Impact of Agricultural Practices on Soil Productivity and Sustainability of Abis Experimental Research Station (AbisERS), Egypt

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ABSTRACT

The Faculty of Agriculture, Alexandria University, owns an experimental research station located in Abis area (AbisERS), Southern East Alexandria City, with a total area of 209.6 ha. Over the years, numerous research studies were conducted on AbisERS. However, lack of a comprehensive historical database to document land and crop management practices and the related soil productivity is apparent. The present study aims to develop a geo-info-base assessing soil quality/productivity and sustainability based on the soil management practices. Surface soil samples were collected from 153 geo-referenced locations and analyzed to obtain major soil quality/productivity indicators. QuickBird satellite image and geographic information system (GIS) were utilized to build a digital geo-referenced database to develop soil quality indicator maps. Moreover, stepwise multiple regression analysis was applied to identify factors affecting the soil productivity. Other data was extracted from previous work of Darwish (1977) and Al-Attar (1980) and the available farm records.

Results showed high variations in all measured soil indicators within the AbisERS. The salinity/sodicity indicator map showed that 19 % of the area was non-saline/non-sodic, 55 % moderate-saline/non-sodic, and 26 % was saline-sodic soils. As an average, the soil salinity increased from 2.3 ± 0.9 in 1977 to 4.6 ± 5.4 dS/m in 2007, reflecting low efficient management practices that control soil salinization. The SAR also increased from 4.6 ± 1.8 in 1977 to 6.0 ± 5.2 in 2007. The low efficiency of the drainage system resulted in fluctuating water table and increase soil salinity/sodicity risks. The study also revealed unbalanced use of nutrients. P was infrequently and insufficiently applied during the last 20 years. Therefore, soil available P was lowered to the deficiency level in 63.6 % of the area and was correlated with wheat yield. Soil Organic matter content (OM) averaged 2.6% ± 0.2% in 1977 that reduced to 1.9 ± 0.6% in 2007.

Based on the available soil and crop data, it was evident that soil productivity is low. Wheat and rice yields did not exceed 4.3 and 4.5 Mg/ha, respectively. These yields were generally lower than the average- national yields of both crops. The gap between the actual and the attainable yields of wheat and rice might be as wide as 3.0 and 4.5 Mg/ha, respectively. Multiple regression analysis for soil properties and yield indicated that soil salinity (EC), P, and OM were among the most soil properties limiting crop yield. Soil deterioration and nutrient depletion observed in this study could be explained mostly by agriculture management practices followed on AbisERS.

Key words: Soil productivity – sustainability – Soil deterioration – Soil salinity - Phosphorus depletion.

INTRODUCTION

The Faculty of Agriculture, Alexandria University owns an Experimental Research Station in Abis area (AbisERS) 10 Km from the Faculty premises, since 1948. As any experimental research station belongs to an educational institute, AbisERS mission is to provide means to carry on scientific research and training. In each season and after satisfying the research demands and students training needs, the reminder of the total area is uniformly cultivated with some cash crops as a part of the faculty community service as well as a self raising fund for research. Over many years, huge number of experiments or research projects with different purposes was conducted on the AbisERS. Most of these studies have been limited to specific objectives and conducted on very small areas (not exceeded 0.25 to 0.5 ha each), therefore, there is no a complete report or data base that document soil and crop management practices and soil productivity which can be used by researchers or by the administrators to better manage soil in sustainable manner.

Soil quality has quite different meanings to different soil scientists (Blum 1998, Schonholtz et. al., 2000, Wander et. al, 2002). The basic concept behind it is fitness of a soil for specific use, and is considered as the capacity of a soil to function. In an agricultural context, soil quality is defined as "the soil's fitness to support crop growth without resulting in soil degradation or otherwise harming the environment" (Acton and Gregorich, 1995) and often defined in terms of soil productivity (Carter et al., 1997). Some authors (e.g. Warkentin, 1995) have suggested that soil quality is simply related to the quantity of crops produced. An assessment of the changes (positive or negative) in soil quality/productivity over time is needed to evaluate the impact of different management practices (Zhen et. al., 2006), where enhancing food production while reversing soil degradation is critical. Doran and Parkin (1994) suggested that soil quality assessments could be used as a management tool or aid to help farmers select specific management practices and as a measure of sustainability.

The main scientific-based tool to estimate soil quality/productivity is soil testing. Therefore, soil quality Indicators (SQI's) have been developed to provide information on the impacts of agricultural practices on land and environmental degradation. Soil organic carbon (SOC), infiltration, aggregation, pH, microbial biomass, forms of N, salinity, and available nutrients as indicators of soil, are most often reported attributes and are chosen as the important indicators of soil quality/productivity and agricultural sustainability (Gregorich et al.1994, Karlen et al.1997, Wang and Gong 1998). On the other hand, crop yield is considered most reliable to clearly reflect soil quality/productivity differences. There are many other indicators for soil quality but no is suitable for all purposes and contexts. The selection is based on indicators that are considered useful to that particular site. It is important to be able to select attributes that are appropriate for the task (Zhen et. al., 2006).

In arid and semi-arid regions soil salinity, high exchangeable sodium, high pH, and low calcium and magnesium combine to cause the soil to disperse (Rhoades et. al., 1992; Van Lynden at. al., 2004). The dispersion of soil particles destroys soil structure and prevents water movement into and through the soil by clogging pore spaces (Churchman et. al., 1993). Both soil salinity and sodicity limit plant growth and productivity (Ayers and Westcot, 1985, Pessarakli, 1994; Van Lynden et al, 2004). In general, salt affected soil problems do not develop overnight, nor are they solved quickly. Other soil chemical properties represent the supply of nutrients and effects of contaminants. Managing soil chemical quality requires the control/management of salinity, sodicity, organic matter and careful management of nutrients and other chemical inputs.

