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Resource Management Series

Volume 6

INVENTORY STUDIES

New Lands of Egypt

Agronomy

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Volume 6

Resource Management in the New 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

Acronyms

ARC = Agricultural Research Center

BBWV = Broad Bean Wilt Virus

EC = Electrical Conductivity

ESP = Exchangeable Sodium Percentage

FAO = Food and Agriculture Organization of the United Nations

FCRI = Field Crops Research Institute

ICARDA = International Center for Agricultural Research in the Dry Areas

IPM = Integrated Pest Management

MALR = Ministry of Agriculture and Land Reclamation

SWRI = Soil and Water Research Institute

TMV = Tomato Mosaic Virus

UNDP = United Nations Development Programme

WUE = Water-Use Efficiency

Executive Summary

Current productivity in the newly reclaimed lands suffers seriously from a number of constraints. In general, the New Lands are characterized by water scarcity and an imbalance of soil fertility. The soils are sandy to light-sandy loams with high pH, permeability and water infiltration rates. Some of the loamy sands and sandy loams are calcareous. Macro- and micronutrients as well as the organic matter are strongly deficient.

The success of New Lands reclamation is not measured by the magnitude of reclaimed areas but rather in terms of production achieved. Cropping patterns in the New Lands are largely dependent on:

- Farmer experience.
- Soil fertility and inputs.
- Water availability.
- Availability of livestock.
- Household size and labor availability.
- Financial means, marketing, and other facilities.

There are notable differences in the cropping patterns due to these factors.

Farmer settlers have the advantage of experience and large households, thus they leave less land fallow than the graduates. The graduates' major constraints to intensive cultivation include shortages of labor and cash for inputs. A favorite winter crop is pea, which occupies about 35% of the total cultivable area in Nubaria and El Bustan. However, in general there is no fixed crop rotation in the New Lands.

Investors have planted a significant area with fruit trees, but graduates and farmer settlers have allocated a larger area to field and vegetable crops. The main fruits grown are citrus, apple, pear, grape, and peach.

Crop diversification varies according to the agroecological zones in the New Lands. For calcareous soils (Sugar Beet area) with heavy texture and high moisture-holding capacity, berseem is recommended as the major fodder crop in winter. Fodder sorghum should be introduced as the major summer feed crop. Both crops are preferable to perennial alfalfa, which does not perform well in heavy soils. Faba bean should continue to be promoted as the major food legume suitable to this type of soil.

In sandy soils, crops that are resistant to drought and require light soil texture should be given preference. Pea should be the major food legume, replacing faba bean, and alfalfa should be the main fodder crop, replacing berseem and fodder sorghum. Groundnut is at present the only oil crop that has proven its adaptability to sandy soils in drought areas.

Vegetables and fruit trees have a high potential in both calcareous and sandy soils. An exception among fruit trees is citrus, which does not grow well in calcareous soils and in soils with a high pH. The present trend of establishing citrus orchards should be discouraged. Low chilling-requirement pears and peaches should be promoted. Fruit trees give a stable income to farmers, and do not need much labor once established.

High salinity may kill crops, or at least have adverse effects on growth and yield. Growing salt-tolerant crops such as cotton, sugar beet, and barley, as well as salt-tolerant fodders, is an appropriate choice for improving productivity in such soils. Moreover, an irrigated rice ecosystem might be sustainable in saline soil agriculture.

For both settler farmers and graduates, raising livestock is of considerable importance in terms of recycling soil fertility, although livestock numbers are relatively small. Production is mainly oriented towards home consumption of milk, meat, and eggs, and the production of manure. Berseem and alfalfa are the main legume fodder crops and are utilized for grazing, cutting, and making hay. During the summer months forage is particularly scarce due to the reduced area under perennial alfalfa.

The application of farmyard manure, moved from the Old Lands to the newly reclaimed lands, has resulted in the spread of weeds, as well as root rot and wilt problems.

Thirty winter weed species were identified in wheat and faba bean fields. *Avena* spp. are the dominant grassy weeds, followed by *Lolium* spp. and *Polypogon* spp. The most common broad-leaf weeds are *Anagallis arvensis*, *Emex spinosus*, and *Chenopodium album*. About 50% of the faba bean fields sampled were heavily infested with *Orobanche crenata*. Several common summer weeds have also been identified.

Herbicides are commonly used to control weeds. However, new farming and agricultural tactics must be suggested to reduce the need for herbicides. Crop rotation and new, competitive crops are essential in alleviating weed problems.

The lack of appropriate agricultural machinery restricts production potential. The rapid increase in the use of agricultural machinery, particularly tractors and tillage equipment, has not been accompanied by the mechanization of other agricultural operations. Constraints include the lack of appropriate equipment for fertilizing, seeding, land leveling, harvesting, and threshing.

Common wheat stem and leaf rusts are also found in the New Lands, but most common wheat varieties are genetically resistant. Common root rot, *Helminthosporum* sp. and *Fusarium* spp. are observed in some places. Slugs and snails are occasionally found in the New Lands but do not cause significant losses. Aphid infestation of cereal plants is not significant.

In contrast, the foliar diseases—chocolate spot (*Botrytis fabae*) and rust (*Uromyces fabae*)—are the main factors hindering faba bean production in the New Lands, especially in the north sector of Tahrir Province.

Several diseases and insects seem to be economically important in tomato, fruit tree, and other field crops common in the New Lands. Chemicals seem to be the main tool for controlling damages caused by disease and insects.

Integrated Pest Management is accepted in principle for sustainable agriculture. Yet relatively little research is being conducted on crop rotations and crop management practices for pest control in dry lands. Research should also be directed towards breeding as a biologically important pest control strategy.

Wheat has been widely adopted in the New Lands (sandy and calcareous soils) to meet the basic needs for food grains, and as a cash crop. Wheat is suited for both surface and sprinkler irrigation. However, wheat productivity under New Lands conditions is only about 3 t/ha, far below the national average (5.5 t/ha).

Wheat production in the New Lands is seriously constrained by the use of inappropriate agronomic practices. Seeding rates and planting dates are not always optimal and the majority of farmers broadcast their seed, which makes weeding a difficult and labor-intensive operation. The natural fertility of desert soils is very low in terms of macro- and micronutrients, and considerably larger amounts of fertilizers are required in comparison with the Old Lands. Nevertheless, present fertilizer applications are still largely based on rates and methods suitable to the Old Lands. Low irrigation efficiency and water shortages further depress yields. The harvest of grain is generally done manually or by using inefficient threshers, entailing considerable yield loss and labor. Cultivars adapted to desert conditions have not been yet developed.

Future work will undoubtedly concentrate on improving both transpiration efficiency (long-term objective) and crop management (short-term objective) to increase water-use efficiency. Moreover, breeding for high vigor, early maturation, and better utilization of water and nutrients is also highly desirable.

In contrast, the incidence of foliar diseases and the improper plant population densities and sowing dates are the main limiting factors constraining the production of winter food legumes in the New Lands. Moreover, lack of rhizobia inoculation suitable to New Lands conditions has also had a devastating effect on plant growth and seed yield. In view of these problems, there is a growing awareness of the need to develop cultivars resistant to disease, as well as management practices that ensure higher seed yield and lower disease infestation.

Finally, there is a need to conduct long-term, system-oriented research to evaluate productivity, profitability, and environmental impact of a range of low input and innovative cropping systems.

Introduction

The irrigated agricultural land of Egypt consists of about 1.87 million ha of Old Lands and about 0.625 million ha of New Lands reclaimed since 1952. It is estimated that the New Lands will expand to about 1 million ha by the year 2000. In general, the New Lands are characterized by water scarcity and an imbalance of soil fertility. Soils are sandy to light-sandy loam with high pH, permeability, and water infiltration. Some of the loamy and sandy loams are calcareous. There is a strong deficiency of macro- and micronutrients as well as organic matter.

Productivity in the newly reclaimed lands suffers seriously from a number of constraints:

- Soils are in general very poor in macro- and micronutrients, with high permeability and low water-holding capacity.
- Water shortages further depress yields.
- There is a shortage of fertilizers, and a lack of appropriate technologies for fertilizer management; phosphate and potassium applications are low, resulting in inefficient use of nitrogen.
- There is a lack of improved cultivars adapted to the desert environment.
- There is a labor shortage and lack of appropriate machinery, particularly for land preparation, weeding, harvesting, and threshing.
- There are crop disease and pest problems, especially with horticultural crops.
- Traditional crop management is inefficient; broadcast planting of grain and fodder crops results in inappropriate plant population densities and does not allow mechanized weeding, sufficient manual weeding, harvesting, and threshing.
- Livestock management is poor, and there is a shortage of summer feed. Therefore, cropping patterns require careful decisions that take into consideration the limiting factors affecting returns.

Land Use and Cropping Patterns

Basically, the same crops planted in the Nile Valley have been adopted in the New Lands. Crops can be divided into cereal, food legume, fodder, oil, vegetable, fruit tree, and wind break. The proportions of these crops are affected by the following:

- Requirements:
  - Food grain for self-sufficiency.
  - Cash crops to increase income.
  - Fodder crops for animal production.
  - Improved soil fertility for long-term sustainability.
- Environmental factors:
  - Soil structure and fertility.
  - Water availability, quality, and irrigation system.
  - Climate.
- Production potential of different crops.
- Farm size and land use.
- Human and financial resources.
- Marketing system, transportation, and infrastructure.

These challenges are so strongly interrelated that it is difficult to give one priority over another. Each is an important factor in itself and is dependent on having knowledge of the others.

In this context, patterns adopted by different land users in the New Lands reveal a number of factors. Cropping patterns, according to different grower categories for selected crops, are illustrated in Table 1. Graduates and small holders allocate most of their land to field crops, followed by vegetable crops. Fruits are the favorite crop for investors, who allocate 70.6% of their cultivable area to them. Labor shortages and lack of farming experience are major constraints for graduates, affecting their efficiency and successful settlement. Settler cropping patterns are closely related to the keeping of livestock, with field crops used not only for household consumption but also for animal feed.

The area planted with winter crops in the New Lands increased from 197,700 to 282,000 ha between 1980–1984 and 1985–1990 (Abo Elenein, 1994). Summer crops increased from 138,750 to 172,667 ha over the same period, while permanent crops increased from 41,580 to 81,292 ha. Berseem is the most common winter forage legume, occupying 35 and 38% of the winter crop area in the two periods, respectively (Fig. 1). Rice occupied 30.9 and 28.2% of the summer crop area in the two periods, respectively (Fig. 2). Permanent crops represented 17.4 and 22.4% (Abo Elenein, 1994), where fruits, the most common permanent crops, represent 59 and 68% of the permanent crop area in the two periods, respectively (Fig. 3). Unlike the Old Lands, where soils are relatively uniform, crop rotations in the New Lands are not fixed. This is because of the many soil types, which include sandy, calcareous, clay, and salt-affected soils as well as a large number of gradations of these types. Crop diversification should take place according to agroecological zones, as discussed below.

Table 1. Comparison of cropping patterns for different grower categories, average of five survey areas in the New Lands of Lower Egypt.

Cropping patterns	Graduates	Small holders	Investors	Other groups
Average area in use (fed)	5.36	5.75	28.50	7.36
Winter field crops (fed)	4.23	3.67	2.38	4.62
Winter vegetable crops (fed)	0.86	1.17	2.69	1.02
Summer field crops (fed)	2.32	3.55	1.46	3.00
Summer vegetable crops (fed)	2.12	0.71	1.97	0.13
Fruits (fed)	0.04	0.37	20.37	1.13
Total area planted (fed)	9.56	9.47	28.87	9.89
Percent vegetables	31.10	19.90	16.10	11.60
Percent fruits	0.40	3.90	70.60	11.40
Percent field crops	68.50	76.20	13.30	77.00
Cropping intensity	1.79	1.71	1.73	1.50

1 hectare = 2.38 feddans.

