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RESPONSE OF SOME FIELD CROPS TO PROPER TILLAGE UNDER SALT AFFECTED SOILS IN NORTH NILE DELTA

Gendy, A. A. S.
Soils, Water and Environment Res. Inst., Agric. Res. Center, Giza, Egypt

ABSTRACT

A field trial was conducted at Al-Hamool region, Kafr El-Sheikh Governorate, Egypt, during the two successive growing seasons 2009 and 2009/2010. The main goal of the present work is to study the effect of improving drainage conditions and chemical, physical properties of studied soil. Consequently, cultivation new crops in this area such as faba bean in winter season and new variety of hybrid rice as a summer crop. In the summer season, the soil was treated before transplanting of rice with the following treatments: 1. subsoiling, 2. subsoiling + application of 1.5 ton gypsum fed^{-1}, ,3. subsoiling + application of 1 ton gypsum fed^{-1}. + 50 kg calcium super phosphate, 4. subsoiling + 200 kg phosphogypsum fed^{-1} (byproduct of acid production). In the winter season faba bean variety Sakha 2 was planted and the treatments were: 1. control, 2. 100 kg calcium superphosphate 15.5% + 1 ton gypsum fed^{-1}. + 100 kg phosphogypsum fed^{-1}., 3. 100 kg calcium superphosphate 15.5% + 1 ton gypsum fed^{-1}, 4. 200 kg phosphogypsum, 5. 100 kg calcium superphosphate 15.5% + 100 kg phosphogypsum, 6. 1.0 ton gypsum fed^{-1}, 7. 1 ton gypsum fed^{-1} + 200 kg phosphogypsum, 8. 200 kg calcium superphosphate 15.5% fed^{-1}

The main results of the present study can be summarized as follows:

- Decreasing the mean values of exchangeable sodium percentage (ESP) as a result of application of soil amendments.
- Increasing the mean values of total porosity, hydraulic conductivity and lowering the level of water table depth from soil surface.
- The losses of ammonium cation (NH_4^+) was decreased while the loss of nitrate ion, was increased.
- Decreasing salinity of groundwater after rice and faba bean cultivation.
- The production of hybrid rice was high under the conditions of this soil. The highest mean value is 5.7 tons fed^{-1} with the subsoiling combined with application of 200 kg phosphogypsum fed^{-1}.
- The production of faba bean was increased as a result of decreasing salinity of this soil with cultivation a high tolerant variety (Sakha 2) to salinity and the highest mean value is 12.0 ton fed^{-1} under application of 100 kg calcium superphosphate 15.5% + 1 ton gypsum fed^{-1} + 100 kg phosphogypsum fed^{-1}.

From the abovementioned results, it could be recommended to give more care to the conditions of drainage and good farming practices for these soils with addition of soil amendments such as gypsum, calcium superphosphate and phosphogypsum, and cultivating new crop varieties that is tolerant to salinity for obtaining high productivity.

Keywords: Proper tillage, salt affected soils, subsoiling, gypsum, phosphogypsum

INTRODUCTION

As a result of a great effort which was done from 1990 till 2007 and up to now and making completeness for which was done by installation the network drainage system and applying soil amendments. The work was done before rice cultivation in summer season in 2009 and before planting of faba bean in 2009 and 2010.

Getting work opportunity has become one of the main problems facing the government nowadays. In the last years the new reclaimed soils had been distributed on the youth graduates with a rate of 5 feddans for every one. The government constructed many new villages, provided them with infrastructure. Youth graduates villages are mainly concentrated in the northern part of Nile Delta. Most of these soils located especially in the Northern Nile Delta have been deposited under the conditions of sea or saline lake, thus they are characterized by heavy texture, surface accumulation of soluble salts and low concentration of organic matter (El-Mowelhi and Hamdi, 1975).

Saline sodic clay soils with low permeability are mostly found in the northern part of Nile Delta. Improving such soils need a comprehensive technique and effort due to many controversial factors, subsoiling has generated considerable interest in the past few years (Moukhtar *et al.*, 2003).

Generally, subsoiling improves drainage only if the operation allows water to move down through a compacted layer into a soil zone of relatively high conductivity or for disturbed soil so that water can move laterally more rapidly towards an existing underground pipe system. Ellington *et al.* (1991) and Said (2002) revealed that soil compaction influenced soil strength, bulk density, distribution and continuity of pores with consequent adverse effect on drainage, root penetration, aeration, biological processes and nutrient uptake. All of which could have a direct bearing on crop production.

A secondary drainage and subsoiling ploughing are widely used in heavy soils to improve productivity of pastures and crops (David, 2002). Subsoiling in the drainage mode seeks to lift and shatter the soils beds to improve structure and so improve the water movement to the permanent pipe system (Abdel-Mawgoud *et al.*, 2006).