Geographic Information System (GIS) has emerged as an efficient tool for spatial analysis of natural resources and database management (ESRI, 2002). It is also became an efficient tool in soil productivity assessment to automate the transformation of soil data into soil information (Kumar and Metra, 1999) and helps in guiding to a better resource management.

The present study aimed to evaluating soil quality/productivity and management practices in AbisERS and to develop a geo-info base to provide a tool for researchers, students and agronomists to better plan and execute their future research/management based on accurate and reliable information.

MATERIALS AND METHODS:

Site description:

The Abis Experimental Research Station (AbisERS) is located 10 km south of the faculty of Agriculture main premises. It is bounded by longitudes 29° 57' 58" and 29° 59' 37" E; and latitudes 31° 12' 13" and 31° 13' 12" N, having 209.6 ha (around 500 Feddans) total acreage. The first part is 146.7 ha (Al-Kalaa farm) located north and the second is 62.9 ha (Al-Ershadia farm) located south the railway Cairo-Alexandria. Al-kalaa farm is composed of 14 plots (numbered from 1 to 14) each is separated by one irrigation channel and one drain tail (Fig.1), and Al-Ershadia farm is composed of 3 main plots (from 1 to 3). The plot area ranges between 10 and 17 ha and divided into 3 to 5 subplots. The total cultivated area of AbisERS is about 154 ha and the reminder area is used for other agricultural activities. Climatic data reveal that rainfall ranges between 50 – 285 mm/year between October and Febraury. Temperature ranges between 9 – 18 °C in winter and 21 – 32 in summer. Relative humidity ranges between 10 % in December to 70 % during summer.

The Abis soil is formed on lacustrine deposits. These deposits were part of Maryout Lake adjacent to the north western edge of the Nile Delta (Said, 1962). It is characterized by its stratified mode of formation, and presence of shells layer somewhere in the profile. The soil of Abis ERS is a *Vertic Torrifluvents*. The soil texture is a clay loam to sandy clay loam at the top, and is clay mixed with shells at a depth of 0.4 to 0.5 m. The CEC of the surface soil layer (0.0 – 0.3 m) ranged between 22 to 29 meq/100g soil, and the $CaCO_3$ content ranges between 7.2 to 12.6 % (Darwish, 1977). Canal water with EC = 0.5 dS/m is available for surface irrigation technique used at the Abis area.

Soil sampling:

Soil sampling strategy was designed using QuickBird satellite image of the AbisERS obtained in March 2006. A grid scheme of 100 m spacing was overlain on the geo-referenced Quick Bird image and the coordinates of the soil samples locations were obtained (Fig. 1). After eliminating the non-agricultural locations, 153 surface soil samples (0 – 0.3 m depth) were collected during April - May 2007 from each geo-referenced location. GPS instrument (Garmin, 1999) was used to reach the soil sampling locations. The collected soil samples were air dried, ground, passed through 2 mm sieve and stored at room temperature for latter analysis.

Soil chemical analysis:

The collected soil samples were analyzed for soil characteristics that include soil reaction (pH), electric conductivity (EC), soluble cations and anions, organic carbon (OC), calcium carbonate content, and available macronutrients (N, P, K).

Electrical conductivity (EC) and water soluble ions were measured in the soil paste extracts as described by Rhoades (1982). The soil pH was measured in 1 : 2.5 soil : water suspension (McLean, 1982). Soil organic carbon content was determined by the wet-oxidation method of Walkley and Black (Nelson and Sommers, 1982).

Available nitrogen (NH_4-N and NO_3-N) was extracted by 2 N KCl and determined after distillation (Keeney and Nelson, 1982). The Available phosphorus was determined by Olsen's method (0.5M $NaHCO_3$, pH 8.5) (Olsen and Summers, 1982) and phosphorus in solution was measured colorimetrically by the ascorbic acid method (Murphy and Riely, 1962). Available K was extracted by ammonium acetate (1N, pH 7) followed by K measurement by the flame photometer (Knudsen et. al., 1982).

GIS soil mapping:

The QuickBird image was used to create an up-to-date digital geo-referenced data base for AbisERS. The image was registered to UTM coordinate system, and on-screen digitizing was used to delineate the boundaries of each plot in the farm. Irrigation and drainage systems, roads and tracks were also digitized (ESRI, 2002).

The spatial distribution maps of the measured soil properties were created using ArcView GIS 3.2a software, ESRI (2002). The soil attributes (Tab. 1) included EC, SAR, OM, available N, P, K. Inverse Distance Weighing (IDW) Interpolation method (Longley et al. 2005) was used to obtain continuous maps of soil qualities, and overlay was used to produce SAR, salinity-sodicity and other combined maps. The area and percentage of each mapping unit were also calculated.

Fig. 1: QuickBird satellite image of AbisERS. Numbers and dots indicate the geo-referenced samples locations.

Table 1: Selected soil quality indicators (SQI) and their threshold value.

Indicator	Very-High	High	Moderate	Low to very low
EC (dS/m) [a]	> 8	4 - 8	2 - 4	< 2
SAR [a]	> 15	13 - 15	10 - 13	< 13
pH [b]	> 8.5	8.2 – 8.5	7.8 – 8.2	< 7.7
OM (%) [b]		≥ 2.5	1.5 – 2.5	< 1.5
Soil-P (mg/kg) [c]	> 25	18 - 25	10 - 17	< 10
Soil-K (mg/ kg) [c]	> 550	350 - 550	200 - 350	< 200
Soil-N (mg/kg)	> 200	100 - 200	50 - 100	< 50

[a] set for threshold values, Ali, R. R. and Kotb, M. M. 2010, [b] set for widely reported organic matter content in Egyptian soils. [c] set for critical level (high) Amer , F. 1994. High classes represent good soil quality for organic matter, N, P, and K on alluvial soils, while represent risky class for EC, SAR, and pH.

