NILE VALLEY REGIONAL PROGRAM
PHASE II

Resource Management Series

Volume 7

INVENTORY STUDIES

New Lands of Egypt
Soil Fertility and Management

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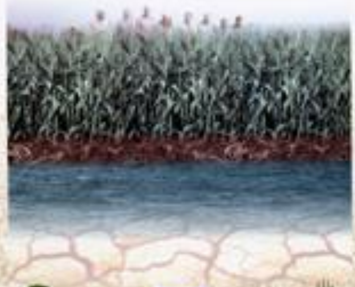

Volume 7

Resource Management in the New Lands of Egypt: Soil Fertility and Management

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Foreword

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

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

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

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

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

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Weights and Measures

1 feddan (fed) = 0.42 hectare = 1.037 acres
1 hectare (ha) = 2.38 feddans
1 ardab wheat = 150 kg
1 ardab barley = 120 kg
1 ardab lentil = 160 kg

Acronyms

AOS = Alpha Olefin Sulphonates
ARC = Agricultural Research Center
CEC = Cation Exchange Capacity
DRC = Desert Research Center
EU = European Union
EC = Electrical Conductivity
ESP =Exchangeable Sodium Percentage
FAO = Food and Agriculture Organization of the United Nations
GARPAD = General Authority for Reclamation Projects and Agricultural Development
GDP = Gross Domestic Product
GOE = Government of Egypt
GTZ = Gesellschaft für technische Zusammenarbeit (German Agency for Technical Cooperation)
h_e = Air-entry suction
IAA = Indole-3 Acetic Acid
ICARDA = International Center for Agricultural Research in the Dry Areas
IPM = Integrated Pest Management
MALR = Ministry of Agriculture and Land Reclamation
NRC = National Research Center
NVP = Nile Valley Project
NVRP = Nile Valley Regional Program
PAM = Polyacrylamide
PVA = Polyvinyl alcohol
PVA_e = Polyvinyl acetate
SWRI = Soil and Water Research Institute
TDS = Total Dissolved Solids
TSS = Total Soluble Salts
UF = Urea Formaldehyde
UNDP = United Nations Development Programme
Ur = Urea
VPG = Viterra Plant Gel
WHO = World Health Organization

Executive Summary

The present study was conducted to collect and review all information and studies on soil management and fertility of the New Lands (calcareous, sandy, and saline-alkaline soils). The results are summarized below.

Physical and Chemical Properties

Calcareous Soil

- The textural classes of calcareous soils are: clay, clay loam, sandy clay loam, gravelly sandy clay loam, and gravelly clay. The fine texture of these soils is affected by the $CaCO_3$ content—which reaches 93% of the total clay and silt fraction—as well as by the media and mechanism of soil particle transportation.
- The $CaCO_3$ percentage is homogeneously distributed throughout the soil profile, ranging between 26 and 59%.
- The bulk density ranges from 1.29 g/cm^3 at the surface to 1.34 g/cm^3 at a depth of 60 cm.
- The available soil moisture for calcareous soils, ranging between 0.1 and 15 atm, is 21%. As the soil moisture potential increases, the retained moisture decreases.
- The soil's air–water balance is the key to its productivity, which depends to a large extent on soil aggregation. Calcium carbonate plays a role in forming soil aggregation. Organic matter is important in forming 5.0–2.0 and 0.84–0.42 mm clods and aggregates, respectively, especially in the bottom layer of partially reclaimed soil. A diameter between 1 and 2 mm is dominant, comprising about 50% of total aggregates. This diameter is the most important for aggregation.
- The total soluble salts of these soils varies from 4–50 mmhos/cm at 25°C, which indicates that non-saline, non-alkaline soils have extremely high salinity levels.
- The soil reaction of these soils ranges from slightly alkaline (7.8–8.0) to moderately and strongly alkaline (8.0–9.6).
- The total exchange capacity of clayey loams is 13.3–17.8 meq/100 g. This value increases to 22 meq/100 g in soil of a clayey texture.
- The exchangeable Na is less than 15%. Cation exchange capacity (CEC) and Na-exchangeable values play a distinct role in soil moisture content of calcareous soils.
- The organic matter content of these soils is relatively low, at 0.23–1.50%, and the maximum accumulation of organic matter is usually confined to the top few centimeters, sharply declining with depth.
- From a mineralogical point of view, the results show that the predominant clay minerals in these soils are polygorshite, constituting approximately 50–60% of the total clay. Other minerals such as illite, montmorillonite and kaolinite are also present in lesser amounts.

- Morphological studies show that the calcareous soils of the Mediterranean coastal zone were formed under arid conditions. From a geological point of view, these soils were formed from different sources, namely limestone, bed shale, and marl of the Libyan plateau, and oalitic or lime sand grains.
- Concerning soil macronutrient content (NPK), the results show that nitrogen levels are very low, ranging between 5.2 and 17.5 ppm in the topsoil and between 3.5 and 14.3 ppm in the subsurface layer. The available phosphorus in the surface layer had a medium level (10–19 ppm). The phosphorus level decreases with depth, resulting in a low level in the subsurface layer. The available potassium in these soils is very high, ranging between 300 and 500 ppm.
- As regards the available value of micronutrients extracted by DTPA, the results show that the available values of Zn, Cu, Mn, and Fe were adequate, according to the classification of Lindsay and Norval (1978).

Sandy Soil

- This soil is structureless, because it does not contain much clay or organic matter. Thus, there is no possibility for natural development of structure.
- Bulk density values are high, ranging from 1.68 g/cm^3 at the surface to 1.74 g/cm^3 in the subsurface layer.
- The values for field capacity and wilting point are 8–9 and 2–3% of soil moisture content, respectively. This reflects a low level of water holding capacity, field capacity, and available water.
- The electrical conductivity (EC) values of these soils are very low, ranging between 0.2 and 0.5 mmhos/cm at 25°C.
- The soil reaction of these soils is slightly alkaline, ranging between 7.6 and 7.7.
- The organic matter is low, varying from 0.35 to 0.89%.
- Concerning macro- and micronutrient content, the results show that NPK and micronutrient levels are very low. Total soluble N extracted with 1% K_2SO_4 is low, ranging between 20 and 40 ppm. The available phosphorus (Olsen) levels are moderate, ranging between 6 and 9 ppm. The soluble and exchangeable potassium extracted by the ammonium acetate method is moderate, with average values of 165 ppm K_2O.

Saline–Alkaline Soils

- The texture of these soils is relatively heavy, ranging from clay to clay loam. It is finer on the surface than in the subsurface. The clay content ranges between 40 and 43%, and the texture ranges from silty clay to silty clay loam.
- The available water is high or very high, decreasing slightly with depth. The value of available water ranges between 36.6 and 44.2%.
- EC values range between 9.22 and 12.97 dS/m. This means that these soils are saline.
- Soil reaction ranges between 8.11 and 8.99, which is relatively high due to high ESP.

- Cation exchange capacity is generally high, ranging between 28.8 and 43.13 meq/100 g of soil.
- The exchangeable sodium percentage (ESP) is high, ranging between 36.95 and 50.70, which means that the soils are alkaline.
- Concerning macronutrient content, the results show that available nitrogen is low, decreasing from topsoil to subsurface. It ranges between 13.10 and 20.31 ppm in the topsoil, and between 10.09 and 17.10 ppm in the subsurface. Available P is moderate to high, decreasing with depth. It ranges between 7.41 and 14.01 ppm in the surface layer and between 6.4 and 12.1 ppm in the subsurface layer. Available potassium is moderate to high, and also decreases with depth. It ranges from 315 to 410 ppm in the surface layer and from 211 to 306 ppm in the subsurface.

Soil–Plant Relationships

- Fertilizer use rates, sources, and methods of application, and their effect on yield were studied. The results showed that the use of urea formaldehyde as a slow-release fertilizer in sandy soil, applied as a side dressing in one dose at the rate of 45, 60 and 75 kg/fed before planting, did not greatly affect the fresh and dry weight N uptake in lentil, but did affect yield.
- Nitrogen treatment produced no effect upon lentil branches, seed index, crude protein content or yield.
- The dry matter yield of barley grown in calcareous soils increased along with the increasing nitrogen rate. The highest nitrogen uptake was attained through the addition of calcium nitrate, while the lowest yield came from using sulfur-coated urea.
- Wheat grain and straw yields increased significantly along with N application. The optimum level of N in sandy soils is no more than 110 kg N/fed, with split doses at 10-day intervals, starting from the sowing date and ending at the booting stage.
- The grain and straw yields of wheat significantly increased by increasing phosphorus application in sandy soils. The highest grain and straw yields were obtained at 60 kg P_2O_5/fed.
- Phosphorus application also increased the crude protein, tryptophan, total amino acids and Fe concentration in broad bean seed in calcareous soils.
- Application of $ZnSO_4$ without P treatment, and Zn application by foliar spraying with P, increased dry matter yield and N content of broad bean plants 40 days from sowing in calcareous soil.
- The dry weight of barley plants significantly increased when seed was pretreated in a mixed micronutrient solution. The total Zn uptake increased when seed was pretreated with Zn solution, but was largely depressed when Zn was combined with Fe.
- Total Mn uptake increased when seed was pretreated with Mn combined with other micronutrients in solution, compared with a single Mn treatment or the control.

- Total Fe uptake significantly increased when seed was pretreated in an Fe solution, compared with the control, whereas mixing Fe with other micronutrients—especially Zn—led to significant decreases in total Fe uptake relative to the control.
- The highest response of different pretreatments was obtained in calcareous soil, while the lowest was found in sandy soils.

Drainage of Irrigated Land in Relation to Salinity Control

- One of the earliest subsurface drainage systems in the area was implemented by El Nahda Agricultural Company as part of a 1979 German Agency for Technical Cooperation (GTZ) project.
- A tile drainage system was designed and installed according to data collected from hydrogeological studies and adsorption of the Glover Dum formula.
- The drainage system at El Nahda has a variety of spacings (40, 50, and 60 m). The discharge measurements at the outfall of the tile drains were taken according to the depth of the water table.
- Water table recession during the irrigation interval was 14 days. It was noticed that the drainage discharge stopped 8–10 days after each irrigation.
- The common drainage system in Nubaria is through open channels. There are 3–5 open field ditches carrying the drainage water to the field drain (collector). All the drainage flow in the area is by gravitation.

Soil Improvement

- To improve the hydro-physical characteristics of sandy soil, the application of a natural and/or synthetic soil conditioner helps to optimize air, heat, and water movement, hence increasing water efficiency. A single application of 20 tons of bentonite/fed significantly decreased bulk density and hydraulic conductivity, whereas the total porosity and moisture content of sandy soils was increased.
- Coarse sand decreased, while fine sand, silt, and clay increased when canals were cleared.
- Vegetative growth and straw and seed yields were increased in lentil grown in sandy soil by applying chaffed straw at 10 t/fed and a 10-day irrigation interval.
- The dry matter yield of barley was significantly increased by applying chicken manure. The nutrient content of barley was positively affected by organic manure.
- Nitrogen and potassium concentrations increased in barley plant as follows: control < farmyard manure < budret (sludge) < chicken manure + sawdust < chicken manure + lime.
- Phosphorus in barley increased with organic manuring, particularly chicken residues.
- Organic manure applied at a rate of 15–20 m^3/fed increased nutrient uptake and solved the problem of crust formation, depending on the crop.

- Use of composites with 50–58% organic matter or other source of manure was recommended as a soil conditioner, applied at 20-25 m^3/fed.
- Use of 60 kg/fed of biogas manure was recommended for improving sandy soil and crop productivity.
- Application of Indole-3 acetic acid (IAA) combined with manganese produced a marked increase in total carbohydrates and nitrogenous compounds in faba bean shoots. Adding IAA combined with iron produced the lowest levels.
- Application of Viterra plant gel (VPG) at rates of 0.05 and 0.2 g/100 g soil along with farmyard manure significantly increased NPK, total porosity and hydraulic conductivity of sandy soils, while the bulk density and rate of water evaporation were decreased.
- Salinity was increased by the use of shale as a soil conditioner in sandy soils, due both to the salinity of the material, and, to a lesser extent, to farmyard manure, which is rich in potassium.
- Minia Governorate has many shale and clay deposits. Shale is used as a natural soil conditioner. The results show that shale can be used to improve the properties of sandy soil.
- Application of a bituminous emulsion in sandy soils decreased the extractable amount of the nutrient elements and NO_3 leaching.
- Application of a bituminous emulsion and polyacrylamide increased the aggregation percentage of sand as well as aggregate stability.
- Maximum wheat yield was obtained when a bituminous emulsion and polyacrylamide were applied to sandy soil previously mixed with organic matter.
- Addition of polymers in combination with NPK fertilizer to sandy soils increased plant growth.
- The consumptive water use decreased when soils were mixed with polymers. Fertilizing soil increased the beneficial effect of polymers on consumptive use in faba bean grown in sandy soils.
- The increase in germination rate of faba bean after 15 days was ranked as follows: Bit > PAM > UR > UF > control.
- Using Agrosoke as a soil conditioner on sandy soil at the rate of 3 kg/m^3 of soil to a depth of 30 cm was effective in improving water characteristics.
- In saline–alkaline soils, the amount of removed salt that resulted from the application of gypsum and water varied from 20 to 97%.
- The combined effect of gypsum and water resulted in a distinct drop in soil pH, from 8.3 to 7.0.
- The amount of released exchangeable sodium as a combined function of different levels of applied gypsum and water varied from 14 to 90%.
- The availability of iron, manganese, and zinc was increased by increasing the amount of gypsum.

- Soil pH was decreased by increasing amounts of gypsum in the first and third leachates, and increased slightly in the second leachate. The magnitude of variation in the pH of the leachate depended upon the amount of gypsum and water and upon the period of land use.
- The amount of dissolved salts increased with increasing amounts of both gypsum and water.
- The amount of dissolved iron and zinc in soil leachates increased as amounts of gypsum and water were increased.
- In soils with high salinity and poor drainage, soaking barley seed for 12 hours in 0.1 saline water increased salinity tolerance and grain and straw yields.
- The grain/straw ratio of barley decreased when seed was soaked, in the sense that straw yield was much greater than grain yield.

Soil Conservation

- The use of bituminous emulsion increased the aggregation percentage by 60% and increased soil structure stability in terms of soil resistance against breakdown by tillage or susceptibility to wind erosion. The results show that the tillage and planting methods were effective in reducing soil erosion parameters.
- The positive effect of the suggested treatments for decreasing soil erosion can be ranked as follows: manual tillage with broadcast seeding > normal tillage with rows > traditional tillage with broadcast seeding > traditional tillage with broadcast seeding > minimum tillage with rows > bare soil without cultivation, with a few exceptions. The best method was manual tillage with broadcast seeding.
- The use of sewage water in sandy soils as a source of irrigation and nutrients increased the available Zn, Cu, Mn, and Fe, with Co, Cr, Ni, Cd, and Pb also increased slightly.
- The concentration of Zn, Cu, Mn, and Fe in plant tissue increased under irrigation with sewage water. The concentration of other elements, in both soil and plants, was not toxic. These studies will be continued for several years to detect the status of these elements in the soil and plants.
- Limits for the reuse of sewage water on agricultural land are recommended because of the trace and heavy metals present in reclaimed water.
- Use of sewage sludge (budret) without chemical or biological treatment could result in the transfer of pathogenic microbes to the soil and plants, causing health risks to humans and animals.
- Nitrogen residue led to increasing nitrate contamination in leaching water.
- The content of ammonium N in groundwater was 3–15 times lower than of nitrate N.

Introduction

Egypt's agricultural strategy for the 1990s is to complete its policy reform program in order to increase agricultural productivity per unit of land and water, through more efficient use of these limited resources, reducing the unit cost of production, and thereby increasing national output and farmer income. The strategy underscores the importance of equity and takes into account issues of poverty alleviation as well as ecological sustainability.

The targeted growth rate for agriculture is an average of 3% per annum for the 1990s. This would allow a national GDP growth of 4–5% by the end of the decade, given a population growth rate of about 2.5%.

The policy for water and land resource utilization is to increase efficiency and environmental sustainability. Significant benefits can be achieved from a variety of improvements in land and water use.

Egypt's usable arable land is no more than 4% of the total area of about 1 million km^2. Out of a total arable area of 7.5 million fed (3.15 million ha), some 5.6 million fed (2.35 million ha) are located in the Valley and Delta.

