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The Effect of Biochar Levels on the Efficiency of Nitrogen Absorption and some Growth Traits of Wheat (*Triticum aestivum* .L)

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Abstract

A field experiment was carried out at the second research station of the College of Agriculture , Al-Muthanna University in the agricultural season 2022/2023 to study the effect of adding biochar levels on the efficiency of nitrogen (N) absorption and some growth characteristics of the wheat crop. Biochar was added at four levels (0, 1.5, 2, 2.5) percentage (%) by volume to the soil before planting. Planting took place on 11/23/2022. An experiment was applied in a completely randomized block design (RCBD) with three replications. The means were compared according to the Least Significant Difference (LSD) test at the probability level of >= 0.05. The percentage of chlorophyll in the plant, the efficiency of nitrogen absorption at the flowering and harvesting stages, the height of the plant, the biological yield, and the concentration of nitrogen in the plant at the flowering and harvesting stages were studied. The results of the study showed that there were significant differences when adding biochar in plant height (A3, 107.73 Cm) and chlorophyll content in the leaves (A2 , 48.80 spad and A1 , 48.15 spad) , as all treatments were superior to the control treatment. There were significant differences for adding biochar in the amount of nitrogen in the plant at the flowering (A3 , 395 kg ha^{-1}) and harvesting stage (A3 , 250 kg ha^{-1}), as all treatments outperformed on the control treatment. The results also showed that there were significant differences for adding biochar in flag leaf area (A2 ,71.62 cm^2 and A3 , 70.26 cm^2) and the efficiency of nitrogen absorption at the flowering (A3 , 64.4 %) and harvesting stage (A3 , 50 %).

Key words : biochar , nitrogen efficiency , wheat yield .

i. Introduction:

Nitrogen (N) fertilizer is necessary to maintain soil fertility and plant growth, but nitrate leaching, ammonia volatilization, and nitrous oxide emissions cause high losses of N, leading to low nitrogen use efficiency (NUE), high economic costs, and increase environmental contamination. Studies and research have paid great attention to the use of biochar as a soil amendment, as it affects various soil properties, including pH, bulk density, cation exchange capacity, water conservation, and biological activity. These changes affect soil properties and nutrient interactions in the soil, as well as enhance microbial activity (1). Recently, a body of evidence supports the use of biochar as a solution for improving soil properties (2), and many field experiments show that a significant improvement in soil properties and agricultural production (3) and (4) Charcoal can carry the additive and thus prevent it from being lost and reduce Nitrogen loss (3).

Biochar is a carbonaceous material that can be produced through the pyrolysis process in the absence or presence of very limited amounts of oxygen (5). It is an environmentally friendly material with low cost, fewer environmental risks, improved soil properties compared to chemical fertilizers, and better crop yields (6). Moreover, it is a safe material for improving agricultural soil fertility for various crops, especially in poor conditions (8 and 7). What is most interesting is that locally available waste is thermally decomposed into biochar to improve the relationship between plants, soil and the environment. This also can be important in achieving sustainable agriculture and environment (9) as the biochar is an adsorbent for water and soil pollutants and nutrients to promote sustainable agriculture (10).

Atmospheric N is the main source of nitrogen present in the soil and constitutes 79.8% of the Earth's atmospheric air, and plants alone are unable to benefit from it except through symbiosis between them and microorganisms or fixation freely (11). The amount of N absorbed affects the carbohydrates stored in the plant, as the plant combines nitrogen with carbohydrates resulting from the photosynthesis process, forming amino acids that form proteins. Therefore, a lack of N makes the plant unable to use carbohydrates to produce protein, which leads to the accumulation of carbohydrates in the plant (13). Plant tissues contain a higher amount of N than other elements except oxygen, hydrogen, and carbon. Plants obtain N through their roots absorbing nitrate and ammonium or through a symbiotic relationship with bacteria that fix atmospheric N (27). The increase in plant height results from increased levels of N fertilizer. (15) noted through their study, the loss of N through volatilization depends on conditions related to the soil during the time of adding N fertilizer, such as soil temperature, soil pH, organic content, soil moisture, and the length of time between the time of adding fertilizer and the first amount of irrigation water. Thus, the amount of nitrogen loss through volatilization increases with increasing temperatures and intensity of the winds. The increasing use of urea fertilizer increases the problems and negatives on seeds and seedlings, as it contains biuret, in addition to its high ability to be washed out in the presence of water outside the area of root spread. Therefore, thousands of tons of N fertilizers are usually used in agriculture in recent years, indicating the loss and inefficiency of N fertilizers (16).

