Menoufia J. Soil Sci., Vol. 3 June (2018) : 161 -176

SPATIAL VARIABILITY OF SOIL PROPERTIES AND EFFECTS ON RICE YIELD GROWN ON EL-GEMMIEZA CLAYEY SOIL (MIDDLE OF NILE DELTA OF EGYPT)

M. M. Harvey, B. A. El-Gamal and M. H. Abdel-Aal
Soil, Water and Environment Research Institute, Agric., Res. Center, Giza, Egypt.
Corresponding author: drmoheyharvey@gmail.com

Received: Apr. 14 , 2018 Accepted: Apr. 29 , 2018

ABSTRACT: ***Understanding the relationships between rice yield and soil properties is very critical importance in precision farming. The objective of this work was to evaluate the relationships between special variability of soil properties and rice yield (Oryza sativa). The area under study is 41.67 ha in EL-Gemmieza Agriculture Research Station, of the Agric. Rese. Center (ARC), El Gharbiah Governorate, Egypt (Middle of Nile Delta). The studied location divided into two sites varied in their productivity of rice.***

Soil pH was found slightly alkaline at site (1) and alkaline at site (2). The EC and CEC in site (1) were higher than at site (2). On contrary values of ESP were higher at site (2) than at site 1. Higher exchangeable cations were observed under site (1) than site (2) except of exchangeable -Na^+ showed a contrary behavior. Data also showed that values of soil bulk density were lower under site 1 than site (2) whereas; total porosity, hydraulic conductivity and infiltration rate were higher in site (1) than site (2). Higher values of grain yield, straw yield, harvest index and NPK content and uptake in grain and straw were found in site (1) than in site (2).

The values of variation coefficients (CV) of the most studied traits showed low variability (< 20). At site 1 there is a significant correlation at 5% level with positive trends between grain yield and the traits of CEC, soluble K, exchangeable Ca^{++}, Mg^{++}, available N and K, total porosity and hydraulic conductivity. While, negative significant correlations at 5% level with negative trends were noticed between exchangeable Na^+ and bulk density.

On the other hand, result of satirical analysis of site 2 indicated a positive and significant correlations between grain yield of rice plant and all the traits of harvest index, N and K uptake in straw, CEC, O.M, exchangeable - Ca^{++}& K^+, available - N & available -P, total porosity and hydraulic conductivity.

As the results of the stepwise regression analysis of site (1), it can arrange the soil physical characteristics, as their effective on rice yield, in the following order of: infiltration rate > soil total porosity > saturated hydraulic conductivity (Ksat). While the order of soil chemical characteristics were: ESP > pH > EC > O.M. As for soil available nutrients, their continuation factors were 90.7, and 7.0 % for soil available–K & available–N, respectively. For site (2) it can arrange the soil physical characteristics, as their effective on rice yield, in the following order of: bulk density > saturated hydraulic conductivity. While the order of soil chemical characteristics was: ESP > pH > CEC > O.M. As for soil available nutrients, their continuation factors were 91.1 and 5.6 % for soil available–K, and P, respectively.

Key words: ***Rice, Clayey soil, Spatial variability, Soil physical properties, Soil chemical properties.***

INTRODUCTION

Understanding field spatial variation and the relationships with crop response may substantially increase the input effectiveness and average crop yield (Virgilio *et al.,* 2007). Soil is a continuous

spatial-temporal heterogeneity. The study and application of soil spatial variation regulation is the basic gist for rational land resource utilization and crop layout. Special variability is an effective way to allocate crops with local conditions. Thus, this variability occurs since the soil formation and continues even after the achievement of a dynamic equilibrium. However, the management practices on the soils also affect significantly the soil variability (Castrignanò *et al.,* 2000), especially as a result of the successive agricultural activities and erosion. As the soils from the agriculture activities are heterogeneous, the analyses of the soil properties of the study area are necessary for an adequate determination of the management of the agriculture zones. The chemical properties typically relate more directly to the sustainability of the agro ecosystem, in addition to variability in crop yield (Li *et al.,* 2012).

Rice (*Oryza sativa L.*) is the world's most important food crop and energy source for about half of the world's population and ranks second in production after wheat (Manjappa and Shailaja, 2014). In Egypt rice is considered the most popular and important field crop for several reasons: as a staple food after wheat for Egyptian population, as a exporting crop, as a land reclamation crop for improving the productivity of the saline soils widely spread in North delta and coastal area, and finally it is a social crop in which all farmers family member could gain money during its growing season.

Soil is critical to crop growth because it provides a growth environment and indispensable nutrients, and any degradation of soil quality may result in decreased productivity, quality, and thus profitability of the crop (Juhos *et al.;* 2016). Soil properties can be determined primarily from physical, chemical, and biological aspects (DFPJA 2011). The chemical properties typically relate more directly to the sustainability of the agro ecosystem, in addition to variability in crop yield (Li *et al*.; 2012). These properties can also be more easily improved than others, through proper fertilization and other farm management practices Gray and Morant (2003). Thus, soil fertility may also refer to its chemical properties, with different aspects taken into consideration. The availability of nutrients in soil depends upon soil pH, organic matter, adsorptive surfaces and other physical, chemical and biological conditions in the rhizosphere (Jiang *et al*. 2009). The deficiency of nutrients are the major constraints to productivity, stability and sustainability of soils (Chaudhari *et al*. 2012). Bhat *et al*. (2017) found negative correlation between pH of surface soils and both nitrogen and phosphorus and positive correlation with calcium and the soil surface organic carbon showed positive correlation with available nitrogen and phosphorus. Rahman *et al.* (2008) found that the highest positive correlations were obtained for bulk density, saturated hydraulic conductivity, pH, exchangeable Na, organic matter, EC, N, exchangeable K, exchangeable Ca with rice yield. Li *et al.* (2017) found a negative correlation with rice yield and pH but a positive correlation with CEC, exchangeable K and Mg. Ezrin *et al.* (2010) showed that from stepwise analysis the apparent electrical conductivity (ECa) which explains almost 50% of the yield variability. The analyses results show that both low and high ECa values are associated with a decrease in yield productivity. Olabode (2015) reported that soil pH has negative correlation with sodium, base saturation and magnesium. Also soil organic matter has positive relationship with base saturation but negatively correlated with available phosphorus and sodium at the top soil. Chung *et al*. (2005) showed that by

