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Improvement of Soil Physical and Chemical Properties under Irrigation with Saline Water Conditions in Ras Sudr Area - South Sinai

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ABSTRACT

The objective of this work is to study the improvement of soil physical properties under different soil treatments using saline water. The field experiment was conducted at Ras Sudr station South Sinai. in sandy loam soil in order to study the effect of the application of farmyard manure (FYM), agricultural elemental sulfur (A.S.) and their combinations (FYM + A.S.) on some soil physical and chemical properties. The experiment used three rates of farmyard manure (10, 15 and 20 ton/fed), three rates of agricultural sulfur (50, 75 and 100 kg/fed) and their mixtures by 20 ton/fed farmyard manure with each of 50, 75 and 100 kg/fed of agricultural sulfur. In addition, three levels of irrigation water applied (50, 75 and 100% from available water). The barley crop (Giza 123) as indicator which was planted in November, 2017 using drip irrigation system. Irrigation water used for the experiment has values of, Ec and SAR (sodium adsorbed ratio) 8.96 $dS.m^{-1}$ and 22.74, respectively. The results showed that the effect of all studied soil treatments were significantly decreased the soil bulk density, while the effects of irrigation water applied rates were significantly increased relatively to control. Hydraulic conductivity values were significantly decreased by using different rates of FYM and combination FYM+A.S., while it significantly increased using A.S treatment alone relatively to control. The increase of soil available water was in the order FYM+A.S. > FYM > A.S. > control. Their values were affected significantly by different treatments and integrated application rates of FYM + A.S. Hydraulic conductivity values were significantly decreased with increasing irrigation water levels. Data clearly evident that the size of water stable aggregates as well as mean weight diameter were improved due to the use of FYM and combination FYM + A.S. as compared to application of A.S. alone. The EC values decreased with increasing rates of FYM and combination (FYM+A.S.), while reverse trend was noticed with A.S. alone. Application of soil treatments decreased each of SAR, ESP and pH, while these parameters were increased with increasing levels of irrigation water applied. The effect of the treatments on Investment Ratio (I.R.) could be arranged as follow: 20 ton/fed FYM + 100 Kg/fed A.S. >15 ton/fed FYM >20 ton /fed FYM + 75 Kg/fed A.S. > 20 ton/fed FYM > 20 ton/fed FYM + 50 Kg/fed A.S. > 10 ton/fed FYM >75 Kg/fed A.S. >100 Kg/fed A.S. > 50 Kg/fed A.S.> control under 100% irrigation water applied.

Keywords: soil physical properties, saline soil, calcareous soil, agricultural sulfur and soil amendments Investment Ratio.

INTRODUCTION

The expansion of the agricultural soils in Egypt depends on the reclamation of new lands, which are mainly in desert zone as part of them in Sinai Peninsula. These soils are characterized by high content of $CaCO_3$ and salinity level, which causes risks of salinity in arid and semi-arid environments resulting from the accumulation of salts by the long continued use of saline water in irrigation and may result in deteriorating the soil. In addition, using of low quality waters such as underground water and drainage water as well as treated sewage water is a most essential. The excessive discharge of the ground water with low quality has occurred, which has imposed a further increase in soil salinization Poustini and Siosemardeh (2004). In addition, excessive sodium may indirectly decrease plant growth by its deleterious effect on soil structure Helmy *et al.* (2013), as it also leads to deterioration of its physiochemical, and biological properties and loss of soil fertility. Salinization processes have a serious impact on soil functions such as its ability to act as a buffer and filter against pollutants, the loss of soil organic matter (SOM), its participation in the water and nitrogen cycles and its ecosystem services in supporting the health of the environment and biodiversity. This affect in the agricultural productivity by causing disruptions to the processes of nitrogen uptake and plant growth development, limited crop growth, productivity, and reducing the yield of a wide variety of crops Shomeili *et al.* (2011) and Fayez and Bazaid (2014). Since high salts content may adversely influence soil physicochemical properties and crop yields, food security could be limited as a consequence Diacono and Montemurro (2015). Therefore, saline and saline-sodic soils must be reclaimed to improve physio-chemical and biological properties or develop management practices that maintain satisfactory levels of fertility for sustainable productivity. Various strategies have been applied for remediating saline-sodic soils all with their main aim of replacing the Na^+ ions on the soil surface exchange sites and soil solution with Ca^{2+} and Mg^{2+} (Qadir et al. 2001). This may be due to cation exchange of Na^+ by Ca^{2+} or Mg^{2+}.

There are several techniques used to combat salt stress as well as improve the soil physio-chemical properties and the productivity of salt affected soil, e.g. soil amendments mixed into soil to improve the physical properties, such as water retention, permeability, and water infiltration, also supply nutrients. They make changes in a number of ways to promote healthy plant growth and allow water and nutrients to more easily move through the soil Qadir *et al.* (2001) and Ammari *et al.* (2008). Organic amendments including sphagnum peat, wood chips, straw, compost, manure, biosolids, sawdust and wood ash,….ect, which increases water infiltration, water-holding capacity, and aggregate stability, Diacono and Montemurro (2015). Physical and chemical properties of soil can be improved by using compost, which may ultimately increase crop yields. Therefore, use of compost is the need of the time. Physical properties like bulk density, porosity, void ratio, water permeability and hydraulic conductivity were significantly improved when farmyard manure (10 ton. ha^{-1}) was applied in combination with chemical amendments, resulting in enhanced wheat yield in sodic soil Hussain *et al.* (2001). Other organic materials like rice straw, wheat straw, rice husk and chopped salt grass also improved these physical properties of a saline sodic soil. The tillering, plant height, biomass and paddy yield were significantly increased Hussain *et al.* (1998). Hudson (1994) mentioned that, the organic matter content in soil is directly related to different physical soil properties namely, bulk density, porosity, water infiltration and water holding capacity. Inorganic amendments include vermiculite, perlite, pea gravel and sand, which applied for improve and reclaim of saline soils to avoid applying the chemicals as soil amendments, and reduce the salt concentration in the soil upper layers, which enhanced the plants growth by leaching the excessive ions released from soil to the deeper layers, Junbao *et al.* (2010). Elemental sulfur (S) as a soil amendment is generally used as a standard added to soil for pH reduction, Slaton *et al.* (1999) and Jaggi *et al.* (2005).

