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The Integrated Levels Impacts of Farmyard Manure with Phosphorus Fertilizers and Irrigation on Soil Properties and Wheat Productivity under Saline Soils in North Delta, Egypt

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ABSTRACT

To study the effect of Farmyard manure with or without phosphorus fertilization and irrigation deficit under salt affected soils on yield and yield components of wheat (*Triticum aestivum* L) and some soil properties as well as productivity of irrigation water (PIW) and economic return an experiment was conducted at North Nile Delta area for two winter seasons (2016/17 and 2017/18). A split-plot complete randomized plot design with three replicates was used. Two irrigation levels, I_{full} (50 % moisture depletion) and I_d (70 % moisture depletion) occupied the main plots. Farmyard manure (FYM) and two P sources (super phosphate, Ps, and ammonium phosphate, Pa) were applied to the sub-main plots. The results can be summarized as follows:FYM improved wheat productivity. So, FYM increased the grain yield and straw yield by 40.85 and 14.54, %, respectively over the control.The grain yield was increased by 13.25 and 15.90 %, while the increases in the straw yield were 5.19 and 1.71 % in plots received Ps or Pa, respectively. P fertilization combined with FYM was more effective on wheat productivity. Therefore, the application of Ps+ FYM increased the grain and straw yields, by 56.50 and 17.92%, respectively, also the corresponding increases with Pa+FYM were 56.37 and 14.17%, respectively over the control. Irrigation deficit (I_d) adversely affected the wheat productivity. I_d decreased the grain yield and straw yield, by 11.75 and 5.30 %, respectively compared to I_{full}.FYM application with or without P fertilizers were more pronounced relative to P fertilizers individual or untreated soils in reducing the salinity and sodicity of the soil. Data showed 15.62 and 14.26% decreases in EC_e for Ps+FYM and Pa+FYM, respectively than untreated soils. The corresponding values of SAR were 8.45 and 8.06%, respectively.Irrigation at 50% soil moisture depletion resulted in decreased ECe (9.70%) and SARe (7.39 %) than irrigation at 70% depletion. The application of FYM with or without P fertilizers resulted in enhancing the HC, AW, SP and buke density comparing to P fertilizers alone or untreated soils especially with the irrigated at 50% soil moisture depletion. FYM application with or without P fertilizers in heavy clay salt affected soils were more pronounced in enhancing PIW and increasing net return and economic efficiency relative to P fertilizers alone or untreated soils especially when irrigated at 50%soil moisture depletion.The maximum net return and economic efficiency for wheat yields were achieved from Ps +FAY under full water requirements.

Keywords: FYM, P; soil properties; wheat yield, yield components.

INTRODUCTION

In order to achieve the self-sufficiency from wheat in Egypt, the proper agronomic practices are to be followed. Application of organic amendments plays an important role in improving soil properties, soil fertility and can replace part of the expensive chemical fertilizers. Nutrients are released more slowly from organic manure and they are stored for a longer time in the soil, thus ensuring a long residual effect (Abou Elmagd *et al*., 2005 and Tadesse *et al* 2013). Organic manure application improved soil physical and chemical properties due to enhance water holding capacity of soil, cation exchange capacity, soil aeration, soil bulk density, aggregate stability, seed germination and plant growth (Sultani *et al*. 2007, Loper, *et al*. 2010, Salahin *et al*. 2011, Aiad *et al*. 2012, Assefa, 2015, Schoebitz and Vidal, 2016 and Adugna, 2016), increase the saturated hydraulic conductivity (Ndiaye, *et al*, 2007). Application of farmyard manures have positive effects on the soil physical and chemical properties (Suja and Sreekumar, 2014), since water holding capacity and organic carbon content were increased, while bulk density was decreased (Lentz and Lehrsch, 2014). In addition, farmyard manure at the rate of 30-ton ha^{-1}, decreased the soil bulk density from 1.46 to 1.38 g cm^{-3} (Talenghani *et al*., 2006). Organic amendments can alleviate the adverse effects of soil salinity in arid areas. Consequently, with the scarcity of freshwater, organic matter is an effective alternative to decrease soil EC and ESP by forming soil aggregates and breaking capillary rise in reclaimed salt-soil (Bai, *et al*, 2013). Oustani, *et al* (2015) observed significant interaction between poultry manure (PM) and salinity level and the highest yield (44.55 $mtha^{-1}$) was recorded with 60-ton $PMha^{-1}$ in high saline soils (5.9 dSm^{-1}), so, 60 ton $PMha^{-1}$ is an optimal amount producing the best potato yields under saline conditions in arid soils. Under salt affected soil, Zoghdan *et al*. (2019) reported that, the highest reduction of ECe, SAR and ESP were induced by the interaction between application of 10-ton compost fed^{-1} with full irrigation treatment, while the lowest reductions were recorded with 90 kg N fed^{-1} and irrigation cut-off at 70 % of furrow length.