The land traditionally farmed beside the Nile and in the Delta is called the Old Lands. Lands newly reclaimed from the desert are called the New Lands. New Lands developed prior to 1978 are called "old" New Lands, and those developed since 1978 are known as the "new" New Lands. The land problem has recently been aggravated by the removal of some of the Old Lands from agricultural production for urbanization and industrialization. The population pressure and the increasing food requirements make reclamation of land the only available option for further expansion of irrigated agriculture. A master land plan for Egypt was prepared in 1986. It estimated the area of land that could be reclaimed using Nile water at 2.88 million fed (1.21 million ha), and using groundwater, 570,000 fed (239,500 ha). The total agricultural area in the Nile Valley and Delta is about 3.45 million fed (1.45 million ha). However, land reclamation has been a controversial issue because of the large investment and poor performance of large-scale schemes during the 1990s. Some reasons for this poor performance are:

- Lack of planning and project implementation.
- Inadequate knowledge of soils.
- Need for a different construction technology for sandy soils.
- Weak post-implementation assistance in extension training, etc.

Thus, lands which were not fully reclaimed and developed were cultivated, giving rise to drainage and waterlogging problems. The same report goes on to conclude that a number of problems which impacted earlier land reclamation have been resolved. Properly planned and executed land reclamation, which appears unavoidable in Egypt, is quite compatible with the concept of sustainable agriculture because of the extremely scarce and limited land resources. Of the 1.4 million fed (0.59 million ha) reclaimed so far, 558,300 fed (234,580 ha), some 40% of the total area, are located in the West Delta. The "new" New Lands, reclaimed since 1981, amount to 1.03 million fed (0.432 million ha). The location of these lands is detailed below.

Distribution of "new" New Lands in Egypt:

Location	Area (fed)	Percent of Total Area
West Delta	396,883	39
East Delta	290,873	28
Middle Delta	52,075	5
Sinai/East Suez Canal	20,770	2
North Coast (east/west)	112,500	11
Middle/Upper Egypt	113,220	12
New Valley/Western Desert	34,470	3
Total	**1,020,791**	**100**

Source: Land Master Plan of Egypt (1986).

The Government of Egypt (GOE) policy aims to create employment opportunities for jobless graduates—both from high school and universities. Unemployed graduates are allocated 5–6 fed (2.1–2.5 ha) of reclaimed land each for farming, following some initial training in agriculture and irrigation.

This employment-creation program is administered by the Ministry of Agriculture and Land Reclamation's (MALR) General Authority for Rehabilitating Projects and Agricultural Development (GARPAD). From the total area of over a million feddan, some 171,400 fed (72,016 ha), approximately 12% of the total, were distributed to some 33,000 graduates between 1987 and 1991. Some 63% of the distributed area, or 107,500 fed (45,168 ha), is shared by 20,889 graduate settlers in the West Delta as follows:

Distribution of Reclaimed Land in the West Delta:

Location	Area (fed)
Sugar Beet	47,026
West Nubaria	3,295
Along El Nasr Canal	40,360
North Tahrir	15,665
Maryut	500
Total	106,846

The land areas reclaimed in Egypt from 1960 to 1989 are shown in Table 1. In addition to graduates, the reclaimed lands were allocated to landless farmers as well as to private and public sector companies and cooperatives.

Under the current Five Year Plan (1992–97), a further 872,000 fed (366,386 ha) will be reclaimed, with approximately 30% allocated to 50,000 graduates, in accordance with GOE policy.

Farming systems are still evolving, but the economic circumstances of many farms encourage the planting of high-value vegetable crops without proper rotation, encouraging pest buildup. Little research has been undertaken for this environment until very recently.

Table 1. Land reclaimed between 1960 and 1992 (1000 fed).

Year	East Delta	Middle Delta	West Delta	Middle Egypt	Upper Egypt	Other	Total
1960	23.0	2.5	42.9	6.7	-	3.1	78.8
1960/61	1.5	2.0	5.7	-	-	19.0	28.2
1961/62	10.7	17.7	25.2	3.1	9.6	23.1	89.4
1962/63	13.2	23.6	42.9	4.9	13.6	24.2	122.4
1963/64	8.0	33.7	53.9	5.5	23.8	34.5	159.4
1964/65	8.5	27.0	58.9	12.0	16.7	12.9	137.0
1965/66	-	4.0	65.5	22.0	11.1	17.0	119.8
1966/67	-	4.0	27.5	21.5	2.1	2.0	56.1
1967/68	-	2.0	32.0	-	-	-	34.0
1968/69	7.0	19.0	19.1	-	-	-	45.1
1969/70	5.0	7.0	6.0	-	3.0	-	21.0
1970/71	13.0	8.0	-	-	-	-	21.0
1978/79	1.0	-	14.9	0.8	0.5	4.7	21.0
1979/80	8.3	8.1	4.6	-	0.8	2.5	24.3
1980/81	3.7	7.0	2.5	-	1.0	2.1	16.3
1981/82	57.3	1.0	32.5	0.3	4.6	4.2	99.9
1982/83	-	3.4	27.9	1.5	-	10.9	43.1
1983/84	13.0	4.4	18.9	5.1	-	5.2	45.6
1984/85	14.7	2.5	22.4	6.6	-	4.4	50.6
1985/86	11.5	2.3	26.4	15.7	-	5.5	56.5
1986/87	3.5	11.5	36.2	13.0	-	1.7	65.9
1987/88	20.0	2.3	96.2	18.2	-	16.9	153.6
1988/89	-	-	-	-	-	-	170.0
5-Yr. Plan 87/88–91/92	175.0	5.0	214.4	41.5	94.5	219.6	750.0

Reclamation between 1970/71 and 1978/79 is omitted due to its small magnitude.

Objectives

According to the Nile Valley Project (NVP) proposal and financial plan prepared by EU consultants, threats to the sustainability of Egypt's agricultural production demand a resource management strategy and farming systems approach for agricultural research, with: (i) more long-term research in the context of rotations and farming systems in order to improve the practical value and economic feasibility of its recommendation; and (ii) a change from predominantly commodity-oriented to systems-oriented agricultural research. To meet this demand, the long-term resource management component of the Nile Valley Regional Program (NVRP) (Egypt, Phase II) has two elements:

1. Preparatory studies.
2. Long-term research activities.

The preparatory studies comprise:

- Inventory studies.
- Rapid rural appraisals.
- Multidisciplinary surveys.

The inventory studies began in April 1994. Following are the results and conclusions of the relevant papers and reports conducted in the New Lands.

Soil

Calcareous Soil

Several studies were conducted to study the physical and chemical properties of calcareous soils at Nubaria, North Tahrir and Maryut.

Physical Properties

Texture and soil transportation

There is a distinct variation in the textural classes of these soils. In Maryut the texture varies between clay, clay loam, sandy clay loam, gravelly sandy clay loam, and gravelly clay.

The fine texture of these soils is affected by the $CaCO_3$ content, which reaches 93% of the total clay and silt fraction, as well as by the media and transportation mechanism of soil particles. The media diameter (Md Φ) values range between 7.2 Φ (7.0 μm) and 7.4 Φ (6.2 μm) in clayey layers, while the gravelly sandy clay loam layers are between 2.6 Φ (175.0 μm) and 4.3 Φ (53.0 μm). The high value of the sorting parameter (δ I Φ) (2.55–3.80 Φ) indicates that the Maryut soil is very poorly sorted, and transported mainly in aqueous media. These soils are mainly transported by suspension and rolling. The results also show that $CaCO_3$ is homogeneously distributed throughout the soil profile, ranging between 26 and 59% (Abd El Naim, 1989; Negm *et al.*, 1990a; Mohamed *et al.*, 1973).

Soil moisture characteristics and bulk density

The bulk density ranges from 1.29 g/cm^3 in the surface layer to 1.34 g/cm^3 at a depth of 60 cm (Abd El Naim, 1989).

The percentage of retained moisture is based on three soil–water constants, i.e., field capacity, wilting point, and available water. These three soil moisture constants depend mainly on the degree of fineness of the main skeleton and the cation exchange capacity (CEC) in calcareous soils.

The simple correlation coefficients between these three constants, and the clay and silt percentages (CEC and ESP) are positive and highly significant. However, they are negatively correlated with fine, coarse, and total sand percentages.

The studies also show that the available soil moisture in calcareous soils, ranging between 0.1 and 15 atm, was 21%. As the soil moisture potential increases, the retained moisture decreases. Generally, the retained moisture is dependent on texture, pore geometry, and $CaCO_3$ content. $CaCO_3$ has a low water adsorption capacity, but its presence may affect the soil moisture-holding property in two ways: the domination of $CaCO_3$ in sandy soil decreases the retained soil moisture, whereas its dominance in silt and clay may increase retained moisture (Mohamed *et al.*, 1973). It can thus be concluded that the soils which have the highest contents of clay, CEC, and ESP, have the highest water retained at field capacity, wilting point, available water and total porosity, with decreasing bulk density.

Aggregation

Soil air/water balance is the key to soil productivity, which depends to a large extent on soil aggregation. Calcium carbonate plays a role in forming 1.0–2.0 and 2.0–5.0 mm clods, as well as 8.0–2.5 and 2.5–0.24 mm water stable aggregation.

Organic matter is important in forming 5.0–2.0 mm clods and 0.84–0.42 mm aggregates, especially in the bottom layer of partially reclaimed soil (Shawky *et al.*, 1974). The results also show that in calcareous soils, 1–2 mm aggregate diameters are dominant, comprising about 50% of total aggregates. These diameters are the most important for aggregation in alluvial Egyptian soil (Wahdan, 1985).

The value of air-entry suction (h_e) in undisturbed samples of different soils was also investigated. The results show that there is a relationship between this parameter and certain physical and chemical soil properties. Results varied from 3.45 cm for sandy soil to 52.12 cm for clayey soil; i.e. the finer the texture of the soil, the larger the h_e value (El Kommos, 1990).

Chemical Properties

Total soluble salts (TSS)

The total soluble salts of these soils varied. The EC of saturated extractions of calcareous soils in Nubaria was less than 4 mmhos/cm. Based on these data, it can be concluded that these soils are non-saline and non-alkaline, whereas in Maryut some studies showed the TSS of the uppermost 20 cm to be 50 mmhos/cm at 25°C, indicating extremely high salinity levels (Mohamed *et al.*, 1973).

Soil reaction (pH)

The soil reaction of these soils was slightly alkaline at Nubaria (7.8–8) and moderately to strongly alkaline (8–9.6) at Maryut.

Cations exchange capacity (CEC)

The cation exchange capacity of clay loam ranges between 13.3 and 17.8 meq/100 g soil, increasing to 22 meq/100 g in clay soil. The exchangeable Na is less than 15%. CEC and Na exchange play a distinct role in soil moisture content of calcareous soils.

Organic matter content

The organic matter content of these soils is relatively low, ranging between 0.23 and 1.50%. The maximum accumulation of organic matter is usually confined to the top few centimeters, and declines sharply with depth.

Mineralogical Analysis

Mineralogical studies show that the predominant minerals in the calcareous clay soil of Maryut are polygorshite, representing 50–60% of the clay. Other minerals such as illite, montmorillonitic, and kaolinite are also present, but in lesser amounts (Mohamed *et al.* 1973; Negm *et al.*, 1990).

Morphological Studies and Classification

The morphological description of the calcareous soils of West Nubaria shows that the upper layer is generally weakly developed, recently formed and without diagnostic horizons. The subsoil layers are older, relatively more developed, with diagnostic horizons, such as calcic, and alluvial clay layers, reflecting the successive cycles of formation under different climatic conditions (El Toukhy *et al.*, 1987). According to the soil taxonomy (1975) based on morphological and physiochemical properties (Table 2), the soils of West Nubaria can be classified as entisols and aridisols.

Entisols

The soils representing the piedmont-like plain (Figs. 1, 2, and 3) have no diagnostic horizon other than an ochric epipedon. The texture is very fine loamy sand to depths sometimes greater than 50 cm. The soils are not permanently saturated with water. These soils are therefore classified as entisol psamments or entisol orthents, the latter having a slightly or moderately fine texture (Figs. 4 and 5, respectively) at the lower layers.

Aridisols

The morphological features and analytical data of Profile 5 permit its classification to the order aridisols and sub-order orthids. The profile has calcic horizons at a depth of 40–85 cm (Fig. 6). The pedological diagnostic horizons reflect preclimatic humic conditions in the Pleistocene, whereas Sawy *et al.* (1989) report that the calcareous soils of the western Mediterranean coast have acquired a wide range of morphological features that may reflect different stages of weathering or environmental conditions during the process of soil formation.

Morphological observation shows that the soil profiles have acquired different morphological features that are either geoselic or pedorelic. The soils of the western Mediterranean coast belong to the following taxonomic categories:

- Oalitic lime sand grains of the coastal ridge. Oalitic torripsamments, sandy, carbonatic, moderately sloping, thermic.
- Young alluvial soils lacking a diagnostic subsurface horizon. Typic torriorthents, loamy, nearly level, thermic.
- Soils highly enriched with gypsum crystalluria. Typic gypsiorthids, sandy, gypsic, moderately sloping, thermic.
- Soil profiles acquiring calcic horizons. Typic calciorthids, fine loamy, carbonatic gently sloping, thermic.
- Soils acquiring horizons highly enriched with salt accumulation. Typic solorthids, fine loamy, carbonatic, nearly level, thermic.

Table 2. Field morphological description of the studied soil profiles.

	Location	Physiographic unit	Land use	Horizon	Depth (cm)	Color		Texture class	Structure	Consistency	Boundary
						Dry	Moist				
1	October Farm	Plain convex	Broad bean	C1	0-10	10 YR 7/6	6/6	S	Sg	Lo	cs
				C2	10-40	10 YR 7/6	6/6	S	Sg	Lo	cs
				C3	40-100	10 YR 7/6	6/6	S	Lm	Lo	cs
				C4	110-150	10 YR 7/6	6/6	S	Lm	Lo	-
2	Looloa Farm	Plain convex	Grape vines	C1	0-20	10 YR 7/6	6/6	S	Sg	Lo	cs
				C2	20-60	10 YR 7/6	6/6	S	Lm	Lo	cs
				C3	60-150	10 YR 5/8	5/8	LS	Lm	Sh	-
				C4							
3	Beheira Assoc. Co.	Plain	Tomato	C1	0-25	10 YR 7/6	6/6	LS	Sg	Lo	cs
				C2	25-40	10 YR 6/6	5/6	LS	Lm	Lo	cs
				C3	40-85	10 YR 6/4	5/4	SL	Lm	Sh	cs
				C4	85-150	10 YR 6/4	5/4	LS	Lm	Sh	-
4	Grinco	Plain convex	Barley	C1	0-25	10 YR 7/6	6/6	S	Sg	Lo	cs
				C2	25-55	10 YR 6/6	5/6	SL	Lm	Sh	cs
				C3	55-100	5 YR 5/8	4/8	SCL	Lm	Sh	-
				C4							
5	Nuba Seeds Co. 1st Farm	Plain	Barley	C1	0-30	10 YR 7/6	6/6	S	Sg	Lo	cs
				C2	30-50	10 YR 6/6	5/6	S	Lm	Lo	as
				C3	50-75	5 YR 5/8	4/8	SL	Lm	Sh	cs
				C4	75-150	5 YR 7/8	5/8	SCL	Lm	h	-
6	Nuba Seeds Co. 2nd Farm	Plain		C1	0-20	10 YR 6/4	5/4	SL	Lm	Sh	as
				C2	20-45	10 YR 6/6	5/6	SL	Lm	Sh	aw
				C3	45-100	7.5 YR 5/4	5/4	SCL	Lm	Sh	-
				C4							

Texture: S = Sandy, L = Loamy, SCL = Sandy clay loam.

Structure type: Sg = Single grain, M = Massive.

Consistency: Lo = Loam, Sh = Slightly hard, h = Hard.

Boundary: as = Abrupt smooth, aw = Abrupt wavy, cs = Clear smooth.