Upon the oxidation of S, sulfuric acid occurs and attacks insoluble calcium bounded P minerals and converts them into soluble and plant available P forms Arai and Sparks (2007). Jaggi *et al.* (2005) reported that the pH of alkaline soil was decreased by the addition of elemental S. Also, Mohamed (2006) concluded that the application of amendments, such as sulfur and manure, to soil irrigated with saline water, either individually or in combination increased the volume of quickly drainable pores, water holding pores and total useful pores of the soil following the intermittent leaching. Also, S application significantly increased the electrical conductivity and solubility of SO_4^{-2}, $H_2PO_4^-$ and K^+ of the soil water extracts during the period of incubation and under varying conditions of water quality Mohamed (2006) and Mohamed *et al.* (2007). Abdallah *et al.* (2013) and Ahmed *et al.* (2016) stated that sulfur compounds have been used for reclaiming sodic soils. These materials supply Ca^{2+} directly or dissolve calcium carbonate due to hydrogen ions, thereby, enhancing the replacement of Na^+ from the exchange sites when followed by leaching. The structure of the sodic soils improves as exchangeable Ca^{2+} increases. Improvements in the soil structure enhance water penetration and thus help to leach the salt more easily and effectively.

This work was carried out to study the improvement in some physical and chemical soil properties of studied calcareous soil as affected by different application rates of FYM, A.S. and their combination, under three levels of irrigation water applied.

MATERIALS AND METHODS

Field experiment was carried out in Ras Sudr station South Sinai, calcareous sandy loam soil texture, to study improvement of some soil physical and chemical properties under irrigation with saline water conditions. The experimental treatments were three rates of farmyard manure (10, 15 and 20 ton/fed), three rates of agricultural sulfur (50, 75 and 100 kg/fed) and combination of 20 ton/fed farmyard manure with each of 50, 75 and 100 kg/fed of agricultural sulfur under three levels of irrigation water were applied (50, 75 and 100% from available water). These treatments were added to soil a two weeks before planting and mixing in 15 cm soil depth. Barley crop (Giza 123) was planted in November, 2017 as a guide crop, under drip irrigation system. The EC and SAR (Sodium Adsorbed Ratio) for irrigation water were, 8.96 dSm^{-1} and 22.74, respectively. All plots were fertilized with ammonium nitrate (134 kg/fed, 33.5% N) in three doses, super phosphate (15.5 % P_2O_5) at rate of 200 kg/fed in three equal doses (the first was at sowing, the second was at thinning while the third was applied two weeks after thinning). Also, potassium sulphate (48% K_2O) at the rate of 48 kg/fed was applied after thinning.

At the end of the growing season, the barley production, grains and straw yields ($ton.fed^{-1}$) were recorded.

The soil samples were collected from the soil surface of each treated plots in the end of the experiment, for the physical and chemical analyses, which were determined using the standard methods given by Richards (1954). Data of soil analyses are tabulated in Table (1). The experimental is a complete randomize plot design with three replicates. Statistical analysis of variance of all studied treatments was ANOVA and the least significant difference (L.S.D) at 0.05 % level.

Table 1. Some physical and chemical properties of the studied soil.

Soil properties	Values
Particle size distribution (%)	
Course Sand	23.98
Fine Sand	52.20
Silt	12.69
Clay	11.13
Texture class	Sandy loam
Bulk density ($Mg.m^{-3}$)	1.51
Field capacity (%)	14.52
Wilting point (%)	5.63
Available water (%)	8.89
Total $CaCO_3$ (%)	51.08
Organic matter (%)	0.41
EC ($dS.m^{-1}$, soil paste extract)	9.28
pH (Soil paste)	7.81
Soluble cations ($meq.L^{-1}$)	
Ca^{2+}	21.24
Mg^{2+}	15.45
Na^+	38.13
K^+	1.25
Soluble anions ($meq.L^{-1}$)	
CO_3^{2-}	—
HCO_3^-	10.36
Cl^-	39.07
SO_4^{2-}	26.67
SAR	8.91
ESP	10.62

RESULTS AND DISCUSSION

1- Soil bulk density

Data in Table (2) revealed that soil bulk density values (under 50% irrigation water applied from available water) was lower for treatment 20 ton FYM +100 Kg/fed A.S. (1.25 $Mg.m^{-3}$), meanwhile its value was 1.47 $Mg.m^{-3}$ for treatment 100 Kg/fed A.S., however it was the maximum (1.59 $Mg.m^{-3}$) under control. In addition, it was evident that soil bulk density was decreased under all the treatments as compared to control. The results clearly indicated that integration of farmyard manure with agricultural sulfur reduced the soil bulk density. Data showed clearly that all soil amendments which were used (Farmyard manure, Agricultural sulfur and their combinations) significantly decreased the values of the soil bulk density relative to control, also different levels of the irrigation water applied were significantly increased affected, but it was no significant effect between 50 & 75 % irrigation water applied, Table (3). At the same time, data also showed that increasing level of water applied lead to an increase in the values of bulk density. These increments progressively were increased with increasing irrigation water, this added salinity to the soil under 100% irrigation water applied, and it was clear by using agricultural sulfur than farmyard manure and their combinations. Also it could have beneficial effect on the soil bulk density and reduced the effect of different levels of water applied as follows: combinations (FYM+A.S.) >

FYM > A.S. The favorable effect of combinations enhancing the soil physical properties, may be attributed to the high content of FYM with A.S. This could be explained by microbiological effect of Thiobacillus spp. On dissolving S Yang *et al.* (2010). So, the positive effect of sulfur application was clear in calcareous soil, which means the importance of sulfur application for this soil.

These results may be due to the increase of salts in the irrigation water which progressively would increase sodium ion in the soil solution. These ions caused the dispersion of particles, such dispersion causes a decrease in the bulk volume of soil which led to an increase in the soil bulk density. Similar result was reported by Nikos *et al.* (2003).

Table 2. Effect of different treatments on some soil physical properties.