Subsoiling will enhance downward movement of irrigation water carrying of excess salts from surface layers. Afterwards, regular subsequent irrigations will gradually reduce the salt concentration in groundwater at least when close to soil surface. The percolation of water will constitute a temporary from preventing the saline groundwater in subsurface soil layers from linking with the upper ones (Moukhtar *et al.*, 2002b and Moukhtar *et al.*, 2003).

Improved crop growth following subsoiling and mole drains are generally considered to be the result of the physical shattering of the hardpan, which allows to increase water penetration into the subsoil. Therefore, may also accelerate the leaching of sodium from the subsoil thereby further reducing the possibility of reformation of the hardpan (Lickacz, 1993). Subsurface tillage operations lowered the water table. Thus, soil salinity and sodicity in the topsoil were reduced after subsoiling and moling installation.

Many investigators found a promising result of subsoiling technique combined with drainage for improving soil conditions (El-Hadidi *et al.*, 2003). Phosphogypsum application led to increase soybean seeds and straw yields (El-Saady, 2004).

The main target of the present work is to improve drainage conditions of the studied area. Consequently, cultivation new field crops in this area such as faba bean and new varieties of hybrid rice.

MATERIALS AND METHODS

A field experiment was conducted at Al-Hamool, Kafr El-Sheikh Governorate, Egypt. The soil in the site is clay in texture. Surface field drains were at 40 m apart down to 1 m in depth serve the selected area. Physical and chemical properties of the studied soil profile were studied. An area of four acres was sûbjected to subsoiling, gypsum, superphosphate and phosphogypsum application which added during tillage processes. The subsoiling treatments were implemented at distances of 1.6 m and 0.60 m in depth.

In the summer season (2009), the soil was treated before transplanting of rice with the following treatments: 1) subsoiling, 2) subsoiling + application of 1.5 ton gypsum fed^{-1}, 3) subsoiling + application of 1 ton gypsum fed^{-1}. + 50 kg calcium super phosphate (15.5%), 4) subsoiling + 200 kg phosphogypsum fed^{-1} (byproduct of acid production). For all abovementioned treatments the recommended dose of nitrogen and potassium fertilizers were added.

In the winter season (2009-2010) faba bean was planted and the treatments were 1) control (without any application of soil amendments), 2) 100 kg calcium superphosphate 15.5% + 1 ton gypsum fed^{-1} + 100 kg phosphogypsum, 3) 100 kg calcium superposphate + 1 ton gypsum fed^{-1}, 4) 200 kg phosphogypsum, 5) 100 kg calcium superphosphate + 100 kg phosphogypsum, 6) 1 ton gypsum fed^{-1}, 7) 1 ton gypsum fed^{-1} + 200 kg phosphogypsum and 8) 200 kg calcium superphosphate 15.5% fed^{-1}. Secondary drainage tunnels filled with crop residues (cotton stalks rapped with rice straw) rectangular with the plots open lateral drains.

Soil samples were taken from the following depths (0-30 cm, 30-60 cm, 60-90 cm, 90-120 cm and 120-150 cm). Ground water samples were taken then analyzed for chemical properties.

The particle size distribution, total calcium carbonate and organic matter were determined according to Black (1965). Soil bulk density, undisturbed soil samples were taken to a depth of 1.2 m to determine soil bulk density according to Klute (1986). Hydraulic conductivity (K): The soil hydraulic conductivity was measured in the field by auger-holes method according to Van Beers (1970). Also, total soluble salts, soluble ions of saturated soil paste extract were determined using the standard methods described by Page *et al.* (1982). Exchangeable sodium percentage calculated from formula $ESP = 1.8667 + 0.9228\ (SAR) + 0.001\ (SAR)^2$ according to Gazia *et al.* (2008).

A set of observation wells were installed in the midway between lateral drains to measure the water table depth through an irrigation interval.

Planting dates for the two studied crops were took place on June and October for rice and faba bean, respectively. Harvesting dates were in September for rice and April for faba bean. Finally yield and its components for the two studied crops were determined at the end of the growing seasons.

Randomized complete block design was used through this study with three replicates. Table (1) represents the soil analysis before planting the two crops.

Table (1): Some soil physical and chemical properties before amelioration treatments.