The reclamation of salt-affected soils should be done by simple leaching practices to bring them to non-saline, non-sodic soils for economical crop production. Sufficient water should be available for reclamation, irrigation and leaching practices (Pazira and Homaee, 2010). Sarraf, *et al*., (2010) concluded that, the solved salts leaching from the alluvial, heavy textured, saline and sodic soils of the region using the intermittent water application (intermittent salt leaching method) has been effective in reducing the soluble salts, especially in the soil profile shallow layers. Abd El-Kader,*et al* (2010) indicated that 1798 m^3/acre irrigation water along with two 6 ton composted or chicken manure/acre gave the highest yield of okra (104% increase) as compared to 1199 or 2398 m^3/acre. Khafagy and Salama (2018) found that, the narrow irrigation intervals which were received the highest amount of irrigation water had favorable effective to improve physio-chemical characteristics of heavy clay salt effect soils and increase productivity of irrigation water for wheat crop compared to wider irrigation intervals.

P is the second most important macro nutrient and plays significant role in physiological and biochemical reactions such as photosynthesis (Mehrvarz *et al*., 2008). So, grain yield and P accumulation by wheat are higher for higher P rates (Singh *et al* 2000). In addition, P availability to the crops is highly enhanced by the biological processes, especially in which the source is organic amendments as their major nutrient (Nziguheba and Noman, 2005), where its availability was increased dramatically with poultry

manure (Bodruzzaman, 2010). Therefore, the combined of FYM and NP fertilizers were more effective for wheat than one of them individually (Chekolle 2017) because the nutrients from the organic manures are supplemented with inorganic nutrients that are readily available to plants (Ayoola and Makinde, 2008). In addition, Aatif, *et al*. (2017) concluded that 120 kg P ha^{-1} with 9 tons FYM ha^{-1} improved yield and yield components of wheat.

The quantity of crop residues in Egypt range from 30-35 million tons/yr of which 7 million as animal feed and 4 million as organic manure are being utilized (Abou Hussein, *et al* (2010). So, it can be composted to improve the soil fertility and to replace part or complete of the chemical fertilizers. For instance, the organic amendments alone produced more favorable effects on soil productivity, while NPK fertilizers plus manure are the preferred option to increase soil organic carbon, improve soil fertility and quality and consequently, increase crop yield (Liu *et al*, 2017). The combined application of inorganic fertilizers like P which is relatively immobile in the soil and organic amendments like compost or FYM improves its availability and raises the agricultural productivity (David *et al*. 2003). Also, application of P (120 kg ha^{-1}) and FYM (9 tons ha^{-1}) improved wheat yield and its components (Baqa *et al*, 2015, Muhammad *et al*, 2017 and Phullan, *et al*, 2017), soil pH and bulk density decreased, while soil organic carbon, porosity and uptake of NPK nutrients were higher than one of them alone Meena, *et al*., 2018). The incorporation of organic manures along with mineral fertilizers can help in improving soil properties and reduce nutrient leaching, thereby increase the efficacy of mineral fertilizers (Tadesse *et al* 2013) and significantly increased the wheat productivity (Shah *et al*, 2013). Therefore, an integrated use of inorganic enhances efficiency of the chemical fertilizers due to reducing nutrient losses (Schoebitz and Vidal, 2016).

This study investigated the effects of FYM, phosphorus and irrigation levels and their integrations on some soil properties, wheat productivity, productivity of irrigation water (PIW) and economic return from wheat production under salt-affected soils.

MATERIALS AND METHODS

Field site and the experimental treatments:

The experiments were carried out in Elriad district at North Delta, Kafrelsheikh Gov., Egypt, during two winter seasons (2016-17 and 2017-18) to study the effect of phosphorus, Farmyard manure and irrigation levels on soil physio-chemical properties, wheat productivity, productivity of irrigation water (PIW) and economic return from wheat production under salt-affected soils in North Nile Delta. The experiment was located at 31.3 Latitude and 31.2 Longitude. Some soil properties before conducting the experiments are presented in Table 1. The experiment was laid out in a split-plot design with three replicates as follows:

Main plots:

Irrigation treatments:

1- I_{full} (50 % moisture depletion).
2- I_d (70 % moisture depletion).

Sub- main plots:

Organic amendments (FYM) and phosphorus sources (Super and ammonium phosphate):

1- P_0 (Without amendments and phosphorus)
2- P_s (Superphosphate)
3- P_a (Ammonium Phosphate)
4- FYM (Farmyard manure)
5- Ps + FYM (Superphosphate + Farmyard manure)
6- Pa + FYM (Ammonium Phosphate +Farmyard manure)

FYM, at rate of 10tonha^{-1} was added before tillage operation as well as Ps and Pa were applied at rate of 120 kgha^{-1} with tillage before sowing. Seed rate for wheat variety Sakha 94 was used at 120 kg ha^{-1} on flat border. All the other recommended agronomic practices were applied uniformly to all plots. All plots received 175 kgha^{-1} nitrogen (as urea 46.5%) was applied in two doses, following first and second irrigates respectively.

Measurements:

Plant height, 1000-grain weight, grain and straw yields were determined. Soil samples before planting and after harvesting from 0-30 cm depth as well as FYM were subjected to chemical and physical analysis according to Richards (1954, Jackson (1973), Garcia (1978), Black (1983) and Klute (1986) as shown in Tables 1&2.

