University of Thi-Qar Journal of agricultural research

Thi-Qar Journal of agricultural research

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 1 (2024) PP 397-405

https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

Effect of planting depth and charcoal levels on barley (*Hordeum vulgare* L.) yield and components

Muaid Shaker Ali

Crop Field department, Agriculture & Marsh College, University of Thi-Qar, Thi-Qar, Iraq

E-mail: muaid-ali@utq.edu.iq

Abstract

An experiment was conducted to study the effect of using different levels of charcoal on barley crop planted at different depths in the fields of the College of Agriculture and Marshlands, University of Thi Qar during the fall season of 2023 in order to determine the possibility of providing quantities of water held by charcoal for the germination and growth of barley crop in Thi Qar, Iraq. The charcoal levels were (0, 0.50 and 0.75) kg/1 kg of soil and the planting depth levels were (0, 5 and 10 cm) so that the experimental units were arranged according to factorial experiments using a complete randomized block design with three replications. The results showed the significant effect of the two study factors and their interaction on the studied traits of barley crop, as the significant effect of charcoal was observed at the level of (0.75) kg/1 kg soil on the trait ((plant height (cm), flag leaf area (cm2), tillers per plant, number of spikes per plant, and weight of 100 grains (g)) at a rate of (53.8 cm, 25.04 cm2, 6.856 tillers per plant, 5.30 spikes per plant, 3.942 g) respectively, while the level (0.50 kg/1 kg soil) recorded the highest rate in the traits ((total grain yield (kg per half square meter), biological yield (kg per half square meter), and harvest index%) at a rate of (1.058 kg, 15.71 kg, and 6.57%) respectively. Also, the planting depth (5 cm) had a significant effect on all studied traits and differed from the rest of the planting depths. The best combination was using charcoal at a level of (0.5 kg per 1 kg of soil) with a depth of (5 cm), which confirms the importance of using charcoal to improve soil properties and provide water for the crop to grow well and give the best yield.

Keywords: Barley crop, charcoal, planting depths

I. Introduction

Barley (*Hordeum vulgare* L.) is an important cereal fodder crop that is globally and locally important. It ranks third in importance. It has been used as food for humans and animals for more than ten thousand years ago. The area where this crop is grown in the world is estimated at (70) million hectares with a productivity of (60) million tons, and In Iraq, this crop comes after wheat in terms of cultivated area and production (Jaber, 1997). Canada, Germany, Russia, France and Spain lead the production and export of this crop. It is resistant to difficult growth conditions in arid and semi-arid areas, such as cold, drought, alkalinity and salinity, and it is resistant to bushes and competes with weeds due to its rapid growth and faster maturation than wheat (Grando, 2002).

One of the problems of field crops is the emergence of seedlings, which has a close relationship with the type and variety of the crop, in addition to soil factors such as temperature, availability of moisture and other environmental factors surrounding the crop (Sinha and Ghildyal, 2005). Controlling agricultural operations can play a role in increasing the yield, whether grain or biological. Therefore, providing moisture in the grain feeder continuously has an important role in the process of seedling germination. The use of biochar, which is a stable organic carbon compound, is mostly made by thermal decomposition of biomass (plant waste) at temperatures ranging from (300-1000 C) in low or no oxygen conditions (Jeffery et al., 2011). Therefore, it is one of the types of organic improvers. Biochar is very porous, so its addition to soil improves many physical properties of the soil such as bulk density, total porosity, pore size distribution, soil moisture content, soil water conductivity, and aggregate stability (Atkinson et al., 2010). Charcoal production is affected by the reaction conditions during the combustion process, such as temperature, heating duration, and biomass components (Li et al., 2014). Temperature is one of the most important factors controlling charcoal production, as high temperatures break down hydrocarbons, increase gaseous substances, and reduce charcoal production (Rajkovich et al., 2012). Charcoal produced from plant waste often contains a high percentage of carbon and low concentrations of nutrients such as nitrogen and phosphorus (Waters et al., 2011). Charcoal has a high surface area that increases with the increase in the temperature of biomass combustion, which makes it an important advantage for charcoal (Downie et al., 2009). The ability of charcoal to hold and retain water and the amount of materials mixed on the surfaces of charcoal depend on its surface area (Antal and Grenli, 2003).

