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Attempting Rice Cultivation in Sandy Soil Improved with Compost and Bentonite under Drip Irrigation System

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ABSTRACT

Many other countries have large areas of sandy soil it can be cultivated with some soil properties improvements and reduce water loss during irrigation thus, increase water use efficiency. The present study aims to evaluate the effect of adding compost (Com) 10 ton ha^{-1}, bentonite (Ben) 10 ton ha^{-1}, and a mixture of (compost 5ton ha^{-1} and bentonite 5 ton ha^{-1} (Com/Ben) on the performance of four rice varieties Giza 178, Sakha 107, Hanyou 73 and Hanyou 737 and some physical and chemical properties of a sandy loam soil under drip irrigation system. The results showed that used Com and Com/Ben resulted a significant reduction in soil pH and soil EC as well as soil contents of Na, K, and Mg, compared with control in the soil layer (0-20cm). The treatments significantly increased organic matter, water holding capacity, field capacity, wilting point, available water, and water-holding pores, while all treatments significantly decreased hydraulic conductivity and quick drainage pores in soil layer (0-20cm) compared with the control. Rice plants have been died before the flowering stage under Com and Ben soil amendments in addition to control. Grain yield, harvest index and water use efficiency have been calculated for the rice varieties under com/Ben mixture only. Rice plants under Com/Ben showed the highest root length, plant height, tillers number hill^{-1} and biomass yield in comparison to Com, Ben, and control. Hanyou 737 gave the highest biomass yield, grain yield, harvest index and the highest water use efficiency under Com/Ben followed by Hanyou 73.

***Keywords**:* Rice crop; Compost; Bentonite; Sandy loam soil; Soil Properties.

INTRODUCTION

In Egypt, with the large increase in the population and the decrease in the areas of agricultural lands, it is difficult to provide the population's food needs through vertical expansion, so the best solution will be to provide these needs through horizontal expansion by increasing the area cultivated with crops through the reclamation of new lands (Abdel-Hamid *et al*., 2016). Although, Egypt has vast areas of land that can be cultivated, most of these areas have sandy soils that require great effort and exorbitant costs to become productive. Sandy soils in general suffer from severe poverty and their weak ability to hold water, which results in a large amount of water being lost during the irrigation process and the loss of many nutrients by washing (Kheir *et al*., 2016; Bhanu *et al*., 2018). Sandy soils are poor in properties due to low rainfall and high temperature. Therefore, the scientists focused their research on a practice that could increase water use efficiency and reduce water loss during irrigation (Aly *et al*., 2015). Agriculture represents the main usage of water. Where nearly eighty percent of Egypt's water resources are used for irrigation (Randa, 2014). Modern irrigation methods lead to saving on the water without loss to crops (Nadia *et al*., 2014).

Higher water use efficiency will result in more water being available to irrigate more land and produce more crops. To overcome the previous sandy soil problems, some natural materials are added that improve the physical and chemical properties of the soil. Bentonite contains mostly a 2: 1 clay mineral montmorillonite, which is an individual from the smectite family (Benkhelifa *et al*., 2008). Bentonite has been suggested as a great material for enhancing sand soil worldwide (Satje and Nelson, 2009). Adding bentonite with the sandy soil gave higher contained Mg, Mn, Ca, Zn, CEC and available (K and P) (Czaban and Siebielec, 2013). The bentonite significantly increased the content of soil water, organic C, clay, and silt in sandy soil (Czaban *et al*., 2014). Bentonite addition improves the fertility of sandy soils.

The increased accumulation of total nitrogen and organic carbon resulting from the addition of bentonite in the sandy soil may be an important measure that intensifying carbon sequestration in the soil (Churchman *et al*., 2012; Czaban *et al*., 2013). The contents of silt and clay in the top layer significantly increased with the addition of bentonite. Bentonite partially translocated in deep layers, but the biggest proportion in the top soil layer (Czaban et l., 2013).

The biodegradability of organic matter under aerobic conditions results in a relatively stable matter known as compost (Paulin and Peter, 2008). It is one of the most important factors that contribute to increasing crop productivity and sustainable agriculture. Also, compost is the ideal solution for increasing soil fertility, as it improves the chemical and physical properties and increases the organic matter and nutrients in the soil (Getinet, 2016). The compost improves the properties of soil (biological, physical, and chemical), increasing the nutrients, yield of crops and improving the quality of the crop, the economic efficiency increased to some extent (Yumin and Pengcheng, 2016). Compost is a good organic fertilizer because it

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contains nutrients (N, P, K, Ca, Mg and S), trace elements as well as organic matter and increases CEC due to being rich in functional groups into the soil (Agegnehu *et al*., 2014). Compost provides nutrients to the soil and improves its water holding capacity (WHC) (Edwards and Hailu, 2011; Zemanek, 2011) The treated soil with compost increased its WHC by 1.57 times compared to control (Brown and Cotton, 2011). The addition of compost improves soil physical properties such as hydraulic conductivity bulk density and infiltration rate (Christina *et al*., 2020). Compost also contributes the most to soil productivity.

