Effect of Biochar and Bentonite Application in Availability and Uptake of N, P and K for Faba Bean in Desert Soil

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Abstract

A field experiment was carried out to evaluate effect of some soil conditioners (biochar and bentointe) in availability and uptake of N, P and K for Faba bean in desert soil. The study included four levels of biochar (Seek) 0, 10, 20 and 30 Mg ha^{-1} (S_0, S_1, S_2 and S_3) and four levels of bentonite 0, 10, 20 and 30 Mg ha^{-1} (B_0, B_1, B_2 and B_3). The experiment was carried out according to randomized complete block design (RCBD) with three replicates were used. The results indicated that the application of biochar and bentonite significantly affected in nutrients availability and uptake under study. The forth level of biochar and bentonite gave the highest values of N, P and K availability reached 67.79, 16.60 and 202.69 mg kg^{-1} soil for N,P and K availability, respectively for biochar and 66.83, 15.49 and 184.57 mg kg^{-1} soil for bentonite. The results showed also that the fourth level of biochar and bentonite gave the highest values of N, P and K uptake reached 45.64, 12.53 and 23.82 kg ha^{-1}, respectively for biochar and 47.97, 11.86 and 22.71 kg ha^{-1}, respectively for bentonite. As for the interaction between two amendments the treatment (S_3B_3) was the most efficient in giving the highest values for available N, P and K it reached 72.43, 20.53 and 217.13 mg kg^{-1} soil, respectively and nutrients uptake reached 55.97, 14.94 and 32.14 kg ha^{-1}, respectively.

Keywords: biochar, bentonite, nutrients uptake, faba bean, desertification.

تأثير أضافة الفحم الحيوي والبنتونايت في جاهزية وامتصاص N و P و K لنبات الباقلاء في تربة صحراوية

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المستخلص

اجريت تجربة حقلية بهدف معرفة تأثير بعض مصلحات التربة (الفحم الحيوي والبنتونايت) في جاهزية وامتصاص N و P و K لنبات الباقلاء في تربة صحراوية. تضمنت التجربة اربعة مستويات من الفحم الحيوي نوع (Seek) هي 0 و5 و10 و 15 ميكاغرام هـ$^{-1}$ ورمز لها S_0 و S_1 وS_2 و S_3 واربعة مستويات من البنتونايت هي 0 و 10 و 20 و 30 ميكاغرام هـ$^{-1}$ و رمز لها (B_0 و B_1 و B_2 و B_3). اجريت تجربة عاملية باستعمال تصميم القطاعات كاملة التعشية وبثلاثة مكررات. أظهرت النتائج أن زيادة مستوى إضافة كل من الفحم الحيوي و البنتونايت اثرت تأثيراً معنوياً في جاهزية وامتصاص المغذيات قيد الدراسة ، لقد حقق المستوى الرابع من الفحم الحيوي والبنتونايت أعلى القيم في جاهزية N و P وK في التربة بعد الحصاد اذ بلغت 67.79 و 16.60 و 202.69 ملغم كغم $^{-1}$ تربة للمغذيات على التتابع للفحم الحيوي و 66.83 و 15.49 و 184.57 ملغم كغم $^{-1}$ تربة للمغذيات على التتابع للبنتونايت كما أوضحت النتائج ايضا بان المستوى الرابع من الفحم الحيوي والبنتونايت اعطى اعلى القيم في امتصاص المغذيات في الجزء الخضري للنبات اذ بلغت 45.64 و 12.53 و 23.82 كغم هـ$^{-1}$ N و P وK على التتابع اما بالنسبة للبنتونايت فقد بلغت القيم 47.97 و 11.86 و22.71 كغم هـ$^{-1}$ للمغذيات على التتابع. أما بالنسبة للتداخل بين اضافة المصلحين فقد تفوقت المعاملة (S_3B_3) في تحقيق اعلى جاهزية N و P وK بلغت 72.43 و20.49 و 217.13 ملغم كغم $^{-1}$ تربة على التتابع و اعلى قيمة لامتصاص N و P وK 55.97 و 14.94 و 32.14 كغم هـ$^{-1}$ على التتابع.

الكلمات المفتاحية: الفحم الحيوي، البنتونايت، امتصاص المغذيات، الباقلاء، التصحر.

