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INTERACTION EFFECT OF SOME SOIL AMENDMENTS ON THE QUALITY OF SANDY SOILS CULTIVATED WITH WHEAT

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ABSTRACT: A pot experiment was applied to investigate the effect of different amendments on some properties of sandy soil and its productivity of wheat plants. Three-factors computer model were implemented, X_1 (cheese whey + super absorbent Polymer (SAP)), X_2 (biochar + SAP) and X_3 (compost+SAP). Some physical and chemical properties of sandy soil and wheat yield were estimated. The obtained results appeared that the values of bulk density, real density, porosity and moisture content (field capacity, FC, wilting point, WP, and available water, AW) of the tested soil were positively influenced by the applied soil amendments. The maximum AW was increased till 8.11% with application of 10, 10 and 80% of (cheese whey +SAP), (biochar + SAP) and (compost +SAP), respectively. Significant increases in wheat yield, were observed due to amendments addition. All the wheat growth characters showed an enhancement by the application of soil amendments as compared to the control. The maximum wheat grain yield was recorded with the application of (cheese whey+ SAP), (biochar+ SAP) and (compost+ SAP) at a rates of 10, 10 and 80%, respectively. This increase was 0.84 ton fad.$^{-1}$ in comparison with the control.

Key words: X_1= cheese whey + SAP, X_2 = biochar + SAP, X_3 = compost + SAP, super absorbent polymer (SAP).

INTRODUCTION

Sandy soils widely exist in arid and semi-arid regions such as the east and west desert areas of Egypt. Increasing the productivity of the lands is one of the major targets of the agricultural policy. The productivity of sandy soils is mostly limited by several agronomic obstacles. However, natural soil amendments contribute significantly to provide a reservoir of soil water to plants. In addition, soil amendments improve the water retention in dry, coarse soils likewise it showed an effective role in adjusting the pH of the soil. Several applications of natural soil conditioners were carried out to improve some physic-bio-chemical properties of sandy soils. Many researchers are interested in improving the physical and chemical condition of the sandy soil, thus, enhance crop production. Therefore, used natural soil amendments to improve soil structure, aeration, water-holding capacity and availability of water to plants were detected. Types of soil amendment, their role and the interaction between different amendments is important. In this concern, Agegnehu *et al*. (2015) showed that the application of natural amendments (compost and biochar) improved physical properties and nutrients availability of sandy soil and thereby uptake of water and nutrients by the plants. Demir and Gulser (2015) and Miller *et al*. (2015) reported that application of compost led to improve soil physical properties such as soil bulk density, plant available water (PAW), and soil water retention. Inal *et al*. (2015) reported that combined application of compost and biochar together increased soil physical, chemical, biological properties and plant growth. Ekebafe *et al*. (2013) found that application of superabsorbent polymers (SAPs) and/or biochar, increase soil fertility and agricultural yields, likewise improve soil structure, aeration and water penetration.

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On the other hand, wheat is the second most important food crop in the developing world after rice. In recent years, wheat production levels have not satisfied demand, triggering price instability and hunger riots. With a predicted world population of 9 billion in 2050, the demand for wheat is expected to increase by 60%. To meet this demand, annual wheat yield increases must rise from the current level of below 1% to at least 1.6%.

The objectives of this study were to evaluate the combination effect of some soil locally natural produced amendments on some chemical and physical properties of sandy soil cultivated with wheat plants as an indicator crop.

MATERIALS AND METHODS

A pot experiment was carried out to study the effect of applied some natural soil amendments. Uncultivated sandy soil of El-Khatara experimental farm were used. Some physical and chemical characters of the used sandy soil were determined and shown in Table 1.

The computer model represented by Gipesa diagram according to Moussa *et al*. (1986) was used in this study. This model facilitates the assessment of any three experimental factors and their interactive effect on any soil or plant for estimating the optimal combination.

In order to study the effect of various soil conditioner components on soil or plant qualitative or quantitative values, the sum of those components must be equal to 1 or 100%. The three components in this study were cheese whey + Super Absorbent Polymer (SAP), biochar + SAP and compost + SAP which are designated as X_1, X_2 and X_3, respectively are placed at the heads of a triangle similar to that used in describing soil texture. Each factor amounts equal to 100% of its maximum value in these sites. The level of each factor decreases gradually when moving from the concerned head towards the opposite side at which the level reaches to zero, when drawing the lines representing the different levels of each factor, different intersections will result. Every intersection represents certain combination with a cost equal to 2000 LE/faddan. Finally, the diagram will show 66 intersection points, which will cover all the possible combinations between the three factors. The triangle is divided by 9 lines parallel to the three sides. The side represents the zero level of the factor represented on the opposite head, while the following line represents 10% of the maximum value of the factor and then every following line will increase by 10% of the maximum (Fig. 1).

The actual thirteen combined treatments, which are illustrated in Fig. 2 and presented in Table 2 were chosen to carry out this experimental work. In this design the sum of the three factors will be always 100% of the maximum values, *i.e.*, $X_1+ X_2+X_3=100\%$with a cost = 2000 LE/faddan.

All the data obtained from the different combined treatments were passed to the computer to give the results represented on the triangle at the same site of the concerned combined treatments. These results take numbers equal to or less than 10, and the number 10 represents the maximum value attained for this attribute. The other numbers represent values relative to maximum one.

Moreover, the program calculates the average value, determination coefficients, correlation coefficients, fisher criterion, mean square error between replicates, t criterion for control and maximum and minimum values of the attribute. Table 3 describe some properties of the cheese whey, biochip and compost.

Plastic pots of 25 cm height and 21 cm diameter were filled with 10 kg soil for each, mixed with appropriate level of soil amendment as described in Table 2. Soil amendments (cheese whey + SAP, biochar + SAP and compost + SAP) were applied before wheat cultivation and thoroughly mixed well with the soil surface layer (0-15 cm). Four replicates of each treatment were applied. The pots were planted with 20 wheat grains (*Tritcium vulgar* C.V., Sakha 93) thinned to 5 plants per pot. All the treatments were received recommended dose of the mineral fertilizer according to the program of Egyptian Ministry of Agriculture.

The following growth characters, grain yield (ton/ feddan), weight of 1000 grains (g), spike length (cm) and plant height (cm) were recorded according to Cottenie *et al*. (1982). After harvesting soil samples were taken for physical and chemical analyses.