Treatment	Rates	W.A%	Bulk density Mg.m^{-3}	Porosity %	0.33 bar	15 bar	A.W %	H.C. cm.h^{-1}	H.C. class
Farmyard manure (FYM)	10 ton/fed	50	1.41	46.79	20.57	4.10	16.47	5.51	Moderate
		75	1.41	46.79	20.96	4.88	16.08	5.31	
		100	1.45	45.28	20.33	4.91	15.42	5.15	
	15 ton/fed	50	1.33	49.81	21.87	5.68	16.19	5.31	
		75	1.33	49.81	21.45	5.38	16.07	5.21	
		100	1.38	47.92	21.71	5.51	16.20	5.18	
	20 ton/fed	50	1.27	52.08	24.94	6.40	18.54	5.01	
		75	1.29	51.32	24.59	6.35	18.24	4.89	
		100	1.29	51.32	24.69	6.73	17.96	4.83	
Agricultural Sulfur (A.S.)	50 Kg/fed	50	1.48	44.15	16.88	4.42	12.46	7.70	Moderate rapid (M.R.)
		75	1.49	43.77	16.24	3.92	12.32	7.42	
		100	1.50	43.40	16.14	4.09	12.05	7.34	
	75 Kg/fed	50	1.48	44.15	17.68	3.97	13.71	7.69	
		75	1.50	43.40	17.25	3.81	13.44	7.54	
		100	1.51	43.02	16.37	3.89	12.48	7.38	
	100 Kg/fed	50	1.47	44.53	18.25	3.17	15.08	7.91	
		75	1.48	44.15	18.01	4.05	13.96	7.63	
		100	1.51	43.02	16.85	3.87	12.98	7.57	
Mixed (FYM+A.S.)	20 ton FYM +50 Kg/fed S	50	1.27	52.08	24.08	5.91	18.17	5.42	Moderate
		75	1.28	51.70	24.60	6.54	18.06	5.37	
		100	1.29	51.32	24.10	6.53	17.57	5.18	
	20 ton FYM +75 Kg/fed S	50	1.29	51.32	24.45	5.84	18.61	5.59	
		75	1.27	52.08	24.19	5.89	18.30	5.57	
		100	1.28	51.70	24.47	6.64	17.83	5.47	
	20 ton FYM +100 Kg/fed S	50	1.25	52.83	24.99	5.94	19.05	6.03	
		75	1.26	52.45	24.91	6.21	18.70	5.67	
		100	1.27	52.08	24.71	6.33	18.38	5.61	
Control		50	1.59	40.00	12.72	3.42	9.30	7.06	M.R.
		75	1.60	39.62	13.01	3.67	9.34	6.92	
		100	1.62	38.87	13.29	3.96	9.33	6.85	

Table 3. Statistical analysis ANOVA of soil treatments and irrigation rates of available water applied.

Soil property		Bulk density	F.C.	A.W	H.C.	S. Agg.	MWD	EC	pH	SAR	ESP	I.R.
Treatment	Sign.	***	***	***	***	***	***	***	***	***	***	***
	$LSD_{0.05}$	0.018	0.57	0.55	0.11	3.262	0.073	0.35	0.036	0.4114	0.492	0.05
W.R	Sign.	**	*	***	***	**	*	***	ns	**	**	***
	$LSD_{0.05}$	0.01	0.312	0.30	0.062	1.79	0.039	0.19	.0195	0.225	0.27	0.03
Rank Mean of treatments addition												
10 ton/fed FYM		c	d	c	f	d	cd	b	ab	b	b	bc
15 ton/fed FYM		d	c	c	f	c	ab	cd	bc	c	c	ab
20 ton/fed FYM		e	ab	ab	g	b	a	d	c	c	c	ab
50 Kg/fed A.S.		b	g	f	b	e	d	a	d	d	d	c
75 Kg/fed A.S.		b	f	e	b	d	cd	a	e	d	d	c
100 Kg/fed A.S.		b	e	d	a	d	cd	a	f	ef	ef	c
(20 ton FYM+50 Kg /fed A.S.)		e	b	b	f	c	ab	c	g	de	de	ab
(20 ton FYM+75 Kg/fed A.S.)		e	ab	ab	e	b	bc	b	h	ef	ef	ab
(20 ton FYM+100 Kg/fed A.S.)		f	a	a	d	a	ab	b	i	f	f	a
Control		a	h	g	c	f	e	a	a	a	a	d
Rank Mean of irrigation water applied from available water												
50 %		b	b	c	c	b	b	c	a	b	b	c
75 %		b	ab	b	b	b	a	b	a	ab	ab	b
100 %		a	a	a	a	a	a	a	a	a	a	a

F.C.= Field capacity, A.W.= Available water, H.C.= Hydraulic conductivity, S.Agg.= Stable aggregates, MWD= Mean weight diameter, SAR= Sodium adsorption ratio, ESP= Exchangeable sodium percentage, I.R.= Investment Ratio

2- Soil moisture retention and available water

The influenced of FYM and A.S. as well as their combinations on the water holding capacity, soil water retention and available water, has been given in Table (2) and Fig. (1). It is evident that soil moisture content at field capacity was increased with increasing rates of different studied treatments, where the increase of soil moisture content at field capacity was in the order combination FYM+A.S. > FYM > A.S. > control. Results in Table (3) clearly indicated that addition of FYM insignificantly increased under irrigation water applied. Also data reveal that soil moisture content at field capacity as affected by different treatments rates and integrated application of FYM + A.S. was significant variations.

In the same trend, the increase rate in available water was 43.53, 42.56 and 49.84% for 10, 15 and 20 ton/fed FYM, whereas 25.40, 32.38 and 38.30% for 50, 75 and 100 kg/fed A.S. and 48.82, 50.03 and 51.18% for combination 20 FYM + (50, 75 and 100 kg/fed A.S.) relative to control, respectively. There was slight effect on the increase rate of available water under 20 ton/fed FYM and combination 20 FYM + (50, 75 and 100 kg/fed A.S.). This may be due to the high percent of $CaCO_3$ has slight effect on the soil moister content at field capacity and also adding the FYM to soil increases the amount of available water in soil.

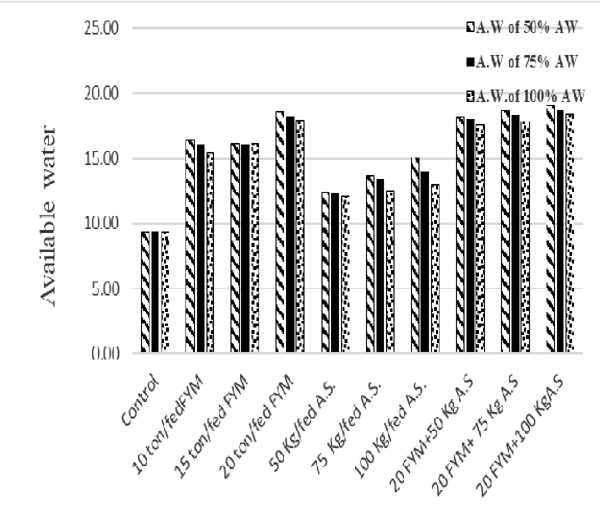

Fig. 1. Available water as affected by different treatments and irrigation water applied.