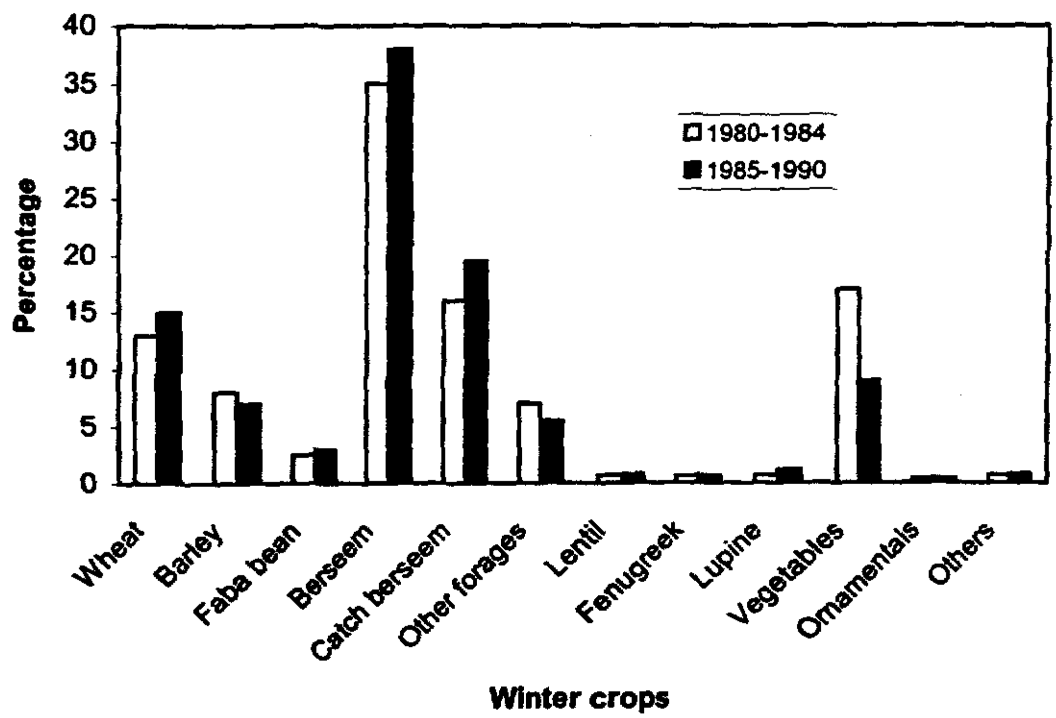

Fig. 1. Cropping patterns for different winter crops in the New Lands.

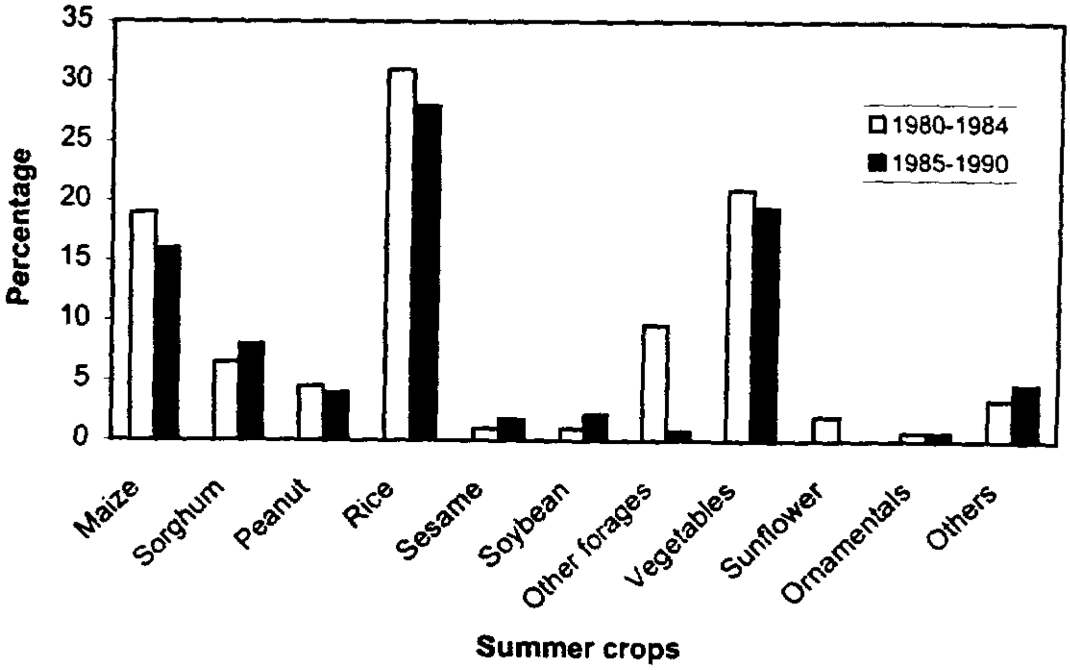

Fig. 2. Cropping patterns for different summer crops in the New Lands.

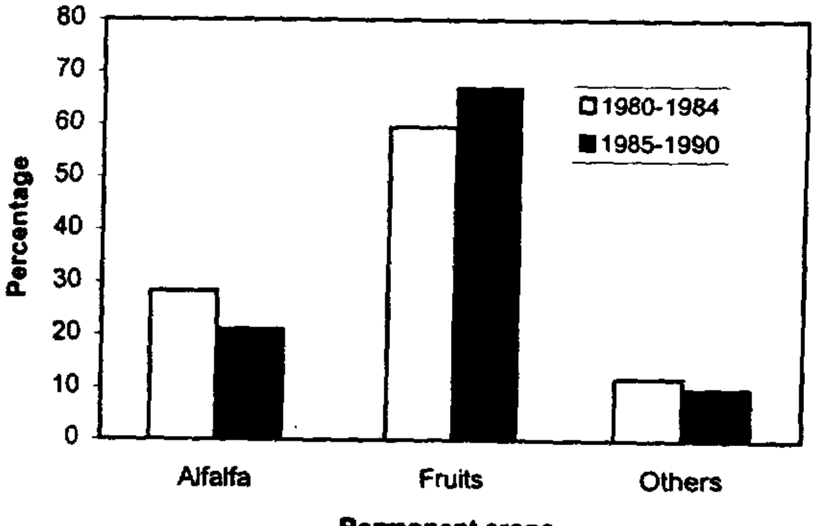

Fig. 3. Cropping patterns for different permanent crops in the New Lands.

Agroecological Zones

New Lands of the West Delta

This area comprises a total of 285,000 ha, with priority reclaimed desert areas of about 110,000 ha located in Lower Egypt, situated on either side of the Alexandria–Cairo Desert Road and along El Nasr Canal. The area is bound by Nubaria Canal to the east, the ridges of the Mediterranean coast to the north, and by the southern periphery of El Nasr Canal command. There is a predominantly Mediterranean climate influenced by the arid conditions of the Western Desert. This region consists of three major areas: El Bustan, Nubaria, and the Sugar Beet area, which differ in their soil properties.

El Bustan

Generally, soils of El Bustan are highly permeable and well-drained. The topography of the land is flat. The most important soil constraint in the area is the low moisture-holding capacity (6% by volume) and the coarse textures which dominate in the area. The area is very deficient in organic matter and all macro- and micronutrients. Thus the following are required:

- Irrigation methods which favor frequent, small water applications. Surface drip and sprinkler are the best methods of irrigation under these conditions. Flood irrigation cannot be used in these soils, partly because of the rapid loss of irrigation water and nutrients by leaching.
- Adequate fertilization for minor and major nutrients, a proper balance between nutrients, and appropriate methods of application to minimize losses.

The soils are suitable for a wide range of crops such as cereals (wheat, barley), alfalfa, food legumes (pea, lentil, lupine), oil crops (groundnut, sunflower, sesame), vegetables (watermelon seed, tomato, potato), and fruit trees (grape, apple, pear, peach, olive, fig).

Nubaria

The soil of Nubaria is slightly saline, predominantly sandy and loamy sand. The topography is flat to gently undulating. Soil fertility is poor, especially total N content and organic matter, indicating a rapid decomposition of organic matter. Other macronutrients (P, K) are low, and micronutrients (Fe, Mn, Zn, Cu) are seriously deficient. The calcium carbonate ($CaCO_3$) content is about 10%. Water-holding capacity on these sandy soils is about 8% by volume. Due to the high infiltration rate of the soil, sprinkler and drip irrigation systems are the most suitable. A dense soil layer 2–3 m deep has been found, which may impede soil water drainage and create a perched water table through irrigation. Cropping patterns similar to those at El Bustan are suitable.

Sugar Beet area

The Sugar Beet area is located along the extension of El Nasr Canal, west of the Delta. Along the canal, there is a flat to very gently undulating plain. Most of the soils are calcareous clay loams, silty clay loams, and permeable clays.

The soil of the Sugar Beet area is completely different from those in the sandy areas further south. It is characterized by high calcium carbonate content throughout the entire profile.

Calcic and gypsiferous horizons are present in many parts of the area, and may be indurated in some locations. Soil profiles are very deep to moderately deep. Soil permeability decreases with depth. The topsoil, especially in silty areas, has an unstable soil structure.

The main limitations are related to the presence of high calcium carbonate and heavy soil texture. These limitations are poor surface layer characteristics due to the precipitation of calcium carbonate and the formation of a calcareous crust on the soil surface, high soil salinity created by low infiltration rates, and a high water table, as well as high pH values—due to the presence of calcium carbonate—which cause deficiencies in some macro- and micronutrients, particularly phosphorus fixation. The water-holding capacity is about 13% by volume. Deep and intensive drainage systems should be provided to prevent waterlogging and salinization. Flood irrigation systems are suitable under traditional agricultural practices in these soils, but surface and subsurface drip irrigation can be used successfully, with proper management practices.

The soils are suitable for a wide range of crops such as cereals (wheat, maize), fodder (berseem, sorghum), food legumes (faba bean, lentil, cowpea), oil crops (sunflower, sesame), cotton, sugar beet, vegetables (table watermelon, tomato), and fruit trees (except citrus, due to high pH).

Cropping pattern and biological concepts

In the New Lands areas of the West Delta (El Bustan, Nubaria, Sugar Beet), major winter crops are fodder legumes, wheat, faba bean, and pea. In summer, the most important crops are maize, watermelon (fruit and seed), and groundnut (Table 2).

Table 2. Common crop rotation in the New Lands of the West Delta desert.

Crop	Calcareous				Sandy soil in Nubaria and El Bustan			
	Sugar Beet		West Nubaria		Rotation I†		Rotation II‡	
	Winter %	Summer %	Winter %	Summer %	Winter %	Summer %	Winter %	Summer %
Berseem	35		30					
Alfalfa							20	20
Sugar beet	5		30					
Faba bean	25		15		10			
Wheat	20		15		25		20	
Barley					30		5	
Pea							30	
Vegetables (1)	7		4		15		10	
Maize		36		20				
Groundnut						20		30
Watermelon		30		20				
Watermelon seed						35		15
Tomato	8	12	6	12	20	15	15	10
Cotton		7						
Vegetables (2)		3		2		5		3
Summer forage		12		13		10		12
Cowpea				13		10		10
Sunflower				20				
Sesame						5		

† I Crop and animal production.
‡ II Oil crop and animal production.
(1) Winter vegetables.
(2) Summer vegetables.

Alfalfa as a perennial legume is suitable to sandy and low water-holding capacity soils, because of its relative tolerance to water stress and good soil-improving capacity due to its extensive root system and nitrogen-fixing capability. On the other hand, berseem as a winter fodder legume needs more water and nutrients, as well as shorter irrigation intervals. These characteristics make berseem less appropriate for sandy soils. Moreover, berseem needs a relatively compact soil for proper seeding, thus the heavier calcareous soils with surface irrigation are more suitable.

Faba bean is one of the most common winter crops in the calcareous soils of the Sugar Beet area. It is a soil-improving crop with a deep root system containing bacterial nodules by which the deeper soil layers are enriched with organic matter and nitrogen, penetrating the hard carbonate and/or gypsum layers.