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

Soil characteristics	Values	Soil characteristics	Values
Particle size distribution (%)		**Physical properties**	
sand	90.30	**Saturation percent (%)**	18.00
Silt	5.94	**Available water AW (%)**	4.92
Clay	3.76	**Field capacity FC (%)**	6.54
Texture class	Sandy	**Wilting point WP (%)**	1.62
		Air dried soil moisture (%)	0.46
		Bulk density (g cm^{-3})	1.72
		Real density (g cm^{-3})	2.74
		Total porosity (%)	37.00
Chemical properties		**Soluble cations and anions**	
$CaCO_3$ (%)	0.37	**(meq L^{-1})**	
pH (1:2.5 soil water suspension)	8.45	**Ca^{++}**	1.80
EC, dS m^{-1} (saturated paste extract)	0.70	**Mg^{++}**	3.64
Organic matter (g kg^{-1})	0.50	**Na^{+}**	0.84
Available macronutrients (mg Kg^{-1})		**K^{+}**	0.42
N	20.53	**CO_3^{--}**	-
P	1.37	**HCO_3^{-}**	1.54
K	59.69	**CL^{-}**	1.40
		SO_4^{--}	3.76

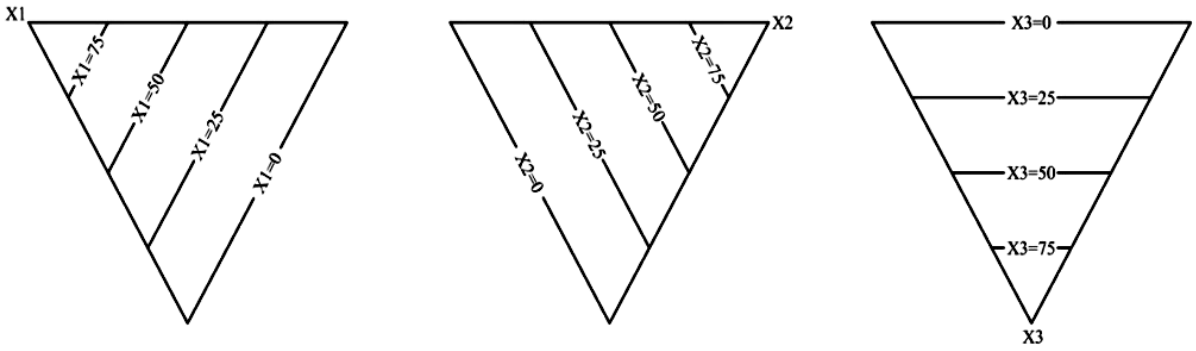

Fig. 1. Gipesa diagram

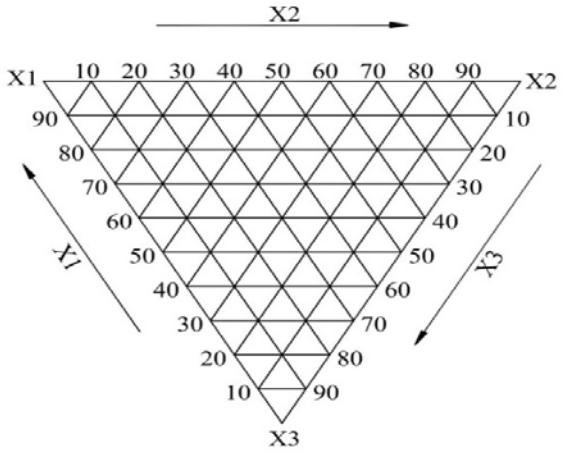

Fig. 2. Guide for the (X_1), (X_2) and (X_3) point combination of each treatment on triangle diagram

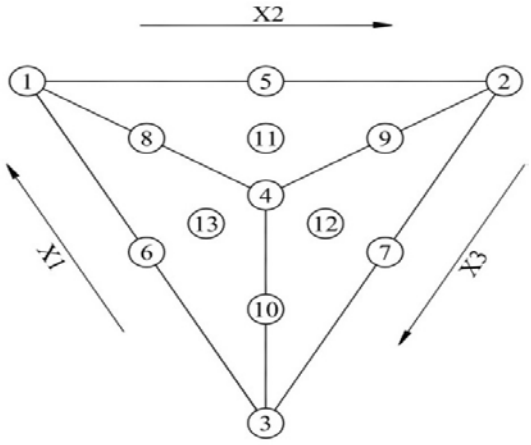

Fig. 3. Chosen Location of the thirteen treatments

Table 2. The thirteen chosen treatments as percentages and Kg fad.$^{-1}$

Treat. No.	Treatments as percentages (%)			Treatments as amount					
	(X_1)	(X_2)	(X_3)	(X_1)		(X_2)		(X_3)	
				Cheese whey (kg fad.$^{-1}$)	SAP (kg fad.$^{-1}$)	Biochar (kg fad.$^{-1}$)	SAP (kg fad.$^{-1}$)	Compost (kg fad.$^{-1}$)	SAP (kg fad.$^{-1}$)
1	100	0	0	131.5	5.5	0	0	0	0
2	0	100	0	0	0	500	5.5	0	0
3	0	0	100	0	0	0	0	5000	5.5
4	33.3	33.3	33.3	43.78	1.83	166.5	1.83	1665	1.83
5	50	50	0	65.75	2.75	250	2.75	0	0
6	50	0	50	65.75	2.75	0	0	2500	2.75
7	0	50	50	0	0	250	2.75	2500	2.75
8	66.6	16.6	16.6	87.57	3.66	83	0.91	830	0.91
9	16.6	66.6	16.6	21.82	0.91	333	3.66	830	0.91
10	16.6	16.6	66.6	21.82	0.91	83	0.91	3330	3.66
11	44.4	44.4	11.1	58.38	2.44	222	2.44	555	0.61
12	44.4	11.1	44.4	58.38	2.44	55.5	0.61	2220	2.44
13	11.1	44.4	44.4	14.59	0.61	222	2.44	2220	2.44

Table 3. Some physical and chemical characteristics of the used soil amendments

Character	Soil amendments		
	Cheese whey	Biochar	Compost
pH (1:2.5 water suspension)	6.42	8.53	7.23
EC (dSm^{-1})	7.21	4.22	3.30
Organic matter ($g\ kg^{-1}$)	591.90	15.60	290.40
Organic carbon ($g\ kg^{-1}$)	343.3	9.70	168.45
Total N ($g\ kg^{-1}$)	18.00	10.9	10.00
C/N ratio	19.10	0,90	16.85
P ($g\ kg^{-1}$)	6.00	0.70	1.10
K ($g\ kg^{-1}$)	21.70	11.00	13.00
Moisture content (%)	-	-	25.00
Weight of 1 m^3 (kg)	-	-	650

Bulk density (g cm^{-3}), real density (g cm^{-3}), total porosity (%) and air dried soil moisture (%) were determined according to Baruah and Barthakur (1997). Available water (%), field capacity (%) and wilting point (%) according to Deleenheer and De Boodt (1965). Electrical conductivity (EC) according to Jackson (1973). Soil pH according to Cottenie *et al.* (1982). Soluble cations and anions according to Black (1965). Sodium and potassium were estimated as described by Cottenie *et al.* (1982). Calcium, magnesium and organic matter according to Jackson (1973).