Water consumptive use (C.U): was calculated according to (Israelson and Hansen, 1962) as follows:

$$CU = \sum_{i=1}^{i=n} \frac{Pw_2 - pw_1}{100} X D_{bi} X D_i$$

Where:

C.U. : Water consumptive use in cm.

Pw_2 : Soil moisture percent after irrigation in the i th layer

Pw_1 : Soil moisture percent before the next irrigation in the i th layer

D_{bi} : Bulk density gcm^{-3} of the i th layer of the soil

D_i : Depth of the i th layer of the soil, cm

i : Number of soil layer sampled in the root zone depth (D).

Applied irrigation water:

The amount of irrigation water was measured by using a rectangular sharp crested weir. The discharge was calculated using the following equation as described by (Masoud, 1969).

$$Q = CL(H)^{1.5}$$

Where:

Q = Discharge (m^3s^{-1})

L = Length of the crest (m).

H = Head above the weir (m).

C= Empirical coefficient determined from discharge measurement.

Productivity of irrigation water (PIW, kgm^{-3}): was calculated according to Ali *et al*., (2007) as follows:

$$PIW = Gy/WA,$$

Where:

Gy= Grain and straw yields, kg ha.$^{-1}$,

WA= Water applied, m^3 ha^{-1}

Economic evaluation: Cash inflows and out flows for various treatments (at prices of the local market) were calculated, and some economic indicators were estimated according to the equations outlined by FAO, (2000). Such as:

- **Net return**: it can be calculated by deducting the total cost from the total return, (LEha.$^{-1}$)
- **Economic efficiency**: it can be calculated by dividing the total net return on total cost

Statistical Analysis:

The obtained data were analyzed statistically using analysis of variance according to Gomez and Gomez (1984).

Treatment means were compared using the least significant difference test (LSD) at 0.05 level.

Table 1. Some chemical and physical properties of the top soil layer before experiment.

Depth (cm)	EC (dsm^{-1})	pH (1:25)	SAR	CEC	Soluble cations ($meqL^{-1}$)				Soluble anions ($meqL^{-1}$)			
					Ca^{+2}	Mg^{+2}	Na^{+1}	K^{+}	CO_3^{-2}	HCO_3^{-}	Cl^{-1}	SO_4^{-2}
0-30	6.5	7.8	13.5	35	13.7	7.8	44.5	0.7	0.0	5.5	30.9	29.9

	Particle size distribution %			Texture class	Soil moisture characteristics %			Bulk density	OM
	Clay	Silt	Sand		F.C.	P.W.P.	A.W.	Mgm^{-3}	%
0-30	51.98	29.68	18.34	Clayey	40.38	20.61	19.77	1.25	1.98

Table 2. Some chemical characteristics of Farmyard manure.

DM	Ash	pH	TOC	Total N	C/N ratio	Total K	Total P	Phenolics (1:25)	Carbohydrates	
									Total	Water soluble (1:25)
(%)		(1:25)	(%)						$Mg\ g^{-1}$	
3.5	30.5	7.6	31.7	3.75	8.4	43.1	11.0	10.8	122.6	10.2

Humification (1:100)					
TEC (%)	C_{HA} (%TEC)	C_{FA}	HD (%)	HR	HI
9.2	65.8	10.1	75.9	22.1	0.3

Total heavy metals ($\mu g\ g^{-1}$)						
Co	NI	Pb	Cd	Cu	Zn	Cr
4	14	60	6	66	340	9

RESULTS AND DISCUSSION

Effect of different treatments on wheat productivity:

Data regarding the yield (grain and straw) and some yield components (plant height and 1000-grain weight) of wheat as affected by different treatments are reported in Tables 3-6. Statistical analysis of the data revealed that the yield and yield components of wheat grown are significantly affected by the application of FYM with or without both P fertilizers in both growing seasons. It could be observed that the yield ant its components in the 1st season are approximately like that in the 2nd season.

Effect different treatments on plant height and 1000-grain weight:

Effect of the organic fertilization:

The effect of FYM on plant height and 1000-grain weight of wheat was somewhat higher than control, whereas FYM slightly increased both parameters by about 1.01 % and 1.6 %, respectively comparing to the control as shown in Tables (3 and 4).

Effect of inorganic fertilization:

Regarding the effect of phosphate fertilizers, the results show that both of super phosphate (Ps) and ammonium phosphate (Pa) slightly increased plant height (1.06 and 1.58 %, respectively) and thousand-grain weight (2.34 and 2.28 %, respectively). The results showed also positive significant interactions between both P fertilizers and FYM on vegetative growth and grain filling. Therefore, the application of Ps fertilizers with FYM increased plant height and thousand-grain weight by 5.04 and 7.7 %, respectively, the corresponding increase of both parameters due to application of Pa fertilizers with FYM were 3.06 and 6.10 %, respectively comparing to the untreated plots.

Effect of irrigation level:

The mean data values showed that the irrigation level significantly affected both vegetative growth and grain filling. The irrigation deficit (I_d) decreased the plant height and thousand-grain weight by 8.84 and 3.42 %, respectively compared to the recommended irrigation level (full water requirements, I_{full}).

Finally, the statistical analysis of data revealed that the plant height and thousand-grain weight significantly affected by the interaction between all studied treatments as shown in Table 4.