In sandy soil, sprinkler irrigation can hinder faba bean production due to moisture coherence, which encourages foliar diseases, especially chocolate spot. However, promising yields have been obtained in sandy soil using resistant cultivars (for example, Giza Blanca and Giza 461).

Pea (*Pisum sativum*) is the major winter crop in the sandy soils of Nubaria and El Bustan due to:

- Nitrogen fixation and extensive rooting system.
- Suitability to sprinkler irrigation (because of its short stature and the location of offshoots near the soil surface).
- Early cash income due to the short crop cycle.

Wheat is grown mainly to meet basic needs and also as a cash crop. Moreover, it is suited for both surface and sprinkler irrigation systems. The common varieties adopted by farmers, Sakha 8 and Sakha 69, are disease resistant and salt tolerant. The high-yielding variety Giza 163 is also widespread, especially under calcareous soil conditions.

Maize and table watermelon, which require a relatively high and stable water supply, are therefore well-adapted to the calcareous soils of the Sugar Beet area, with its higher moisture retention capacity and more reliable flood irrigation system. Table watermelon is suitable for calcareous soils with a high water table because it is not irrigated after germination, surviving on the existed soil moisture content. Drought-resistant seed watermelon is better adapted to sandy soil due to:

- Resistance to pests and fungi, and salinity tolerance.
- Short growing cycle.
- Easily stored.
- High cash earner.

Groundnut is the second biggest summer crop, after watermelon seed, in El Bustan. It is not grown in calcareous soil because of the crusty soil surface and the formation of plow pans. Small holders in the Sugar Beet area, Nubaria, and El Bustan are cautious in their adoption of vegetables due to high labor costs and expensive inputs, and the risks related to pests, disease, and irrigation shortage. However, tomato seems to be a good cash crop for the small holder, and it occupies about 8% of the cultivated land in winter and 17% in summer. Farmers prefer the determinate varieties due to lower labor and financial requirements.

Most of the fruit trees growing in the New Lands are in the West Delta desert. Fruit trees are grown mostly by investors and rarely by small holders. Low chilling is a major limiting factor for growing apple and pear trees. Peaches suffer from unsuitable root stock as well as iron deficiency, especially in calcareous soil. Sandy storms (*khamasin* winds) during blossoming and fruit setting cause severe damage to flowers and young shoots. Inappropriate pruning and lack of chemical fertilizers at the proper time are common constraints. Wind breaks have been established by most investors, but most of the farmer settlers are not convinced of the direct benefits to crop production. An exception among fruit trees is citrus, which does not grow well on calcareous soil or on soil with a high pH. Citrus is mostly cultivated by small holders. Table 3 depicts a common crop rotation for fruit trees and annual crops on the sandy soil of the New Lands.

Table 3. Crop structure for common crop rotation in the New Lands; sandy or sandy calcareous soils, mixed farm (fruit trees and annual crops).

Crop	Winter %	Summer %
Fruit trees†	50	50
Vegetables‡	25	
Berseem, broad beans, lupine, onion, vegetables§	25	20
Sesame, peanuts		20
Forage (Sudan grass)		10

† Grapes, figs, olive, palm dates, apple, peaches, mango, citrus, etc.

‡ Green peas, strawberry, tomato, garlic, etc.

§ Watermelon (table and seed), eggplant, pepper, squash, cucumber, etc.

El Hamoul

El Hamoul is situated in the northern part of the Delta, and is a natural extension of the Delta clay soils. The main source of irrigation is Nile water mixed with drainage water. The soils are very deep silty clays which may include a thin to moderately thick layer of bluish clay or loamy sand. The soils are poorly drained with a high water table. They are saline to moderately saline, with sodium chloride as the dominant salt. Magnesium cations dominate the exchange complexes in some of these soils, which are referred to as "Mg-affected soils." Permeability and hydraulic conductivity are low to very low. The main limitations in these soils are the high salt content, presence of alkalinity and low hydraulic conductivity. Artificial drainage is essential to enhance leaching and to lower the water table. Improvement of the physical conditions of the soil, which improves permeability, can be achieved by the use of soil amendments, e.g. gypsum, organic manure, and special organic soil conditioners. Traditional flood irrigation can be used.

Growing salt-tolerant crops such as cotton and sugar beet may provide the key to improving the productivity of saline soils (Table 4). Barley followed by a salt-tolerant fodder crop is another suggestion.

An irrigated rice ecosystem could perhaps be more sustainable for a saline soil agricultural system. This is because flooding favors saline soil agricultural systems by leaching salts, bringing soil pH close to neutral, and increasing availability of P and Fe, as well as maintaining soil N fertility.

New Lands of the East Delta

This area comprises about 255,000 ha. The surface soil varies in texture, and may be fine, medium, or coarse. The subsurface soil ranges from sandy clay to clay loam in some areas and slightly gravelly to loamy sand in others. The main soil limitations in the area are the low water-holding capacity, hence, low available moisture, low nutrients, and the presence of gypsum in some places. Salinity is widespread in many places, with electrical conductivity of the saturation paste extract as high as 75 mmhos/cm. The coarse texture of the parent material of the river terrace soil may create drainage problems.

Table 4. Common crop rotations in the New Lands (clay saline soils in El Hamoul).

Crop	Cotton rotation		Crop rotation	
	Winter (%)	Summer (%)	Winter (%)	Summer (%)
Sugar beet	33		20	
Berseem				
Catch berseem	23			
Barley mixture			33	
Broad beans/lupine	10			
Vegetables (1)	20			
Wheat or barley	14		20	
Rice or corn		20		20
Summer forage		27		14
Rice				33
Cotton		20		
Sunflower		13		
Vegetables (2)		20	14	20
Lupine			13	
Cowpea				13

(1) Winter vegetables.

(2) Summer vegetables.

Leaching of soil salinity will be easy to control. Because of the sandy nature and low nutrient content, these soils require adapted fertilization management. Sprinkler irrigation is recommended for field and fodder crops, and gate-pipe irrigation is possible. For vegetables and fruit trees, drip irrigation is the most suitable system. Fertigation practices are suitable for the application of nutrients. Careful soil management practices are needed to optimize the use of water and nutrients by plant roots. The soils are suitable for cereals (wheat, barley), food legumes, oil crops, fodder crops, specific vegetables, and fruit trees, e.g. citrus and mango (Sheta, 1994).

New Lands of Middle Egypt

The soils are sandy loam to sandy, but in most areas coarse sands are dominant with very low moisture retention.

The New Lands in Middle Egypt (West El Fashn and Samaloot in Beni Sueif governorate) include about 23,000 ha. The cropping pattern in this area during the winter is mainly tomato (60%), wheat (25%), and onion (15%). In summer, tomato is again the most important crop (20%), followed by table watermelon (15%). About 50% of the lands are fallow during the summer due to the high expense of irrigation water. The wheat/fallow/tomato rotation allows break periods that reduce nematode infestation in tomato fields.

New Lands of Upper Egypt

This area could extend to as much as 300,000 ha, but the priority areas are only about 80,000 ha. Generally, the soil is sandy loam to coarse sand, with low available moisture. A few calcareous soils are found.

The typical crop rotation for the New Lands in Upper Egypt (Qena and Sohag) is wheat (50%) followed by tomato (20%). The remaining 30% is planted with winter legumes (faba bean, lupine, fenugreek, berseem) and some vegetables. During the summer, 100% of the land is fallow. High temperatures in this area may retard the irrigation system due to high evaporation, irregular intervals between irrigation, and high irrigation costs. From the farmer's point of view this rotation has the advantage over wheat production because it (i) provides legumes that fix nitrogen; (ii) incorporates a fallow period that leaves the soil undisturbed to accumulate organic matter; and (iii) provides vegetables that need extensive fertilizers and management. However, wheat needs as many as 16–20 irrigations during the growing season to give a good crop.

The New Valley

The New Valley comprises a series of natural depressions hollowed to a depth of between 100 and 400 m below the Libyan plateau in the western desert. The total area of these depressions is about 7,000 km^2, including both El Kharga and El Dakhla Oases. The cultivated area is estimated at 60,000 ha.

Groundwater, provided by springs and wells, is the only resource in the area, as rainfall is almost nil. Salt-tolerant crops are preferred. Cereals, legumes, fodder, oil crops, vegetables, and grapes may also be suitable.

Water Requirements

The main objective of irrigation is to provide plants with sufficient amounts of water to prevent stress that may cause yield reduction or poor fruit quality at harvest. The timing and amount of water applied are governed by the prevailing climatic conditions, crop and soil moisture-holding capacity, and root development as determined by the type of crop and stage of growth. In principle, the need for irrigation can be determined on the basis of monitoring the soil, the plant, and the micro-climate (Abo Hadid, 1994).

Crop rotation can be useful in determining how much water should be applied. The evapotranspiration information is used to estimate the volume of water required to satisfy short-term and seasonal water requirements for fields, farms, and even for the entire region, and for designing water-storage and delivery systems.

One of the key factors to increasing agricultural production in Egypt is to ensure better use of water resources, and increase the value of crop production per unit of water consumed.

The amount of irrigation water applied to the soil is determined by how irrigation systems are managed. Usually, greater amounts of water are applied with low-cost surface irrigation than with expensive sprinkler systems. Most of the excess water applied with surface irrigation is wasted in evapotranspiration and depletion (Table 5). Changing irrigation systems, or improving irrigation methods, may lead to better water-use efficiency and reduce irrigation costs (Abd El Maksoud *et al.*, 1988).

Table 5. Relationship between crops, soil and water.

Crop	Location	Soil type	Irrig. N	Irrig. L	Irrig. I	ET (mm)	WUE (kg/cm)	Irrig. (mm)	Reference
Wheat	Nubaria	Calc.	3-5						
	Nubaria	Calc.	4		20				
	Nubaria	Calc.	-	8b	-		38.14		
	Ismailia	Sandy	17	-	-	444.9		625	
	Fayoum	Calc.	-	30d	-	417			El Sebsy (1993)
	El Bustan	Sandy				585.(c)	24-29		Yousef and Eid
						535.(p)			(1994)
Barley	Nubaria	Calc.				260	40-25.8		Emara (1992)
	Belbeis	Light				257 (SP)			
	Abis	Clay				315 (flood)			
Faba bean	Abis	Clay				263.5 (CF)			
						227–233 (SF)			
	Nubaria	Calc.				318			
	Southwest desert (extreme conditions)					600–700			
Lentil		Sandy				410			
	Ismailia								
Chickpea		Sandy				132			

N = Number of irrigations
L = Soil moisture level
I = Irrigation interval
d = Soil moisture depletion
b = Soil water suction in bar
c = Conventional method
p = Evaporation pan
CF = Continuous flow
SF = Surge flow
SP = Sprinkler
ET = Evapotranspiration
WUE = Water-use efficiency
Calc. = Calcareous

Table 6 compares the water requirements of some suggested crops grown in different New Lands locations. Data indicate that crop rotations of berseem/cotton or summer fodder are high water consumers, whereas winter wheat and food legumes are moderately to relatively low water consumers. Data also show that vegetables consume less water than oil crops in summer.

Profitability

As shown in Table 7, seed watermelon ranks first in net profit (LE 1,790), followed by summer tomato (LE 743), pea (LE 714), alfalfa (LE 470), winter tomato (LE 462), and berseem (LE 401). In terms of net profit for each LE spent, seed watermelon comes first (LE 2.53 per LE spent) followed by alfalfa (LE 1.1 per LE spent), berseem (LE 1.09 per LE spent), and summer tomato (LE 0.81 per LE spent).

Table 6. Suggested crop rotation of winter and summer crops and their water requirements (ET/mm) in the New Lands.