RESULTS AND DISCUSSION

Values of bulk density, real density and total porosity of the tested soil were positively influenced by the application of X_1(cheese whey + SAP), X_2 (biochar + SAP) andX_3 (compost + SAP) to the soil. Table 4 and Fig. 4 show that soil real density as affected by different combinations of (cheese whey + SAP), (biochar + SAP) and (compost + SAP) is ranged between 2.55 to 2.63 g cm^{-3}while control recorded 2.74 g cm^{-3}. Scanning the different treatments, it could be detected that the most effective treatments was the single application of (compost + SAP) which induced a reduction in soil real density from 2.74 g $cm^{-3}$to 2.55 g cm^{-3}. The reduction of soil real density associated with the compost application may be due to the law density of the applied compost (0.19 g cm^{-3}). The other single treatments of (cheese whey + SAP), and (biochar + SAP) achieved a reduction in soil real density as compared to the control. This reduction took the following descending order (compost +SAP)> (biochar + SAP) > (cheese whey + SAP). Fig. 4 illustrated that there was a very little change in soil real density (No9) occupied all the triangle area, which means that the change in soil real density was only in the second decimal number.

Soil bulk density is one of the most effective parameters which improve soil physical properties. Table 4 and Fig. 5 show that soil bulk density was affected by different combinations of (cheese whey +SAP), (biochar + SAP) and (compost +SAP). Wherever, it was ranged from 1.52 to 1.64g cm^{-3} compared to the control (1.72g cm^{-3}).The individual application of (cheese whey +SAP), (biochar + SAP) and (compost +SAP) resulted 1.64, 1.62 and 1.52 g cm^{-3}, respectively. These results appeared the effective role of compost +SAP in reducing soil bulk density compared with (cheese whey +SAP) or (biochar + SAP). Fig. 5 reveal that there are no big changes in soil bulk density as affected by the used amendments in which No. 9 occupied all the triangle area as that of real density.

Table 4. Some soil physical properties and moisture relations as affected by different combination of used amendments

Treat. No.	Treatment percentages%			pH	EC, $dS.m^{-1}$	Bulk density ($g.cm^{-3}$)	Real density ($g.cm^{-3}$)	Total porosity (%)	OM (%)	Soil maximum water holding capacity (%)	Soil field capacity (%)	Soil wilting point (%)	Soil available water (%)
	X_1 Cheese whey +sap	X_2 Biochar +SAP	X_3 Compost +SAP										
1	100	0.0	0.0	7.90	1.08	1.64	2.62	37.40	0.12	20.43	11.19	5.06	6.13
2	0.0	100	0.0	8.37	0.85	1.62	2.63	38.36	0.11	23.49	12.93	6.00	6.93
3	0.0	0.0	100	8.27	1.42	1.52	2.55	42.09	0.20	29.37	15.18	7.33	7.85
4	33.3	33.3	33.3	7.87	1.02	1.60	2.59	38.12	0.10	22.39	11.25	5.16	6.09
5	50	50	0.0	7.81	0.93	1.63	2.60	37.65	0.14	21.27	12.23	6.01	6.22
6	50	0.0	50	7.93	1.95	1.58	2.58	38,46	0.12	23.26	13.05	7.07	5.98
7	0.0	50	50	8.23	0.97	1.57	2.58	38.91	0.14	21.14	11.04	5.03	6.01
8	66.6	16.6	16.6	7.91	1.35	1.61	2.59	37.92	0.15	20.65	11.62	6.04	5.58
9	16.6	66.6	16.6	8.15	0.79	1.61	2.60	38.34	0.12	19.18	10.12	5.07	5.05
10	16.6	16.6	66.6	8.14	1.42	1.56	2.56	39.02	0.16	28.68	14.93	7.03	7.90
11	44.4	44.4	11.1	8.04	1.37	1.62	2.59	37.92	0.13	21.23	10.09	5.04	5.05
12	44.4	11.1	44.4	8.11	1.79	1.60	2.58	37.75	0.15	23.69	12.30	6.21	6.09
13	11.1	44.4	44.4	8.35	1.90	1.59	2.56	38.35	0.14	24.42	13.76	6.43	7.33
Control				8.45	0.70	1.72	2.74	37.00	0.05	18.4	6.54	1.62	4.92
						*-0.89	*-0.62	_		**0.90	**0.93	**0.72	_

Correlation coefficients with: * Total porosity (%) ** Soil available water (%)

AVERAGE VALUES
1 2.60 2.62 2.64 2.62 = 2.6200
2 2.62 2.64 2.63 2.64 = 2.6325
3 2.56 2.54 2.57 2.54 = 2.5525
4 2.58 2.60 2.59 2.59 = 2.5900
5 2.63 2.58 2.61 2.64 = 2.6025
6 2.58 2.60 2.59 2.55 = 2.5800
7 2.58 2.60 2.60 2.55 = 2.5825
8 2.60 2.60 2.61 2.58 = 2.5975
9 2.60 2.62 2.61 2.59 = 2.6050
10 2.55 2.58 2.57 2.55 = 2.5625
11 2.61 2.59 2.63 2.61 = 2.5975
12 2.58 2.57 2.58 2.60 = 2.5825
13 2.59 2.59 2.60 2.57 = 2.5675
coeff. deter.= .7498088
correlation function= .8659149
criterion fisher f(12 , 39)= 9.740062
soct= 1.441877E-02
control=-2.722216E-02
t= .4028099
control=-2.606944
t= 38.5753
control=-5.195833
t= 76.88343
2.6200 2.6104 2.6022 2.6003 2.6096 2.6025
2.6047 2.6088 2.6148 2.6227 2.6325
2.6110 2.6047 2.5990 2.5989 2.6091 2.5989
2.6022 2.6074 2.6145 2.6209
2.6025 2.5987 2.5948 2.5956 2.5941 2.5966
2.6010 2.5975 2.6101
2.5945 2.5925 2.5894 2.5903 2.5920 2.5849
2.5833 2.6001
2.5870 2.5859 2.5829 2.5831 2.5737 2.5721
2.5909
2.5800 2.5790 2.5753 2.5677 2.5638 2.5825
2.5735 2.5718 2.5666 2.5584 2.5749
2.5675 2.5642 2.5560 2.5681
2.5620 2.5564 2.5621
2.5570 2.5569
2.5525