Prof. No.	Depth, cm	Sand %	Silt %	Clay %	Texture class	Bulk density gm cm^{-3}	Hyd. cond. m day^{-1}	EC, dS m^{-1}	ESP %	OM%	$CaCO_3$ %
1	0-30	19.73	33.38	46.89	Clay	1.362	0.126	19.20	20.02	1.19	3.14
	30-60	19.52	25.39	55.63	Clay	1.377		43.20	36.84	1.05	1.96
	60-90	18.25	22.81	58.94	Clay	1.398		91.20		0.75	1.86
	90-120	17.27	23.86	58.87	Clay	1.403		194.88		0.52	1.71
2	0-30	21.08	32.71	46.21	Clay	1.372	0.155	13.20	12.74	1.54	3.29
	30-60	20.84	27.23	51.93	Clay	1.382		29.23	25.04	1.19	2.13
	60-90	19.11	24.16	56.73	Clay	1.406		48.09		0.81	1.89
	90-120	18.24	23.67	58.09	Clay	1.411		70.72		0.63	1.85

RESULTS AND DISCUSSION

1. Some physical properties:

The physical properties of the studied soil were improved as a result of good cultural practices:

1.1. Soil bulk density and total porosity:

Data in Table (2) showed that the values of both bulk density and total porosity were affected by the studied treatments.

Table (2): Some soil physical properties after harvesting rice and faba bean

Soil treat.	Depth (cm)	After rice			After faba bean		
		Bulk density (gm/cm^3)	Total porosity %	Hydr. cond. m day^{-1}	Bulk density (gm/cm^3)	Total porosity, %	Hydr. cond. m day^{-1}
T_1	0-30	1.260	52.45	0.260	1.22	53.96	0.526
	30-60	1.326	49.96		1.28	51.70	
	60-90	1.360	48.68		1.38	47.92	
	90-120	1.393	47.43		1.39	47.55	
T_2	0-30	1.123	57.62	0.280	1.20	54.72	0.500
	30-60	1.187	55.21		1.21	54.34	
	60-90	1.220	53.96		1.37	48.30	
	90-120	1.320	50.19		1.38	47.92	
T_3	0-30	1.232	53.51	0.300	1.32	50.19	0.314
	30-60	1.283	51.58		1.38	47.92	
	60-90	1.353	48.94		1.48	44.15	
	90-120	1.447	45.40		1.49	43.77	
T_4	0-30	1.130	57.36	0.410	1.30	50.94	0.290
	30-60	1.353	48.94		1.31	50.57	
	60-90	1.377	48.04		1.47	44.53	
	90-120	1.397	47.28		1.48	44.15	

T_1: subsoiling, T_2: subsoiling + application of 1.5 ton gypsum fed^{-1}, T_3: subsoiling + application of 1 ton gypsum fed^{-1}. + 50 kg calcium super phosphate (15.5%), T_4: subsoiling + 200 kg phosphogypsum fed^{-1}.

The values of soil bulk density were decreased as a result of application of soil amendments. On the other hand, the total porosity values were increased compared to data obtained before conducting the treatments. Subsoiling combined with application of 1.5 ton gypsum fed^{-1} led to decrease soil bulk density compared to other treatments.

This finding could be attributed to the effect of subsoiling on breaking soil clods and bigger granular into small crumbs as well as breaking and cracking the compacted layers (Amer, 1990).

The results given in Table (2) also showed that the soil management practices had a marked positive effect on total soil porosity in the top soil (0-30 cm) since it increased due to subsoiling.

Subsoiling was superior to gypsum application in enhancing soil porosity, Jodi Delong (2004) stated that the theory behind subsoiling is to shatter a compacted deep layer in the soil to increase water movement, increase total porosity, better aeration of the root and excess additional nutrients for plant growth.

1.2. Hydraulic conductivity "K":

The obtained values of hydraulic conductivity (Table 2) using the auger hole method before conducting of soil management treatments varied between 0.126 to 0.155 m day^{-1} and classified as slow whereas, after growing season (Table 2). It ranged between 0.260 and 0.411 after harvesting rice and 0.290 and 0.526 m day^{-1} after harvesting faba bean and classified as moderate. Results indicated that providing such a soil with drains and subsoiling operations caused an increase in hydraulic conductivity. The improved "K" values due to the lowering of the groundwater table depth which resulted in better structure of the top soil and consequently reduced surface drainage problem (Van De Goor, 1972).

Some soil chemical properties:

Soil salinity:

Soil salinity expressed as electrical conductivity (EC in dS m^{-1}) values for the studied soil profiles as affected by subsoiling and gypsum application is shown in Tables (3 and 4). It is obvious that the reduction in soil salinity was more pronounced in the topsoil. The average salinity of soil profile decreased after harvesting of rice crop compared with those obtained before rice transplanting where the value was 11.52 dS m^{-1} and decreased to reach 6.85 dS m^{-1} and profile 4 decreased from 13.20 before planting to 9.24 after harvesting of faba bean where the salinity in soil decreased in top soil (0-30 cm) in all profiles. Data also showed that the values of EC increased with increasing depth.