Table 3. Mean values of plant height and 1000-grain weight of wheat as affected by different treatments (average of two seasons).

Treatments	Plant height (cm)		1000 grain weight (g)	
	Mean	Relative change %	Mean	Relative change %
P_0	106.13	0.00	40.58	0.00
P_s	107.25	1.06	41.53	2.34
P_a	107.80	1.58	41.50	2.28
FYM	107.20	1.01	41.23	1.60
P_s+FYM	111.48	5.04	43.70	7.70
P_a+FYM	109.38	3.06	43.05	6.10
Full irrigation	113.13	6.60	42.66	5.13
Deficit irrigation	103.28	-2.68	41.20	1.54

Table 4. Plant height and 1000-grain weight of wheat as affected as affected by different treatments.

Treatments		2016/2017		2017/2018	
Irrigation	Amendments	Plant height (cm)	1000 grain weight (g)	Plant height (cm)	1000 grain weight (g)
Full irrigation	P_0	111.7	40.7	110.8	40.8
	P_s	112.1	42.1	112.1	42.1
	P_a	112.0	42.0	112.0	42.0
	FYM	111.6	41.0	111.9	41.8
	P_s+FYM	117.0	45.0	117.0	45.1
	P_a+FYM	114.6	44.6	114.7	44.7
Mean		113.2	42.6	113.1	42.8
Deficit irrigation	P_0	99.8	40.9	102.2	39.9
	P_s	101.5	41.7	103.3	40.2
	P_a	103.0	41.0	104.2	41.0
	FYM	101.9	41.0	103.4	41.1
	P_s+FYM	106.2	42.4	105.7	42.3
	P_a+FYM	104.3	41.4	103.9	41.5
Mean		102.8	41.4	103.8	41.0
LSD 0.05	I	2.02	1.02	1.98	0.98
	A	1.13	0.55	1.06	0.63
	IxA	2.46	1.12	2.07	1.32

The results showed that the tallest plants (117.0 cm) and the maximum weight of thousand-grain (45.1 g) were found in the plot treated by FYM with Ps under full water requirements. On the other hand, the shortest plants (99.8 cm) and the minimum thousand-grain weight (39.9) were recorded from the unfertilized plots with deficit irrigation. These results are in somewhat harmony with those obtained by Aatif *et al*. (2017).

Effect different treatments on wheat grain and straw yields (Tables 5and 6):

Effect of the Farmyard manure:

Statistical analysis of the data revealed that the FYM with and without phosphate fertilizers have desirable effect on grain and straw yields. The mean values of both growing seasons indicated FYM increased the grain and straw yields as shown in Table 5. The grain and straw yields showed 40.58% and 14.54% increases, respectively over the control due to application of FYM, comparing to that produced from the untreated plots. These results are agreed with the finding of Muhammad *et al*. (2017) who concluded that the application of organic-matter is one of the most important factors for increasing the productivity of wheat, due to significant contribution of organic P to P nutrition of plants.

Effect of inorganic fertilization:

Regarding the effect of phosphate fertilizers, the mean results of both growing seasons showed that Ps and Pa significantly increased the wheat productivity comparing to the check plots. The obtained results showed 13.25 and 15.90 % increases of grain yield in plots treated by Ps or Pa, respectively, while the increases in straw yield were 5.19 and 1.71 % with both P sources, respectively over that produced from the control plots. The results showed also that the interactions between P fertilizers and FYM strongly affected wheat productivity, especially with the fruits. Therefore, the application of Ps as well as Pa fertilizers with FYM increased the grain and straw yields by 56.50 and 17.92 % as well as 56.37 and 14.17%, respectively, comparing to the untreated plots. These results agree with findings of Assefa (2015) who found that the application of organic materials alone or in combination with inorganic fertilizer helped in maintenance of soil fertility and crop productivity, where P availability is increased dramatically with poultry manure (Bodruzzaman, 2010). Also, applying of P fertilizer can increase wheat yield, even in soils having high amount of P (Jackson *et al*, 1997). In addition, Wang *et al*. (2004) concluded that the combination of mineral fertilizers and FYM gave the best crop yield and soil quality. Also, application of P (120 kg ha^{-1}) and FYM (9 tons ha^{-1}) improved wheat yield and its components (Baqa *et al*, 2015, Muhammad *et al*, 2017 and Phullan, *et al*, 2017).

Effect of irrigation level:

The mean data values show that the irrigation treatments significantly affected both vegetative and fruits productions. The irrigation deficit (I_d) negatively affected wheat growth since it decreased the grain yield and straw yield by 11.75 and 5.30 %, respectively compared to the plots received full water requirements (I_{full}). These results could be enhanced with those obtained by Al-Harbi *et al* (2008) who suggested that the controlled irrigation is essential for high yields because the crop is sensitive to both over and under irrigation.

These results are in somewhat harmony with those obtained by Oustani, *et al* (2015) who observed significant interaction between poultry manure and soil salinity on the crop production. Also, according to Abd El-Kader, *et al* (2010) the proper irrigation water quantity along with composted or chicken manure gave the highest productivity.

Table 5. Mean values of grain and straw yields of wheat as affected by different treatments (average of two seasons).

