Research Findings

Manual cultivation near Ismaelia. Photo by M. Marchand.

Country Report on Egyptian Agriculture and Summary of IPI Experiments

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Introduction

Egypt lies in the northeastern corner of the African continent and has a total area of about 1 million km^2. It is bordered by the Mediterranean Sea in the north, by the Gaza Strip, Israel and the Red Sea in the east, by Sudan in the south and by the Libyan Arab Jamahiriya in the west. Its north-south extent is about 1,080 km and its maximum east-west extent about 1,100 km. The Egyptian terrain consists of a vast desert plateau interrupted by the Nile Valley and Delta, which occupy about four percent of the total area of the country.

Climate

Mild rainy winters and hot dry summers typical of a Mediterranean climate are experienced in the Mediterranean coastal areas, including the Nile Delta. South of Cairo, the rest of Egypt experiences a desert climate. The average temperature during summer months in the south may rise up to 41˚C and around 35˚C in the north. The spring season brings temperate climatic conditions accompanied by dust storms. Mild weather with bright sunny days and some rain is experienced in the winter

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season but the nights are cold. The average temperature during winter months is around 21°C in the south and 13°C in the north. The most humid area is along the Mediterranean coast, where the average annual rainfall is around 200 mm. Precipitation decreases rapidly to the south; Cairo receives an average of 29 mm of rain each year, and in many desert locations it may rain only once in several years.

Map 1. Map of Egypt and the African continent.

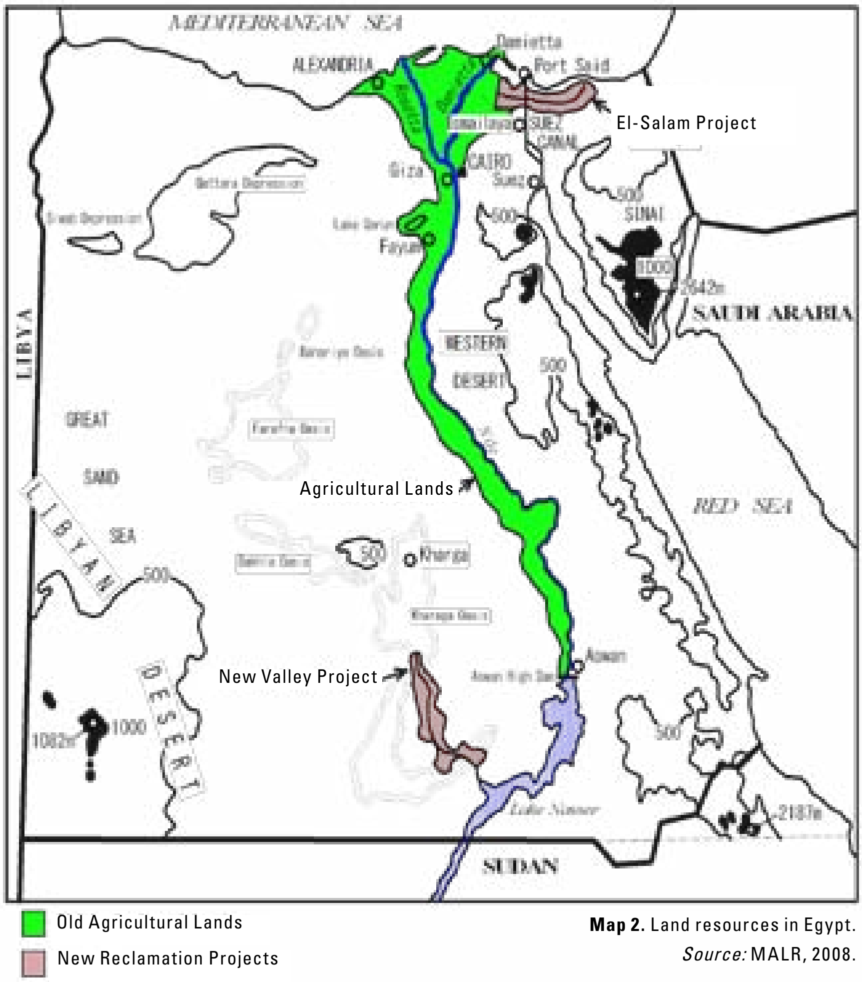
Land and water resources

The majority of the country area is desert land. Most of the cultivated land is located close to the banks of the River Nile, its main tributaries and canals, and in the Nile Delta. Rangeland is restricted to a narrow strip, only a few kilometers wide, along the Mediterranean coast and its bearing capacity is quite low. There is no forest land.

