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Effect of Bentonite and Compost Applications in Some Chemical Properties of Soil, Growth of Sorghum (*Sorghum bicolor* L.) in Desert Soil

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Abstract:
A pot experiment was conducted to evaluate effect of some soil amendments as bentointe and compost in some chemical properties and plant growth parameters of sorghum in desert soil. Five levels of bentointe (0, 3, 6, 9 and 12% and Three levels of compost (0, 40 and 80 Mg ha^{-1}) were used in the study. Randomized complete block design (RCBD) with three replicates were used. The results showed that the bentonite and compost application significantly affected all the chemical properties under study and plant parameters. The level 12% of bentonite gave the highest rate of increase of 2.33, 54.25 and 21.35% for pH, O.M and CEC and increased plant height, leaf area and chlorophyll content of 15.67, 33.10 and 27.27% respectively. The results showed also that the level 80 Mg ha^{-1} of compost gave the highest rate of decease in pH by 1.34% and increase by 139.77, 113.21 for O.M and CEC while the plant parameters increased by 7.82 , 14.19 and 27.27% for plant height , leaf area and chlorophyll content respectively. As for the interaction, the treatment (C2B0) achieved the lowest value for pH reaching 7.21, while the treatment (C2B4) achieved the highest value for the content of organic matter, CEC and plant parameters under study. The results showed a positive significant linear correlation between bentonite level with the chemical properties of the soil and plant parameters.

Keyword: Bentonite, Compost, Soil amendments (Conditioners), Sorghum, Correlation

Introduction

Desertification or soil degradation is defined as a change in soil that leads to a decrease in its productivity or failure of plants to grow in it. With the passage of time, and unless the deterioration has stopped, the land is deserted and joined to the deserts of the neighboring regions, and there is no doubt that man is the first maker of desertification, and he is also the affected person at the same time. (Al-Janabi, 2016;Al-Zubaidi, 1992). Most of the desert lands contain sandy soils, which include large areas in the world. In Iraq, sandy soils constitute a wide area that extends from the northwest to the southeast, and it forms a large strip of width between 5 – 25 km (Al-Zubaidi,1992).

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Sandy soils suffer from many problems, although they are well ventilated and drained due to the high percentage of large pores, which makes their total porosity low when compared to clay soils and is quick to drain because of its low ability to retain water and the available water was few, the specific surface area andcation exchange capacity (CEC), which may reach 6 – 10Cmole $_{+}$ kg $^{-1}$ soil and its organic matter content is very low. So it is considered a poor soil in its nutrient availability and its ability to retain nutrients is low (Al-Janabi, 2016;Aharonov-Nadborny et al., 2017).

Many methods have been used as practical attempts with the aim of optimal agricultural use of sandy or structureless soils in desert and desertified lands to overcome its agricultural determinants by improving the physical, chemical and biological properties of the soil, increasing the availability of the nutrients in it and increasing its productivity, the most important of these means is the use of some industrial or natural amendments (conditioners) which it was organic or mineral. Mineral natural amendments, such as clay sediments represented by bentonite clay, have been used widely in the world for its role in improving many physical properties of sandy soils, such as increasing the moisture content and water conductivity, improving soil construction and forming stable aggregates, as well as improving chemical properties such as increasing cation exchange capacity and organic matter content. Organic matter, reducing soil pH and increasing nutrient availability (Tallai, 2011;Semalulu et al., 2015).Soil amendments known as organic or mineral materials that improve one or more properties of the soil, whether they are physical, chemical or biological and thus contribute to raising the fertility of the soil and increasing its productivity and these improvements may be natural or manufactured (De Boodt, 1978).

Several researchers who used bentonite clay as an enhancer for sandy or gypsum soils in their study indicated that it contributed to improving most of the soil physical and hydrophysical properties, such as water conductivity and moisture content at field capacity, available water and bulk density (Hamouda et al., 1999; Croker et al., 2004;Moulaand Farhan,2010).