Treatments	Grain yield ($tonha^{-1}$)		Straw yield ($tonha^{-1}$)	
	Mean	Relative change %	Mean	Relative change %
P_0	3.87	0.00	5.40	0.00
P_s	4.38	13.25	5.68	5.19
P_a	4.48	15.90	5.49	1.71
FYM	5.45	40.85	6.18	14.54
P_s+FYM	6.05	56.50	6.37	17.92
P_a+FYM	6.05	56.37	6.16	14.17
Full irrigation	5.36	38.55	6.04	11.89
Deficit irrigation	4.73	22.41	5.72	5.96

Table 6. Grain and straw yields of wheat as affected by different treatments.

Treatments		Season (2016/2017)		Season (2017/2018)	
Irrigation	Amendments	Grain yield ($tonha^{-1}$)	Straw yield ($tonha^{-1}$)	Grain yield ($tonha^{-1}$)	Straw yield ($tonha^{-1}$)
Full irrigation	P_0	3.92	5.46	3.94	5.50
	P_s	4.55	5.74	4.58	5.71
	P_a	4.57	5.63	4.68	5.65
	FYM	6.19	6.31	6.24	6.42
	P_s+FYM	6.39	6.69	6.49	6.62
	P_a+FYM	6.35	6.41	6.40	6.33
Mean		5.33	6.04	5.39	6.04
Deficit irrigation	P_0	3.79	5.29	3.82	5.34
	P_s	4.17	5.62	4.22	5.64
	P_a	4.25	5.35	4.43	5.33
	FYM	4.67	5.96	4.69	6.04
	P_s+FYM	5.63	6.02	5.70	6.13
	P_a+FYM	5.71	5.94	5.73	5.97
Mean		4.70	5.70	4.77	5.74
LSD 0.05	I	0.199	0.235	0.321	0.572
	A	0.053	0.103	0.174	0.23
	IxA	0.224	0.183	0.248	0.426

Effect of different treatments on soil properties (Tables 7 and 8):

Changes in chemical properties:

Effect of the fertilization: The results in Tables 7 and 8 reveal that the P fertilizers slightly effect on soil chemical properties. The values of ECe and SARe were somewhat increased by 0.15 and 0.19 %, respectively for both P sources comparing with the untreated plots.

Regarding the effect of Farmyard manure, results indicated that FYM application with or without P fertilizers were more pronounced relative to untreated soils in reducing the salinity and sodicity of the soil. This may be due to the improved soil physical properties such as bulk density, porosity, aggregates stability and infiltration rate that affect water-air relationships in the root zone (Gibberson, *et al*, 2016).

Table 7. Mean values of some soil chemical properties as affected by different treatments after the 2nd season.

Treatments	EC (dSm^{-1})	Relative change %	SAR	Relative change %
Control	6.66	0.00	12.96	0
P_s	6.67	0.15	12.99	0.19
P_a	6.67	0.15	12.99	0.19
FYM	6.31	-5.33	12.22	-5.75
Ps+FYM	5.62	-15.62	11.87	-8.45
Pa+FYM	5.71	-14.26	11.92	-8.06
Full irrigation	5.98	-10.19	12.04	-7.10
Deficit irrigation	6.56	-1.45	12.93	-0.21

Table 8. Some chemical properties of soil as affected by different treatments after the 2nd season.

Amendments	Full irrigation		Deficit irrigation	
	EC (dSm^{-1})	SAR	EC (dSm^{-1})	SAR
Control	6.61	12.76	6.71	13.15
P_s	6.45	12.69	6.89	13.28
P_a	6.47	12.71	6.87	13.26
FYM	6.03	11.68	6.58	12.75
Ps+FYM	5.12	11.16	6.12	12.57
Pa+FYM	5.21	11.24	6.21	12.59
Mean	5.98	12.04	6.56	12.93

Results also showed that, FYM with P fertilizers effects were superior to without P fertilizers on reducing soil salinity and sodicity. The values of EC_e showed 5.33%, decreases due to application of FYM and it decreased SARe values by 5.75 % compared to the untreated soils. Additionally, the application of FYM combined with P fertilizers showed 15.62 and 14.26% decreases in EC_e for Ps+FYM and Pa+FYM, respectively compared to the untreated soils. The corresponding values of SAR were 8.45 and 8.06%, respectively compared to the untreated plots.

Effect of irrigation level: The obtained results showed clear effects of deficit irrigation (I_d) on the chemical properties. The application of I_d system increased ECe and SARe values by 9.70% and 7.39 %, respectively over that with full water requirements (I_{full}). The decrease of ECe and SARe under full irrigation which was received the higher values of irrigation water can be attributed to increase the leaching of Na^+ ions compared with calcium and magnesium salts and consequently decreasing of SAR**.**

On the other hand, the chemical properties are slightly affected by the interaction between the studied treatments. The best interaction was between application of Ps+FYM with I_{full} since it achieved the lowest values of ECe (5.12 dSm^{-1}) and SAR (11.16). The highest ECe and SAR values (6.89 dSm^{-1} and 13.28, respectively) were recorded in plots treated by Ps without FYM under defect irrigation. These results are in line with those obtained by Wang *et al*. (2004).