calculating path coefficients calcium has the highest direct effect and magnesium has the highest indirect effect on the yield of rice. Sarker *et al.* (2012) found positive relationship between grain yield of rice and root mass density while, grain yield and bulk density were negatively correlated. Mamun *et al.* (2015) reported that soil parameters and rice yield varied considerably throughout the study areas and their coefficients of variation ranged from 8.77 to 71.04%. Slight variability was observed for soil organic matter (SOM) and available K. Talpur *et al*. (2013) found that the availability of nitrogen (N) decreases and availability of phosphorus (P) increased at 31-45cm depth. It was also observed that soil fertility has an indirect relation with depth in case of nitrogen and phosphorus. Cerri *et al.* (2012) reported that Correlations of chemical and physical attributes of soil with sugarcane yield are weak, and, per se, they are not able to explain sugarcane yield variation, which suggests that other variables, besides soil attributes, should be analyzed. Li *et al.* (2017) found a negative correlation with rice yield and pH and CEC and a positive correlation were observed between available P, K and Mg from 92 peat soil paddy fields on a large-scale farm located in the Kanto Region of Japan. Therefore, the current work aimed to study spatial variability of soil properties and analyze the relationships between rice yield and selected soil properties.

MATERIALS AND METHODS

Study Area

The current investigation was conducted at a test area of 41.67 ha at the EL-Gemmieza Agriculture Research Station, Agric. Res. Center (ARC). El Gharbiah Governorate, Egypt, Middle of Nile Delta (30° 43' latitude and 31° 47' longitude) during summer the growing season of 2017. This research work is designed to compare between the spatial variability of soil properties of the two sites under study and to define the role of this spatial variability on rice grain yield; through determined the statically correlations between rice productivity and a lot of physical and chemical attributes of soil. Soil characteristics of the two sites were analyzed according to Klute (1986) and the pore size distribution are shown in Table (1). The climate data of the experimental zone is characterized by a cool winter with low rain fall and hot summer. Recorded weather data, as well as reference evapotranspiration in the experimental site for rice growing season are presented in Table (2).

Crop management

Rice *(Oryza sativa* L., *Sakha 104)* seedlings of 25 old days were transplanted on the 16th of May 2017. The irrigation of two sites was applied after transplanting up to 2 weeks before harvest. Phosphorus fertilizer was carried out with soil preparation at rate of (100 kg P fed^{-1} as ordinary calcium super phosphate (15.50% P_2O_5). Nitrogen was applied at rate of 200 kg N fed^{-1} as urea (46% N) in 3 equal splits (1/3 basal, 1/3 at active tillering stage and 1/3 at panicle initiation stage) and potassium was added at rate of 50 kg K fed^{-1} as potassium sulphate (48% K_2O). Rice plants were harvested after 110 days from transplanting. Grain and straw yields (Ton fed^{-1}) of rice were measured at harvesting from a central area (20 m^2) samples were taken with 4 replicates of each site.

Sample preparation and analysis

Air – dried samples of rice grain and straw samples were taken at two sites and dried at 70^{o}C, weighted and grounded with a mill. A 0.5 g of oven – dried samples was digested according to (Jackson 1967) and analyzed for convert N, P and K according to Cottenie *et al.;*

91982). Total N content was determined using the micro Kjeldahl. Total phosphorus was determined by ascorbic acid using spectrophotometer and total potassium was measured using the flame photometer. Four soil profiles of each studied site were dug and soil samples were taken of soil depth of 0-30 cm. The samples were air-dried and ground to pass through a 2 mm sieve. Electrical conductivity (EC) was determined in a saturated paste of soil. The soluble cations (Na^+ Mg^{2+}, Ca^{2+} and K^+) and anions (HCO_3^- and Cl^-) were determined in soil paste extract as described by (Rhoades, 1954). Soil pH was determined in 1:2.5 (soil: water) suspension using Beckman pH meter as out lined by Soil Laboratory Staff (1984). Cation exchange capacity CEC was determined using sodium acetate solution 1.0 N with pH 8.2 and ammonium acetate 1.0 N with pH 7 (Cottenie *et al.,* 1982). Exchangeable cations were displaced using ammonium acetate solution 1.0 N with pH 7. Available nitrogen of soil was extracted by using 1 M KCL and determined according to (Cottenie *et al*., 1982). Available phosphorous in soil was extracted in soil with 0.5 N $NaHCO_3$ and determined using spectrophotometer at wavelength 880 as described by (Cottenie *et al*., 1982). Available potassium of soil was extracted with 1 N ammonium acetate and determined using flame photometer as described by (Cottenie *et al*., 1982). Organic carbon was measured by the procedure of Walkley and Black rapid titration method, as outlined by (Kim 1996). Bulk density was determined using soil core method. Total porosity was computed from according the following equation: TP= (1 - B_d/P_d) x 100; *Where: (TP): total porosity, (B_d): bulk density and (P_d) : particle density (2.65 g/cm^3).*

Saturated hydraulic conductivity (K_{sat}) was determined using constant head methods. Infiltration rate was determined by using double ring cylinder. Stability index of soil aggregates was determined using wet sieving according to the method described by (Cavazza 1981).

Table (1). Pore size distribution of the studied sites.

Soil depth (cm)	Site 1					Site 2				
	Particle size distribution				Texture grade	Particle size distribution				Texture grade
	Coarse sand	Fine sand	Silt	Clay		Coarse sand	Fine sand	Silt	Clay	
0-30	8.21	11.33	28.69	51.77	clay	6.73	11.30	31.06	50.91	clay

Table (2). Weather data of the experimental zone and reference evapotranspiration in (2005-2015 average*) growing season.

Month	T- max	T- min	T-mean	RH	Wind speed (ms^{-1})	S.R	ETo
May	34.3	17.2	25.8	34.8	4.2	27.3	8.9
June	38	20.1	29.1	36	4.3	29.3	9.8
July	38.6	21.5	30.1	41.5	4.2	28.7	9.3
August	38.6	22.1	30.3	43.2	3.9	26.7	8.8
September	35.6	20.9	28.3	46.8	4	22.9	7.6
October	30.9	17.8	24.3	48.8	3.8	18.7	6

(T- max) and (T- min): maximum and minimum temperatures (°C), (T-mean): mean of temperatures, (RH): relative humidity, (S.R): solar radiation ($MJm^{-2}day^{-1}$), and (ETo): reference evapotranspiration ($mmday^{-1}$) * Source: Water Requirement and Field irrigation Res., Dept.