Bentonite has been used by many researchers and found that this clay mineral is one of the best mineral enhancers for different soils, especially coarse texture in different countries of the world due to its great role in improving most of the soil physical, chemical and biological properties, increasing nutrient availability, raising soil fertility, increasing plant growth and yield and improving its quality (Satjeand Nelson, 2009;Youssef, 2013).

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One of the manufactured soil improvers is alsomostly from plant waste and now its production has become from animal wasteand city wastes (sludge). Its use has increased since its period in improving the physical and chemical properties. In addition to that, it is considered a source of some nutrients in the soil, which contributes to raising the fertility of the soil and increasing its productivity. Although compost is considered a short-term soil amendment, it does not have a negative impact on the soil or the environment if compared to other soil conditioners such as oil derivatives andit is economically inexpensive (Wallace and Carter ,2007 ; Horrocks et al., 2016 ; Al-Saadiand Al-Wardy, 2019).

Sorghum has increased due to the success of its cultivation in most conditions of relatively high climatic and water stress and gives a good yield in arid and semi-arid regions. This crop is distinguished by its high tolerance to drought and salinity (28). Sorghum kernels are highly nutritious, containing 70-80% carbohydrates, 11-13% protein, 2-5% fat and 1- 3% fiber (Prasad and Staggenborg, 2009).

Although many studies have been conducted that use natural and synthetic soil amendments (conditioners) (mineral and organic), especially bentonite and organic wastes in the world, but these studies are still limited in Iraq, so this study aimed to evaluate the effectof mineral soil amendment (bentonite) and organic (compost)in some chemical properties of soil and the growth parameters of sorghum in desert soil.

Materials and Methods

Desert soil was chosen with a loamy sand texture, which was collected from the surface horizon 0-30 cm, taken from the Al-Nukhayb location of Anbar governorate, and it was located within 45 km from the Al-maqdisKarbala city. Some physical and chemical properties of the soils were estimated according to Richards (1954) and Page et al., (1982) (Table 1). A pot experiment was conducted at the Faculty of Agricultural Research Farm in Al-Jadiriya. The experiment included five levels of bentonitewhich are 0, 3, 6, 9, and 12% (Table 2) shows some properties of the bentonite clay used in the study.Three levels of compost which are 0, 40 and 80 Mg ha^{-1} (Table 3) shows some properties of the compost. Compost and bentonite were added after they were homogeneously mixed with the soil, according to the experiment treatments. Sorghum (Sorghum bicolor L. Moench) (Enkath variety) was sown on 29 /7/2020 as an Autumn season, Nitrogen was added at 320 kg N ha^{-1} as urea (46% N) and phosphorous at 200 kg $P_2O_5ha^{-1}$ was added as triple superphosphate (TSP). (46% P_2O_5) and potassium at a level of 200 kg K_2O ha^{-1} in the form of potassium sulfate ((K_2O

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50%) according to the fertilizers recommendation for nitrogen, phosphorus and potassium for sorghum (Ali et al., 2014).Nitrogen fertilizer was added in two doses, the first when planting and the second after 30 days of planting. As for phosphate and potassium fertilizers, it was added in one dose when planting and for all treatments.

Table 1. Some chemical and physical properties of soil.

Property		Value	Unit	Available nutrients	Value	Unit
ECe (1:1)		4.30	dS m^{-1}	NH_4^+	16.40	mg kg^{-1} soil
pH (1:1)		7.41		NO_3^-	11.60	
O.M		7.00	g kg^{-1} soil	P_{Olsen}	4.12	
Carbonate minerals		303.1	g kg^{-1} soil	$K(NH_4OAc)$	287.13	
CEC		6.22	$Cmol_+kg^{-1}$ soil	Bulk density	1.63	Mg m^{-3}
Soluble ions	Ca^{++}	9.11	mmole L^{-1}	Field capacity	7.60	%
	Mg^{++}	5.06		Wilting point	1.63	
	Na^+	11.12		Particle size analysis		
	K^+	2.14		Clay	144.0	g kg^{-1} soil
	$CO_3^=$	-		Silt	40.0	
	HCO_3^-	2.50		Sand	816.0	
	$SO_4^=$	5.32		Texture	Loamy sand	
	Cl^-	28.14				

Table 2. Some properties of bentonite used in study.