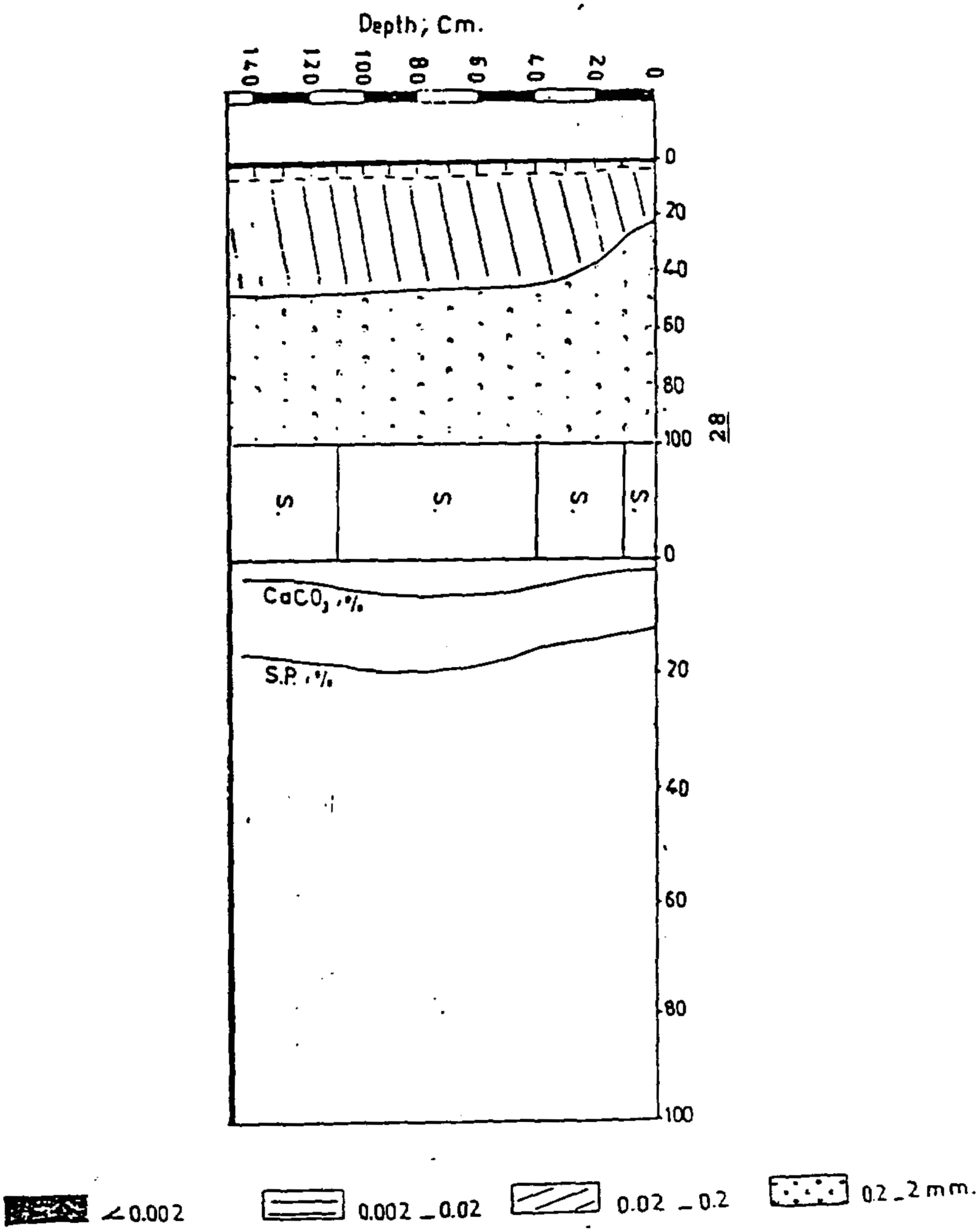

Fig. 1. Nubaria sandy typic torripsamments (Source: El Toukhy *et al.*, 1987).

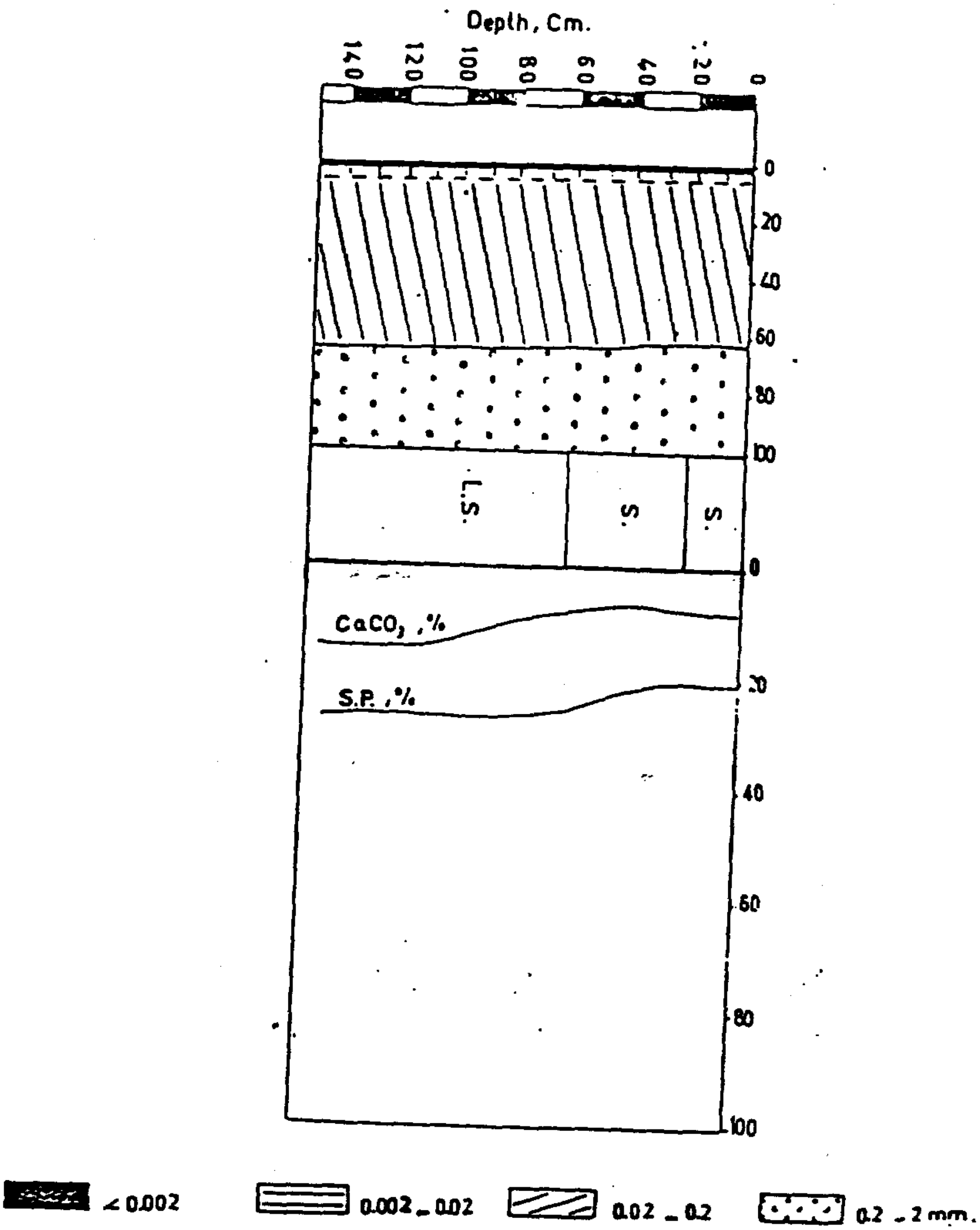

Fig. 2. Nubaria sandy/loam sand; typic torripsamments (Source: El Toukhy *et al.*, 1987).

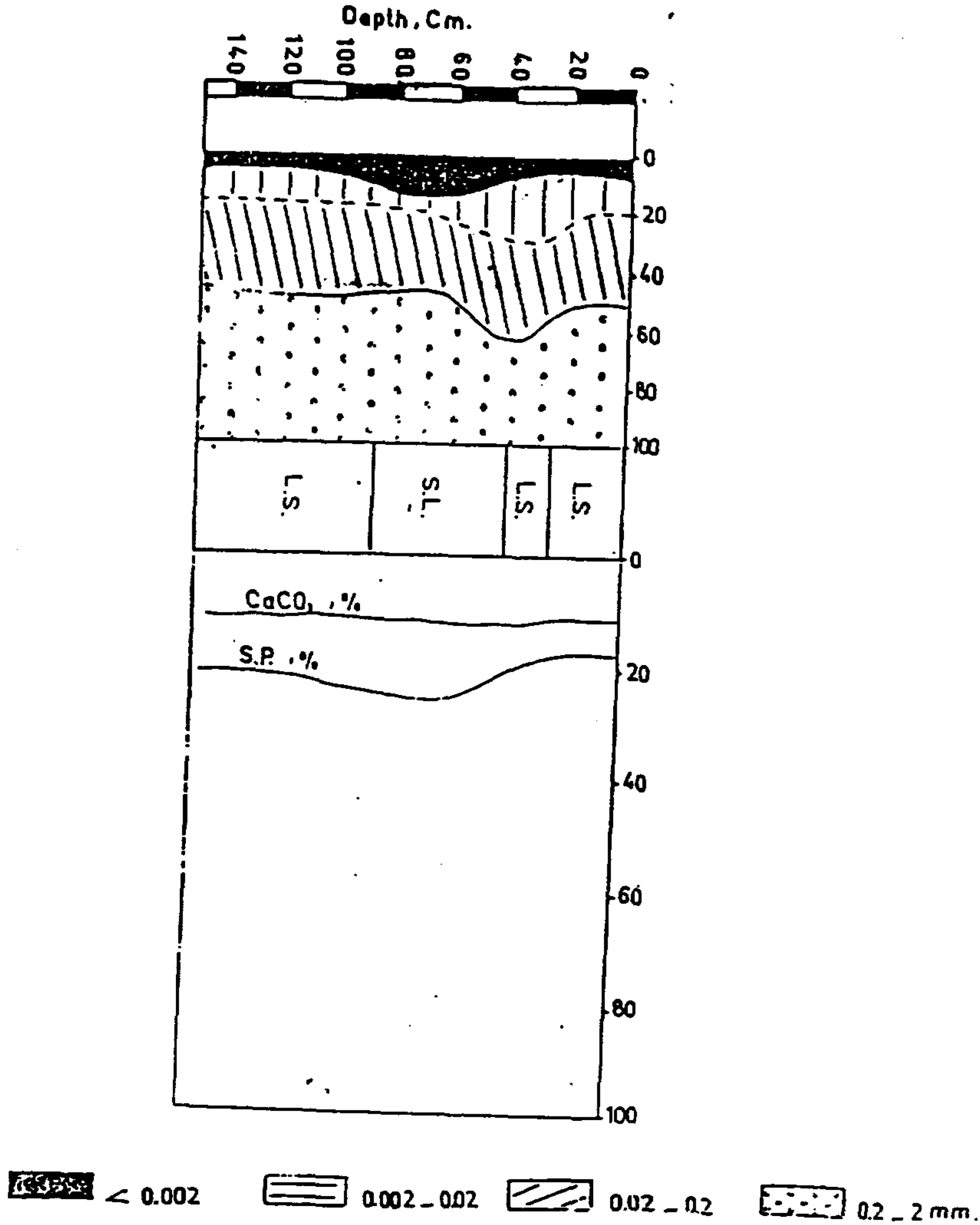

Fig. 3. Nubaria loamy sand/sandy loam; typic torripsamments (Source: El Toukhy *et al.*, 1987).

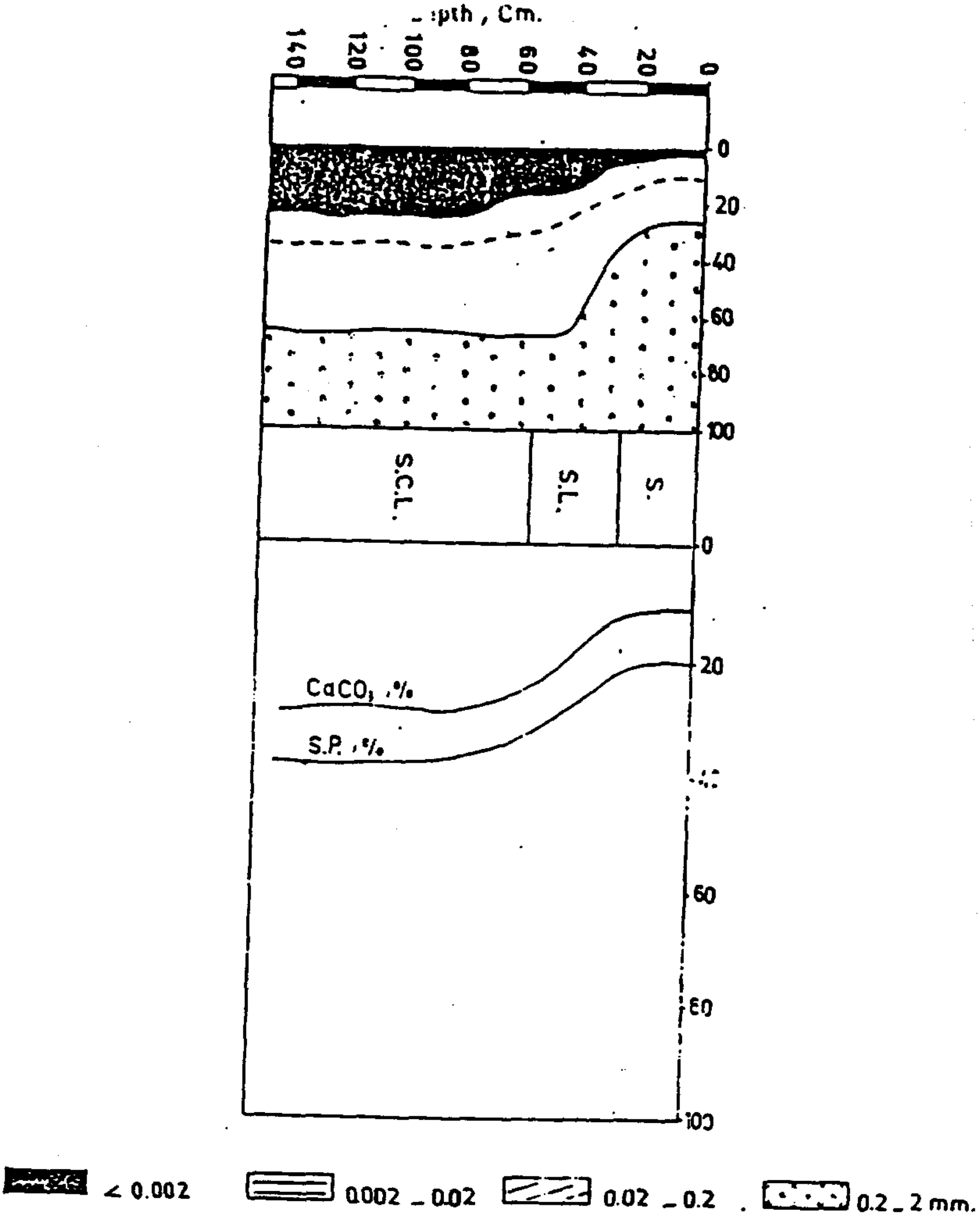

Fig. 4. Nubaria sandy/sandy loam/sandy clay loam; typic torriorthents (Source: El Toukhy *et al.*, 1987).

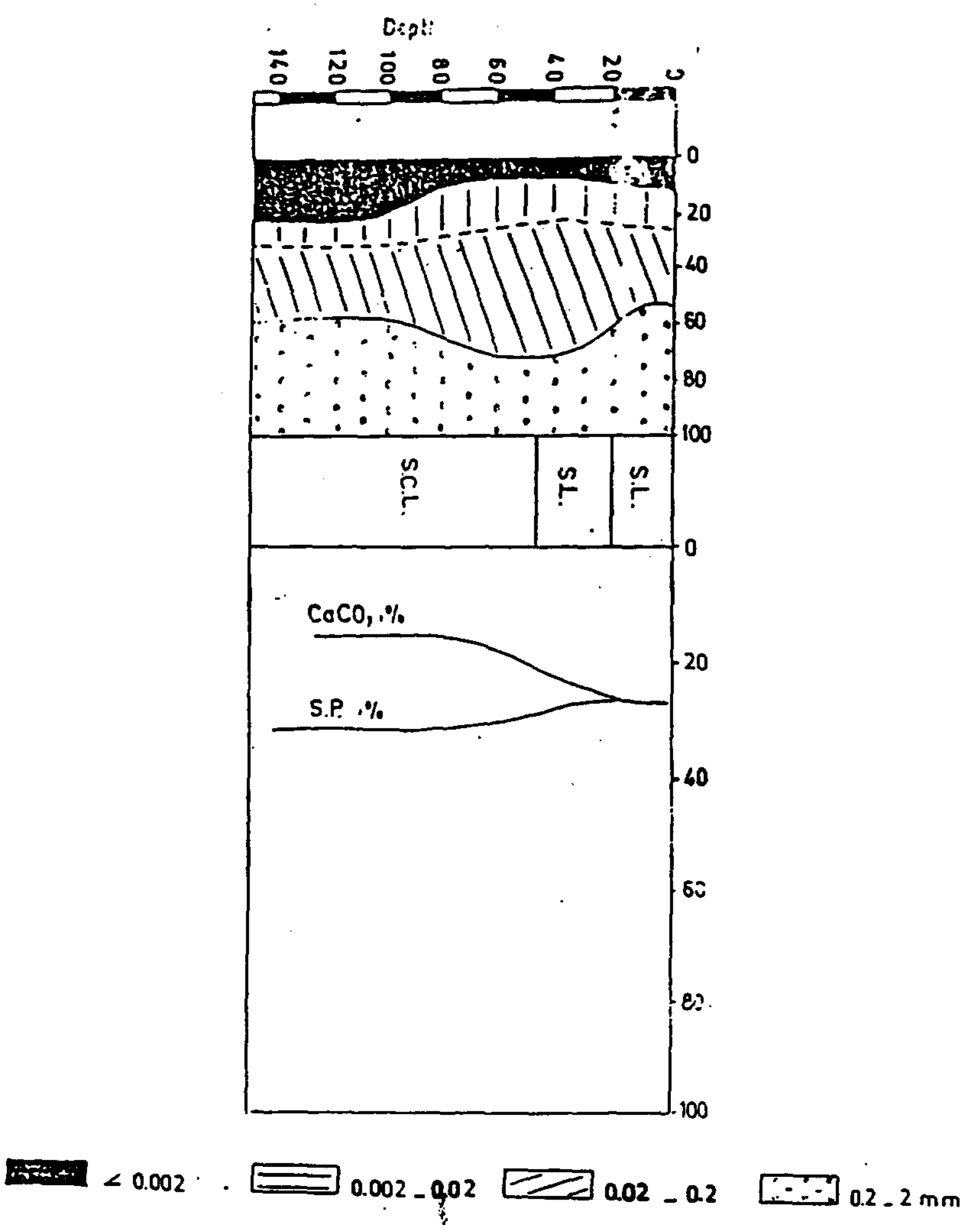

Fig. 5. Nubaria sandy loam/sandy clay loam; typic torriorthents (Source: El Toukhy *et al.*, 1987).