RESULTS AND DISCUSSION

Status of spatial variability in soil properties, at the studied sites, before plowing and after harvested as well the affected the yield and yield quality of rice with these variables, will be discussed next.

General trends

Spatial variability of soil properties

The spatial variability of soil properties of the two studied sites before plowing and planting and after harvesting are shown in Tables (3), (4), (5) and (6). Data indicated that available macro nutrients were higher in site (1) than site (2). Soil pH was found slightly alkaline at site (1) and alkaline at site (2). Data also showed that EC and CEC in site (1) were higher than at site (2). On contrary values of ESP were higher at site (2) than at site (1). Higher exchangeable cation was observed under site (1) than site (2) except Na^+ showed opposite direction. Data also showed that values of soil bulk density were lower under site (1) than site (2). As a result of total porosity (TP) inversely proportional to the bulk density higher TP were observed under site (1). As soil bulk density decreases the total pore space increases and consequently influence saturated hydraulic conductivity (Ksat) in the studied sites. Li *et al*. (2017) found positive correlation between rice yield and available P and K. Mindari *et al.* (2015) found that rice yield negatively correlated to the exchangeable values of Na, SAR, bulk density and dust content and positively correlated with organic - C, fertilizer, exchangeable of Ca^{++}, Mg^{++}, and K^+, as well as soil's CEC.

Table (3). Soil physical properties of the studied sites before plowing.

Site 1					Site 2				
Bulk density (Mg m-3)	TP (%)	Total stable aggregates (%)	Ksat (cm h^{-1})	IR (cm h^{-1})	BD (Mg m^{-3})	TP (%)	Total stable aggregates (%)	Ksat (cm h^{-1})	IR (cm h^{-1})
1.17	55.72	75.60	1.09	10.55	1.32	50.06	63.78	1.09	8.50

BD=Bulk density, TP= Total porosity, Ksat= Hydraulic conductivity and IR= Infiltration rate

Table (4). Soil chemical properties of the studied sites before plowing.

Site 1									
Soluble cations (mmolc L^{-1})				Soluble anions (mmolc L^{-1})				EC (ds m^{-1})	Soil pH (1:2.5)
Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	SO_4^-	HCO_3^-	CO_3^{--}		
5.4	4	12.93	0.33	17.47	3.44	1.77	Nil	2.30	7.84
Exchangeable cations (cmolc kg^{-1})				ESP	Available macronutrients (mg kg^{-1})			CEC (cmolc kg^{-1})	OM (%)
Ca^{2+}	Mg^{2+}	Na^+	K^+		N	P	K		
18.77	17.7	6.12	1.88	13.58	41.27	7.54	340	45.05	1.84
Site 2									
Soluble cations (mmolc L^{-1})				Soluble anions (mmolc L^{-1})				EC (ds m^{-1})	Soil pH (1:2.5)
Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	SO_4^-	HCO_3^-	CO_3^{--}		
2.33	2.47	11.00	0.30	11.77	2.67	1.57	Nil	1.63	8.44
Exchangeable cations (cmolc kg^{-1})				ESP	Available macronutrients (mg kg^{-1})			CEC (cmolc kg^{-1})	OM (%)
Ca^{2+}	Mg^{2+}	Na^+	K^+		N	P	K		
17.63	15.34	10.23	1.21	22.89	33.7	4.94	301.67	44.69	1.51

Table (5). Soil physical properties of the studied sites after harvesting

Site 1					Site 2				
Bulk density (Mg m^{-3})	TP (%)	Total stable aggregates (%)	Ksat (cm h^{-1})	IR (cm h^{-1})	BD (Mg m^{-3})	TP (%)	Total stable aggregates (%)	Ksat (cm h^{-1})	IR (cm h^{-1})
1.02	61.51	73.36	3.09	12.74	1.33	49.81	61.68	2.11	9.23

BD=Bulk density, TP= Total porosity, Ksat= Hydraulic conductivity and IR= Infiltration rate

Table (6). Soil chemical properties of the studied sites after harvesting.

Site 1									
Soluble cations (mmolc L^{-1})				Soluble anions (mmolc L^{-1})				EC (ds m^{-1})	Soil pH (1:2.5)
Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	SO_4^{-}	HCO_3^{-}	CO_3^{--}		
3.05	2.55	10.95	0.22	12.87	2.64	1.27	Nil	1.68	7.81
Exchangeable cations (cmolc kg^{-1})				ESP	Available macronutrients (mg kg^{-1})			CEC (cmolc kg^{-1})	OM (%)
Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}		N	P	K		
19.83	18.44	5.88	2.25	12.٥٨	44.15	8.63	362.28	46.74	2.09
Site 2									
Soluble cations (mmolc L^{-1})				Soluble anions (mmolc L^{-1})				EC (ds m^{-1})	Soil pH (1:2.5)
Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	SO_4^{-}	HCO_3^{-}	CO_3^{--}		
2.11	1.98	11.08	0.18	11.56	2.49	1.49	Nil	1.54	7.99
Exchangeable cations (cmolc kg^{-1})				ESP	Available macronutrients (mg kg^{-1})			CEC (cmolc kg^{-1})	OM (%)
Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}		N	P	K		
19.29	16.70	9.80	1.52	20.45	26.81	5.62	284.57	47.92	1.46

Infiltration rate at the two studied sites after harvesting are shown in Table (7) and illustrated in Fig. (1). The steady-state infiltration rate was 43.7 cm hr^{-1} and was achieved in about 3.9hour period whereas, site (2) the steady-state infiltration rate was 33.0 cm hr^{-1} and was achieved in about 2.35 hours' period. The high initial infiltration rate may be due to the decrease in bulk density and increase in sand percentage as mentioned by Goldhammer and Peterson (1984). Also Elkhidir (1985) mentioned that the high infiltration rate was mainly due to heavy cracking of soil. It can be concluded that the accumulation of calcium and magnesium salts would generally improve soil physical properties and this increases infiltration rate as mentioned by Ayers and Westcot (1994). Elsheikh (2002) obtained 172 mm/h in the first five minutes in the experiment conducted at Kenana Project.

Table (7). Infiltration rate parameters at two studied sites after harvesting.