Property	Value	Unit	Oxides content	%
ECe	3.14	dS m^{-1}	P_2O_5	0.65
pH	7.00		K_2O	0.50
Carbonate minerals	130.10	g kg^{-1} soil	CaO	0.58
Gypsum	2.40		MgO	0.18
CEC	60.1	$Cmol_+kg^{-1}$ clay	Fe_2O_3	1.52
Particle size analysis			Al_2O_3	34.58
			Na_2O	0.18
Clay	899.0	g kg^{-1} clay	SO_3	0.23
Silt	99.0		SiO_2	51.96
Sand	2.0		Cl	0.05

The experiment continued until the crop reached final maturity and the crop was harvested on10 /11/2020.The average leaf area of three plants growing in each experimental unit of the fourth leaf was calculated by leaf area = length X width X 6.18 (Elsahookie and Cheyed, 2014). The chlorophyll content in the leaves of the sorghum was estimated as an averageof threeplantsfor the experimental unitusing a Chlorophyll meter of SPAD-50 (Minnotti et al., 1994) .

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Table3.Some properties of compost used in study.

Property	Value	Unit
ECe (1:5)	4.02	dS m^{-1}
pH (1:5)	7.43	--
Nitrogen	1.51	%
Phosphorus	1.01	
Potassium	1.40	
Organic carbon	44.5	
O.M	56.2	
C : N	20.5	---

Afactorial experiment was carried out according to the design of randomized complete block design (RCBD) with three replications. Least significant difference test (LSD) was used to compare the mean of the different treatments at the level of significance 0.05.Regression equations were used to describe the relationship between soil properties and plant parameters withbentonite (Steeland Torrie, 1980)

RESULT AND DICUSSION

Chemical properties of soil after harvest

Soil reaction (pH)

The results showed a significant effect of the two study factors (bentonite and compost level addition) and their interactionin soil reaction (pH) (Table 4). Increased bentonite level led toincrease of soil pH by 1.23, 1.50, 1.92 and 2.33% for added levels 3, 6, 9 and 12% respectively,compared to the control (0%).

The results, (Table 4) also showed that increasing the level of compost addition from 0 to 40 and 80 Mg ha^{-1} led to a decrease pH by 0.54 and 1.34% for the two levels of compost, respectively, compared to the non-addition treatment.The results showed that the two study factors adversely affected soil pH interaction. Bentonite contributed to raising soil pH while compost contributed to reducing it. Although both factors had a slight effect but it was significant.

As for the interaction between bentonite and compost, the results were shown in (Table 4), and its effect was significant on the soil reaction. The results indicated that the lowest value of soil reaction degree was 7.21 when treatment (C2B0), with a decrease of 2.57% compared to the control (C0B0) of 7.40, while the highest value was 7.52 for treatment (C0B4), with an increase of 1.62%. The percentage of decrease in the soil pH was more than the percentage of increase compared to the treatment for the interaction. This indicates that the addition of compost was more effective in the soil reaction than bentonite.

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Organic matter (O.M)

The results showed in (Table 4) that the organic matter content increasedby 7.69, 19.43, 35.63 and 54.25% for the levels of bentonite was superior to 12% in giving the highest organic matter content in the soil.As for compost, the results showed a significant effect on the content of organic matter in the soil after harvest (Table 4). Increasing the level of addition from 0 to 40 and 80 Mg ha^{-1} led to an increase in the organic matter content, increasedby 91.81 and 139.77% for compost levels, respectively, compared to the control. The third compost of 80 Mg h^{-1} is gave the highest value for the organic matter content in the soil.

Table4. Effect of bentonite and compost application in some chemical properties of soil.