Location	Winter crop	%	ET/mm	Summer crop	%	ET/mm	Total ET/mm
Sugar Beet	Wheat	33	590	Vegetables	20	550	1,140
Sugar Beet		20	435	Sunflower	31	440	1,030
El Hamoul		25	520	Vegetables	20	550	985
El Bustan		20	500	Groundnut	25	780	1,300
El Bustan	Barley	20	295	Vegetables	20	570	1,070
El Hamoul	Berseem	20	590	Vegetables	20	560	855
Sugar Beet		30	615	Cotton	20	760	1,350
El Hamoul		13	560	Cotton	33	755	1,370
El Bustan		33	630	Sudan grass	13	835	1,390
West Nubaria	Faba bean	13	295	Maize	33	355	985
El Hamoul		14	390	Sudan grass	13	835	1,130
El Hamoul		14	390	Corn forage	13	700	995
El Hamoul	Lentil	14	320	Cowpea	13	780	1,075
El Bustan		14	320	Sesame	14	660	1,050
El Bustan				Sunflower	14	735	1,125
El Bustan				Vegetables	14	550	940
El Bustan				Sunflower	14	560	880
El Bustan				Sesame	14	735	1,055
El Bustan				Vegetables	14	550	870

Source: Water Management Department, Soil and Water Research Institute (SWRI).
ET = Evapotranspiration.

Table 7. Total cost and net profit (LE/ha) for common crops in the New Lands (1992).

Crop	Total cost (c)	Net profit (p)	Rank p	Ratio (p/c)	Rank p/c
Faba bean	899.4	194.7	11	0.216	11
Barley	761.6	228.9	9	0.301	10
Peanut	990.19	84.97	12	0.086	12
Maize	746	45.1	13	0.060	13
Peas	1,371.8	714.7	3	0.521	9
Watermelon (seed)	709.2	1,790.6	1	2.525	1
Wheat	440.35	246.6	8	0.560	8
Berseem	368.26	401.4	6	1.090	3
Catch berseem	243.63	194.9	10	0.800	5
Alfalfa	427.73	470.5	4	1.100	2
Sesame	350.97	252.7	7	0.720	6
Winter tomato	810.7	462.1	5	0.570	7
Summer tomato	917.0	743.2	2	0.810	4

Winter crops: wheat, faba bean, pea, winter tomato, barley, alfalfa, berseem.
Summer crops: Peanut, sesame, maize, watermelon seed, tomato.

In general, there is no fixed cropping pattern for the New Lands. Rotating crops should be regenerative and diversified—regenerative in providing crop residue for organic matter, and diversified in the range of crops and commodities produced. Maintaining the organic matter of the soil is vital to long-term productivity. Moreover, it is important to the aggregate structure essential to soil erosion, soil and water conservation, and healthy roots. The second element of diversification is to make seasonal inputs (management) available at the proper time and in adequate quantities. This will replace traditional, inefficient labor practices with appropriate mechanization, reduce inputs and net losses, and accelerate the biological processes that lead to a sustainable system.

For alternative farming systems, legumes are an effective and often profitable way to supply nitrogen. The major result is improved cereal yield through integration with seed legumes, alfalfa, and seed berseem, with further breeding for disease/pest resistance, N fixation, and yield (Nassib *et al.*, 1990). However, in arid and semi-arid regions, or during drought, deep-rooted, non-irrigated legumes may decrease subsoil moisture and reduce ensuing crop yields. Therefore, attention should be given to livestock as a farm enterprise in order to attain the economic and biological benefits of crop/livestock interaction, particularly when related to soil fertility management (Abo Akkada, 1990). Another benefit is the use of soil nutrients from deep underground by deep-rooted crops. In the process, these plants may bring the nutrients to the surface, making them available to subsequent shallow-rooted crops, especially if crop residue is not removed.

Crop/livestock operations are well-suited to many alternative farming systems in terms of soil fertility recycling and ability to make crop rotations economically feasible and increase net return. Berseem and alfalfa are the main legume fodder crops and are utilized for grazing, cutting, and making hay. Fodder sorghum has been successfully introduced in the New Lands as a summer crop, but only in a small area. Moreover, areas under perennial alfalfa are still scarce. Crop rotations using leguminous fodder reduce fertilizer and pesticide requirements and provide a valuable feed and nitrogen source.

Using cover crops in the rotation may provide additional erosion control and allow the planting of food crops on more suitable land, particularly if these crops are used as green manure. Livestock manure also becomes a valuable source of organic matter, nitrogen, and other nutrients, such as potassium and phosphorus.

The Forage Research Department of the Field Crops Research Institute (FCRI), ARC, reported that an application of 30 m^3 of farmyard manure significantly boosted the forage yield of sorghum, millet, and Sudan grass grown in sandy soil at Ismailia (Fig. 4). Moreover, adding 100 kg N/fed (238 kg N/ha) with farmyard manure dramatically increased the forage yield of the three crops. However, no significant differences were detected in the forage yield of the three crops by using 100 or 120 kg N/fed, with or without applying farmyard manure. Generally, research in this area has been neglected in recent years because agricultural policy has focused only on the cropping system and has increasingly separated crop and livestock activities. Indeed, research is needed in the areas of crop and forage rotation and manure handling to enhance crop/livestock interactions.

Consequently, future research must emphasize a farming system involving crop and pasture legumes as conservation farming practices. The introduction of fodder legumes could be potentially valuable for restoring soil fertility and structure, increasing water holding capacity, and providing improved forage for animal production. Moreover, a legume/grasses system, in conjunction with conservation tillage technology, may play an important role in reducing soil erosion, evaporation losses, and temperature at the soil surface. Conservation tillage, when combined with crop rotation and fertilizers, could provide alternative farming practices with greater flexibility.

Diversification, a basic alternative concept, generally reduces risks by spreading them among a number of crops and animals. However, very little is known about the aggregate impact of possible crop rotations in the New Lands, thus further studies are warranted.

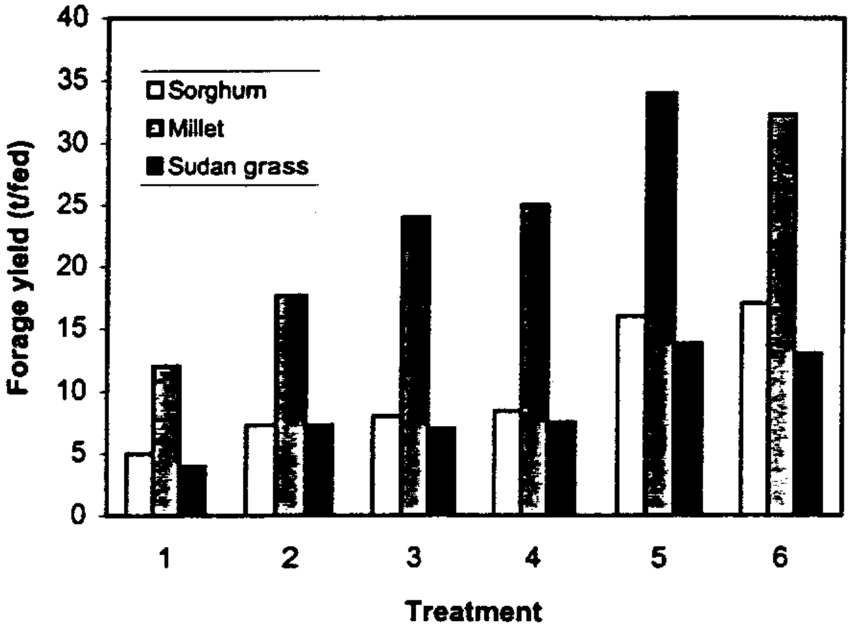

Fig. 4. Forage yield of sorghum, millet, and Sudan grass in response to farmyard manure and nitrogen. 1 = Control; 2 = 30 m^3 farmyard manure; 3 = 100 kg N/fed; 4 = 120 kg N/fed; 5 = 2 + 3; 6 = 2 + 4.

Soil Fertility and Field Cultivar Screening Programs

Sandy Soils

The traditional approach to improved productivity of sandy soils has been to cover the surface of the soil with a layer of silt from the Delta, mixed with animal manure, also from the Delta. This traditional approach should be changed for the following reasons:

- It is not practical for cultivating large areas of desert.
- It attempts to artificially change the environment in which the plant forms its roots.
- It uses up fertile Delta soil that is no longer being replenished by Nile silt.
- It brings to the virgin New Lands such undesirable intruders as nematodes and weed seed.

Integrated approaches for improving productivity of sandy soils should be based on the belief that a desert should be treated as a desert and that any trials for improving productivity should be environmentally compatible with desert conditions and should be economically reproducible under Egyptian social and technical constraints.

A number of disciplines contribute to the implementation of this integrated approach for improving productivity of sandy soils. The integrated farming system should cover the following disciplines:

- Forestry: for windbreaks and shelterbelts to give wind and erosion protection, animal feed, and fertility to the soil.
- Crops: for fodder, green manure, and food.
- Animal husbandry: for sheep fattening to provide manure for soil improvement as well as generating an important source of farm income.
- Water management and irrigation systems.
- Economics: for input/output analysis.

Plowing crop residue to introduce green manure for improving soil productivity has been tried, and is now being evaluated. An alternative approach, based on zero or minimum tillage practices, is potentially valuable for improving on-site control of wind erosion of soil, and for reducing energy inputs.

The minimum tillage approach for improving productivity of sandy soils may be appropriate, but it is essential to realize that:

- Water supply, nutrients, and energy costs are primary constraints in desert agriculture; optimum land and water management is a major goal.
- Cropping systems in the desert are different from conventional systems in the valley; accordingly, there is a need for appropriate rotations in desert environments.

Nevertheless, crop rotation studies in sandy soils are scarce. El Hawary *et al.* (1994) studied the effect of peanut and sunflower as crops preceding wheat using different levels of farmyard manure. Wheat yield increased more when peanut was the preceding crop. The addition of farmyard manure increased yield by 11.35%:

Calcareous Soils

Special soil management practices are needed in calcareous soils to prevent the formation of a surface calcareous crust and to alleviate the effect of high soil pH and salinity on the availability of nutrients in the plant root zone. Application of organic and green manure is a key management practice to overcome these limitations. Special fertilization practices are essential to correct the deficiencies of the major and minor nutrients.

Hassan *et al.* (1973) studied the contribution of soil and P fertilizer, using labeled superphosphate and wheat plants, to measure the effect of N application on wheat growth. Wheat was grown on a highly calcareous soil from Mariut, a clay loam soil from the University of Cairo Experimental Station, and a sandy loam soil from the University of Ain Shams Experimental Station. The results show that:

- The dry weight of wheat plants and total P taken up increases with N application.
- The concentration of P in the plant tissues does not increase with N application.
- The effect of N application on P derived from both soil and fertilizer sources is not manifested in the early stages of growth from seeding to tillering.

Application of N stimulates plant growth and increases P uptake from both sources in the growth stage, with the highest effect in the last stage of growth. The relative increase in the contribution of soil P due to N application is greater than the corresponding relative increase in the contribution of P fertilizer.

Because of the ability of calcareous soils to fix soluble phosphates, it was suggested that phosphate be applied at relatively high rates to satisfy the P-fixing capacity of the soil. Several researchers, however, showed that micronutrient—especially Fe—availability to plants supplied with excessive amounts of P decreased. Work by Alwash (1978) showed that application of P up to 6 mg/100 g soil decreases NH_4OAC^- and EDTA Fe-extractable to about half the amount extracted without P. The high application of P induces lower Fe uptake by wheat seedlings. Recognizing that plants growing in $CaCO_3$-rich soils are low in Fe content, any further decrease in Fe-absorption due to excessive P application might cause Fe-deficiency in the growing plants.

Ragab (1980) showed that Zn concentration in corn shoots is reduced by P application, whereas root concentration increases in most cases. Zinc concentration and uptake by corn grown on calcareous clay-loam soil was lower than that grown on alluvial clay loam soil. Root Zn increases as Zn increases in all soils.