	Icumulative (cm/ hr)	Iinstaneuos (cm/ hr)	Iaverage (cm/ hr)	Ibasic (hr)	R^2
Site 1	$2.1744T^{0.609}$	$79.45T^{-0.391}$	$130.46T^{-0.391}$	3.9	0.995
Site 2	$1.5923T^{0.7655}$	$73.134T^{-0.235}$	$95.538T^{-0.235}$	2.35	0.983

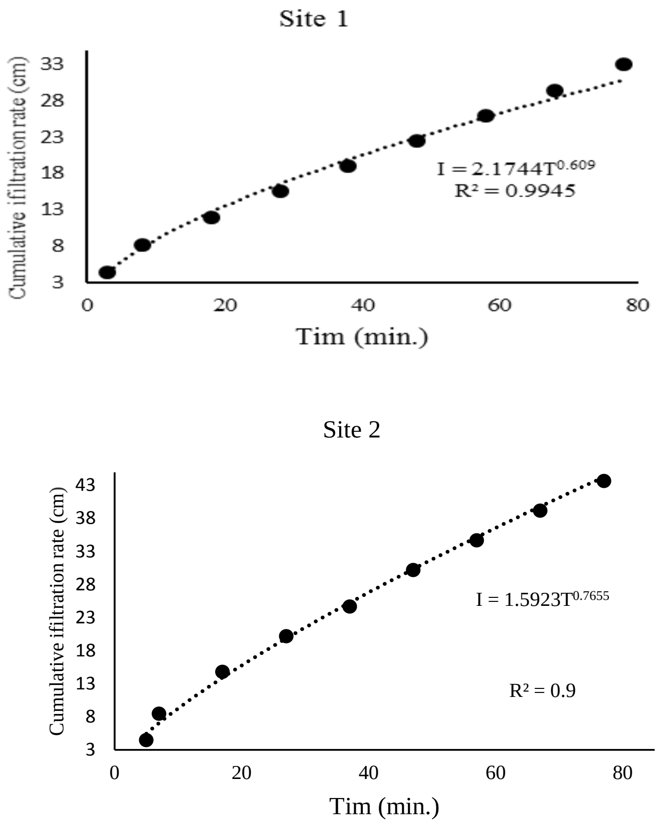

Fig 1. Infiltration rate at two studied site after harvesting.

Rice yield

Table (8) shows the effects of spatial variations of soil properties on yield and yield quality of rice. Data cleared that site (1) has higher values of grain yield, straw yield, harvest index and NPK content and uptake in grain and straw than in site (2). This difference may be due to different in the soil chemical and physical properties in the two studied sites specifically soil pH, organic matter, available P, cation exchange capacity. The crops could also have benefited from soil physical properties including reduced soil density, increase porosity and soil aeration. These results are accordance to Li *et al.* (2017) who found a negative correlation with rice yield and pH but a positive correlation with CEC, exchangeable K and Mg. Sarker *et al.* (2012) found that grain yield and bulk density were negatively correlated.

Table 8. Rice yield and NPK contents and their uptake at two studied sites.

	Grain yield (Ton fed^{-1})	Straw yield (Ton fed^{-1})	Harvest index (%)
Site 1	3.120	4.28	42.15
Site 2	2.88	3.95	42.17
	NPK Content in grain (%)		
	N	P	K
Site 1	1.89	0.23	0.59
Site 2	1.55	0.19	0.42
	NPK Uptake in grain (kg h^{-1})		
	N	P	K
Site 1	58.97	7.17	18.45
Site 2	44.64	5.47	12.10
	NPK Content in straw (%)		
	N	P	K
Site 1	1.11	0.16	1.303
Site 2	0.99	0.14	1.07
	NPK Uptake in straw		
	N	P	K
Site 1	47.54	6.85	55.81
Site 2	39.11	5.53	42.27

Statically Diagnostic for Relations of Spatial variable of soil traits with Rice Grain yield

Simple correlation analysis and coefficient of variation

The descriptive statistics of all characteristics of grain yield of rice plant and physio-chemical properties of soil at the two studied sites after harvesting are summarized in Tables (9) and (10). The values of variation coefficients (CV) of the most studied traits showed low variability (< 20).

The analysis of correlation coefficients for different traits with grain yield helps to decide on the relative importance of these traits and their values as selection criterions (Leilah and Al-Khateeb, 2005).

It has shown that at site (1) there is a positive and significant correlation at 5% of probability level between grain yield and the traits of CEC, soluble K, exchangeable Ca^{++}, Mg^{++}, available N and K, total porosity and hydraulic conductivity. Also, significant correlation with negative trend was showed between exchangeable Na^{+} and bulk density. Result analysis of site (2) indicated the positive and significant correlation between grain yield of rice plant and harvest index, N and K uptake in straw, CEC, O.M, exchangeable Ca^{++}, K^{+}, available N, available P, total porosity and hydraulic conductivity. These results are in agreement with those obtained by Mindari *et al*. (2015). Liu *et al.;* (2014) and Mamun *et al.;* (2015) indicated that rice yield was strongly and positively

correlated with pH, K and S, and negatively with soil organic matter. Moreover, no significant correlation was observed between rice yield and N or P. These results are in agreement with those obtained by Mindari *et al*. (2015) who reported that rice yield was negatively correlated to the exchangeable values of Na, SAR and bulk density. It was positively correlated with exchangeable of Ca^{++}, Mg^{++}, and K^{+}, as well as soil's CEC. Rice yield positively correlated with soil's physical and chemical characteristics in the following order: permeability > CEC > texture of sand > organic C > exchangeable K > NPK > exchangeable Ca > soil's exchangeable Mg. The values of simple correlation coefficients among different traits are given in Tables 9 and 10. Hossain *et al*. (2015) shows that soil salinity (EC) is significantly positively correlated with soil pH, total P content, exchangeable K and exchangeable Mg. Moreover, soil salinity (EC) is negatively correlated with soil OM and total N. Neither bulk density nor exchangeable Ca content was significantly associated with soil salinity (EC) of paddy field soils. Olabode (2015) found a negative correlation of soil pH with sodium, base saturation and available phosphorus at irrigated soil of rice production.

Stepwise linear regression

To assessment the most effective soil characteristics on rice grain yield, the obtained data were exposed to statistical analysis of stepwise regression by using SSPS program (V23). By using the stepwise regression equations, it can mathematically have predicted the contribution of any effective soil character on the yield expressed as "contribution %". The stepwise regression equations presented in Tables (11) and (12) showed the soil characteristics which had the most effective role on grain yield production of rice.