Bentonite (B)	pH			C Mean	O.M (g Kg^{-1})			C Mean	CEC ($Cmol_{+}kg^{-1}$soil)			C Mean
	Compost (C)				Compost (C)				Compost (C)			
	C0	C1	C2		C0	C1	C2		C0	C1	C2	
B0	7.40	7.32	7.21	7.31	15.3	25.0	33.7	24.7	7.84	9.12	19.85	12.27
B1	7.44	7.41	7.36	7.40	17.0	27.3	35.4	26.6	8.71	20.01	24.79	17.84
B2	7.46	7.43	7.38	7.42	17.7	31.1	39.7	29.5	12.89	21.79	26.12	20.27
B3	7.49	7.46	7.41	7.45	18.7	37.2	44.6	33.5	14.82	23.59	28.35	22.25
B4	7.52	7.48	7.44	7.48	19.0	43.5	51.8	38.1	16.68	26.51	30.85	24.68
B Mean	7.46	7.42	7.36		17.1	32.8	41.0		12.19	20.20	25.99	
LSD0.05												
Bentonite	0.08				1.4				1.74			
Compost	0.06				1.4				1.35			
B X C	0.14				2.5				3.01			

Interaction between bentonite and compost, it had a significant effect on the content of organic matter. The results showed that the highest value for the content of organic matter for the interaction between the two study factors was with the treatment (C2B4), as it reached 51.8 g kg^{-1} soil, with an increase of 238.56% over the control treatment for interaction (C0B0) reached 15.3 g kg^{-1} and the results showed that both the study factors bentonite and compost had a positive effect in increasing O.M and compost was more effective compared to bentonite.

Cation exchange capacity (CEC)

The results showed in (Table 4) that the CEC increased by 45.40, 65.20, 81.34 and 101.14% when increasing bentonite level from 0 to 3, 6, 9, and 12%, respectively, compared to the control (0%), the level of 12% of bentonite addition was higher in achieving the highest value for soil CEC. The results also showed in (Table 4) that the addition of compost had a significant effect on the cations exchange capacity as increasing the level of addition from 0 to 40 and 80 Mg ha^{-1} increased CEC, reaching as mean of 12.19, 20.20 and 25.99 $Cmol_{+}$ Kg^{-}

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^{1}soil, with increase of 65.71 and 113.21% for the two levels of compost respectively compared to the control. The third level of addition of 80 Mg ha^{-1} gave the highest increase in CEC, and compost was the most efficient than bentonite in increasing the soil CEC. The results also showed a significant effect of the interaction between bentonite and compost on CEC (Table 4). The highest value for CEC was at(C2B4) treatment, as it reached 30.85 Cmol$_{+}$kg^{1-} soil, and its lowest value at the control (C0B0)) was 7.84 Cmol$_{+}$kg^{-1}soil, with an increase of 293.49%. This is evidenced by the large positive effect of the interaction between bentonite and compost in increasing soil CEC.

The addition of bentonite clay had an effect on the chemical properties of the soil under study (pH, EC, O.M, and CEC). The results indicated that soil pH increased with increasing bentonite level of addition. Although the increases were slight, it was significant, perhaps due to the fact that pH of the bentonite clay (pH 7.0) (Table 2) contributed to the increase in the release of the hydroxyl ion (OH^{-}) to the soil solution, as well as the content of carbonate minerals ($CaCO_3$) in it (130.1 gkg^{-1} soil) has contributed to raising soil reaction(Yssaadand Belkhodja, 2007;Al-Ani, 2009). Bentonite added in the study is Ca-bentonite containing high concentrations of calcium, magnesium and sodium which, when released from the bentonite, caused an increase in pH of the soil under study (Czabanand Siebielec, 2013;Semalulu et al.,2015).The results are also agree with what were found by (Osman et al., 2008; Satjeand Nelson, 2009; Tallai, 2011 ; Jenaand Kabi, 2012).