Introduction

Desert consist of sandy soils, which include large areas in the world. Sandy soils are well aerated and drainable and their total porosity low as compared to clay soils which made its ability to retain water and the available water low as well as low specific surface area and it is a poor soil in its cation exchange capacity (CEC), organic matter content and nutrient (Al-Janabi, 2016). Some methods have been used to improving the sandy soils in desert and desertified lands to overcome its agricultural determinants by improving the physical, chemical and biological properties of the soil, increasing its nutrients availability and productivity, the most important of these means is the use of some industrial or natural amendments which it was organic or mineral. Natural amendments, such as

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clay represented by bentonite clay, have been used widely in the world for its role in improving many soil properties and increasing available nutrients (Al-Kinani and Jarallah,2021). Organic or mineral materials that improve most soil properties,fertility of the soil and increasing its productivity(Tawfiq, 2009). Many of soil conditioners have been used in coarse-textured soils with the aim of improving their properties and improving their fertility and yield of various agricultural crops, such as bentonite clay (Al-Kinani and Jarallah , 2021,2022) and zeolite (Hassan and Mahmoud, 2013). Also, organic conditioners were used from different animal and vegetable sources, compost and waste from cities and factories (Al-Kinani and Jarallah, 2021; Al-Saadi and Al-Wardy,2019). In addition, using biochar which is a modern soil conditioner (Al-Tameemi and Jaber, 2019; Liu et al., 2019). Biochar is defined as a carbon-rich organic material produced from the thermal and chemical decomposition of living mass at a temperature of 400-800 °C under conditions of low oxygen or a limited amount of it (Gul et al., 2015). It was found that biochar is one of the compounds resistant to microbial decomposition in soil (Biederman and Harpole, 2013). Many studies focused on the use of biochar as an improvement of the biological, physical and chemical characteristics of degraded soils as well as improving soil fertility and productivity for various agricultural crops (Hui,2021; Kizito et al., 2019 ; Shah et al.,2021; Xiang et al.,2017). Many researchers found that bentonite enhancers coarse texture soil, increasing nutrient availability, plant growth and productivity (Abed et al., 2016; Al-Hayani et al., 2022 ;Al-Kinani and Jarallah, 2021; Molla et al., 2014). The importance of the Faba bean crop is not that it is a major source of protein and energy and a good and cheap alternative to meat and fish protein, but rather its ability to fix atmospheric nitrogen through root nodules formed on its roots with has an examination of the presence of bacteria in the soil been conducted and rotations cycles (Fagaria, 2005). This study was aimed to evaluate the effect of two types of soil conditioners (biochar and bentonite) in some macronutrients N, P and K) availability and their uptake for Faba bean in Iraqi desert soil.

Materials and Methods

A field experiment was conducted at desert soil with sandy loam texture in Al-Karma district of Al-Anbar Governorate. The experiment was divided into 3 blocks, each one includes 15 experimental unit and the distance between them was 1 m while the distance between blocks was 2 m. Soil samples were collected from the layer (0 – 0.3 m) before planting. Some physical and chemical properties of the soils were measured by (Page et al.,1982) Table 1.

Table 1. Some physical and chemical properties of soil before planting.

Property		Value	Unit
EC (1:1)		3.20	dS m^{-1}
pH (1:1)		7.40	
O.M		7.60	g kg^{-1} soil
Carbonate minerals		263.15	
CEC		4.11	C $mol_{+}kg^{-1}$ soil
Soluble ions	Ca^{++}	19.32	m mole L^{-1}
	Mg^{++}	9.24	
	Na^{+}	3.65	
	K^{+}	0.88	
	$CO_3^{=}$	-	
	HCO_3^{-}	1.00	
	$SO_4^{=}$	0.91	
	Cl^{-}	22.65	
Available nutrients	NH_4^{+}	11.20	mg kg^{-1} soil
	NO_3^{-}	18.80	
	P	4.23	
	K	116.14	
Bulk density		1.64	Mg m^{-3}
Field capacity		9.38	%
Wilting point		2.50	
Available water		6.88	
Particle size analysis			
Clay		124.0	g kg^{-1} soil
Silt		116.0	
Sand		760.0	
Texture		Sandy loam	

The experiment included four levels of biochar (Seek Chinese origin: it is an organic charcoal produced from bamboo cane) which are 0, 5, 10, and 15 Mg ha^{-1} and their symbols (S_0, S_1, S_2 and S_3) Table 2 shows some characteristics of the biochar. Four levels of bentonite were used which 0, 10, 20 and 30 Mg ha^{-1} and their symbols (B_0, B_1, B_2 and B_3) some characteristics of the bentonite clay (Table 3). Both conditioners were added after mixing them with the soil. Faba bean (*Vicia faba* L.)

Table 2. Some characteristics of biochar (Seek).