Historical Data:

In order to represent changes of soil characteristics or qualities in relation to the current management practices, data of the AbisERS obtained in 1977 (Darwish 1977) and in 1980 (Al-Attar 1980) were taken into consideration and extracted for the task of comparison. The extracted data from these studies were that represented only top-soil samples (0.0 – 0.3 m soil depth) of 36 soil profiles, which were collected during May-June 1975 by Drwish (1977), and of 33 soil profiles which collected during May-June in 1980 by Al-Attar (1980). The data extracted from both studies were statistically analyzed together and appears in this study as data 1977. Also yield data and management practices with respect to fertilizer application were collected from the available farm records (unpublished data). Descriptive statistical parameters (max, min, mean, standard deviation) and multiple correlation analysis were estimated using Microsoft Office Excel software 2007.

RESULTS AND DISCUSSION

Cropping system and fertilization:

As mentioned above most of research studies on the AbisERS have been limited to specific objectives and conducted on very small areas that not exceeded 0.25 to 0.5 ha each. Moreover, the research experiments are systematically conducted in fixed places dedicated to research activities and didn't randomly distribute within the whole experiment station. The total yearly area specified for research and teaching didn't exceed 18 ha, which reflect less than 10 % of the seasonally cultivated area. Therefore, the specific research management could not be taken into consideration in this study. About 90 % of the total area was uniformly cultivated with field crops. The cropping system was a rotation of wheat, clover, and bean in winter followed by rice, forage and maize in summer.

With respect to fertilizers management, the data gathered from records indicated that the fertilization program was based only on N fertilizers. Potassium (K) fertilizer was not applied at all for any crop. Surprisingly, neither phosphorus (P) nor organic matter (OM) was also applied to any crop, at least, between 1997 and 2007, except in the small areas of research experiments. The rates of N applied per hectare were 158 kg for winter wheat, 220 kg for rice, 158 for maize, and 55 kg for clover. The recommended rates of fertilization per hectare were 160 – 180 kg N, 40 kg P_2O_5, for winter wheat; 95 – 145 kg N, 40 kg P_2O_5 for rice; and 215 – 290 kg N, 55 kg P_2O_5, for maize (MALR, 2003).

Fertilizers need to be applied at the level required for optimal crop growth based on crop requirements and agro-climatic considerations. At same time negative externalities should be minimized (Gruhn, et. al., 2000). Over application of fertilizers is economically wasteful (Smaling and Brown, 1996), and can damage the environment. Under application, on the other hand, lower the yield in short term, and in long term jeopardize the sustainability through soil mining and erosion (Gruhn et. al., 2000). Indeed, the application of no K fertilizer is due to the fact that, most of the Egyptian alluvial (clay) soils are high in soluble and exchangeable K (FAO, 2005). Therefore, the fertilizers management practices in Egypt do not include K fertilizers for field crops grown on alluvial soils (Nile Delta soils). In such a case, K required for plant growth and yield depends on the supply of K from the indigenous soil sources.

The no application of P and organic matter deteriorate soil quality/productivity and creates nutrient imbalance. Such balance of nutrient application is necessary for sustainability. Gruhn et. al. (2000) showed that wheat yields become uneconomical after 5 years when only N fertilizer is applied. The actual rates of fertilizer N applied to crops by the agronomists on AbisERS seemed to be within the recommended rates (MALR, 2003) only for wheat, whereas for maize it was lower than recommended and for rice crop it was higher than the maximum amount recommended. Matching fertilizers application with crop requirements involves using all available information to establish the soil nutrient status and crop requirements prior to making fertilizer application decisions.

Soil quality/productivity indicators:

Salinity/Sodicity:

The accumulation of excessive amounts of salts in soils is a characteristic of arid and semi-arid regions (Bernstein. 1962). This is due to high evaporation than precipitation rates in those regions. In Egypt, nearly 1 million ha in the irrigated area suffer from salinization problems, water logging and sodicity (FAO, 2005). Results indicated a high variability of soil salinity within the AbisERS in 2007 (Tab. 2), which varies between 1.2 and 22.7 dS/m with a mean value of 4.6 ± 5.4 dS/m. The high standard deviation obtained (higher than the mean value) reflects high variability of the EC within the studied area. The maximum EC recorded in 1977 and 1980 was only 4.2 dS/m with mean value of 2.3 ± 0.9 dS/m. The SAR also showed a wide range between 2.0 and 28.3 with a mean value of 6.0 ± 5.2. On the contrary, SAR showed lower values and less variability in 1977 than 2007 (Tab. 2). Regardless the survey method and the number of observations, these results reflect an increase of soil salinity and sodicity risks over the 30 year. However, The AbisERS received irrigation water from Al-Mahmoudia canal (branch of the River Nile) which has a good quality for irrigation water with EC = 0.5 dS/m. In agreement with Darwish (1977) and Al-Attar (1980), the main cause of soil salinity/sodicity risks is the poorly developed surface drainage system. Huge amount of agricultural drainage water usually release to drains in summer due to rice cultivation in Abis. This is combined with poor slope and small leveling differences between the drain tiles of the AbisERS and the main drain of Abis region (results not shown) resulted in flow back of water to AbisERS which keep high and fluctuated water-table level (Tab. 2). In addition, the spared and increase of salinity/sodicity during this period (1977 – 2007) can be attributed to low efficient management that control soil salinity/sodicity risks.