Fore site (1), it can arrange the soil physical characteristics, as their effective on rice yield, in the following order of: infiltration rate > soil total porosity > saturated hydraulic conductivity(Ksat). Their contribution factors (%) were 84.5, 10.9 and 3.9 %, respectively. While the order of soil chemical characteristics was: ESP > pH > EC > O.M and their contribution factors (%) were 88.9, 7.5, 2.1 and 1.0 % respectively. As for soil available nutrients, as shown in Table (11), their continuation factors were 90.7, and 7.0 % for soil available–K, and N, respectively.

As regard to site (2), from the stepwise regression equations presented in Tables (12) it can arrange the soil physical characteristics, as their effective on rice yield, in the following order of: bulk density > saturated hydraulic conductivity. Their contribution factors (%) were79.9 and 11.3 %, respectively. While the order of soil chemical characteristics was: ESP > pH > CEC > O.M and their contribution factors (%) were 85.6, 7.7, 4.4 and 2.1 %, respectively. As for soil available nutrients, as shown in Table (12), their continuation factors were 91.1 and 5.6 % for soil available–K, and P, respectively. Ranjbar *et al.* (2015) found that according to the results of stepwise regression analysis grain yield of wheat was dependent on number of the tillers without spikes per plant, the biological yield and the harvest index. Yan *et al.* (2007) by using the method of stepwise regression installed a relationship between chemical parameters of soil (6 main limiting factors of growth) and cotton yield. In this method EC, organic carbon, total nitrogen and the exchange capacity of cation entered in the equation and totally made clear 42% of the variations of plant yield.

Table (9). Regression equations describing the relationship between rice grain yield (Y) against soil properties (X) at site (1) after harvesting.

Variable	Simple regression equation	Correlation coefficient	C.V
Grain yield (Ton fed^{-1})	Y= 3.754960 + 0.37303 Straw yield	0.424	9.30
Harvest index (%)	Y = 1.52301 + 0.05593 Harvest index	0.421	3.07
N content in grain (%)	Y = 2.82347 + 1.11622 N content in grain	0.239	3.78
P content in grain (%)	Y = 5.50556 - 1.83069 P content in grain	0.398	3.51
K content in grain (%)	Y= 3.754960 + 0.37303 K content in grain	0.386	16.79
N uptake in grain (Kg fed^{-1})	Y = 2.10494 + 0.03064 N uptake in grain	0.664*	13.38
P uptake in grain (Kg fed^{-1})	y = 5.3836 - 0.029941 P uptake in grain	0.269	7.71
K uptake in grain (Kg fed^{-1})	y= 0.0174 4 + 4.34518 K uptake in grain	0.586*	19.28
N content in straw (%)	Y = 5.38574 - 0.31557 N content in straw	0.052	5.29
P content in straw (%)	Y = 4.7877 + 0.91058 P content in straw	0.051	3.24
K content in straw (%)	Y = 3.57308 + 1.0449 K content in straw	0.225	17.54
N uptake in straw (Kg fed^{-1})	Y = 5.3991 - 0.01045 N uptake in straw	0.247	13.76
P uptake in straw (Kg fed^{-1})	Y = -1.389 + 0.14593 P uptake in straw	0.427	16.25
K uptake in straw (Kg fed^{-1})	Y = 5.353348 - 0.013 K uptake in straw	0.087	19.47
EC(dSm^{-1})	Y = 0.306644 + 0.01677 EC	0.162	10.72
pH	Y = -1.34801 + 0.807929 pH	0.367	18.36
CEC (cmolc kg-1)	Y = 0.43651 - 0.07293 CEC	0.836*	1.46
ESP	Y = 5.130239 - 0.01461 ESP	0.011	2.96
O.M (%)	Y = 5.66090 - 0.393454 O.M	0.388	7.98
Soluble Ca^{++} (mmolc L^{-1})	Y = 0.146979 + 1.469568 Soluble Ca^{++}	0.247	13.02
Soluble Mg^{++} (mmolc L^{-1})	Y = 5.19414 - 0.10686 Soluble Mg^{++}	0.092	18.80
Soluble Na^{+} (mmolc L^{-1})	Y = 1.284454 + 1.1507 Soluble Na^{+}	0.253	17.77
Soluble K^{+} (mmolc L^{-1})	Y = 5.154227 - 0.98162 Soluble K^{+}	0.552*	18.19
Exchangeable Ca^{++} (cmolc Kg^{-1})	Y = 8.39326 - 0.17826 Exchangeable Ca^{++}	0.681*	19.97
Exchangeable Mg^{++}(cmolc Kg^{-1})	Y = 7.789074 - 0.15639 Exchangeable Mg^{++}	0.541*	2.71
Exchangeable Na^{+} (cmolc Kg^{-1})	Y = 5.407380 - 0.07619 Exchangeable Na^{+}	0.584*	2.61
Exchangeable K^{+} (cmolc $Kg-^{1}$)	Y = 5.743451 - 0.40088 Exchangeable K^{+}	0.263	9.35
Available N (mg $kg-^{1}$)	Y = 6.345603 - 0.035781 Available N	0.636*	9.62
Available P (mg kg^{-1})	Y = 5.368862 - 0.06469) Available P	0.484	7.88
Available K (mg kg^{-1})	Y = 6.026707 - 0.00357 Available	0.573*	19.91
BD (Mg m^{-3})	Y = 4.339754 - 0.618972 BD	0.751*	9.56
TP (%)	Y = 5.98003 + 0.164023 TP	0.784*	6.75
Ksat (cmh^{-1})	Y = 4.574375 + 4.574375 Ksat	0.694*	3.85
Infiltration rate (cm/ hr)	Y = 2.836528 + 2.52865 Infiltration rate	0.814*	19.60

Table (10). Regression equations describing the relationship between rice straw yield (Y) against soil properties at site (2) after harvesting.