Distribution of soluble ions through soil profiles:

Distribution of soluble ions through the soil profiles were shown in Tables (4 and 5). Generally, soluble ions clearly decreased as a result of subsoiling and gypsum applications. Chloride and sodium are the dominant ions in the saturation soil paste extract with all treatments.

Table (3): Some chemical properties of the studied soil before transplanting rice:

Treat.	Profile No. Depth (cm)	EC dS m^{-1} at 25°C	Anions meq L^{-1}				Cations meq L^{-1}				pH 1:2.5	SAR	ESP %
			$CO_3^{=}$	HCO_3^-	Cl^-	$SO_4^{=}$	Ca^{++}	Mg^{++}	Na^+	K^+			
T1	P1												
	0-30	11.52	-	5.00	90.0	131.64	66.60	69.40	88.0	2.64	7.80	10.67	11.83
	30-60	24.00	-	2.00	280.0	499.77	81.40	136.20	559.0	5.17	7.90	53.60	59.20
	60-90	55.58	-	2.00	960.0	420.16	133.20	356.40	884.0	8.56	8.01	56.49	57.18
	90-120	73.92	-	1.75	1520.0	591.98	236.80	633.60	1228.0	15.33	8.04	58.87	59.65
	120-150	74.88	-	3.75	1520.0	536.99	148.00	668.00	1228.0	16.74	7.47	60.79	61.66
T2	P2												
	0-30	19.20	-	2.50	220.0	200.12	88.80	128.80	201.0	4.02	7.87	19.27	20.02
	30-60	43.20	-	1.75	620.0	402.36	177.60	284.80	554.0	7.71	7.91	36.45	36.84
	60-90	91.20	-	1.50	2000.0	805.21	333.00	551.00	1910.0	12.71	8.00	90.86	93.97
	90-120	194.88	-	2.00	3300.0	1052.33	444.00	1052.00	2830.0	28.33	7.77	103.47	108.06
	120-150	181.44	-	2.50	3300.0	1344.72	518.00	978.00	3130.0	21.22	7.31	116.01	122.38
T3	P3												
	0-30	10.56	-	2.50	40.0	176.40	59.20	76.80	81.0	1.90	7.84	9.82	11.03
	30-60	40.16	-	1.50	330.0	91.96	81.40	136.20	201.0	4.86	7.93	19.27	20.02
	60-90	43.20	-	1.75	640.0	263.26	118.40	248.80	530.0	7.81	8.04	39.11	39.49
	90-120	62.40	-	2.25	1080.0	506.07	207.20	418.40	948.0	14.72	7.41	53.59	54.19
	120-150	65.28	-	3.50	1200.0	579.83	207.20	500.00	1060.0	16.13	7.47	57.45	58.18
T4	P4												
	0-30	13.20	-	1.75	240.0	29.30	111.00	52.20	105.0	2.85	7.80	11.63	12.74
	30-60	29.23	-	2.50	400.0	222.64	251.60	61.20	306.0	6.34	7.92	24.46	25.04
	60-90	48.09	-	1.50	740.0	352.63	148.00	393.00	542.0	8.13	8.11	32.89	33.30
	90-120	70.72	-	2.25	1400.0	484.89	266.40	495.20	1108.0	17.54	8.05	56.79	57.50
	120-150	50.92	-	4.50	740.0	355.01	103.60	385.20	638.0	12.71	8.02	41.62	42.01

T_1: subsoiling, T_2: subsoiling + application of 1.5 ton gypsum fed^{-1}, T_3: subsoiling + application of 1 ton gypsum fed^{-1}. + 50 kg calcium super phosphate (15.5%), T_4: subsoiling + 200 kg phosphogypsum fed^{-1}.

Table (4): Some chemical properties of the studied soil after harvesting rice.