El Sokkary *et al.* (1981) showed that application of P to a highly calcareous soil generally increases plant dry weight. In soils not treated with Zn, P additions increase Zn uptake by plants, and in soils treated with Zn, P additions decrease Zn uptake. Plants grown for four weeks contained lower amounts of Zn relative to those grown for eight weeks.

Orabi *et al.* (1982) stated that in calcareous soils Zn uptake is increased by P application whether Zn is applied or not.

Farmers have adopted a wide range of tillage practices. Conservation tillage practices in calcareous soils may advance some of the goals of alternative farming systems, such as increasing organic matter and reducing soil erosion. However, some conservation tillage practices may increase the need for pesticides, particularly herbicides. Conservation tillage changes soil properties in ways that affect plant growth. Plant nutrients in no-tillage soils are more stratified than those in soils under reduced or conventional tillage. Nutrients also tend to concentrate in the upper portion of the soil profile. However, in winter, the cooler temperatures resulting from no-tillage can slow early season plant growth. With no-tillage, the soil is also more likely to be compact, which can also reduce plant growth.

But conventional tillage may also disrupt the life cycle of beneficial organisms, and require more energy and larger tractors. Chisel plowing, the most widely used form of reduced tillage, requires large tractors but uses less energy than moldboard plowing. Although conventional tillage creates more bacterial activity and has a "boom-or-bust" effect on nutrient cycling processes, no-tillage or other conservation tillage provides a slower but more even rate of nutrient release. Legumes are an effective source of nitrogen in some conservation tillage systems, although different tillage methods can influence the amount of nitrogen available to subsequent crops.

In calcareous soils, flood irrigation is the most common system, although the resulting soil compression reduces seedling emergence. Therefore, no-tillage hampers the maintenance of leveling and ditches as a means to control irrigation and decrease crop density.

Ridge tillage is a form of conservation tillage with significant erosion control benefits, overcoming some of the soil temperature, irrigation, weeds, and soil compression problems associated with no-till systems. Ridge tillage removes residue from the top of the ridges and disturbs the soil enough to create a seedbed. Soil on the ridges is also generally warmer than between ridges or in fields without ridges. Warmer soil facilitates crop germination. Tilling only the top of the ridges disturbs fewer weed seeds, reducing weed germination. Erosion is slowed because soil and crop residue between the ridges is not disturbed. Weeds that emerge later in the growing season tend to be between the ridges. Cultivation easily controls these weeds and reduces soil compression in crop rows, thereby enhancing plant root growth and water infiltration.

Cool-season food legumes such as faba bean, lentil, and chickpea have been investigated in calcareous soils (Hussein and El Deeb, 1992; Hussein *et al.*, 1992, 1993). Sowing date, plant density, control measures for foliar diseases, and the use of disease-tolerant varieties have been recommended.

Fertilizer application on faba bean has been studied by several investigators (Abd El Aziz *et al.* 1982; Hussein *et al.* 1993). Results show that addition of P fertilizer reduces chocolate spot and rust diseases and increases productivity.

Hegab *et al.* (1988) found that Mn chelate is an effective treatment for increasing seed and straw yield of faba bean in calcareous soils.

Sugar beet, sunflower, and safflower are also grown satisfactorily (Hegab *et al.* 1986, 1987).

Saline and Alkaline Soils

Maximum crop production results from planting high-yielding cultivars in soils of good tilth containing optimum levels of available plant nutrients under favorable weather conditions. Yields are reduced when one or more factors are limiting. The main constraints to crop production on alkaline soils are low or unbalanced soil fertility, high levels of free $CaCO_3$ or exchangeable Na^+, salinity, and poor external or internal drainage. Several investigators have shown that high salinity may kill crops or have adverse effects on growth, yield and its components.

El Zohry (1990) found that the highest germination percentage is obtained when growing Sakha 8 wheat cultivar, and the lowest with Giza 155. Irrigation with 3,000 ppm Na, Ca, and Mg chlorides gives better seedling emergence than 4,000 ppm. The dry weight of wheat plants irrigated with 2,000 ppm is significantly higher than those irrigated with 4,000 ppm. Tarrad *et al.* (1988) found that growth and yield of wheat are markedly reduced when irrigated with saline water, particularly in calcareous soils. Grain yield and its components are significantly higher at 50 mM NaCl in irrigation water than at 100 mM. It was suggested that the two tested wheat cultivars (Sakha 8 and Sakha 69) could do well with saline irrigation water up to 50 mM NaCl.

Salinity also has deleterious effects on soybean growth, yield, and yield components. Increasing sodium chloride in irrigation water results in a remarkable reduction in pod numbers and seed yield. Sodium content increases in both leaves and seeds with increasing sodium content in irrigation water (Soliman, 1984).

Kamel *et al.* (1969). Ashour and Thalooth (1971) found that saline irrigation water, up to 6,000 ppm, greatly decreases the dry weight of sugar beet tops. Dry weight of the roots was not significantly affected by irrigation with 4,000 ppm saline water. These results are supported by Reda *et al.* (1980).

Soliman *et al.* (1993) report that rice cultivars differ in their response to salinity. Giza 159 and 175 are considered salt tolerant, Giza 161 and 113 are considered moderate, but IR28 is very sensitive.

Crop rotation design of saline and alkaline soils should be based on sensitivity and tolerance. Some assessments are made as follows:

Exchangeable sodium percentage (ESP) of different crops.

40-60%	20–40%	10–20%	2–10%
Grasses:	Cotton	Clover	Deciduous fruit
Agropyron	Wheat	Rice	Nuts
Rhodes grass	Alfalfa, rye	Fig	Citrus
Bermuda grass	Barley	Olive	Pear
	Beets	Grape	Apple
	Tomato	Maize	Peach
	Rape, kale		
	Sorghum		

The choice of crop rotation includes proper demonstration of the transitional period, crop sequence, proportion of applied irrigation water for leaching out residual salts, and the amount of gypsum added (El Behairy, 1950; El Balkeny, 1952).

Crop resistance to saline water.

Crop	Max. EC†/cm	Crop	Max. EC/cm
Barley	28.0	Cantaloupe	16.0
Cotton	27.0	Spinach	15.0
Sugar beet	24.0	Tomato	12.5
Wheat	20.0	Broccoli	13.5
Sorghum spp.	18.0	Cabbage	12.0
Sesbania	16.5	Cowpea	8.5
Safflower	14.5	Cucumber	10.0
Broad bean	12.0	Almond	7.0
Rice	11.5	Plum	7.0
Corn	10.0	Beans	6.5
Flax	10.0	Strawberry	5.5
Soybean	10.0	Blackberry	6.0
Groundnut	6.0	Boysenberry	6.0
		Raspberry	6.0

† EC = Electrical conductivity.

Conclusions and Recommendations

The main constraints to crop production in the New Lands are soils with low or unbalanced soil fertility, high levels of free $CaCO_3$, salinity, and shortages of irrigation water, as well as poor external or internal drainage. Crop production in the New Lands can be increased by modifying the soil and providing good-quality water in the root zone, or by adapting plants to fit existing or slightly modified soil conditions, or using a combination of both approaches. The latter is probably the most economical.

Adapting crops to existing soil conditions minimizes the cost of modifying the soil, but the resulting crops may be low in yield and/or poor in quality. Optimum returns may result from cultivars which have high yield potential but will tolerate less than optimum soil conditions. Soil fertility levels must be sufficient to allow maximum growth.

Crop quality is intimately associated with balanced soil fertility and water availability, which must be considered in all breeding programs.

Programs to screen cultivars for adaptation to environmental problems should include the effects of soil modification on resulting crop yield and quality. Otherwise, genetic material which is superior only when the soil has been modified for optimum production will be discarded. The net result is that returns from crop production will not be as high as is economically possible under harsh environments. Suggestions for screening programs to overcome these problems are given as follows:

- Preliminary tests should include differential response to fertilizers on several different soils. Without such trials, potentially high-yielding cultivars requiring fertilizers may be excluded from further trials because of poor performance.
- Off-station tests should be conducted on fields of low, average, and high soil fertility, with varying levels of management, so that cultivars can be selected for each level of fertility and management.

- The interaction of other factors—such as crop quality and insect, disease, and lodging resistance—with fertility must be studied during response tests. Research results have shown marked interactions between some of these factors; their effects must be balanced against yields obtained in these tests.
- Economic analysis is essential to determine if the cost of inputs will be compensated for by high yields. Cultivars with lower yield potential may be the most economical in the short run for some areas if the input costs are much lower and extra capital is difficult to obtain. Efforts should be made to modify soil for maximum crop production as soon as is economically feasible.
- Development of cultivars for problem soils requires an interdisciplinary approach. Cooperation among agronomists, crop physiologists, plant geneticists, and soil scientists is essential to determine which species and cultivars will respond to which management practices. Each must understand the limitations of the ecosystem under consideration to determine the combination of soil management and variety selection, which will provide the greatest return to the grower.

Weeds, Pests, and Diseases

Weeds

Recently, a weed survey was conducted by the Weed Control Research Department, Field Crops Research Institute. The survey covered 50 fields around El Bustan. A total of 30 winter weed species were identified in wheat and faba bean fields (Table 8). The results show that *Avena* spp. (33.3%) are the dominant grassy weed. Other results show 8.3% for *A. fatua*, 14.6% for *A. sativa*, and 10.4% for *A. sterilis*.

Table 8. Some important common winter weeds in the New Lands.

Scientific name	Family	Common name
Anagallis arvensis	Primulaceae	Scarlet pimpernel
Avena fatua	Gramineae	Wild oat
A. sativa	Gramineae	Oat
A. sterilis	Gramineae	Sterile Oat
Cynodon dactylon	Gramineae	Bermuda grass
Phalaris paradoxa	Gramineae	Hood canary grass
Emex spinosus	Gramineae	
Beta vulgaris	Chenopodiaceae	Sea beet
Calendula micrantha	Chenopodiaceae	White beet
Chenopodium album	Chenopodiaceae	Common lamb's-quarter
Chenopodium murale	Chenopodiaceae	Goosefoot
Capsella bursa-pastoris	Cruciferae	Shepherd's purse
Coronopus squamatous	Cruciferae	Goosefoot
C. nilotica	Cruciferae	Goosefoot
Cyperus rotundus	Cruciferae	Nut grass
Sisymbrium irio	Cruciferae	
Sencio desfontaini	Compositae	
Sonchus oleraceus	Compositae	Annual sow thistle
Euphorbia poplus	Euphorbiaceae	Petly spurge
Lolium multiflurom	Euphorbiaceae	
Kochia indica	Euphorbiaceae	
Malva parviflora	Malvaceae	Little mallow
Medicago intertexa	Leguminosae	California bur clover
Melilotus indica	Leguminosae	Indian sweet clover
Plantago lagopus	Plantaginaceae	
Orobanche crenata	Orobanchaceae	Scalloped broomrape
Polypogon monspeliensis	Polygonaceae	
Rumex dentatus	Polygonaceae	
Spergula sp.	Caryophyllaceae	
Stellaria media	Caryophyllaceae	

Lolium multiflorum and *Polypogon monspeliensis* are also common in most fields, with a frequency of 14.6 and 12.5%, respectively. The most common broad-leaf weeds are *Anagallis arvensis* (27%), *Emex spinosus* (18%), and *Chenopodium album* (28%).

About 50% of faba bean fields sampled were heavily infested with *Orobanche crenata*. The infestation varied between 5 and 13 spikes/m^2.

Brassica tournefortii, *Beta vulgaris*, and *Melilotus* spp. are the dominant weeds found in the newly reclaimed areas in Minia governorate.

The common summer weeds found in the New Lands are shown in Table 9.

Table 9. Some important common summer weeds in the New Lands.