Variable	Simple regression equation	Correlation coefficient	C.V
Straw yield (Ton fed^{-1})	Y = 3.014434 + 0.530344 Straw yield	0.445	3.757
Harvest index (%)	Y = -3.70559 + 0.117742 Harvest index	0.522*	4.714
N content in grain (%)	Y = 2.862605 + 2.862605 N content in grain	0.239	1.794
P content in grain (%)	Y = 4.2453038 - 0.60773 P content in grain	0.029	7.575
K content in grain (%)	Y = 0.3924309 + 0.13812 K content in grain	0.011	25.948
N uptake in grain (Kg ha^{-1})	Y = 0.620192 + 0.022268 N uptake in grain	0.421	17.063
P uptake in grain (Kg ha^{-1})	Y = 4.10175 + 0.001713 P uptake in grain	0.001	8.431
K uptake in grain (Kg ha^{-1})	Y = 3.398473 + 0.041192 K uptake in grain	0.302	18.592
N content in straw (%)	Y = 4.25837 - 0.0122334 N content in straw	0.003	4.534
P content in straw (%)	Y = 4.56666 - 5.000123 P content in straw	0.185	10.733
K content in straw (%)	Y = 3.671082 + 0.39490 K content in straw	0.111	24.89
N uptake in straw (Kg fed^{-1})	Y = 4.02945 + 0.003623 N uptake in straw	0.514*	20.975
P uptake in straw (Kg fed^{-1})	Y = 4.4725122 - 0.189902 P uptake in straw	0.525*	9.588
K uptake in straw (Kg fed^{-1})	Y = 3.552689 + 0.0240409 K uptake in straw	0.421	20.24
EC(dSm^{-1})	Y = 2.874721 + 1.765799 EC	0.296	6.609
pH	Y = 4.750333 - 0.078364 pH	0.087	8.515
CEC (cmolc kg^{-1})	Y = 0.102865 + .0873515 CEC	0.689*	2.473
ESP	Y = 6.863814 - 0.131412 ESP	0.421	2.603
O.M (%)	Y = 3.418449 + 0.5223568 O.M	0.631*	5.995
Soluble Ca^{++} (mmolc L^{-1})	Y = 4.454166 - 0.375001 Soluble Ca^{+}	0.115	13.363
Soluble Mg^{++} (mmolc L^{-1})	Y = 4.2969981 - 2.73921 Soluble Mg^{++}	0.165	19.876
Soluble Na^{+} (mmolc L^{-1})	Y = 3.705099 + 0.0781456 Soluble Na^{+}	0.163	32.013
Soluble K^{+} (mmolc L^{-1})	Y = 4.324074 - 1.29635 Exchangeable Ca^{++}	0.432	19.051
Exchangeable Ca^{++} (cmolc Kg^{-1})	Y = -1.930175 + 0.32536 Exchangeable Mg^{++}	0.708*	20.54
Exchangeable Mg^{++}(cmolc Kg^{-1})	Y = 0.686445 + 0.211960 Exchangeable Na^{+}	0.498	2.713
Exchangeable Na^{+} (cmolc Kg^{-1})	Y = 6.66666 - 0.265632 Exchangeable K^{+}	0.479	4.377
Exchangeable K^{+} (cmolc $Kg\text{-}^{1}$)	Y = 2.520008 + 1.40003 Available N	0.607*	5.27
Available N (mg $kg\text{-}^{1}$)	Y = 3.598673 + 0.0189706 Available N	0.568*	8.101
Available P (mg kg^{-1})	Y = 3.633839 + 0.119511 Available P	0.797*	11.69
Available K (mg kg^{-1})	Y = 3.5008524 + 0.0025203 Available K	0.321	35.9
BD (Mg m^{-3})	Y = 4.0077274 - 4.007727 BD	0.415	10.978
TP (%)	Y = 4.261334 + 0.012376 TP	0.711*	11.027
Ksat ($cmh\text{-}^{1}$)	Y = 4.406806 + 1.52178 Ksat	0.567*	7.928
Infiltration rate (cm/ hr)	Y 3.2459876 + 4.872315 Infiltration rate	0.492	16.971

Table (11). Stepwise regression equations of the most effective soil characteristics on rice yield at site (1).

Step	Stepwise regression equations	R^2
	Soil physical properties	
1	Y= 3.320 + 1.121543 Infiltration rate	0.845
2	Y = 2.89765 + 1.054984 Infiltration rate + 4.25674 Total porosity	0.954
3	Y= 4.924789 + + 2.92659 Infiltration rate + 3.98765 Total porosity + 3.87654 Ksat	0.993
	soil chemical properties	
1	Y= 3.946 - 0.800 ESP	0.889
2	Y= 4.2543- 0.3456 ESP - 0.086 pH	0.964
3	Y= 3.87645 - 0.46298 ESP - 0.0587 pH - 0.01145 EC	0.985
4	Y= 2.984567 - 0.362872 ESP - 1.548952 pH - 0.106598 EC + 2.84563 O.M	0.995
	Soil available nutrient	
1	Y = 4.805432 + Available K	0.907
2	Y = 3.58023 + 3.398721 Available K + 3.109856 Available N	0.977

Table (12). Stepwise regression equations of the most effective soil characteristics on rice yield at site (2).

Step	Stepwise regression equations	R^2
	Soil physical properties	
1	Y= 4.97651 - 2.476529 Bulk density	0.799
2	Y = 2.89765 - 1.054984 Bulk density + 4.25674 Hydraulic conductivity	0.912
	soil chemical properties	
1	Y= 2.98643 - 0.357538 ESP	0.856
2	Y= 3.394864 - 0.087453 ESP - 0.196422 pH	0.933
3	Y= 2.765932 - 0.398728 ESP - 0.1948632 pH + 1.839834 CEC	0.977
4	Y= 3.28564 - 0.524437 ESP - 0.138365 pH + 1.4867432 CEC + 2.098357 O.M	0.998
	Soil available nutrient	
1	Y = 2.86342 + 2.765498Available K	0.911
2	Y = 2.1138745 + 2.9365117 Available K + 1.56387 Available P	0.967

CONCLUSION

Spatial variability is an effective way to allocate crops with local conditions. As the soils from the agriculture activities are heterogeneous, the analyses of the soil properties of the study area are necessary for an adequate determination of the management of the agriculture zones. Special variability is an effective way to allocate crops with local conditions.