Rice (*Oryza sativa L.*) is the staple food of more than 2.7 billion people in the world (Fairhurst and Dobermann, 2002), production in 2019/2020 is about 501.4 million tonnes in the world (FAO, 2020). By 2025, 15 of the 75 million hectares of irrigated rice crop in Asia are likely to suffer from water shortages (Tuong and Bouman, 2003). Rice is grown in a variety of ecosystems, from high and lowlands, irrigated to rainfed, to deepwater conditions. Rice needs a large amount of freshwater. However, the scarcity of freshwater resources threatened the production of rice crops (IWMI, 2000). Water scarcity requires the adoption of alternative systems that necessitates less water to produce the rice crop. Many technologies reduce water losses and increase water productivity such as ground cover systems (Lin *et al*., 2002), alternate wetting and drying (Li, 2001), and saturated soil culture (Borell *et al*., 1997). Aerobic rice is a new concept of rice cultivation. It constitutes the cultivation of rice under non-puddled, aerial soil that is not submerged with irrigation (Bouman *et al*., 2002).

Egypt has a large area of sandy soil with water scarcity challenges, hence we as researchers are trying to investigate new techniques to grow the strategic crops under the sandy soil.

The present study aims to evaluate the effect of adding bentonite and compost on some of the physical and chemical properties of sandy loam soils under modern irrigation systems. This investigation aims to try to cultivate rice and evaluate the performance of drought-tolerant rice varieties in sandy loam soil under a drip irrigation system. We are trying to investigate new techniques to grow strategic crops in sandy soil and improving its properties regarding the prevention of water losses.

MATERIALS AND METHODS

Two field experiments have been carried out during the 2019 and 2020 summer seasons in El Gazaly Village, El Dalangat, El Behaira Governorate Egypt to study the effect of soil amendments on the performance of four rice varieties and some physical and chemical properties of a sandy loam soil under drip irrigation system. Some properties of soil and amendments (compost and bentonite) are shown in Tables (1 and 2). Four rice varieties have been tested; two *O. sativa* (Egyptian inbred varieties), namely Giza 178 (Indica-Japonica type) and Sakha 107 (Japonica type) and other two *O. sativa*, indica type (Chinese hybrid combinations), namely Hanyou 73 and Hanyou 737. Rice varieties were tested under three soil treatments in addition to control. The rice varieties have been selected based on a varietal survey that has been done for 14 entries under an aerobic condition in sandy soil to identify promising varieties as phase one. The soil treatments were (10 ton/ha compost, 10 ton/ha bentonite, and mix treatment of 5 ton/ha compost plus 5 ton/ha bentonite) in addition to control; with no soil enhancers. The experiments were carried in a split plot design in three replicates. Soil amendments were placed in the main plots and rice varieties were devoted in the sub-plots. The amendments were mixed with soil in 20 cm of the soil layer. Rice seeds were drilled by hand in shallow furrows spaced 15 cm apart and were covered with 3 cm soil. Row to row space was maintained at 40 cm. Two seeds per hill were used for sowing in the aerobic field at the range of 95 kg/ha for all rice varieties under study. The experiment was carried out under a drip irrigation system; with a 30 cm distance between two nozzles, about 82500 drippers per hectare, and an exchange rate of about 1.8 L/hour. Each variety was grown in a 4.2 m^2 (1.2 m * 3.5 m) plot by direct seeding. Total applied water was calculated in the range of 4.18 m^3/plot/season as shown in Table (3). Nitrogen (Urea 46% N) was applied injection ally into the irrigation system to supply plants in the range of 140 kg N/ha in four equal doses with irrigation system during vegetative stage, while the P_2O_5 and K_2O were applied as a basal application at the rate of 360 Kg/ha superphosphate (15% P_2O_5) and 120 kg/ha Potassium sulfate (50 % K_2O). After harvesting biological and grain yield were determined. The water use efficiency (WUE) was computed as WE= grain yield (kg /plot)/ total applied water (m^3/plot).

Soil samples (0 - 20 cm and 20 - 40 cm) have been taken from each plot and analyzed for some physical and chemical properties. pH values were determined by using a pH meter in soil/water suspension (1:2.5 w/v). Electrical conductivity (EC) was determined by using EC meter according to Chapman and Pratt, (1961). On the other hand, cations and anions were determined according to a method of Jackson, (1967). Organic matter content was determined according to Walkley and Black Method Black, (1982). The water holding capacity (WHC) (% volume) according to Inbar *et al*., (1993). The hydraulic conductivity according to Klute, (1965). Field capacity, wilting, and point pore size distribution are calculated from pF curves according to De-leenher and De-Boodt, (1965). The available water capacity (AW) is calculated as the difference between FC and WP.