Characteristic	Value	Unit
EC (1:5)	3.18	dS m^{-1}
pH (1:5)	7.15	-
N	1.31	%
P	0.65	
K	1.65	
O.C	25.32	
O.M	43.65	
C : N	19.33	-

Spain cultivar (Luz-de-otono variety) was sown in 17/10/2021 for winter season, N was added at 100 kg N ha^{-1} as urea (46% N) and P at 120 kg P_2O_5 ha^{-1} was added as TSP. (46% P_2O_5) and K at a level of 40 kg K_2O ha^{-1} in the form of K_2SO_4 (50% K_2O) according to the fertilizers recommendation of board bean (Ali et al., 2014). N was added in two doses, As for P and K fertilizers, they were added once. At the end of the experiment the crop was harvested in 26/3/2022.

Table 3. Some characteristics of bentonite.

Characteristic		Value	Unit
ECe		3.14	dS m^{-1}
pH		7.00	
$CaCO_3$		130.10	g kg^{-1}
Gypsum		2.40	
CEC		60.1	C $mol_+ kg^{-1}$ clay
Oxides content	P_2O_5	0.65	%
	K_2O	0.50	
	CaO	0.58	
	MgO	0.18	
	Fe_2O_3	1.52	
	Al_2O_3	34.58	
	Na_2O	0.18	
	SO_3	0.23	
	SiO_2	51.96	
	Cl	0.05	
Particle size analysis			
Clay		899.0	g kg^{-1} clay
Silt		99.0	
Sand		2.0	
Texture		Clay	

A mean of vegetative dry weight was measured for five plants per experiment unit. Nitrogen, phosphorus and potassium availability in soil were determined according to (Page et al., 1982), While their concentration were determined in vegetative part to (Jackson,1958). Nutrient uptake calculated as follows:

Nutrient uptake = $Nutrient\ con, (\%) \times Vegetativedry\ weight$

A factorial experiment was carried out within randomized complete block design (RCBD) with three replications. Least significant differences test (LSD 0.05) was used to compare the means of the treatments (Steel and Torrie,1980).

Results and Discussion

Nutrients availability after harvest

Nitrogen

The results in Table 4 showed an increase in nitrogen availability with an increase in the level of addition of biochar by 17.44, 30.55 and 40.41% for added levels 5, 10 and 15 Mg ha^{-1} respectively, compared to 0 Mg ha^{-1} and forth rate gave the highest of available nitrogen in the soil. The results also showed that available nitrogen increased with the increase bentonite application from 0 to 10, 20 and 30 Mg ha^{-1} by 13.23, 24.38 and 33.53% for added levels respectively, compared to 0 Mg ha^{-1}. The results showed a significant effect of the interaction between biochar and bentonite in nitrogen availability and the forth level of biochar and bentonite outperformed in achieving the highest value of nitrogen availability with treatment S_3B_3, which amounted to 72.43 mg kg^{-1} soil with an increase of 111.60% compared to the control treatment (S_0B_0) 34.23 mg kg^{-1} soil. It appears that the addition of both factors together to the soil was more efficient in increasing the availability of nitrogen than if each was added separately to the soil.

Table 4. Effect of biochar and bentonite in N availability (mg kg^{-1} soil) after harvest.

Biochar (S)	N				B
	Bentonite (B)				
	B_0	B_1	B_2	B_3	Mean
S_0	34.23	43.60	55.13	60.13	48.28
S_1	45.53	55.27	60.40	65.60	56.70
S_2	56.43	61.37	65.17	69.13	63.03
S_3	64.00	66.43	68.30	72.43	67.79
S Mean	50.05	56.67	62.25	66.83	
LSD 0.05	Biochar	Bentonite	S×B		
	0.74	**0.**74	1.47		

Phosphorus

Also table 5 explained available P increased by 33.62, 65.89 and 102.93% for the levels of biochar which was superior to 15 Mg ha^{-1} in giving the highest P availability value. The results also showed that the bentonite significant effect in phosphorus availability. The available phosphorus increased by 9.85, 33.10 and 57.26% for three levels of bentonite 10, 20 and 30 Mg ha^{-1} respectively, compared to (0 Mg ha^{-1}). The third rate of bentonite gave the higher value of available phosphorus, which was 15.49 mg kg^{-1} soil and the highest increase compared to the other three levels. Interaction between biochar and bentonite significantly affect on available phosphorus after harvest. Treatment S_3B_3 gave the highest value of available phosphorus, which reached to 20.53 mg kg^{-1}soil with an increase of 231.13% than the control (S_0B_0)) which reached to 6.20 mg kg^{-1}soil which indicates that each factors had a positive effect on increasing the availability of phosphorus in soil. It appears that the addition of both factors together to the soil was more efficient in increasing the availability of phosphorous than if each was added separately to the soil.