The special variations of rice productivity at EL- Gemmieza region can be classified by delineating site specific properties. Since, productivity is influenced by soil characteristics, the special pattern of productivity could be caused by corresponding variation in certain soil properties. Determining the source of variation in productivity can help achieve more effective site-specific management. Using stepwise regression based on the order of traits importance, at site 1 indicated that soil physical characteristics, as their effective on rice yield, in the following order of: infiltration rate > soil total porosity > saturated hydraulic conductivity(Ksat). Their contribution factors (%) were 84.5, 10.9 and 3.9 %, respectively. While the order of soil chemical characteristics was: ESP > pH > EC > O.M and their contribution factors (%) were 88.9, 7.5, 2.1 and 1.0 % respectively. As for soil available nutrients, as shown in Table (12), their continuation factors were 90.7, and 7.0 % for soil available–K, and N, respectively. For site 2, the soil physical characteristics, as their effective on rice yield, in the following order of: bulk density > saturated hydraulic conductivity. Their contribution factors (%) were79.9 and 11.3 %, respectively. While the order of soil chemical characteristics was: ESP > pH > CEC > O.M and their contribution factors (%) were 85.6, 7.7, 4.4 and 2.1 %, respectively. As for soil available nutrients, their continuation factors were 91.1 and 5.6 % for soil available–K, and P, respectively.

REFRENCES

Ayers, R. S. and D. W. Westcot (1994). Water quality in agriculture. Irrigation and drainage paper No.29, Food and Agriculture Organization of the United Nations, Rome, Italy.

Bhat, Z.A., S.A. Padder, A.Q. Ganaie, N.A. Dar, H.U. Rehman and M.Y. Wani (2017). Correlation of available nutrients with physicochemical properties and nutrient content of grape orchards of Kashmir. Journal of Pharmacognosy and Phytochemistry. 6(2): 181-185.

Castrignanò, A., L. Giugliarini, R. Risaliti and N. Martinelli (2000). Study of spatial relationships among some of a field in central Italy using multivariate geostatistics. Geoderma, 97: 39-60.

Cavazza, C. (1981). Device for the extemporaneous preparation of a solution under sterile conditions." U.S. Patent No. 4,244,467. 13 Jan.

Cerri, D.G.P. and P.S.G. Magalhães (2012). Correlation of physical and chemical attributes of soil with sugarcane yield. Pesq. agropec. Bras. Brasília, 47 (4): 613-620.

Chaudhari, P.R., D.V. Ahire and V.D. Ahire (2012). Correlation between Physico-chemical properties and available nutrients in sandy loam soils of Haridwar. J Chem Biol Phys Sci. 2(3) 1493-1500.

Chung, S.O., K.A. Sudden and T.C. Chung (2005). Path analysis of factors limiting crop yield in rice paddy and upland corn fields. Biosys. Engin. 30, 45-55.

Cottenie, A., M. Verso, L. Kiekens, G. Veighe and R. Camerlynck (1982). Chemical Analysis of Plants and Soils. Lab. Anal .and Agrochem. State Univ., Gent. Belgium, Chapter 2, 3, PP.14-54.

“DFPJA” (2011). (Department of fertilizer and pesticide, National federation of agricultural cooperative associations of Japan, JA Zen-Noh) Guide to Soil Diagnosis and Fertilizer Calculation (Tokyo, Japan: Rural Culture Association Press) pp 12-3, 16, 72-7 (in Japanese)

Elkhidir, A. M. (1985). Furrow irrigation in cracking clay soils with special reference to the Sudan. Ph.D. Thesis, Civil Engineering Department. Southampton University.

Elsheikh, M.A. (2002). Techniques for improving efficiency of long furrow irrigation in Kenana Sugar State. Ph.D. Thesis, Faculty of Agriculture, Omdurman Islamic University.

Ezrin, M.H., M.S.M. Amin, A.R. Anuar and W. Aimrun (2010). Relationship between Rice Yield and Apparent Electrical Conductivity of Paddy Soils. Am. J. Applied Sci., 7 (1): 63-70.

Goldhammer, D.A. and C.M. Peterson (1984). A comparison of linear move sprinkler and furrow irrigation on cotton: A case study. Dep. Of Land, Air, and Water Resources, Land, Air and Water Res. Pap. 10012. Univ. of Calif., Davis.

Gray, L. C. and P. Morant (2003). Reconciling indigenous knowledge with scientific assessment of soil fertility changes in southeast Burkina Faso Geoderma 111: 425-3

Hossain, N., M. Muhibbullah, K. M. B. Ali and M. H. Molla (2015). Relationship between soil salinity and physico-chemical properties of paddy field. Soils of Jhilwanja Union, Cox's Bazar, Bangladesh. Journal of Agricultural Science; 7(10): 166-180.

Jackson, M. L. (1967). Soil Chemical Analysis Prentice Hall of India Pvt. Ltd., New Delhi; p. 205

Jiang, Y., G. Zang, D. Zou, Y. Qin and W. J. Liang (2009). Profile distribution of micronutrients in an aquic brown soil as affected by land use. J Plant Soil Environ. 2009; 155(11): 468-476.

Juhos, K., S. Szabób and M. Ladányic (2016). Explore the influence of soil quality on crop yield using statistically-derived pedological indicators Ecolo. Indic. 63: 366-730.

Kim, H. T. (1996). Soil Sampling, Preparation and Analysis. Marcel Dekker, Inc. New York, Basel, Hong Kong: 67-68.

Klute, A. (1986). "Methods of soil analysis part I. physical and mineralogical methods". 2nd ed., Agro. Madison, Wisconsin, U.S.A.

Leilah, A. A. and S. A. Al-Khateeb (2005). Statistical analysis of wheat yield under drought conditions. J. Arid. Environ. 61: 483-496.

Li. Y., X. Chen, I. H. Shamsi, P. Fang and X. Lin (2012). Effects of irrigation patterns and nitrogen fertilization on rice yield and microbial community structure in paddy soil Pedosphere 22(5): 661-720.

Li, D., T. Nanseki, Y. Chomei and S. Yokota (2017). Fertilizer nitrogen, soil chemical properties, and their determinacy on rice yield: Evidence from 92 paddy fields of a large-scale farm in the Kanto Region of Japan. 3rd International Conference on Agricultural and Biological Sciences (ABS 2017) IOP Conf. Series: Earth and Environmental Science 77 (2017) 012011. doi :10.1088/1755-1315/77/1/012011.

Liu, Z., W. Zhou, J. Shen, P. He, Q. Lei and G. Liang (2014). A simple assessment on spatial variability of rice yield and selected soil chemical properties of paddy fields in South China. Geoderma 235–236: 39–47.