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

Properties	Soil
Particle size distribution (%)	
Sand	74.70
Clay	9.28
Silt	16.02
Textural class	Sandy Loam
O.M %	0.69
pH(1:2.5)	7.79
EC dS/m	2.20
Soluble cations (meq/l)	
Ca^{++}	3.60
Mg^{++}	5.20
K^+	0.38
Na^+	13.45
Soluble anions (meq/l)	
Cl^-	12.40
HCO_3^{-}	2.97
SO_4^{--}	7.26

Table 2. Some chemical properties of the compost and Bentonite

Properties	compost	Bentonite
O.M %	43.70	4.80
pH(1:2.5)	8.50	8.97
EC(1:2) dS/m	1.36	1.29
Ca %	8.20	4.0
Mg %	3.60	4.8
Na %	0.18	0.42
N %	2.27	0.79
P %	0.13	0.06
K %	2.72	0.73

Table 3. Irrigation scheduling based on growth stages.

Month	Irrigation hours	Water applied (m^3/irrigation time)	Total applied water (m^3/ha)
1st of May to 20th May	7	148.5	1039.5
20th of May to 20th July	30	148.5	4455
20th of July to 20th of August	30	148.5	4455
Total applied water m^3/hectare			9949.5

Statistical analysis

Statistical analysis was used the analysis of variance procedures for split plot design and means were compared using the LSD test (P< 0.05) (SAS Institue, 1996). The variance homogeneity between the two seasons were tested after the Bartlett test. Combined analyses of variance were performed among the two seasons, according to Cochran and Cox (1957). While grain yield, harvest index, and water use efficiency have been calculated for the rice varieties under the Com/Ben mixture as mean.

RESULTS AND DISCUSSION

Results

1. Soil properties

The obtained data in Tables (4-6) indicated that soil amendments had a significant effect on the properties of soil. The varieties and interaction between soil amendments and varieties had no significance on the soil properties in both soil depths.

Effect of compost, bentonite and a mixture of compost and bentonite on the soil chemical properties.

Soil Salinity and soil pH.

The obtained data in Table (4) indicated that all soil application treatments had a significant effect on soil EC under both soil depths.

For the soil layer (0-20cm) the result showed that used compost as soil amendment alone and Com/Ben resulted in a significant reduction in soil pH (7.52 and 7.64) respectively, compared to the control (7.77). The soil treated with bentonite had the highest pH (7.95). On the other side, soil pH was no-significant in 20-40 cm of the soil layer.

The effect of compost, bentonite alone, or in mixtures on soil salinity expressed as electrical conductivity (EC dS/m) are presented in Table (4), Data showed that soil salinity decreased with the soil treated by previous treatments compared to the control. This decrease was significant in 0-20cm of the soil layer. The compost and com/ben resulted in a significant reduction in soil EC (1.36 and 1.30), respectively. Regard to the soil layer (20-40 cm) the result showed that compost and Com/Ben reduced soil EC (0.58 and 0.52), respectively.

Table 4. Effect of compost, bentonite, and a mixture of compost and bentonite on the soil chemical properties.

Treatment	pH	EC dS/m	Na^{+2} meq/l	K^{+} meq/l	Ca^{+2} meq/l	Mg^{+2} meq/l
A – Soil amendments			0-20 cm			
Control	7.77 ±0.05	2.19 ±0.08	13.31 ±0.33	0.42 ±0.02	3.46 ±0.54	5.40 ±0.45
Com	7.52 ±0.12	1.36 ±0.04	7.70 ±0.10	0.15 ±0.01	1.93 ±0.06	3.66 ±0.23
Ben	7.95 ±0.02	1.99 ±0.08	11.53 ±0.58	0.63 ±0.09	2.80 ±0.20	4.06 ±0.61
Com/ Ben	7.64 ±0.17	1.30 ±0.04	6.30 ±0.05	0.14 ±0.02	2.93 ±0.17	3.60 ±0.50
A – Soil amendments			20-40 cm			
Control	7.89 ±0.17	0.74 ±0.06	3.97 ±0.27	0.08 ±0.01	2.20 ±0.83	2.50 ±0.26
Com	7.83 ±0.19	0.58 ±0.03	3.08 ±0.18	0.10 ±0.04	1.10 ±0.06	1.80±0.07
Ben	8.03 ±0.03	0.69 ±0.06	3.30 ±0.27	0.14 ±0.02	1.40 ±0.11	2.80 ±0.31
Com/ Ben	7.85 ±0.22	0.52 ±0.01	1.78 ±0.05	0.07 ±0.01	1.46 ±0.06	2.50 ±0.74
			LSD 0.05			
Amendments 0-20	0.27	0.14	1.13	0.18	1.10	1.22
Amendments 20-40	ns	0.18	0.712	0.06	ns	ns

***ns:no-significant *± standard deviation**

Soluble Cations.

Data in Table (4) indicated that all soil application treatments had a significant effect on soil contents of sodium, calcium, and magnesium in 0-20 cm of the soil layer.

The compost as soil amendment alone and Com/Ben resulted in a significant reduction in soil contents of sodium (7.70 and 6.30), potassium (0.15 and 0.14), and magnesium (3.66 and 3.60) for both amendments respectively compared with control. In the same way, the lowest soil contents of calcium in this soil layer were obtained by compost followed by bentonite with averages of 1.93 and 2.80 meq/l, respectively.