The soil quality map for EC/SAR (Fig. 2) showed that only 19% of the area was non-saline/ non-sodic, while 55% was moderate-saline/non-sodic, 10 % saline/risky-sodic, and 16% was saline/sever-sodic soils. The most affected plots were 4, 2, 12, and 13 in Al-Qalaa farm and plot 2 and 3 in Al-Ershadia farm. In comparison, Darwish (1977) approximately calculated the salinized area and reported that 52.7 % was non-saline with high productivity, 33.8 % moderate saline, and 13.5 % was high saline and having low productivity. Based on the comparison, shifting from non-to moderate-saline and from moderate- to high-saline soils is expected to be occurred. The measured soil pH value (not shown) was ranged from 7.8 to 8.1, except in the saline/sodic areas where the pH was 8.6 ± 0.1. Saline-sodic soils are high in sodium and other salts. They typically have EC greater than 4 dS/m, SAR greater than 13, and/or exchangeable sodium percentage (ESP) greater than 15, and soil pH can be above or below 8.5 (Ayers and Westcot, 1985). They can have the characteristics of either a saline or sodic soil, depending on whether sodium or calcium dominates (Ayers and Westcot, 1985; So and Aylmore, 1993; Summer, 1993). Both soil salinity and sodicity are known to limit plant growth and productivity (Pessarakli, 1994).

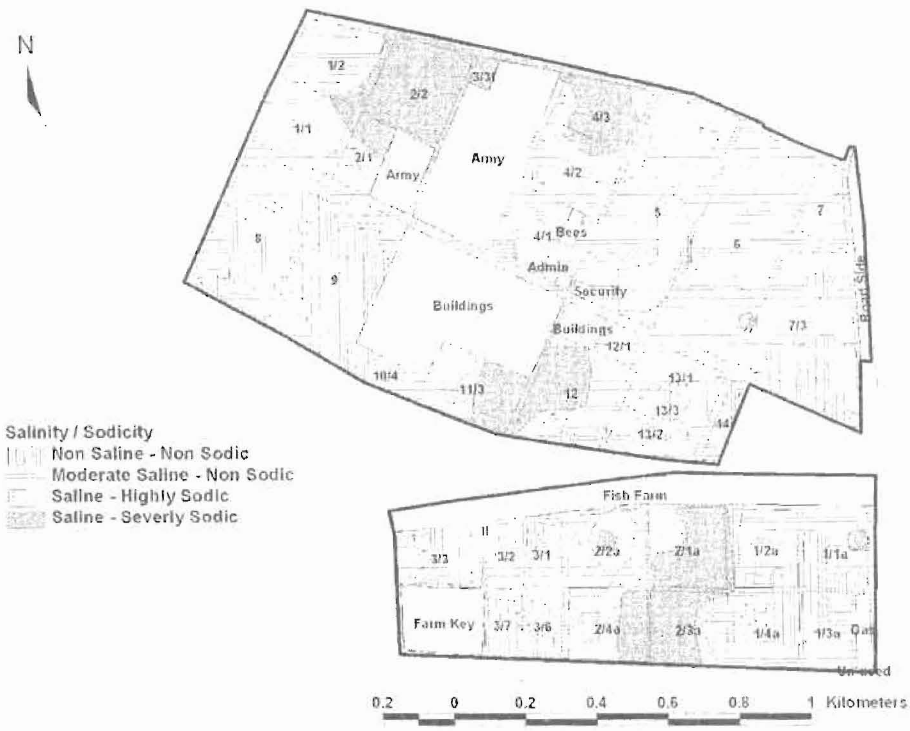

Fig. 2: Soil quality indicator map of Electrical conductivity (EC) and SAR within AbisERS

Table. 2: Statistical parameters for selected soil quality/productivity indicators of AbisERS in 1977 and 2007. Data presented for 1977 was extracted from Darwish (1977) and El-Attar (1980).

Indicator/	EC dS/m		SAR		OM %		Av. P ppm		Water table cm	
year	1977	2007	1977	2007	1977	2007	1977	2007	1977	2007
Min	1.4	1.2	2.0	2.0	2.5	0.2	20.1	2.7	30	30
Max	4.2	22.7	7.5	28.3	2.8	2.7	74.8	44.0	80	80
mean	2.3	4.6	4.6	6.0	2.6	1.9	33.7	12.9		
SD	0.9	5.4	1.8	5.2	0.2	0.6	15.1	7.5		

n = 69 for data of 1977, n= 153 for data of 2007. Soil samples were collected during May-June in both presented dates.

Organic matter and available nutrients indicators:

The OM content of soils is controlled by the balance between inputs of OM (manure, crop residues, etc.) and rates of decomposition in soils. It has been widely recognized as a key indicator of soil quality, particularly for agricultural soils (Nortcliff, 2002). Only small and scattered spots (represent 3%) in the cultivated area of AbisERS could be classified as good or high in its content (with respect to Egyptian soils), where OM % was between 2.5 and 2.7%. The majority of the area (75 %) was in moderate class (1.5 – 2.5%), while 22 % was low to very low (≤ 1.5 %). As presented in table 2 the AbisERS soil was nearly homogenized in its OM content in 1977 with mean value of 2.6 % ± 0.2 compared to lower content and high variability in 2007. The addition of organic materials to the soil must equal the loss due to decomposition to maintain the sustainability of the system. It helps sustain soil quality/productivity by improving retention of mineral nutrients, increasing the water holding capacity of soil and increasing soil biological activity (Woomer et al., 1994). The improvement of soil structure stability by organic matter is not only reported for non-saline/non-sodic soils (Dexter, 1988; Tisdall and Oades, 1982), but also for saline/sodic soils (Emerson et. al. 1986; Ringasamy and Olsson, 1991; Barzegar et al., 1997). Application of organic matter significantly reduce soil bulk density hence increase soil porosity and the infiltration rate (Barzegar et. al., 2002). This resulted in greater root distribution and penetration and hence greater nutrient and water uptake by wheat crop (Dexter, 1988 and Barzegar et al., 2002). Abis soil is considered calcareous with CaCO3 content of 7 -12 in surface soil layer and presence of shells in the subsurface. Application of organic matter to saline/sodic calcareous soil can slowly release Ca from the $CaCO_3$ and hence reducing the sodicity risk (Gehad 2003). The depletion of organic matter in AbisERS is expected to reduce soil productivity and add more negative effect on plant stress due to salinity/sodicity.