Mamun, M. A. A., M. M. Haque, Q. A. Khaliq, M. A. Karim, A. J. M. S. Karim, A. J. Mridha and M. A. Saleque (2015). Assessment of soil chemical properties and rice yield in Tidal submergence ecosystem. Bangladesh Agron. J., 18(2) 79-87.

Manjappa, G. U. and H. Shailaja (2014). Association analysis of drought and yield related traits in F2 population of Moroberekan/IR64 rice cross under aerobic condition." Int. J. of Agric. Sci. Res 4(2): 79-88.

Mindari, W., P. E. Sasongko, Z. Kusuma and Syekhfani (2015). Characteristics of saline soil and effect of fertilizer application to rice yield. International Journal of Agronomy and Agricultural Research (IJAAR), 6 (1): 7-15.

Olabode, A. D. (2015). inter-relationship and variability assessment among physical and chemical soil properties for sustainable irrigated rice production in nigeria. J. Environ. Res. Develop., 9(3): 715-724.

Rahman, M. H., A. Okubo, S. Sugiyama and H. F. Mayland (2008). Physical, chemical and microbiological properties of an Andisol as related to land use and tillage practice. Soil & Tillage Research 101: 10–19.

Ranjbar, A., A. R. Sepaskhah and S. Emadi (2015). Relationships between wheat yield, yield components and physico-chemical properties of soil under rain-fed conditions. International Journal of Plant Production. 9(3): 433-466

Rhoades, R. L. (1954). Diagnosis and Improvement of Saline and Alkali Soils. *USDA Agriculture Handbook*, No. 60 US Gov. Printing office: *Washington*.

Sarker, M. M., M. A. Matin, M. G. Hossain, M. M. R. Sarker and M. S. Huda (2012). Effect of tillage, fertilizer and manure on root mass density, soil properties and their correlation on rice (*Oryza sativa* L.) yield. Bangladesh J. Agric. Res. 37(3): 529-535.

Soil Laboratory Staff (1984). Analytical methods of the service Laboratory for Soil, Plant and Water analysis part (I): methods for soils analysis, Royal Tropical Institute, 63 Mauristskade, and Amsterdam.

Talpur, M. A. J. I., S. Changying, A. Junejo and A. A. Tagar (2013). Impact of rice crop on soil quality and fertility. Bulg. J. Agric. Sci., 19: 1287-1291.

Virgilio, N. D., A. Monti and G. Venturi (2007). Spatial variability of switchgrass (*Panicum virgatum* L.) yield as related to soil parameters in a small field. Field Crop Res. 101: 232-239.

Wilding, L. P. (1985). Spatial variability, its documentation, accommodation and implication to soil surveys. In: D.R. Nielsen and J. Bouma (Eds.), Soil Variability. Pudo, Wagenigen, the Netherlands.

Yan, L., S. Zhou, L. Feng and L. Hong-Yi (2007). Delineation of site-specific management zones using fuzzy clustering analysis in a coastal saline land. Computers and Electronics in Agriculture. 56: 174-186.

التغيرات المكانية لخواص التربة ومحصول الأرز النامى فى أرض طينية خلال موقعين فى منطقة الجميزة (وسط الدلتا نهر النيل – مصر)

محيى محب هرفى ، بشير أبو بكر الجمل ، محمد حافظ عبد العال

معهد بحوث الأراضى والمياه والبيئة – مركز البحوث الزراعية – الجيزة – مصر.

الملخص العربى

فهم العلاقة بين محصول الأرز وخصائص التربة له أهمية خاصة للوصول للزراعة النموذجية. يهدف هذا البحث لدراسة التغيرات الدقيقة لخواص التربة على محصول الأرز. تمت الدراسة فى محطة بحوث الجميزة التابعة لمركز البحوث الزراعية محافظة الغربية مصر على مساحة ١٠٠ فدان. تم اختيار موقعان مختلفان فى انتاجية محصول الأرز . أظهرت صفات التربة وأن قيم ال pH تميل الى القلوية فى الموقع الأول وقلوية فى الموقع الثانى وكانت قيم EC و CEC والمسامية الكلية ومعامل التوصيل الهيدروليكى المشبع ومعدل الرشح فى الموقع الأول أعلى من الموقع الثانى والعكس كان فى قيم ESP والكثافة الظاهرية. وجدت أعلى قيم للكلتيونات المتبادلة فى الموقع الآول ماعدا الصديوم أظهر اتجاها معاكسا. كان محصول الحبوب ومحصول القش ومحتوى النبات والممتص من NPK أعلى فى الموقع الأول بالمقارنة بالموقع الثانى . كان معامل الإختلاف لمعظم صفات التربة أقل من ٢٠% وكان هناك معامل إرتباط موجب قوى بين محصول ألأرز وكل من CEC البوتاسيوم الذائب – الكالسيوم والمغنسيوم المتبادل – النيتروجين والفوسفور الميسر فى التربة ومعامل التوصيل الهيدروليكى وارتباط سالب مع الصديوم المتبادل والكثافة الظاهرية فى الموقع الأول . أما فى الموقع الثانى كان هناك ارتباط معنوى بين محصول الحبوب وكل من دليل الحصاد – والممتص من النيتروجين والبوتاسيوم فى القش – CEC– نسبة المادة العضوية – الكالسيوم والبوتاسيوم المتبادل – النيتروجين والفوسفور الميسر – المسامية الكلية ومعامل التوصيل الهيدروليكى . أظهرت نتائج الآنحدار المتدرج للموقع الأول أن الصفات الطبيعية المؤثرة فى محصول الأرز تتبع الترتيب الآتى : معدل الرشح > المسامية الكلية > معامل التوصيل الهيدروليكى > بينما كانت الصفات الكيميائية كالآتى ESP > pH > EC > المادة العضوية > البوتاسيوم الميسر > النيتروجين المتيسر بينما كانت الصفات الطبيعية فى الموقع الثانى تتبع الكثافة الظاهرية > معامل التوصيل الهيدروليكى والصفات الكيميائية ESP > pH > المادة العضوية والمغذيات الميسرة البوتاسيوم > الفوسفور.

<u>أسماء السادة المحكمين</u>

أ.د/ طـــارق أبـــو الضيفــــان مركز البحوث الزراعية - الجيزة

أ.د/ الحسينى عبدالغفار أبوحسين كلية الزراعة – جامعة المنوفية