Respect to the soil layer (20-40cm) the results confirmed that all soil amendments decreased soil contents of sodium compared to the control treatment. The experimental soil that was treated with compost showed soil content of calcium (1.10) and magnesium (1.80). Moreover, the soil treated with com/ben showed the lowest soil contents of sodium (1.78) and potassium (0.07). In all cases, the differences among all soil amendments were not significant for all previous parameters except for the soil content of both sodium and potassium.

It could be clear that compost and (Com/Ben) showed a great improvement in all soil chemical properties where both treatments resulted in a great decrease in both EC and soil content of sodium in the upper soil layer. The superiority of compost in improving soil chemical properties compared to bentonite.

Organic matter.

Data in Table (5) revealed that the addition of compost, bentonite, and a mixture of compost and bentonite significantly increase soil contents of organic matter in 0-

20cm of the soil layer compared to control. In the same way, all treatments insignificant increase the same measurements in 20-40cm of the soil layer. For the soil layer from 0-20 cm, the results in Table (5) revealed that the addition of compost followed by (Com/ Ben) to the soil gave the highest percentages of organic matter (1.40 and 1.23%).

Effect of compost, bentonite, and a mixture of compost and bentonite on the soil physical properties.

Hydraulic conductivity.

The effect of compost, bentonite, and a mixture of compost and bentonite on hydraulic conductivity were presented in Table (5). All treatments significantly decrease hydraulic conductivity in 0-20 cm of the soil layer compared to control. The hydraulic conductivity insignificant decrease in 20-40cm of the soil layer. The addition of the Com/ Ben followed by compost led to the largest decrease in the hydraulic conductivity values with averages of 11.70 and 18.70 cm hr^{-1} for the two treatments, respectively.

Soil-Water Constants.

The results shown in Table (5) confirmed that all soil application treatments significantly increase water holding capacity, field capacity, wilting point, and available water in 0- 20cm of the soil layer compared to control. In the same way all treatments insignificant increase the same measurements in 20-40cm of the soil layer.

On the other hand, the addition of (Com/ Ben) followed by the compost alone resulted in obtaining the highest percentage of water holding capacity (32.80 and 30.27%), field capacity (18.22 and 16.80%), and the wilting point (7.21 and 7.05%) in addition to the highest values of available water with averages of 11.01 and 9.75% for the two treatments, respectively.

In the same way, the effect of all application treatments was not significant at all water measurements in the soil layer 20-40cm.

The increase in all water relations in the surface layer of the soil was in all cases associated with the addition of compost, whether it was singly or combined with bentonite, and this was mainly due to the rise in organic matter in compost Table (3) and its great ability to hold water.

Table 5. Effect of compost, bentonite, and a mixture on organic matter, hydraulic conductivity, and Soil-water constants of sandy loam soil.

Treatment	OM %	Hydraulic conductivity (Ks) cm hr^{-1}	WHC%	FC%	WP%	AW
A – Soil amendments			0-20 cm			
Control	0.73 ±0.04	25.86 ±1.49	28.80 ±078	14.44 ±0.61	6.90 ±0.13	7.54 ±0.68
Com	1.40 ±0.07	18.70 ±1.05	30.27 ±0.50	16.80 ±0.88	7.05 ±0.08	9.75 ±0.96
Ben	0.83 ±0.09	22.24 ±2.04	29.19 ±0.17	15.45 ±0.19	7.07 ±0.07	8.38 ±0.14
Com/ Ben	1.23 ±0.03	11.70 ±0.98	32.80 ±0.65	18.22 ±0.99	7.21 ±0.08	11.01 ±0.10
A – Soil amendments			20-40 cm			
Control	0.68 ±0.07	28.33 ±1.64	25.04 ±0.80	13.64 ±0.32	6.21 ±0.40	7.43 ±0.45
Com	0.75 ±0.02	28.18 ±2.22	25.36 ±1.02	14.30 ±0.14	6.60 ±0.05	7.70 ±0.20
Ben	0.66 ±0.13	24.99 ±1.98	25.23 ±1.12	14.26 ±0.86	6.65 ±0.05	7.74 ±0.91
Com/ Ben	0.74 ±0.15	22.76 ±2.80	26.28 ±1.40	14.60 ±0.25	6.63 ±0.11	7.97 ±0.35
			LSD 0.05			
Amendments 0-20	0.2	11.41	2.28	2.01	0.30	2.27
Amendments 20-40	ns	ns	ns	ns	ns	ns

***ns:no-significant *± standard deviation**

Pore size distribution.

Table (6) showed that a significant effect on the quick drainage Pores (QDP) and the water-holding pores (WHP) in the surface layer (0-2cm) as a result of adding (Com, Ben and Com/Ben) while no significant effect due to the previous treatment on slow drainage pores (SDP), and fine capillary pores (FCP) in the same layer.

Table 6. Effect of compost, bentonite, and a mixture of compost and bentonite on the pore size distribution of sandy loam soil.