The available P was as similar as organic matter, but with higher magnitude of reduction and variability within the AbisERS. Available P was ranged between 20.1 to 74.8 ppm in 1977 with mean value of 33.7 ppm ± 15.1, which was reduced to 2.7 to 44.0 ppm with mean value of 12.9 ppm ± 7.5 in 2007 (Tab. 2). The low level of chemical fertilizer use, decline in soil organic matter, and the insufficient attention to crop nutrient studies contribute the most to the loss of soil quality/productivity (Kumwenda et al., 1996). In 2007, the soil quality map for available P and K (Fig. 4) showed that 64% of the area was in class low of P, or in other words, lower than the critical level of field crops, and the reminder area (36%) was in class high or optimum. Plotting available P in different plots and subplots cultivated with wheat in the same year of soil sampling versus wheat yield (Fig. 5) indicated that available P level in soil was among the most critical factors affecting wheat yield.

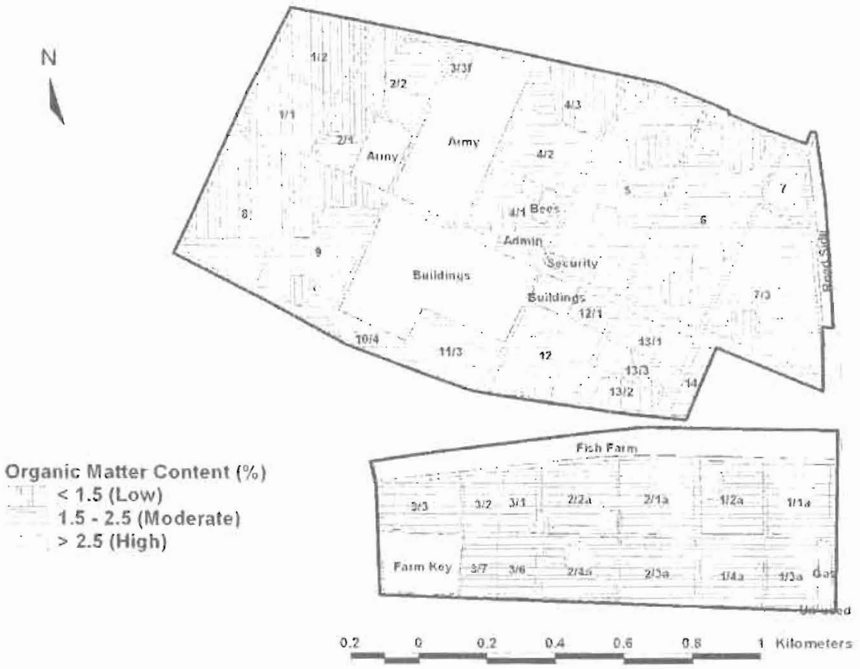

Fig. 3: Soil quality indicator map of organic matter within AbisERS.

Critical value of soil-P that limit plant growth is generally considered the Olsen-P value below which crop yield responses to P application should be expected and above which crop yield response to additional P fertilizer applications are small (Mallarino and Blackmer 1992). Unfortunately, critical soil-P value for wheat cannot be predicted from figure 5 because of other factors like salinity/sodicity, organic matter, and other management practices were not optimal and therefore the wheat yield was highly affected by complex matrix of stresses and was lower than average national yield.

Although, there was no application of K fertilizer over the 30 years (1977 – 2007), the most of the AbisERS area (80%) was moderate to high (Fig. 4). Such results reflect the high buffer power of clay soils of the old agriculture land in Egypt (Nile delta soil) that replenish soil solution K from its indigenous resources (Balba, 1979), and this is proportional to CEC. But, it seems that the concept of no K application in traditional Egyptian agriculture is no longer sufficient and needs to be re-examined. As indicated in Figure 4, there was nearly 27% of the area low in available K or in other words lower than the critical level of soil K to field crops grown on clay soils. The application of K fertilizer in such areas may increase the yield. SQI map for available N (results not shown) showed that 80 % of the area was in class high ($\geq$ 100 ppm N).

The results of soil quality indicators and their distributions in AbisERS reflected heterogeneous in term quality/productivity with increase in soil salinity/sodicity risks and depletion of organic matter, P, and for some extent K. It is concluded that, if the current soil management practices are continued, soil deterioration and nutrient depletion will increase and jeopardize the sustainability of the soil resource (Tittonel et. al. 2008; Zhen et al. 2006).

To link soil properties and yield of wheat in the year 2007, six independed variables were selected for multiple regression analysis. The resulted regression model was:

Yield = 1.52 + (0.20 P + 0.003 K + 0.01 N+ 0.66 OM – 0.18 EC – 0.02 SAR),

with multiple regression R = 0.76, and coefficient determination R^2 = 0.58. The analysis showed that OM, P, and salinity(EC) were identified as significant determination for wheat yield. Unfortunately, water table level was not monitored in all plots cultivated with wheat in 2007; therefore, it was not tested in the multiple regression analysis. Positive effects of organic matter on plant growth and productivity is mainly due to its role in improving soil quality in both short and long term. The yield increase due to P depends on the amount of phosphate fertilizers added and the P soil test level (Robertson et al., 2008; Tang et al., 2009). As indicated above, there was no P fertilizer added, therefore, the positive effect motioned in this study is due to soil-P. The negative effect of EC on crop yield is widely reported in arid regions.

In order to better manage soil quality and productivity on AbisERS, the soil quality indicator maps of OM, P, and K were transformed to a soil management map using the GIS system (Fig. 6). The map and soil test data of each plot were used in 2008 and 2009 as a tool to guide and help in developing soil management and fertilizer recommendation based on site specific management practices (Chang et al. 2004; Pagani et al., 2013). Figure 6 showed that 27 % of the area is needed OM, P, and K, while 73% is needed P, and OM. In addition, application of gypsum ($CaSO_4$. $2H_2O$) is supposed to be fordable for nearly 30 % of the area (see Fig. 2), and enhancing the drains efficiency.