3- Saturated hydraulic conductivity:

The effect of different soil amendments under studied and rates of irrigation water (50, 75 and 100% from available water) on soil hydraulic conductivity (H.C.), are shown in Table (2) and Fig. (2). Data showed clearly that, the hydraulic conductivity values decreased with the increasing rates of FYM and increasing levels of irrigation water applied relatively to control. It was observed that the lowest decrease percentage of hydraulic conductivity was 29.5% at 20 ton/fed FYM and 100% water applied. Meanwhile, the hydraulic conductivity values were increased with the increasing rates of (A.S). It was observed that the highest increase percentage of H.C. value 12.1% was obtained at 100 Kg/fed A.S and 50% water applied. The results obtained in present investigation are in accordance with those recorded by Mohamed *et al.* (2007) and Appa (2012). The combination treatments led to a decrease in the hydraulic conductivity values, as the lowest decrease percentage value by 24.3% has been recorded by application of 20 ton/fed FYM + 50 Kg/fed A.S. under 100 % water applied.

The results also showed clearly that, the hydraulic conductivity values decreased progressively with increasing levels of irrigation water from 50 to 100% of available water, this is due to increasing salinity level addition in the soil, under different soil amendments, the H.C. values were at 50 > 75 > 100% of irrigation water applied. The Hydraulic conductivity of soil was significantly increased with increasing of different A.S. rates. Meanwhile, it was decreased significantly with different FYM rates and their combination with A.S., Table (3).

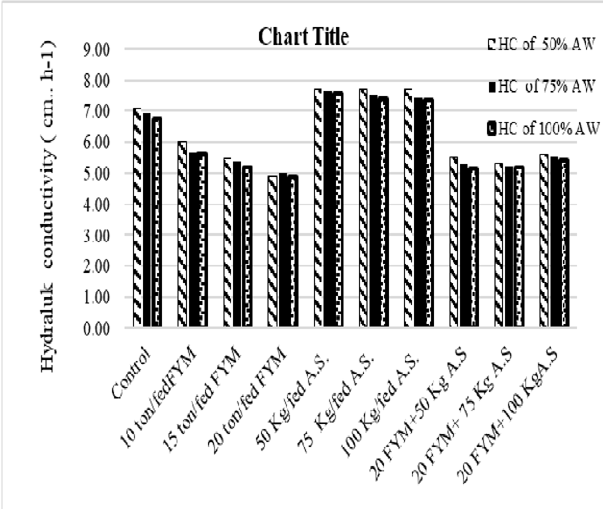

Fig. 2. Hydraulic conductivity (cm.h^{-1}) as affected by different treatments and irrigation water applied.

4- Water stable aggregates

Data pertaining to fractions of water stable aggregates of different size as effected by farmyard manure, agricultural sulfur and their combination treatments under different rates of irrigation water applied studied was given in Table (4) and Fig (3) . Data clearly indicated that the total stable aggregates values could be arranged as the following: (20 ton/fed FYM + 100Kg/fed A.S) > (20 ton/fed FYM+ 75Kg/fed A.S.) > (20 ton/fed FYM) > (20 ton/fed FYM+ 50Kg/fed A.S.) > (15 ton/fed FYM) > (10 ton/fed FYM) > (100 Kg/fed A.S) > (75 Kg/fed A.S) > (50 Kg/fed A.S) > control. In addition, the different size fractions of water stable aggregates were significantly increased as affected by different treatments rates Table (3). It was evident that the size of water stable aggregates was improved due to use of FYM and combination FYM + A.S. as compared to application of A.S. alone. The change fraction of water stable aggregates of finer size (1-0.5 mm) were 1.08, 1.12 and 1.47% for 10, 15 and 20 ton/fed FYM. Also there values were 1.12, 1.19 and 1.32% for 50, 75 and 100 kg/fed A.S. and 1.55, 1.38 in addition 1.54 for 20 ton/fed + 50, 75 and 100 kg/fed A.S. under 100% irrigation water applied relative to control, respectively. Likewise, the Mean Weight Diameter (MWD) of the stable aggregates were (1.93, 2.5 and 2.86%), (1.79, 1.94 and 1.84%) and (2.36, 2.20 and 2.52%) relative to control at the same sequence. With respect to 50 and 75% irrigation water applied similar tendency of increase in soil aggregates and MWD of stable aggregates was obtained under 100% irrigation water applied. The percentage of different water stable aggregates size unites as well as the MWD of stable aggregates are relatively high, thereby the ability of such soil to conduct water expressed by H.C. values are moderately.

Table 4. Effect of different treatments and irrigation water applied on soil aggregates.

Treatments	Rates	Water applied %	Soil aggregates of different size (%)						water stable aggregates				M W D
			>4 mm	4-2 mm	2 -.85 mm	.84 -.5 mm	.5- .25 mm	<0.25 mm	>2 mm	>1 mm	>0.5 mm	Total	
FYM	10 ton/fed	50	0.68	1.86	2.20	5.44	49.22	40.60	1.72	13.89	35.26	50.87	0.40
		75	1.29	1.09	2.75	3.42	36.99	54.45	3.28	13.81	32.13	49.22	0.38
		100	0.00	3.32	8.04	7.35	23.82	57.47	5.24	16.74	32.98	54.96	0.42
	15 ton/fed	50	0.63	3.11	4.50	5.14	35.57	51.05	3.06	17.16	35.18	55.4	0.43
		75	1.06	3.32	4.39	7.30	25.77	58.15	3.26	17.46	38.12	58.84	0.44
		100	2.66	2.34	4.51	7.69	39.83	42.97	4.42	19.3	36.08	59.8	0.55
	20 ton/fed	50	1.96	2.56	2.82	2.83	45.63	44.19	5.61	20.25	41.8	67.66	0.48
		75	0.35	4.32	8.27	6.13	43.31	37.62	3.36	20.72	40.86	64.94	0.52
		100	3.85	3.34	6.13	3.03	33.97	49.67	4.58	22.08	44.18	70.84	0.63
A.S.	50 Kg/fed	50	0	1.51	3.68	7.15	23.08	64.58	3.86	15.8	30.17	49.83	0.31
		75	0.00	3.49	3.14	5.63	24.84	62.89	2.36	13.64	29.16	45.16	0.36
		100	0.00	1.99	8.40	9.46	20.34	59.81	4.62	14.11	30.87	49.6	0.39
	75 Kg/fed	50	0.00	2.89	7.36	11.20	18.95	59.60	4.25	15.13	29.91	49.29	0.41
		75	0.54	1.71	3.03	2.52	27.72	64.49	2.02	15.01	30.78	47.81	0.33
		100	0.00	4.67	5.41	9.22	18.82	61.88	7.49	15.21	33.14	55.84	0.43
	100 Kg/fed	50	0.00	3.49	2.09	6.79	17.67	69.96	2.26	16.46	32.11	50.83	0.33
		75	0.00	4.49	6.95	6.51	16.15	65.90	2.86	15.21	34.18	52.25	0.42
		100	0.00	4.69	4.56	8.12	16.53	66.10	2.11	14.96	34.74	51.81	0.40
Mixed (FYM+A. S.)	20 ton FYM +50 Kg/fed S	50	1.70	1.76	2.82	7.61	45.82	40.30	3.34	18.47	36.05	57.86	0.47
		75	2.24	3.89	1.97	10.45	27.60	53.86	6.93	15.98	37.13	60.04	0.52
		100	1.04	5.13	5.18	7.45	31.11	50.09	7.83	16.89	40.2	64.92	0.52
	20 ton FYM +75 Kg/fed S	50	0.40	1.04	2.33	9.34	33.79	53.10	6.63	18.68	37.17	62.48	0.34
		75	2.12	2.42	5.16	4.05	40.48	45.77	5.04	19.54	39.68	64.26	0.51
		100	2.12	2.31	4.01	2.46	48.77	40.33	6.75	20.56	41.2	68.51	0.50
	20 ton FYM +100 Kg/fed S	50	0.41	3.13	3.58	9.94	35.00	47.95	5.69	24.33	42.31	72.33	0.43
		75	2.08	2.43	5.28	10.54	35.41	44.25	8.28	20.51	41.26	70.05	0.53
		100	2.11	3.43	5.48	7.02	39.04	42.92	9.26	19.91	42.96	72.13	0.56
Control		50	0.00	0.46	0.94	2.42	20.93	75.25	0.95	4.99	19.17	24.16	0.22
		75	0.00	0.57	0.65	2.87	22.66	73.25	1.00	4.86	19.79	24.65	0.22
		100	0.00	0.69	1.05	3.42	21.93	72.91	1.15	5.15	20.16	25.31	0.23