Table 5. Effect of biochar and bentonite in P availability (mg kg^{-1} soil) after harvest.

Biochar (S)	N				Mean
	Bentonite (B)				
	B_0	B_1	B_2	B_3	
S_0	6.20	7.17	8.43	10.90	8.18
S_1	8.53	9.47	12.10	13.60	10.93
S_2	10.73	11.80	14.80	16.93	13.57
S_3	13.93	14.83	17.10	20.53	16.60
Mean	9.85	10.82	13.11	15.49	
LSD 0.05	Biochar	Bentonite	S×B		
	.025	0.25	0.51		

Potassium

The forth rate (15 mg ha^{-1}) outperformed in achieving the availability of potassium, which reached to 202.69 mg kg^{-1} soil. The results also showed that the available potassium increase of 4.23, 9.39 and 14.90% for three levels of bentonite 10, 20 and 30 mg ha^{-1} compared to without addition Table 6. The results shows the superiority of the forth level in achieving the highest value of available potassium as it 184.57 mg kg^{-1} of soil compared to the other levels. For the interaction between biochar and bentonite had a significant effect on potassium availability after harvest. The treatment S_3B_3 outperformed as it gave the highest value of available potassium, which reached to

217.13 mg kg^{-1}soil with an increase of 125.52% over the lowest value which was the control treatment for the interaction (S_0B_0), which reached 125.13 mg K kg^{-1} soil.
Two factors had a positive effect in their interaction on potassium availability.

Table 6. Effect of biochar and bentonite in K availability (mg kg^{-1} soil) after harvest.

Biochar (S)	N Bentonite (B)				Mean
	B_0	B_1	B_2	B_3	
S_0	125.13	140.23	150.63	158.87	143.72
S_1	154.83	160.07	167.30	172.47	163.67
S_2	169.27	175.47	179.33	189.80	178.47
S_3	193.33	194.63	205.67	217.13	202.69
Mean	160.64	167.60	175.73	184.57	
LSD 0.05	Biochar	Bentonite	S×B		
	1.92	1.92	3.85		

The addition of biochar led to an increase nitrogen, phosphorus and potassium availability in the soil after harvest of the Faba bean plant. This may be due that biochar is the source of some nutrients present in its composition after mineralization such as nitrogen and phosphorous, in addition to its contribution to reducing the loss of nutrients through leaching and volatilization (Ding et al., 2016). As well as, it contributes to increasing the exchange capacity of positive ions and increasing nutrients availability such as potassium (Kizito et al., 2019; Lee et al., 2021), and biochar works to reduce soil pH which contributes to increasing the availability of some nutrients such as nitrogen and phosphorus (Nigussie et al., 2012). It was also noted that biochar has a high adsorption capacity and its contribution to increasing nitrogen and phosphorus availability and its ability to retain these two nutrients and reduce their loss (Huang et al., 2020). It was also found that the active groups possessed by biochar (carboxylic and phenolic groups) compete with phosphorus for adsorption sites and increase its availability. It also increases soil cations exchange capacity (CEC), thus increasing the cations availability such as nitrogen (ammonium ion) and potassium (Jiang et al., 2015). Many researchers have found that the addition of biochar to the soil led to an increase in the availability of many nutrients, including nitrogen, phosphorus and potassium, as well as its role in retaining nutrients and reducing their losses through volatilization and leaching and increasing the efficiency of the use of fertilizers added to the soil (Li et al., 2021; Zahra et al., 2021). Sasmita et al. (2017) obtained a positive linear correlation between phosphorus availability and biochar addition level.
Bentonite addition increased nitrogen, phosphorus and potassium availability in the soil after harvest. This may be attributed to the its addition to coarse-textured soils such as the study soil (loamy sandy) (Table 1) led as an improver for different soil properties, as it contributes to increasing soil CEC which increases nutrients availability (Salih, 2000; Sacchi, 2010) and increases the ability of the soil to retain nutrients. It reduces theirs loss under leaching and increases fertilizer use efficiency (Yssaad et al., 2011). And because of its high cations exchange capacity (up to 150 $Cmol_{+}kg^{-1}$) and its ability to increase the moisture content in the soil, it contributes to increasing the availability of most nutrients Ca, Mg, K, N and P (Minhal et al., 2020). It was also found that bentonite reduces the fixation of phosphorus and potassium in the soil and increases the ability of the soil to retain water and reduces the loss of nutrients (Iskander et al., 2011). The results agree with many researchers who obtained in their studies an increase in most nutrients, including nitrogen, phosphorus, and potassium, as a result of adding bentonite clay to the soil, especially coarse texture (El-Etr and Hassan, 2017 ; Abdeen, 2020).
Interaction between biochar and bentonite had a positive and significant effect on available nitrogen, phosphorous and potassium because both factors of the study contributed to improving the soil properties such as increasing soil CEC, organic matter content and reducing pH which led to an increase in the availability of nutrients (N, P and K). It appears from the results that the biochar was more effective in increasing nutrients availability as compared to bentonite. The addition of biochar and bentonite conditioners to coarse soils had a better effect than if they were added separately, A number of studies that used biochar bentonite together as improvers for sandy soils found similar results (Eldardiry and Abd El-Hady, 2015 ; Abbas et al.,2018 ; Al-Kinani and Jarallah, 2022).