Changes in physical properties:

Effect of the fertilization: The obtained results in Tables 9&10 illustrat slight effects of the P-fertilizers on hydraulic conductivity (HC) and saturation percentage (SP) but, do not effects on bulk density (Bd), available water (AW). The results showed that the application of Ps and Pa fertilizers slightly increased soil HC (0.49 and 0.49%, respectively) and SP (0.17 and 0.15%, respectively).

Table 9. Mean values of some physical properties of soil after 2nd season as affected by different treatments.

Treatments	Hydraulic conductivity ($cmday^{-1}$)	Relative change%	Bulk density (gcm^{-3})	Relative change%	Available water (%)	Relative change%	Saturation percentage (%)	Relative change%
Control	1.530	0.00	1.27	0.00	19.01	0.00	79.69	0.00
P_s	1.538	0.49	1.27	0.00	19.02	0.05	79.83	0.17
P_a	1.538	0.49	1.27	0.00	19.02	0.03	79.81	0.15
FYM	1.658	8.37	1.22	-4.13	20.43	7.47	81.13	1.80
Ps+FYM	1.672	9.25	1.21	-4.49	20.62	8.44	81.58	2.37
Pa+FYM	1.664	8.73	1.22	-4.09	20.56	8.15	81.62	2.42
Full irrigation	1.625	6.23	1.24	-2.48	20.11	5.79	80.97	1.60
Deficit irrigation	1.574	2.88	1.25	-1.89	19.44	2.25	80.25	0.70

Table 10. Some physical properties of soil after the 2nd season as affected by different treatments.

Amendments	Full irrigation		Deficit irrigation		Full irrigation		Deficit irrigation	
	Hydraulic conductivity ($cmday^{-1}$)	Bulk density (gcm^{-3})	Hydraulic conductivity ($cmday^{-1}$)	Bulk density (gcm^{-3})	Available water (%)	Saturation percentage (%)	Available water (%)	Saturation percentage (%)
Control	1.550	1.260	1.510	1.270	19.14	79.8	18.87	79.58
P_s	1.555	1.270	1.520	1.270	19.13	80.01	18.91	79.64
P_a	1.560	1.260	1.515	1.280	19.16	80.04	18.87	79.58
FYM	1.693	1.215	1.623	1.220	20.88	81.96	19.98	80.29
Ps+FYM	1.702	1.210	1.641	1.216	21.12	81.91	20.11	81.24
Pa+FYM	1.692	1.216	1.635	1.220	21.23	82.07	19.89	81.17
Mean	1.625	1.239	1.574	1.246	20.11	80.97	19.44	80.25

Concerning the effect of the Farmyard manure, the results showed positive effects of FYM combined or not with P on the physical properties. Therefore, the application of FYM individually increased the HC values by 8.37%; AW (7.47 %) and SP (1.80%) and they decreased the values of soil Bd (4.13%) comparing to the untreated soils. Also, the application of FYM combined with Ps or Pa fertilizers increased the values of HC (9.25 or 8.73 %, respectively), AW (8.44 and 8.15%, respectively) and SP (2.37 and 2.42%, respectively), and reduced the Bd (4.49 and 4.09 %, respectively) comparing to the check treatment. In generally, FYM application with or without P-fertilizers were more pronounced relative to P-fertilizers individual and untreated soils in enhancing soil physical properties that affect water-air relationships in the root zone. These results may be in somewhat attributed to that organic manure improved soil physical properties through aggregation enhancement and increase hydraulic conductivity (Ndiaye, *et al*, 2007). Also,

organic manure improved water infiltration rate (Bhattacharyya, *et al*, 2007), decrease bulk density (Dorado *et al*., 2003), enhance water holding capacity, soil cation exchange capacity and soil aeration (Hargreaves *et al*., 2008).

Effect of irrigation level: The deficit irrigation (I_d) slightly affected the studied physical properties. The application of I_{full} increased HC, AW and SP by 3.26, 3.46 and 0.89 %, respectively while, Bd was decreased by 0.60% compared to that obtained with I_d.

In addition, the soil properties are affected slightly by the interaction between different treatments. However, the application of FYM with P-fertilizer under full irrigation is the best interaction because it achieved relative high values of HC, AW and SP as well as relative low soil Bd value. These results are in line with those obtained by Wang *et al*. (2004) who observed that the combination of mineral fertilizers and FYM gave the best soil quality.

Water applied (WA, m^3ha^{-1}) and productivity of irrigation water (PIW, kg m^{-3})

Data presented in Table 11 indicate that, the irrigation at 50% soil moisture depletion had received the highest amount of irrigation water compared to the irrigation at 70% soil moisture depletion. Total amount of water applied (m^3ha^{-1}) including rainfall (7.5cm, mean of two seasons) of wheat crop was shown in Table (6). The average values of applied water were 5075 in the first season and 5055 in the second season with an average of 5065 $m^3ha.^{-1}$ under 50% soil moisture depletion. While, the amount of applied water was 4570 in the first season and 4594 in the second season with an average of 4582$m^3ha.^{-1}$ under 70% soil moisture depletion.