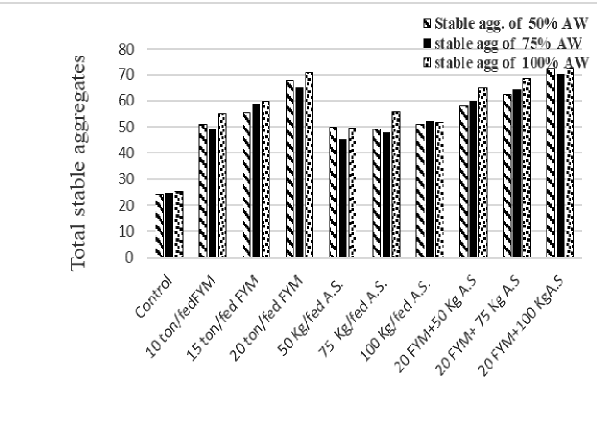

Fig . 3. Total stable aggregates as affected by different treatments and irrigation water applied.

5- Soil salinity (EC)

Data in Table (5) and Fig. (4) reveal that the effect of different FYM rates and combination FYM with A.S. in soil was significantly decreased the soil salinity (EC) values relative to the control Table (3). The higher reduction in the EC value was 7.41 dS/m for the soil treated with 20 ton/fed FYM at 50% irrigation water applied. This due to, the FYM improved soil physical properties which in turn facilitate the leaching of salts outside from the root zone, which agree with Beheiry and Soliman (2005). Meanwhile, data recorded that, it was significantly increased with increasing of A.S. rates, the higher EC value was 9.98 dS/m for the soil treated with 100 Kg/fed A.S. at 100% irrigation water applied. The benefit of addition different soil amendments on decrement of soil salinity arranged as follows: FYM > combination (FYM+A.S.) > A.S. In addition, the results indicated that the soil salinity (EC) increased progressively, with increasing rates of irrigation water applied. These increments may be resulted from addition of a large amount of salts irrigation water applied at 100% level of available soil moisture.

6- Sodium adsorption ratio (SAR):

Sodium adsorption ratio (SAR) is a measure of the relative preponderance of dissolved sodium in soil solution of soil paste compared to the amount of dissolved calcium and magnesium. The data in Table (5) showed that the SAR values of investigated soil were lowered significantly due to FYM and A.S. treatments, while the SAR values of combination (FYM+A.S.) were less than that found in the FYM and A.S. under irrigation water applied (50, 75 and 100%). The values of SAR were markedly decreased with increasing treatments rates of FYM, A.S. and their combination relatively to control. The higher value 10.58 was recorded in control under 75% irrigation water applied, while the lower one 5.66 was recorded at 20 ton/fed FYM+100 Kg/fed A.S. under 50% irrigation water applied. Also, data showed that, the effect of irrigation water applied at 50, 75 and 100% at all different treatments was insignificant increment in SAR values Table (3). The reduction in SAR of the soil with FYM was due to the release of organic acids causing mobilization of native calcium present as $CaCO_3$ in the soil. The values of SAR become lower either due to an increase in divalent cations (Ca + Mg) or decrease in monovalent cation (Na). Values of Na could decrease during leaching while Ca + Mg increase due to reactions of organic acids with $CaCO_3$ after the application of FYM. The divalent cations (Ca + Mg) increased the net concentration of the soil solution. However, a part of these cations would be also precipitated with carbonates (CO_3) and bicarbonates (HCO_3) presented in the soil. The released Ca increased the Ca concentration of the soil solution resulting in a decrease of soil SAR value.

7- Exchangeable sodium percentage % (ESP)

The effect of soil amendments and irrigation water applied (50, 75 and 100% available water) on ESP was recorded. Data in Table (5) and Fig. (5) showed that, the ESP values decreased with increasing FYM rates, these decrements were 18.42%, 27.56% and 28.43% for 10, 15 and 20 ton/fed FYM, while A.S. decreased the ESP values with 34.78%, 34.78% and 39.13% for 50, 75 and 100 Kg/fed A.S., meanwhile combination (FYM+A.S.) decreased the ESP values 37.24, 37.37 and 46.13 for 20 ton/fed FYM with (50, 75 and 100 Kg/fed A.S.) under 50% irrigation water applied relative to the control, respectively. The same trend of decrease in soil ESP values due to FYM, A.S. and combination of them under 75 and 100% irrigation water applied was observed. Also, data showed that, effect of irrigation water applied 50, 75 and 100% at all different treatments was insignificant increment in ESP values Table (3). These results may be due to that the role of sulfur depends mainly on Thiobacillus microbe Yang *et al.* (2010) which react with it producing sulfuric acid which could dissolve the $CaCO_3$ and released Ca^{2+} ions, thereby, enhancing the replacement of Na^+ from the exchange sites and improve soil structure by increasing exchangeable Ca^{2+}. Soil structure will enhance water penetration and thus help to leach the sodium salts more easily and effectively. Similar finding was reported by Ali (2006). Also, the added amendment is organic matter which can dissolve insoluble calcium salts by evolving organic acids in soils Yamada *et al.* (2003) so replacing the exchangeable sodium ions, which are then leached out of the root zone and neutralizing the residual sodium carbonate in soil, to reduce soil pH value Choudhary *et al.* (2011).