Scientific name	English name
Cenchrus biflorus	
Convolvulus arvensis	Field bindweed
Conyza linifolia	Fleabane
Cynodon dactylon	Bermuda grass
Cyperus rotundus	Nut grass
Dactyloctenium aegyptium	Egyptian finger grass
Digitaria sanguinalis	Crab grass
Dinebra retroflexa	Negil el Nimr
Echinochloa colonum	Deccan grass
Eleusine indica	Wire grass
Euphorbia prunifolia	Laban el Homara
Portulaca oleraceus L.	Purslane
Setaria viridis	Green bristle grass
Sida alba	Prickly sida
Solanum nigrum	Black night shade

Control of broad-leaf weeds with post-emergence herbicides in wheat and barley is relatively simple, but such is not the case with grassy weeds. A contact herbicide such as Broomoxynil or Staran is appropriate for broad-leaf weeds in newly reclaimed areas because it has no residual effect, either in the soil or in the plant. The greatest advances have been made in the control of wild oat by several selective herbicides according to the growth stages of both wheat and oats.

A major tenet of low-input sustainable agriculture concerns the need for reducing herbicide application. This sounds good in theory but can be difficult in practice. However, new farming and agricultural tactics may reduce the need for herbicides. Crop rotation and new competitive crops may alleviate some weed problems.

Hassanien *et al*. (1993) found that planting the same wheat field in rotation with berseem dramatically reduced the fresh weight of wild oats from 1,255 g/m^2 in the wheat/wheat rotation to 154 g/m^2 in the wheat/berseem rotation without using any weed control treatments (Fig. 5). El Marsafy and Hassanien (1993) found that using berseem (clover) or faba bean as a preceding winter crop with weed control treatment in the wheat rotation significantly decreased the population of weeds in farmers' fields (Fig. 6). Hassanien *et al*. (1993) describe the effect cutting berseem had on reducing the population of common weeds. The interaction between the number of cuttings and weed species was obvious (Table 10).

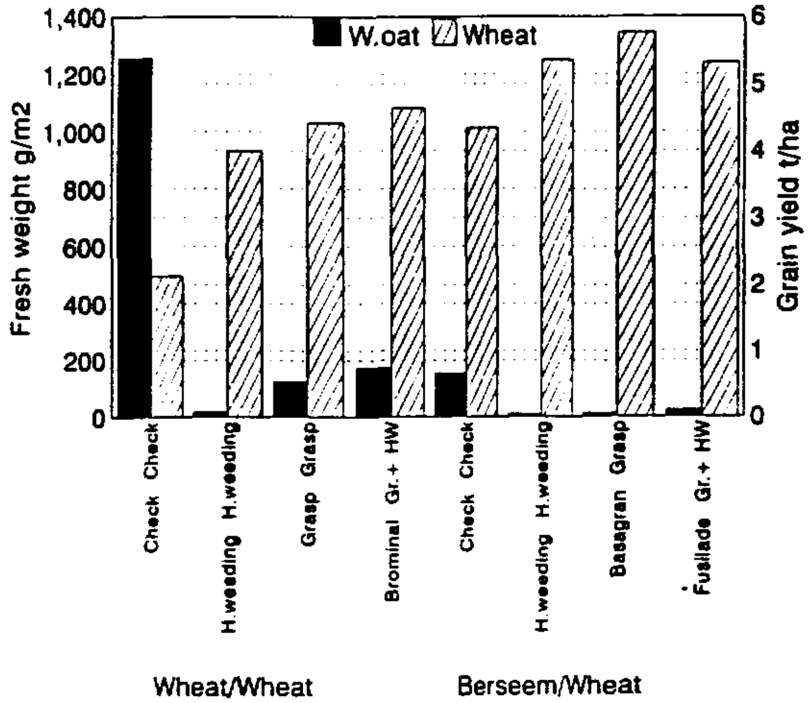

Fig. 5. Effect of berseem/wheat rotation on the control of wild oats.

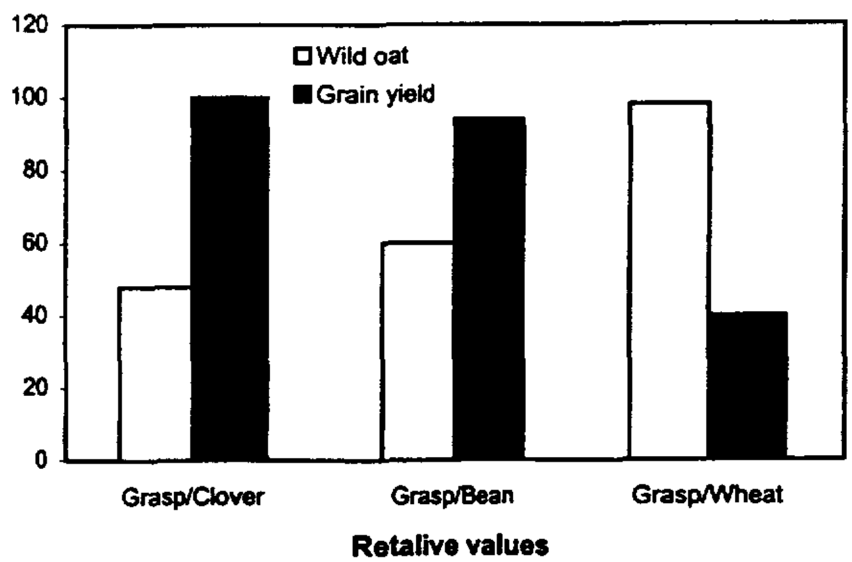

Fig. 6. The correlation between wild oat fresh weight and wheat grain yield.

Table 10. Effect of cutting on weed infestation in berseem at Mallawy (1992/93).

Weed species	Number of cuttings			
	1	2	3	4
Ammi majus L.	30.7†	0	0	0
Beta vulgaris L.	40.0	45.5	0	0
Brassica nigra L.	68.0	39.9	28.7	0
Cichorium endivia L.	293.8	112.1	96.0	65.1
Sonchus oleraceus L.	75.5	35.0	23.6	9.8
Total	**507.7**	**239.1**	**148.3**	**74.9**
Avena fatua L.	135.0	109.1	0	0
Phalaris minor Retz.	23.8	12.5	0	0
Total	**158.8**	**121.8**	**0**	**0**

† No. of weeds/m^2.

Scouting and staging the growth of crops and weeds may be critical in reducing the use of chemical treatments. Using seed contaminated with weed seed should be avoided as much as possible. Applying animal manure during certain periods before soil application can also reduce the viability of weed seed for germination.

Pests and Diseases

Wheat

Wheat rust, mainly leaf rust (*Puccinia recondita*) and stem rust (*Puccinia graminis*), have been found in the New Lands, but, due to the resistant genetic makeup of Egyptian wheat cultivars as well as climatic conditions unfavorable for rust development, low severity was observed. Loose smut disease (*Ustilago tritici*) is found, particularly on Sakha 61 and Sakha 69 if seeds are untreated with specific fungicides. The infection was very rare on other varieties.

Common (dry land) root-rot disease has been found in the New Lands due to salinity and drought, but does not cause economic damage. The causal agent, *Cochliobolus sativus* (*Helminthosporum sativum*) has been isolated. Fusarium strains were not determined (it could be *F. culmorum* or *F. graminearum*), but were classified as white- and red-pigmented strains. Analysis of the results showed that the red pigmented Fusarium strain was more prevalent than *C. sativus* and the white pigmented strain.

A high incidence of powdery mildew (*Eryciphe graminis*) was noticed on durum and some bread wheat varieties in the New Lands in Qena and Sohag governorates. This disease is expected to be more important in Upper Egypt due to climatic conditions such as high humidity and high temperature.

Cereal leaf beetle, slugs, and snails are found in specific localities in the New Lands, but do not cause significant yield losses. Observation of aphids on cereal plants has not been significant.

Faba bean

The foliar diseases—chocolate spot (*Botrytis fabae*) and rust (*Uromyces fabae*)—are the main constraints to faba bean production in the newly reclaimed lands, especially in the north sector of Tahrir Province. However, methods of chemical control are a good tool for prevention of damage caused by these two diseases. Moreover, root rot and seedling diseases are the major constraints in the New Lands of Middle Egypt because of the prevailing temperatures.

The broad bean wilt virus (BBWV) transmitted by bean aphids is the major faba bean pest observed in the New Lands. Broad bean aphids can be controlled with chemicals (Dimethoate and Malathion).

Other crops

In pea fields, the major disease is powdery mildew, against which fungicides such as Robigan, Sandovan, or Bravo can be used. But these chemicals are not always available to farmers, nor are there any proven recommendations for their application.

The major pest observed in groundnut fields is cotton leaf worm (*Spodoptera littoralis*), which can be controlled by cotton dust. A common disease is late leaf spot (*Cercospora personatum*), which can be controlled with sulfur spray or copper/sulfur dust.

The two economically important maize diseases are smut and late wilt, while the major pests are corn stalk borer (*Busseola fusca*) and sorghum borer (*Sesamia certica*).

Tomato leaf roll and tomato mosaic virus (TMV) infection are serious tomato diseases. TMV is transmitted by the white fly, especially in the early stages of plant development. After transplanting, the crop must be sprayed with Cynox and Sumithion to protect against the white fly.

Some fungal attacks of *Monilia laxa* and *Sphaeroteca pannosa* (mildew) and *Corineum bejerinkii* occur on peach. The damage caused by insects and mites such as aphid, *Ceratitis capitata* (Mediterranean moth fly), white fly, *Cydia molesus*, *Zeuzera pyrina* (leopard moth), and grape fruit moth is severe. Nematodes do not seem to be a serious problem at present; some modest infestations occur on some of the older farms. The main source of nematodes is irrigation water. A high concentration of nematodes in soils could occur when trees are mature. At that time, however, the trees are more resistant to this parasite. The number and timing of spraying are mostly adequate on investors' farms but small holders rarely carry out plant protection measures.

Accordingly, chemical control seems to be the main tool for controlling damage caused by plant disease, pests, and weeds. Crop rotation, sufficient and balanced fertilization, proper sowing date, and repeated harrowing are tactical management methods that could provide a good foundation for the control of plant pests, but cultural methods are usually insufficient. Moreover, many of the practices associated with low-input sustainable agriculture require better management. However, many farmers around the world have already realized the benefits of integrated pest management (IPM), one of the cornerstones of sustainable agriculture. In addition, genetic tolerance against insects and disease is increasingly feasible and ecologically sensible.

Mechanization

Acute labor shortages and high wages cause small farmers and graduates to rely on crops with low labor requirements and to keep part of their farms fallow. However, farmer settlers with families of six or seven are capable of operating mainly with family labor. The large investors do not appear to have the same labor problems. Unfortunately, the best mechanization system for a small-scale farming system has not yet been identified, developed, or adopted in the New Lands, or for the rest of Egypt. Major constraints due to the lack of labor mean that sowing and harvesting are done by hand due to the scarcity of sowing machines, as well as harvest and threshing equipment. Some farmers use cutters and reapers, and large-scale investors use combines. There are some sowing machines and tractors, but not nearly sufficient to cover the needs of the newly settled areas. In general, there is a shortage of appropriate machinery, particularly for crop establishment, weeding, harvesting and threshing. This leads to inappropriate plant density and uneven stand, the absence of mechanized weed control, and yield losses.

The estimate of the number and type of farm machinery and equipment is based on the incremental requirements of the presently settled New Lands farmers and the needs of future areas. Indeed, foreseeing the need for additional appropriate farm machinery would significantly improve cultural practices. In assessing the machinery needs for the New Lands, the specific requirements of calcareous and sandy soils should be considered:

- Land leveling and sub-soiling, which are presently carried out alongside sprinkler irrigation, should be restricted to flood irrigation, particularly on calcareous soils where gypsum hardpans occur.
- Chisel plows should be limited to heavier soils, and the practice of two operations for primary tillage should be continued.
- Cultivators such as the spring tune, duck foot, and disc harrows should be used only on sandy soil for both cultivation and weeding.
- In sandy soils, one pass per cultivation is recommended, rather than two.
- Machinery that can be used on all types of soil is required to alleviate the labor shortage, facilitate timely and proper farm operations, and reduce harvest losses.
- Expansion of improved seed drills and planters provides a proper plant population and allows inter-row cultivation.
- The use of manure spreaders allows more even application and saves labor. In addition, they can be used as trailers.
- The current rear-mounted cutter bar has not proved to be suitable for cutting green crops on small fields. Therefore, front-mounted mowers and/or reapers should be provided.
- Modern and efficient drum threshers would reduce post-harvest losses and save labor.
- Additional knapsack sprayers would facilitate proper pest and disease control and foliar micronutrient application.