Productivity of irrigation water is generally defined as crop yield per cubic meter of water applied (Ali *et al*., 2007). Data presented in Table 11 illustrat that the values of PIW for wheat grain and straw yields were greatly influenced by different treatments. FYM application with or without P fertilizers were more pronounced relative to P fertilizers individual or untreated soils in enhancing PIW. This may be due to the improved soil properties and reduce nutrient leaching with amendments application, thereby increase the efficacy of mineral fertilizers (Tadesse *et al* 2013) and significantly increased the wheat productivity (Shah *et al*, 2013). Results revealed that, the overall mean values of PIW for grain yield with full irrigation varied from 0.78 to 1.27 kg m^{-3} with an average of 1.06 kgm^{-3} while, under deficit irrigation varied from 0.83 to 1.25 kg m^{-3} with an average of 1.03 kgm^{-3}. One the other hand, PIW values for straw yield was achieved high values with deficit irrigation (varied from 1.16 to 1.33 kg m^{-3} with an average of 1.25 kgm^{-3}) than full irrigation (varied from 1.08 to 1.31 kg m^{-3} with an average of 1.19 kgm^{-3}). This is due to the less amount of irrigation water with deficit irrigation.

Table 11. Over all values of water applied (m^3ha^{-1}) and productivity of irrigation water (Kgm^{-3}) for both grain and straw yields of wheat crop as affected by different treatments.

Irrigation	Amendments	water applied m^3ha^{-1}	Yields ($kgha^{-1}$)		Productivity of irrigation water (Kgm^{-3})	
			Grain	Straw	Grain	Straw
Full irrigation	P_0	5065	3928	5484	0.78	1.08
	P_s	5065	4565	5726	0.90	1.13
	P_a	5065	4626	5639	0.91	1.11
	FYM	5065	6216	6363	1.23	1.26
	P_s+FYM	5065	6437	6650	1.27	1.31
	P_a+FYM	5065	6377	6372	1.26	1.26
Mean		5065	5358	6039	1.06	1.19
Deficit irigation	P_0	4582	3804	5316	0.83	1.16
	P_s	4582	4197	5628	0.92	1.23
	P_a	4582	4338	5340	0.95	1.17
	FYM	4582	4683	5999	1.02	1.31
	P_s+FYM	4582	5665	6074	1.24	1.33
	P_a+FYM	4582	5722	5951	1.25	1.30
Mean		4582	4735	5718	1.04	1.25

Data in Table 12 indicated that the highest net return (average, 9205 LE ha^{-1}) and economic efficiency (average, 0.64) for wheat yields were obtained with full irrigation while, the lowest net return (6950 LE ha^{-1}) and economic efficiency (0.49) were achieved with deficit irrigation for all treatments.

Table 12.Over all values of total revenue, total cost, net return and economic efficiency of wheat crop as affected by different treatments (Price (LE) according to the local market price).

Irrigation	Amendments	Grain yield revenue (LE.ha-1)	Straw yield revenue (LE.ha-1)	Total revenue ($LE.ha^{-1}$)	Costs of VAP ($LEha^{-1}$)	Land rent for season (LEha-1)	Treatments cost (LEha-1)	Total cost ($LE.\ ha^{-1}$)	Net return ($L.E.\ ha^{-1}$)	Economic efficiency
Full irrigation	P_0	11785	6581	18366	6200	6600		12800	5566	0.43
	P_s	13694	6871	20565	6200	6600	750	13550	7015	0.52
	P_a	13879	6766	20645	6200	6600	800	13600	7045	0.52
	FYM	18648	7636	26284	6200	6600	1800	14600	11684	0.8
	P_s+FYM	19310	7980	27291	6200	6600	2250	15050	12241	0.81
	P_a+FYM	19131	7646	26777	6200	6600	2300	15100	11677	0.77
Mean		16075	7247	23321	6200	6600	1580	14117	9205	0.64
Deficit irrigation	P_0	11413	6379	17791	6200	6600		12800	4991	0.39
	P_s	12590	6754	19344	6200	6600	750	13550	5794	0.43
	P_a	13013	6408	19421	6200	6600	800	13600	5821	0.43
	FYM	14050	7199	21249	6200	6600	1800	14600	6649	0.46
	P_s+FYM	16996	7288	24284	6200	6600	2250	15050	9234	0.61
	P_a+FYM	17167	7142	24309	6200	6600	2300	15100	9209	0.61
Mean		14205	6862	21066	6200	6600	1580	14117	6950	0.49

- Costs of VAP = Costs of variable agriculture practices ($LE\ fed^{-1}$) including (Plowing, land leveling, planting, labor wags, irrigation, fertilizers, best side, harvesting ….et

-Price of grain yield = 3000 LE ton^{-1} and straw = 1200 LE ton^{-1}.

-Net return: it can be calculated by deducting the total cost from the total return, ($LEha.^{-1}$)

- Economic efficiency: it can be calculated by dividing the total seasonal net return on total seasonal cost

It can be concluded that under such conditions of the current study, the irrigation at 50% soil moisture depletion (full irrigation) are the most economically effective that ameliorate saline clay soil which were led to increase the yields. FYM application with or without P fertilizers were more pronounced in enhancing net return and economic efficiency relative to P-fertilizers or untreated soils. This may be due to the improved soil properties and increased the wheat productivity under FYM application (Tadesse *et al* 2013 and Shah *et al*, 2013). Results also showed that, both P-fertilizers application (Ps or Pa) nearly the same in the values of net return and economic efficiency and were more pronounced in increasing net income comparing with untreated soils.

