is comparable to glyphosate on faba bean, particularly in the crop-tolerance margin which makes chemical control, as one component of the integrated control package, easier to use by farmers (Hassanein *et al.* 1991; Zahran *et al.* 1991a; El Sherbeeny *et al.* 1993).

A few studies have been carried out to control *Orobanche* in lentil (Zahran and Hassan 1990) and chickpea (Zahran *et al.* 1991b). Glyphosate, Sceptor and/or Pursuit were effective against *Orobanche*, resulting in seed yield increases of 24.7 and 72 percent for chickpea and lentil, respectively.

Viral diseases

In 1991/92, a viral epidemic destroyed the faba bean crop on about 60,000 ha in two major faba bean producing governorates (Minya and Beni Sueif) in Middle Egypt. Faba bean production was reduced by about 40 percent. The epidemic was associated with an excessively cold winter and an outbreak of aphid vectors. Preliminary tests conducted in 1991/92 suggested the involvement of Faba Bean Necrotic Yellow Virus (FBNYV), a recently identified virus of faba bean. In 1992/93, yield losses due to viral diseases were about 20 percent, because conditions were not as favorable to aphids, which transmit FBNYV. In 1992/93, two surveys (in early February and mid March) on disease with an emphasis on viral disease (Fig. 1) confirmed FBNYV as the main causal organism for the 1991/92 epidemic. The results of the two surveys showed the presence of six viruses on faba bean with varying frequencies; FBNYV (49.3 percent), Bean Yellow Mosaic Virus (BYMV, 24.3 percent), Broad Bean Wilt Virus (BBWV, 4.2 percent), Cucumber Mosaic Virus (CMV, 0.4 percent), Alfalfa Mosaic Virus (AMV, 0.3 percent), and Bean Leaf Roll Virus (BLRV, 0.2 percent) (Makkouk 1993; Rizkallah *et al.* 1993). FBNYV causes chlorosis, thick leaves, leaf rolling, stunting, necrosis, and complete killing of the faba bean plants, which then turn black.

Fortunately, FBNYV is not seed transmitted, because it is a phloem-limited plant virus, which is transmitted by aphids. The potential danger of such a virus is considerable in North Africa and West Asia, where the virus has been detected. Resistance of faba bean to FBNYV has not been detected thus far and very little information is available about this virus. The Egyptian national program has begun concentrated efforts to cope with this problem. Other viral diseases, such as BYMV, which is seed transmitted, deserve special attention in Egypt.

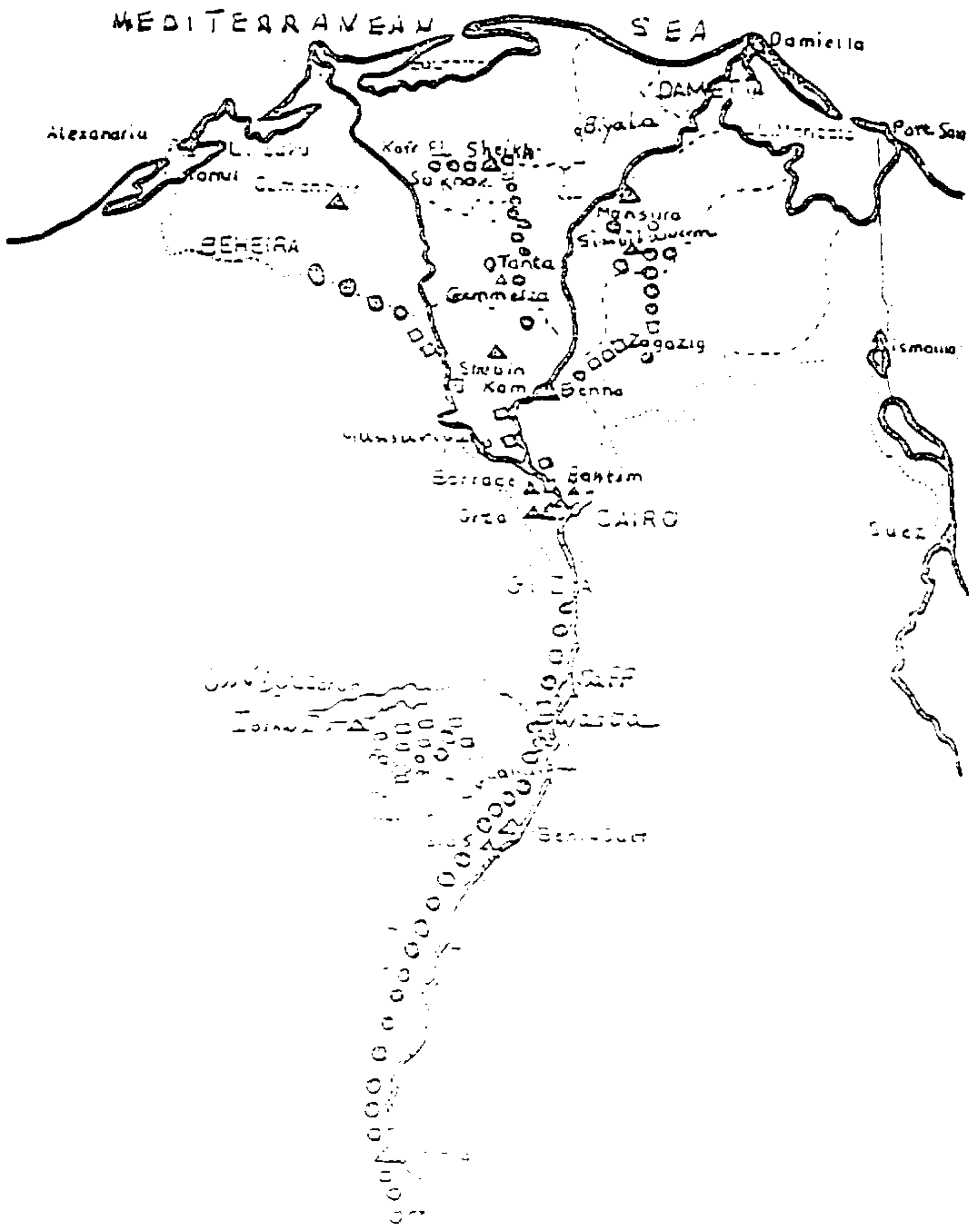

Fig. 1. Map of Egypt showing locations of faba bean fields surveyed in March 1993. □ = fields where mosaic/mottle symptoms were more common; O = fields where yellowing/stunting/leaf rolling/necrosis symptoms were more common.

Insect pests

Aphids, mainly *Aphis craccivora*, are the major insect pests causing yield losses to faba bean and lentil. These aphids affect faba bean via direct feeding and by transmitting viral diseases. In addition, leaf miner (*Liriomyza trifolii*) causes severe damage. In a multi-year study, Fam and Bishara (1983) reported obvious losses in yield of faba bean plants infested by aphids and leaf miners. Yield reductions were 72 percent for aphids and 57 percent for leaf miners. Faba bean lines with some aphid resistance have been identified, but these have not been developed for commercial production. As part of the Nile Valley Regional Program, several breeding lines of both faba bean and lentil, together with commercial cultivars, have been tested in the field and the greenhouse for aphid infestation. Very few breeding lines have proved promising, as they consistently have a low aphid population. Other lines appear to have some tolerance, as they produce high yields in the presence of aphids (Bishara *et al.* 1992).

It is unlikely, however, that host-plant resistance alone will provide an acceptable control of aphid on faba bean and lentil. Both host-plant resistance and chemical control will be required. High aphid infestation often makes insecticide treatment necessary, thus reliable and practical recommendations for the proper timing are needed. In experiments conducted by Bishara *et al.* (1991), critical infestation levels for control were determined using the susceptible Giza 402 cultivar. The lowest aphid infestation and highest yield were achieved with full protection (weekly spraying with Pirimor insecticide), followed by spraying once when 10 percent of plants were infested. Applications at 20 and 30 percent infestation resulted in higher aphid populations and yield losses. This illustrates that one properly timed application is sufficient for aphid control, and that the economic threshold is at 10 percent infested plants.

The leaf miner infestation rate is higher in early (October) sowings in the Delta. Agricultural practices have no effect on infestation (Fam and Bishara 1983).

At present, chemical control is the most or the only effective technique available to reduce insect pest damage. Therefore, breeding for high yield potential and resistance to major insect pests and diseases is of vital importance.

More studies are needed on the population dynamics of pest species and their natural enemies in relation to weather data and IPM.

Non-parasitic weed control

Weeds constitute one of the major constraints to cool-season food legume production. Yield reduction due to weed competition ranges from 24 to 30 percent in faba bean (Zahran 1983). In Egypt, as hand labor has become expensive and scarce, chemical weed control becomes necessary and practical. The predominant weed species, according to Zahran (1983), are: *Ammi* spp. (especially in Middle Egypt, 32–36 percent), *Beta vulgaris*, *Chenopodium* spp., *Euphorbia* spp., *Medicago hispida*, *Melilotus indica*, and *Rumex* spp., for annual broad leafed weeds. *Echinochloa* spp., *Phallaris* spp., and *Polypogon monspoliensis* are the dominant annual grasses in Lower Egypt (57 percent). *Cynodon dactylon* is the dominant perennial grass in Upper Egypt.

Faba bean

Results of experiments covering the Lower, Middle, and Upper Egypt agro-climatic zones (Zahran 1983) show that the critical period for weed–faba bean competition begins six weeks after sowing. Effective weed control can be achieved through either hand hoeing twice (5 and 10 weeks after sowing) or the use of Igran as a post-sowing herbicide at a rate of 2.5 kg a.i./ha followed by one supplementary hoeing (10 weeks after sowing). Zahran says that glyphosate (Lancer) spray (2 percent) as a pre-sowing herbicide is recommended where grassy weeds are a problem. Fusilade (PP009) can be applied selectively for grass control (1 percent spray for annuals and 2 percent for perennials). These results have been supported by a series of experiments conducted in six governorates in the Delta and Nile Valley under the NVRP between 1985 and 1988. Igran or Gesagard applied post-sowing at a rate of 2.5 kg a.i./ha is recommended as a successful alternative to hand hoeing. Recent research in the Delta, Middle, and Upper Egypt found that *Ammi majus* and *Convolvulus arvensis* populations were reduced by the use of Igran post-sowing at a rate of 2.98 kg a.i./ha (Hassanein *et al.* 1991), or by a combination of Topogard (pre-emergence at 0.63 l/ha) + Modown (post-emergence one month after sowing) at 0.185 L/ha (Tawfik *et al.* 1991). Moreover, Hassanein *et al.* (1991) recommend the use of Igran (post-sowing) at a rate of 2.38 kg a.i./ha plus Fusilade (post-emergence) at 0.3 kg a.i./ha for good control against *Phallaris* spp. and other annual grasses in the Delta.

Lentil

Satisfactory control of weeds in lentil fields in both the Delta and Middle Egypt can be achieved by the use of Gesagard (post-sowing) either alone at a rate of 1.5 kg a.i./ha or at a reduced rate (1.19 kg a.i./ha post-sowing) along with Fusilade applied one month after sowing at a rate of 0.298 kg a.i./ha. This combination reduced the annual weed population a remarkable 93.2 percent in the Delta and 78.9 percent in Middle Egypt (Hassanein *et al.* 1991).