Ymax= 2.6325Ymin= 2.5525
X_1 9 9 9 9 9 9 9 9 9 9 10X_2
9 9 9 9 9 9 9 9 9 9
9 9 9 9 9 9 9 9 9
9 9 9 9 9 9 9 9
9 9 9 9 9 9 9
9 9 9 9 9 9
9 9 9 9
9 9 9
9 9
9
X_3

Fig. 4. Soil real density g.cm^{-3}, as affected by cheese whey + SAP, biochar+ SAP and compost + SAP. Ymax= X_1=0, X_2=100, X_3=0 Ymin= X_1=0, X_2=0, X_3=100

AVERAGE VALUES
1 1.63 1.64 1.65 1.64 = 1.6400
2 1.61 1.62 1.64 1.62 = 1.6225
3 1.53 1.51 1.53 1.52 = 1.5225
4 1.61 1.61 1.59 1.60 = 1.6025
5 1.63 1.62 1.64 1.63 = 1.6300
6 1.60 1.59 1.59 1.57 = 1.5875
7 1.58 1.59 1.58 1.56 = 1.5775
8 1.60 1.61 1.63 1.61 = 1.6125
9 1.61 1.62 1.62 1.60 = 1.6125
10 1.54 1.59 1.55 1.57 = 1.5625
11 1.63 1.60 1.62 1.63 = 1.6200
12 1.60 1.61 1.60 1.62 = 1.6075
13 1.61 1.58 1.59 1.60 = 1.5950
coeff. deter.= .8878331
correlation function= .9422489
criterion fisher f(12 , 39)= 25.72469
soct= 1.240401E-02
control=-3.944433E-02
t= .6292818
control=-1.621389
t= 25.86711
control=-3.195833
t= 50.98527
1.6400 1.6170 1.5860 1.5668 1.5790 1.6300
1.6283 1.6267 1.6252 1.6238 1.6225
1.6305 1.6214 1.6011 1.5892 1.6056 1.6207
1.6197 1.6182 1.6165 1.6143
1.6205 1.6221 1.6091 1.6013 1.6114 1.6114
1.6105 1.6127 1.6057
1.6100 1.6189 1.6101 1.6031 1.6045 1.6061
1.6068 1.5967
1.5990 1.6120 1.6039 1.5945 1.5980 1.5989
1.5873
1.5875 1.6013 1.5908 1.5861 1.5889 1.5775
1.5755 1.5868 1.5705 1.5768 1.5673
1.5630 1.5686 1.5627 1.5567
1.5500 1.5465 1.5457
1.5365 1.5343
1.5225

Ymax= 1.64 Ymin= 1.5225
X_1 10 9 9 9 9 9 9 9 9 9 9 X_2
9 9 9 9 9 9 9 9 9 9
9 9 9 9 9 9 9 9 9
9 9 9 9 9 9 9 9
9 9 9 9 9 9 9
9 9 9 9 9 9
9 9 9 9
9 9 9
9 9
9
X_3

Fig. 5. Soil bulk density g.cm^{-3}, as affected by cheese whey + SAP, biochar+ SAP and compost + SAP after wheat crop. Ymax=X_1=100, X_2=0, X_3=0Ymin=X_1=0, X_2=0, X_3=100

The obtained results in Table 4 and Fig. 6 demonstrate that the total soil porosity ranged from 37.40 to 42.09%, as affected by different combinations of (cheese whey +SAP), (biochar + SAP) and (compost +SAP), that appeared the effective role of (compost + SAP) on raising the soil porosity by more that 13.7% compared to the control (37%). It is ought to be mentioned herein that the most positive effect of the first three treatments received the maximum dose of (cheese whey +SAP), (biochar + SAP) and (compost +SAP) followed the order (compost +SAP)> (biochar + SAP)> (cheese whey + SAP), which mean that application of 100% X_1, X_2 and X_3 as a single treatment resulted in 80, 90 and 100% of the maximum total porosity, respectively. These results once more obvious the favorable use of compost.

Soil pH is contributing soil nutrients solubility and availability to plant and may effects soil microorganism. Soil pH as affected by different combinations of X_1(cheese whey + SAP), X_2 (biochar + SAP) andX_3 (compost + SAP) are manifested in Table 5 and Fig. 7 is ranged between 7.81 and 8.37, while the value recorded at the control was 8.45. Soil pH values showed a reduction after wheat crop as a result of added amendments as compared to the control. The minimum pH value was occurred with the treatment of 60% (cheese whey + SAP) + 40% (biochar + SAP). On the other hand, the maximum pH value was induced with (biochar + SAP) treatments. The obtained results pointed out that the pH of the soil received (cheese why + SAP), (biochar+ SAP) and (compost + SAP) were 7.90, 8.37, and 8.27, respectively.

The pH values decreased gradually in the triangle Fig. 7 from X_2 toward X_1, which refer to the beneficial effects of applied organic amendment to reduce soil pH, specially cheese whey. The relationship between application of organic amendment and soil reaction are due to CO_2 and organic acids which produced during the decomposition of organic materials.

Many workers reported that organic manure affected the soil pH, El-Fayoumy *et al*. (2000), Mahmoud (2000), Basyouny (2002), El-Maddah (2005) and Wahdan *et al.* (2005), they reported that increasing the applied organic manure rates resulted in an increase of soil organic matter content as well as a decrease of soil pH.