Table 5. Effect of different treatments and irrigation water applied on some soil chemical properties.

T*	Rates/ Fed	Water applied (%)	Soluble cations (meq/L)				Soluble anions (meq/L)				EC ($dS.m^{-1}$)	pH	SAR	ESP
			Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{-2}	HCO_3^-	Cl^-	SO_4^{-2}				
FYM	10 ton	50	24.27	17.99	38.63	1.21	-	9.27	42.81	30.02	8.21	7.8	8.40	9.80
		75	27.33	18.26	43.00	1.21	-	8.49	52.44	28.87	8.98	7.78	9.01	10.50
		100	28.62	19.93	46.45	1.20	-	9.04	53.42	33.74	9.62	7.8	9.43	10.98
	15 ton	50	26.42	16.87	34.79	1.02	-	8.22	42.21	28.67	7.91	7.77	7.48	8.70
		75	25.91	17.22	35.33	1.24	-	7.31	44.24	28.15	7.97	7.76	7.61	8.86
		100	26.83	16.70	37.92	1.15	-	6.12	47.06	29.42	8.26	7.75	8.13	9.47
	20 ton	50	23.88	16.09	33.04	1.09	-	8.81	36.91	28.38	7.41	7.78	7.39	8.60
		75	26.19	16.88	34.72	1.21	-	7.26	40.31	31.43	7.9	7.75	7.48	8.71
		100	26.59	15.33	35.31	0.97	-	6.61	40.77	30.82	7.82	7.73	7.71	8.98
A. S.	50 Kg	50	33.22	21.33	35.31	2.14	-	9.64	48.25	34.11	9.2	7.67	6.76	7.83
		75	33.68	21.13	36.81	1.18	-	8.72	48.44	35.64	9.28	7.71	7.03	8.16
		100	35.48	21.10	38.99	1.13	-	8.63	47.06	41.01	9.67	7.69	7.33	8.52
	75 Kg	50	38.41	17.35	35.70	1.54	-	8.47	46.99	37.54	9.3	7.64	6.76	7.83
		75	38.00	17.84	35.68	1.08	-	7.27	46.18	39.15	9.26	7.68	6.75	7.82
		100	39.64	18.18	38.52	1.06	-	8.01	48.59	40.8	9.74	7.62	7.16	8.32
	100 Kg	50	38.33	20.92	34.49	1.16	-	8.25	45.55	41.1	9.49	7.6	6.34	7.31
		75	38.32	21.21	35.10	1.17	-	7.93	46.02	41.85	9.58	7.57	6.43	7.43
		100	39.32	21.97	36.69	1.82	-	7.52	46.11	46.17	9.98	7.59	6.63	7.67
Mixed (FYM+A.S.)	20 ton FYM +50 Kg/fed S	50	30.55	19.04	32.47	1.04	-	8.05	40.99	34.06	8.31	7.46	6.52	7.54
		75	30.21	19.45	32.88	1.16	-	7.9	41.11	34.69	8.37	7.48	6.60	7.63
		100	29.56	19.79	34.46	1.19	-	7.65	42.77	34.58	8.5	7.51	6.94	8.05
	20 ton FYM +75 Kg/fed S	50	30.74	21.06	33.12	1.18	-	7.77	40.22	38.11	8.61	7.46	6.51	7.52
		75	32.61	21.45	33.16	1.18	-	7.72	40.45	40.23	8.84	7.45	6.38	7.36
		100	33.49	22.13	31.61	1.07	-	7.57	40.49	40.24	8.83	7.43	5.99	6.89
	20 ton FYM +100 Kg/fed S	50	35.92	21.16	30.25	1.17	-	7.56	39.06	41.88	8.85	7.36	5.66	6.47
		75	33.69	20.22	33.81	1.18	-	7.26	38.06	43.58	8.89	7.39	6.51	7.53
		100	34.94	21.83	32.99	1.84	-	7.21	36.53	47.86	9.16	7.41	6.19	7.13
Control		50	24.87	18.45	48.13	1.25	-	9.86	47.51	35.33	10.03	7.81	10.34	12.01
		75	25.00	18.58	49.37	1.25	-	8.81	51.67	33.73	9.42	7.80	10.58	12.27
		100	26.24	21.45	51.36	1.26	-	10.20	52.73	37.37	9.28	7.81	10.52	12.21

T = Treatment

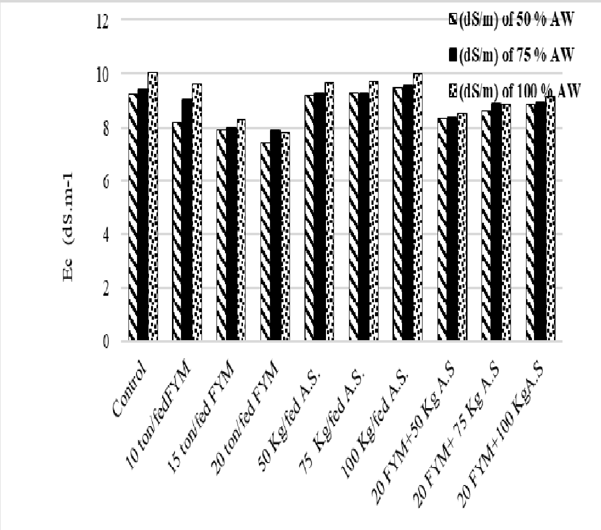

Fig. 4. Ec (dS.m^{-1}) as affected by different treatments and irrigation water applied.

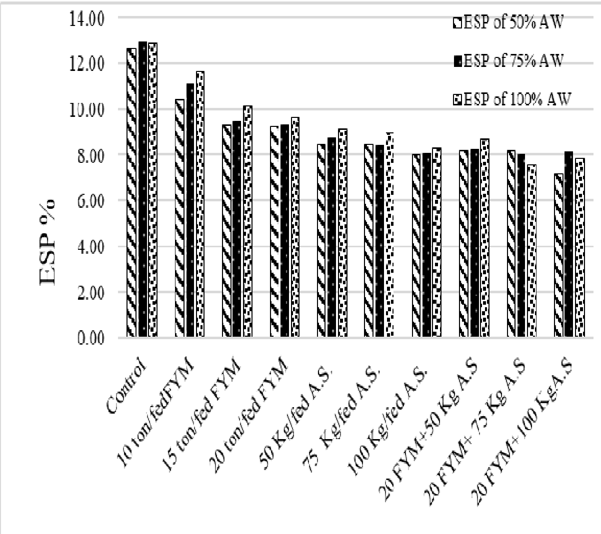

Fig. 5. ESP (%) as affected by different treatments and irrigation water applied.