Wheat and Rice yields:

Crop growth and yield are determined by a number of factors such as genetic potential of crop cultivar, soil quality, agriculture practices, and biotic and abiotic stresses (Tollenaar and Lee 2002). In this context, the cumulative effect of yearly negative nutrient balance on crop yields is often seen through the impact of soil erosion on productivity (Gruhn et. al. 2000). Figure 7 represents the yield of wheat and rice on AbisERS in different years of production. The yield obtained in 1977 (Darwish, 1977) and in 2011 (this study) cannot be compared with other yields. The varieties used in recent years (2004 to 2011) are high yielding varieties compared to that used in 1977, especially for rice crop. On the other hand, in 2011. and during the Egyptian revelation (from 25 January 2011 up to the end of 2012) everything was run out of control. This is reflected in high reduction of wheat and rice yield.

The dotted line in fig 7 represent the average national yield cross years(2000– 2012)and cultivars, which is 6.6 Mg/ha for wheat (Mahmoud, 2014), and 9.65 Mg/ha for rice crop (Abel Fatah and Mansour, 2015). Taking the average national yield as a reference yield, there were a gap of 3.45 Mg/ha for wheat and 5.42 Mg/ha for rice between the yield in 2007 and the attainable yield. The uptake of applied nutrients is often affected by resource imbalance (Kho 2000), as for example in this study, lack of P may limited plant growth and prevent uptake of applied N.

The observed gab between the current and attainable yield can be explained by current management practices that deteriorated soil quality/productivity and created high variability between plots within the AbisERS. The variability in soil productivity between plots within the farm can be better seen in figure 8. The yield obtained in 2007 from plot Q6 (Alqalaa farm) reached 4.32 t/ha compared to only 1.15 Mg/ha from plot Q4. In general, the application of P, OM, gypsum, and enhancing the efficiency of drains resulted in increase of wheat and rice yields in 2008 and 2009 and reduced the gab to nearly 2.0 for wheat and to 1.9 Mg/ha for rice crop (Fig. 7). This, also, reduced the variability between plots (Fig. 8). The enhancement of wheat and rice yields based on soil test and soil information (geo-info base) indicated a large potential for improving actual crop productivity on AbicERS. Special efforts are needed to overcome the serious problems of deteriorating soil quality and mining soil in AbisERS. In this context, suitable soil test made before planting and application of targeted, sufficient, and balanced quantities of inorganic and organic fertilizers will be necessary for high yields and improving soil quality/productivity. The faculty of agriculture, University of Alexandria should take the necessary steps to facilitate problem solving studies to optimize resources management practices, good communications between staff at the faculty and the agronomists at AbisERS, and to provide different oriented training for the agronomists.

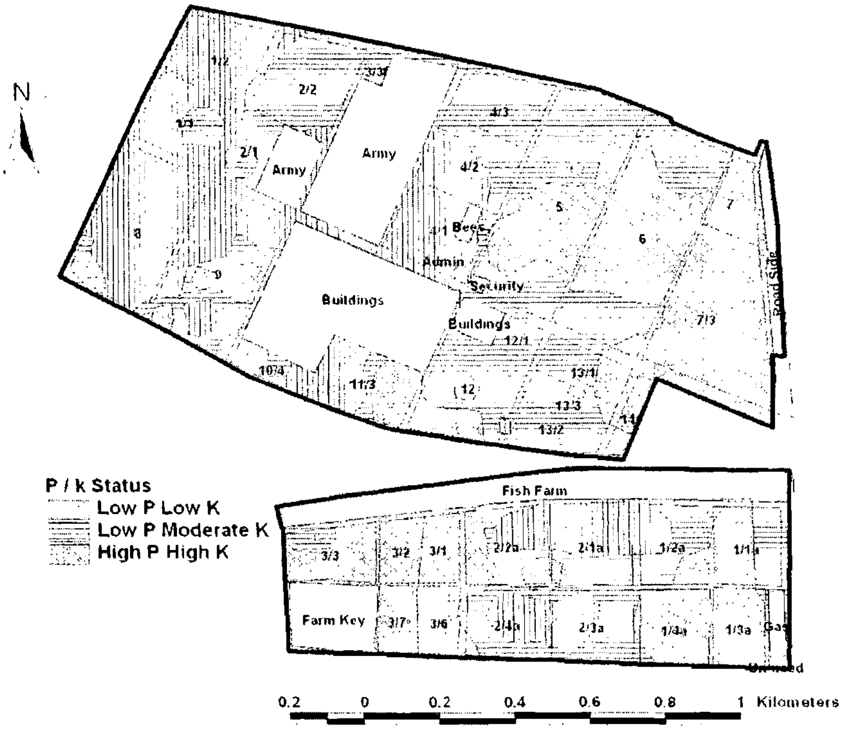

Fig. 4: Soil quality indicator map of phosphorus (P) and potassium (K) within AbisERS.