The content of organic matter increased with the increase bentonite level. This may be due to the fact that the mineral of bentonite clay form stable complexes with the organic matter within the clay layers and that each unit of organic matter is associated with 10 units of clay (Dexter et al.,2008). It was also found that the addition of bentonite clay increases the accumulation of organic carbon and total nitrogen,reduces the rate of their decomposition, and increases the activity of micro-organisms (Tawfiq, 2009). The results are consistent with what was confirmed (Yssaadand Belkhodja, 2007;Czaban et al., 2014; El-Etr, and Hassan, 2017).

The addition of bentonite increased soil CEC. This may be attributed to the fact that the bentonite clay is of a type 2: 1 (three layers) and has a high specific surface area ranging from 150 - 80 Cmol$_{+}$kg^{-1} and its particles are have a strong negative charge, as it is a source of negative charges in soil (Ding et al., 2009) and the CEC of the bentonite clay used under the study is (60.1 Cmol$_{+}$kg^{-1}) (Table 3) which contributed to increasing the cations exchange capacity and this

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is agree with were confirmed by (Salih (2000) and Sacchi (2010)and Czabanand Siebielec (2013) andMinhal et al., (2020) found a positive linear relationship between the CEC of sandy soil with bentonite level addition.

As for the addition of compost and its effect on soil chemical properties of the soil under study,the addition of compost led to a decrease in soil pH and this may be attributed to the formation of various organic acids as well as the release of hydrogen ions and carbon dioxide (CO_2) as a result of decomposition and forming carbonic acid (Cline et al.,1982;AliandShakir, 2018).Several researchers have found in their studies a decrease in soil reaction due to the addition of compost (Osman et al., 2008;Wolka and Melaku, 2015; Al-Saadiand Al-Wardy, 2019).

As for the effect of compost added on the organic matter content, the results indicated an increase in soil organic matter with an increase compost addition. This may be due to the high content of compost from organic matter or organic carbon, which contributes to increasing OM content. Compost used in the study with a high content of organic matter (56.2% and this is equivalent to 44.5% of organic carbon) (Table 3) and contributed to increasing OM content of the soil under study in addition to that, increasing the content of organic matter increases the activity of microorganisms in their decomposition and so on addition of organic waste, and biomass in the soil (Assafi et al.,2010 ;Sohil et al.,2012 ;Wolkaand Melaku, 2015 ;Adugna, 2016 ; Al-Saadiand Al-Wardy, 2019).

Compost addition also led to an increase thesoil CEC after harvest and may be due to the fact that it has a surface area and a high cations exchange capacity (300 - 1400 $Cmol_+ kg^{-1}$) and its possession of high negative charges due to its possession of chemically active groups such as hydroxyl groups (OH) phenolic, alcohol groups (OH), methoxyl groups (OCH_3), carboxyl groups (COOH) and amines groups (NH_2) (Amlinger et al., 2007;AliandShakir, 2018).The results showed that the addition of the two factors as soil conditioners had a significant role in improving the chemical properties of the soil, and this was confirmed by a number of studies (Osman et al., 2008;Hassanand Mahmoud, 2013;El-Etrand Hassan 2017). This is in agreement with the findings of several researchers (Arthur et al., 2012; Wolka and Melaku, 2015;Adugna, 2016).

Plant Parameters

Plant height

The results showed in (Table 5) that the plant height increased with increasing bentonite level by 5.00, 8.36, 12.69 and 15.67% for the levels 3, 6, 9 and 12%,

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respectively, compared to the control. The results showed that the level (12%) gave highest value for plant height compared to other levels. The results also showed that the addition of compost had a significant effect on plant height (Table 5). The plant height an increase of 3.35 and 7.42% for the levels of compost 40 and 80 Mg ha^{-1}respectively, compared to the control. The third level of addition gave the highest value of plant height in comparison with the other two levels. As for the interaction between the two factors (bentonite and compost), its effect was significant on plant height (Table 5). The fifth level of bentonite and the third level of compost in the treatment (C2B4) was superior in giving the highest value of plant height of 160.8 cm, with an increase of 24.55% over the control treatment for interaction (C0B0) which gave a value of plant height of 129.1 cm. Both factors (bentonite and compost) contributed to their Interacting effects in increasing plant height better than if they were added separately.