Treat.	Profile No. Depth (cm)	EC dS m^{-1} at 25°C	Anions meq L^{-1}				Cations meq L^{-1}				pH 1:2.5	SAR	ESP
			$CO_3^{=}$	HCO_3^-	Cl^-	$SO_4^{=}$	Ca^{++}	Mg^{++}	Na^+	K^+			
T1	P1												
	0-30	6.85	-	2.75	37.50	147.38	81.40	63.36	41.75	1.38	8.10	4.91	6.42
	30-60	6.96	-	2.25	25.00	174.50	46.25	98.25	55.25	2.00	7.98	6.50	7.91
	60-90	8.91	-	2.00	55.00	209.45	62.90	117.30	83.50	2.75	8.03	8.80	10.06
	90-120	16.31	-	2.50	130.00	265.32	81.40	136.20	176.00	4.22	8.00	16.87	7.72
	120-150	19.57	-	2.25	160.00	378.10	74.00	211.60	248.00	6.75	8.03	20.75	21.45
T2	P2												
	0-30	14.13	-	3.00	110.00	249.70	66.60	164.60	129.50	2.00	7.90	10.61	13.13
	30-60	14.13	-	2.50	90.00	173.58	96.20	84.00	82.50	3.38	8.04	7.18	9.96
	60-90	20.65	-	1.75	190.00	310.68	88.80	183.20	226.00	4.43	8.05	19.38	20.13
	90-120	32.61	-	2.50	440.00	536.24	148.00	382.40	442.00	6.34	7.96	27.15	27.65
	120-150	31.96	-	1.75	80.00	203.57	62.90	107.10	113.00	2.32	7.96	12.26	13.33
T3	P3												
	0-30	8.04	-	2.25	45.00	155.84	49.95	89.45	62.00	1.69	7.94	7.45	8.78
	30-60	11.96	-	2.50	75.00	259.75	70.30	86.10	110.50	2.85	7.96	12.50	13.55
	60-90	13.04	-	1.75	85.00	324.15	62.90	110.50	124.00	3.70	8.00	15.04	14.33
	90-120	18.48	-	1.75	160.00	286.47	88.80	149.20	206.00	4.22	8.10	18.88	19.65
	120-150	17.39	-	2.25	160.00	288.49	96.20	169.00	181.00	4.54	8.03	15.71	16.62
T4	P4												
	0-30	9.24	-	2.25	70.00	185.96	74.00	109.60	72.50	2.11	7.94	7.57	8.91
	30-60	14.13	-	1.75	115.00	216.19	92.90	130.90	138.50	2.64	8.00	14.08	15.05
	60-90	27.18	-	1.75	300.00	349.47	96.20	243.80	307.00	4.22	8.05	23.54	24.15
	90-120	35.46	-	2.25	75.00	190.52	74.00	119.80	72.50	1.47	7.94	7.37	8.72
	120-150	39.13	-	2.75	540.00	516.13	133.20	424.40	496.00	5.28	7.82	29.70	30.16

T_1: subsoiling, T_2: subsoiling + application of 1.5 ton gypsum fed^{-1}, T_3: subsoiling + application of 1 ton gypsum fed^{-1}. + 50 kg calcium super phosphate (15.5%), T_4: subsoiling + 200 kg phosphogypsûm fed^{-1}.

Exchangeable sodium percentage (ESP%):

The obtained results declare that ESP values were affected by subsoiling and application of phosphogypsum and calcium superphosphate. Data in the same table also show that the reduction in the ESP values was realized in all soil layers. The ESP values in the top soil become less than 15% giving a good indication of soil improvement. The values of ESP decreased from 11.83% before transplanting of rice to reach 6.42% at harvest.

The same trend was observed in all soil profiles and the values were 20.02% decreased to reach 13.13% in one soil profile and other soil profiles took the same trend and the values decreased from 11.03, 12.74 to reach 8.78 and 8.91% in soil profiles, respectively. The same trend was obtained under cultivation of faba bean whereas the mean values of ESP% were decreased.

Soil pH:

Data in Table (4 and 5) showed that application of phosphogypsum, gypsum and calcium superphosphate led to slight decrease in values of soil pH. These results are in agreement with those obtained by El-Saady (2004).

Table (5): Some chemical properties of the studied soil after harvesting faba bean

Treat.	Profile No. Depth (cm)	EC dS m^{-1} at 25°C	Anions meq L^{-1}				Cations meq L^{-1}				pH 1:2.5	SAR	ESP
			$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$	Ca^{++}	Mg^{++}	Na^{+}	K^{+}			
	P1												
T1	0-30	5.17	-	3.50	30.00	51.19	41.60	17.80	24.00	1.29	7.78	4.40	5.95
	30-60	13.61	-	4.00	140.00	130.62	93.60	64.80	112.00	4.22	7.73	5.82	7.27
	60-90	19.05	-	2.50	200.00	134.58	52.00	86.60	191.00	7.48	7.82	21.78	
	90-120	30.84	-	2.50	380.00	167.61	83.20	95.00	362.00	9.91	8.02	9.44	
	120-150	46.26	-	3.50	720.00	664.90	166.40	190.00	632.00	4.00	7.97	13.35	
	P2												
T2	0-30	6.13	-	3.00	65.00	67.95	36.40	37.85	60.00	1.70	7.80	9.85	11.05
	30-60	21.69	-	2.00	230.00	144.27	62.40	66.30	243.00	4.57	7.88	30.30	30.74
	60-90	34.89	-	2.00	480.00	183.70	104.00	113.80	442.00	5.90	7.96	23.18	
	90-120	66.64	-	3.00	920.00	288.77	166.40	190.00	844.00	11.39	7.96	63.22	
	120-150	47.15	-	3.50	720.00	271.67	166.40	150.40	668.00	10.37	7.78	53.06	
	P3												
T2	0-30	8.77	-	3.00	75.00	552.02	46.80	17.55	64.00	1.72	7.85	8.59	9.87
	30-60	25.46	-	1.50	320.00	144.43	62.40	96.00	306.00	1.53	7.98	34.38	34.70
	60-90	13.20	-	2.50	130.00	76.80	52.00	47.00	108.00	2.30	7.85	15.34	
	90-120	33.95	-	2.25	500.00	152.96	81.20	136.60	432.00	5.41	7.87	35.32	
	120-150	52.81	-	4.50	840.00	166.36	124.80	192.00	784.00	10.06	7.67	62.27	
	P3												
T4	0-30	6.32	-	2.00	30.00	48.08	38.16	16.92	22.80	2.20	7.83	6.25	7.90
	30-60	18.14	-	3.00	190.00	149.59	62.40	76.80	201.00	3.99	7.92	24.10	12.30
	60-90	23.34	-	2.50	300.00	129.14	83.30	180.00	264.50	3.79	7.83	23.06	
	90-120	30.60	-	2.30	320.00	96.90	59.40	50.80	305.60	3.00	7.90	41.86	
	120-150	45.90	-	1.30	520.00	387.30	58.10	226.40	620.00	7.00	8.1	52.01	