Chickpea

Weeds in chickpea fields in Middle and Upper Egypt can be controlled by either hand hoeing twice (30–40 and 70–80 days after emergence) or the use of Igran, Topogard, or Gesagard as post-sowing herbicides combined with hand hoeing once 50 days after sowing (Hassanein *et al.* 1991.

Currently, chemical control is commonly used in farmers' fields since hand hoeing is no longer practical.

Recommendation Packages

Faba bean

Delta

Cultivar:	Giza 461 or improved Giza 3 (tolerant to foliar diseases).
Seeding rate:	184.5 kg/ha to achieve about 25–27 plants/m^2.
Fertilizer:	36 kg N + 72 kg P_2O_5/ha.

Weed control: Igran, 2.98 kg/ha (post-sowing) or hand hoeing twice, 5 and 10 weeks after sowing.

Sowing date: Mid November.

Disease control: Dithane 45 sprayed at 250 g/100 L of water.

Aphid control: A recommended insecticide when needed.

A total of 57 demonstration plots were conducted in Beheira and Kafr El Sheikh governorates between 1989 and 1992. On average, the recommended package increased faba bean seed yield by 31 percent compared to farmers' traditional practices.

Middle and Upper Egypt

Cultivar: Giza 402 (tolerant to *Orobanche*) or improved Giza 2.

Seeding rate: 184.5 kg/ha to achieve 25–27 plants/m^2.

Fertilizer: 36 kg N + 72 kg P_2O_5/ha.

Weed control: Glyphosate (Lancer) at a rate of 34 a.i./500 L water/ha combined with N, P, K (1:1:2) sprayed twice at the onset of flowering and three weeks later (for *Orobanche* control). For other weeds, Igran at 2.98 kg/ha (post-sowing) or hand hoeing twice, 5 and 10 weeks after sowing.

Sowing date: First half of November in Middle Egypt and first half of October in Upper Egypt.

Aphid control: A recommended insecticide when needed.

A total of 449 demonstration plots were conducted in Beni Sueif, Minya, and Fayoum governorates between 1989 and 1992. Yield increases resulting from the application of this package were 35, 29, 22, and 17 percent over the farmers' package, respectively.

Lentil

Cultivar: Giza 370.

Seeding rate: 95 kg/ha to achieve about 300 plants/m^2.

Fertilizer: 36 kg N + 72 kg P_2O_5/ha along with *Rhizobium* inoculation.

Weed control: Gesagard post-sowing at 1.5 kg a.i./ha.

Sowing method: Wet method (Herati using a rotovator to cover the seeds).

Sowing date: Second half of November (Delta) and first week of November (Middle Egypt).

Disease control: One spray with Redomil Mz 58 percent at conc. of 250 g/100 L water to control downy mildew.

Aphid control: With Pirimor at the rate of 714 g/ha.

A total of 195 demonstration plots were grown between 1989 and 1992 in Sharkia, Kafr El Sheikh, Dakahlia, Beheira (Delta), and Assiut (Middle Egypt). On average, the recommended package increased lentil seed yield by 46 percent over the farmers' package.

Chickpea

Cultivar: Giza 531.

Seeding rate: 100 kg/ha treated with Quinolate (3 g/L kg seed) to achieve about 33 plants/m^2.

Fertilizer: 36 kg N + 72 kg P_2O_5/ha along with *Rhizobium* inoculation.

Weed control: Igran post-sowing at 2.98 kg a.i./ha + hand hoeing once 50 days after sowing.

Sowing date: Mid November (Delta) and first week of November (Middle Egypt).

The application of this package in Beheira and Assiut governorates resulted in yield increases of about 40 and 56 percent, respectively.

Future research on cool-season food legumes

- The effect of soil tillage system (zero, minimum, and traditional tillage) on soil-borne diseases that have posed a serious threat to faba bean in recent years, especially in Middle and Upper Egypt, should be investigated.
- More attention should be given to viral diseases in faba bean, especially Faba Bean Necrotic Yellow Virus and Bean Yellow Mosaic Virus, the prevailing viral diseases in faba bean fields.
- More study is needed on the population dynamics of aphids and their natural enemies in relation to weather data and the various components of IPM.
- The leaf miner is becoming a serious threat to faba bean, causing appreciable yield losses, therefore studies should focus on this insect pest.

Soybean as a Summer Legume Crop

Production constraints

Competition

Soybean has to compete with corn, rice, and cotton for arable land. In addition, soybean has a higher production cost and a lower net return per hectare than maize. In addition, marketing has recently became a problem for farmers. This has led to a decline in soybean acreage from 62,000 ha in 1983 to 44,430 ha in 1991, and to 18,290 ha in 1993, though the national goal was for 105,000 ha.

Lack of varieties with proper maturity for cropping system

Damage by leaf feeding insects

This is caused primarily by cotton leaf worm (*Spodoptera littoralis*) and red spider (*Tetrany untica*).

Need to reduce N fertilizer input costs

Research achievements

- The two cultivars, Crawford and Clark, require 120–130 days to maturity. Developing early maturing varieties is needed. Therefore, a crossing program was started in 1983, with crosses made using those two cultivars. The Food Legumes Research Program (FLRP) now has lines that mature in 80–90 days and yield 0.42–0.53 t/ha. In the 1991 growing season, seed multiplication of some of these lines began. In 1992, on-farm trials were started, so that the lines can be evaluated to find a place for the crop in the rotation. Results of the 1992 and 1993 seasons are promising, especially for L-82.
- In Egypt, where soybean is mainly grown under irrigation, the major problem is cotton leaf worm, which appears in June and July. If the crop is planted in June, as is the case when soybean follows a wheat crop, the worms will attack the plants. Extensive defoliation and large losses in yield can be expected. Therefore, insecticides have been used extensively as the principal means of defense in soybean fields. This usually causes problems such as pest resistance to insecticides, rising costs, destruction of useful insects and animals, accumulation of undesirable residues and environmental pollution. The solution seems to be planting earlier or developing new high-yielding cultivars that have resistance to such a dangerous defoliator. The FLRP has been successful in developing new soybean lines (120 days to maturity) resistant to cotton leaf worm (Awadalla *et al.* 1990; Abd El Monam *et al.* 1991). The new lines have been planted in June during the last three years under heavy natural infestation with cotton leaf worm. They showed great resistance (15–20 percent defoliation) and produced 20–25 percent more yield compared with the two commercially grown cultivars, Clark and Crawford (more than 50 percent defoliation). Moreover, another line resistant to red spider mite and moderately resistant to cotton leaf worm has been developed.
- Application of N fertilizer in farmers' fields is heavy (179–238 kg N/ha) because of failure or limited nodulation by local rhizobia. In 1983 on-farm trials conducted by the Soil Microbiology Research Section of ARC, using the locally produced seed inoculum mixed with imported fine peat as a carrier, was able to nodulate soybean as effectively as imported inoculum and produced higher yield than did application of 250 kg N/ha (Abdalla *et al.* 1985). Accordingly, in 1984 an inoculum program was started, and the locally produced inoculum consistently nodulated soybean in farmers' fields (a total of 2,520 ha in eight governorates). In 1989 the program was expanded to 37,800 ha. In 1990, enough inoculum was available for all certified seed. Now inoculum is widely used. However, high amounts of N fertilizer are still applied in farmers' fields, though the recommended rate is only 35.5 kg N/ha. The application of only the recommended amount would save large amounts of N fertilizer, which is considered one of the major production costs, and at the same time protect the environment from possible pollution with leached nitrate.

Cereal Production

Wheat

Cultural practices

Irrigation and fertilization

- Water consumptive use is 49, 47, and 44 cm for wet, medium, and dry water levels of 25, 50, and 75 percent soil moisture depletion, respectively. Daily evapotranspiration rates for wheat parallel the increase in the vegetative growth of the plant and decline at the end of the season due to crop maturity.
- Irrigation scheduling for wheat recommends the first irrigation three weeks after sowing, with up to four more irrigations depending on temperature, soil type, and rainfall.
- The following results relate to the effect of irrigation practices on wheat production (Miseha *et al.* 1984):
    - Long-run irrigation using corrugated furrows increased grain yield of wheat by 19 percent over farmer's practices.
    - Mean values of water applied were 4,581, 4,662, and 5,034 m^3 of water/ha for corrugation, long border, and small basins, respectively.
    - Using long furrows (50 m long) saved about 10 percent of irrigation needs compared with small basins.
    - Water-use efficiency values were 0.86, 0.98, and 1.09 kg of wheat grain/m^3 of applied water, for farmers' method, long corrugation borders, and corrugated furrows, respectively.
- The following results relate to the effect of irrigation and N fertilization on wheat (Badawi *et al.* 1984):
    - Irrespective of soil moisture, the monthly water consumption increased gradually until it reached its peak through March and April—earlier in Upper Egypt than in the Delta—and declined during maturity.
    - Water consumptive use increased as available soil moisture increased. Soil moisture stress induced a reduction in water consumptive use.
    - The water consumptive use by wheat under field conditions was 38 cm at Sakha, 40.7 cm at Gemmeiza, 43.7 cm at Sids, and 45.7 cm at Shandaweel, using the 50 percent soil moisture depletion level and the 143 kg N/ha level.
    - Water consumptive use data can be used as a guide to scheduling irrigations for wheat.
    - Differences in grain yield between the 25 and 50 percent soil moisture depletion treatments were not significant. Thus, 5–6 irrigations proved adequate for wheat.

- The recommended number of irrigations and N rate are 179 kg N/ha + 71 kg P_2O_5 with 5 irrigations.

- Mitkees *et al.* (1991) studied the effect of delaying the first irrigation on wheat to estimate losses due to delay of the first irrigation because of winter canal closure. Results show the negative effect of the delay on grain yield (11 percent) and straw yield (19 percent). In general, durum wheat was least affected by the closure.
- The effect of biuret content in urea on wheat yield under different methods of fertilization was studied by Hamissa *et al.* (1984c). Concentrations up to 3 percent had no hazardous effect on wheat crop yield. To be on the safe side, urea should not contain more than 1.5 percent biuret.
- The effect of seeding rate and N fertilizer on wheat at Upper Egypt and Fayoum was studied by Mitkees *et al.* (1992). They found no clear trend with different seeding rates due to compensatory factors in different locations. For N fertilizer, the highest grain yield was obtained using 140–180 kg N/ha in Upper Egypt, and 214 and 255 kg N/ha in Fayoum and New Valley, respectively.
- Increasing the N level up to 250 kg N/ha produced the highest GY, above which GY was reduced. Increasing the seeding rate had no effect on GY. No effect was detected by applying micronutrients (Zn, Mn, Fe) (Abdel Shafi *et al.* 1992).

Sowing methodology

- To obtain the highest yield in Upper Egypt the following are recommended:
  - In Sohag: cultivars Giza 164, Sohag 1, Sohag 2, and Beni Sueif 1 are recommended. Giza 164 is recommended in Qena and Aswan Governorates.
  - A sowing date in early November, with adequate land preparation and a seeding rate of 158 and 178 kg/ha for dry and wet sowing methods, respectively (for good crop establishment), are recommended.
  - N fertilizer at 180 kg N/ha for the Old Lands applied in 3 split doses is recommended. P_2O_5 application at a rate of 35 kg/ha at land preparation is recommended.
- The effect of dry and wet sowing methods on wheat crop establishment in the Old and New Lands at Qena, Sohag, and the New Valley was studied by Eissa *et al.* (1993). The effect of sowing method differs from one location to another. In general, seed drilling exceeded other sowing methods in Qena.
- The effect of herbicides on wild oat in wheat was studied by Tammam *et al.* (1993). This study shows that the new herbicide Grasp is as effective in controlling wild oat as Suffix.
- The effect of seeding rate and N fertilizer on wheat grain yield in Upper Egypt was studied with the following results:
  - Increasing N level up to 214 kg/ha may be necessary to increase grain yield.
  - High grain yield may be obtained by using 160–190 kg seed/ha.
  - Grain yield was reduced by increasing N level to 250 kg N/ha.