Treatment	Pore size distribution			
	QDP%	SDP%	WHP%	FCP %
A – Soil amendments			0-20 cm	
Control	62.93 ±0.39	15.45 ±0.76	19.91 ±0.85	1.71 ±0.65
Com	59.12±0.26	14.90 ±1.05	24.24 ±0.61	1.74 ±0.34
Ben	60.10 ±0.23	14.93 ±0.99	23.27 ±0.39	1.70 ±0.32
Com/ Ben	58.93 ±0.36	14.85 ±0.98	24.51 ±0.65	1.71 ±0.55
A – Soil amendments			20-40 cm	
Control	66.45 ±0.60	14.94 ±0.53	17.36 ±0.48	1.25 ±0.76
Com	65.93 ±0.85	14.00 ±0.41	18.37 ±0.75	1.70 ±057
Ben	65.98 ±0.98	14.93 ±0.58	17.78 ±0.63	1.31 ±0.25
Com/ Ben	65.84 ±0.84	13.89 ±0.32	18.58 ±0.80	1.69 ±0.46
			LSD 0.05	
Amendments 0-20	2.62	ns	3.69	ns
Amendments 20-40	ns	ns	ns	ns

***ns:no-significant *± standard deviation**

While these additives had no significant effect on the quick (QDP), slow drainage pores (SDP), water-holding pores (WHP), and fine capillary pores (FCP) in the lower soil layer (20-40 cm). The addition of (Com/ Ben) resulted in the largest percentage decrease in the quick drainage pores (58.93 and 65.84%) in both the top and bottom layers of soil respectively. The addition of (Com/ Ben) reduced the percentage of slow drainage pores in the surface layer of soil (14.85%) compared to the control (15.45%). All the treatments also led to increase in the percentage of water holding pores in both soil layers. The highest percentage of water holding pores in the surface layer was obtained after adding (Com/ Ben) (24.51%), followed by the compost alone (24.24%).

2. Agronomic Characters.

The agronomic characters i.e.; maximum plant height, maximum root length, maximum No. of tillers, and biomass yield have been estimated for the rice varieties under all soil treatments in the 2019 and 2020 season. Rice plants have died before the flowering stage under Com, Ben soil treatments in addition to control. Grain yield, harvest index, and water use efficiency have been calculated for the rice varieties under the Com/Ben mixture only.

Data illustrated in Table (7) showed surviving of rice plants under various soil treatments for all rice varieties under study, where all plants died before flowering under control, Com and Ben for all rice varieties. Hanyou 73 and Hanyou 737 had surviving abilities more than Giza 178 and Sakha 107 under all soil treatments. Rice plants had been headed and produced firtel tillers under Com/Ben soil treatments and recorded the longest duration (130, 122, 132, and 129 days) for Giza 178, Sakha 107, Hanyou 73, and Hanyou 737 rice varieties, respectively.

Data in Table (8) showed significant effects of soil amendments and rice varieties on all agronomic characteristics under study of rice plants. The addition of all soil conditioners, alone or in combination, significantly increased all the growth characteristics of rice compared to the control. In general, the addition of the combined treatment of compost and bentonite (Com/ Ben) resulted in obtaining the highest root length (20 cm), the highest plant height (79.83 cm), the highest number of tillers hill^{-1} (14.00), and the highest biomass yield (1.87 Kg/plot).

As for varietal performance, the results in Table (8) showed a wide diversity among the four rice varieties in all growth traits. Sakha 107 variety was the earliest among all tested genotypes and it showed the lowest values of plant height, root length and number of tillers hill^{-1} as well as biomass yield followed by Giza 178. Hanyou 737 gave the longest root length (16.80 cm) the highest tillers number hill^{-1} (11.30) and biomass yield (1.29 Kg/plot). on the other hand, Hanyou 73 gave the highest plant height (63.83 cm).

Table7. Plants surviving (days) under various treatments.

Treatments	Control	Com	Ben	Mixture of Com/Ben
Giza 178	24	65	68	130
Sakha 107	22	67	68	122
Hanyou 73	30	75	75	132
Hanyou 373	28	72	70	129

Table 8. Effect of soil amendments and varietal performance on, plant height root length, No. of tillers/hill, and biomass yield.

	Plant height (cm)	Root length (cm)	No. of tillers/hill	Biomass Yield (Kg/plot)
A – Soil amendments				
Control	33.00±8.41	6.54±1.94	2.72±2.11	0.21±0.28
Com	61.08±6.15	16.80±2.83	10.92±3.17	0.78±0.27
Ben	55.17±7.23	16.34±1.78	10.33±1.76	0.72±0.70
Com/ Ben	79.83±6.23	20.00±1.72	14.00±0.81	1.87±0.07
$L.S.D_{0.05}$	0.81	0.51	0.37	0.11
B- Rice varieties				
Giza 178	50.92±16.79	13.49±5.15	8.03±4.24	0.62±0.43
Sakha 107	49.92±18.04	12.60±5.29	7.43±3.66	0.58±0.42
Hanyou 73	63.83±17.84	16.78±5.09	11.02±4.80	1.19±0.88
Hanyou 737	63.42±19.00	16.80±5.72	11.30±5.04	1.29±0.85
$L.S.D_{0.05}$	0.90	0.47	0.54	0.15
A * B F test	**	**	**	**

***± standard deviation**

For the interactions between soil amendments and rice varieties, the results indicated that, four rice cultivars differed significantly in their responses to the used soil amendments for plant height, root length, tiller number per hill, and biomass yield as shown in Table (8) and Figure (1) Hanyou 73 recorded the highest value of biomass yield (2.٥٢ Kg/plot) under Com/Ben soil amendment followed by Hanyou 737 (2.٤٩ Kg/plot) as hybrid combinations. While the lowest values of biomass yield (1.23 Kg/plot) had been produced by Sakha 107 under Com/Ben soil amendment.