Egypt occupies a total area of around 100 million ha. The agricultural land area is about 3.2 million ha, covering three different production zones:

1. The old irrigated lands, an area of 2.3 million ha, lying in the Nile Valley and Delta, represent the most fertile soils in Egypt.
2. The "newly" reclaimed lands, a potential area of 0.8 million ha, which include the newly reclaimed desert lands of sandy and calcareous origin, where soil is poor in organic matter and in macro- and micronutrients.
3. The rain-fed areas, about 0.1 million ha of sandy soil, located in the Northwest Coast and North Sinai.

On a per capita basis, the area of cultivated land in Egypt is among the lowest in the world, and is estimated at 0.05 ha.



Map 2. Land resources in Egypt.
Source: MALR, 2008.

Soils

The Egyptian soils vary with respect to their texture, from sandy to heavy clay soils, as shown in Table 1. The average value of total soluble nitrogen is low and organic matter is also low, and the soil reaction is slightly alkaline. The available phosphorous values, determined by Oslen's method, are moderate. However, the available potassium (extracted by 1 N ammonium acetate solution) ranges between low and high. The DTPA extractable micronutrients (Zn, Mn and Fe) show lower values of Zn in sandy soils and sandy calcareous soils, and adequate amounts of Mn and Fe in all tested soils. See Table 1.

Table 1. Typical analysis of Egyptian soils.

Location	North Delta	South Delta	East Delta	West Delta	Middle Egypt	Sinai	Toshka	Upper Egypt
Texture	Clay	Clay loam	Sandy	Sand calcar.	Loamy clay	Sandy	Sandy clay loam	Loamy
pH (soil; water1:2.5)	7.9-8.3	7.8-8.2	7.6-7.9	7.7-8.1	7.5-8.1	8.6-9.1	8.32-8.56	7.7-8.2
T.D.S. (%)	0.2-0.5	0.2-0.4	0.1-0.6	0.2-0.6	0.1-0.5	0.35-0.46	0.11-0.13	0.1-0.4
$CaCO_3$ (%)	2.6-4.4	2.0-3.1	1.0-5.1	11.0-30.0	2.3-4.9	2.17-7.47	2.2-3.5	2.5-5.1
O.M. (%)	1.9-2.6	1.8-2.4	0.4-0.9	0.7-1.5	1.5-2.0	0.17-0.29	1.5-2.0	1.2-1.9
Soluble N (ppm)	25.0-50.0	30-60	10.0-20.0	10.0-30.0	20.0-30.0	10.0-21.0	7.25-39	20.0-25.0
Available P (ppm)	5.4-10.0	3.5-16.5	2.0-20.0	1.5-10.5	2.5-20.0	0.1-0.37	3.26-12	3.0-18.0
Available K (ppm)	250-500	250-300	105-358	100-300	250-380	163-192	148-285	280-400
Available Zn (ppm)	0.5-4.0	0.6-6.0	0.5-1.2	0.4-1.5	0.8-3.9	0.8-1.6	0.98-1.85	0.5-4.0
Available Mn (ppm)	13.1-45.6	11.2-37.2	3.0-11.7	10.0-20.0	8.6-51.9	1.4-3.1	0.48-2.45	10.0-47.0
Available Fe (ppm)	20.8-63.4	19.0-27.4	6.7-16.4	12.0-18.0	13.0-37.0	3.0-4.0	1.02-1.98	12.4-40.8

Source: Soils Water and Environment Research Institute, Egypt.

Water resources

The River Nile is the main source of water for Egypt, with an annual allocated flow of 55.5 billion m^3 yr^{-1} under the Nile Waters Agreement of 1959. The chemical characteristics of Nile water are described in Table 2.

Underground water

Underground water is an important source of freshwater in Egypt. As underground water is a constant temperature and not exposed to pollution, it can be used directly without treatment and is a safe source of potable water.

Egypt is currently developing a water resources plan (ending in 2017), and under this framework, aims to save 6.5 billion m^3 of underground water.

Table 2. Some chemical properties of Nile water.