- The effect of dry and wet sowing on wheat crop establishment in Fayoum was studied by Abou Warda *et al.* (1993). Wet sowing and covering seeds with a cultivator gave the highest grain and straw yields.
- The effect of seeding rate and N fertilizer on wheat grain yield in Fayoum Governorate was studied. The best combination of N and seeding rate was 120 kg/ha seed and 143 kg N/ha.

Biotic and abiotic Stresses

- Gouda *et al.* (1993) studied the effect of different agricultural practices on wheat yield under saline condition in Fayoum Governorate and the North Delta. Different seeding rates did not significantly affect grain yield, whereas NPK significantly increased grain yield, especially when urea was the source of N, rather than ammonium sulfate or ammonium nitrate.
- The effect of high temperatures on the identification and development of heat-tolerant wheat germplasm in Upper Egypt was studied by Abdel Shafi *et al.* (1993). The study concluded that multiplicational testing is very important in screening for heat stress. Late planting could offer a means to select for heat-tolerant germplasm. This will be useful in identifying measurable traits associated with grain yield under heat stress.

Wheat diseases

In Egypt, wheat is liable to attack by many foliar diseases, such as rusts and powdery mildew, which have eliminated many susceptible wheat cultivars (Abdel Hak and Kamel 1972; Abdel Hak *et al.* 1982). Although powdery mildew on wheat was only a minor problem in the past, in the future it will be more serious, especially in Upper Egypt (Sherif 1977; El Daoudi *et al.* 1991). New wheat cultivars have been developed with an adequate level of rust resistance, but the appearance of new virulent pathotypes makes the effective life of a cultivar very short. Therefore, the development of new resistant genotypes should be continued.

A survey and identification of wheat diseases and virulent physiological races of leaf rust is carried out annually. Testing and evaluating of local and exotic materials at both seedling and adult stages are also carried out annually.

Stem rust has been severe in Middle Egypt, mainly on durum wheat. Leaf rust infection has been higher than stem rust in the north (Beheira and Nubaria). In the Delta, leaf rust and stem rust occur frequently, while a slight infection with stripe rust has been observed at Gemmeiza and Sakha.

Severe powdery mildew infection was found in 1990/91, especially in durum wheat in Upper Egypt. An epidemic is expected, according to changes in climatic conditions. The PM disease incidence is higher in Upper Egypt than rust. The introduction of new high yielding cultivars, which need more fertilization and irrigation, between 1974 and 1980, has resulted in heavy infection with PM. A high incidence of PM was recorded on bread and durum wheat in Upper Egypt, due to the high humidity and temperature. The average loss in Upper Egypt due to PM is about 19.8 percent (Sherif *et al.* 1993).

Only a slight infection with loose smut has been found, but the disease still exists and is serious (El Daoudi *et al.* 1991). It was most noticed in wheat areas in Upper Egypt and the

Northwest Coast. Severe infection was found in fields planted with untreated seed. In the new wheat areas the disease should garner more attention because most of the wheat growers use seed from their own fields, thus, the level of infection will increase year after year.

During 1991/92 and 1992/93, symptoms of common root-rot were found in wheat and barley fields in Marsa Matrouh. Common root-rot fungi are aggressive pathogens on plants under stress; dry and saline soil, as well as warm weather, are the most important predisposing factors.

Yellowing and dwarfing problems of cereals seriously affect production all over the world (Maramorsch and Harris 1981). Barley Yellow Dwarf Virus (BYDV) has recently contributed to that problem in Egypt (Aboul Atta *et al.* 1991).

Aphid on wheat

Aphid is the most destructive pest attacking wheat in Egypt. It causes serious damage by sucking the plant sap and transmitting viral diseases such as BYDV. El Hariry (1979) and Tantawi (1985) surveyed four species of aphid: *Rhopalosiphum padi, R. maidis* Fitch, *Schizaphis graminum*, and *Sitobion avenae* Fab attacking wheat plants in Egypt. The Russian species, *Duiraphis noxia* Mord, is also found in Egypt.

- Losses in GY ranged from 4–23 percent due to aphid infestation. The aphid infestation score ranged from 1.7 to 3.3. Over the last few years, yield losses due to aphid ranged from 5 to 38 percent (Tammam 1989).
- Tantawi (1985) and El Heneidy *et al.* (1991) estimated wheat yield losses due to aphid infestation at 7.5–23 percent in Middle and Upper Egypt, where the highest infestation occurs. Current aphid control in wheat fields is dependent mainly on chemical insecticides regardless of the direct or indirect impact on the environment, particularly the harmful effect on natural enemies (predators). Sharp declines in the numbers of predators (40–48 percent) and parasitism (66 percent) were observed after spraying (El Heneidy *et al.* 1991). An integrated pest control program is needed for aphid control in wheat fields.

Barley

Cultural practices and fertilization

The followings are the main findings of the Barley Research Program:

- Response of the newly released cultivars of barley to N, P, and K were studied by Hamissa *et al.* (1984).
- Grain yield was increased by fertilization up to 143 kg N/ha. Beyond this rate, crop yield was negatively affected due to lodging.
- No significant differences were detected for grain yield between 107 and 143 kg N/ha.
- No response was obtained due to either P or K. Accordingly, fertilization with these two elements cannot be recommended.
- The effect of number of cuttings and N dose on green material and grain yield of barley was studied. No significant reduction in yield was detected when one cutting was made

at 25 cm height, which gave 4.5–7 tons of green material/ha. There was a response to N doses up to 107 kg N/ha, with one cutting of barley giving 4.5–7 t/ha of green material with little if any grain yield reduction.

- Different seeding rates on barley yield made no appreciable difference in grain yield. The highest grain yield was obtained at 95–107 kg/ha.
- Developing heat-tolerant barley cultivars for use in Upper Egypt and the New Valley is essential. Heat stress influences barley production and quality in Upper Egypt and the New Valley. This is due to the high temperatures during the growing season, especially during pollination, fertilization, and grain filling. Thus, breeding for heat-tolerant barley cultivars is a main objective.

Biotic stresses

Disease

In Egypt, barley is vulnerable to many foliar diseases such as leaf rust, powdery mildew, net blotch, and leaf stripe, which reduce the yield of susceptible cultivars substantially (Abdel Hak and Ghobrial 1977). The severity of the disease and losses in yield vary from one year to another depending on the prevailing climatic conditions and pathogens in a given area.

Net blotch is well known on barley grown in humid climates. In Egypt, the disease caused negligible damage until 1949, and is now reported to cause considerable damage especially in the humid areas of the Nile Delta (Abdel Hak *et al.* 1969). It occurs in practically all fields throughout the Delta during the last week of February and March, while it is rarely found in southern regions (Ghobrial *et al.* 1982).

Powdery mildew was also negligible until late 1967, when most of the exotic and local cultivars were damaged by this pathogen. It is found extensively in the Delta and Middle Egypt and decreases towards the south.

Leaf rust occurs annually in Egypt, especially in the northern parts of the Delta where high humidity is favorable for the disease development (Ghobrial 1981).

Covered smut, being a seed-borne disease, is very important because of the continuous use of infected seed. Abdel Hak *et al.* (1975) and Abdel Hak and Ghobrial (1977) report a variety of infections ranging from traces to 5 percent depending on grain infection, soil temperature, and moisture parameters.

Barley leaf stripe, another seed-borne disease, has also been observed on some barley cultivars (Abdel Hak and Ghobrial 1977).

Recently, Barley Yellow Dwarf Virus has been observed in barley fields and is vectored by several species of aphid. It is generally present throughout the dry areas but varies from year to year depending on the conditions for aphid multiplication. The disease is diagnosed by yellowing and stunted plants.

Screening barley genotypes for resistance to the major diseases is carried out annually at the seedling stage in the greenhouse and at the adult stage under field conditions. It has been possible to identify some genotypes that combine both high-yield potential and a good level of resistance to more than one disease.

Aphid

Surveys show that the corn leaf aphid *Rhopalosiphum maidis* (Fitch) is the dominant aphid species on barley in northern parts of the country. In Middle Egypt, *R. padi* and *R. maidis* represent 85 percent of total aphids on barley, along with the green bug *Schizaphis graminum* at 12 percent and *Sitobion avenae* at 3 percent. It has been possible to identify some genotypes that exhibit resistance to aphid build-up.

Laboratory screening of resistant barley genotypes to *Rhopalosiphum maidis* is carried out annually.

Weed control

The study of the effect of some herbicides on weeds in barley shows that Brominal or Koril DS can both be used effectively to control annual broad-leaved weeds. The herbicide Grasp can be used to control annual grassy weeds. A mixture of Brominal and Grasp is used to control both classes of weeds with improved barley productivity.

Recommendations for Cereal Production

It should be emphasized that additional yield increases can result from improving on-farm activities such as cultural practices, soil management, and drainage system efficiency. The gap is still wide between the actual and potential on-farm yields. Therefore, it is anticipated that if proper technologies are applied and constraints facing cereal production are minimized, 20–25 percent yield increases could be gained in the farmers' fields. For improvement of cereal production, the following are recommended:

Wheat

Cultivar:	High-yielding wheat cultivars should be used for each location.
Sowing date:	The first week of November in Middle and Upper Egypt and the second half of November in the Delta are suitable.
Seeding rate:	The recommended rates are 158 and 178 kg seeds/ha for dry and wet sowing, respectively, sown broadcast. For seed drilling, 95–120 kg seeds/ha is recommended.
Fertilization:	N fertilizer application at 180 kg N/ha for the Old Lands and 238 kg N/ha for the New Lands is recommended. This amount should be split into three doses. P application during land preparation at a rate of 35 and 70 kg P_2O_5/ha for the Old and New Lands, respectively, is recommended. K_2O at a rate of 57 kg/ha during land preparation is recommended if the soil is deficient in K.
Weed control:	For broad-leaf weeds, Brominal at a rate of 600 cm^3/200 L water/fed or Granstar at a rate of 8 g/200 L water/fed is recommended. For grassy weeds, Arelon at a rate of 1.25 L/200 L water/fed is recommended.
Aphid control:	Malathion 57 percent (2.38 l/ha) is recommended if needed on infested spots only.