3. Grain yield and related characters.

The presented data revealed the clear effect of the Com/Ben mixture on grain yield and related characters. The combined addition of compost and bentonite resulted in the largest increase in grain yield kg/plot, the highest harvest index and the highest water use efficiency.

In respect to the rice varieties effect, the results in Figures (2,3, and 4) confirmed a wide diversity among the four rice varieties in all yield traits. Hanyou 737 recorded the highest grain yield (1.10 kg/plot), harvest index (44.31%), and the highest water use efficiency (0.263 kg/m^3) followed by Hanyou 73 gave grain yield (1.08 kg/plot), harvest index (43.23%) and the water use efficiency (0.258 kg/m^3). On the other hand, Sakha 107 recorded the lowest grain yield (0.49 kg/plot), harvest index (39.53%) and the lowest water use efficiency (0.117 kg/m^3).

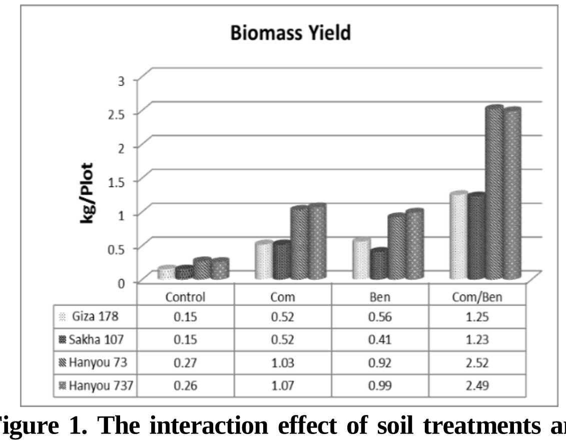

Figure 1. The interaction effect of soil treatments and rice varieties on biomass yield (Kg/Plot).

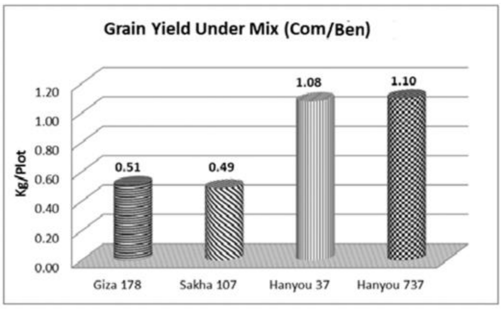

Figure 2. Effect of varietal performance on grain yield (Kg/plot) under Com/Ben.

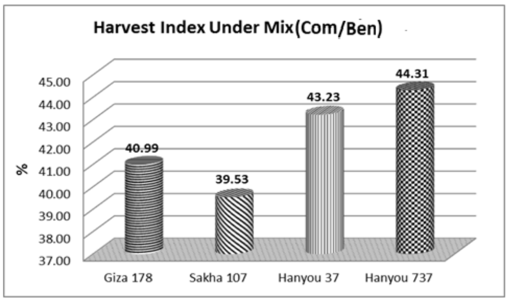

Figure 3. Effect of varietal performance on harvest index (%) under mix of compost and bentonite.

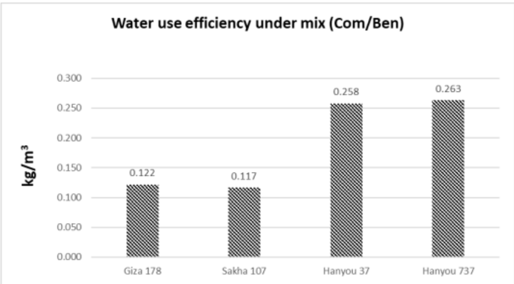

Figure 4. Effect of varietal performance on water use efficiency (Kg grain yield/m^3) under the mix of compost and bentonite.

Discussion

In this study applying bentonite increased soil pH. The bentonite led to a slight increase in soil's pH (Czaban and Siebielec, 2013; Alghamdi *et al*., 2018). While compost decreased soil pH. The decrease in pH with compost may be due to the production of some organic acids and carbon dioxide in the soil resulting from oxidation of organic soil amendments by microorganisms (Doaa, 2012). The limited effect of compost on the pH of the soil due to its richness in alkaline cations such as calcium, magnesium, potassium and sodium that has been edited from the organic matter due to mineralization. (Agegnehu *et al*., 2014). The use of compost regularly maintains or enhances the pH of the soil (Soheil *et al*., 2012).

The obtained data indicated that all soil application treatments soil caused a significant decrease soil content of sodium. This may be due to Na salts are easily soluble in water leaving the system of soil and leaching into the lower depths (Doaa, 2012).