Nutrients uptake in plant

Nitrogen

Nitrogen uptake in vegetative part increased significantly with the increase biochar level added, as the values increased by 18.46, 34.05 and 52.34% for levels 5, 10 and 15 Mg ha^{-1}, respectively compared to the control treatment Table 7. The results also explained the increase bentonite levels 10, 20 and 30 Mg ha^{-1} increased N uptake by 18.24, 49.70 and 70.89% for bentonite levels, respectively compared to the control treatment. The treatment (S_3B_3) gave the highest value for N uptake of 55.97 Kg ha^{-1} with an increase of 154.29% compared with (S_0B_0).

Table 7. Effect of biochar and bentonite in N uptake in vegetative part (Kg ha^{-1}).

Biochar (S)	N uptake				B
	Bentonite (B)				
	B_0	B_1	B_2	B_3	Mean
S_0	22.01	26.79	33.80	37.23	29.96
S_1	26.26	29.42	38.78	47.49	35.49
S_2	28.82	35.97	44.66	51.18	40.16
S_3	35.18	40.56	50.84	55.97	45.64
S Mean	28.07	33.19	42.02	47.97	
LSD 0.05	Biochar	Bentonite	S×B		
	1.39	1.39	2.78		

Phosphorus

The results in Table 8 show that P uptake increased significantly with increasing biochar levels with an increase of 33.03, 59.51and 90.72% for the levels of adding biochar 5, 10 and 15 Mg ha^{-1} , respectively, compared to the treatment (0 Mg ha^{-1}). The bentonite addition had a significant effect on P uptake with an increase of 31.67, 45.79 and 69.19% for the levels of adding bentonite 10, 20 and 30 Mg ha^{-1}, respectively compared to the control treatment. Interaction between biochar and bentonite affect significantly in P uptake. The (S_3B_3) was superior value of 14.94 Kg ha^{-1} with an increase of 208.68% with (S_0B_0) which 4.84 Kg ha^{-1}. The addition of biochar and bentonite together was better in increasing P uptake than adding each of them separately.

Table 8. Effect of biochar and bentonite in P uptake in vegetative part (Kg ha^{-1}).

Biochar (S)	P uptake				B
	Bentonite (B)				
	B_0	B_1	B_2	B_3	Mean
S_0	4.84	6.15	7.10	8.18	6.57
S_1	5.85	8.35	9.25	11.51	8.74
S_2	7.24	10.31	11.56	12.80	10.48
S_3	10.11	12.13	12.96	14.94	12.53
S Mean	7.01	9.23	10.22	11.86	
LSD 0.05	Biochar	Bentonite	S X B		
	0.21	0.21	0.42		

Potassium

Results in Table 9 show that K uptake increased significantly with increasing biochar levels with an increase of 35.78, 77.79 and 121.38% for the levels of biochar added 5, 10 and 15 mg ha^{-1} , respectively, compared to (0 mg ha^{-1}) treatment. Bentonite addition had a significant effect on K uptake with an increase of 23.85, 43.67 and 83.00% for the levels of bentonite added 10, 20 and 30 mg ha^{-1}, respectively compared to the control treatment. The interaction between biochar and bentonite affect significantly in K uptake. The (S_3B_3) was superior the highest value of 32.14 Kg ha^{-1} with an increase of 309.43% of (S_0B_0) which it 7.854 Kg ha^{-1}. Both amendments (biochar and bentonite) effects in increasing K uptake in plant.

Table 9. Effect of biochar and bentonite in K uptake in vegetative part (Kg ha^{-1}).