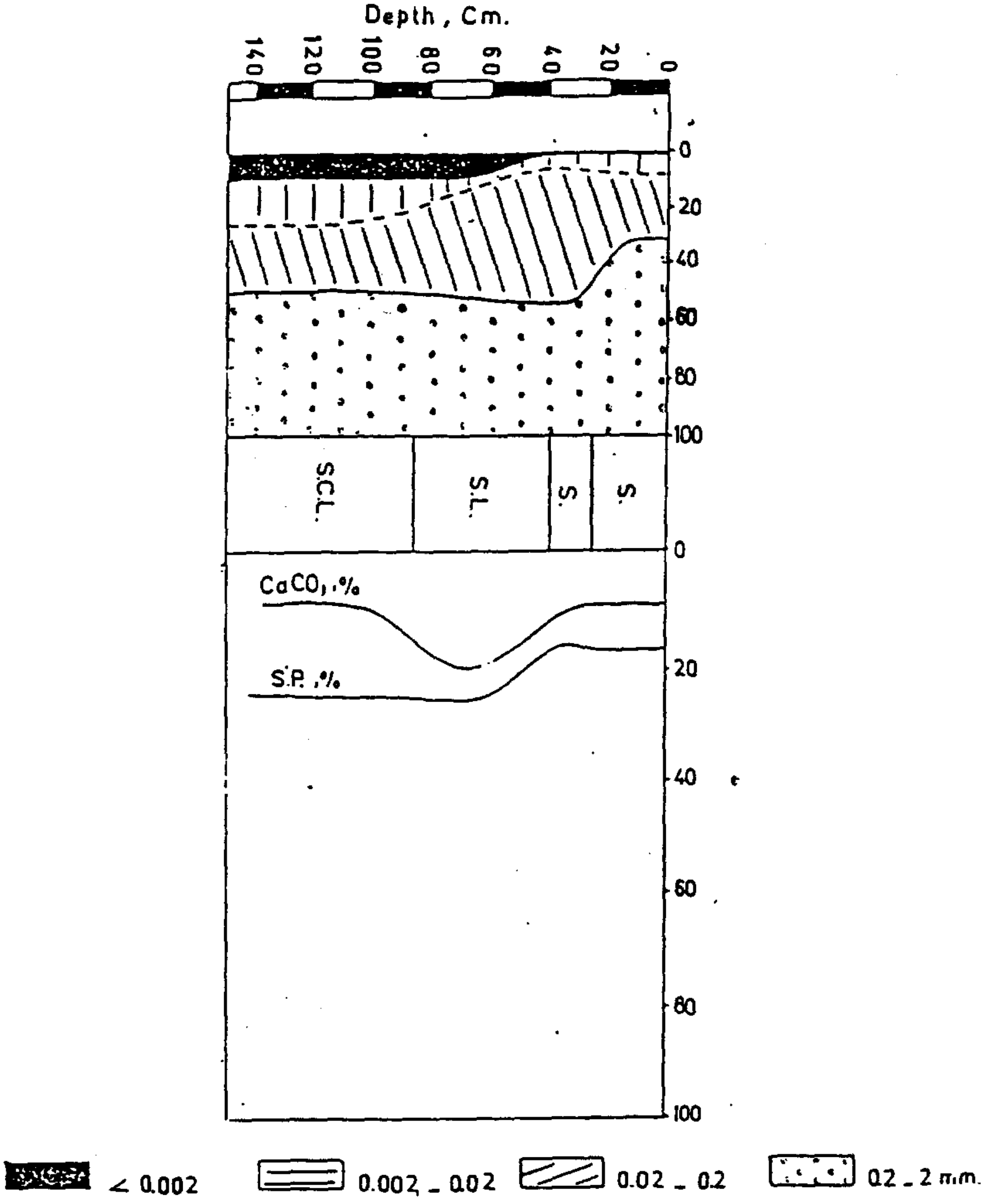

Fig. 6. Nubaria sandy/sandy loam; calciorthids (Source: El Toukhy *et al.*, 1987).

Soil profiles show an altered subsurface horizon, reddish in color with conspicuous red iron micro-areas in the form of nodules and iron patches. Further down are grayish lacustrine deposits, aeric haplaquents, fine loams, carbonatic, nearly level, thermic.

Therefore, the calcareous soils of the Mediterranean coastal zone of Egypt are formed under arid conditions, and, from the geological point of view, these soils are formed from different resources, namely limestone, bed shales, marls of the Libyan plateau, and oalitic line sand grains.

Extensive soil surveys and land evaluation were conducted by the Remote Sensing Unit on an area of about 3,000 fed. Details of this study are as follows:

Soil Survey and Land Evaluation	Area (1,000 fed)
El Saff and El Kurimat	300
Eastern Desert and Sharkia	800
Ismailia	700
East Suez Canal	200
West Nubaria	300
Extension of West Nubaria (Bahig-Burg El Arab)	300
Comparing Landsat and SPOT Satellite Systems	300
North of Sinai (Romana and Balosa)	25
North of Sinai (Kantara Shark and Kantara Gharb)	25
Total	**2,950**

Crust formation in clayey and calcareous soils

Crust formation is considered an important problem, particularly in calcareous soils in Egypt. In these soils, thin sections of surface crust show the presence of calcified shells cemented by fine crystallites of calcite as plasma; skeleton mineral grains are relatively small and few. The formation of crust in clayey soils is explained by the process in which saline clay suspensions are deposited by drying. In calcareous soils, cementation between shells and oalitic sands by fine crystalline calcium carbonate is hard enough to form continuous discrete surface crust (Labib *et al.*, 1975).

Fertility Status

Nitrogen

Calcareous soils are usually low in organic matter, and nitrogen is often the most limited nutrient. Therefore, the efficient use of nitrogen in plant production is an essential goal in crop management. Studies confirm that nitrogen availability is considered very low, ranging between 5 and 18 ppm in topsoil and between 4 and 14 ppm in subsurface layers. This low nitrogen content is expected under arid conditions, where a great loss due to volatilization and leaching takes place.

Phosphorus

Total phosphorus content in calcareous soil varies widely, ranging between 300 and 1,000 ppm with a mean of 600 ppm (El Damaty *et al.*, 1971). The variation in phosphorus content can be attributed to type of parent material, climatic conditions under which the soil was developed, degree of weathering, organic matter content, and microbial activity. Generally, phosphorus content in calcareous soil increases as soil particle size decreases (as fine textured soil increases).

Upper layers of soil usually contain more phosphorus than the lower ones. Negm (1979) found that in the calcareous soils of El Amal region in North Tahrir, the total phosphorus content in the second soil layer (30–60 cm) was about 100 ppm less than in the upper layer (0–30 cm).

Studies show that under calcareous soil conditions, phosphorus is less available to growing plants, as it is fixed with $CaCO_3$ and changed from soluble form to fixed form and then rendered less available to growing plants. Several investigators studied the effect of $CaCO_3$ in calcareous soil on phosphorus fixation. The results show that the percentage of phosphorus fixed from added phosphate ranged between 26 and 98%. On the other hand, other studies show that the availability of natural or applied phosphorus was not affected by the existing $CaCO_3$. Therefore, the role of $CaCO_3$ in phosphorus fixation may be due to its effect on soil pH and the supply of Ca^{++} ions to the soil mix. The studies confirm that available phosphorus in the surface layer is in the medium range (10–19 ppm). Phosphorus levels decrease with depth, resulting in low levels in the subsurface layer (2–6 ppm) (Abd-El Naim, 1989).

Potassium

The studies show that the available potassium in these soils is very high, ranging between 300 and 500 ppm. The high values of soluble potassium in these soils may be due to the high content of exchangeable potassium in equilibrium with soluble forms.

Micronutrient status

Iron

Iron occurs in different forms: (i) as a component of several minerals such as illite, biotite bentonite, glauconite, epidate, hornblend, euqite and their weathering products; and (ii) as iron oxides and hydroxides such as goethite, hematite, magnetite, and amorphous iron oxides. Under Egyptian conditions, total iron content ranges between 5,400 and 34,000 ppm, with the lowest amount in calcareous soil and highest amount in alluvial soil. The total amount of Fe is positively correlated with organic matter, clay, and salt; however, a negative relation was found between Fe and soil pH.

As for available Fe, results show that Fe in calcareous soils is very low, between 2 and 6 ppm, with an average of 4 ppm.

Zinc

Under calcareous soils, the results of several studies show that values of total zinc vary between 40 and 95 ppm, according to landform, texture, type of clay mineral, etc. The total zinc content also decreases with depth and is highly related to soil texture, organic matter content, soil pH and calcium carbonate percentage. The NH_4, HCO_3, DTPA extractable zinc in these soils ranges between 1 and 3 ppm. These values are adequate for calcareous soils, according to the classification of Lindsay and Norval (1978).

Copper

The amount of native copper in soil depends on the geographical distribution, land form, parent materials, texture, and type of clay minerals. For calcareous soils, the studies show that total copper ranges between 13 and 17 ppm. The lowest values were recorded in soils having a sandy texture, while the highest values were associated with heavier loams and clay loams. The DTPA extractable copper in these soils ranges from 1 to 3 ppm, which is adequate for plants.

Manganese

The values of total manganese in soil vary according to the texture of the parent materials and mode of soil fractions. Studies show that manganese ranges between 400 and 533 ppm. The DTPA extractable Mn in these soils ranges from 1 to 10 ppm, which is considered adequate for plants in calcareous soils, according to Lindsay and Norval (1978).

Availability of micronutrients to plants

Balba (1990) calculated the Fe, Mn, and Zn absorbed by wheat and maize plants, using a modified Neubouer technique. A significant positive correlation existed between the amounts absorbed and the values obtained using the above extractants. This is an indication of the applicability of these methods to soil fertility testing for Fe, Mn, and Zn. The values of the nutrients absorbed also indicated the low level of available nutrients in calcareous soils, as compared with Nile alluvial soils. In $CaCO_3$ rich soils, it is the $CO_3^{=}$ and not the Ca^{++} that causes nutritional and physiological disturbances in the growing plants.

Balba (1990) determined the ratio and amount of Fe^{++} and Fe^{+++} in different parts of 20- and 40-day-old faba bean plants grown under different levels of HCO_3^-. The Fe^{++} and Fe^{+++} concentration in the plants varied according to age, the plant part, the order of leaves, and HCO_3^- treatment. Between the first and second dates, 2.4 µg Fe^{++} and 3.2 µg Fe^{+++} were translocated upwards from the "lower leaf." At the second sampling date, the lower iron content in the "lower leaf" under the HCO_3 treatment suggests that the supply of iron to the roots was restricted. Thus, 1.1 µg Fe^{++} had to move upward from the "lower leaf," while its Fe^{+++} content was not materially changed. The iron content of the "bud leaf" was almost evenly divided into Fe^{++} and Fe^{+++} at the first date. At the second date, most of the iron content of the bud leaf was in the ferrous form. Under HCO_3^- treatment, the ferrous iron content of the bud leaf and the flower was similar to the content of the corresponding parts of the normal plants. Their ferric iron content was much lower than in normal plants. The same tendency was observed by Abd El Naim (1989a) and El Falaki and Wahby (1984).

Sandy Soil

Sandy soils are very important for horizontal expansion in Egypt, as they constitute most of the soil in the New Lands. The physical and chemical properties of these soils are discussed below.

Physical Properties

These soils are structureless, because their clay and organic matter content is very low. Thus, there is no possibility for natural development of structure (Abd El Naim, 1989). Bulk density is high, ranging from 1.68 g/cm^3 in the surface layer to 1.74 g/cm^3 in the subsurface layer. Water holding capacity, field capacity and available water are low. Field capacity and wilting point were 8–9% and 2–3% of soil moisture content, respectively.

Chemical Properties

These soils are slightly alkaline (average pH = 7.7). The EC values are very low, between 0.2 and 0.5 mmhos/cm. The organic matter content is low, varying between 0.35 and 0.89% (Abd El Naim, 1989; Abd El Hamid *et al.*, 1986).

Fertility Status

Sandy soils are very poor in NPK and micronutrients. Total soluble nitrogen extracted with 1% K_2SO_4 is low, ranging between 10 and 14 ppm. Available phosphorus, determined by Olsen's method, is moderate (6–9 ppm). Soluble and exchangeable potassium extracted by the ammonium acetate method is moderate, with an average value of 165 ppm K_2O. Regarding micronutrients extracted by DTPA, the results of several studies show very low Fe values, ranging between a and 8 ppm; Zn levels are also low, less than 1 ppm; Mn ranges between 2 and 6 ppm; and Cu between 1 and 5 ppm.

Saline–Alkaline Soil

Physical Properties

Soil texture

The soil texture is relatively heavy and differs between clay to clay loamy. The clay content ranges between 40 and 43%.

Available water

In general, available water is high or very high, and decreases slightly with depth in El Hamoul. This is expected, due to the high clay content and consequently high water holding capacity. Available water ranges between 36.6 to 44.2%. Generally, available water depends mainly on clay content. (El Fayume, 1989).

Chemical Properties

Soil salinity

At El Hamoul, which is representative of saline soils, EC values range between 9 and 13 mmhos/m. Salt usually accumulates on the surface.

Soil reaction

The pH is between 8.11 and 8.99, which is relatively high due to high ESP.

Cation exchange capacity and exchangeable sodium percent

Cation exchange capacity is generally high, ranging between 28.8 and 43.13 mg/100 g. The CEC values are high due to the high clay and organic matter content. The exchangeable sodium percent in the soils around El Hamoul is high, ranging between 36.95 and 50.70, which means that the soil is alkaline.

Fertility Status

Available nitrogen

Available nitrogen in these soils is low, and decreases from topsoil to subsurface. It ranges between 13 and 20 ppm in the topsoil and between 10 and 17 ppm in the subsurface.

Available phosphorus

Available P is moderate to high and decreases with depth. It ranges between 7 and 14 ppm in the surface layer and between 6 and 12 ppm in the subsurface layer.

Available potassium

Available potassium is moderate to high, and also decreases with depth. It ranges from 315 to 410 ppm in the topsoil and from 211 to 306 ppm in the subsurface soil. Available Fe, Zn, Cu and Mn range from 18 to 26, 0.5 to 1, 2 to 5, and 10 to 18 ppm, respectively.

Soil and Plant Relationships

Samples were collected for analysis from fields planted with wheat, barley, and faba bean, from several newly reclaimed areas (Table 3). Physical and chemical properties as well as the macro- and micronutrient content of soil at the different locations are presented in Tables 4 and 5. Plant tissue analysis of barley, wheat and faba bean are presented in Tables 6, 7 and 8.

Table 3. Number of soil and plant samples collected from various locations.

Location	Soil	Plant		
		Wheat	Barley	Faba bean
Maryut	1,264	-	-	-
North Tahrir	904	-	-	-
South Tahrir	50	-	-	-
Gianaclease	476	-	-	-
Nuba Seeds Co.	582	50	80	20
Sugar Beet	70	17	-	17
West Nubaria	46	23	10	23
El Bustan	40	-	-	-
Ismailia	100	-	-	-
Minia	65	34	-	35
Kafr El Sheikh	475	42	-	-

Source: Micronutrient and Plant Nutrition Problems in Egypt, National Research Center (NRC), 1989.

Table 4. Averages of some physical and chemical properties of soil at various locations.