Electrical conductivity is a soil parameter that indicates indirectly the total concentration of soluble salts and is a direct measurement of salinity. Results illustrated in Table 4 and Fig. 8 declare that soil electrical conductivity was affected by the different combinations of (cheese whey + SAP), (biochar + SAP), and (compost +SAP). Electrical conductivity was ranged from 1.95 to 0.79 dSm^{-1} compared with control which recorded 0.70 dSm^{-1}. These results pointed out that application of such amendments led to increase soil electrical conductivity. Moreover, Table 4 reveals that EC of the first three individual treatments which received only the maximum dose of (cheese whey + SAP), (biochar +SAP), or (compost +SAP) recorded decreased in soil EC to 1.08, 0.85 and 1.42 dSm^{-1}, respectively. In other words the individual treatments which received the maximum dose of (cheese whey + SAP), (biochar + SAP) and (compost +SAP) resulted as EC values equal to 50, 40 and 70% of the maximum EC value. The maximum value is denoted by No.10 and obtained with 40,0 and 60% of (X_1, X_2 and X_3), respectively. Scanning the other EC values of Fig.(8) it could be recognized that the minimum soil EC value denoted by No.1on the triangle (0.32 dSm^{-1}) resulted from application of 60,40 and 0% of X_1 (cheese whey + SAP),X_2 (biochar + SAP), and X_3 (compost +SAP), respectively. It is seem that the combination effect between cheese whey and biochar has a marked decreasing on soil electrical conductivity compared with other combinations.

However, the addition of (biochar +SAP) to the soils led to slightly increased in EC values compared with control, the soils amended with (cheese whey +SAP) and (compost +SAP) showed a higher EC than the untreated soils. These results suggested that application of compost induced an increase in soil salinity.

Thus, the decrease effectiveness took the following descending order (biochar +SAP) > (cheese whey +SAP) > (compost +SAP).

Similar results have been reported by Sarwar *et al*. (2003), Niklasch and Joergensen (2001), Selvakumari *et al*. (2000) and Gonzalez *et al*. (2010), which indicated that EC increased in acidic as well as alkaline soils when organic materials of different nature were applied to the soil.

AVERAGE VALUES
1 37.30 37.40 37.50 37.40 = 37.4000
2 38.55 38.63 37.64 38.63 = 38.3625
3 42.23 41.55 41.46 43.15 = 42.0975
4 37.59 38.08 38.61 38.22 = 38.1250
5 38.02 37.20 37.16 38.25 = 37.6575
6 37.98 38.84 38.61 38.43 = 38.4650
7 38.75 38.84 39.23 38.82 = 38.9100
8 38.46 38.08 37.55 37.60 = 37.9225
9 38.07 38.16 38.93 38.22 = 38.3450
10 39.60 38.37 39.69 38.43 = 39.0225
11 37.54 38.22 38.40 37.55 = 37.9275
12 37.98 37.35 37.98 37.69 = 37.7500
13 37.83 38.99 38.84 37.74 = 38.3500
coeff. deter.= .877998
correlation function= .9370155
criterion fisher f(12 , 39)= 23.38891
soct= .4883073
control= .2788887
t= .7091303
control=-38.28222
t= 97.34019
control=-76.90166
t= 195.5378
37.4000 38.1501 39.1865 40.0484 40.2748 37.6575
37.7627 37.8858 38.0268 38.1857 38.3625
37.4076 37.7519 38.4594 39.0691 39.1203 37.9511
38.0666 38.2083 38.3763 38.2608
37.5179 37.5333 37.9886 38.4230 38.0836 38.1831
38.3172 38.2159 38.2647
37.7309 37.4941 37.7742 38.1101 38.1852 38.1725
38.1860 38.3742
38.0466 37.6345 37.8160 38.1303 38.1828 38.2863
38.5893
38.4650 37.9544 38.1143 38.3483 38.5170 38.9100
38.9861 38.4538 38.6688 38.8781 39.3363
39.609939.1328 39.3694 39.8682
40.3364 39.9912 40.5057
41.1656 41.2488
42.0975

Ymax= 42.0975Ymin= 37.4
$X_1$8 9 9 9 9 8 8 8 9 9 9 X_2
8 8 9 9 9 9 9 9 9 9
8 8 9 9 9 9 9 9 9
8 8 8 9 9 9 9 9
9 8 8 9 9 9 9
9 9 9 9 9 9
9 9 9 9 9
9 9 9 9
9 9 9
9 9
10
X_3

Fig. 6. Soil total porosity (%), as affected by cheese whey + SAP, biochar+ SAP and compost + SAP after wheat crop. Ymax=X_1=0, X_2=0, X_3=100Ymin=X_1=100, X_2=0, X_3=0

AVERAGE VALUES
1 7.94 7.87 7.89 7.90 = 7.9000
2 8.37 8.39 8.35 8.37 = 8.3700
3 8.30 8.25 8.28 8.27 = 8.2750
4 7.85 7.88 7.89 7.87 = 7.8725
5 8.05 8.09 7.06 8.07 = 7.8175
6 7.93 7.96 7.92 7.93 = 7.9350
7 8.20 8.24 8.26 8.23 = 8.2325
8 7.94 7.90 7.89 7.91 = 7.9100
9 8.13 8.16 8.18 8.15 = 8.1550
10 8.10 8.15 8.17 8.14 = 8.1400
11 8.01 8.05 8.07 8.04 = 8.0425
12 8.12 8.09 8.13 8.11 = 8.1125
13 8.37 8.33 8.36 8.35 = 8.3525
coeff. deter.= .6848746
correlation function= .8275715
criterion fisher f(12 , 39)= 7.063355
soct= .14167
control= .3077784
t= 1.452917
control=-7.525277
t= 35.52428
control=-15.755
t= 74.374
7.9000 7.8373 7.6422 7.43577.3388 7.8175
7.8772 7.9623 8.0728 8.2087 8.3700
7.8826 7.9117 7.7883 7.6334 7.5678 8.0596
8.1153 8.1784 8.2491 8.3281
7.8774 7.9782 7.9063 7.7827 8.0259 8.0701
8.1039 8.3072 8.2934
7.8844 8.0367 7.9962 7.8838 7.9344 8.1767
8.3441 8.2659
7.9036 8.0873 8.0579 7.9366 8.1999 8.3597
8.2456
7.9350 8.1299 8.0916 8.1733 8.3541 8.2325
7.9786 8.1645 8.0971 8.3273 8.2266
8.0344 8.1912 8.2792 8.2279
8.1024 8.2099 8.2364
8.1826 8.2521
8.2750

Ymax= 8.37Ymin= 7.338837
X_1 9 9 9 8 8 9 9 9 9 9 10 X_2
9 9 9 9 9 9 9 9 9 9
9 9 9 9 9 9 9 9 9
9 9 9 9 9 9 9 9
9 9 9 9 9 9 9
9 9 9 9 9 9
9 9 9 9 9
9 9 9 9
9 9 9
9 9
9
X_3

