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Article

The impact of biochar and perlite on the soil's physical characteristics and capacity to hold moisture

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Abstract
A field experiment was conducted in clay-textured soil during the agricultural season 2021-2022 at Al-Muthanna Governorate, Al-Suwayr District - Albugrad region, longitude "5. 16' 36°31, and a latitude '0'. 52' 27 ° 45, to study the effect of biochar and perlite on soil's physical properties and barley's growth and yield. The experiment used a Randomized Block Design (RCBD) with two factors and three replicates. The biochar factor treatments included four levels of biochar at the level (0% B0, 0.5% B1, 1% B2, 1.5% B3). In comparison, the treatments of the second factor perlite included four levels. They are the addition of agricultural perlite at the level (0% P0, 0.5% P1, 1% P2, 1.5% P3). Mixing biochar with agricultural perlite for all treatments with soil to a depth of 30 cm. Barley (*Hordeum vulgare* L.) cultivar Iba 99 was planted on 1/11/2021. Crop service operations were carried out from adding chemical fertilizers, jungle control and irrigation until the end of the experiment and harvest on 9/9/2022. The results showed the superiority of the B3 biochar treatment (1.5% biochar) in improving most of the physical and chemical properties of the soil, the average weighted diameter of the wet and dry sifters (0.92 and 4.74 mm), while the treatment P3 (1.5% perlite) recorded the highest total porosity of the soil (49.03%).

Keywords: Biochar, perlite, physical properties, soil, moisture

Introduction

Soil degradation, including reduced fertility and increased erosion, is a significant concern in global agriculture. Long-term soil cultivation can lead to soil degradation, depletion of soil organic matter, and severe soil erosion. Moreover, the decrease in organic matter in the soil reduces the overall stability of the soil, so it is necessary to address soil degradation in simple and sustainable ways. In recent years, there has been a growing interest in applying biochar, which can be defined as a solid fine-grained material. It was obtained by charring biomass in isolation or with little oxygen. It can be added to the soil to improve its properties, increase the availability of elements and reduce environmental pollution[1].

In recent years, many studies and research have been conducted aiming to reduce water consumption in the agricultural sector, including the use of some natural and chemical products, which were added to the soil or plants to reduce evaporation and provide as much water as possible for the roots of plants, they were called moisture preservatives, and one of these materials is perlite[2]. Perlite is small white granules 1 to 5 mm in diameter, resulting from the softening of silicon volcanic rocks to 900 - 1000 ° C. As a result of this heating, the grain size increases from 4 to 20 times its original size[3].

The availability of natural resources is one of the world's most critical challenges because of the urgent need for them to support development plans and provide basic local needs to support the national economy. Water is one of the most important resources and the most influential in the development of societies, especially in arid and semi-arid areas, due to the scarcity of water and the connection of its imports from its sources in neighboring countries to the water policies of those countries. There are many problems that rivers suffer from in Iraq, including the decline in Iraq's water revenues from the imports of the Tigris and Euphrates. Added to these problems is the phenomenon of desertification, the persistence of high temperatures and the drying up of agricultural lands in areas lacking water. Therefore, the current study aims to demonstrate the effect of biochar and perlite on the physical properties of the soil and its ability to conserve moisture.

Materials and Methods

A field experiment was carried out during the winter agricultural season (2020-2021) at Al-Muthanna Governorate, Al-Suwayr District, Albugrad region, which was geographically located at longitude 5". 16 ´36°31 and latitude 0´´. 52 ´ 27 ° 45 in clay soil. The land was prepared for settlement and modification operations, was plowed by two plows, orthogonally, using a turn$ plow, and then the soil was softened. Divide the field into three sectors with dimensions of 50 x 200 = 100 m^2, leaving a distance of 2 m (a guard area) between one block and another and a distance of 1 m between one experimental unit and another. Each block was divided into 16 experimental units with a 2 x 2 = 4 m^2 distance.
Barley (*Hordeum vulgare* L.) cultivar Iba 99 was planted on 1/11/2021 at a seeding rate of 120 kg ha^{-1} in lines. The distance between one line and another is 20 cm, with 10 lines in each experimental unit. Thinning operations were performed on the plants after germination of the third true epicotyl, adding the chemical fertilizer to all the experimental units evenly and according to the tried fertilizer recommendation. Nitrogen fertilizer was added as urea (N% 46; at 100 kg ha^{-1}) [4] in two batches at planting and after 45 days of planting. Phosphate fertilizer was added all at once when planting with 100 kg ha-1 as mono superphosphate fertilizer. Potassium fertilizer was added in an amount of 40 kg ha^{-1}. Pipes carried out irrigation, and the irrigation water quantities were determined for all experimental units based on the mechanical irrigation meter, adding the amount for the washing requirements until the end of the experiment and harvesting on 9/4/2022.
The initial physical and chemical properties were measured and estimated for the field soil used in the study with three replicates for a depth of 0-30 cm according to the methods shown below in Table 1.
Soil P.H. was estimated based on Jackson[5], Electrical conductivity (E.C.) in a soil solution based on [6], the availability of nitrogen, phosphorous, and potassium was estimated based on [6], the cation exchange capacity, and bulk density according to [7], organic matter according to [5].