Agegnehu *et al*., (2014) reported that compost is a rich nutrient useful such as N, P, K, S, Mg, and Ca plus a varied of essential elements. Soheil *et al*., (2012) revealed that the amount of elements increased as a result of compost application. In another study, Brown and Cotton, (2011) indicated that, soils amended with compost have similar concentrations of nutrients available to the plant compared with conventional fertilized soil and higher concentrations of micronutrients and macronutrients compared to control.

In this study applying compost and bentonite increased soil organic matter. Several previous studies confirmed that adding compost to the soil is an effective way to raise the organic matter in the soil due to the high level of stable C (Daniel and Bruno, 2012; Saoussan *et al*., 2020). Also. Bouajila and Sanaa, (2011) reported that the use of compost a significant increase organic carbon. The soils with bentonite added contained significantly higher amounts of organic carbon to contain significantly more humins (Czaban et l., 2013), through the subsequent incorporation of higher amounts of plant residues into the soil (Churchman et l., 2012).

The addition of compost is known to improve the hydraulic conductivity of soil characteristics (Olson *et al*., 2013; Cannavo *et al*. 2014; Dewpura and Chinthani, 2019). The hydraulic conductivity is linked indirectly to increase soil carbon, where this can be an indication of the formation of aggregates in the soil (Chen *et al*., 2014). The physical environment of the soil is improved by amending the compost, including hydrophysical properties as it enhances permeability coefficient (Angin *et al*., 2013), hydraulic conductivity (Yazdanpanah *et al*., 2016) and water penetration and water retention (Karak *et al*., 2016).

Particle size, structure and OM content generally affect field capacity and available water holding capacity. However, sandy soils will hold significantly lower water than clay soils. The compost alone or combined with bentonite improves available water and holding capacity this may due to the amount of organic matter in compost (Saoussan *et al*., 2020). Brown and Cotton (2011) noted that increasing organic carbon is an important factor in improving the soil's ability to retain water (WHC). The compost application has a greater impact on soil's ability to hold water in coarse soils. Vengadaramana and Jashothan, (2012) showed that with the increase in compost utilization rates, soil moisture content has increased indicating a significant improvement in the water holding capacity and water availability. Schmid *et al*., (2017) pointed out that using compost on a compacted sandy loam resulted in a 6-9% increase in water content compared to the control. Adding compost can increase the water available to the plant (Sax *et al*., 2017). Compost application has a positive impact on the retention of soil moisture (Zemanek, 2011) and increased the soil available water holding capacity (Brown and Cotton, 2011; Doaa and Mohamed, 2019). Noah *et al*., (2010) noted that compost improved water use efficiency compared to other treatments. Christina *et al*., (2020) reported that the compost incorporation generally with soil improved the downward movement of water, reduced hydraulic conductivity, water loss by deep seepage, and increased water content and plant available water. Compost application can be considered beneficial in slowing rapid leaching by minimizing water movements within and out the soil (Dewpura and Chinthani, 2019).

The significant improvement in the ability of sandy soils to hold water after adding bentonite and compost is often due to a decrease in drainage pores and an increase in water-preserving pores. These changes increase the capillary height (Lazányi, 2005). Suzuki *et al*., (2007) indicated that the addition of bentonite increased the water holding capacity of sandy soils, as the field capacity increased significantly, with relative stability at wilting point. Therefore, the bentonite treatments led to a significant increase in the water content available for crop growth. Bentonite has a colloidal structure in water. It is a natural absorbent smectite clay (Vitthal and Charles, 2016). Bentonite contains an abundant amount of montmorillonite that allows high swelling in gel-like shapes when water is added. This leads to increases in water holding capacity (WHC) and available water (AW). The use of bentonite in sandy soils at different rates reduces the amount of moisture lost due to evaporation mainly due to the role of clay deposits in increasing soil aggregation that decreases the pore area. Sandy soil is improved to loamy sand with increased fine particles as bentonite. Where led to a decrease in macro-pores and hydraulic conductivity dramatically. On the other side, the available moisture, field capacity, and water holding capacity were progressively increased (Hassan and Abdel Wahab, 2013; Doaa and Dalal, 2021). Abd El-Hady and Ebtisam, (2016) reported that adding bentonite to sandy soil improved water holding capacity and decreased water loss. Alghamdi *et al*., (2018) found that the physical properties of sandy soil have been enhanced by bentonite and compost. The treatments increased the soil's capacity to hold water. Compost improves available water, while bentonite improves the hydraulic properties. This is because bentonite stays in the soil for a longer time and resists biological decomposition while Com overcomes the negative effect of the chemical properties of the soil as a result of the additions of bentonite.

Adding bentonite to sandy soils improved its redistributes pores, changes their size and porosity (Satje and Nelson, 2009). This change in pore size and distribution often results in a significant increase in the slow drainage pore ratio (<0.3, 0.3-3, and 3-30 μm) and a decrease in the fast drainage pore ratio (from 30 to 300 μm) after adding bentonite to the soil (Suzuki *et al*., 2007). Francesc *et al*., (2016) indicated that the number of water useful pores (WHP) was increased by adding organic matter. It leads to a better structure that is reflected in the increased water holding capacity. The compost can improve soil pore space, pore size and promote the formation of granular structure (Zhang and Wang, 2014; Yumin and Pengcheng, 2016). This study recommends the use of a bentonite-compost mixture.