Fig. 7. Soil pH as affected by cheese whey + SAP, biochar+ SAP and compost + SAP after wheat crop. Ymax= X_1=0 X_2=100 X_3=0Ymini= X_1=60X_2=40 X_3=0

AVERAGE VALUES
1 1.06 1.07 1.10 1.12 = 1.0875
2 0.88 0.80 0.89 0.84 = 0.8525
3 1.42 1.44 1.40 1.42 = 1.4200
4 1.04 1.00 1.06 0.99 = 1.0225
5 0.90 0.95 0.92 0.97 = 0.9350
6 1.99 1.95 1.93 1.96 = 1.9575
7 0.95 1.02 0.99 0.95 = 0.9775
8 1.35 1.38 1.33 1.35 = 1.3525
9 0.76 0.80 0.81 0.79 = 0.7900
10 1.45 1.40 1.43 1.41 = 1.4225
11 1.36 1.39 1.40 1.34 = 1.3725
12 1.82 1.80 1.78 1.79 = 1.7975
13 1.90 1.88 1.93 1.90 = 1.9025
coeff. deter.= .9962985
correlation function= .9981476
criterion fisher f(12 , 39)= 874.7705
soct= 2.690721E-02
control= .678889
t= 7.353703
control=-1.607222
t= 17.40938
control=-2.235
t= 24.20945
1.0875 1.0150 0.8081 0.5506 0.3266 0.9350
0.9129 0.8936 0.8771 0.8634 0.8525
1.3741 1.3179 1.1132 0.8440 0.5943 1.3180
1.1899 1.0104 0.7796 0.8521
1.6044 1.5505 1.3341 1.0392 1.2843 1.1013
0.8129 1.2536 0.8644
1.7784 1.7128 1.4707 1.1361 0.9524 1.3478
1.6025 0.8894
1.8961 1.8048 1.5230 1.1347 1.6197 1.8262
0.9271
1.9575 1.8265 1.4910 1.6287 1.9248 0.9775
1.9626 1.7779 1.3747 1.8983 1.0406
1.9114 1.6590 1.7466 1.1164
1.8039 1.4698 1.2049
1.6401 1.3061
1.4200

Ymax= 1.9626Ymin= .3265801
X_1 5 5 4 2 1 4 4 4 4 4 4 X_2
7 6 5 4 3 6 6 5 3 4
8 7 6 5 6 5 4 6 4
9 8 7 5 4 6 8 4
9 9 7 5 8 9 4
9 9 7 8 9 4
10 9 7 9 5
9 8 8 5
9 7 6
8 6
7
X_3

Fig. 8. Soil EC dS.m^{-1} as affected by cheese whey + SAP, biochar+ SAP and compost+ SAP after wheat crop. Ymax= X_1=40X_2=0 X_3=60Ymini= X_1=60 X_2=40 X_3=0

Results in Table 4 and Fig. 9 indicate that application different combination of X_1 (cheese whey + SAP), X_2 (biochar + SAP) and X_3 (compost + SAP) augmented soil organic matter content compared with the control. The maximum soil organic matter was obtained by the single compost treatment which recorded 0.20%. The other single treatment of cheese whey and biochar resulted 60and 50% of the maximum *i.e.* 0.12 and 0.11%, respectively. Fig. 9 demonstrate that in addition to the beneficial effect of applied compost on soil physical and chemical properties, it showed likewise an enhancing effect on raising the soil organic matter. It is considered as an ultimate source of micronutrients and microbial activity. These results are supported by Sparks (1995), Giusquiani *et al*. (1995) and Sarwar *et al*. (2003).

Soil moisture content (saturation percentage, SP, field capacity, FC, wilting point, WP and available water, AW) followed the same trend, as noted from the output computer sheet, so, available water has been selected to represent these moisture characters which show a highly significant correlation coefficient (r = 0.90,0.93 and 0.72),respectively. Results in Table 4 and Fig. 10 reveal that soil available water ranged between 4.31 and 8.11%; the maximum soil available water 8.11% was occurred by 10,10 and 80% of the X_1 (cheese whey +SAP), X_2 (biochar + SAP) and X_3 (compost + SAP), respectively. Application of single treatment of X_1 (cheese whey + SAP), X_2 (biochar + SAP) andX_3 (compost + SAP) resulting a soil available water equals 70, 80 and 90% of the maximum soil available water, respectively. Thus, the increased soil available water took the following descending order (compost + SAP) > (biochar + SAP) > (cheese whey + SAP). Moreover, Fig. 10 show that the soil available water decreased gradually in the triangle from the X_1 (cheese whey + SAP) head toward the X_2 (biochar + SAP) and X_3 (compost+ SAP), this observation emphasizing the role of X_3 in raising soil water retention.

The obtained results stated that application of compost has a marked pronounced useful effect on soil moisture characters. Similar results have been reported by Mohamed (2011) who indicated that the water holding capacity of sandy soil was increased with animal manure. Tom (2006) stated that soil organic matter enhances soil water retention because of its hydrophilic nature and its positive influence on soil structure, increasing soil organic matter increase soil aggregate formation, enhance infiltration, water retention and the pores that retain plant available water. The role of soil natural amendment in improving soil water retention doesn't depend only on its highly water adsorption property, but also on its ability to form aggregates.

Results in Table 5 represent grains yield (ton fad.$^{-1}$), straw yield (ton fad.$^{-1}$) biological yield (ton fad.$^{-1}$), weight of 1000 grain (g), plant height (cm) and spike length(cm)as affected by all the possible combinations of X_1 (cheese whey + SAP), X_2 (biochar + SAP) andX_3 (compost + SAP). Obtained results reveal that all growth characters showed an increase by the application of soil amendments as compared to control treatment. However, the results showed that the application of X_3 (compost +SAP) has more pronounced effect on wheat growth characters as compared to X_1 (cheese whey +SAP) or X_2 (biochar +SAP).

On the other hand, all the wheat growth characters appeared the same triangle trend and have a highly significant correlation coefficient with grains yield (r = 0.70, 0.93, 0.88,0.74 and 0.76), respectively. Therefore, grains yield (ton fad.$^{-1}$) Fig. 11 was chosen to represent these group of wheat growth characters.