Barley

Cultivar:	Using high-yielding varieties for each location, i.e. Giza 121 for Middle and Upper Egypt, Giza 123 and 124 for the Delta, and Giza 125 and 126 for rainfed areas and the New Lands are recommended.
Sowing date:	The second week of November in Middle and Upper Egypt and the second half of November in the Delta are recommended.
Seeding rate:	120 kg seeds/ha in the Old Lands and 70 kg seeds/ha in rainfed areas are recommended.
Fertilization:	N fertilizer application at 100 kg N/ha for the Old Lands and 140 kg N/ha for the New Lands is recommended. P application during land preparation at a rate of 35 and 70 kg P_2O_5/ha for the Old and the New Lands, respectively, is recommended. K_2O at a rate of 57 kg K_2O/ha during land preparation is recommended, especially in sandy soils deficient in K.
Weed control:	For broad-leaf weeds, Brominal at a rate of 600 cm^3/200 L water/fed or Granstar at a rate of 8 g/200 L water/fed is recommended. For grassy weeds, Arelon at a rate of 1.25 L/200 L water/fed is recommended.
Aphid control:	Malathion 57 percent (2.38 L/ha) is recommended, if needed, on infested spots only.

Livestock Production

Cattle and Buffalo

Cattle, mainly native *baladi*, represent approximately 55 percent of the national herd, while buffalo represent 45 percent. The decline in the cattle population, according to the 1982 census, is associated with the increase in exotic breeds (mainly Friesian) and crossbreeds, estimated at 607,527 head comprising 22.5 percent of the total national cattle herd (Table 6).

Table 6. National distribution of the cattle herd according to breed (native breeds excluded).

Breed		Number		
		Male	Female	Total
Exotic	1	30,904	64,697	95,601
	2	9,665	70,871	80,536
Cross bred	1	218,639	388,888	607,527
	2	18,450	78,189	96,639
Total	1	868,132	1,826,147	2,694,279
	2	567,805	2,338,402	2,906,207

1 = Recently published survey by the Ministry of Agriculture.
2 = Agricultural census 1982, by the Ministry of Agriculture, published in 1988.

Geographical distribution of cattle and buffalo

A high percentage of the cattle population is in the Delta (Lower Egypt) governorates (60 percent), while only 38 percent are in Middle and Upper Egypt (Table 7). The three leading governorates in the Delta are Beheira (14.7 percent of the total cattle population and 24 percent of the Delta), Sharkia (10.4 percent of the total and 17.1 percent of the Delta), and Kafr El Sheikh (8.2 percent of the total and 13.5 percent of the Delta).

Table 7. Geographical distribution of cattle and buffalo.

Zone		Cattle		Buffalo	
		Holders	Cattle	Holders	Buffalo
Delta	1	71,073	154,420	58,184	108,456
	2	748,039	1,607,348	817,472	1,336,050
	T	819,112	1,761,768	875,656	1,444,506
Nile Valley	1	80,434	135,192	107,523	146,414
	2	500,615	974,298	549,693	786,494
	T	581,049	1,109,490	657,216	932,908
Total	1	152,197	292,899	165,734	255,253
	2	1,256,923	2,613,308	1,367,442	2,123,308
	T	1,409,120	2,906,207	1.533,176	2,378,561

1 = Owners who have no land.
2 = Owners who own land.
T = Total owners.
Source: The agricultural census of 1982, published by the Ministry of Agriculture in 1988.

The three main governorates for cattle in the Nile Valley (Middle and Upper Egypt) are Minya (6.7 percent of the total and 17.5 percent of the Nile Valley), Beni Sueif (6.4 percent of the total and 16.8 percent of the Nile Valley), and Assiut (6 percent of the total and 15.7 percent of the Nile Valley).

The buffalo population is concentrated in the Delta region, with Dakahlia, Sharkia, and Beheira as leading governorates. Middle and Upper Egypt comprise only 39.2 percent of the total buffalo population, with Sohag, Assiut, and Minya as the leading governorates.

Ownership and stocking density of cattle and buffalo

According to the 1982 agricultural census, about 93.2 percent of the cattle in Egypt is owned by small farmers (farm size less than 2 fed). The average herd size in this category is between 1.5 and 2.5 animals. Buffalo ownership is similar.

The impact of small holders in terms of livestock ownership will continue, because every farmer wishes to own a cow and/or a buffalo as well as a donkey for farm work and transportation. Only a small part of the population is found on medium-sized farms, where 10–100 animals are kept and used either as meat and/or for a dairy herd. The large farming companies, either private or public, can own more than 100 head. Most of these farms are in the Delta and in the New Lands, established following the economic reforms in the early seventies.

Sheep and Goats

The national sheep and goat herds are estimated at 3,370,672 and 2,747,558 head, respectively, according to the last census of the Ministry of Agriculture in 1982, published in 1988.

Geographical Distribution of Sheep and Goats

- 55.3 percent of the sheep population is concentrated in the Nile Valley, mainly in Sohag Governorate.
- 34.7 percent of the sheep population is located in the Delta, mainly in Beheira, Sharkia, and Damietta Governorates.
- 64.8 percent of the goat population is in the Nile Valley, mainly in Assiut, Sohag, and Qena Governorates.
- 24 percent of the goat population is located in the Delta governorates, mainly in Sharkia and Beheira.

Ownership of sheep and goats

According to Ministry of Agriculture data, the ownership of sheep and goats is distributed among more than one million owners, of which 17 percent have no land and own 21 percent of the sheep and 24.7 percent of the goats.

Other Species

Camels

There were 134,514 head of camel in Egypt in 1982, according to the agricultural census, mainly in the Delta (38.3 percent) and Nile Valley (51.3 percent). A recent survey by the Food Security Department of the Ministry of Agriculture in 1989 showed that the total population had increased to 160,900 head. The highest concentrations are in Assiut (34,000 head) and Qena (33,000 head).

Horses, donkeys, and mules

Except for the 1982 agricultural census (Table 5), there is no available published data on the magnitude of population, distribution, and growth for horses, donkeys, and mules. However, the use of these animals in farm work has obviously been affected by the development of the agriculture sector and the reform policies that have been adopted during the last ten years. Mechanization in most agricultural operations is the main reason behind the lower numbers seen today (Aly 1990).

Yields of Animal Products

Red Meat Production

Beef and veal dominate the meat sector in Egypt. They provide nearly 84.9 percent of the total red meat consumption (Table 8). The consumption of mutton and lamb is estimated at 1.5 kg/capita/year (15.1 percent of total red meat consumption).

Table 8. Sources of red meat.

Source	*Percentage*
Total national consumption	100.0
Buffalo veal	6.1
Beef	55.5
Aged cattle and buffalo	10.1
Sheep and goat	15.1
Imported live animals	6.1
Imported frozen meat	7.1

Source: General Organization for Veterinary Services, unpublished data 1989 (after Aly 1990).

Camel meat

The consumption of camel meat is limited to certain areas: Sharkia and Beheira in the Delta and Qena in Upper Egypt. Most of the camels for slaughter (75,000–80,000 head per year) are imported from Sudan (based on data from the General Organization for Veterinary Services 1989).

Current data on national red meat production is difficult to obtain. The only accurate figures are those on the number of slaughtered animals from the General Organization for Veterinary Services, whose mandate is to supervise the country's 320 public and private slaughter houses. The Chamber of Commerce and the Central Administration for Animal Production, MALR, publish figures on locally produced red meat. These figures are derived from the slaughter houses plus an estimate of animals slaughtered elsewhere (about 120,000 tons for aged and herd replacement and 85,000–90,000 tons for sheep, goats, camels, and surplus females from the dairy herds (Table 9, after Aly 1990).

Table 9. Red meat production (1980–1989).

Year	Quantity (tons)	
	1	2
1980	335,000	355,000
1981	357,000	343,000
1982	308,000	345,000
1983	419,000	367,000
1984		383,000
1985	372,000	331,000
1986		383,000
1987	436,000	358,000
1988		345,000
1989	472,000	350,000

Source: 1. Chamber of Commerce, Cairo 1989. 2. Central Administration for Animal Production, Ministry of Agriculture 1990 (after Aly 1990).

Milk and dairy products

Crop productivity is considered high in Egypt, but this is not true for livestock productivity, especially milk. However, the introduction of new farming systems as a result of agricultural policy reform in the early Eighties has significantly improved this sector.

Milk production in 1980 was about 1,860,000 tons, reaching 2,173,309 tons in 1989 (Table 10). The figures in the table are estimates based on the number of productive females in the national herd and average yield.

Table 10. Milk production (1980–89).

Year	Production (tons)
1980	1,860,000
1981	1,232,000
1982	1,251,000
1983	1,507,000
1984	
1985	2,101,258
1986	2,006,641
1987	1,970,215
1988	
1989	2,173,309

Source: Administration for Animal Production, Ministry of Agriculture, unpublished data 1990.

Cow milk represents 42 percent and buffalo milk 57 percent of the milk production in Egypt (Ministry of Agriculture 1980–89).

In a survey covering eight villages in four governorates in the Delta, average milk yield from native cows was found to be 925 kg, and 1,550 kg from buffalo. Data from the Central Fund for Animal Wealth and Development (1990) show that average milk yield per cow ranges between 754 and 1093 kg, and is between 851 and 1,554 kg per buffalo (Aly 1990).

Poultry

Broiler production

In the early 1980s the Egyptian government promoted commercial broiler production as an efficient means to meet the increased demand for animal protein. As a result, commercial production has expanded rapidly (Table 11).

Table 11. Broiler production† (1981–1990).

Year	Commercial operations (tons)	Imports (tons)
1981	202,509	121,000
1982	275,923	
1983	253,273	
1984	322,240	
1985	303,019	54,000
1986	287,927	45,000
1987	281,429	36,000
1988	240,000	24,000
1989	231,600	12,000
1990	239,700	8,000

† Sixty million chickens are supplied by the rural sector annually.
Source: Ministry of Agriculture, unpublished data (after Aly 1990).

Production mix

An estimated 25 percent of Egypt's poultry comes from non-commercial production of chicken, duck, geese, and pigeon flocks. Chickens and other fowl are kept for both egg and meat production.

Egg production

During the early 1980s, the Egyptian government encouraged egg production. This resulted in expansion through the development of large commercial enterprises. The layer industry, however, faces as many constraints as the broiler industry. Egg production declined sharply in 1988 following the elimination of the imported corn subsidy. Nevertheless, some broiler operations converted to layer operations in 1989 as a result of relatively better returns from layers.

Prior to 1980, the public sector was responsible for about 75 percent of egg production. This estimate was recently altered to 86 percent (Aly 1990). Analysis of production capacity according to the size of the operation shows that large operations of 15 million eggs and above are responsible for 58.9 percent of the total estimated capacity in Egypt. Operations between one million and 15 million eggs are estimated at 19.5 percent, while those of less than one million represent 21.6 percent (Aly 1990; Table 12).

Table 12. Egg production (1980–1990).

Year	Total	Commercial (million eggs)	Imports
1980	2,210	360	1,750
1981	2,551	1,108	1,443
1982	3,490	2,064	1,426
1983	3,752	2,327	1,425
1984	4,550	3,130	1,420
1985	4,833	3,489	1,344
1986	4,700	3,360	1,340
1987	4,565	3,365	1,200
1988	4,200	2,800	1,400
1989	4,500	2,800	1,700
1990	4,000	2,400	1,600

Source: Ministry of Agriculture 1989 published, and 1990, unpublished (after Aly 1990).

Animal and Poultry Feed

Feed is the most expensive input in the animal and poultry business, representing 60–70 percent of the total running cost. Feed production expansion in Egypt is constrained by the limited cultivable land and the compelling need to intensify land use to meet the needs of the ever-increasing human population.

Government policy focuses on:

1. Increasing green fodder per area unit.
2. Increasing corn production to reach self-sufficiency.
3. Searching for new resources for feed compounds, and ensuring the production of high quality feed compounds.