Mechanization Services

Information regarding the amount of agricultural equipment in the New Lands is not available. However, some reports provide the following information:

- The Gianaklis Agricultural Engineering and Mechanization Company was set up by the Ministry of Agriculture and Land Reclamation (MALR) in 1987 with the objective of providing hire services, with priority to the private sector—small holders, cooperatives and investors. About 70% of its services are for small farmers. The company operates five service centers, two each in El Bustan and Nubaria, and one in the Sugar Beet area. Each service center operates about 10 tractors, mostly 75 hp Universal (Romanian), and ancillary implements (disc harrows, chisel plows, planting riders, cutter bars, rotovators, levelers, seed drills, balers, and threshers). There are twelve 3 m combines. Company tractors and equipment are maintained at the service centers and repaired at the main center. Sometimes these services are also provided to private tractor owners for a cash payment. Hire charges are set at modest levels, e.g. LE 8/hr for each of the following implements: thresher, disc harrow, ridger, moldboard, and mower. The major problems of the company are the high cost of equipment and spare parts, the irregular supply of spare parts, and the scarcity of certain equipment and machines.
- The Nubaria Agricultural Engineering and Mechanization Company was started in 1983 as a Government of Egypt company under the Ministry of Agriculture, principally to run a hire service for government farms, private agricultural companies and small farmers. It provides services in the field of farm mechanization, land reclamation and engineering. The company has a total of 90 tractors—of which 40 are 80 hp Belarus, 15 are 100 hp Renault, 15 are 55 hp Zetor, and 20 are 100 hp Fortschritt—and 38 combines (4.25 m). Only three combines have a width narrow enough for small farmers. Their mode of operation is not based on service centers like the Gianaklis Company, but on mobile mechanization camps, which consist of four or five tractors with a mobile workshop, that provide services in a particular area for two to three months. Large-scale farmers and government farms receive preferential services.
- The Nubaria Experimental Station of the UNDP/FAO project has eight tractors of different make and capacity, mainly for test purposes but also for hire to small holders. The cost of hire services is lower than government rates. The project is testing a wide variety of equipment under on-farm conditions.
- The Italian Mechanization Project has approximately 50 Fiat tractors of different capacities for various agricultural operations, tree crop cultivation, and forage harvesting. Ten combines (4.8 m) are available for grain crops. Workshops and the training of staff are also financed. The project is located at the Nubaria Mechanization Company and assists in the Company's activities. The project assists government farms, as well as small holders.
- Most tractor owners are farmer settlers who have some assets, with which they buy a new or a secondhand tractor. Usually these tractors are equipped with a chisel plow, a disc harrow, a leveler or a ridger. Spare parts supply, maintenance, and repair services are not perceived as a problem. Often maintenance is done by the farmer himself, and for repair the tractor is sent to a private garage available in the vicinity. The cost of disc harrowing is LE 15/hr, and chisel plowing LE 8/hr.

Crop Yield and Adaptive Research

Crop yield data have been difficult to collect and evaluate due to the scarcity of information and variations depending on the source. Table 11 provides average yields for the different target groups and the national average according to 1990 estimates. Farmers with 14 years of experience averaged yields at or close to the national average. However, the average yields of the other target groups have been far below the national average. This indicates that yield in the New Lands has not met its full potential due to environmental and agronomic limitations. New settlers, graduates, and landless farmers have little or no control over these limiting factors. A key goal is to accomplish higher yields by methods that are profitable and environmentally sustainable.

Table 11. Average yield potential (t/fed) of different crops in the New Lands compared to the national average (1990 estimates).

Crops	Landless settlers (4–5 Years)		Graduates (2–3 Years)		Experienced graduates and farmer settlers (14 years)	National average
	Sandy	Calcar.	Sandy	Calcar.	Calcar.	
Winter crops						
Wheat	1.3	1.4	0.7	0.9	1.6	2
Barley	1.2	1.4	0.5	—	—	1.2
Faba bean	0.5	0.9	0.3	0.4	1.2	1
Pea (green)	2.7	1.9	1.3	1.1	2.7	—
Berseem (4 cuts)	20	25	6	11	20	40
Alfalfa (4 cuts)	13	—	10	—	—	—
Tomato	8.8	7	4	4	10	10.6
Summer crops						
Watermelon (table)	5	7	—	2	8.8	—
Watermelon (seed)	0.4	0.3	0.14	0.15	0.4	—
Maize	1.6	2	—	0.6	2	2.2
Groundnut	0.6	—	0.3	—	—	0.9
Alfalfa (5 cuts)	30	—	—	—	—	—
Sunflower	—	—	—	—	—	—
Tomato	6	5	—	—	7	10.3
Fodder sorghum	18	21	15	20	25	40

1 hectare = 2.38 feddans.

In the New Lands, lack of nutrients and water are restricting productivity. Lack of appropriate varieties and inadequate management practices also lower productivity. Hence, the application of a strategy involving the development of plants and new agricultural methods that utilize inputs more efficiently could obtain modest to high productivity under different farming systems. The modified research strategy in this area focuses on fertilizer and water-use efficiency, and on organic matter in the soil.

Wheat

The increasing food demand has led to the cultivation of wheat under marginal conditions. Drought resistance and heat tolerance are major breeding constraints. Salinity is also a problem on about 30% of the cultivated areas in Egypt.

In sandy soils, nutrient and water deficiencies restrict productivity. However, there is considerable potential for improved wheat yield on irrigated desert land (Table 12). Wheat production has been quickly adopted by growers under New Lands conditions, producing about 280,000 tons with an average grain yield of 3.8 t/ha in 1992 (Abdel Ghani *et al.*, 1994).

Table 12. Total area (million hectares), mean productivity (P) (t/ha), and wheat production (WP) (million tons) in the irrigated New Lands (1990–1992).

Location	1990			1991			1992		
	Area	P	WP	Area	P	WP	Area	P	WP
Irrigated desert New Lands	0.24	2.6	0.41	0.36	3.5	0.22	0.37	3.8	0.25
New Valley	0.03	3.4	0.02	0.04	3.3	0.02	0.39	3.4	0.02
South Sinai (saline groundwater)	—	—	–	--	–	—	0.04	1.8	0.01
Total	0.27	—	0.43	0.40	—	0.24	0.80	—	0.28

The appropriate cultivars are those that most efficiently use all the water and nutrients that management can make available. Most cultivars have a longer crop cycle, and use more water and fertilizer under New Lands conditions. However, the range of values obtained among selected genotypes of the New Lands Advanced Yield Trial–1993 (Table 13) suggests that grain yield in the desert New Lands was restricted to 3.0–3.5 t/ha (average grain yield of New Lands was 3.0 t/ha in 1992) compared with the highest yield of 5.5 t/ha achieved in the same year from wheat sown in the Old Lands.

The actual production level attainable under New Lands conditions is affected by a multitude of factors:

- Genetic crop characteristics.
- Environmental conditions that are not easily modified, particularly temperature.
- Limited availability of plant nutrients for at least part of the growing season.
- Under temperate conditions, the moisture supply, especially on lighter soils, may be insufficient for optimum crop production.

In this situation, two questions need to be answered: (i) what is the attainable yield of wheat under New Lands conditions; and (ii) what additional management practices could be applied to bring this about?

Table 13. Average grain yield (t/ha) of some wheat genotypes tested under New Lands conditions.

Variety and pedigree	Middle Egypt Expt. I	Middle Egypt Expt. II	Nubaria	Ismailia	North Sinai	Salhia	Khatara	Mean
Sakha 69	3.3	5.9	3.7	2.9	3.3	4.6	3.9	3.9
Giza 164	1.4	3.7	2.8	2.3	3.6	4.6	4.7	3.3
Sohag 3	2.1	3.1	2.3	1.5	3.1	3.6	3.7	2.8
Beni Sueif 1	3.0	4.2	2.8	2.1	3.1	5.1	4.6	3.6
HD2172/PAVON"S"//1185 . 57/MAYA74"S"	2.9	4.7	2.7	2.8	2.9	4.1	4.0	3.4
AU/UP301//GLL/SX/3/PE W"S"/4/MAI"S"/MAYA "S"//PEW	3.3	4.2	2.7	3.0	3.6	4.4	4.3	3.6
KAUZ"S"	4.4	3.1	2.5	2.6	2.7	4.8	4.1	3.5
BRES/BOW"S"	3.8	4.0	2.3	2.5	3.8	5.2	4.8	3.8
GDOVZ 447/CADEALFEN	1.4	3.7	2.5	2.6	2.7	3.9	4.1	3.0
I.s.4	1.6	4.4	2.2	2.6	3.8	4.8	3.9	3.3
HD 2206/HORK"S"/3/ NAPO 63/INIA 66//WERN"S"	3.8	3.7	3.0	2.5	2.8	3.9	3.6	3.3
PVN"S"	1.6	4.7	2.4	2.5	3.7	4.8	4.8	3.5
Mean	2.7	4.1	2.6	2.5	3.2	4.5	4.2	3.4
LSD 0.05	3.6	2.2	1.0	0.2	0.4	0.4	0.4	
CV %	12.9	16.3	15.0	4.0	8.8	6.4	7.1	

Source: New Lands Advanced Yield Trial, Wheat Department (1993).

The most important crop characteristics under desert conditions are the dynamics of the green area, rate of phenological development, and response to environmental factors and inputs.

Results from El Bustan (Fig. 7) show that late planting reduced grain yield by about 43%. Short-cycle cultivars—Sids 13, Sids 14, and Sids 15—had relatively higher yields when planted late compared to the long-cycle cultivars—Sakha 69 and Sakha 8. The highest grain yields were obtained by Sakha 8 and Sakha 69 when planted early.

Studies on seeding rate and NPK fertilization resulted in a recommended package of 160 kg seeds/ha, with 215, 70, and 60 kg N, P, and K per ha, respectively (Abo Warda, 1993; Mitkees *et al.*, 1994). For maximum grain yield, N fertilization should be applied in six equal doses, the first dose at the one shoot stage, then four doses at seven-day intervals, with the sixth dose at the boot stage.

Abdel Ghani *et al.* (1993) found that increasing N up to 250 kg/ha produces the highest grain yield under the heat stress conditions of the sandy soils in Upper Egypt. Increasing the seeding rate slightly affects grain yield. Abdel Shafi *et al.* (1992) found no significant differences due to micronutrient application. In calcareous soils, increasing the seeding rate from 70 to 170 kg/ha significantly increases grain yield and yield components (Abo Warda, 1993).

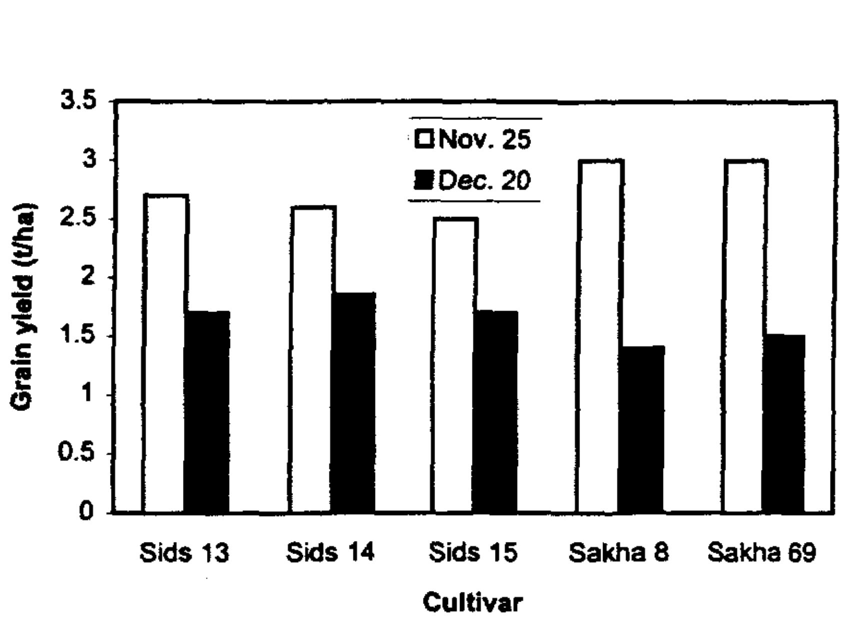

Fig. 7. Effect of planting date on grain yield of some wheat genotypes at El Bustan (1992).