CONCLUSION

FYM with or without P fertilizers increased wheat production than P individually. So, P with FYM strongly increased the grain and straw yields of wheat. Irrigation deficit adversely affected the wheat productivity comparing to the full water requirements. FYM application with or without P fertilizers were more pronounced in improving chemical and physical properties of the soil, where it affects water-air relationships in the root zone especially without deficit irrigation. FYM application with or without P fertilizers were more pronounced in enhancing soil properties and increased the wheat productivity and consequently, increased net return and economic efficiency.

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تأثير إضافة سماد المزرعة والسماد الفوسفاتى والري على خصائص التربة وإنتاجية القمح بالأراضى المتاثرة بالأملاح بشمال الدلتا ، مصر

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لدراسة تأثير سماد المزرعة مع أو بدون التسميد الفوسفاتى ونقص مياه الري في الاراضي المتأثرة بالأملاح على محصول القمح ومكوناتة وبعض خصائص التربة وايضا انتاجية مياه الري والعائد الاقتصادي، أجريت تجربة بشمال دلتا النيل خلال موسمي الشتاء(٢٠١٦/١٧و ٢٠١٧/١٨) باستخدام قطع منشقة كاملة العشوائية مع ثلاثة مكررات. ووضعت القطع الرئيسية لمستويين ري، I_{full} (الري بعد استنفاذ ٥٠ % من رطوبة التربة) او I_d (استنفاد ٧٠٪ من الرطوبة) ، بينما احتلت القطع الشقية بمعاملات المحسنات: سماد المزرعة (FYM) ، واثنين من الأسمدة الفوسفاتية : سوبر فوسفات (Ps) ، وفوسفات الأمونيوم (Pa). ويمكن تلخيص نتائج الدراسة فى التالي:زاد إنتاج القمح بإضافة سماد المزرعة، حيث ارتفعت إنتاجية الحبوب والقش بنسبة ٤٠.٨٥ ، ١٤.٥٤ ٪ ، على التوالي بإضافة سماد المزرعة.وزاد محصول الحبوب بنسبة ١٣.٢٥ و ١٥.٩٠ ٪ ، في حين ارتفع محصول القش بنسبة ٥.١٩ و ١.٧١٪ مع التسميد بالسوبر فوسفات و فوسفات الأمونيوم على التوالي.التسمد الفوسفاتى مقترن سماد المزرعة كان أكثر فعالية في إنتاجية القمح. حيث زيادة محصول القمح من الحبوب والقش على التوالي بنسبة ٥٦.٥٠ و ١٧.٩٢٪ مع استخدام سماد السوبر فوسفات مع سماد المزرعة ومقدار ٥٦.٣٧، ١٤.١٧% باستخدام سماد فوسفات الأمونيوم مع سماد المزرعة على التوالي.أثر نقص الري (الري عند استنفاذ ٧٠% من رطوبة التربة) سلبًا على إنتاجية القمح. حيث انخفض محصول الحبوب والقش بواقع ١١.٧٥ و ٥.٣٠٪ على التوالي مقارنة بالقطع التي تلقت أحتياجاتها المائية كاملة. إضافة سماد المزرعة مع أوبدون سماد الفوسفات كان اكثر وضوحا في تقليل ملوحة وصودية التربة مقارنة بالارض الغير معاملة اوالسماد الفوسفاتي منفرد. حيث انخفضت الملوحة بمقدار ١٥.٦٢، ١٤.٢٦ % للمعاملات سوبرفوسفات + سماد المزرعة، فوسفات الأمونيوم + سماد المزرعة ، وكذالك انخفضت الصودية بمفدار ٨.٤٥، ٨.٠٦% لنفس المعاملات على التوالي مقارنة بالارض الغير معاملة.الري عند استنفاذ ٥٠% من رطوبة التربة ادى الى انخفاض الملوحة مقدار ٩.٧٠% والصودية مقدار ٧.٣٩% مقارنة بالري عند استنفاذ ٧٠% من رطوبة التربة.إضافة سماد المزرعة مع أوبدون سماد الفوسفات والري عند استنفاذ ٥٠% من رطوبة التربة أدى إلى تحسين التوصيل الهيدروليكي والماء الميسر والسعة التشبعية والكثافة الظاهرية للتربة مقارنة بالأرض الغير معاملة أو إضافة سماد الفوسفات منفرد. إضافة سماد المزرعة مع أوبدون سماد الفوسفات والري عند استنفاذ ٥٠% من رطوبة التربة أدى إلى تحسين انتاجية مياه الري وزيادة صافي العائد والكفاءة الاقتصادية مقارنة بالأرض الغير معاملة أو إضافة سماد الفوسفات منفرد. عموما لوحظ أن أعلى عائد صافي وأعلى كفاءة إقتصادية من انتاج القمح قد تحقق نتيجة اضافة سماد السوبرفوسفات مع سماد المزرعة خصوصا مع الري عند استنفاذ ٥٠% من رطوبة التربة .