Location	Texture	Percent					pH	EC
		Sand	Silt	Clay	$CaCO_3$	OM		(mmhos/cm)
Maryut	Calcareous	54	17	29	34	1.0	8.4	0.8
North Tahrir	Calcareous	62	13	25	30	1.0	8.2	0.8
South Tahrir	Sandy	89	6	5	1	0.4	8.5	0.3
Gianaclease	Sandy	85	3	12	20	0.9	8.4	0.3
Nuba Seeds Co.	Calcareous	90	6	4	15	0.6	7.9	0.6
Sugar Beet	Sandy	40	34	26	38	0.6	8.0	0.5
West Nubaria	Sandy	90	6	4	9	0.2	8.6	0.2
El Bustan	Sandy	93	4	3	6	0.1	8.5	0.1
Ismailia	Sandy	87	4	9	1	0.9	8.5	0.2
Minia	Sandy	80	10	10	2	1.3	8.4	0.3
Kafr El Sheikh	Clay	48	29	23	5	1.9	8.2	1.8

Table 5. Average of macro- and micronutrient soil content at various locations.

Location	mg/100 g soil				ppm			
	N	P	K	Na	Fe	Mn	Zn	Cu
Maryut	24	1.3	54	-	5.9	13.9	1.8	1.2
North Tahrir	14	1.5	52	-	6.4	9.4	2.4	2.6
South Tahrir	38	0.7	12	-	2.4	6.1	0.5	1.4
Gianaclease	17	1.4	41	-	4.5	9.1	2.4	2.2
Nuba seed	27	1.8	36	-	5.7	9.3	2.6	2.7
Sugar beet	20	0.8	15	-	1.5	1.2	0.3	0.3
West Nubaria	12	1.1	8	-	1.5	0.4	0.2	0.2
El Bustan	10	0.4	4	-	1.2	0.6	0.2	0.4
Ismailia	32	0.7	8	-	7.7	12.7	2.4	1.8
Minia	46	1.8	22	-	8.0	21.0	0.9	3.9
Kafr El Sheikh	69	2.8	28	82	26.0	18.4	1.0	4.9

Source: Micronutrients and Plant Nutrition Problems in Egypt, NRC, 1989.

Table 6. Average of macro- and micronutrient content of barley at various locations.

Location	Percent			ppm			
	N	P	K	Fe	Mn	Zn	Cu
Maryut	-	-	-	-	-	-	-
North Tahrir	-	-	-	-	-	-	-
South Tahrir	-	-	-	-	-	-	-
Gianaclease	-	-	-	-	-	-	-
Nuba Seed Co.	2.5	0.30	1.9	78	44	27	3
Sugar Beet	-	-	-	-	-	-	-
West Nubaria	2.1	0.19	0.9	114	23	34	11
El Bustan	-	-	-	-	-	-	-
Ismailia	-	-	-	-	-	-	-
Minia	-	-	-	-	-	-	-
Kafr El Sheikh	-	-	-	-	-	-	-

Source: Micronutrient and Plant Nutrition Problems in Egypt, NRC, 1989.

Table 7. Average of macro- and micronutrient content of wheat at various locations.

Location	Percent			ppm			
	N	P	K	Fe	Mn	Zn	Cu
Maryut	-	-	-	-	-	-	-
North Tahrir	-	-	-	-	-	-	-
South Tahrir	-	-	-	-	-	-	-
Gianaclease	-	-	-	-	-	-	-
Nuba Seed Co.	2.3	0.20	3.1	102	75	23	9
Sugar Beet	1.6	0.17	2.1	147	50	21	8
West Nubaria	2.1	0.18	1.7	123	30	15	7
El Bustan	-	-	-	-	-	-	-
Ismailia	-	-	-	-	-	-	-
Minia	3.6	0.32	3.8	132	76	32	12
Kafr El Sheikh	3.3	0.22	3.4	146	33	21	14

Source: Micronutrient and Plant Nutrition Problems in Egypt, NRC, 1989.

Table 8. Average of macro- and micronutrient content of faba bean at various locations.

Location	Percent				ppm		
	N	P	K	Fe	Mn	Zn	Cu
Maryut	-	-	-	-	-	-	-
North Tahrir	-	-	-	-	-	-	-
South Tahrir	-	-	-	-	-	-	-
Gianaclease	-	-	-	-	-	-	-
Nuba Seed Co.	2.6	0.20	3.4	101	58	31	4
Sugar Beet	3.0	0.20	1.9	170	43	15	11
West Nubaria	2.8	0.18	1.2	110	37	21	15
El Bustan	-	-	-	-	-	-	-
Ismailia	-	-	-	-	-	-	-
Minia	4.4	0.42	2.7	179	56	47	13
Kafr El Sheikh	-	-	-	-	-	-	-

Source: Micronutrient and Plant Nutrition Problems in Egypt, NRC, 1989.

Fertilizer Use, Rate and Method of Application and Their Effect on Plant Production

Several investigators have studied the response of different crops to fertilizer use, rates, sources, and methods of application under both calcareous and sandy soil conditions in newly reclaimed lands.

The amount of fertilizer added to the soil should not exceed what is actually needed, otherwise, both crop and yield would be harmful to the environment. Water-soluble fertilizers are most easily assimilated by plants, but a sizable portion is wasted as it is washed out of the soil by irrigation water. The nutrients also leach through drainage water, especially when the soil is coarse in texture.

One method to reduce losses from applied N fertilizers is to use slow-release fertilizers. Results show that neither fresh nor dry weights, nor N content, are greatly affected, but that the effect is greater when using slow-release N fertilizer compared to ordinary fertilizers.

Urea formaldehyde (UF) was evaluated as a slow-release fertilizer. Compared with urea, it was found that nitrogen fertilization had no effect upon lentil branches, seed index, crude protein content or yield. The only exception occurred with UF, with 60 or 75 kg N/fed and/or with the lowest N levels in combination (15 + 45 N/fed as urea and UF fertilizers, respectively). Seed yield was about 12% higher than with the three fertilizers: ammonium sulfate, ammonium nitrate and urea (Mohamed *et al.*, 1992).

The interaction between sources, nitrogen fertilizers and moisture levels on plant growth in calcareous soil was also investigated. The results showed that the dry matter yield of barley plants grown in calcareous soils increased. Nitrogen uptake under moist conditions (both optimum and high moisture) was markedly increased by an increased nitrogen rate. The highest nitrogen uptake was obtained by adding calcium nitrate, while the lowest was due to the application of sulfur-coated urea. Moreover, irrespective of source and rate of nitrogen fertilizer, nitrogen uptake increased more under optimum moisture levels than under high moisture levels (Heggy *et al.*, 1987). Balba and Nassem (1968) showed that the loss from different fertilizers occurred in the following order: NO_4OH > $(NH_4)_2\ SO_4$ (AS) > urea > NH_4NO_3 (AN). The loss from $Ca(NO_3)_2$ was very low, since it does not contain or form NH_4. Loss of NH_3 from AS, was greater than from AN, based on NH_4 content. Therefore, AN, AS and $Ca(NO_3)_2$ are recommended for calcareous soils.

Reaction of ammonium nitrate when applied to calcareous soil can be described as: $2NH_4NO_3 + CaCO_3 \rightarrow Ca(NO_3)_2 + (NH_4)_2CO_3$. The $Ca(NO_3)_2$ formed is soluble, and $(NH_4)_2CO_3$ equilibrium is more likely to take place. For ammonium sulfate, the reaction is: $(NH_4)_2SO_4 + CaCO_3 \rightarrow CaSO_4 + (NH_4)_2CO_3$. The solubility of $CaSO_4$ is low.

On the other hand, splitting nitrogenous fertilizers for wheat has been recommended in sandy soils. The results show that grain and straw yields of wheat significantly increase along with increased N application. It is recommended that the level of N in sandy soils should not exceed 110 kg N/fed, split into seven doses at 10-day intervals starting from sowing and ending at booting. The splitting of N levels had a significant effect on wheat yield only with high levels of nitrogen. No response on wheat yield was obtained with splitting low levels of nitrogen. Splitting of 110 kg N/fed into five doses is recommended from an economic point of view, since there is no significant difference between five and seven split doses (Abd El Naim and McCuistion, 1992).

Phosphorus is also an essential element for wheat, and consequently for satisfactory yield. The results show that grain and straw yields of wheat are significantly increased by increasing phosphorus in sandy soils. The highest grain and straw yields were obtained at a level of 60 kg P_2O_5/fed (Abd El Naim *et al.*, 1990). Phosphorus also plays a very important role for legume crops. The results show that in calcareous soils phosphorus application increases crude protein, tryptophan, total amino acids and Fe concentration in broad bean seed. Application of $ZnSO_4$ on soil without P treatment and the application by foliar spraying with P was superior in increasing dry matter yield and N content of broad bean plants 40 days from sowing (Abd El Aziz *et al.*, 1982). Balba (1990) showed that bean and wheat respond to an application of 200 kg superphosphate/fed. Further application does not result in a significant response in calcareous soils, whereas 40 kg K_2O/fed significantly increases seed yield of bean.

Both the effect of soaking barley seed for an optimum period (3 hr) and the effect of Fe and Mn solution on uptake and dry matter production of four-week-old barley seedlings grown in sandy calcareous soils were investigated. The results show that dry matter increases significantly when seed is pretreated for 3 hours in a mixed micronutrient solution. The highest response of seed pretreatment was obtained on calcareous soil, while the lowest was found in sandy soil (Ismael *et al.*, 1980). Total zinc uptake increases significantly with seed pretreatment in Zn solution when compared with a control, but is largely depressed when Zn is combined with Fe. Total Mn uptake increases significantly when seed is pretreated in Mn combined with other micronutrients in solution.

Total Fe uptake is significantly increased when seed is pretreated in an Fe solution when compared with the control treatment. Mixing Fe with other micronutrients, especially Zn, leads to significant decreased Fe uptake.

The effect of foliar application of micronutrients on wheat, barley and faba bean in calcareous, sandy and alkaline soils was studied. The results show that micronutrient (Fe, Mn, Zn) application increases seed yield of wheat by 21%, barley by 45%, and faba bean by 69% in West Nubaria and Minia. The dry weight of faba bean is significantly increased by N application to 69 kg N/fed. The recommended rate for fertilization with micronutrients is 3 g/L of Zn, Fe, Mn in sulfate form and 0.5 g/L in a chelate foliar spray (Abd El Hady, 1987).

Drainage of Irrigated Land in Relation to Salinity Control

Few studies have been conducted on drainage problems in calcareous soils. About 250,000 feddan west of the Nubaria canal are already under production. Most of this area is calcareous soil, with calcium carbonate content usually between 10 and 50%, with more than 70% of carbonate present in the silt and clay fraction (UNDP/FAO, 1978).

Reclamation of the area started in 1956. The rise of the water table, the occurrence of secondary salinization and the consequent deterioration of productivity necessitated the implementation of a drainage system. One of the earliest subsurface drainage systems in the area was built for El Nahda Agricultural Company in 1979 by the German Agency for Technical Cooperation (GTZ) project. The tile drainage system in the area was designed and built with various spacings (40, 50, and 60 m).

The common drainage system in Nubaria is open channel. This system covers most of this area. For each *drawa* there are 3–5 open field ditches, carrying the drainage water to the field drain (open *drawa* drain), which discharges it into a *hosha* drain (collector). All the drainage flow in the area is by gravitation (Fahmy *et al.*, 1989).

Soil Improvement

Soil Conditioner Application for Sandy and Calcareous Soils

To improve the hydro-physical characteristics of sandy soil, application of a natural and/or synthetic soil conditioner is beneficial to optimize air, heat, and water movement, thus increasing water-use efficiency.

One of the soil conditioners used in several trials to improve the fertility and hydro-physical properties of sandy soils is Nile suspended matter. However, using these materials can result in the transfer of Valley soil problems, such as weeds and disease, to the virgin sandy soils. Therefore, intensive studies have been performed using Egyptian bentonite as a soil conditioner. The results show that bulk density and hydraulic conductivity values are significantly decreased by the application of bentonite, whereas there were highly significant increases in total porosity and moisture content. Lentil yield increased significantly along with the rate of bentonite application. From an economic point of view, a single application of bentonite will improve soil structure with a subsequent increase in crop productivity. Moreover, the increased production will cover the cost of the products within three crop seasons. This includes rates of application up to 20 tons/fed (Abd El Naim *et al.*, 1990b; El Halawany *et al.*, 1991).

The use of organic manure as a soil conditioner in calcareous soils was also investigated. The results showed that the dry matter yield of barley plants is significantly increased by application of chicken residue. The nutrient content of barley is positively affected by organic manuring. It was found that the concentrations of nitrogen and potassium increase in the following order: control < farmyard manure < budret < chicken and sawdust < chicken and lime. Phosphorus increases with organic manuring, particularly with the addition of farm chicken residue (Negm *et al.*, 1990b). Ahmed (1967) showed that the dry weight of maize and barley increased with the application of 15 t/fed organic manure in the sandy soils of South Tahrir. El Leboudi *et al.* (1990), using farmyard manure, chicken manure, town refuse and budret as organic manure to improve the physical and chemical properties of sandy soils, concluded that total humus and its fractions of humic and fulic acids in the soil increase with the application of all studied manures. The availability of the studied elements (N, P, K, Fe, Zn, and Cu) significantly increases during the incubation period. Highly significant positive correlations have been established between organic acid and available N, Zn and Cu in both sandy and calcareous soils, and with Fe in sandy soils. Abd El Naim *et al.* (1990a) and Salem *et al.* (1987) found that the maximum grain yield of wheat was obtained by applying 20 m^3/fed of organic manure in combination with 30 kg P_2O_5/fed in calcareous soils.

Mahmoud *et al.* (1968) found that the addition of winter or summer green manure or compost in equal quantities to the sandy soils of South Tahrir increased soil organic matter, total nitrogen and soil microbial flora. They also found that in addition to chemical fertilizers, clover or peanut green manure or an equal amount of compost significantly increased sesame and maize yield compared with a control treatment with chemical fertilizers alone. El Gala *et al.* (1987) reported that the application of either poultry manure, sulfur or flexible foam to sandy soils increased dry matter yield through the five cuttings of forage sorghum, and the combined effect of the three amendments increased yield by 238%

over the control. Results also showed that the increase in total uptake of Fe, Mn and Cu was due to the poultry manure and sulfur with flexible foam treatment. The increases, compared to the control, were 172, 322, and 158%, respectively. Application of these amendments also increased the availability of micronutrients and P to plants grown in sandy soils. In calcareous soils, application of sulfur at the rate of 500 kg/fed in combination with deep plowing greatly increased the availability of nutrients to plants (Salem *et al.*, 1987).

The effect of Azolla application on physical and chemical properties of calcareous soils was also investigated (El Sherif and Abd El Naim, 1990). The use of Azolla as a nitrogen fertilizer significantly increased the dry matter yield and water utilization efficiency of lettuce. The maximum yield was obtained by applying 300 g Azolla/10 kg soil. El Soueni (1987) reported that the use of compost containing 50–58% organic matter significantly improved soil productivity, promoting the growth of plants, increasing the soil water and nutrient retention capacity, and supplementing the soil nutrients by creating suitable conditions for microorganisms necessary for plant growth and by reducing soil erosion in sandy soils.

Alaa El Din *et al.* (1987) found that a maximum increase in macro- and micro-elements in carrot roots is obtained when manure is applied at the rate of 60 kg N/fed. The N content significantly increased under a combined treatment of 15 kg N in the form of manure with 45 kg N/fed in the form of ammonium sulfate. Application of 60 kg N/fed as ammonium sulfate was similarly effective.

El Shimi *et al.* (1987) found that application of manure at the rate of 60 kg N/fed with $ZnSO_4$ at a low rate (10 kg/fed) positively affected the growth of corn. Corn fertilized with 60–120 kg N/fed as manure significantly increased grain yield, between 28.5 and 30.9 ardab/fed. Therefore, they recommend an application rate of 60 kg N/fed.

Nairooz *et al.* (1987) studied the effect of chelated iron and manganese and Indole-3 acetic acid (IAA)—either separately or mixed—on seed yield, and protein and carbohydrate content of faba bean grown in calcareous soils. The treatments of IAA, along with an application of manganese and IAA combined with a foliar application of manganese, resulted in a marked increase in total carbohydrates and nitrogenous compounds in the shoots, while adding IAA combined with an application of iron gave the highest levels in the seeds.

On the other hand, the iron and manganese content in plants is increased by foliar application as compared to soil application. Treatment with IAA decreases the iron and manganese content of seed.

Addition of Viterra plant gel (VPG) at rates of 0.05 and 0.2 g/100 g soil, and farmyard manure, significantly increased macronutrient amounts (NPK).

Diab *et al.* (1988) found that total porosity and hydraulic conductivity were significantly increased, while bulk density and rate of water evaporation were decreased as a result of VPG application. On the other hand, application of farmyard manure was less effective in improving the physical properties of soil.

Studies on polyvinyl alcohol (PVA), polyvinyl acetate (PVA_e), bitumen, farmyard manure, and *tafla* (shale) as soil conditioners added to sandy soil showed that salinity was increased by shale in particular, due to the salinity of the material, and to a lesser extent by farmyard manure, which was rich in potassium Abd El Salam et al., 1988). The results also showed that reclamation of sandy soils using conditioners is dictated by economic considerations. Salinity may be a potential hazard when using *tafla*.