Scanning the output computer sheet in which all possible combination of X_1 (cheese whey + SAP), X_2 (biochar + SAP) and X_3 (compost + SAP) on wheat grain yield, it could be detected that the maximum which indicated by number 10 on the triangle (2.37 ton fad.$^{-1}$) obtained with 10, 10 and 80% of X_1, X_2 andX_3 respectively. The single treatment of X_1, X_2 and X_3 resulted 70, 70 and 90% of the maximum grain yield. These results suggest that application of (compost +SAP) in combination with (cheese whey + SAP), and (biochar + SAP) has more beneficial effects on wheat grain yield. In this contexts application of single treatment of X_1, X_2 and X_3 resulted grain yield equal to 1.82, 1.72 and 2.22 ton fad.$^{-1}$,respectively. Whereas control recorded 1.53 ton fad^{-1}. These results are in agreement with many investigators, Tanveer *et al*. (2010) found that the maximum

AVERAGE VALUES
1 0.10 0.13 0.14 0.12 = 0.1225
2 0.12 0.09 0.13 0.11 = 0.1125
3 0.21 0.18 0.22 0.20 = 0.2025
4 0.10 0.10 0.12 0.10 = 0.1050
5 0.16 0.13 0.13 0.15 = 0.1425
6 0.12 0.12 0.14 0.12 = 0.1250
7 0.15 0.13 0.16 0.14 = 0.1450
8 0.16 0.15 0.16 0.15 = 0.1550
9 0.12 0.13 0.10 0.13 = 0.1200
10 0.15 0.16 0.18 0.16 = 0.1625
11 0.13 0.13 0.15 0.13 = 0.1350
12 0.13 0.15 0.17 0.15 = 0.1500
13 0.16 0.13 0.14 0.15 = 0.1450
coeff. deter.= .8116753
correlation function= .9009302
criterion fisher f(12 , 39)= 14.00743
soct= 1.356355E-02
control=-1.666668E-02
t= .2542753
control=-.1566667
t= 2.390186
control=-.3
t= 4.576952
0.1225 0.1591 0.1670 0.1475 0.1014 0.1425
0.1405 0.1365 0.1305 0.1225 0.1125
0.1170 0.1519 0.1580 0.1364 0.0881 0.1331
0.1285 0.1241 0.1197 0.1170
0.1145 0.1475 0.1516 0.1278 0.1309 0.1238
0.1188 0.1262 0.1225
0.1150 0.1460 0.1478 0.1216 0.1098 0.1265
0.1335 0.1290
0.1185 0.1473 0.1467 0.1179 0.1347 0.1414
0.1365
0.1250 0.1514 0.1482 0.1433 0.1501 0.1450
0.1345 0.1583 0.1524 0.1596 0.1545
0.1470 0.1680 0.1697 0.1650
0.1625 0.1806 0.1765
0.1810 0.1890
0.2025

Ymax= .2025Ymin= 8.812001E-02
X_1 6 7 8 7 5 7 6 6 6 6 5 X_2
5 7 7 6 4 6 6 6 5 5
5 7 7 6 6 6 5 6 6
5 7 7 6 5 6 6 6
5 7 7 5 6 6 6
6 7 7 7 7 7
6 7 7 7 7
7 8 8 8
8 8 8
8 9
10
X_3

Fig. 9. Soil organic matter (%) as affected by cheese whey + SAP, biochar+ SAP and compost + SAP after wheat crop. Ymax= X_1=0 X_2=0 X_3=100Ymini= X_1=50 X_2=40 X_3=10

AVERAGE VALUES
1 6.16 6.00 6.23 6.12 = 6.1275
2 6.90 6.83 7.04 6.93 = 6.9250
3 7.84 7.58 8.15 7.85 = 7.8550
4 5.97 6.15 6.17 6.10 = 6.0975
5 6.21 6.33 6.11 6.21 = 6.2150
6 5.97 5.85 6.12 5.98 = 5.9800
7 5.95 6.01 5.92 6.18 = 6.0150
8 5.58 5.51 5.67 5.59 = 5.5875
9 5.10 4.99 5.06 5.05 = 5.0500
10 7.88 8.24 7.59 7.90 = 7.9025
11 5.06 5.13 4.97 5.05 = 5.0525
12 6.08 6.13 6.05 6.09 = 6.0875
13 7.29 7.14 7.54 7.35 = 7.3300
coeff. deter.= .9841147
correlation function= .9920256
criterion fisher f(12 , 39)= 201.3418
soct= .1309808
control= .7997217
t= 3.92624
control=-5.598055
t= 27.48369
control=-10.8525
t= 53.28042
6.1275 5.8711 5.6995 5.2874 4.3093 6.2150
6.3072 6.4243 6.5663 6.7332 6.9250
5.9362 5.6775 5.5578 5.2518 4.4341 5.0967
5.1391 5.2567 5.4493 6.5230
5.8258 5.6190 5.6055 5.4599 5.0651 4.9828
5.0257 6.0916 6.2310
5.7963 5.6957 5.8425 5.9115 5.6542 6.1195
6.6463 6.0490
5.8477 5.9075 6.2689 6.6067 6.9281 7.1134
5.9770
5.9800 6.2544 6.8846 7.4515 7.4929 6.0150
6.1932 6.7364 7.6897 7.7848 6.1630
6.4873 7.3535 7.9891 6.4210
6.8623 8.1058 6.7890
7.3182 7.2670
7.8550

Ymax= 8.1058 Ymin= 4.3093
X_1 7 7 7 6 5 7 7 7 8 8 8 X_2
7 7 6 6 5 6 6 6 6 8
7 6 6 6 6 6 6 7 7
7 7 7 7 6 7 8 7
7 7 7 8 8 8 7
7 7 8 9 9 7
7 8 9 9 7
8 9 9 7
8 10 8
9 8
9
X_3

Fig. 10. Soil available water (AW) (%) as affected by cheese whey + SAP, biochar+ SAP and compost + SAP after wheat crop. Ymax= X_1=10 X_2=10 X_3=80 Ymin=X_1=60 X_2=40 X_3=0

Table 5. Some wheat yield characters as affected by different combination of used amendments