8- Soil pH

Data pertaining to the effect of FYM, agricultural sulfur and combination of them on the soil pH value under irrigation water applied (50, 75 and 100%) from available water, are reported in Table (5). The lowest pH value of soil 7.36 was recorded due to the application of 20 ton FYM +100 Kg/fed A.S., also it was statistically significant as compared to other treatments Table (3). However, the highest pH value about 7.81 was observed under control treatments irrigation water applied. The data observed that the pH values were significantly decreased as compared with control. The increase in levels of FYM from 10 to 20 ton/fed resulted in a significant decrease in pH from 7.8 to 7.75, a slight decrease of soil pH values was found in the soil treated by FYM compared to untreated soil.

This may be due to the soil buffering capacity, El-Maghraby and Shaban (2011). On the other hand, the favorable effects of FYM on decreasing soil pH due to organic and inorganic acids formed during FYM decomposition as well as improving the structure of the calcareous soil was also reported by Beheiry and Soliman (2005) and El-Fishy (2009). In the same trend, the increase in level of sulfur from 50 to 100 Kg/fed resulted in a significant decrease in pH from 7.69 to 7.59. These decreases in soil pH values are associated with increases in EC values, which may be attributed to solubilization and increase in amount of soluble compounds and producing H_2SO_4 acid, also the phenomenon of salt effect under studied soil conditions, similar results have been reported by Wiedenfeld (2011) and Modaihsh *et al.* (1989). While pH values under combination of 20 ton FYM with (50, 75 and 100 Kg/fed A.S.) were 7.51, 7.43 and 7.41 at 100% irrigation water applied. There was no significant difference of irrigation water (50, 75 and 100% from available water) on pH values. These results could be attributed to the reduced amounts of soluble and exchangeable sodium and increased forms of both soluble and exchangeable calcium due to amendments applications. Also, the positive effect of organic substances on improving soil chemical properties could be due to release of CO_2 during the degradation process and thus decreased the precipitation of Ca^{2+} and CO_3 ions in the $CaCO_3$ form, as a result of the S oxidation due to the buffering capacity and the presence of high $CaCO_3$ content in soil.

9- Economical evaluation:

Data presented in Table (6) show that the Investment Ratio (I.R.) resulting from the addition of each treatment was dependent upon the total costs of such soil conditioners.

Total gain/Total cost expressed as the investment ratio of each treatment.

As shown in Table (6) and Fig. (6), the highest investment ratio 1.98 was recorded with applying 20 ton/fed FYM +100 Kg/fed A.S. at 100% irrigation water applied. Whereas, the lowest 1.46 was recorded with control. Generally, application of FYM alone or in combination with A.S. could be used economically significantly for maximizing investment ratio Table (3). Also, 100% gained higher net return percentage comparing with 50 and 75% irrigation water applied. The effect of the treatments of soil on net return percentage could be arranged as the following: 20 ton/fed FYM + 100 Kg/fed A.S. >15 ton/fed FYM >20 ton/fed FYM + 75 Kg/fed A.S. > 20 ton/fed FYM > 20 ton/fed FYM + 50 Kg/fed A.S.> 10 ton/fed FYM >75 Kg/fed A.S. >100 Kg/fed A.S. > 50 Kg/fed A.S.> control under 100% irrigation water applied.

Table 6. Effect of different treatments and irrigation water applied on net return.

Applied Treatments		Irrigation water applied of AW%	Economical evaluation — Input/ fed: NPK+ seeds + rent+ Pesticides+ management	Organic Matter	Agriculture Sulfur	Irrigation water price	Total cost	Output / fed: No. of plants /m^2	No. ears/ /m^2	Weight of grains ton	Weight of straw ton	Price of grains	Price of straw	Total gain	Investment Ratio (I.R.)
			Market Price (LE)												
FYM	10 ton/fed	50	5280	200	0	460	5940	206	618	2.86	1.83	8597	1829	10426	1.76
		75	5280	200	0	550	6030	218	654	3.03	1.94	9097	1939	11036	1.83
		100	5280	200	0	680	6160	230	690	3.20	2.05	9598	2050	11648	1.89
	15 ton/fed	50	5280	300	0	460	6040	213	639	2.96	1.89	8889	1892	10781	1.78
		75	5280	300	0	550	6130	228	684	3.17	2.03	9515	2030	11545	1.88
		100	5280	300	0	680	6260	241	723	3.36	2.15	10057	2148	12205	1.95
	20 ton/fed	50	5280	500	0	460	6240	220	660	3.06	1.96	9181	1959	11139	1.79
		75	5280	500	0	550	6330	233	699	3.24	2.07	9723	2072	11795	1.86
		100	5280	500	0	680	6460	247	741	3.44	2.20	10308	2201	12509	1.94
A.S.	50 Kg/fed	50	5280	0	150	460	5890	198	594	2.75	1.76	8263	1758	10021	1.70
		75	5280	0	150	550	5980	215	645	2.99	1.91	8972	1912	10884	1.82
		100	5280	0	150	680	6110	218	654	3.03	1.94	9097	1941	11038	1.81
	75 Kg/fed	50	5280	0	225	460	5965	201	603	2.79	1.78	8388	1785	10173	1.71
		75	5280	0	225	550	6055	218	654	3.03	1.94	9097	1941	11038	1.82
		100	5280	0	225	680	6185	225	675	3.13	2.00	9390	2001	11390	1.84
	100 Kg/fed	50	5280	0	300	460	6040	203	609	2.82	1.80	8471	1803	10274	1.70
		75	5280	0	300	550	6130	220	660	3.06	1.96	9181	1959	11139	1.82
		100	5280	0	300	680	6260	226	678	3.14	2.01	9431	2008	11439	1.83
Mixed (FYM+A.S.)	20 ton FYM +50 Kg/fed S	50	5280	500	150	460	6390	224	672	3.11	1.99	9348	1992	11340	1.77
		75	5280	500	150	550	6480	239	717	3.32	2.13	9974	2126	12099	1.87
		100	5280	500	150	680	6610	249	747	3.46	2.21	10391	2212	12603	1.91
	20 ton FYM +75 Kg/fed S	50	5280	500	225	460	6465	227	681	3.15	2.02	9473	2019	11492	1.78
		75	5280	500	225	550	6555	242	726	3.36	2.15	10099	2152	12251	1.87
		100	5280	500	225	680	6685	257	771	3.57	2.29	10725	2288	13013	1.95
	20 ton FYM +100 Kg/fed S	50	5280	500	300	460	6540	229	687	3.18	2.04	9556	2036	11593	1.77
		75	5280	500	300	550	6630	246	738	3.43	2.19	10266	2192	12458	1.88
		100	5280	500	300	680	6760	264	792	3.67	2.35	11017	2350	13367	1.98
Control		50	5280	0	0	460	5740	160	480	2.23	1.72	6677	1725	8402	1.46
		75	5280	0	0	550	5830	166	498	2.31	1.77	6927	1774	8701	1.49
		100	5280	0	0	680	5960	169	507	2.35	1.80	7053	1798	8851	1.49