Parameter	Unit	Value
pH		7.3
EC	dS m^{-1}	0.37
Na^+	meq L^{-1}	0.89
Ca^{++}	meq L^{-1}	1.66
Mg^{++}	meq L^{-1}	0.95
Cl^-	meq L^{-1}	0.56
SO_4^+	meq L^{-1}	1.31
HCO_3^-	meq L^{-1}	1.8
Total N	ppm	4.5
NH_4^+	ppm	0.54
NO_3^-	ppm	1.43
Total P	ppm	0.17
K^+	ppm	1.9

Source: Abd el-Hady, 2007.

Rain water

Rain is a scarce resource for much of Egypt. The northwest coast of Egypt receives around 1.3 m^3 annually, which decreases gradually as you go south; southern Egypt receives only a trace of rain each year. Rainfall therefore remains a limited and unreliable source in agricultural development, but can continue to play a role in pasture cultivation in desert areas and irrigation in the North Coast.

Drainage water

Since the 1950's, Egypt has started to re-use agricultural drainage water, which is treated and mixed with Nile water for use in irrigation (Table 3). Stations were established along parts of the Nile Delta to lift and push drainage and Nile water into canals for land irrigation. The quantity of drainage water used was estimated at 8 billion m^3 for 2007/2008.

Water use

Total water withdrawal in 2008 was estimated at 76.6 billion m^3. This included 60 billion m^3 for agriculture (78.3 percent), 6.6 billion m^3 for municipalities (9 percent) and 7.6 billion m^3 for industry (10 percent). Apart from that, 0.2 billion m^3 was used for navigation, i.e. water used by ships for cooking, engines and other on board uses (Table 4).

Re-use of agricultural drainage water is through its return to rivers and as irrigation, and amounted to 8 billion m^3 yr^{-1} in 2007/2008. Of the 2.97 billion m^3 yr^{-1} of treated wastewater, 1.3 billion m^3 yr^{-1} is re-used for irrigation, while the rest is pumped into main drains where it mixes with drainage water and is then used for irrigation. Treated wastewater is usually used for landscape irrigation of trees in urban areas and along roads.

Table 3. Water resources in Egypt during 2002-2008 (in billion m^3).

Resources	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Nile water	55.5	55.5	55.5	55.5	55.5	55.5
Ground water	6.1	6.1	6.1	6.1	6.2	6.5
Drainage water	4.4	4.8	5.1	5.4	5.7	8
Sewage recycling	0.9	1	1.1	1.2	1.3	1.3
Rain & flash floods	1.3	1.3	1.3	1.3	1.3	1.3
Desalination	0.06	0.06	0.06	0.06	0.06	0.06
Total	68.26	68.76	69.16	69.56	70.06	72.66

Source: Bahgat, 2008.

Table 4. Water resources usage in Egypt (in billion m^3).

Sector	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Irrigation	57.6	58.1	58.5	59.0	59.3	60.0
Municipal	5.2	6.0	6.1	6.1	6.3	6.6
Industry	6.2	6.5	6.8	7.0	7.3	7.6
Evaporation	2.1	2.1	2.1	2.2	2.2	2.2
Navigation	0.2	0.2	0.2	0.2	0.2	0.2
Total	71.3	72.9	73.7	74.5	75.3	76.6

Source: Bahgat, 2008.

Table 5. Total cropped area in 2008/2009 (about 16.3 million feddan*).

Crop	Area (million feddan)
Wheat	3.20
Berseem and other forage crops	2.90
Maize	2.70
Vegetables	2.35
Orchard	1.60
Oil crops	0.52
Cotton	0.50
Legumes	0.43
Sugar beet	0.37
Sugar cane	0.32
Other crops (medicinal and aromatic plants; ornamentals)	0.30

*Feddan = 0.42 ha

Source: Agricultural Statistics, 2010

Cropping systems

The Egyptian climate is generally favorable all year round and is suitable for growing a wide variety of crops. Field crops cover roughly 90 percent of the total cropped area and 10 percent is vegetables and fruits grown on the old and new reclaimed land.

Under prevailing cropping patterns there are usually two crops a year in the same field giving a cropping index of 200 percent, whereas a cropping index of 300 percent is achieved in the vegetable areas. The perennial sugarcane and permanent orchard areas have a cropping index of 100 percent. The cultivated area is slightly more than 6.848 million ha (Table 5), with an average cropping intensity of 176 percent. There are three growing seasons in Egypt: winter - from November to May; summer - from April/May to October; and "Nili" - from July/August to October.