The natural shale deposits of Minia Governorate are a possible source of material to be used for improving soil properties, water-use efficiency and plant growth in sandy and calcareous soils. Application of shale to these soils increases the percentage of clay and silt, makes their texture more fine, and increases total porosity, soil moisture at field capacity, wilting point, water holding capacity, available water, and swelling percent. It also increases organic matter content, EC and CEC. There are slight decreases in $CaCO_3$ content and pH (Maatouk and Morsy, 1988).

The use of a hydrophilic material (bituminous emulsion, polyacrylamide, and urea formaldehyde) as a soil conditioner was investigated to evaluate its effect on both soil and plant. Availability, mobility, and leachability of nutrients and heavy metals, aggregation and aggregate stability, and biological activity were tested. Plant growth and nutrient element uptake by plants were also evaluated.

The results show that addition of bituminous emulsion decreases the extractable amount of the nutrients and NO_3 leaching. This effect increases with the increasing concentration of the emulsion. On the other hand, addition of polyacrylamide has only a slight effect on the retention and release of the nutrient elements and NO_3 leaching. Urea formaldehyde can be used as a soil conditioner, a slow-release fertilizer and as a nitrification inhibitor. Bituminous emulsion and polyacrylamide increase aggregate stability. Maximum yield of wheat was obtained when bituminous emulsion and polyacrylamide were applied on a sandy soil previously mixed with organic matter (El Amir *et al.*, 1988; El Hady *et al.*, 1989). Moreover, El Naggar *et al.* (1988) found that treating the soil with polymer increased faba bean plant growth, height and tillering. Application of polymers along with NPK fertilizers to sandy soils increased their effectiveness on plant growth. The consumptive use of water decreases by mixing polymers with soil.

Similar results were observed in experiments with broad bean at an experimental farm on the Cairo–Suez Desert Road. The sandy soil was treated with polyacrylamide (PAM) and urea formaldehyde (UF), either as a surface treatment or mixed in the soil. The highest germination rate, plant dry weight, nitrogen content and seed yield of broad bean were obtained with UF treatments, followed by PAM, UF mulch, PAM mulch and then the control. These results were correlated with preserved soil moisture and evaporation (Hekal, 1992).

The effects of polyacrylamide, curasol AH (PVAC), and both urea formaldehyde and bituminous emulsion, on seed germination and growth in sandy clay loam and crust-forming highly calcareous soil ($CaCO_3$ = 46.6%) were investigated. The germination process, plant growth, and dry matter production were increased by soil conditioning. Moreover, the beneficial effects of soil conditioners were evident from the increased nutrient uptake and both water and fertilizer use efficiencies. These lead convincingly to the conclusion that synthetic soil conditioners furnish adequate plantation conditions for crust-forming highly calcareous soils. The response to conditioners varies with the conditioner used and rate of application. The price of conditioners and ease of application are other factors to be considered (El Hady and Lotfy, 1987).

The effects of bituminous emulsion, PAM, UF and urea (Ur) at rates of 50, 20, 75, and 40 g/m^2, respectively, were studied on faba bean plants grown on sandy soils of Salhia Project (Shabab area).

It was found that the germination rate of bean seedlings was increased after 15 days in the following order: bituminous emulsion> PAM > Ur > UF > control, while at 30 days it was UF > bituminous emulsion > Ur > PAM > control. The application of conditioners to sandy soils induced significant increases in nodulation, dry matter and N content of bean crops. Bit and UF had a higher stimulative effect on soil microorganisms than PAM and Ur. The seed yield increased by 20, 18, 15, and 11% as a result of treating soil with UF, Bit, PAM, and Ur, respectively (Awad *et al.*, 1988). Using 250 kg/fed of bituminous emulsion is recommended for sandy soils. The cost was about 20 LE (El Hady *et al.*, 1987b).

Studies on the effect of using Agrosoke as a soil conditioner on sandy soils were carried out at Ismailia. Bulk density was decreased by increasing the rate of Agrosoke. The amount of irrigation water decreased by about 20 to 60% as the Agrosoke level was increased. In general, an application of 3 kg Agrosoke per one cubic meter of sandy soil to a depth of 30 cm was more effective in improving water characteristics (Abd El Naim *et al.*, 1986).

Gypsum Application and Leaching Requirements for Newly Reclaimed Alkali Soils

Various chemical compounds have been used to try to improve alkali soils. Gypsum is often recommended to reclaim and improve their physical and chemical properties. Several investigators have discussed the chemistry of micronutrients in alkali soils, since nutrients such as Fe, Mn, Zn, and Cu are usually immobile. The solubility and availability of these elements are influenced by soil pH, organic matter and oxidation–reduction reactions.

The effects of using different levels of gypsum with successive leaching of different rates of added water on some chemical properties of newly cultivated alkali soils in Sharkia Governorate (San-El Hagar region) were investigated. The percentage of removed salts from the soil varied between 20 and 97%, dependent upon the amount of applied gypsum and water and upon the amount of initial soluble salts.

The combined effect of gypsum and water resulted in a distinct decrease in soil pH, from 8.3 to 7.0, 8.2 to 7.0, and 7.7 to 6.7 for the soils in the study. The percentage of released exchangeable sodium as a combined function of different levels of applied gypsum and water varied from 14 to 90%.

The availability of iron increased from 2 to 2.3 times, and manganese from 3.7 to 3.9 times by increasing the amount of gypsum. The availability of zinc increased from 4.0 to 7.3 times when gypsum was increased. The availability of Fe, Mn, and Zn increased from 1.5 to 1.8, 2.3 to 2.8, and 2.1 to 4.0 times, respectively, by increasing the amount of water above field capacity (Abd El Fattah *et al.*, 1987a).

The effect of different rates of gypsum and water on the chemical properties of three successive soil leachates was investigated (Abd El Fattah *et al.*, 1987b). The pH decreased with increasing gypsum for the first and third leachates, and increased slightly for the second. The magnitude of the variation in pH of the leachate was dependent upon the amount of gypsum and water and upon the period of land use. The magnitude of the increase in dissolved salts was also dependent upon the amount of gypsum and water and the period of land use. The amount of dissolved iron and zinc in the soil leachates increased along with increasing amounts of gypsum and water. The ratio of dissolved iron and zinc in soil leachates at different rates of applied gypsum to that without gypsum for the three levels varied from 1.7 to 2.5, and from 1.1 to 4 times, respectively.

A barley experiment was conducted in highly saline, poorly drained soil. The experiment included reclamation of soil by gypsum followed by flushing with water and two seed treatments: wet seed which was soaked in a 0.1% salt solution for 12 hours, and dried, unsoaked seed. The experiment was conducted in soils of different salinity levels. Grain and straw yields were increased by soaking the seed in saline water, leading to higher plant salinity tolerance. Increasing soil salinity caused a decrease in yield. The grain/straw ratio decreased when seed was soaked in the sense that the increment in straw yield was much greater than the increment in grain yield. Thus, proper leaching along with gypsum application definitely causes an improvement in soil properties as well as yield. Soaking of seed in 0.1% saline water for 12 hours induced salinity tolerance into barley plants (Salem, 1985).

Soil Conservation

Wind Erosion and Conservation Tillage

Soil erosion is the most serious and prevalent disease of the land. It is a major environmental concern of modern times. Erosion is essentially a smoothing or leveling process, with soil and rock particles being carried, rolled, or washed downwards by the force of gravity. The main agents that loosen and break down particles are wind and water.

Wind erosion is a serious problem in many parts of the world where there is not enough vegetation to cover and protect the soil. Wind erosion is worse in arid and semi-arid areas where the following conditions frequently occur: loose, dry, finely divided soil, large open fields, and strong winds. This is the natural condition in arid lands and along seashores, lakes, oceans, and rivers. It is also a common feature on cultivated loam land anywhere. Sand dunes are common land forms in such places, and storms of flowing sand have long been a danger to desert inhabitants.

The use of bituminous emulsions to improve the hydro-physical properties of sandy soil and to stabilize its structure has been tested successfully during the past several years. Application rates of 0.25, 0.5, 0.75, and 1% by weight for each bituminous emulsion have been examined. Diluted emulsions were sprayed on moistened soil with a commercial point sprayer and mixed with a small rake. The final moisture content in the treated soil was 18%.

The use of aggregate (AG) percentage in diameters greater than 2 mm as an index for aggregate formation and stability, and soil resistance against breakdown by tillage or susceptibility to wind erosion, were also investigated. The use of bitumen emulsion, 1% bitumen emulsified with Alpha Olefin Sulfonates (AOS) with 20 carbon atoms in its molecule, increased the AG percent up to 60 (El Hady *et al.*, 1987a).

Also studied was the effect of tillage and planting methods on soil loss. Three tillage and two planting methods were evaluated. The tillage methods were: minimum tillage (5 cm), traditional tillage (about 15 cm), and manual tillage using the traditional axe to a depth of about 30 cm. All tillage operations were performed across the direction of slope. The planting methods used were broadcast and narrow spaced (25 cm) rows. Bare soil without cultivation was used as a control treatment.

The effect of treatment and interaction between tillage practices and planting systems on surface runoff, soil loss, particle size distribution of soil loss, nutrient loss, and barley yield were investigated. The results show that the tillage and planting methods are very effective in reducing soil erosion. The positive effects of the suggested treatments on reducing soil erosion ranked as follows: manual tillage with broadcast > manual tillage with rows > traditional tillage with broadcast > traditional tillage with rows > minimum tillage with broadcast > minimum tillage with rows > bare soil without cultivation treatment, with few exceptions. This means that the best treatment was manual tillage with broadcast planting (Sharkawy, 1991).

Environmental Considerations

Reuse of Sewage Water and Sludge

The residual effect of heavy in sewage water used in sandy soils as a source of irrigation and nutrition was studied (Abd El Naim and El Awady, 1989). The results show that the available Zn, Cu, Mn, and Fe are increased by irrigation with sewage water, while the available Co, Cr, Ni, Cd, and Pb are increased slightly. The concentrations of Zn, Cu, Mn, and Fe in plant tissue are increased by irrigation with sewage water.

The results also indicate that there has been no accumulation of toxic levels of heavy metals following the continuous use of sewage water for irrigation of sandy soil over 10 years. These studies will be continued for several years to detect the status of heavy metals in soil and plants (Abd El Naim and El Awady, 1989). Because Cd, Cu, Mo, Ni, and Zn can cause serious health risks to animals and humans, safe limits have been recommended whenever sewage water is being considered for reuse in irrigation.

According to WHO, FAO, and the Egyptian Academy of Science and Technology, the safe limits of trace and heavy metals in treated water used in irrigation are:

- Total soluble salts < 2000 ppm
- Exchangeable sodium percent < 10
- pH 6.5–8.5
- Chloride < 355 ppm for surface irrigation, < 69 ppm for sprinkler irrigation.
- Sodium < 207 ppm for surface irrigation, < 115 ppm for sprinkler irrigation.

Element	**Long term† (ppm)**	**Short term‡ (ppm)**
Cadmium	0.01	0.05
Copper	0.20	5.00
Nickel	0.20	2.00
Zinc	2.00	10.00
Molybdenum	0.01	0.05
Lead	5.00	10.00
Iron	5.00	20.00
Cobalt	0.05	5.00

† Water used continuously on all soil.

‡ Water used for a period of up to 20 years on fine-textured neutral or alkaline soils.

Use of sewage sludge (budret) in trials to improve the fertility and hydro-physical properties of sandy soils is widespread in the New Lands as a source of organic manure or soil conditioners. The results show that the use of these materials without chemical or biological treatment could result in the transfer of pathogenic microbes, such as coliform bacteria, salmonella, shigella, and protozoa to the soil and plant. When the latter is consumed by humans or domestic animals, it may adversely affect their health. Also, using untreated sludge greatly increases the heavy metal content in soils and contaminates the growth media and virgin sandy soils with Pb, Co, and Cd (Abd El Naim *et al.*, in press). It can be concluded that if sewage sludge (budret) is used as a soil conditioner it must be treated chemically or biologically before use to avoid groundwater contamination and health risk to humans and animals. The chemical and biological analyses of untreated sewage sludge are shown in the following table:

Chemical and Biological Analyses of Untreated Sewage Sludge at Abu Rawash Station

Sewage sludge	
Total N percent	1.7
Total P percent	0.6
Total K percent	0.3
Organic matter percent	47.2
Organic carbon percent	27.4
C:N ratio	1:16
pH	5.85
Total soluble salt percent	1.1
Moisture percent	42
Weight of cubic meter	533 kg
Pathogenic microbes	
Coliform bacteria	9×10^4
Salmonella, shigella	4×10^3
Heavy metal content (available ppm)	
Fe	13817
Mn	219
Zn	223
Cu	320
Cd	4.6
Co	2.4
Ni	26.1
Pb	195.6

Impact of Pesticides and Fertilizers on the Environment and Public Health

About 810,000 tons of nitrogen, 165,000 tons of P_2O_5 and 28,000 tons of potassium (K_2O) are released into the Egyptian environment each year. In addition, many tons of various chemical pesticides are applied annually. Most of these chemicals are associated with agricultural production. The various pesticide and fertilizer nutrients pollute the soil as well as the water. These chemicals cause various ecological and public health problems, including: destruction of fish and wildlife, reduction of beneficial natural enemy populations, poisoning of honeybees, and reduction of crop pollination. They also cause more problems, such as the reduction of energy flow and stability in ecosystems, the increase of pesticide resistance in pests, the reduction of biological diversity, the increase in stream and lake eutrophication from fertilizer nutrients, and the pollution of aquatic systems from nutrient enrichment (Pimentel, 1989).

Nitrogen constitutes more than half of the nutrients added to the Egyptian environment. Natural sources are primarily animals and biological N fixation. Fertilizer nutrients reach surface and groundwater by various means, primarily by soil erosion and leaching. Schroder (1985) reported that the harvest of maize, for example, removes from 25 to 50% of the nitrogen applied. Additional amounts (15 to 25%) are lost by volatilization, and 10 to 50% by leaching.

The health hazards of fertilizers are relatively minor compared to pesticides. The primary health concern of fertilizer nutrients is the presence of nitrate in drinking water. The reasons for high nitrate leaching include:

- Excessive N fertilization.
- High N demand of crops until harvest.
- Plant residues with high content of nitrogen.
- Growing shallow rooting crops.

Kragt and de Vries (1987) showed that the high application of animal manure in agriculture causes strong nitrate pollution of groundwater.

Ubavic *et al.* (1987) found that ammonium nitrogen content was 3 to 15 times lower than nitrate nitrogen content, ranging between 0.8 and 4.9 NH_4-N mg/L, while nitrate nitrogen content was between 2.4 and 83.7 NO_3-N mg/L

Fuleky (1987) reported that by increasing the dose of nitrogen fertilization, nitrate content in the soil profile was increased. Between 30 and 40% of nitrogen fertilizer can be found in the top three meters of the soil profile. The amount of this accumulated nitrate is equal to several hundred kilograms of nitrogen. The maximum nitrate accumulation can be found at a depth of 160–260 cm. With high nitrogen doses, nitrate accumulation can be found below the 3-m depth.

The risk of NO_3 leaching can be avoided if knowledge of both the crop requirement and the NO_3-N pool at the site (Kadar *et al.*, 1987).

To determine the rate of N fertilization, we must keep in view the mineral N content of the soil. Fertilizer recommendations should be based on soil test calibration and mineral N content of the soil (Sandor *et al.*, 1987).

Using wastewater sludge on agricultural land as a supplemental fertilizer and soil conditioner has been recommended as a viable alternative to disposal of this waste after treatment. The nitrate contents are of particular concern in that they can contaminate surface and groundwater through run-off and percolation. Limits for trace and heavy metals should be maintained if sewage water is to be reused for agriculture.

A summary of the inventory studies on soil management and fertility in the New Lands is presented in Tables 9, 10, and 11 for calcareous, sandy, and saline–alkaline soils, respectively. The main recommendations for soil and fertilizer management are also indicated.

Table 9. Summary of inventory studies on soil management and fertility of the New Lands: calcareous soil.