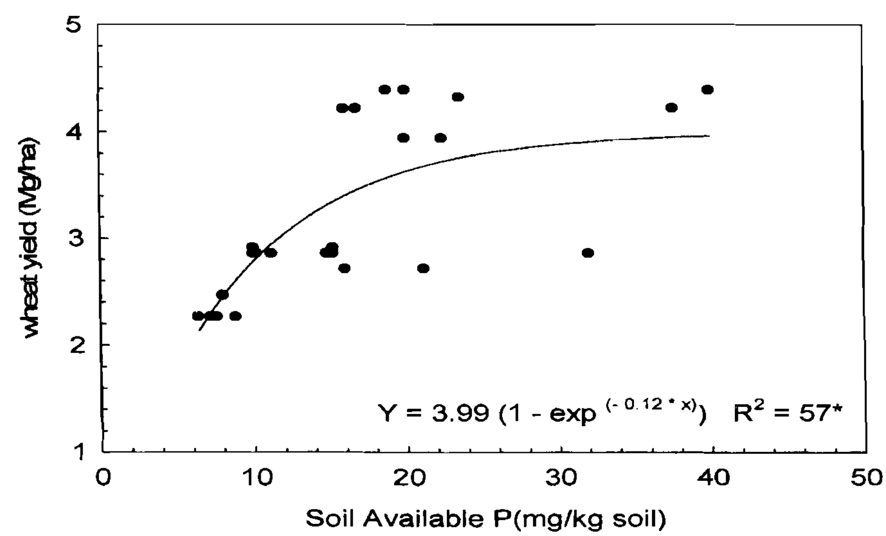

Fig. 5: Relationship between soil available-P (Olsen P) and wheat yield in plots and sub-plots cultivated with wheat in 2007.

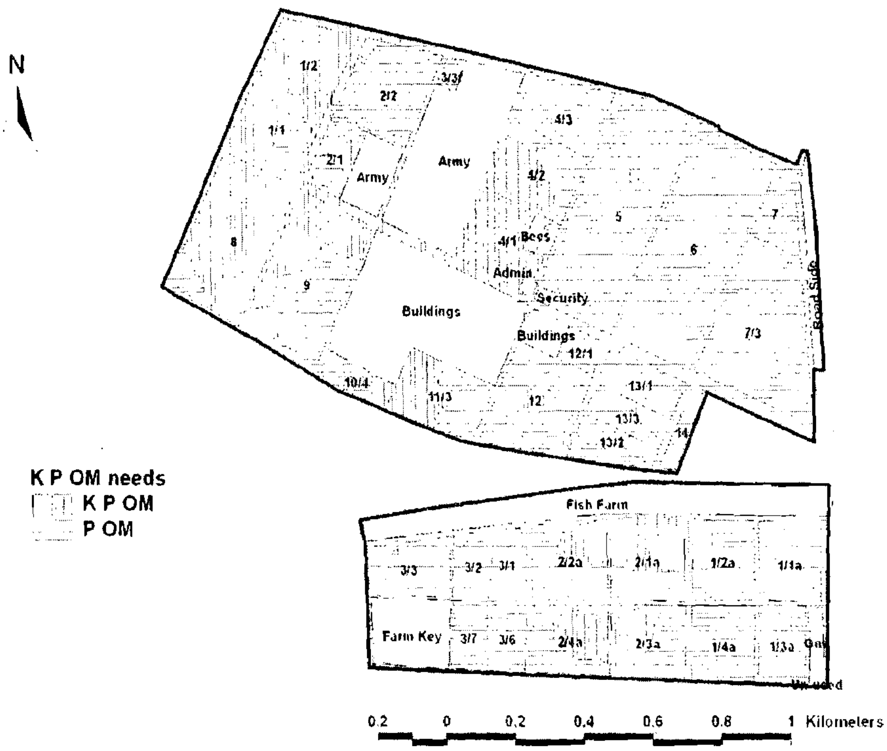

Fig. 6: Soil management map according to their need of OM, P, and K in AbisERS.

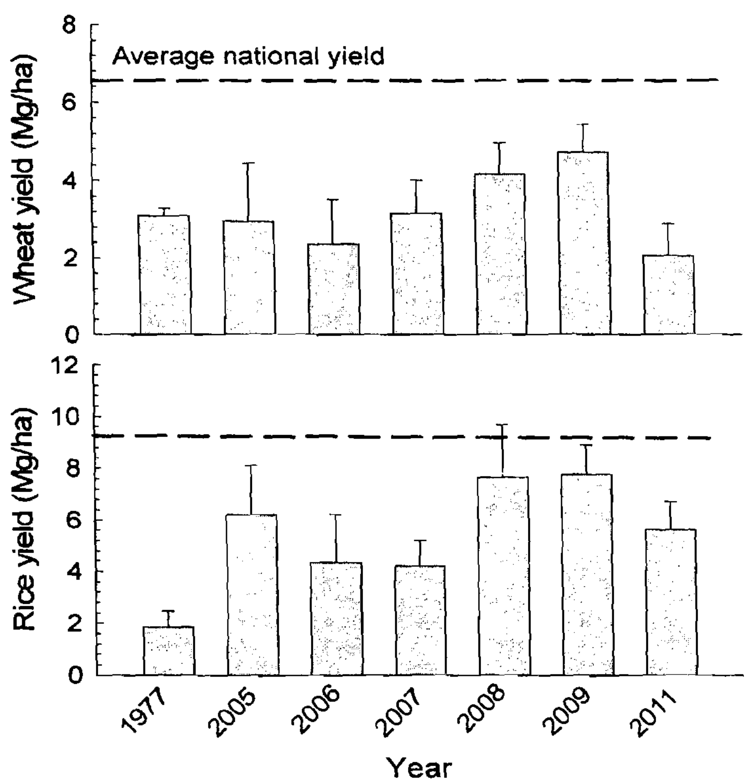

Fig. 7: Wheat and rice crop yields (Mg/ha) with years in AbisERS. Long dashed line represents average national yield.