Leaf area

The results showed a significant effect of bentonite added in the leaf area (Table 5) as it increase by 10.03, 19.58, 29.64 and 33.10% bentonite levels 3, 6, 9 and 12%, respectively, compared to the control.The results shown in (Table 5) indicated an increase in the leaf area as it reached as amean of 3749.1, 3883.7 and 4281.2 cm^2 $plant^{-1}$ for addition levels 0, 40 and 80 Mg ha^{-1} respectively, with increase by 3.59 andrespectively,compared to the control.

Table 5. Effect of bentonite and compost application in growth plant parameters of sorghum.

Bentonite (B)	Plant height (cm)			C Mean	Leaf area (cm $plant^{-1}$)			C Mean	Chlorophyll (Spad)			C Mean
	Compost (C)				Compost (C)				Compost (C)			
	C0	C1	C2		C0	C1	C2		C0	C1	C2	
B0	129.1	132.7	140.2	134.0	3153.3	3289.0	3619.2	3351.8	42.47	48.67	49.03	46.72
B1	137.6	141.3	143.2	140.7	3532.1	3593.1	3939.1	3688.1	44.57	51.73	54.07	50.12
B2	140.2	144.3	150.4	145.2	3763.6	3848.7	4412.3	4008.2	51.23	54.40	54.83	53.49
B3	145.5	144.9	158.0	151.0	4064.4	4324.5	4647.3	4345.4	54.57	56.93	58.80	56.77
B4	148.1	155.8	160.8	155.0	4232.2	4363.3	4788.1	4461.2	57.73	59.73	61.40	59.46
B Mean	140.1	144.8	150.5		3749.1	3883.7	4281.2		50.11	54.19	55.63	
LSD0.05												
Bentonite	1.2				30.3				1.10			
Compost	0.9				23.5				0.85			
B X C	2.0				52.5				1.91			

14.19% for levels 40 and 80 Mg ha^{-1}

The results showed that there was a significant effect of the interaction between the two factors (bentonite and compost). The results shown in (Table 5) showed that the interaction treatment (C2B4) gave the highest value for the leaf area of

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the plant which reached to 4781.2 cm^2 $plant^{-1}$ with an increase of 51.84% compared to the interaction control (C0B0), which gave the lowest value for the leaf area. It reached 3,153.3 cm^2 $plant^{-1}$.

Chlorophyll content

The results showed (Table 5) that there was a significant effect of bentonite added in chlorophyll content in the leaves of the sorghum. Chlorophyll content increased with the increase bentonite level added by 7.28, 14.49, 21.51 and 27.27% for the levels of bentonite 3, 6, 9 and 12%, respectively,as compared to the control.The results also showed (Table 5) a significant effect of the level of compost addition on the chlorophyll content of sorghum. The increase in the compost level increased the chlorophyll content by 8.14 and 11.02% for the two levels of addition 40 and 80 Mg ha^{-1}compared to the control.The results showed a significant effect of the interaction between the level of adding bentonite and compost on the chlorophyll content. The interaction treatment (C2B4) as it gave the highest value for the chlorophyll content of 61.40 Spad with an increase of 44.57% over the control(C0B0) which gave the lowest value of 42.47 Spad.The interaction of both factors gave the highest value to the chlorophyll content in the leaves, indicating the positive effect of these two soil conditioners, which can be used together better than adding each of them separately.

The results indicated that there was a significant increase in the growth parameters of the sorghum plant (plant height, leaf area and chlorophyll content in the leaves) with an increase in the level of addition of bentonite. Its properties have varied roles in the soil, it has a role in increasing the ability of soil to retain water by close large pores in the soil, increasing water available in the root zone, and increasing plant growth (Salih, 2000;Iskander et al., 2011).In addition, its role in increasing the soil CEC and increasing the nutrients availability, preventing it from loss during the washing process and raising the efficiency of mineral fertilizers added in coarse textured soils such as study soil, which contributed to increasing the absorption of water and nutrients by the plant and this was reflected in the increase in plant growth and increase in height plant, leaf area and chlorophyll content (Sitthaphanit et al., 2010 ; Hassanand Mahmoud, 2013;Youssef, 2013 ; Salmanand Abd Al-Whaab, 2016).