Wheat productivity in both New and Old Lands has been studied. The number of spikes per unit area is the most critical factor affecting wheat productivity in the New Lands. Although equal seeding rates were used in both regions, the number of spikes per unit area was lower in the New Lands than in the Old Lands (Table 14). This can be attributed to the lower fertility of the New Lands, especially concerning nitrogen. This is based on the increase in the number of spikes per unit area following the nitrogen application (El Sayed and Fayed, 1992; Abo Warda, 1993). The role of nutrients and their interactions—particularly nitrogen—on wheat productivity in the New Lands needs further investigation.

Table 14. Average number of spikes per square meter of some wheat cultivars (1992/93 and 1993/94).

Cultivar	*Gemmeiza*	New Lands		
		Sugar Beet	El Bustan	Nubaria
Sakha 8	546	493	400	384
Sakha 69	576	500	433	396
Giza 163	645	550	478	439
Giza 164	585	429	413	429
Gemmeiza	583	500	428	388

Source: Wheat Crop Modeling Experiments, Wheat Research Department, FCRI.

Movable and fixed sprinkler systems are widely used in the New Lands (El Refaie *et al.*, 1988). Wheat needs about 500–550 mm of water over the course of its growing season—from November to the first of May (140–150 days)—to produce an economical grain yield under New Land conditions. The number of irrigations applied is between 20 and 22, at 5–7 day intervals. The amount of water per application is 20–25 mm, which takes about 2 hours.

During the critical stages of plant growth, periods of 2 hours twice a week are recommended. At planting, 50–100 mm is recommended to ensure good plant germination. This amount should be applied every 2–3 days for a period of 2 hours each time. Wind often hampers sprinkler irrigation, therefore, application times should be in the early morning or before sunset to minimize wind effects. However, new irrigation technologies are still in the development stages.

The potential for increased water-use efficiency by improved management practices could result in much greater increases. Breeding for early vigor and short duration are also highly desirable for increased WUE. Other considerations for water-use efficiency are:

- Optimizing the soil–water balance.
- Maximizing transpiration efficiency.
- Reducing the depth of irrigation.
- Matching rotations, crops, and cultivars to a sustainable water supply.

Winter Food Legumes

Cool-season food legumes (faba bean, lentil, and chickpea) are among the most important staple foods in Egypt due to their high nutritive value in terms of both energy and protein content. Seed legumes also have the advantage of nitrogen fixation.

Winter legumes have a lower water requirement, especially lentil (300–350 mm). Chickpea may also be grown in saline soils. This illustrates the importance of winter legumes under New Lands conditions where low soil fertility, water availability, and salinity are common problems. However, productivity of these legumes can be constrained by biotic and abiotic stresses.

Faba bean

Faba bean is one of the most common winter crops, occupying about 15% of the cultivable New Lands. The incidence of foliar diseases, low plant populations, and inappropriate sowing dates are the main limiting factors constraining production of the crop in newly reclaimed areas. Lower plant densities are significantly less infected with chocolate spot and rust diseases, but high plant populations are required for higher seed yield. Population densities of 33 plants/m^2 give the highest yield under New Lands conditions in the sandy soils of Minia and the calcareous soils of Nubaria (Dessouky, 1989; Hussein *et al.*, 1992, 1993; Hussein and Khalil, 1993; Khalil *et al.*, 1993). However, a population density of 33 plants/m^2 increases the infection with chocolate spot and rust diseases (Dessouky, 1989; Khalil *et al.* 1993).

Giza Blanca, a disease-tolerant variety, has a significantly higher seed yield—44.9% more than the susceptible variety Giza 3 at a high plant density of 33 plants/m^2 (Khalil *et al.*, 1993). The chemical fungicide Dithane M45 increased yield by about 92% over no chemical treatment. It is obvious that moisture condensation around faba bean plants due to dense populations and irrigation water strongly encourages foliar disease infection, but using resistant varieties and chemical treatment could overcome this problem in the New Lands.

Delaying the sowing date decreases the incidence of natural infection with foliar diseases in Nubaria. Planting faba bean on November 1 resulted in a significantly higher seed yield—

about 9.4, 19.0, and 45.5% higher than planting on October 15, November 15, and December 1, respectively (Dessouky, 1989). This result indicates that the planting date is one of the important limiting factors to faba bean productivity.

A series of experiments was conducted in successive years in Nubaria in calcareous and sandy loam soils to study the role of P fertilizer application on faba bean productivity. In general, the application of P fertilizer significantly reduces chocolate spot and rust disease severity, which leads to higher productivity (Sirry, 1959; Hamdi *et al.*, 1965; Hegazy, 1968; Abd El Aziz *et al.*, 1982; Hussein *et al.*, 1993).

Screening faba bean for foliar disease resistance under New Lands conditions has shown that at Nubaria, the three commercial cultivars Giza 2, Giza 3, and Giza 402 are highly susceptible, the promising cultivar Giza Blanca is moderately resistant, while Giza 461 and the new line ILB 938 exhibit high resistance (Khalil *et al.*, 1991; Nassib *et al.* 1992). The researchers found that the mean percentages of seed yield increases due to the frequency of Dithane spraying were 22.0, 11.7, and 26.6% for Giza 3, Giza 461, and Giza Blanca, respectively.

Rhizobia inoculation and/or N fertilization showed remarkable effects on plant growth and seed yield of faba bean, especially when grown in newly reclaimed soils. A study under Nubaria conditions showed that the increase in seed yield due to rhizobia inoculation and N fertilization was about 0.7 t/ha (Hassan *et al.*, 1993c).

Lentil

The area planted to lentil in the Nile Valley decreases annually, and has reached about 6,119 ha, with an average seed yield of 1.726 t/ha. This may be due to strong competition from other winter crops such as wheat, berseem, faba bean and sugarcane. The total production is still far below local consumption. The target goal of the national policy is to increase total production by introducing lentil in newly reclaimed areas, and also under the rained conditions of the Northwest Coast and Sinai. Results of nine demonstrations in 1991/92 showed the possibility of expanding the area cultivated under lentil in the newly reclaimed areas of Nubaria.

The major constraints to lentil production in the New Lands are weed infestation and fungal diseases such as downy mildew and *Stemphylium*. Extensive studies in Nubaria and the Sugar Beet area indicate that control of such fungi is ineffective using common methods of control, but resistant varieties could be a solution to this problem (Hassan *et al.*, 1993a).

Due to the crop's low water requirement, introducing lentil to the newly reclaimed areas may not be enough to sustain high yields, because lentil may need more fertilizer to attain a good yield under such poor soil fertility. The results from different field experiments conducted on the calcareous soils of the Nubaria region clearly indicated that application of NPK combined with a foliar application of micronutrients—Mn, Zn, and Fe—at 60 and 75 days from sowing significantly boosted seed yield (Rizk *et al.*, 1992; Azmi *et al.*, 1993).

Consequently, low nitrogen content in the newly reclaimed soils can hinder lentil production. However, exploitation of biological nitrogen fixation by rhizobia through inoculation can contribute appreciable amounts of nitrogen to lentil plants, save large amounts of chemical N fertilizer, and reduce production costs. Rhizobia inoculation alone showed positive effects on plant growth and yield of lentil grown in the newly reclaimed soil of Nubaria. Application of 50 kg N/ha to rhizobial-inoculated plants at planting time dramatically increased seed yield and led to enhancement of other plant characteristics (Hassan *et al.*, 1993a).

Chickpea

Chickpea is also an important seed food legume for human nutrition in Egypt. It is grown in a wide range of environments. Recently, it has been expanded to the newly reclaimed areas in Nubaria. In this new area, production constraints include the use of inappropriate cultivars, root rot and wilt diseases, and lack of an effective native *Rhizobium* population.

Extensive field experiments have been conducted under a wide range of environmental conditions at El Bustan and Nubaria to evaluate an improved production package using the promising chickpea cultivar, Giza 195, planted on ridges 60 cm apart with 10 cm between hills, a seeding rate of 95 kg/ha, and seed inoculation with rhizobia (ICARDA strain No. 44). Other experiments were also conducted in the Old Lands at Assiut using the cultivar Giza 531. The advantage of using Giza 195 for the New Lands is due to its reduced susceptibility to *Ascochyta* blight, a common disease in this area. The results show that chickpea yield ranged from 1.4 t/ha at Nubaria to 2.2 t/ha in El Bustan, with an average of 1.8 t/ha, while the Old Lands experiments averaged 2.8 t/ha (Khattab *et al.*, 1993).

Khalil and Khattab (1992) showed that soaking the seeds of Giza 195 in 200 ppm succinic acid for eight and 12 hours produced the highest seed yields—5.9 and 1.3 t/ha for sandy loam soil (Beheira) and sandy soil (Ismailia), respectively.

Hassan *et al.* (1992, 1993b) reported that applying N fertilizer to inoculated chickpea plants at flowering led to higher increases in yield and less N fertilizer, by about 60%, in the newly reclaimed areas of Nubaria.

Future Outlook

Sustainable agriculture is easy to plan, but it is difficult to implement. In general, much is known about the components of sustainability, but not nearly enough is known about how the system works as a whole. Several alternative agricultural systems that are responsive to natural cycles and biological interactions have been developed. Alternative systems to improve crop production under the fragile conditions of the New Lands should be economically sound, socially acceptable, and environmentally safe.

- Crop rotations that mitigate weeds, disease, and insect problems, increase available soil nitrogen, reduce the need for synthetic fertilizers, and reduce soil erosion should be favored.
- When combined with crop rotation and applied fertilizers (NPK and trace elements), conservation tillage could provide an alternative agricultural method with greater flexibility in cropping.
- Fodder and grain legume farming systems, such as crop/livestock enterprises that maintain organic matter, improve soil structure and water holding capacity, and increase forage production should be developed.
- Integrated pest management should be introduced, which reduces the need for pesticides by crop rotation, scouting, weather monitoring, use of resistant cultivars, thinning of plants, and biological control.
- Improved management systems that improve plant health and increase water and nitrogen-use efficiency should be introduced.
- Irrigation schedules should be revised.
- Improved farm machinery systems that alleviate labor problems and reduce yield losses during harvest should be introduced.
- Genetic improvement of crops should be considered, including:
    - Short-duration cultivars that can withstand limited water availability.
    - Increasing nutrient utilization.
    - Disease and insect resistance.
    - High N fixing ability of legumes.
    - Tolerant to micronutrient deficiency varieties.
    - Salt-tolerant varieties.

Research needs and priorities include:

- Crop rotations, in terms of a better understanding of:
    - Biological activity of soil nutrient/organic matter interactions.
    - Stability of an integrated crop/forage/livestock farming system.
    - Suitability of no-tillage production systems.
    - Use of crop residue for erosion control and water conservation.
    - Plant pests (weed, disease, and insects).

- Study of the relationship among plant nutrient requirements and soil water extraction, as well as water, heat, and salinity stresses.
- Study of weed control technology in conservation production systems.
- The modeling of physical and biological systems and model validation to create a historical meteorological database with real-time management models.

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