Most crops are grown in the Delta and the Nile Valley, with the exception of rice (Delta mainly) and sugarcane (Middle and Upper Egypt). The main winter crops are wheat and clover or berseem *(Trifolium alexandrinum)*. Berseem is grown over three months with two cuts as a soil improver (short berseem) usually preceding cotton, or over six to seven months, with four to five cuts as a fodder crop or grazed by tethered cattle (long berseem). Minor winter crops are (amongst others) pulses, barley and sugarbeet. In summer, cotton and rice are important cash crops, while maize and sorghum are major subsistence crops. Details of area cropped in 2008/2009 are given in Table 5.

Fertilizer requirements

Significant efforts have been focused on increasing crop production and tackling constraining factors. One key target is the proper fertilization of various crops which will obviously increase the demand for chemical fertilizers. Rate of increase in fertilizer use in Egypt has accelerated in recent years, especially for nitrogen fertilizers, followed by phosphate and potassium fertilizers. This is primarily due to the increase in cropping area, the increase in fertilizer application for various crops, and depletion of Nile irrigation water of some nutrients (K and micronutrients, together with the silt) due to the construction of the High Dam in Aswan.

Numerous studies have firmly established the deficiency of most Egyptian soils in organic matter and nitrogen (N) content. Phosphorus (P) availability to plants, however, ranges between sufficiency and marginality, although the total P content in most Egyptian soils is quite high. Potassium is moderate to high in the old lands, however there are sporadic responses to K fertilizer especially with some horticultural crops and on sandy as well as some calcareous soils.

Table 6. Fertilization requirements for various field crops (kg ha^{-1}).

Crops	Old land			New land		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
			kg ha^{-1}			
Cotton	60	22.5	24	-	-	-
Maize	120	15	24	140	30	48
Rice	40-60	15	24	-	-	-
Soybean	40	30	24	-	-	-
Beans	40	30-45	48	60	45	48
Wheat	90	22.5	24	100-120	30	24-48
Broad bean	15	30	24	15	30	48
Clover	15	22.5	24	20	30	24
Sunflower	30-45	15	24	45-60	30	24
Peanut	30	30	24	45	30	24
Sesame	30	22.5	24	45	30	24
Sugar beet	60	15	24	75-100	30	48

Source: Abd el-Hadi *et al.*, 2009.

The fertilizer requirements in Egypt are mainly estimated according to crop needs and the area allocated for each crop, as well as the optimum economical rates of fertilizers for each crop (Table 6) which are obtained from average results of long-term trials conducted on each crop under different agro-climatic conditions and the nutrient amounts removed by the crop (Table 7).

Other factors to be taken into consideration in estimating fertilizer requirements include:

1. Crop rotation and its effect on crop response to fertilizers.
2. The horizontal expansion in the newly reclaimed area.
3. Soil test values and plant tissue tests.
4. The residual effect of fertilizers and organic manures.
5. Crop intensification, whether by increasing the plant number per unit area or by intercropping.
6. The release of new varieties of various crops with high-yield potential.
7. The nutritional balance for various crops.
8. The fertilizing value of different sources of fertilizers.
9. Use of irrigation and drainage systems.

Fertilizer requirements are dependent on cropping conditions: the "old land" is the Nile Delta and the Nile Valley, where soils are better quality than in the "new land", or reclaimed lands from the desert, which are pure sand with low fertility (Fig. 1). The old land represents the traditional cropping area (arable land). It is two percent of the country. The extension of the cropping area in the desert is a prerequisite to ensure food security in Egypt.

Fertilizer consumption

It should be noticed from the data reported in Fig. 2 that the ratio of $N:P_2O_5:K_2O$ was 74.64:13.68:1 in 1979/1980 which declined to 20.7:3.28:1 in 2008/2009 since the consumed amount of K_2O increased from 6.7 thousand tonnes in 1979/1980 to 55 thousand tonnes in 2008/2009, and this has a positive effect on NPK balance.