Chemical properties	Parameters	Unit	Value
	pH	--	7.40
	EC	dS m^{-1}	5.50
	Nitrogen availability	mg kg^{-1}	13.48
	Phosphorous availability	mg kg^{-1}	13.33
	Potassium availability	mg kg^{-1}	166.23
	CEC	centimol kg^{-1}	21.40
	Organic matter	gm kg^{-1}	1.20
Physical properties	Sand	gm kg^{-1}	30.30
	Silty		21.00

	Clay		48.70
	Texture	--	Clay
	bulk density	megagram m^{-1}	1.33

Table 1. Some chemical and physical properties of field soil.

Parameters	Unit	Value
pH	--	7.20
EC	dS m^{-1}	4.00
Calcium	mmol L^{-1}	16.00
Magnisium		14.00
Soduim		150.00

Table 2. Some chemical properties of river water used for irrigation.

Results

Bulk density of soil

Table 3 showed no significant differences when adding different levels of biochar in the bulk density of the soil, while the bulk density decreased with the addition of biochar.

The same table also indicates no significant differences in the addition of perlite levels in the soil's bulk density.

Perlite / Biochar	0%	0.5%	1%	1.5%	Biochar mean
0%	1.38	1.31	1.36	1.29	1.33
0.5%	1.36	1.33	1.31	1.29	1.32
1%	1.24	1.27	1.33	1.34	1.30
1.5%	1.28	1.32	1.28	1.28	1.29
Perlite mean	1.31	1.30	1.32	1.30	
L.S.D$_{0.05}$	Perlite	Biochar	Interaction		
	N.S.	N.S.	N.S.		

Table 3. Effect of biochar and perlite on the bulk density of soil (microgram m^{-3}).

Total porosity of the soil

Table 4 showed no significant differences in the levels of biochar addition in the total porosity of the soil. The high values of the total porosity of the soil may be attributed to the addition of biochar and perlite in the surface layer of the soil. It has a significant role in improving soil construction and reducing bulk density.

The results in Table 4 also show significant differences with the increase in the levels of perlite addition to the soil. The treatment P3 (1.5% perlite) outperformed all treatments in recording the highest percentage of total soil porosity, amounting to 49.03%, with an increase of 3.44% compared to the control treatment of 47.40%, with an insignificant difference from the treatment P2 (1% perlite), with an average of 47.13%.

Perlite / Biochar	0%	0.5%	1%	1.5%	Biochar mean
0%	45.84	46.76	46.80	47.44	46.71
0.5%	48.49	44.87	46.34	48.93	47.16
1%	47.07	45.30	48.22	50.19	47.70
1.5%	48.21	48.08	47.17	49.54	48.25
Perlite mean	47.40	46.25	47.13	49.03	
L.S.D$_{0.05}$	Perlite	Biochar	Interaction		
	1.688	N.S.	N.S.		

Table 4. Effect of biochar, perlite and interaction on soil total porosity (%).

Wet sieve:

Table 5 showed a significant effect of the levels of biochar addition on the characteristic of the average weighted diameter of the wet sieves of the soil. The results indicate the superiority of the B3 addiction treatment (1.5 biochar) by recording the highest average soil diameter of 0.92 mm, with an increase of 61.40%, which differs significantly on all transactions except transaction B2. It was followed by treatment B2, which amounted to 0.87 mm, with an increase of 52.63%. As for treatment B1 0.72 mm, no significant difference was recorded, despite an increase of 26.32%, whereas the comparison treatment recorded the lowest average for the weighted diameter, which was 0.57 mm.

Perlite / Biochar	0%	0.5%	1%	1.5%	Biochar mean
0%	0.54	0.52	0.75	0.49	0.57
0.5%	0.82	0.86	0.63	0.60	0.72
1%	0.92	0.76	0.82	0.99	0.87
1.5%	0.89	1.15	1.00	0.64	0.92
Perlite mean	0.79	0.82	0.80	0.68	
L.S.D$_{0.05}$	Perlite	Biochar	Interaction		
	N.S.	N.S.	N.S.		