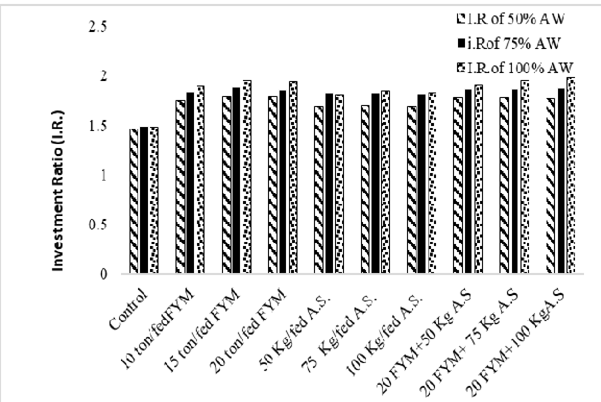

Fig. 6. Investment Ratio (I.R.) as affected by different treatments and irrigation water applied.

CONCLUSION

From the above mentioned results, it can be concluded that increasing application rates of FYM and combination FYM+A.S. led to improving the soil chemical properties i.e. pH, EC, SAR and ESP, this led to improve the soil physical properties under investigation, especially the treatment 20 ton/fed FYM + 100 kg/fed A.S. In case of different rates A.S. treatment alone it could be recommended as a suitable material in order to supply S to plants and to lower the soil pH. However, sulfur increased salinity in the soil. Therefore, high rates of sulfur should be avoided, especially in coarse-textured soils. Also, application of FYM alone or combination with A.S. could be used economically for maximizing investment ratio.

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تحسين الخواص الفيزيائية والكيميائية للتربة تحت ظروف الرى بالمياه المالحة بمنطقة رأس سدر ـ جنوب سيناء.

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الهدف من هذه الدراسة هو تحسين الخواص الفيزيائية والكيميائية للتربة الجيرية بإستخدام المعاملات المختلفة تحت ظروف الرى بالمياه المالحة. لتحقيق ذلك أجريت تجربة حقلية بمحطة بحوث رأس سدر جنوب سيناء، في نوفمبر 2017. لدراسة تأثير إضافة سمادالمزرعة (FYM) والكبريت المعدنى الزراعي (A.S.) ومخلوط (FYM+A.S.) على بعض الخواص الفيزيائية والكيميائية للتربة. تم إستخدام ثلاثة معدلات من سماد المزرعة (10 و 15 و 20 طن/فدان) وثلاثة معدلات من الكبريت الزراعي (50 و 75 و 100 كجم/فدان) ومخلوط من 20 طن/فدان سماد المزرعة مع كل من 50 و 75 و 100 كجم/فدان من الكبريت الزراعي. مع إستخدام ثلاث مستويات من مياه الري وهى (50 و 75 و 100٪ من الماء الميسر) تم زراعة محصول الشعير (جيزة 123) كمحصول دليلى وذلك باستخدام نظام الري بالتنقيط بمياه مالحة ذات Ec و SAR 8.96 ديسيسيمينز/متر و 22.74 على التوالي. وقد أظهرت النتائج مايلى :انخفاض معنوى فى قيم الكثافة الظاهرية نتيجة معاملة التربة بسماد المزرعة بصورة منفردة أو مخلوط مع الكبريت الزراعى مقارنة بالكنترول بينما زادت قيم الكثافة الظاهرية مع الزيادة فى معدلات مياه الرى من 50 الى 75 الى 100% من الماء الميسر. توجد زيادة معنوية فى الماء الميسر نتيجة اضافة المعاملات المختلفة وكانت الزيادة فى قيم الماء الميسر لمعاملة مخلوط سماد المزرعة + الكبريت الزراعى > سماد المزرعة > الكبريت الزراعى > الكنترول. كما أظهرت النتائج ايضا انخفاض معنوى فى قيم التوصيل الهيدروليكى بشكل كبير نتيجة اضافة معدلات مختلفة من FYM عن اضافة مخلوط (FYM+A.S.) مقارنة بالكنترول. كما انخفضت قيم التوصيل الهيدروليكى بشكل كبير مع زيادة مستويات مياه الري. اوضحت النتائج ايضا زيادة نسبة التجمعات الثابتة وايضا متوسط الاقطار الوزنية نتيجة استخدام FYM وايضا معاملات الخلط بين (FYM+A.S.) مقارنة بمعاملات الكبريت الزراعى. انخفضت قيم EC مع زيادة معدلات الاضافة من سماد المزرعة وايضا معاملات الخلط بين (FYM+A.S.) بينما اوضحت النتائج عكس ذلك فى حالة معاملة التربة بالكبريت الزراعى بصورة منفردة. لوحظ انخفاض فى قيم SAR، ESP ودرجة الحموضة بزيادة معدلات الإضافة من سماد المزرعة وايضا معاملات الخلط (سماد الزرعة + الكبريت الزراعى)، بينما ازدادت قيم SAR، ESP ودرجة الحموضة مع زيادة مستويات مياه الري تحت الدراسة. يمكن ترتيب تأثير معاملات الدراسة على نسبة عائد الاستثمار كما يلى: 20 طن/فدان سماد المزرعة + 100 كجم/فدان كبريت زراعى > 15 طن/فدان سماد المزرعة > 20 طن/فدان سماد المزرعة + 75 كجم/فدان كبريت زراعى > 20 طن/فدان سماد المزرعة > 20 طن/فدان سماد المزرعة + 50 كجم/فدان كبريت زراعى > 10 طن/فدان سماد المزرعة > 75 كجم/فدان كبريت زراعى > 100 كجم/فدان كبريت زراعى > 50 كجم/فدان كبريت زراعى > الكنترول تحت معاملة مستوى ماء الرى 100% من الماء الميسر فى التربة.