Feed resources

Forage crops

Two of the principal summer and winter crops are cotton and wheat. Both affect forage production. Until recent years, these two crops were not financially attractive to farmers due to low profitability. As a result, farmers have increased their enterprises where government imposes least control, notably in forage production.

Although animal production levels are low, animal product prices have continued to increase, giving reasonable margins to farmers. While farmers are looking to their herds as a good source of income as well as a secure and inflation-proof investment, forage crops continue to show high profitability. In recent years, pricing policy reforms have remarkably increased the profitability of wheat and cotton, and this has had a negative impact on the area cropped with berseem (*Trifolium alexandrinum*), the main winter forage crop (Table 13).

Table 13. Area cropped to berseem (1980–88).

Year	Full season (ha)	Short season (ha)
1980	723,240	415,800
1981	737,520	429,240
1982	751,800	383,880
1983	783,720	365,400
1984	828,240	350,700
1985	807,660	385,560
1986	783,720	365,400
1987	718,620	341,880
1988	677,880	331,800

Source: Central Administration for Agricultural Economics, Ministry of Agriculture (unpublished data 1989).

Berseem, which is a fast-growing and highly nutritious winter legume forage crop, is planted in October and November, and follows cotton or rice in the rotation. A full season crop remains in the ground until May and gives 4–5 cuts per season. A short-season berseem crop is grown on land to be cropped with cotton in March/April, and gives one or two cuts. Average yield varies between 14 and 19 tons of green material per cut per ha for multiple-cut berseem. Short-season berseem yields between 24 and 28 tons per ha.

Relating berseem production to the nutritional requirements of Egypt's livestock in winter shows an excess of protein and a shortage of energy. A 1989 study by the Field Crops Research Institute, ARC, estimated the production of berseem at 64.55 million tons of green material (55.95 million tons from multiple cut and 8.7 million tons from short season). The study assessed the potential of berseem to increase productivity by at least 25 percent through the use of certified seed and a crop fertilization program.

Fodder beet could play a major role in the forage system. A study by the Forage Research Section, ARC (1988) showed that dry matter yield of fodder beet was similar to that of berseem (about 14 tons per ha), but fodder beet exceeded berseem in the amount of energy obtained. The units of energy were 13,090 UFL/ha for fodder beet and only 9,520 UFL/ha for berseem. Moreover, fodder beet was found to be more palatable, thus increasing the intake of dry roughage. It can be transplanted later in the season than berseem. However, one of the major constraints to fodder beet expansion in Egypt is storing the crop after harvest. Making silage of fodder beet may offer a solution to this problem.

Summer forage crop production is relatively low because the land is fully committed to human crop production. The available data estimate the area planted to summer forages at 83,073 ha. The main summer forage crops are sorghum and sorghum hybrids. According to the data available from the FCRI, the production of summer forages is estimated at 3.6 million tons. The area planted to alfalfa crop is about 5,000 ha, producing 3.2 million tons. Overall forage production is illustrated in Table 14.

Table 14. Forage production (1989).

Source	Green material (tons)
Berseem	64,650,000
Alfalfa	3,200,000
Summer forage	3,600,000
Total	71,450,000

Source: Field Crops Research Institute, Agricultural Research Center, Technical Report 1990.

Compound feed

Livestock feed. Recent reports by the Ministry of Agriculture and Land Reclamation (1990) estimate production at 2.5 million tons of compound feed mix. Manufacturing capacity is 4.5 million tons. Ingredients used by feed compounders are shown in Table 15.

Table 15. Quantities of feed ingredients *(tons) available to compounders* (1990).

Energy source		Protein source		Fibrous residue		
Ingredient	Quantity	Ingredient	Quantity	Ingredient	Quantity	Other
Corn	45,000	Cotton seed cake	350,000	Rice hulls	18,000	Limestone
Wheat bran	1,100,000	Soybean meal	40,000	Crop residues	250,000	Salt
Rice bran	50,000	Sunflower cake	3,000			
Rice screening	50,000	Linseed meal	8,000			
Molasses	80,000	Beans	40,000			
Corn + cob	100,000	Rice germ meal	18,000			

Source: Ministry of Industry (unpublished data 1990).

Poultry feed. The estimated capacity of poultry feed manufacturing facilitates is around 3.5 million tons annually. Over the last three years, production figures have ranged between 2.2 and 2.5 million tons of compound feed. The compounders of poultry feed use a limited number of ingredients, such as yellow corn, soybean meal, and concentrated formula premixes (Table 16).

Table 16. Ingredients (tons) in the production of poultry feed mixes (1990).

Energy source		Protein source		Feed additives	
Ingredient	Quantity	Ingredient	Quantity	Ingredient	Quantity
Corn	1,480,000	Soybean meal	300,000	Limestone	200,000
Wheat bran	470,000	Concentrates	220,000		

Source: Ministry of Agriculture, Central Administration for Animal Production.

Fibrous agricultural residues

National production is estimated at about 15.7 million tons annually, including cereal straw, berseem hay, maize stover, corn cobs, sugarcane tops, rice husk, and rice straw (Table 17). Sugar beet tops and cotton hulls are also utilized.

Table 17. Fibrous agricultural residues produced in Egypt (1990).

Fibrous agricultural residues	Quantity (tons)
Wheat straw	2,800,000
Bean straw	400,000
Berseem straw	200,000
Barley straw	200,000
Berseem hay	350,000
Maize stalks	4,500,000
Corn cobs	600,000
Rice straw	2,500,000
Rice hull	400,000
Bagasse	1,000,000
Sugarcane tops	800,000
Cotton hulls	35,000
Total	15,785,000

Source: Academy of Scientific Research and Technology, National Animal Feeding Project 1990.

Some of these residues are included in the concentrate compounds to produce a complete feed compound for ruminants. The use of fibrous agricultural residue is limited to 4.5 million tons because of its low nutritive value, the lack of information available to farmers on how to increase nutritive value, and the economics of collecting residue from small holdings.

Net feed balance

The available feed resources expressed as quantities and nutritive value are presented in Table 18. If the values presented in the table are correct there is no feed deficit.

Table 18. Contribution of feed resources to national production (1990).

Source	Quantity (tons)	TDN† (tons)	DP‡ (tons)
Green forages	71,450,000	9,228,5000	1,429,000
Compounded feed	2,500,000	1,375,000	250,000
Fibrous agricultural residue	15,785,000	5,524,750	
Total		16,128,250	1,679,000

† TND = total digestible nutrition.

‡ DP = Digestible protein.

Market, prices, and quality

Compounded feed distribution has been controlled by the Ministry of Agriculture. Quotas were set to allocate supplies for the following categories:

1. Quarantine.
2. State companies.
3. Large and private owners with a minimum of 10 head who insure their animals.
4. Enterprises and owners who deliver their milk to Misr Dairy Company.
5. All poultry enterprises, based on the number of fowl owned.

The quota system was adopted because of the feed industry subsidies. The system consequently has afforded very little opportunity to small holders to participate unless they form a cooperative to meet the minimum requirements.

The government has taken action to regulate the livestock/poultry feed industry in addition to the old quota system. The Ministerial Decree issued in 1984 allows the private sector to invest in the feed industry, ending government control over the industry. The decree also regulates the formulation, raw materials, and nutrients required for production as well as quality control.

Consequently, most of the raw materials are in the free market, except cotton seed cake, which goes to the government-owned factories. Animal and poultry feed prices are uncontrolled. Factories can get the raw materials, manufacture feed, market it, and the better the quality the better the profit. The feed formulation industry is very innovative due to high competition amongst producers.

Feed formulation and quality of ingredients are the basic elements of the quality control system adopted by the Ministry of Agriculture (Central Laboratory for Food and Feed). The Central Administration for Animal Production, working in coordination with the CLFF, has specialists at every governorate level whose job is to follow up on quality control and make sure the system is not violated.

The new free system of feed distribution applies for ruminants and poultry feed compounds. For ruminants, 900,000 tons is allocated to the participants of the National Project for Buffalo Veal Development and those farmers who deliver their milk to Misr Dairy Co. The remainder is in the market on a competitive basis.

Table 19 summarizes the current trends of livestock feed compounds and their prices during 1980–90. The regular feed is a formula licensed by the Ministry of Agriculture and produced by the factories owned by the Ministry of Industry. Free feed is produced on a free formulation basis and is controlled by various quality control agencies.

Table 19. Livestock compound feed production and prices (1980–1990).

	Regular feed		Free feed	
Year	Quantity (tons)	Price (LE/ton)	Quantity (ton)	Price (LE/ton)
1980	1,112,000	42		
1982	1,060,000	42	100,000	102
1984	1,224,000	42	300,000	124
1986	120,000	95	450,000	160
1988	1,200,000	117	810,000	280
1989	1,200,000	190	1,170,000	300
1990	900,000	235	16,000,000	330

Source: Ministry of Industry, Ministry of Supply and Ministry of Agriculture (unpublished data 1990)

Cropping Patterns and Rotations

Crop rotations are used to: i) improve soil tilth and structure; ii) provide nitrogen for crops following legumes in a rotation; iii) improve infiltration and reduce erosion; iv) lessen economic risk by diversifying crops; v) allow better labor distribution; and vi) enable better weed, insect, and disease control. Rotations are an essential part of managing the soil to produce the maximum consistent return over a long period. Unfortunately, at the beginning of this century, rotation disappeared as an important tool of farm planning in all private farms. Fragmentation of farm size due to the Agrarian Reform Laws and by the natural inheritance law caused crop rotation to end. There is now a very credible school of thought which relates deteriorating soil characteristics and consequent decreasing crop production and increasing pest, insect, and disease incidence, with the absence of rotation systems.

General Features of Crop Rotations

Despite the absence of crop rotation on private farms, some general features of crop rotation remained due to government policy aimed at protecting strategic agricultural commodities. In addition, since water is available year-round, and agriculture is fully irrigated, continuous cropping is the general rule all over the country. A number of different crop rotations are followed throughout the country, depending on crop and soil flexibility (Shafshak 1973). Two-year rotations are often used in poor soils in the northern parts of the Delta. These soils tend to be saline or alkaline. Cotton and rice are the usual summer crops and berseem is the winter crop. The most commonly followed rotation is a standard three-year cotton rotation. Berseem is planted in winter as a cash crop, with one or two cuttings taken. This is followed by cotton as the summer crop. The second division is planted in winter with wheat, followed by maize or other summer crops, and the third with berseem and legumes followed by maize, rice, or grain sorghum, depending on the region.

In a socioeconomic study conducted by Basheer *et al.* (1983) in Kafr El Sheikh and Minya Governorates, representing the Nile Delta and Valley, the crop rotations in Kafr El Sheikh were rice/faba bean/rice, cotton/faba bean/rice, and cotton/faba bean/maize. In Minya they were maize/faba bean/maize and cotton/faba bean/maize..

One special rotation is the sugarcane rotation. The area cropped to sugarcane is about 113,000 ha, with an average yield of 100–120 t/ha. The main producing governorates are Qena, Aswan, and Minya. The crop is usually planted either in October or between February and April. The cane crop is harvested 12–14 months after planting, followed by 4–5 ratoons taken at 12 month intervals. Thus, the crop is on the field between 5 and 6 years, after which the land is often planted with winter (mainly wheat) and summer (mainly cotton) crops for one or two years, then replanted with a new cane crop.