Treat. No.	Treatment percentages (%)			Grains yield (ton fad.$^{-1}$)	Straw yield (ton fad.$^{-1}$)	Biology Yield (ton fad.$^{-1}$)	Weight of 1000 grains (g)	Plant height (cm)	Spike length (cm)
	X_1 Cheese whey+SAP	X_2 Biochar +SAP	X_3 Compost +SAP						
1	100	0.0	0.0	1.82	2.79	4.61	40.94	75.70	10.00
2	0.0	100	0.0	1.72	2.88	4.60	37.33	74.87	9.52
3	0.0	0.0	100	2.22	3.27	5.49	54.86	85.92	12.22
4	33.3	33.3	33.3	2.05	2.88	4.93	52.40	78.45	11.70
5	50	50	0.0	2.04	3.02	5.06	45.53	75.95	11.47
6	50	0.0	50	2.14	3.09	5.23	48.34	83.35	11.32
7	0.0	50	50	2.08	2.93	5.01	44.41	79.17	11.62
8	66.6	16.6	16.6	2.10	2.84	4.94	50.09	78.02	10.25
9	16.6	66.6	16.6	2.09	2.95	5.04	46.60	75.92	10.67
10	16.6	16.6	66.6	2.37	3.19	5.56	55.11	83.07	11.70
11	44.4	44.4	11.1	2.11	2.92	5.03	46.03	76.90	11.47
12	44.4	11.1	44.4	2.12	3.01	5.13	50.37	80.25	11.60
13	11.1	44.4	44.4	2.07	3.11	5.18	49.10	78.07	11.75
Control				1.53	1.91	3.44	39.18	63.50	7.10
Correlation coefficients with grains yield (ton fad.$^{-1}$)				_	0.70	0.93	0.88	0.74	0.76

AVERAGE VALUES
1 1.83 1.85 1.81 1.80 = 1.8225
2 1.71 1.74 1.73 1.71 = 1.7225
3 2.21 2.20 2.25 2.23 = 2.2225
4 2.03 2.07 2.05 2.05 = 2.0500
5 2.03 2.06 2.06 2.04 = 2.0475
6 2.12 2.13 2.16 2.15 = 2.1400
7 2.10 2.07 2.09 2.06 = 2.0800
8 2.12 2.11 2.09 2.11 = 2.1075
9 2.10 2.09 2.11 2.07 = 2.0925
10 2.38 2.36 2.35 2.39 = 2.3700
11 2.08 2.14 2.12 2.10 = 2.1100
12 2.09 2.13 2.11 2.15 = 2.1200
13 2.05 2.10 2.07 2.08 = 2.0750
coeff. deter.= .9881294
correlation function= .994047
criterion fisher f(12 , 39)= 270.5365
soct= .0194497
control= .2033335
t= 2.590563
control=-2.02
t= 25.73574
control=-4.231667
t= 53.9134
1.8225 2.0427 2.2367 2.2646 1.9865 2.0475
2.0265 1.9835 1.9185 1.8315 1.7225
1.9048 2.0346 2.1614 2.1455 1.8469 2.0997
2.0792 2.0439 1.9940 1.8112
1.9777 2.0404 2.1234 2.0869 2.1350 2.1297
2.1170 1.9921 1.8913
2.0412 2.0601 2.1226 2.0889 2.0915 2.1055
2.0086 1.9628
2.0953 2.0936 2.1590 2.1514 2.1394 2.0435
2.0257
2.1400 2.1411 2.2326 2.2187 2.0968 2.0800
2.1753 2.2026 2.3434 2.1685 2.1257
2.2012 2.2779 2.2586 2.1628
2.2177 2.3671 2.1913
2.2248 2.2112
2.2225

Ymax= 2.3671 Ymin= 1.7225
X_1 7 8 9 9 8 8 8 8 8 7 7 X_2
8 8 9 9 7 8 8 8 8 7
8 8 8 8 9 8 8 8 7
8 8 8 8 8 8 8 8
8 8 9 9 9 8 8
9 9 9 9 8 8
9 9 9 9 8
9 9 9 9
9 10 9
9 9
9
X_3

Fig. 11. Grain yield of wheat plant (ton fad.$^{-1}$) as affected by cheese whey + SAP, biochar+ SAP and compost + SAP after wheat crop. Ymax= X_1=10 X_2=10 X_3=80 Ymin= X_1=0 X_2=100 X_3=0

wheat grain yield of 4083 Kg.ha^{-1} induced with the application of compost. Tayebeh *et al*. (2010) reported that using combination of organic and inorganic fertilizer achieved a highest yield without negative effect on seed quality. Duong (2013) found that compost increased plant growth and nutrient uptake with increasing N and P availability whereas plant growth achieved the maximal after 4 months. The studies of Abou-Hadid *et al.* (2001), Nweke and Nsoanya (2013) and Nweke *et al*. (2014) showed that the application of organic amendments to soils increases yield of crops and improves soil parameters and the ability of the soil to hold plant nutrient elements. Mohamed (2007) found that grains and straw yields of wheat were increased due to application of the cheese whey at a rate of 210 m^3/fad.

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التأثير التفاعلي لبعض محسنات التربة على جودة الأراضي الرملية المزروعة بالقمح

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أجريت تجربة أصص بالصوبة الزجاجية لكلية الزراعة جامعة الزقازيق- مصر، واستخدمت التربة الرملية غير المزروعة من أراضي مزرعة الخطارة -محافظة الشرقية، حيث تم استخدم موديل الحاسب الآلي ثلاثي العوامل كالآتي: X_1 (شرش اللبن + الهيدروجيل)، X_2 (الفحم النباتي + الهيدروجيل) و X_3 (الكمبوست+ الهيدروجيل) لدراسة تأثير إضافة توليفات هذه المحسنات على بعض خواص التربة الفيزيائية والكيميائية و بعض خصائص النمو لنبات القمح، أشارت النتائج إلى أن قيم الكثافة الظاهرية والكثافة الحقيقية والمسامية والمحتوى الرطوبي للتربة (السعة الحقلية، نقطة الذبول، وكمية المياه الميسرة) قد تأثرت إيجابيا مع إضافة المحسنات، وتشير النتائج إلى إن اعلي زيادة للماء الميسر بالتربة بنسبة ٨.١١% ينتج من إضافة (١٠+١٠+٨٠%) من (شرش اللبن+ الهيدروجيل)، (الفحم النباتي+ الهيدروجيل) و(الكمبوست+ الهيدروجيل)، على التوالي، وقد سجلت المعاملة المكونة من١٠و١٠و٨٠% من كل من (شرش اللبن+الهيدروجيل)، (الفحم النباتي+الهيدروجيل) و(الكمبوست+ الهيدروجيل) أعلى محصول للحبوب بزيادة ٠.٨٤ طن/فدان مقارنة بالكنترول.

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