Biochar (S)	K uptake				B
	Bentonite (B)				
	B_0	B_1	B_2	B_3	Mean
S_0	7.85	9.96	11.70	13.52	10.76
S_1	10.63	13.21	14.44	20.15	14.61
S_2	13.24	17.45	20.80	25.03	19.13
S_3	17.93	20.86	24.36	32.14	23.82
S Mean	12.41	15.37	17.83	22.71	
LSD 0.05	Biochar	Bentonite	S×B		
	0.37	0.37	0.74		

The addition of biochar led to a significant increase in the amount N, P and K uptake in Faba bean, this may be attributed to the addition of biochar as an improver to the coarse texture like study soil (sandy loam) and its addition contributed to improving soil physical and chemical properties as well as increasing some nutrients availability including nitrogen, phosphorus and potassium being a source of nutrients for nitrogen and phosphorus and its role in increasing soil CEC and reducing soil pH by forming organic acids as a result of its decomposition, and the humic acids that have the ability to hold nutrients such as phosphorus, which leads to an increase in its availability and a decrease in its loss. All of its roles mentioned contributed to nutrients availability (N, P, and K), which led to an increase in their uptake and content in the bean plant (Sun et al., 2018; Simansky, et al., 2022). The results are consistent with what was obtained by a number of researchers (Kizito et al., 2019;Santos et al.,2019; Lee et al., 2021) who obtained in their study an increase in the content and uptake of nitrogen, phosphorus and potassium in the plant after adding biochar to coarse texture soil.

As for the increase in nitrogen, phosphorus and potassium uptake in plant with an increase in bentonite addition levels, this may be attributed to the role of bentonite clay in improving the physical and chemical properties of the study soil as well as improving its fertility (increasing the available nutrients, including nitrogen, phosphorus and potassium), which were reflected in the increase in these uptake in the Faba bean. (Semalulu et al. 2015, Minhal et al. 2020, and Al-Kinani and Jarallah, 2021). A number of researchers obtained an increase in the content and absorption of nutrients (nitrogen, phosphorus, and potassium) for yellow corn, white corn, potatoes, and vegetable crops as a result of adding bentonite clay as an improver to coarse-textured soil (El-Etr and Hassan, 2017 ; Al-Kinani and Jarallah, 2022).

The interaction between the addition of biochar and bentonite, its effect was positive in increasing the uptake and content of nutrients nitrogen, phosphorus and potassium in the vegetative part and grains. The interaction effect of these two conditioners excelled in achieving the highest values and rates of increase in the absorption of the nutrients under study compared to if each was added separately, and this was confirmed by the results of studies of researchers who used biochar, bentonite and organic residues in coarse-textured soils and obtained an increase in the content and nutrients uptake (nitrogen, phosphorous, and potassium) (Wyszkowski et al., 2009; Ajayi and Horn, 2016 ; Abbas et al., 2018).

Conclusion

It can be concluded the addition of soil conditioners (seek biochar and bentonite) significantly affects the availability of nutrients (nitrogen, phosphorus and potassium). The addition of biochar and bentonite achieved a great response to the Faba bean plant represented by increasing the parameters of vegetative growth and nutrient uptake. The effect of the two conditioners to the soil together was more efficient in increasing nutrients availability and their uptake in plant under study compared to adding each of them separately.

References

Abbas, M. S., Sh. Soilman, A.. Moustafa, Z. R & Abd El-Reheem, K. M. (2018). Effect of some soil amendments on yield and quality traits of sugar beet (*Beta vulgaris* L.) under water stress in sandy soil. *Egyption Journal of Agronomy,* 40(1), 75-88.

Abdeen, S. A. (2020). Biochar, bentonite and potassium humate effects on saline soil properties and nitrogen loss. *ARRB*, 35(12),45-55.

Abed, Y.M., Abdul-Ratha, H. A. & Hadown, H.A. (2016). Effect of biofertilizer produced from local isolates of *Pseudomonas putida* and *Pseudomonas fluorescens* on some soil characteristics and yield of wheat (*Triticum aestivum* L). *Iraqi Journal of Agricultural .Sciences*, 47(6), 1413 – 1422.

Ajayi, A.E., & Horn, R.(2016). Comparing the potentials of clay and biochar in improving water retention and mechanical resilience of sandy soil. International *Agrophyicss*, 30,391-399.

Al-Hayani, A.S.J.Z., Al-Hassoon, S. N. H. & Al-Obaidi, M.A.J. (2022). Adsorption of copper on surfaces of feasible materials (plant waste, sludge and bentonite metal). *Iraqi Journal of Agricultural Sciences*, 53(3),654 – 659.

Ali, N. S., Rahi, H. S. & Shaker A. A., (2014). *Soil fertility*. Dar Al- Kotob Alamya. Amman. Jordon. pp: 307.