T_1: subsoiling, T_2: subsoiling + application of 1.5 ton gypsum fed^{-1}, T_3: subsoiling + application of 1 ton gypsum fed^{-1}. + 50 kg calcium super phosphate (15.5%), T_4: subsoiling + 200 kg phosphogypsum fed^{-1}.

Groundwater table depth before and after rice and faba bean cultivation:

The water table depth were varied from 113 cm and 95 cm before transplanting of rice and 78 to 80 cm after harvesting of rice. The variations in the groundwater salinity at different water table position under abovementioned crops is shown in Tables (6 and 7). The salinity of groundwater was 139.6 dS m^{-1} in profile 2 before conducting the treatments and 24.48 dS m^{-1} in profile after harvesting rice crop while the mean values of soil salinity of groundwater after harvesting of faba bean increased compared with values obtained after harvesting rice. This finding might be due to decreasing number of irrigations in case of faba bean comparing with rice, which received a large number of irrigations that decreased the soil salinity of groundwater table.

Table (6): Chemical analysis of groundwater.

Profile	EC dS m^{-1}	Anions (meq L^{-1})				Cations (meq L^{-1})				Water table depth (cm)
		CO_3^{-}	HCO_3^{-}	Cl^{-}	$SO_4^{=}$	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	
Before planting rice										
P1	76.6	-	17.5	1400.0	100.0	236.8	715.2	504.0	62.3	113
P2	139.6	-	8.60	2900.0	1908.6	592.0	1312.0	2770.0	143.2	115
P3	68.3	-	21.70	1040.0	473.4	236.8	323.2	928.0	47.1	95
P4	55.1	-	22.00	800.0	546.7	266.4	277.6	784.0	40.7	95
After planting rice										
P1	24.48	-	23.5	220.0	322.81	177.60	80.80	301.00	6.91	78
P2	55.80	-	24.5	880.0	598.31	296.00	329.60	864.00	13.21	79
P3	39.16	-	22.5	520.0	512.71	296.00	180.00	566.00	13.21	80
P4	50.91	-	23.5	720.0	597.15	355.50	147.70	824.00	13.45	80

Table (7): Chemical analysis of groundwater after harvesting of faba bean.

Profile	EC dS m^{-1}	Anions (meq L^{-1})				Cations (meq L^{-1})				Water table depth (cm)
		CO_3^{-}	HCO_3^{-}	Cl^{-}	$SO_4^{=}$	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	
Before planting										
P1	46.82	-	40.0	72.0	311.93	208.0	276.2	580.0	7.73	88
P2	51.07	-	48.0	800.0	311.64	249.6	304.8	596.0	9.24	83
P3	55.33	-	48.0	840.0	301.51	208.0	267.2	704.0	10.31	90

Water table drawdown through faba bean growing season:

As clearly shown in Figure (1), the values of water table drawdown due to improvement of drainage system conditions after irrigation gives the chance for the effective root zone to dry, shrink and form water pathways. It is worthy to mention that the drying process plays an important role in the drainage of heavy clay soils because it improves the soil structure and permeability.