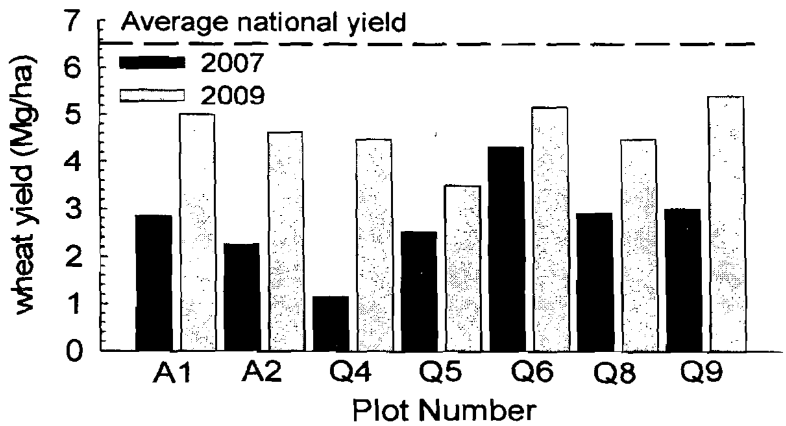

Fig. 8: Wheat yield variability in AbisERS in years 2007 and 2009. Letters: A presents Al-Ershadia farm, Q presents Alqalaa farm. Numbers present plot numbers in each farm.

CONCLUSION

- High and Fluctuated water table level and absence of soil management practices that control soil salinity/sodicity spread soil salinization and sodicity risk in AbisERS.
- The soil is heterogeneous in term quality/productivity with depletion of organic matter, P, and for some extent K.
- The observed gaps between current and attainable crop yields can be explained by the current soil management practices that deteriorating soil quality and jeopardize the sustainability of resources.
- There is a large potential for improving actual crop productivity on AbisERS trough fertilizer application based on soil info-base and crop requirement, enhancing the efficiency of the drainage system, and applying organic matter and gypsum to control salinity/sodicity risk.

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الملخص العربى

تأثير الممارسات الزراعية على إنتاجية وإستدامة الأرض بمحطة البحوث الزراعية بأبيس، مصر

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تمتلك كلية الزراعة – جامعة الإسكندرية محطة بحوث تجريبية فى منطقة ابيس(AbisERS) تبلغ مساحتها ٢٠٩,٦ هكتار. وعلى الرغم من اجراء عدد هائل من الدراسات البحثية بالمحطة عبر سنوات طوال، إلا انه لايوجد قاعدة بيانات متكاملة لتسجيل الممارسات الزراعية لادارة الأرض والمحصول وإنتاجية التربة. وتهدف الدراسة الحالية لتطوير قاعدة معلومات جغرافية تقيم جودة/انتاجية التربة إعتمادا على الممارسات الحالية(وقت الدراسة) للموارد الأرضية. وقد تم فى هذه الدراسة تجميع ١٥٣ عينة تربة سطحية تغطى محطة البحوث محددة جغرافيا وتم تحليلها للحصول على المؤشرات الدالة على جودة/انتاجية التربة. وقد تم استخدام نظام المعلومات الجغرافية(GIS) لإنتاج خرائط جودة التربة. كذلك تم أجراء تحليل معامل الإرتداد المتعدد لإحصائى لتحديد العوامل المؤثرة على إنتاجية التربة. كما تم استخلاص بعض البيانات بغرض المقارنة من دراسة سابقة(Darwish 1977) وتقرير سابق (Al-Attar 1980) وكذلك على بعض البيانات من سجلات محطة البحوث.

اوضحت النتائج اختلافات كبيرة داخل مساحة محطة البحوث فى كل المؤشرات المقاسة. فقد اضحت خريطة توزيع الملوحة والصودية ان ١٩% فقط من المساحة تربة غير ملحية غير صودية، بينما هناك ٥٥% من المساحة فى مدى اراضى متوسطة الملوحة غير صودية و٢٦ % من المساحة ارض ملحية صودية. وكمتوسط عام وجد ان ملوحة التربة قد اذدادت من ٢,٣ ± ٠,٩ فى عام ١٩٧٧ الى ٤,٦ ± ٥,٤ فى عام ٢٠٠٧ مما يعكس تأثير ممارسات زراعية لا تعمل على التحكم فى ملوحة التربة خلال هذة الفترة. كذلك وجد زيادة فى نسبة الصوديوم المدمص SAR من ٤,٦ ± ١,٨ فى عام ١٩٧٧ الى ٦,٠ ± ٥,٢ فى عام ٢٠٠٧. ويرجع السبب الرئيسى فى ارتفاع الملوحة والقلوية الى سوء نظام الصرف الذى يؤدى الى ارتفاع وتذبذب مستوى الماء الأرضى. كذلك اوضحت الدراسة استخدام غير متوازن للعناصر الغذائية. فمثلا ادى الإستخدام الغير منتظم لعنصر الفوسفور الى استنزاف العنصر فى حوالى ٦٣,٦ % من المساحة. ووجدت علاقة معنوية بين مستوى الفوسفور فى الأرض وانتاجية محصول القمح. كذلك وجد انخفاض واضح فى محتوى الأرض من المادة العضوية، حيث كان المتوسط فى عام ١٩٧٧ هو ٢,٦ % ± ٠,٢ بينما انخفض الى ١,٩ % ± ٠,٦ فى ٢٠٠٧.

وكما اشارت النتائج الى انخفاض جودة التربة اشارت ايضا الى انخفاض الإنتاجية، حيث لم تزد انتاجية محصول القمح والأرز عن ٤,٣ و٤,٥ طن/ هكتار على التوالى. وهذه الإنتاجية كانت فى المتوسط اقل بكثير من المتوسط العام للدولة لكلا المحصولين حيث بلغت الفجوة بين المتوسط العام وانتاجية المحطة ارقام تذيد عن ٣,٠ و٤,٥ طن/هكتار فى كلا المحصولين. وقد اضحت نتائج معامل الإرتداد المتعدد الى ان ملوحة التربة والمادة العضوية ومستوى الفوسفور المتاح فى التربة تعتبر من اكثر العوامل المؤثرة على الإنتاجية. وقد خلصت الدراسة الى أنه فى حال استمرار الممارسات الزراعية الحالية سوف يؤدى الى مزيد من تدهور جودة وانتاجية التربة ومزيد من استنزاف العناصر مما يهدد استدامة الموارد الأرضية بمحطة البحوث.