The effect of crop rotation on production has been studied by several investigators. Shafshak *et al.* (1974), reviewed the results of the permanent crop rotation experiment at Bahtim and found that the grain yield of wheat in the three-year rotation was about 29 percent more than the two-year rotation. Growing clover in a two-year rotation reduced weed density more than clover in a three-year rotation. Wheat and maize in three-year rotations had less weeds than in two-year rotations (Shafshak *et al.* 1981). Growing clover in a three-year rotation reduced the nematode population by 17.5 percent. Similarly, a three-year rotation reduced the nematode population in the rhizosphere of wheat by 64 percent over the two-year rotation. Shafshak *et al.* (1982) showed that crop rotation did not significantly affect fresh and dry forage yield of clover. Insignificant increases were recorded in forage yield in the two-year rotation, indicating that Egyptian clover can be considered a self-compatible crop in rotation. Significant increases in fresh and dry forage yields of clover grown were recorded in rotation with cotton that had been fertilized with green and farmyard manure, compared with untreated and N fertilized cotton rotations.

Aly *et al.* (1993) found that maize yield was not significantly affected by two-year or three-year crop rotation. On the other hand, Badr *et al.* (1993), found that the highest seed cotton yield/ha was obtained from growing cotton in a three-year rotation. The increases were 30.6 and 60.7 percent over a two-year rotation and monoculture system, respectively. Planting cotton on the 20th of March had a favorable effect on yield in both crop rotations compared with an earlier (1st March) or later (1st April) planting.

Preceding Crop and Crop Sequence

Salem (1973) and Shafshak *et al.* (1974, 1982, and 1984) on maize, and El Moghazy *et al.* (1984) and Kamel *et al.* (1991b) on cotton found that legumes as preceding crops were superior to non-legumes in their effect on yield. Alfalfa and fallow preceding soybean increased yield more than other summer crops (cowpea, soybean, cotton, maize). Faba bean and berseem as preceding winter crops had a favorable effect on soybean yield. Faba bean and lentil were significantly influenced by the preceding summer crop.

Pea, *fahl* berseem (single cut), and fodder maize as crops preceding wheat were studied by Zahera and Seif El Nasr (1993) under two rates of N fertilizer (60 and 80 kg N/fed). *Fahl* berseem had a more favorable effect than fodder maize on wheat productivity, but pea ranked first. Wheat was improved with the higher rate of nitrogen. Seif El Nasr *et al.* (1993) found that maize yield was improved after faba bean more than after berseem or wheat. Berseem was more effective than wheat as the preceding crop.

Biomy (1993) concluded that both dry matter and seed yield of maize grown after faba bean or wheat grown after soybean were remarkably increased over a preceding unfertilized fallow. Abo El Soud (1992) reported that faba bean plants fixed the highest amount of atmospheric N, followed by berseem and soybean. The amounts of N_2 fixed by berseem and soybean were 60 and 50 percent that of faba bean, respectively. Moreover, Abdel Wahab *et al.* (1989) found that the amounts of N_2 fixed by soybean plants grown in South Delta were 22, 58, and 199 kg/ha after 42, 67, and 115 days from sowing, respectively.

Hassan *et al.* (1990) state that the addition of high N fertilizer rates (107 kg N/ha) leads to a marked decrease in nodulation of faba bean and the amount of N_2 fixed. Plants receiving a starter dose of 35.5 kg N/ha showed the greatest number of nodules, dry weight, plant N content, and the amount of N_2 fixed. This reflects the important role of leguminous crops in the rotation and their beneficial effects on growth and yield of subsequent cereal crops.

Crop Sequence and Sustainability

The effect on soil nutrient content due to growing certain summer and winter legume crops in succession was studied by El Debaby *et al.* (1984). Preceding summer crops were fallow, maize, cotton, soybean, cowpea, and alfalfa, and the succeeding winter crops were berseem, faba bean, and lentil. Fallow increased the total N and available P significantly compared with maize, although the highest fraction of soluble N was observed after maize. Soluble P in the soil was greatly affected by soybean and maize, with P content decreasing twice as much as fallow. Soybean showed higher capability to absorb and hence to remove soil soluble K than did the other tested crops. Growing legumes after fallow significantly increased the soil content of total N and available P. No clear effect on soil-soluble P and K due to growing winter legume crops after preceding summer crops was observed.

Soil fertility levels for available N, P, and K after growing pea, *fahl* berseem, and fodder maize showed that the soil was enriched with N after pea (105 ppm), after *fahl* berseem (66 ppm) and after fodder maize (33.6 ppm). N, P, and K were decreased to 56.3, 38.3, and 25.6 ppm, respectively, by growing wheat, indicating that wheat makes better use of available N after pea than after *fahl* berseem or fodder maize (Zahera and Seif El Nasr 1993).

Seif El Nasr (1993) studied the effect of three preceding winter crops, i.e., faba bean, wheat, and berseem, before the summer maize crop. The highest N content was found after harvesting faba bean, and the lowest after wheat, with berseem in the middle. The lowest P content was found after berseem, and the lowest soluble K was found after faba bean. After wheat harvest, soil content of these nutrients decreased, especially N content, to less than half that recorded after harvesting faba bean and berseem.

Higher rates of N fertilizer help sustain nutrient content after wheat or after maize. El Hattab (1957) stated that abundant amounts of residues left after growing berseem and the gradual decomposition of these residues furnish a continuous source of N during the subsequent growing season. Shafshak *et al.* (1982) found that wheat grain and straw yields are higher after cotton treated with green manure or farmyard manure and 60 kg N/fed.

Shafshak *et al.* (1976 and 1981) state that crop rotation is one of the very best means of controlling weeds. Only 30 out of 1,200 weed species survived. The inclusion of inter-drilled crops such as sugarcane and maize in the rotation suppresses the weeds in the following crops. Clover is superior to wheat, barley, and faba bean in reducing the spread of weeds in wheat grown in the following season. In cotton fields, the highest weed densities were found in cotton grown after faba bean or a year after fallow, whereas depressed weed growth was recorded in cotton grown after clover/maize, wheat/maize, barley/maize, and clover (Shafshak 1976).

The residual effect of cotton fertilization significantly affects the spread of nematodes in clover and wheat. The highest nematode population in clover was after cotton supplied with 60 kg N/fed. For wheat, the highest population was after poorly fertilized cotton. Berseem rather than other winter legumes as a preceding crop caused considerable reduction of parasitic root nematodes.

Allelopathy, Antitoxicity, and Crop Sequence

One of the most studied areas of allelopathy is its role in frequent field successions and other natural ecosystems (Rice 1974). There have been many reports of crop/weed or crop/crop allelopathic interactions. These have involved sunflower on soybean and sorghum, and wild oat on numerous field crops. Ferulic acid from field-grown wheat effectively reduces some weeds in a no-till cropping system (Klein and Miller 1980). In Egypt, research related to allelopathy is scarce. Allelopathic effect of alfalfa on some forage crops was studied by Toema (1994). He reports that water extract of seed or root of alfalfa inhibits sweet clover, red clover, red top, Johnson grass, wheat, rye, and triticale. In field trials, positive reactions of alfalfa were found on red top, Johnson grass and triticale, whereas negative reactions of Johnson grass on all other forage crops were found.

Rotation, Soil Characteristics and Water Management

Salty soils are common around El Salam Canal (approximately 250,000 ha), including parts of Damietta, Sharkia, Ismailia, and Port Said Governorates. A major part of this area was flooded with sea water before drying the lakes. In rotations specifically aimed at salt and alkali control, farming system agronomists and soil scientists recommend: i) a crop rotation adapted to these soils which includes proper duration of transitional period, crop sequence, proportion of applied irrigation water used for leaching out residual salts from the soil, and the amounts of gypsum that must be added to alkali soils; ii) the choice of salt-tolerant crops, which is also an excellent insurance against salt and alkali problems (salt content can be reduced by growing crops that accumulate sodium such as some species of grass, e.g., *Atriplex* spp., agropyron, sugar beet, sorghum, sweet clover, rice, barley, and sweet maize); iii) encouraging specific farming systems, i.e., establishing animal production areas or growing grasses and clover; iv) applying new agro-techniques and cultural practices, i.e. modifying tillage and ridging systems and assessing water requirement at different stages of plant growth, which may reduce the harmful effects of salinity; and v) applying a normal crop rotation after a transitional period, which suits the nature of these soils.

When the Nile flood is below standard, or in some fields where water irrigation is a limiting factor (at the tail end of canals), water stress rotations instead of the normal rotations are considered important to economize water and increase water-use efficiency. Dramatic changes in the duration of the rotation as well as the crop sequence within the rotation are the major features of water stress rotations.

El Behairy (1949) and El Balkeiny (1952) suggest a three-phase crop rotation for saline and alkaline soil reclamation. The first phase includes a transitional period for salt leaching and adding gypsum, then growing rice successfully. Rice is followed by berseem. However, if the berseem is poorly germinated, salt leaching and/or adding gypsum continue. Permanent berseem is recommended in winter, and sudan grass, sorghum grass, or lucerne in summer. A barley–rice sequence prior to the second phase is suggested. The second phase is typical salt-tolerant rotation, starting with a two-year rotation of barley–rice/permanent berseem and forage sorghum or rice. A three-year rotation of barley–rice, berseem–forage sorghum, berseem (as a cover crop) –cotton prior to the third phase is recommended. In the third phase, the normal two- or three-year rotation is recommended where wheat and faba bean replace barley, and maize can be satisfactorily grown in the summer.

El Shaaer (1985) recommends a rotation for saline and alkaline soils. He suggests berseem, a mixture of berseem/rye, and berseem/barley/lucerne as winter crops and rice, cowpea, lucerne or sweet maize as summer crops.

Soliman *et al.* (1993) reports that rice cvs Giza 154 and 175 were salt tolerant, Giza 171 was intermediate, and IR-28 was a salt-sensitive cultivar. The Sakha 8 wheat cv was salt-tolerant.

Sustainability

Pure agronomic considerations do not always dictate crop rotation and sequence. The system which suits a particular area depends upon a number of factors whose relative importance is likely to differ from time to time in terms of profit, the degree to which a crop dominates the agriculture economy, suitable soil, the susceptibility of soil to deterioration, the build-up of soil-borne diseases and pests, and the type of farming— intensive or extensive. Sustainable production can be achieved with the help of prior experience and the latest scientific advances to create integrated, resource-conserving, equitable farming systems. Balanced rotations reduce environmental degradation, maintain agricultural productivity, promote economic viability in both the short- and long-term, and maintain stable rural communities and quality of life.

In fact, farmers in Egypt can implement a number of strategies that can help sustain both productivity and profit while reducing adverse effects on the environment. These strategies can be summarized as follows:

- Crop and variety choice.
- Management of soil fertility.
- Pest management strategies.
- Tillage options.
- Crop rotation and cropping system.