The results are agree with what was confirmed by a number of studies that used bentonite clay as conditioner for sandy soils and obtained an increase in the growth parameters of some crops (potatoes, corn, sugar beets, and vegetable crops) (Al-Ani,2009; Shaheen et al., 2013 ;Molla et al., 2014 ; Abbas et al., 2018).

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The addition of compost also led to a significant increase in sorghum growth parameters. This may be attributed to the fact that compost is a source rich in nutrients, especially nitrogen and phosphorous (Table 3), whose availability increases as a result of the decomposition processes in addition to its role in improving the soil physical properties (soil structure, bulk density and moisture content)which contributes to increasing plant water availability and improving chemical properties (reducing pH, and increasing CEC) which led to an increase in nutrient availability and increased activity of microorganisms, which contributes to an increase in biological and physiological processes in plants, which were reflected in the increase in plant growth parameters (Horrocks et al., 2016 ; Abbas et al., 2018 ; Al-Mosawi et al., 2018).Compost prepares nutrients, especially nitrogen, during the mineralization process slowly during the growing season (Adugna, 2016).

The results are consistent with what were obtained Aziz et al. (2010) and Al-Jammas (2018) and Al-Kalaby(2018) who obtained an increase in plant growth parameters (plant height, leaf area and chlorophyll content) for corn and potatoes.

Interaction between the level of addition of bentonite and compost, its positive effect was to increase the growth parameters of the sorghum. The interaction of both factors for the treatment (C2B4) gave the highest increase in plant height, leaf area and chlorophyll content which achieved the increase in the plantparameters for each of the factor alone.The results agree with numberof researcherswho found in their study the superiority of the interacting effect of bentonite and compost in increasing the plant parameters(Osman et al., 2008 ;El-Etr andHassan,2017 ; Abbas et al., 2018).

Correlation relationships

The results showed that the values of the simple linear correlation coefficient (r) for the relationship between the level of addition of bentonite and plant parameters ranged between 0.881 and 0.999, and all the values were significant at the level of 0.05 (Table 6). The high significant correlation coefficient (r) values between bentonite addition level and parameters under study confirm the positive role of bentonite as a soil conditioner and its effect on the physical and chemical properties of soil and in increasing nutrientsavailability which contributed to a high response in the sorghum and increased (N,P and K) content in plant. The linear relationship confirms that the bentonite levels added to the soil did not reach the maximum amount of this conditioner in the soil because all parameters increased gradually with increasing bentoniteadded.A number of

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researchers have obtained in their study a significant linear correlation between the level of bentonite addition with soil properties and plant indices (Salih, 2000; Czaban et al., 2014; Eldardiryand Abd-Hady, 2015).

Table 6. Linear relationship between bentonite level addition with soil chemical properties and plant parameters.

Property	Equation	Correlation coefficient (r)*
Ph	Y= 7.334 + 0.013X	0.955
O.M	Y=25.740 + 1.123X	0.881
CEC	Y=13.616 + 0.974X	0.974
Plant height	Y=134.72 + 1.743X	0.997
Leaf area	Y=3395.72 + 95.87X	0.989
Chlorophyll content	Y=46.886 + 1.071X	0.999

- Table r value at 0.05: 0.878.

While some obtained a second order correlation between the level of addition of bentonite and plant indices (El Saganand Rizk , 2014;Semalulu et al., 2015 ; Khalafand Al-Galbi,.2019).

The correlations are of great importance through which it can predict changes in the different soil characteristics and nutrient readiness as a result of adding the bentonite soil conditioner as well as predict the response of the white corn plant to the levels of bentonite added to the soil.

Conclusions

The addition of soil conditioners under study (bentonite and compost) achieved a great positive effect in improving the various properties of the soil and soil fertility, and adding them together is better than if they were added separately.

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