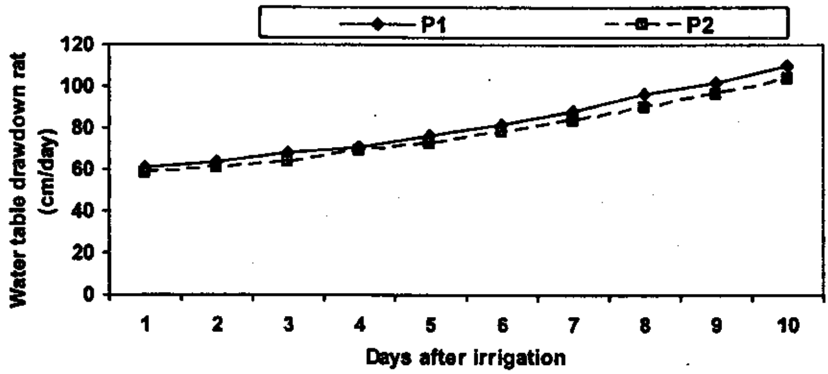

Fig. (1): Average rate of water table drawdown under cultivation of faba bean crop during the growing season.

Ammonium nitrate in groundwater through faba bean growing season:

Data in Table (8) showed that NO_3^- concentration in groundwater varied from 21.00 to 76.25 ppm. The variation in NO_3^- concentration with groundwater might be attributed to many factors mainly environmental and practices condition as well as the form of N-fertilizer applied. El-Agrodi *et al.* (1997) found that in the the NO_3-N in the groundwater varied from 9.5 to 26.26 ppm. Ammonium concentration in groundwater was less than NO_3-N where that the values varied from 5.25 to 10.5 ppm. Ammonium rapidly adsorbed by the colloids, since oxidized into nitrates. Increased NO_3^- in groundwater comparing with NH_4^+, might be increasing leaching rate of NO_3^- compared with NH_4^+ which is adsorbed on particles of clay. These results are in agreement with those obtained by Ramadan *et al.* (2009).

Table (8): Ammonium and nitrate in groundwater through season for faba bean.

No. of days after irrigation	NH_4^+ (ppm)	NO_3^- (ppm)
1	7.0	35.0
2	7.0	68.25
3	8.75	76.25
4	7.0	71.75
5	7.0	31.50
6	7.0	35.00
7	7.0	28.00
8	8.75	36.75
9	10.5	59.50
10	7.0	21.00
11	5.25	56.00
12	10.5	52.00

1. Yield for the two crops:

1.1. Rice grain yield

For better leaching of salts and reduction of exchangeable sodium in the presence of added gypsum rates, all the area of the experiment field was cultivated with rice in summer season, 2009 (varied from 4.2 to 5.7 ton fed^{-1}). Results of rice grain yield of the various treatments are presented in Table (9). Where the best treatment was found with subsoiling combined with application of phosphogypsum treatments.

1.2. Rice straw yield:

Data in Table (9) showed that rice straw yield varied from 5.58 to 7.98 ton fed^{-1}. This could be explained by pronounce improvement in soil physical and chemical characteristics

2.1. Faba bean grain yield:

Data in Table (10) showed that the application of phosphogypsum, gypsum, calcium superphosphate combined with subsoiling and efficient drainage, gave the highest yield for seeds and straw of faba bean comparing with other treatments. Increasing seeds and straw yield under these conditions might be due to improvement of drainage conditions, this results is corresponding with Atwa *et al.* (2009).

Table (9): Effect of soil amendments application on productivity of rice grains and straw yield (mean of three replicates).

Treatment	Grain yield (ton fed^{-1})	Straw yield (ton fed^{-1})
T1	4.2	5.58
T2	4.8	6.72
T3	5.4	7.56
T4	5.7	7.98
F. test	**	**
L.S.D. 0.05	0.339	0.375
L.S.D. 0.01	0.494	0.546

** Highly significant

T_1: subsoiling, T_2: subsoiling + application of 1.5 ton gypsum fed^{-1}, T_3: subsoiling + application of 1 ton gypsum fed^{-1}. + 50 kg calcium super phosphate (15.5%), T_4: subsoiling + 200 kg phosphogypsum fed^{-1}.

Table (10): Effect of soil amendments application on productivity of faba bean plant (mean of three replicates).

Treatment	Seeds yield (ton fed^{-1})	Straw yield (Ton fed^{-1})
T1	1.22	2.13
T2	1.80	3.25
T3	1.70	2.69
T4	1.63	2.47
T5	1.73	2.48
T6	1.46	2.24
T7	1.43	3.36
T8	1.32	2.14
F. test	**	**
L.S.D. 0.05	0.0322	0.0548
L.S.D. 0.01	0.0444	0.0755

** Highly significant

T_1: control, T_2: 100 kg calcium superphosphate (15.5%) + 1 ton gypsum fed^{-1} + 100 kg phosphogypsum fed^{-1}, T_3: 100 kg calcium superphosphate (15.5%) fed^{-1}+ 1 ton gypsum fed-^{1}, T_4: 200 kg phosphogypsum fed^{-1}, T_5: 100 kg calcium superphosphate (15.5%)+ 100 kg phosphogypsum fed^{-1}, T_6: 1 ton gypsum fed^{-1}, T_7: 1 ton gypsum fed^{-1} + 200 kg phosphogypsum fed^{-1}, T_8: 200 kg calcium superphosphate (15.5%) fed^{-1}