The highest amounts of fertilizer were consumed during the period (2004-2007), with an average of 1,556.9 thousand tonnes/

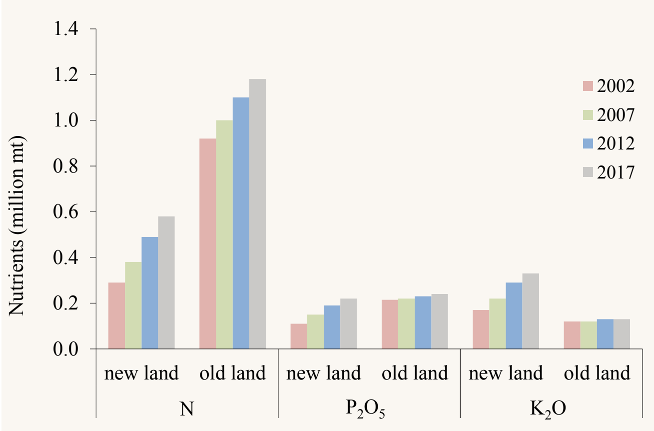


Fig. 1. Estimated fertilizer requirements in the new and old land in Egypt. *Source:* FAO, 2005.

Table 7. Nutrient amounts (kg ha^{-1}) removed by various crop plants (Abd el-Hadi *et al.*, 2009).

Crop	Yield	N	P_2O_5	K_2O	MgO	S
	mt ha^{-1}			--kg ha^{-1}--		
Barley	5	150	55	150	25	20
Maize	6	120	50	120	40	25
Rice	5	100	50	160	20	20
Sorghum	4	120	40	100	30	15
Wheat	6	170	75	175	30	30
Potato	40	175	80	310	40	20
Sugar beet	45	200	96	300	90	35
Cabbage	70	370	85	480	60	80
Carrot	30	125	55	200	30	-
Cucumber	40	70	50	120	60	-
Eggplant	60	175	40	300	30	10
Lettuce	30	90	35	160	15	-
Okra	20	60	25	90	35	10
Radish	20	120	60	120	30	-
Onion and garlic	35	120	50	160	15	20
Spinach	25	120	45	200	35	-
Tomato	50	140	65	190	25	30
Bean	2.4	155*	50	120	20	25
Horse bean	2.4	160*	45	120	20	-
Pea	2.0	125	35	80	15	-
Apple	25	100	45	180	40	-
Banana	40	250	60	1,000	140	15
Citrus	30	270	60	350	40	30
Grape	20	170	60	220	60	30
Mango	15	100	25	110	75	-
Peanut	2	170*	30	110	20	15
Sesame seed	1	50	10	45	10	5
Rapeseed	3	165	70	220	30	65
Soybean	3	220*	40	170	40	20
Sunflower	3	120	60	240	55	15
Cotton (lint)	1	120	45	90	40	20
Sugarcane	100	130	90	340	80	60
Alfalfa	9	240*	65	170	40	25
Red clover	7	175*	45	140	50	20

*Leguminous plants obtain most of their nitrogen from the air.

Source: Principal Bank for Development and Agricultural Credit-Fertilizer Administration.

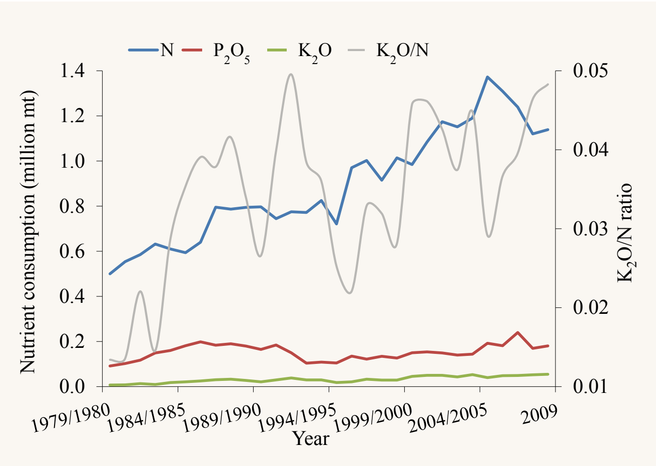


Fig. 2. Consumption of N, P and K fertilizers and the ratio K_2O/N during the period 1980-2009. *Source:* IFA, 2010.