Al-Janabi, H. Y.(2016). *Applied land reclamation*. Dep. of the Univ. Printing Press, Faculty of Agriculture, Al-Qasim Green University, Babylon, Iraq. pp: 245.

Al-Kinani, D. K. S., & Jarallah, A. K. A. (2021). Effect of bentonite and compost applications in some chemical properties of soil, growth of sorghum (*Sorghum bicolor* L.) in desert soil. *Annals of the Romanian Society for Cell Biology*, 25(6),9497-9513.

Al-Kinani, D. K. S., & Jarallah, A. K. A. (2022). Effect of bentonite and compost application in some macro nutrients availability and yield of sorghum (*Sorghum bicolor* L.) in desert soil. *Iraqi Journal of Soil Science*, 22(1) , 134 – 146.

Al-Saadi, M.M., & Al-Wardy, M.M. (2019). Influence of sludge compost on soil properties and tomato plant uptake of metals. *American Journal of Biomedical Sciences and Research*, 2(2), 86-92.

Al-Tameemi, H. J., &. Jaber, H. M. (2019). Effect of biochar on some physical properties of two different textured soil. *Merit Research Journal Agricultural Sciences and Soil Scencesi,* 7(3),43-52.

Biederman, L. A., & Harpole, W. S. (2013). Biochar and its effects on plant productivity and nutrient cycling. A meta – analysis. *Global Change Biology Bioenergy*, 5,202-214.

Ding, Z.H., Wan, Y.S., Hu, X., Wang, S.S., Zimmerman, A.R.& Gao, B.(2016).Sorptionof lend and methylene blue onto hickory biochars from different pyrolysis temperatures: Important of physiochemical properties. *Journal of Industrial and Engineering Chemistry*, 37,261-267

Eldardiry, E.I., & Abd El-Hady, M. (2015).Effect of different soil conditioners application on some soil characteristics and plant growth. I. Soil moisture distribution, barley yield and water use efficiency. Glo. Adv. Res. J. Agric. Sci., 4(7),361-367.

El-Etr, W.M., & Hassan, W. Z. (2017). A study of some sandy soil characteristics treated with combinations of bentonite and vinasse which reflected on productivity of pea crop. J. Soil Sci. and Agric. Eng., Mansoura *Univ.*, 8(10), 545-551.

Fagaria, N.K.(2005). Agronomy and physiology of tropical cover crops. *Journal of Plant Nutrition*, 30,1287-1339.

Gul, S.,J.K. Whalen, Thomas, B.W., Sochdeva, V. & Deng, H.Y. (2015). Physico-chemical properties and microbial responses in biochar- amended soils: Mechanisms and future directions. Agriculture, *Ecosystem and Environment*, 206,46-59.

Hassan, A. Z. A., & Mahmoud, A. M. (2013). The combined effect of bentonite and natural zeolite on sandy soil properties and productivity of some crops. *Topclass Journal of Agricultural Research*, 1(3), 22-28.

Huang, L.Q.,C. Fu, Li, T.Z. Yan, B. Wu, Y. & Zhang, L. (2020).Advances in research on effects of biochar on soil nitrogen and phosphorus. *Earth and Environmental Science*, 424,1-8.

Hui, D. 2021. Effect of biochar application on soil properties, plant biomass production and soil greenhouse gas emissions: A mini-Review. *Agricultural Sciences*,12,213 -236.

Iskander, A. L., Khald, & Sheta, A. S. (2011). Zinc and manganese sorption behavior by natural zeo E.M lite and bentonite. *Annals of Agricultural Sciences*, 56, 43-48.

Jackson, M.L.(1958).Soil Chemical Analysis. Prentice-Hall. Inc. Engelwood. Cliffs N.J.

Jiang, J., Yuan, M. Xu, R. & Bish, D.L. (2015).Mobilization of phosphate in variable-charge soils amended with biochars derived from crop straws. *Soil and Tillage Research*, 146,139-147.

Kizito, S., Luo, H., Lu, J., Bah, H. & Dong, R. (2019).Role of nutrient-enriched biochar as a soil amendment during maize growth: Exploring practical. alternatives to recycle agricultural residuals and to reduce chemical fertilizer demond. *Sustainability* 11, 3211.

Lee, Y.L., Ahmad, O.H., Wahid, S.A. & AB Aziz, Z.F. (2021).Biochar tablets with and without embedded fertilizer on the soil chemical characteristics and nutrient use efficiency of *Zea mays*. *Sustainability*, 13,4878.

Li, S., Li, Z., Feng, X., Zhou, F., Wang, J. & Li, Y. (2021).Effects of biochar additions on the chemical properties, bacterial community structure and rape growth in on acid purple soil. *Plant and Soil Environment*, 67, 121-129.