In this study, the four rice cultivars significantly differ in their performance for all studied traits, and this almost due to the wide diversity among the four genotypes in their genetic and country of origin. Similar results were obtained before by Setiawati *et al*., (2020) who, evaluated two rice cultivars under different organic sources and they found significant differences between the two genotypes in all growth and yield traits. Also, Kumar *et al*., (2017) evaluated the four rice varieties under four NPK levels and they revealed that the four cultivars differ in their growth and yield performances under all NPK levels according to their genetic. Kharel *et al*., (2018) evaluated rice genotypes under different nutrient levels in artificially created stress conditions during reproductive stages and they reported that the rice genotypes showed significant differences for days to flowering, days to maturity, and grain yield.

The results also indicated that added of bentonite and compost combined to the soil resulted in a significant increase in all rice growth and yield compared with bentonite and compost alone, and control. Siavoshi *et al*., (2011); Hoque *et al*., (2018) found that the application of organic fertilizers affected grain and straw yields, nutrient contents of rice, and uptake by grain. Ashik *et al*., (2016) found that different levels of organic fertilizers showed a significant effect on the growth and yield of rice.

CONCLUSION

In this study, the use of compost and a mixture of compost and bentonite lead to a significant reduction in soil pH and soil EC as well as soil contents of Na, K, and Mg compared with control in the soil layer (0-20 cm). With respect to the soil layer (20 - 40 cm), the results confirmed that Com and Com/Ben decreased soil pH and EC as well as soil contents of Na, K, Ca, and Mg compared to the control treatment. The amendments significantly increased soil contents of organic matter and water measurements in 0- 20 cm of the soil layer compared to control. In the same way all treatments insignificant increase the same measurements in 20-40 cm of the soil layer. All treatments significantly decrease hydraulic conductivity in 0-20cm of the soil layer compared to control. There was a significant effect of treatments on both the quick drainage Pores (QDP) and the water-holding pores (WHP) in the surface layer (0-20cm) of the soil compared to control. Used the combined treatment of bentonite and compost resulted in a large increase in all rice growth and yield traits. It could be recommended to cultivate the rice varieties Hanyou 737 and Hanyou 73 in the sandy loam soil with applied the mixture of bentonite and compost to the soil to improve soil physical and chemical properties as well as to obtained grain yield.

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محاولة زراعة الأرز في التربة الرملية باستخدام السماد العضوي والبنتونيت تحت نظام الري بالتنقيط

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يوجد في العديد من الدول مساحات كبيرة من التربة الرملية يمكن زراعتها مع تحسين بعض خصائصها وتقليل فقد المياه أثناء الري وبالتالي زيادة كفاءة استخدام المياه. تهدف الدراسة الحالية إلى تقييم تأثير إضافة الكمبوست ١٠ طن/ هكتار و البنتونيت ١٠ طن /هكتار وخليط من (الكمبوست ٥ طن/ هكتار والبنتونايت ٥ طن /هكتار) على أداء أربعة أصناف أرز جيزة ١٧٨ و سخا ١٠٧ و هانيو ٧٣ وهانيو ٧٣٧ علي الخواص الفيزيائية والكيميائية للتربة الطميية الرملية تحت نظام الري بالتنقيط.اظهرت النتائج أن استخدام الكمبوست وخليط الكمبوست مع البنتونيت أدى إلى انخفاض معنوي في درجة الحموضة والتوصيل الكهربي للتربة وكذلك محتوى التربة من الصوديوم و البوتاسيوم والماغنسيوم مقارنةً بالكنترول في طبقة التربة (٠-٢٠ سم). أدت المعاملات إلى زيادة معنوية في المادة العضوية ، والقدرة على الاحتفاظ بالماء ، والسعة الحقلية ، ونقطة الذبول ، والماء المتاح ، ومسام الاحتفاظ بالماء، بينما قللت جميع المعاملات بشكل معنوي من التوصيل الهيدروليكي ومسام الصرف السريع في طبقة التربة (٠-٢٠ سم) مقارنةً بالكنترول.نباتات الأرز ماتت قبل مرحلة الإزهار في معاملات الكمبوست والبنتونيت و الكنترول. تم حساب محصول الحبوب و مؤشر الحصاد وكفاءة استخدام المياه لأصناف الأرزلمعاملة الخليط بين الكمبوست و البنتونيت فقط. أظهرت نباتات الأرز تحت معاملة الخليط أعلى طول للجذور وطول النبات ومحصول الكتلة الحيوية مقارنةً بالكمبوست والبنتونيت و الكنترول. أعطى صنف هانيو ٧٣٧ أعلى محصول الكتلة الحيوية ومحصول الحبوب ومؤشر الحصاد وأعلى كفاءة في استخدام المياه تحت معاملة خليط الكمبوست مع البنتونيت يليه هانيو٧٣.