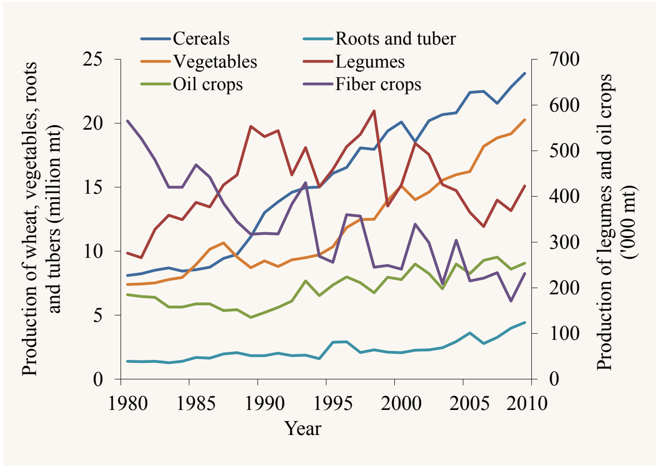


Fig. 3. Total crop production year^{-1}. *Source:* Central Administration for Agricultural Economic, Economic Affairs Sector, MALR.

year; although this increase was accompanied by an increase in crop production during the same period.

From the data presented in Table 7, N fertilizer consumption significantly increased during the period 1980 to 2009, whilst P and K consumption were much lower and more stable.

Crop production

From 1980 to 2009, cereal production increased from 8.1 to 23.897 million mt; legumes increased from 276 to 423 thousand mt; oil crop production increased from 185 to 254 thousand mt; roots and tuber crop production increased from 1.394 to 4.429 million mt; vegetable production increased from 7.402 to 20.275 million mt in 2009; while fiber crop production decreased from 565 to 231 thousand mt (Fig. 3). The higher increase observed in cereal and vegetable crops was accompanied by a steady increase in N fertilizer consumption.

The Activities of the International Potash Institute (IPI) in Egypt

Introduction

The Soil, Water and Environment Research Institute (SWERI), in collaboration with IPI, carried out long-term experiments during the period 1981 to 1990 to evaluate the effect of K application on various crops on farmers' fields under typical prevailing crop rotation. During 1992 to 1995, a series of long-term experiments were carried out in the eastern part of Nile Delta (sandy and sandy loamy soils) to study the efficiency of K on crop production under saline and water stress conditions.

Experimental programs

1. Long-term field trials were conducted at six different Agricultural Research Stations representing different types of soils during seven successive years (1993-2000) to compare effectiveness of KCl (MOP) and K_2SO_4 (SOP) on different crops. The trials were repeated for an additional five years till 2005, on farmers' fields under their traditional agriculture practices.
2. Another long-term field trial was also initiated from the year 2005/2006 till 2012 to investigate the interaction effect of N, P and K on crop yields.
3. From the beginning of the 2009/2010 season, a series of experiments were planned to investigate the interaction effect between K fertilizers and various amount of irrigation water, as well as different irrigation methods.

Workshops and training programs

SWERI, in collaboration with IPI, held dozens of workshops in various Research Stations and Governorates dealing with the importance of balanced fertilization to achieve the highest crop yield in addition to solving some agricultural problems faced by farmers.

In addition, IPI provided support in the publication of booklets concerning K fertilization and symptoms of nutrient deficiency in some important crops, all produced in Arabic. Twenty-five papers from the obtained results were published at international and local scientific workshops and in various Journals through the period (1984 to 2010). Four PhD theses were obtained through the project (in the field of K fertilization).

Conclusions

Egyptian agriculture is an example of semi-arid to arid cropping systems, characterized by a limited cropping area. Water availability is a limiting factor in most parts of the country and competition in water use between population, industry and agriculture is a source of concern. Through the years, crop productivity has increased as a result of increasing fertilizer use,

Map 3. Location of IPI's experimental programs in Egypt.
Source: Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC.

Discussing experiment results of potato crop near Nubaria, west branch of the Nile delta. Photo by M. Marchand.

a strong focus on providing information to fertilizer distributors and retailers, and farmer training to achieve better efficiency for agricultural inputs. The increase in production, especially regarding food production, has been achieved through the development of new cropping areas, so called "new reclaimed lands", in the Sinai desert and in the Toshka region, which means the development of specific irrigation techniques. The role of SWERI and IPI is to promote a better NPK ratio as well as to raise awareness amongst farmers of other limiting factors that occur in the particular Egyptian conditions.

The main challenges are an improvement in crop production to feed an increasing population and to use Nile water in the most efficient way. Concerning nutrient management, the objective of SWRI and IPI cooperation is to convince farmers of a better practice in the use of fertilizers. To achieve this goal, it is necessary to prove through experiments in Research Stations, to show through field demonstrations and finally to explain the use and benefit of balanced fertilization. Communication and education are the two keywords for the success of SWERI and IPI activities and the development of Egyptian agriculture.

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Regional activities/WANA