Liu, X., Liao, J.,Song, H.,Yang, Y., Guan, C. & Zhang, Z. (2019). A biochar-based route for environmentally friendly controlled released of nitrogen: Urea-loaded biochar and bentonite composite. *Science Reports*, 9,9548:1-11.

Minhal, F., Ma׳as, A., Hanudi,E. & Sudira,P.(2020). Improvement of the chemical properties and buffering capacity of coastal sandy soil as affected by clay and organic by-product application. *Soil and Water Research*, 15,93-100.

Molla, A., Ioannou, Z., Dimirrkou,A. & Mollas,S. (2014). Reduction of nitrate nitrogen from alkaline soils cultivated with maize crop using zeolite-bentonite soil amendments. *International Journal Waste Resources*, 4(3) , 1-4.

Nigussie, A., Endalkachew, K. Mastawesha, M. & Gebremedhin, A. (2012). Effect of biochar application on soil properties and nutrient uptake of lettuces (*Lactuca sativa*) grown in chromium polluted soils. American-Eurasian *Journal of Agricultural and Environmental Sciences*,12(3), 369 – 376.

Page, A.L., Miller, R.H. & Kenney, D.R. (1982). *Methods of soil analysis part (2). 2nd ed. Chemical and microbiological properties.* American Society Argon Madison, Wisconsin. pp: 1159.

Sacchi, A.(2010).Improving the cation retention capacity of tropical soil using high activity clays. James Cook University, Australia.

Salih, R.O .(2000). Effect of bentonite addition on some properties of Zubair sandy soil and growth of onion. *Iraqi Journal of Agricultural Science*, 3(1),561-566.

Santos, S.R., Filho, J.F.L. Vergutz,L. & Melo., L.C.A.(2019).Biochar association with phosphate fertilizer and its influence on phosphorus use efficiency by maize. *Ciencia , Agrotecnologia*, 43,1-11.

Sasmita, K.D.,A. Iswandi, A. Syaiful, Y. Sudirman, & D. Gunawan. (2017). Application of biochar and organic fertilizer on acid soil as growing medium for caco(*Theobroma caco* L.) seedling. *International Journal of Sciences Basic and Applied Research*, 36(5),261-273.

Semalulu, O., Magunda, M. & Mubiru, D. N. (2015). Amelioration of sandy soils in drought stricken areas through use of Ca-bentonite. *Uganda Journal of Agricultural Sciences*, 16(2), 195-205.

Shah, T., Tariq, M. & Muhammad, D. (2021).Biochar application improves soil respiration and nitrogen mineralization in alkaline calcareous soil under two cropping systems. *Sarhad Journal of Agriculture*, 37(2),500-510.

Simansky, V., Horak, J. & Bordoloi, S. (2022).Improving the soil physical properties and relationship between soil properties in arable soils of contrasting texture enhancement using biochar substrates: Case study in Slovakia. *Geoderma Regional*, 28,1-15.

Steel, R. G. D., & Torrie, J. H. (1980). *Principles and procedures of statistics*. McGraw – Hill, Inc., N.Y.pp:485.

Sun, H. J., Min,J., Zhang, H.,Feng, Y., Lu, K., Shi, W., Yu,M. & Li,X.(2018).Biochar application mode influences nitrogen leaching and NH_3 volatilization losses in a rice paddy soil irrigated with N-rich waste water. *Environ. Technol.,* 39,2090-206.

Tawfiq, A. J. 2009. Improvement of sandy soil properties by using bentonite. *Kufa Journal of Engineering*, 1(1), 29-39.

Wyszkowski, M., Redziemska, M.& Sivitskaya, V. (2009).Effect of compost, bentonite, zeolite and calcium oxide on mineral nitrogen context in nickel contaminated soil. *Ecological Chemistry and Engineering*, 16(8),1047-1055.

Xiang, Y. Z., Deng, Q. Duan, H.L. & Guo, Y. (2017). Effects of biochar application on root traits: A meta-Analysis. *Global Change Biology Bioenergy*, 9,1563-1572.

Yssaad, H.R., Belkhodja, M.& Chibani,A.(2011).Effect of bentonite on the sandy soil of arid regions: Study of behavior of an association of wheat and chickpea. *Journal of Environmental Science and Engineering*, 5,1668-1677.

Zahra, M.B., Aftab, Z., Akhter, A. & Haider, M.S. (2021).Cumulative effect of biochar and compost on nutritional profile of soil and maize productive. *J. Plant Nutr.*, 441664–1676.