More diverse systems may be more sustainable:

- Rotating legumes and cereals to provide fertility to boost yields.
- Using longer and more complex rotations for more diversity and potential for stability.
- Over-seeding grasses to capture N and help recycle nutrients.
- Introduction of different crop rotations to reduce fertilizer costs and eliminate the need for chemical control of some pests.
- Introduction of specific rotations that can resist salinity and alkalinity problems.
- Introduction of some natural agronomic systems in rotations that reduce chemical inputs (fertilizers, pesticides, and herbicides) to enhance soil arthropod activity and populations of micro-organisms.
- Use of a greater diversity of crops and crop/livestock enterprises as a buffer against climatic and market changes.
- Reduced tillage to increase soil organic matter content, reduce water and soil loss, and improve soil tilth in some soil types.
- Define duration of crop rotation and crop sequence (in relation to the main crop) to move the operation into a more resource-efficient and sustainable mode.
- Use rotations that avoid environmental inputs and preserve sustainable production.

Multiple Cropping Systems

Intensifying the use of available resources provides an outlet to increase production. Increasing the level of intensification from 1.9 (current index) to 3.0 for the existing crop area (11 million fed) means a net addition of more than 2.1 million ha to the cultivated area. With improved techniques for timely planting of a third crop, farmers will be able to take advantage of this cultural practice.

Multiple cropping (more than two crops a year) can be achieved by the introduction of new agro-techniques:

- Use newly-developed short-season crops and/or short duration cultivars for faba bean, soybean, sunflower, wheat, barley, lentil, and rice. No-till systems can replace conventional tillage systems, saving time, cost, and effort.
- Mechanization of land preparation and harvest would save time and cost.

The competition of major summer crops such as rice, cotton, and maize works against the expansion of the area under oil seed crops if the conventional double cropping system is used. The intensive cropping system (three crops/year) offers a good solution to the problem and reduces the oil deficiency gap. The suggested program includes encouraging farmers to use intensive cropping systems.

Tri-cropping systems

- Winter legumes (short duration varieties, SDV)–soybean (SDV)–maize.
- Winter legumes (SDV)–maize–soybean (SDV).
- Faba bean–sunflower (SDV)–maize.
- Faba bean–soybean (SDV)–rice (SDV).
- Wheat (SDV)– soybean (SDV) or mung bean–rice (SDV).
- Wheat (SDV)– soybean (SDV) or mung bean–maize.
- Sugar beet– soybean (SDV) or mung bean–maize.
- Sugar beet–rice (SDV)–sunflower (SDV).

A higher intensification index can be achieved for short-duration crops and cultivars by using a no-till system to save time, cost, and effort. Planting some annual crops (sugar beet) instead of sugarcane (perennial crop) would contribute to increasing crop intensification by multiple sequential cropping.

Using multiple sequential cropping is a new approach towards increasing the intensification rate of cropping in Egypt. Currently, the short-season soybean varieties that mature in 95 days or less could be planted at the end of March or early April after either berseem (two cuttings) or winter vegetables such as potato, and harvested in June in time for either corn planting or rice transplanting (Hassan *et al.* 1985). This new cropping system would allow two crops instead of one during the summer. Moreover, it would minimize the competition that presently exists with other summer crops such as corn, rice, and cotton for arable land, and, in turn, expand soybean area and production. Growing two successive rice crops in Egypt during the summer after a winter legume was tried by Maximos *et al.* (1985), with an early summer crop from April to August, and a late summer crop from September to

November. Yield was more than doubled in some years after flax or clover. With further testing of new entries in subsequent years, the double cropping resulted in a 25–40 percent grain yield increase in 152 days compared to the single crop (120 days). This system needs to be studied more with regard to water consumption use, soil fertility, and soil physical and chemical properties.

Eisa (1986) found that sowing two crops during the summer, i.e., soybean followed by either soybean or maize, gave higher cereal units produced from straw and grain than sowing one crop, i.e., soybean or maize as a full-summer crop. The best cropping pattern included soybean cv S-1345 + maize cv DC-202.

In a recent study, Aly *et al.* (1993), reports that grain yield of wheat in a tri-cropping sequence (potato planted with the last maize irrigation) was superior to that obtained from wheat grown in a sequential cropping system, i.e., maize–potato–wheat, but slightly less effective than the normal two-crop sequence, i.e., maize followed by wheat.

El Hossary *et al.* (1980) emphasize mechanization in crop intensification, suggesting some tri-cropping sequences (three crop/year) are possible with the use of full mechanization for land preparation and harvest and the incorporation of early maturing varieties. They suggest berseem/early-maturing vegetable varieties/cotton and wheat/EMV vegetables/EMV maize; and faba bean/EMV vegetables/rice. A cropping index of 3.0 can easily be reached.

Mixed Cultivation

The practice of mixing crops together in the same field at the same time or in relay at different times to increase land-use efficiency is becoming an important and popular approach to farming systems in Egypt, especially by subsistence farmers. Reasons for this popularity are: the limited cultivated area, which is not meeting the needs of the rapidly increasing population; the increased cost of inputs (fertilizers, pesticides, and insecticides), and the slow increase in agricultural prices. The practice diminishes the competitive ability of berseem against other winter crops, and has a lower variability of annual return than mono-cropping system. Other reasons for its popularity are:

- Profit and resource maximization and efficient water utilization.
- Use of atmospheric N_2 by cereals when mixed with legumes.
- Stability of fertility and sustainability in crop production.
- With intercropping, there is a mixture of susceptible and resistant crops, and thus a certain distance from one host crop to another is important. The more the system resembles the diversity of a naturally resistant or tolerant ecosystem, the higher the success in avoiding destructive levels of plant disease and pests. Intercropping also offers sustained yields through biological diversity (biological buffering), sustained income (economic buffering), and stability in soil fertility.

Intercropping Systems

Ridge intercropping

Corn–soybean intercropping

Intercropping soybean with corn is a cropping system that can help battle the food crisis in Egypt. This pattern of agriculture would help to achieve the national soybean production target (500,000 tons) without disturbing the cropping structure in Egypt. This would require 200,000 ha that can never be allocated within the existing crop structure.

A corn–soybean intercropping pattern of 2:2 is recommended in early planting and 2:4 in late planting for high yield of both corn and soybean (Zahran 1970; Ibrahim *et al.* 1977; El Boray 1978; Metwally 1978; El Habbak 1985).

The increase in plant density of both corn and soybean also results in increased grain and seed yield/ha of corn and soybean (Abdel Raouf 1973; Metwally 1973; El Hefnawy 1975; Amer 1980; Khedr 1982; El Habbak 1985; El Doubi 1992). Sherif (1993) found that intercropping soybean with corn diminishes the rate of N fertilizer, indicating that intercropping economizes the use of N fertilizer per unit area. Galal *et al.* (1980), El Habbak (1985), El Doubi (1992), and Sherif (1993) found that when soybean was intercropped in different spatial arrangements, land resources were better utilized, resulting in land equivalent ratios ranging from 1.30 to 1.65. All intercrop combinations recorded higher values than monoculture of either corn or soybean.

Statistical data from small and medium farms that were using this pattern between 1986 and 1991 show that although yield for each separate component is lower than with monocropping, intercropping increases land utilization between 57 and 84 percent. Economic return increased between 55 and 62 percent for corn and between 61 and 120 percent, for soybean.

Constraints:

- Lack of varieties adapted to intercropping.
- Poor nodulation in soybean in some regions.
- High input costs resulting from pesticide abuse by farmers.
- Lack of experience creates poor application of cultural practices (optimum plant densities and rates of fertilizer in particular).
- Recommended package transfer to farmers through the extension service is still far below the level required.

Sugarcane–legume intercropping

Recently, there has been a great interest in intercropping on cane fields. A variety of crops are being intercropped with cane, such as faba bean, lentil, wheat, medicinal plants, some vegetables (cucumber and tomato), soybean, mung bean, and others. Intercropping in cane-growing areas is expected to expand and gain popularity among cane farmers to meet increasing production cost, maximize land utilization, provide farmers with rapid and higher gross and net returns, and avoid risk of poor yield and fluctuations in international prices of cane. Agricultural policy also supports this farming system to increase production without altering the prevailing structure.

El Geddawi *et al.* (1988) found non-significant differences between wheat grown in pure stands or intercropped with cane. Cane yield was slightly affected by intercropping, but quality was not impaired. Intercropping wheat with cane increases land usage by 70–75 percent compared with monocropping. Economic analysis showed gains due to intercropping estimated at 600 LE/ha compared to a pure stand of cane. Al Sharkawi (1988) reports that intercropping faba bean with cane increases the fresh cane yield as compared with solid planting, and that intercropping cane with wheat, faba bean, and barley increases sucrose yield/ha compared with solid planting.

Nassib (1983) also reports that faba bean and lentil can be successfully intercropped with cane in the sugarcane belt in Upper Egypt. Recently, Hussein *et al.* (1991a) found that intercropping faba bean inoculated with specific rhizobia at a population of 25–33 plants/m^2 in Minya Governorate produced the same yield as that from monocropped faba bean. Moreover, sugarcane yield was slightly improved under this system. Nour *et al.* (1979) found a slight reduction in yield of the intercropped cane (8 tons/ha) but there was an increase in net return. They found that intercropping cane with bean gives a higher income compared with planting cane alone. El Zahawy (1994) studied the effect of intercropping soybean with spring cane and found that cane yield was slightly reduced by intercropping. The relative yield of cane was 0.98. Nevertheless, intercropping led to increases in the land utilization ratio to 1.38. The optimum sowing date for soybean was 13 days after planting the cane and optimum hill spacing was 17.5 cm.

Constraints to cane intercropping:

- Lack of experience and knowledge of how, when, and what to intercrop with cane sometimes leads to negative results. For example, farmers in Sohag and Qena Governorates were keen to intercrop wheat with sugarcane, but ignored the proper N, P, and K fertilizer rates. The practice resulted in severe adverse effects on the yield of both crops.
- In soybean–sugarcane intercropping, it is very important to know the time to plant the cane to cope with processing and avoid delay of soybean sowing.
- Failure of nodulation in soybean in some regions was found.
- Intercropping with first and second ratoons led to poor results due to vigorous growth and dense cane populations.

Sugar beet–faba bean intercropping

To cope with the introduction of sugar beet as a new winter crop in the rotation in the North Delta, many investigators (Nassib *et al.* 1991; Khalil *et al.* 1992; El Borai and Radi 1993) have conducted experiments to study the effect of intercropping faba bean with sugar beet in the farmers' fields at Kafr El Sheikh. Planting faba bean in hills spaced 60 cm apart with sugar beet had a slight adverse effect on sugar beet yield. Increasing faba bean population density by decreasing the distance between hills resulted in a significant reduction in sugar beet yield.

Faba bean–fodder beet intercropping

Planting faba bean on one side of the ridge and fodder beet on the other side is recommended. However, planting fodder beet on top of the ridge was preferable at Sids and Sakha (Ali *et al.* 1984).

Crop mixtures

The practice of mixing crops together (especially forage crops) has been carried out for a long time all over the world. Variability in annual returns of crop mixtures is less than that of sole crops. Forage mixtures show higher nutritive value compared with sole forage crops.

Berseem was mixed with Italian ryegrass by Beshay (1980), El Hakeem (1981), and Hussein and Abdel Latif (1982). The advantages achieved were higher forage yield, lower variability of yield from season to season, a better spread of production over the growth period, lower susceptibility to disease or lodging, and improved quality of the forage crop produced. Grass and legume mixtures showed increases in productivity of yield compared with pure stands of both crops (Ibrahim 1975, ryegrass with berseem; Hefni *et al.* 1978, barley with berseem; Beshay 1980, ryegrass–berseem mixture; El Hakeem 1981, Egyptian clover–ryegrass; Nasr 1981, clover–grass; and Gabra 1984, alfalfa with Nubian grass).