Soil properties		Fertility status (ppm)	Soil improvement methods	Constraints
Physical	Chemical			
Texture: Ranges between clay, clay loan, sandy loam, and gravelly clay.	pH: 8–9.6 CEC: a) In clay loam: 13–17 meq/100g soil	NO_3-N: 4–18 P-Olsen: 10–19 K: 300–500 Fe: 2–6	Application of soil conditioners. a) Natural -Organic manure -Farmyard manure	Crust formation Negative effect of $CaCO_3$ activity on nutrient solubility.
$CaCO_3$%: 26–59	b) In clay soil: 22 meq/ 100 g soil	Mn: 1–10	-Budret (dry sludge)	*Salinity*
Soil moisture %: 31–33		Zn: 1–2	-Chicken manure & sawdust	
Bulk density: 1.3–1.4 g/cm^3	EC: a) In Nubaria: 0.6–1.6 mmhos.	Cu: 1–3	-Chicken manure & lime -Sulfur b) Synthetic	
Total porosity%: 46–48	b) In Maryut: 50 mmhos		-Polyacrylamide (PAM)	
Aggregation (1–2 mm)	Organic matter %:		-Bituminous	
At surface: 54%	a) At surface: 1.5			
At subsurface: 49%	b) At subsurface: 0.2			

Table 10. Summary of inventory studies on soil management and fertility of New Lands: sandy soil.

Soil properties		Fertility status (ppm)	Soil improvement methods	Constraints
Physical	Chemical			
Texture: Sandy	pH: average 7.7	NO_3-N: 1–14	Application of soil conditioners.	Low water holding capacity and field capacity
Available water: 6–7%	CEC: 2–6 meq/100g soil	P-Olsen: 6–9	a) Natural	
Field Capacity: 8–9% of soil moisture	EC: 0.2–0.5 mmhos	K: 80–165 Fe: 1–8	-Organic manure -Farmyard manure	Low levels of macro- and micronutrients
Wilting point: 2–3% of soil moisture		Mn: 2–6 Zn: 0.2–1	-Bentonite (*tafla*) -Canal clearance	Low organic matter High leaching of applied fertilizers
Bulk density: 1.6–1.7 g/cm^3		Cu: 0.4–5	-Compost -Budret (dry sludge)	Use of Nile suspended matter could result in
-Total porosity %: 36–38			b) Synthetic -Viterra plant gel -*Bituminous emulsion* -Agrosoke	transfer of weeds and disease to virgin soil.

The main recommendations for the management of calcareous soils (Table 9) are:

- Sources of N: ammonium sulfate (20.5%), ammonium nitrate (33.5%), and calcium nitrate (15.5%)
- Sources of P: single superphosphate (15.5% P_2O_5), triple superphosphate (37% P_2O_5), and diamonium phosphate (to be used with sprinkler and drip irrigation systems).
- Micronutrients: to be applied on crops in calcareous soils as a foliar application in the form of chelate compounds.
- Seed soaking in micronutrient mixture of Fe, Zn, and Mn increases nutrient uptake and yield.
- Use of sulfur as a soil amendment (at the rate of 500 kg/fed), in combination with deep plowing, is recommended to increase nutrient availability.
- Use of organic manure (at the rate of 15–20 m^3), or compost (50–58% organic matter), or synthetic soil conditioners furnishes adequate plantation conditions for crust-forming, highly calcareous soils.

The main recommendations for the management of sandy soils (Table 10) are:

- Use of crop rotation with legume crops would provide the sandy soil with biologically fixed nitrogen and build soil fertility.
- Use of synthetic soil conditioners improves physical and chemical properties of the soil.
- Use of slow-release fertilizers (as urea formaldehyde) increases the fertilizer efficiency and reduces losses.
- Split application of N fertilizers (up to 5 doses) is recommended for the sandy soils.

The main recommendations for the management of saline and alkaline soils (Table 11) are:

- Gypsum is often recommended as an amendment to improve physical and chemical properties of alkaline soils.
- Salt-tolerant crops should be selected for planting in salt-affected soils.
- Soaking barley seeds in 0.1% saline water increases plant tolerance to salinity.

Table 11. Summary of inventory studies on soil management and fertility of New Lands: saline-alkaline soil.

Soil properties		Fertility status (ppm)	Soil improvement methods	Constraints	Soil conservation methods
Physical	Chemical				
Texture: Clay to clay loamy (clay content ranges between 40 and 43%) Available water: 37–44%	pH: 8–9 CEC: 29–43 meq/100 g soil EC: 9–13 mmhos ESP: 37–51%	NO_3-N: 10–20 P-Olsen: 6–14 K: 215–410 Fe: 18–26 Mn: 10–18 Zn: 0.5–1 Cu: 2–5	Application of gypsum Considering water leaching requirement in managing the irrigation water	High levels of saline content are a great hazard to plant growth and productivity Negative effect of salinity on nutrient uptake by plants	Effective drainage systems are essential to prevent the soil from degrading to saline and/or alkaline soils

Future Research Needs

- Soil studies are needed to characterize the constraints and levels of salinity, sodicity, as well as macro- and micronutrients. Soil profile descriptions are useful to describe the subsurface layers and to identify the presence of layers which might need special treatment during soil preparation. The presence of a water table, impermeable layer, or other undesired morphological features must be identified and described to recommend proper management practices to overcome problems.
- Sub-soiling may be necessary if there is a subsurface layer with low infiltration rate (hard pan). This treatment will enhance the leaching of soil salinity and achieve better aeration in the root zone.
- Installation of an adequate drainage system is necessary if the water table is within 1–1.25 m of the surface.
- Installation of a well-designed sprinkler or drip irrigation system with fertilization facilities is essential, taking into account the water requirements of the crop to be cultivated as well as soil properties. This is essential to assure water and fertilizer application as needed during the different growth stages.
- Frequent irrigation is the usual solution to keeping enough water available in the root zone and to maintaining sufficient moisture for the nutrients. The amount of water applied in each irrigation can be calculated from the water requirements of the plant at different stages, as well as the leaching requirements.
- There is a need to prepare soil maps of land suitability for the New Lands for different soils, water, crops, and climatology.
- More effort needs to be made in the study of soil and water pollution, especially with regard to heavy metals, nitrates, and pesticides.
- More effort is needed to determine the fertilizer requirements for new varieties of vegetable and field crops and to maximize fertilizer utilization efficiency. The impact of this will be to reduce the high amount of fertilizers used relative to production, and to decrease the level of pollution by soluble fertilizers in ground and drainage water.
- Technological packages to increase production for different crops are urgently needed by specialized extension personnel covering different practices, as well as soil, water, and climatological conditions.
- More effort is needed in the study of soil erosion.
- Reuse of sewage water in agriculture will not only alleviate the water shortage problem for agricultural development, but will also remedy the water pollution and health hazards associated with indiscriminate disposal of untreated sewage effluents.
- New studies and demonstration plots are needed to find solutions to farm-level and environmental problems that confront the use of treated wastewater in agriculture. This includes the usage of sewage sludge.

Pollution Control of the Agricultural Environment

Introduction

Soil, water, and air are extremely susceptible to pollution. Gamal (1993) stated that the major problems facing the agricultural environment are: (i) severe intermixing between all networks of irrigation/agricultural drainage, and public and industrial liquid wastes; (ii) major dependence on reuse of drainage and wastewater for irrigation or ineffective treatments; (iii) increasing population density leading to more urbanization; (iv) pollution in rural areas, increasing farm mechanization and dense traffic; and (v) continuous dependence on chemical fertilizers and pesticides. The present section is an attempt to survey sources of pollution in soil and water.

Soil Pollution

Rabie *et al.* (1993) studied the pollution of El Saff soils (adjacent to different industrial and sewage wastes) by heavy metals such as Fe, Mn, Zn, Cu, Pb, and Co. Samples were collected from different sites: (i) irrigated with sewage wastes; (ii) irrigated with industrial wastes; and (iii) virgin and non-irrigated soils. The highest content of trace elements and heavy metals was found in the surface layer of soil irrigated with polluted resources. Analysis of industrial and sewage wastes shows that the concentrations of all heavy metals are generally quite low. However, the continuous use of factory and sewage waste in irrigation leads to a serious problem due to the accumulation of these metals in soils—especially the surface layer in concentrations which would be toxic to plants. Serious problems will develop if these products are used by humans or animals due to their accumulative effect.

Another survey by Aboulrous *et al.* (1993) was conducted to evaluate the levels of Cd, Co, Cu, Pb, Ni, and Zn in 82 samples from the cultivated soils of Egypt, and their associated crops. It was found that heavy metals usually exist near the surface of the soil and increase in maize tissues with increasing levels in the soil. No considerable accumulation of any of the studied metals was observed in maize grain. Abd El Sabour *et al.* (1993) found that increasing the period of sewage effluent irrigation in El Gabal El Asfar elevated orange leaf content of heavy metals. For example: Fe, Zn, Co, and B increased by 3.38, 1.7, 5.2, and 4.9 times, respectively. In Alexandria, El Sokkary and Sharaf (1993) found variations in Zn and Cd in different crop species irrigated with drainage water from domestic and industrial effluents. The bio-accumulation of Zn in the leaves and edible organs markedly varied: chard > spinach > coriander > roquette > parsley > clover > lettuce. For Cd the ranking was chard > spinach > lettuce > parsley > roquette > coriander > clover.

Water Pollution

Pollution of Nile Water

Generally the water of the River Nile is of good quality, with total salinity not exceeding 350 ppm (Table 12). The River Nile is considered the source of life in Egypt. It is therefore subject to multiple uses, and different types of material enter the river, affecting water quality. El Sherbini *et al.* (1993) showed that Nile water quality has deteriorated in some locations. In monitoring studies by the same authors in 13 major sites including barrage locations and heavily polluted areas, they found the average water quality index (AWQI) values, which reflect the composite influence of a number of parameters on the overall water quality. The value is low (17) along the River Nile at Aswan, then increases downstream from the Dam, from 21 near Naga Hamadi to 108 beyond Naga Hamadi. Concerning pesticide residue in the Nile, results show that total organochlorine residues are higher upstream from the Delta Barrage than downstream from the Edfina Barrage. Dogheim *et al.* (1993) found that organochlorine pesticide residues were at higher levels in the Rosetta Branch after the termination of closure. Such residues were within the permissible levels (0.1 mg/L) according to the Canadian Standard Guidelines, 1978. (AWQI = 0 when all pollutants are absent, and AWQI = 100 when all pollutants reach their permissible limits. AWQI values exceeding 100 indicate that the river may be suffering from serious pollution problems.) In general, although the Rosetta Branch receives effluents from various pollution sources, it shows a considerable self-purification capability, resulting in water of good quality.

Table 12. Guidelines for interpretation of water quality for irrigation (after FAO/UNESCO, 1976).

Irrigation problem	Degree of the problem		
	No problem	Increasing problem	Severe problem
Salinity:			
Affects water availability to crop EC (mmhos/cm)	< 0.7	0.7–3.0	> 3.0
Permeability:			
Affects rate of infiltration of the water into and through soil			
EC (mmhos/cm) adj. SAR[1)2)]	< 0.5	> 0.5	< 0.2
Montmorillonite (2:1 crystal lattice)	< 6	6.0–9.0	> 9.0
Illite-Vermiculite (2:1 crystal lattice)	< 8		
Kaolinite-sesqufoxides (1:1 crystal lattice)	< 16		
Specific ion toxicity:			
Affect sensitive crops			
Sodium (adj. SAR)	< 3	3.0–9.0	> 9.0
Chloride (meq/L)	< 4	4.0–10.0	>10.0
Boron (mg/L)	< 0.75	0.7–3.0	> 3.0
Miscellaneous effects:			
Affect susceptible crops			
NO_3-N (or) NH_4-N (mg/L)	< 5	5.0–30.0	>30.0
HCO_3 (meq/L) (overhead sprinkling)	< 1.5	1.5–8.5	> 8.5

pH: Normal range 6.5 to 8.1

Fe: Permissible limit 0.3 ppm.

Zn: Permissible limit 5.0 ppm.

Pollution of Drainage Water

Sometimes waste generated domestically or from industrial sources—villages or towns—finds its way to the open drain, thus the drainage water in certain locations is highly polluted (Bahr El Baqour main drain). Table 13 shows the results of pollution by sewage, industrial waste, fertilizer, and oil in the Nile Delta.

Groundwater Quality

Fresh groundwater which contains less than 1,000 ppm total dissolved solids is found in the central and southern Nile Delta. Generally groundwater salinity exceeds 5,000 ppm outside the Delta. This increase is due to the limited recharge of the water. The suitability of groundwater for irrigation depends on soil type and groundwater quality according to guidelines in Table 13.

Table 13. Sources and degree of pollution in some locations in the Nile Delta.

Location	Source of pollution	NH_4 (mg/L)	NO_3 (mg/L)	BOD (mg/L)	COD (mg/L)	No. colifor (100 ml)
East Delta						
Belbeis Drain	Sewage & ind.	3.9	45.0	-	-	-
Wadi PS	Sewage	3.9	49.0	50	336	11×10^6
Bahr El Baqar	Sewage	3.7	45.5	160	952	24×10^6
Nizam P.S	Textile	2.6	31.0	100	660	21×10^6
Middle Delta						
Segaia PS	Ind. & sewage	1.2	13.0	50	336	24×10^6
Sematay PS	Ind. & sewage	3.0	30.0	-	-	-
PS No. 5	Ind. & sewage	2.7	29.0	-	-	-
Hamoul in PS	Ind. & sewage	1.2	11.8	-	-	-
Bridge Drain 1	Fertilizer			-	-	-
West Delta						
Etay Barroud PS	Sewage	-	-	85	542	12×10^6
Khandak PS	Effluent	-	-	70	282	24×10^6
Khaire PS	Effluent	1.6	22.0	-	-	-
Tabia PS	Effluent	2.6	32.0	30	56	21×10^6
Dushndi PS	Sewage & ind.	1.2	11.8	40	50	15×10^6
Mas PS	Sewage	2.8	28.0	80	100	12×10^6
Qalaa PS	Oil ind. & sewage	-	-	-	-	-

Table 14. Guidelines for assessing water quality for irrigation in reclaimed desert areas with sandy soil (RIGW/IWACO, 1988a, modified from FAO, 1985).

Potential	Degree of restriction in use		
	None	Slight to moderate	Severe
Salinity†			
- TDS (ppm)	< 2,000	2,000-3,500	> 3,500
Specific Toxicity			
- Sodium‡			
• Drip irrigation (ppm)	< 100	100-350	> 350
• Sprinkler irrigation (ppm)	< 70	> 70	
- Chloride‡			
• Drip irrigation (ppm)	<180	180-500	> 500
• Sprinkler irrigation (ppm)	<110	> 110	
Miscellaneous			
- Nitrogen§§ (ppm)	< 5	5-30	> 30
- Bicarbonate†† (ppm)	< 100	100-500	> 500

† Leaching fraction is 0.2.

‡ Most tree crops and wood ornament trees are sensitive to sodium and chloride; most annual crops are not sensitive.

§ As nitrate or ammonium.

†† Applies only for overhead sprinkling.

Under normal irrigation practices and drainage conditions, no problems are expected using water of the "no restriction category." For water in the "slight to moderate restriction" category, careful crop selection and special management practices are required. Such management should include the irrigation method, leaching or drainage practices, and soil and water amendments. The concentration of Na is the restricting factor.

Air Pollution

El Sokkary and Shalaby (1993) studied the contamination of soil, plants and water by mercury emitted from the El Max chloro-alkali plant west of Alexandria. They studied Ag emissions directly into the atmosphere from mercury cells used for chlorine production. They found high concentrations of Ag measured in the air and soils at sites very close to the hot spot, and decreasing with distance. The concentrations of Ag in the leaves and edible organs of the different plant species varied widely and were highly affected by proximity to the hot spot.

Recommendations

- Sewage and industrial drainage water should be filtered before use in irrigation to decrease the content of heavy metals in soils.
- Avoid growing vegetables as well as ornamental and fruit trees around industrial areas.
- Groundwater for should be analyzed suitability for irrigation.
- Avoid excessive fertilization, especially with nitrates.
- Choose suitable crops which can tolerate salinity, especially when using "slight to moderately restricted" water, and choose a suitable irrigation method.
- Heavy metal concentrations and pesticide residues in agricultural products should be monitored.
- Integrated Pest Management systems for pest control should be practiced to avoid excessive use of pesticides by using biological and cultural practices for pest control.

References

Abd El Aziz, I.M., M.H. Mahmoud, M.A.A. Amin and I.A. Ibrahim. 1982. Effect of phosphorus and zinc application by different methods on broad bean plants *Vica faba* in calcareous soils. Zagazig Univ. Res. Bull No. 725.

Abd El Fattah, A., M.K. Matar, A.A. Khamis and M.H. Ghaly. 1987a. Effect of applied Gypsum under different water Regimes on chemical properties of New Reclaimed Alkali Soils. Egypt. J. Soil Sci. 27: 245-258.

Abd El Fattah, A., M.K. Matar, A.A. Khamis and M.H. Ghaly. 1987b. Effect of different rates of Gypsum and water application on chemical properties of alkali soil leachates. Egypt. J. Soil Sci. 27: 275–287.

Abd El Hady, A.H. 1987. Effect of Zn, Mn, Fe-chelates and some foliar fertilizers in the yield of different field and Horticultural crops in Egypt. Proc. of the Sym. on the Application of Special Fertilizers. 21-23 Feb., Alexandria, Egypt.