While the use of biochar reduced the amount of ammonia volatilization by 56% to 63% (17%). Another study also showed that adding biochar to the soil reduced the amount of ammonia volatilization by 45% (18). Ammonia volatilization decreased significantly after adding biochar to the soil due to the adsorption of ammonium by the active groups present on the surface of the biochar, and the reason is also attributed to the micropores of the biochar (19). Several studies have found that biochar reduces N leaching (20). (21) found that biochar produced from plant waste has a high carbon content and a lower concentration of nutrients and minerals such as phosphorus and N compared to biochar produced from animal waste. The use of biochar reduced the saline effect on the soil. Moreover, integrating biochar with fertilization achieved the highest dry weight of shoots, phosphorus concentration, and amount absorbed compared to the rest of the treatments (22). Many researchers have indicated an increase in the mineralization process in the soil treated with biochar and an increase in the concentration of ammonium in the soil. This is due to the nutrient content of the biochar, the nature of the raw materials from which the biochar is produced, and the conditions of formation and temperature that affect the adsorption of ammonium by the biochar (23). (24) indicated an increase in the process of N mineralization and an improvement in soil fertility as well as microbial diversity when adding biochar. Adding biochar to the soil led to increase N mineralization by 18.8%, 19.5%, and 20.2% when adding charcoal by 2%, 4%, and 8%, respectively, compared to the control treatment (25). The objective of this study was to determine the effect of adding biochar levels on the efficiency of nitrogen (N) absorption and some growth characteristics of the wheat crop.

ii. **Material and methods**:

A field experiment was carried out during the winter agricultural season (2022-2023) in Al-Muthanna Governorate at the second agricultural research station affiliated with the College of Agriculture -Al-Muthanna University in the Al-Bandar area, which is 3 km from the center of the governorate. The field experiment was conducted and the process of plowing, amending, and leveling the soil was carried out. The field was planned in three replications , each replication containing four experimental

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units, and the area of the experimental unit was 2 by 2 m which is 4 meters^2. An experiment was carried out using a randomized complete block design (RCBD) with three replications with 12 experimental units and depending on the levels of biochar addition. Planting took place on 23 Nov. after adding charcoal according to the treatment levels. Ten lines were planted in each experimental unit, and the amount of seed was 120 kg ha^{-1} (28). Chemical fertilizer was added to all experimental units equally and according to the followed fertilizer recommendation. Nitrogen was added in the form of urea (46% N) in the amount of 200 kg N ha^{-1} in two batches at planting and 45 days after planting. While for phosphate fertilizer, it was added in one batch at planting in an amount of 100 kg P. ha^{-1} of triple super phosphate fertilizer, and for potassium fertilizer was added in an amount of 120 kg K ha^{-1} of potassium sulfate fertilizer (K 42%) (30). Biochar was added mixed with the soil at a depth of (0-30) cm before planting and was symbolized by the symbol A. The study included four levels of biochar (0, 1.5, 2, 2.5) percentage (%) by volume.

Studied attributes:

1- Chlorophyll guide measured by Chlorophyll meter (SPAD) .
2- Nitrogen concentration in the plant during the flowering stage.
3- Nitrogen concentration in the plant during the harvest stage
4- Plant height.
5- The area of the flag leaf.
6- Biological yield.
7- Weight of dry matter in the flowering stage.
8- The efficiency of N absorption in plants during the flowering and harvesting stages.

iii. Results and discussion :

1- The effect of adding biochar levels on the chlorophyll level in the flowering period 75% (SPAD):

From Table (1), the results showed that all treatments were superior to the control treatment, and from the same table it was shown that treatment A2, in which 2% biochar , was superior to all treatments, as the chlorophyll rating reached 48.80 SPAD, followed by level A1, which reached 48.15 SPAD. In last place came the addition level A3, and in this way it can be concluded that adding biochar has a significant effect on the level of chlorophyll in the plant. This may be due to the plant's slow preparation of nutrients, especially N, and its lack of exposure to washing and volatilization, which leads to improved formation of green pigment in the leaves.

Table (1) The effect of adding biochar levels on the amount of N in the plant and some growth characteristics of the wheat.

Characteristics / Treatments	Chlorophyll (SPAD)	Plant height CM	Amount of N At flowering kg. ha^{-1}	Amount of N At harvesting kg. ha^{-1}	Weight of dry matter at flowering stage Mega gram. ha^{-1}	Biological yield mega gram. ha^{-1}	Flag leaf cm^2
A0	44.41	97.80	206	150	4.317	4.183	50.15
A1	48.15	101.27	289	196	4.860	٤.٩٠٠	61.95
A2	48.80	103.20	316	217	5.217	٥.١٣٣	71.62
A3	47.49	107.73	395	250	5.600	٥.٣٠٠	70.26
LSD	2.289	3.372	٩.٥٩	٧.٠٩	٠.٣٩٣٢	٠.٣٤١١	3.267

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2- The effect of adding biochar levels on plant height (cm):

From Table (1), it noted that there were significant differences for adding biochar on plant height, as the A3 treatment outperformed all treatments, recording (107.73) cm compared to the comparison treatment, which recorded 97.80, followed by A2 and A1, respectively (101.27 and 103.20 cm), and this result is consistent with the findings of (29) that adding biochar led to an increase in the height of the barley plant. This may due to the availability of nutrients and not being subjected to fixation and washing, which was reflected in an increase in vegetative growth, especially the height of the plant.