The effect of N fertilization on productivity of a berseem and barley mixture was studied by Nor El Din *et al.* (1984). They found the following: i) dry matter, starch value, and total digestible nutrients in berseem and the mixture were not affected by N fertilization; ii) interseeding barley with berseem increased these three parameters by 2.4, 1.0, and 1.5 percent, respectively, over berseem in a pure stand; and iii) the yield of the legume–grass mixture was higher than that of legumes or grass in pure stands.

Gabra *et al.* (1984) studied the effect of N, P, and K on forage yield of a mixture. They found that berseem, barley and their mixture are not much affected by the source and level of the fertilizers studied. In most cases, forage yield of pure berseem and for the mixture were nearly the same. Dry matter and starch equivalent yields were somewhat higher for the mixture than for pure-stand berseem.

Khafaga *et al.* (1984) carried out a comparative study for nutritional evaluation of berseem and its mixtures. They found that interseeding berseem with barley and ryegrass improved the nutritive value of the forage compared with pure berseem, and that Tyfon should not be mixed with berseem due to its poor quality.

The Beheira Rural Development Project (BRDP) aimed at increasing productivity of green forage crops by using a mixture of berseem with barley on 1,736 ha in 40 villages in Kafr El Dawar, Abo Homos, and El Mahmodia. The study aimed at reducing berseem acreage and water requirement but increasing nutritive value by increasing dry matter content in the mixture. The results of the study evidenced an increase in production of green forage estimated at 15 percent and reached 20 percent by using *Rhizobium* inoculation. The increase in the second and third cuts was estimated at 12 and 5 percent, respectively. The total cost ratio was 5.5 in the mixture but 3.2 for berseem alone. Water requirement was reduced by 833 m^3/ha.

The practice of mixing *fahl* berseem with either barley or wheat is common on small-scale farms. Gabra *et al.* (1984) noticed that forage yield of a berseem–barley mixture was nearly the same as that of a pure stand of berseem. The dry matter yield was somewhat higher in the mixture than in the pure stand of berseem. Kamel *et al.* (1991c) found that 36 kg of *fahl* berseem seed and 178 kg of wheat seed/ha were an optimum mixture for seed production.

Relay cropping

Cotton growers in recent decades have suffered from the rapid increase in production costs, which have not been matched with an equal increase in prices. Moreover, the deterioration of cotton productivity has been a cogent reason for farmers to avoid cotton production. Because of this, farmers have tried to seek a new farming system to maximize land utilization and result in higher gross income. Cotton has frequently been relayed with onion and garlic. Several investigators found that cotton is not adversely influenced by relay cropping (Eid 1969; Ashoub 1978; El Gahel 1987). On the other hand, several trials on growing long-duration winter crops such as wheat and faba bean before cotton were not encouraging, especially when cotton was preceded by wheat (Kamel *et al.* 1991a).

The feasibility of relaying cotton with faba bean and wheat was studied by Kamel *et al.* (1992). Cotton cv Giza 75 was relayed with both winter crops at two planting dates (15 and 30 March) on either conventional cotton ridges (60 cm apart) or on wide ridges (120 cm apart). Wheat and faba bean were grown on the other side of cotton ridges or in rows on the top of the wide ridges. The data indicate that growth and yield of faba bean on the wide ridges were better than those on conventional ridges. The later relay date for cotton on faba bean had a favorable effect on growth and yield of both faba bean and cotton. Relaying cotton with faba bean had no deleterious effect whether the cotton was planted on the conventional or wide ridges. A similar trend was observed when cotton was relayed with wheat, except that growth and yield of cotton relayed on conventional ridges were better than those on wide ridges.

Agro-techniques in Farming Systems

The following new agro-technologies may help to increase the rate of intensification:

- The change from seeded to transplanted cotton produces desired yields in a shorter period of time, reduces the amount of required chemicals, protects seedlings as well as bolling, reduces losses associated with seedling disease through planting late when soils are warmer, minimizes the rate of seeding which in turn saves additional seed for oil extraction, and allows a shorter growing season with a variety of winter crops to achieve maximum land-use efficiency and net return.
- The change from seeded to transplanted wheat would offer to farmers the possibility of increasing intensification by growing potato as an autumn (*kharifi*) crop between corn and wheat with no appreciable reduction in wheat productivity.
- The change from transplanted to directly seeded rice would save time, effort, and labor, provided that the weed problem could be effectively overcome.
- No-till or minimum tillage systems, especially in the calcareous sandy soils of the newly reclaimed lands in the northwestern plain of Egypt, save fuel and land preparation costs, preserve sustainability, offer flexibility in planting and harvesting time, avoid compacting created by heavy equipment, and reduce the labor requirement.
- Application of modern methods of irrigation, i.e. sprinkler or drip irrigation, increases water-use efficiency.

- Applying organic and natural fertilizers to some major crops saves costs, avoids pollution, and improves sustainability.

Abd El Bar and Atta (1957) found that cotton seed yield of transplanted fields (550 kg/ha) was significantly higher than that of direct-seeded ones (346 kg).

El Zaree (1981) reported that direct seeding on 20 March produced significantly higher yield of cotton seed than seeding on 20 April or transplanting. Helal (1986) found that late sowing or using older seedlings decreased cotton seed yield, but early sown cotton plants and younger seedlings produced higher yield. Radwan (1988) and Kamel *et al.* (1991) found that early transplanting with younger seedling (30 days old) produced satisfactory cotton seed yield compared to that obtained from normal planting. On the other hand, the lowest yield was obtained from transplanting late using older seedlings (50 days old).

Abbas (1981) obtained high yields by transplanting 30-day old seedlings on May 9, whereas low yields were produced by transplanting 40-day old seedlings on May 22.

Results from 20 demonstration plots in five governorates (Sharkia, Dakahlia, Gharbia, Beheira, and Qalubeya) during 1993 were as follows: transplanted cotton gave a yield of 19.5 qentars of cotton seed/ha, which was comparable to direct seeding during March, but significantly higher than seeding late in early May. Transplanted cotton set in fields after faba bean, berseem, or wheat averaged 21.7, 19.1, and 10.3 qentars of cotton seed/ha, respectively. It was also found that seed yield of faba bean was not significantly influenced by the tillage system. A mixture of the herbicide Topogard and Stomp (2.97 Topogard + 4.05 L Stomp/ha) gives effective control of weeds in faba bean fields.

Normal tillage did not differ much from the no-till system in terms of seed and straw yield in faba bean grown after cotton or corn in Minya, but normal tillage was superior to the no-till system when faba bean was grown after rice in Kafr El Sheikh (Nassib *et al.* 1983; Hussein 1991b). The no-till produced slightly higher seed yield of faba bean compared to other tillage systems (chisel/chisel or moldboard/chisel). In addition, N and P uptake was greater in untilled than tilled soil.

In a lentil study in Kafr El Sheikh, minimum tillage was superior to conventional tillage using a chisel plow (Rizk and Hassan 1990).

Current and Future Trends

Corn/early-maturing soybean

Efforts are being made by the Crop Intensification Research Section of the Field Crops Research Institute, ARC to evaluate some early-maturing (80–90 days) soybean cultivars, recently developed by the Food Legumes Research Program (FLRP) for tolerance to intercropping with other summer crops.

Sequential cropping

Newly developed short-season soybean cultivars that mature in 95 days or less could be planted at the end of March or in early April after berseem (two cuttings) or winter vegetables such as potato, and harvested in June in time for either corn planting or rice transplanting (Hassan *et al.* 1985). This system would allow two crops during the summer instead of one. Moreover, it would minimize the competition for arable lands that presently exists with other summer crops such as corn, rice, and cotton, and, in turn, expand the soybean area.

Cash crops

Farmers in some areas in the Delta grow summer vegetables such as potato. After harvest in early June, the land is usually left fallow or planted to corn at a high seeding rate (*darawa*) for animal feed before the next potato crop is planted in September. In one study, early maturing soybean cultivars (95 days or less) were monocropped in this niche, with a yield of 3 t/ha in 96 days and no delay in planting the next potato crop (Hassan *et al.* 1992, unpublished data).

Leaf-feeding insect-resistant soybean after wheat

The FLRP has developed soybean cultivars that are resistant to leaf-feeding insects. They can be planted in June after the wheat or barely harvest as a full season soybean crop. This would minimize or eliminate the high use of insecticides, ending a long-standing cotton leaf worm problem.

Faba bean and cotton system

The FLRP has developed new faba bean cultivars that are resistant to chocolate spot and rust diseases and have high yield potential. These cultivars could be planted as a full-season faba bean crop in October and harvested in late March in time for cotton planting on the faba bean ridges without land preparation (work carried out in Dakahlia Governorate, under the FLRP in 1993/94.

Benefits from New Cropping Systems

- More efficient use of farm resources.
- Greater resource efficiency of farm wastes and by-products.
- Increase in land utilization.
- Stabilization of farm income.
- Minimization of risk.
- Minimization of environmental pollution by reducing N fertilizer rates and insecticide use.
- Increase soybean and faba bean area and production (current demand exceeds local production).

Major Production Constraints

In general, major constraints for crop production and improvement can be categorized into three groups, as illustrated below.

Biological and Technical Constraints

1. Egypt suffers from poor soil fertility associated with salinity, poor water management, excess irrigation, a poor drainage system, high N fertilizer input cost, and the need for other micronutrients. In addition, hand fertilization appears to result in poor distribution.
2. Plant densities are too low and uneven to produce high yield and make efficient use of a high N level. Poor stands may often be associated with seeding by hand and consequent poor distribution and germination.
3. Poor weed control is a major problem in most arable areas.
4. Poor management is practiced, such as:
   - Poor seedbed preparation at planting.
   - Uneven seed depth and cover due to hand seeding.
   - Late planting in some localities.
   - Poor water management (excess or deficit).
   - Primitive methods of harvesting, threshing, transportation, and storage, resulting in extensive grain loss.
5. Insect damage to food legume, wheat and barley plants, especially by aphid, is common. Storage insects lead to grain losses and poor seed quality.
6. Disease damage is prevalent in most field crops where favorable conditions for various diseases are present.
7. Soil salinity and alkalinity problems associated with poor water management represent a major limiting factor for the productivity of most field crops.

Institutional and policy constraints

1. There is a lack of a dynamic and effective extension system.
2. The gap between research and extension still exists.
3. The necessary quantity and quality of inputs are not readily available when needed by the farmers.
4. There is a lack of a dynamic administrative and management system.
5. There is segmentation of various research and production efforts on the same crop into various institutes and sections.

Extension Constraints

Field crop programs require that researchers and extension personnel work closely together to eliminate constraints in crop productivity and production. The mission of this multidisciplinary approach is to reach farmers with improved seed of high quality cultivars and recommended practices as quickly as possible.

Although there are various constraints in the research program, the main problem is how to transfer the already available research results to the farmers. There are many constraints confronting the extension program in Egypt:

1. Lack of communication between research and extension.
2. Isolation of extension agents from one another.
3. Lack of quick and effective delivery of research results to the extension system and then to the farmers.
4. Many farmers are suspicious of governmental agents.
5. Shortage of well-trained extension workers in the districts and villages.
6. Engagement of extension personnel with many other governmental regulations and activities.

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