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مدى استجابة بعض المحاصيل الحقلية للخدمة الجيدة فى الأراضى المتأثرة بالأملاح فى شمال دلتا النيل

الجندى عبدالرازق سليمان جندى
معهد بحوث الأراضى والمياه والبيئة – مركز البحوث الزراعية – الجيزه – مصر

نفذت تجربة حقلية فى منطقة الحامول بمحافظة كفرالشيخ – مصر وذلك خلال موسمى النمو ٢٠٠٩، ٢٠٠٩/ ٢٠١٠م وكان الهدف الأساسى من الدراسة هو أثر تحسين ظروف الصرف و كذلك الخدمة الجيدة وإضافة بعض المحسنات على الخواص الفيزيائية والكيميائية والهيدرولوجية للمنطقة موضع الدراسة ومن ثم إدخال محاصيل وأصناف جديدة بهذه المنطقة مثل الأرز الهجين فى الموسم الصيفى والفول البلدى فى الموسم الشتوى.

وكانت المعاملات فى الموسم الصيفى:

١- الحرث تحت التربة.
٢- الحرث تحت التربة مع إضافة ١.٥ طن جبس/فدان.
٣- الحرث تحت التربة مع إضافة ١ طن جبس/فدان وإضافة ٥٠كجم سوبر فوسفات الكالسيوم (١٥.٥%) /فدان.
٤- الحرث تحت التربة (Subsoiling) وإضافة ٢٠٠كجم فوسفو جيبسيم.

وكانت المعاملات فى الموسم الشتوى كالتالى:

١- كنترول.
٢- إضافة ١٠٠كجم سوبر فوسفات مع ١ طن جبس زراعى /فدان و ١٠٠كجم فوسفو جيبسيم/فدان.
٣- إضافة ١٠٠كجم سوبر فوسفات الكالسيوم ١٥.٥%+ ١ طن جبس زراعى /فدان.
٤- إضافة ٢٠٠كجم فوسفو جيبسيم.

٥- إضافة ١٠٠كجم سوبر فوسفات الكالسيوم ١٥.٥% + ١٠٠كجم فوسفو جيبسيم.
٦- إضافة ١ طن جبس زراعى /فدان.
٧- إضافة ١ طن جبس/فدان مع ٢٠٠كجم فوسفو جيبسيم/فدان.
٨- إضافة ٢٠٠ كجم سوبر فوسفات كالسيوم /فدان

وأوضحت النتائج ما يلى:

- تناقص متوسط القيم بالنسبه للصوديوم المتبادل (ESP) وذلك بسبب الخدمة الجيدة بعمل Subsoiling وإضافة المحسنات.
- إزداد متوسط قيم المسامية الكلية وكذلك قيم التوصيل الهيدروليكى وانخفاض مستوى الماء الأرضى.
- الفقد بالنسبه للأمونيوم والنترات: فقد الأمونيوم تناقص بينما على العكس زيادة فقد النترات.
- تناقص مستوى الملوحة بالنسبه للماء الأرضى بعد حصاد الأرز وكذلك بالنسبه للفول البلدى.
- إنتاج الأرز الهجين كان عاليا ووصل إلى ٥.٧ طن/فدان وذلك تحت ظروف الحرث تحت التربة Subsoiling مع إضافة ٢٠٠كجم فوسفو جيبسيم.
- إزداد إنتاجية الفول البلدى إزداد نتيجة لخفض ملوحة التربة مع زراعة صنف سخا ٢ المقاوم للملوحة.
- وكانت أعلى القيم هى ١.٨ طن/فدان من الحبوب بالنسبة للفول البلدى تحت المعاملة إضافة ١٠٠كجم سوبر فوسفات كالسيوم (١٥.٥%) مع ١طن جبس زراعى/فدان و ١٠٠كجم فوسفو جيبسيم.

لذلك يوصى بالاهتمام بظروف الصرف الزراعى والخدمة الجيدة لهذه الاراضى مع إضافة محسنات التربة من الجبس الزراعى وسوبر فوسفات الكالسيوم والفوسفوجيبسم وزراعة أصناف من المحاصيل المتحملة للملوحة وذلك للحصول على إنتاجية عالية من هذه المحاصيل.

قام بتحكيم البحث

أ.د / احمد عبد القادر طه	**كلية الزراعة – جامعة المنصورة**
أ.د / محمود محمد سعيد	**مركز البحوث الزراعية**