Table 5. Effect of biochar, perlite and interference on the average weighted diameter of the soil wet sieve (mm).

Dry sieve

Table 6 showed a significant effect of the levels of biochar addition on the characteristic of the weighted diameter average of dry sifted soil. The results indicate that treatment B3 (1.5% biochar) was superior to all treatments by recording the highest average diameter of the dry sifted soil of 4.74 mm, with an increase of 14.22%, compared with comparison treatment B0, except for treatment B2, it was not significant, it was followed by treatment B2 (1% biochar) which amounted to 4.28 mm and was not significant despite the increase by 3.13%, whereas, treatment B1 recorded the lowest average soil diameter of 3.99 mm, this was Zhang *et al*.[14] agree, as it was found that the addition of biochar to the soil improves soil cohesion regardless of its texture. It is a treatment for clay soils prone to swelling and cracking that suffer from, because of this cracking from the loss of water and nutrients from the root area in addition to its cutting. Herath *et al*.[15] indicated that biochar's role in increasing the soil's weighted diameter is due to the increase in organic matter and the effectiveness of microorganisms.

Especially the fungi that add sugars and their hyphae that bind soil particles together, which increases the stability of soil aggregates.

Perlite / Biochar	0%	0.5%	1%	1.5%	Biochar mean
0%	4.15	4.48	3.82	4.15	4.15
0.5%	3.39	4.06	4.14	4.37	3.99
1%	4.30	4.39	4.27	4.16	4.28
1.5%	5.12	4.46	4.84	4.57	4.74
Perlite mean	4.24	4.35	4.27	4.31	
L.S.D$_{0.05}$	Perlite	Biochar	Interaction		
	N.S.	0.4786	N.S.		

Table 6. Effect of charcoal, perlite and interference on the average dry sieving weighted diameter (mm).

Discussion

The bulk density decreased with the addition of biochar, which may be due to the decrease in the density of the biochar and the increase in porosity compared with the density of soil minerals. This, in turn, increases the porosity of the soil and reduces the bulk density. These results agreed with th[ose of 8 and 9], who showed a lower bulk density of soil treated with biochar than the non-addition treatment.

Similarly, there were no significant differences in the addition of levels of perlite in the bulk density of the soil, which may be attributed to the increase in the level of addition led to the retention of moisture more than other levels. The increase in the addition level increases the moisture content for longer than the other levels. This reduced the sudden wetting process and the destruction of soil agglomerations when irrigating. It also reduces the process of expansion and contraction, which increases the bulk density values[10]. The results indicate no significant differences in the interaction levels between biochar and perlite in the bulk density of the soil. The spread of the root system of plants at the end of the experiment and its penetration into the soil may lead to increased soil disintegration.

The high values of the total porosity of the soil may be attributed to the addition of biochar and perlite in the surface layer of the soil. It has a significant role in improving soil construction and reducing bulk density.

The spread of the root system of plants at the end of the experiment and its penetration into the soil may lead to increased soil disintegration.

Thus, the increase in its volume and the decrease in the bulk density help to increase the total porosity of the soil. However, [11] mentioned that mixing perlite with soil improves the physical properties of the soil, such as aeration, drainage, and construction, which increases the porosity. As for the interaction levels between biochar and perlite, no significant differences were recorded in the total porosity of the soil.

The reason for the increase in the weighted diameter rate when adding biochar may be attributed to the formation of carnivores when decomposing due to microbial activity and the release of organic acids that help to stabilize the agglomerations, such as Fulvic acid and Polysaccharides, which play an essential role along with the ions with multiple charges Ca^{+2} and Mg^{+2}, together, they contribute to increasing the stability of the assemblies and thus increasing the weighted diameter ratio. [12,13] attributed the role of biochar in increasing the weighted diameter of the soil, the organic matter resulting from decomposition coagulates clay suspensions, leading to linking soil particles with aggregates[15,16].

Conclusions

The study results for biochar addition on the characteristic of the weighted diameter average of dry sifted soil present an excellent agreement with [14]. It was found that the addition of biochar to the soil improves soil cohesion regardless of its texture, and it is a treatment for clay soils prone to swelling and cracking that suffer from, because of this cracking from the loss of water and nutrients from the root area in addition to its cutting. Moreover,[15] indicated that biochar's role in increasing the soil's weighted diameter is due to the increase in organic matter and the effectiveness of microorganisms. Especially the fungi that add sugars and their hyphae that bind soil particles together, which increases the stability of soil aggregates.

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