3- The effect of adding biochar levels on the concentration of N in the plant during the flowering stage :

From Table (1), the results showed that all treatments outperformed the control treatment, which amounted to 206 kg ha^{-1}. Treatment A3 recorded the highest amount of N in the plant at the flowering stage, amounting to 395 kg ha^{-1}, followed by the addition level A2, which amounted to 316 kg ha^{-1}. In last place was the A1 level of addition, which recorded289 kg ha^{-1} that was superior to the control treatment. This indicates that there were significant differences in the N amount in the plant at this stage, which may due to the continuous preparation of N throughout the growth periods and the absence of loss of large quantities of it due to the presence of biochar.

4- The effect of adding biochar levels on the N concentration in the plant at the harvesting stage:

From Table (1), it noted that there were significant differences, as all treatments outperformed the control treatment, and treatment A3 recorded the highest level of nitrogen content in the plant, reaching 250 kg ha^{-1} followed by treatment A2, which recorded 217 kg ha^{-1}.In last place came treatment A1, as its N concentration reached 196 kg ha^{-1},which outperformed the comparison treatment that record 150 kg ha^{-1}. This is due to the major role that biochar plays in preserving and preparing nutrients for plants, as well as improving some of the physical, chemical, and biological characteristics of the soil.

5- The effect of adding biochar levels on the flag leaf area (cm^2):

From Table (1), the results showed that there were significant differences for adding biochar in the area of the flag leaf, as it noted that the A2 treatment outperformed all the treatments, as it recorded 71.62 cm^2, followed by the A3 treatment, which recorded 70.26 cm^2, as all treatments recorded significant differences compared to the control treatment, which recorded 50.15 cm ^{2}. From this, it can be concluded that with increasing levels of adding biochar to the soil, the area of the flag leaf increases as a result of the positive interaction of all the characteristics that biochar works to improve, which is reflected positively on the growth characteristics.

6- The effect of adding biochar levels on the weight of the dry matter in the flowering stage, mega grams per hectare (Mg ha^{-1}):

From Table (1, it noted that there were significant differences for adding biochar in the weight of the dry matter of the plant, as it appeared that the A3 treatment was superior, which recorded 5,600 Mega ha^{-1}, followed by the A2 treatment, which recorded 5.217 mega grams per hectare, as all treatments recorded significant differences compared to the control treatment, which recorded 4.317 Mega ha^{-1}. From this, it can be concluded that the amount of plant dry matter increases with increasing in biochar.

7- The effect of adding biochar levels on the biological yield (Mega gram ha^{-1}) at the harvest stage:

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From Table (1), the results showed that there were significant differences for adding biochar on the weight of the biological , as it noted the superiority of the A3 treatment, which recorded 5,300 Mega gram ha^{-1}, followed by the A2 treatment, which recorded 5.133 Mega gram ha^{-1}, as all treatments recorded significant differences compared to the comparison treatment, which recorded 4.183 Mega gram ha^{-1}. From this it can be concluded that the amount of biological yield increases with increasing in biochar levels.

8- Nitrogen absorption efficiency on flowering and harvesting stages %:

Nitrogen absorption efficiency = the amount of N absorbed in the fertilized treatment - the amount of N in the comparison treatment / the amount of added N x 100. From Table (2), the results showed an increase in the absorption efficiency of nitrogen with increasing in the rate of adding biochar, as the A3 treatment was superior to all treatments (64.4 %) at flowering stage and (50 %) at harvesting stage , and also all treatments were superior to the control treatment for the flowering and harvesting stages. This is consistent with what was found by (25), as it reported that adding biochar to the soil may led to an increase in nitrogen mineralization by 18.8%, 19.5%, and 20.2% when adding charcoal by 2%, 4%, and 8%, respectively, compared to the control treatment, which led to an increase in the efficiency of nitrogen absorption.

Table (2) Effect of adding biochar levels on N absorption efficiency (%):

Treatments / Stages	A0	A1	A2	A3	LSD
Flowering	٠	41.5	55	٦٤.٤	8.7
Harvesting	0	23	33.5	50	9.6

Conclusion : Biochar had a clear effect on the studied traits, such as chlorophyll concentration, plant height, biological yield, nitrogen concentration in the plant, and absorption efficiency in the flowering and harvesting stages. This is a result of the role of biochar in preserving and reducing nitrogen loss.

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