Abd El Hamid, F.A., F. El Said, and F. El Baz. 1986. Studies on soil fertility of Ismailia governorate 1976–1986. Micronutrient Problems and Plant Nutrition project.

Abd El Naim, E.M., R.M. El Awady, R. Abbas and M.E. El Shal. 1984. Changes in sandy soil characteristics and yield productivity by using sewage water. The Second Conference of Agricultural Res. Center. April 9–11, Cairo, Egypt.

Abd El Naim, M. and R.M. El Awady. 1989. Studies on heavy metals removal from sewage water used in sandy soils. The Second Pan-American Regional Conference on Irrigation and Drainage. June 8-9 Canada.

Abd El Naim, M. and R.M. El Awady. 1990. Effect of irrigation with sewage water on the crop productivity of sandy soil of Egypt. Inter. Conf. on High Salinity Tolerant Plants in Arid Region, Dec. 8-15. United Arab-Emirates.

Abd El Naim, M. and W.L. McCuistion. 1992. Response of wheat to split of Nitrogen application in sandy soils of Egypt. Annual Meeting, 1992, American Society of Agronomy Nov., Minneapolis, Minnesota, USA.

Abd El Naim, M. 1989. Soil and water research activities on pilot program in calcareous soil at Nubaria Research Station. Reporting Results Workshop Proceedings. Cairo, Egypt. NARP publication No. 17.

Abd El Naim, M., M.A. El Saied, R. El Awady and M. El Shal. 1987. Effect of fertilization and irrigation with sewage water on the nutrients uptake and yield of faba bean on sandy soils. Fifth Inter. Symp. of CIEC Protection of Water Quality from Harmful Emissions with Special Regards to Nitrogen Sept. 1–4, Hungary.

Abd El Naim, M., M.E.E. Shal, R. Abbas, R.M. El Awady and A.E. Ibrahim. 1986. Effect of Agrosoke (soil conditioner) on sandy soil characters and sunflower plant growth. Agric. Res. Rev. 64: 681–689.

Abd El Naim, M., R.M. El Awady, A. Abd El Shafi and R. Abu Elenein. 1990a. Effect of phosphorus application at different nitrogen intervals on wheat yield in sandy soils. Annual Coordination Meeting NVRP-ICARDA, 23-27 Sept. Giza, Egypt.

Abd El Naim, M., R.M. El Awady and K. El Halwany. 1990b. Effect of bentonite application on the soil characteristics and crop productivity of sandy soils in Egypt. Conference of Soil Fertility and Foliar Fertilization, Jan. 14-15, Cairo Egypt.

Abd El Naim, M., R. El Awady and K. El Halwany. Effect of sewage sludge (budret) application as a soil amendment on crop productivity of sandy soil. Agric. Res. Rev. (in press).

Abd El Reheim, M.A., R.M. El Awady and R.L. Faltas. Changes and distribution on nitrogen, phosphorus and potassium in sandy soils irrigated with sewage water. Bull. Fac. of Agric. Univ., of Cairo, Vol. 37, No. 2.

Abd El Sabour, M.F., S. Abd El Samedd, I. El Gamal and H. Abou-El Naga. 1993. The environmental impact of Cairo sewage effluent in Abu Zabal farm. Egyptian Soil Soc., Fourth Nat. Cong., Nov. 24-25 Cairo, Egypt.

Abd El Salam, A.A., F.M. Habib and M.F. Mostafa. 1988. Evaluating the extent and duration of changes in sand properties upon adding polyvinyl alcotal, polyvinyl acetate, bitumen, *tafla* and farm yard manure. Inter. Symp. on Soil Conditioners, Cairo, Egypt.

Aboulrous, S.A., S. Holah and S.H. Badawy. 1993. Background levels of some heavy metals in soils of Egypt and associated corn plants. Egyptian Soil Sci. Soc. Fourth Nat. Cong. Nov. 24–25 Cairo, Egypt.

Ahmed, K.A.R. 1967. Effect of application of Nile silt and organic matter on the productivity of Southern Tahrir soil. PhD Thesis, Fac. of Agric., Cairo University, Cairo, Egypt.

Alaa El Din, M.N., N.H. Mohamed,. S.A. El Shami and I.M Abd El Aziz. 1987. Utilization of biogas manure as a complete fertilizer for vegetable. First Conference on Fertilizer, Cairo Egypt.

Awad, F., S.M.S. Badr-El Din, and M.A Wahab. 1988. Application of soil conditioners under *Vicia faba* in Salhia, Shabab area, Egypt. Inter. Symp. on the Use of Soil Conditioners for Reclamation and Farming of Desert Land, 11-13 October, Cairo, Egypt.

Balba, A.M. 1990. Alexandria Science Exchange. Calcareous soils classification and properties. Vol. 11 No: 2.

Diab, G.C., A.C. Thabet and I.H. El Sokkary. 1988. Effect of Viterra Plant Gel (VPG) and farmyard manure as soil conditioners on some physical and nutritional, properties of sandy and calcareous soils. Inter. Symp. Soil Conditioners, Egypt.

Dogheim, S., El Moattassem, F. Macklad, N. Shaker, and S. Hassan. 1993. Pesticide residues in the Rosetta branch of the river Nile during the winter closure period (December 1990–May 1991). Nile 2002 Conference, Aswan Egypt poster paper 1-14.

El Amir, S., A. Helalla and M.S. Shawky. 1988. Invading sandy soils with soil conditioners, Inter. Symp. Soil Conditioners, Egypt.

El Damaty, A.H., A. Laboudi and A.H. Hendy. 1971. Retention and release of phosphorous in certain calcareous soils of Egypt, and the influence of incubation process and cycles of wetting and drying. Egypt. J. Soil Sci. 11(1).

El Falaki, A. and H. Hahby. 1984. The chelating agent's validity as extractant for Fe, Mn, Zn, and Cu in Egyptian soils. Agricultural Research Review. 62(4): 235–245.

El Fayume, E. 1989. New approach for land evaluation of some Egyptian Regions Ph.D. thesis, Fac. of Agric., Alex. Univ., Egypt.

El Gala, A.M., M.A. Ozoris and E.M. El Sokkary. 1987. Effect of certain amendments on the availability of Fe, Mn, Cu, Zn, and P to sorghum plants grown in sandy soil. Second National Congress on Problems and Technology for Invading Desert Soils, Cairo, Egypt.

El Hady, O.A and A.A. Lotfy. 1987. Soil conditioners for promoting seedling emergence and plant growth in crust forming highly calcareous soils. Egypt. J. Soil Sci. 27: 467-476.

El Hady, O.A. and B.M. Abd El Hady. 1989. The interaction between polyacrylamide as a conditioner for sandy soils and some plant nutrients. 1-Effect on the Mechanical Strength and the Stability of Soil Structure. Egypt. J. Soil Sci. 29: 51-65.

El Hady, O.A., Y. Barakat and A.H. Hanna. 1987a. Emulsification of bitumen for sandy soils conditioning using Alpha olefin sultanates. Egypt. J. Soil Sci. Vol. 27: 489–499.

El Hady, O.A., A.H. Hanna and S.M.A. Shata. 1987b. Local bitumen as a conditioner for sandy soils: Field application with Brossica. First Conference on Fertilizer (Availability and Needs), Cairo, Egypt.

El Halawany, K.S., M.A. Abd El Reheem, A.E. Ibrahim. 1991. Effect of bentonite application on sandy soils properties and yield of lentil crop. Zagazig J. Agric, Res. 18 (3).

El Hamshary, S.A., A.M. Sorour, M. Hafez and S. Kandeel. 1993. Effectiveness of conventional subsurface drainage and nitrate losses in drainage water in the Nile Delta of Egypt. Egyptian Soil Sci. Society, Fourth Nat. Cong., Nov. 24-25, Cairo, Egypt.

El Kommos, F. 1990. The influence of some soil type properties on air entry suction. Egypt, J. Soil Sci. 30: 571–577.

El Leboudy, A.E., A.S. Ismail, M.A. Negm and S.Y. Montaser. 1990. Organic acids and nutrients availability in calcareous soils. Desert Inst. Bull., ARE. 40: 327–343.

El Massry, A.A. and M.A. Negm. 1986. Effect of organic amendments on some properties of calcareous soils and barley growth. J. Agric. Sci. Mansoura, Univ., 11: 434–439.

El Nagggar, M.F., H.W. Awad, G.H. Doerings and R. Burger. 1988. Evaluation of super absorbent polymer (Hydrogel) and slow release fertilizer for improving soil properties and plant growth in newly reclaimed areas of Egypt. Inter. Symp. Soil Conditioners, Egypt.

El Sherbini, A., M. El Moattassem, Sloterdijk. 1993. Water quality condition of the river Nile. Nile 2002 Conference, Feb., 1-6, Aswan, Egypt.

El Sherif, M. and M. Abd El Naim. 1990. Effect of Azolla application on physical and chemical properties of calcareous soils. Egypt. J. Soil Sci.

El Shimi, S.A, M.N. Abd El Din, M.H. Mahmoud and I.M. Abd El Aziz. 1987. Importance of biogas manure and zinc sulfate for nutrition of corn plant. First Conference on Fertilizers, Cairo, Egypt.

El Sokkary, I.H. and A.I. Sharaf. 1993. Enrichment of soils and plant crops irrigated with wastewater by Zn and Cd. Egyptian Soil Sci. Soc., Fourth Nat. Cong., Nov. 24-25, Cairo, Egypt.

El Sokkary, I.H. and Shalaby E.A. 1993. Contamination of soils, plants and water by mercury emitted from the chloroalkali plant of El Max, west Alexandria city. Egyptian Soil Sci. Soc. Fourth Nat. Cong, Nov. 24-25 Cairo, Egypt.

El Soueni, A. 1987. Organic fertilizers and soil conditioners in Egypt. First Conference on Fertilizer, Cairo Egypt.

El Soueni, A. 1987. Organic fertilizers and soil conditioners in Egypt. First Conference on Fertilizer, Cairo, Egypt. Soil and Water Research Institute.

El Toukhy, A.A., K.S. El Halawany and M.F. Abd El Rehim. 1987. Morphological studies and classification for soils at West Nubaria area. Annuals of Agric. Sci. Moshtohor, Vol. 25 (1).

Fahmy, M.A, S.A.E. Manchary, S. Marie and M. Abd El Motagally. 1989. Validity of some non-steady state equations for the design of tile drains in calcareous soils in Egypt. Egypt. J. Soil Sci. 29: 155-166.

Fuleky, G.Y. 1987. Nitrate movement in a brown forest soil as affected by N-fertilization. Fifth Int. Symposium of CIEC: Protection of Water Quality from Harmful Emission with Regard to Nitrate.

Gamal, A.A. 1993. Proper agricultural practices improve the environment. Egyptian Soil Sci. Soc. Fourth Nat. Cong., Nov 24-25, Cairo, Egypt.

Heggy, S.E., M.A. Mostafa and S.S. Megalah. 1987. The interaction between sources, levels of nitrogen fertilizers and moisture levels on plant growth in some soil of Egypt. SWRI First Conference of Fertilizers, Cairo, Egypt.

Hekal, E.K. 1992. Response of Broad bean plants to some soil conditioners in sandy soils. Egypt. J. Soil 32: 587–596.

Kadar, I., T. Nemeth and G. Kovacs. 1987. Nitrogen efficiency and NO_3-leaching on a calcareous chernozem soil. Fifth Int. Symposium CIEC: Protection of Water Quality from Harmful Emission with Regard to Nitrate.

Kragt, J.F. and W. de Vries. 1987. A simulation model for predicting nitrate leaching on a regional scale. Fifth Int. symposium of CIEC: Protection of Water Quality from Harmful Emission with Regard to Nitrate.

Labib, F., M.Y. Tayel and M.A. Elrashidi. 1975. Crust formation in clayey and calcareous soils. 1-Micropedological study. Egypt J. Soil. Sci. Special Issue.

Land Master Plan of Egypt. 1986. Ministry of Agriculture and Land Reclamation.

Lindsay, D. and M. Norval. 1978. Development of DTPA soil test for zinc, iron, manganese, and copper. Soil Sci. Am. J. 42: 421–428.

Maatouk, M.A. and M.A. Morsy. 1988. Shale deposits of El Minia Governorate as a soil conditioner. Inter. Symp. Soil Conditioners in Egypt, 353-366.

Mahmoud, S.A., S. Tahr, A.H. El Damaty and M.S. Moubarek. 1968. Effect of green manuring on the fertility of sandy soils at the Tahrir province, Jour. Soil Sci UAR 8: 129–143.

Mohamed, M.H., H.H. El Mashady, S.A. Shalaby and M.V. Nyazy. 1992. Preliminary evaluation of urea formaldehyde as a slow-release N-fertilizer for legumes in sandy soil. Zagazig J. Agric, Res. 9: 25–28.

Mohamed, S.A, S. El Demerdash and M.A. Abd El Salam. 1973. Studies of some physical and chemical properties of Maryut soil, ARE. The Desert Inst. Bull. Vol. XX 111 No. 1.

Nairooz, F.I, M.A. Eskarous and A.Y. El Bashbishy. 1987. Reponse of *Vica faba* plants to IAA combination with some micronutrient. Soil and Water Res. Inst. First Conference of Fertilizers, Cairo.

Negm, M.A. 1979. Studies on plant nutrition in calcareous soil. M.Sc. Thesis, Fac. Agric., Cairo Univ.

Negm, M.A, N.G. Fonone and M.J. Mikhail. 1990a. Some correlation between physical and chemical properties of Maryut Desert Soils. Egypt, J. Soil. Sci. 30: 91-105.

Negm, M.A., A.A. El Massary and N.M. Michail. 1990b. Effect of organic amendments on barley and sunflower grown on calcareous soils. Proceeding of the Conference on Soil Fertility and Foliar Fertilization. Jan. 14-16, Cairo Egypt.

Pimentel, D. 1989. Impact of Pesticides and Fertilizers on the Environment and Public Health. Proc. *Conference of Irrigation and Drainage.*

Rabie, F., A. Fawzi, M. Yassanin and W. Hussein. 1993. Content of biogenic and non biogenic heavy metals in El Saff Soils as related to different pollution resources. Egyptian, Soil Science Society Fourth Nat. Congress Nov. 24-25 Cairo, Egypt.

Salem, F.M.A. 1985. Agrochemical Technique for crops production under saline-alkaline soils at San El Hagar Region, M.Sc. Dissertation, Zagazig University.

Salem, M.O., A.A. El Shall, M.M. Wassif and M.H. Hilal. 1987. Effect of sulfur, nitrogen and organic manure application on the growth characters of wheat planted under calcareous soil and saline irrigation water conditions. Soil Sci. Soc. of Egypt. Second National Congress on: Problems and Technology for Invading Desert Soil. Cairo, 15–17 Dec.

Salem, M.O., M.M. Wassif, A.A. El-Shall and M.H. Hilal. 1987. Yield and yield components of wheat plant growth under saline irrigation water as affected by different levels of nitrogen, sulfur, and organic manure. Soil Sci. Soc. of Egypt. Second National Congress on: Problems and Technology for Invading desert Soils. Cairo, 15–17 Dec. 1987.

Salem, N. 1988. Evaluation of some parameters influencing the use of conditioners in soil. Inter. Symp. Soil Conditioners, Egypt.

Samy, S.H., A. El Kady, F. Hanna and S. Abd El Gelil. 1989. Morphology and classification of calcareous soils of the Western Mediterranean Coast of Egypt. Egypt. J. Soil Sci. 29: 315-329.

Sandor, H., K. Andras, and K. Tomas. 1987. Reducing danger of nitrate pollution with rational N-fertilization. Fifth Int. Symposium CIEC.

Schroder, H. 1985. Nitrogen losses from Danish agriculture trends and consequences. Agri. Ecosyst. Environ. 14: 279–289.

Sharkawy, S.F. 1991. Effect of tillage and planting methods on soil loss by rainfall under dry farming. M.Sc., Fac. of Agric., Suez Canal University.

Shawky, M.E, M.A. Naga, S.H.I. Abd Aal and M.S. Heakal. 1974. Aggregate stability and their size distribution in some Halosoils in ARE. The Desert Inst. Bull. Vol. XXIV, No. 12.

Ubavic, M., Z. Rajkovic and S. Manylovic. 1987. Dynamics of mineral nitrogen in underground water in rigoled antropic sand. Fifth Int. Symposium on Protection of Water Quality from Harmful Emission with Regard to Nitrate.

UNDP/FAO. 1978. *Project findings and reclamation. Terminal report of* UNDP/FAO/Egy/78/048 prepared for the Government of Egypt by UNDP/FAO, Rome.

Wahdan, A.A., M. El Shall and A.T. Mostafa. 1985. Soil physical property changes associated with tile drainage application in Upper Egypt. Egypt. J. Soil Sci. 25(1): 11–20.