When charcoal is added to the soil, it increases the surface area of the soil, which has an effect on the chemical, fertility and biological properties of the soil. The reason for increasing the surface area of charcoal is that it contains a large percentage of micropores, which increases the ability of charcoal to retain water. (Joseph and Lehmann, 2015), there are two main reasons for the effect of charcoal on the physical properties of soil, firstly, it increases both the porosity and water conductivity of the soil and reduces its bulk density in addition to increasing the soil's ability to retain water, while the second reason is that charcoal improves the structure of the soil indirectly by providing organic materials for microorganisms in the soil, which secrete gummy materials and organic materials that help bind soil particles together in addition to improving the spread of roots in the soil and their secretions, which increases the stability of soil aggregates and their formation (Burrell et al., 2016). The production of charcoal and its addition to the soil is considered a preventive method to get rid of plant waste and reduce air pollution by carbon dioxide through oxygen-free burning and improve the physical, chemical and fertility properties of the soil (Gamage et al., 2016). Vaccari et al. (2011) found that wheat yield was improved by using charcoal with soil. Both plant height and fresh and dry weight of plants in a study in Egypt were increased by using charcoal from corn cob residues, while barley yield increased by (2.4 to 49.6%) when charcoal was used at 1% and 3% of soil weight, respectively (Rekaby et al., 2019). In another study, plant growth was observed when charcoal was used in agriculture (Naeem et al., 2017).

The depth of cultivation or plowing also plays an important role in the management of field crops, as the agricultural production of field crops depends significantly on the success of the emergence process and successful field establishment (Lech and Kolasinka, 2004). Aqila and Boubaker (2019) indicated in their study in Libya for three depths (3, 6 and 9 cm) that the number of days for barley seedlings to germinate was significantly affected by the depth of cultivation, as the depth of 3 cm recorded the lowest average number of days for emergence (7.78 days) compared to the depth of 9 cm, which recorded the highest rate of emergence (8.67). The germination rate was also higher at the lowest planting depth and reached (77.8%) compared to the other two depths. In another study in Abu Ghraib, Jadou and Baqer (2012) indicated that the highest number of spikes per square meter of a crop was obtained at a planting depth of 6 cm, reaching (555.70 and 536.83 spikes. m^{-2}) for the two planting seasons, while the depth of 3 cm gave the highest average number of grains per spike (58.51 and 69.80 grains. $spike^{-1}$) for the two planting seasons and did not differ significantly from the number of grains per spike at a depth of 6 cm. The lowest number of grains was obtained at depths (9 and 12 cm). They also found that the highest yield was when planting at a depth of 6 cm. The current study aimed to demonstrate the effect of using charcoal in improving the growth of barley plants grown at different planting depths.

II. Materials and methods

This study was conducted on barley crop in the fields of the Agriculture and Marshes College, University of Thi Qar, in the autumn agricultural season 2023, to know the effect of planting depths and charcoal levels on the yield and components of barley crop under the conditions of Thi Qar Governorate, Iraq with a clayey mixture soil. The study included soil plowing and taking a sample to measure (Ec = 5.5 melimose. cm^{-1}) and (PH = 7.5) of the soil. The field was divided into three

University of Thi-Qar Journal of agricultural research
Thi-Qar Journal of agricultural research
ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 1 (2024) PP 397-405
https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

replications, so that each one contained 9 experimental units with an area of 1 m² and the distance between one replicate and another 50 cm and between one experimental unit and another within the same replicate 0.25 meters, as the experimental units were arranged according to factorial experiments using a randomized complete block design (R.C.B.D). The seed germination test was conducted in three replicates in the laboratory using 100 seeds in Petri dishes (representing the replicates) and the percentage was 75.3%. The study also included two factors, the first is the planting depth at three depths (0 - 5 - 10) cm, and the second factor included charcoal levels at three levels (zero - 0.50 - 0.75) g/1 kg of soil, where charcoal was mixed with the soil according to the plan and planting date was on 10/28/2023, which is the date of the first irrigation as well and according to the depths mentioned above, and germination date was on 11/5/2032. As for the second irrigation, it was less than the first, taking into account the rainy periods, and the total was 7 irrigations, as the flowering date was on 2/19/2023, and the crop was harvested on 4/4/2023 by mowing the middle of the each experiment unit with an area of half a square meter and leaving it for a period until it completely dried.

Characteristics studied

A number of growth indicators of the crop were studied, including:

1- Number of tillers per plant by taking ten plants from the midlines of the each experimental unit.
2- Plant height cm (ten plants).
3- Flag leaf area, as mentioned by (Kalra and Dhiman, 1977) by taking 10 plants from the midlines of the experimental unit and according to the equation below:
   Flag leaf area = leaf length * maximum width * 0.858
4- Number of spikes (ten plants) per plant.
5- Number of grains per spike. By taking ten spikes from the harvested plants.
6- Weight of 100 grains (g). By weighing the grains of 10 spikes from the harvested plants.
7- Biological yield kg per half square meter.
8- Total grain yield kg per half square meter.
9- Harvest index according to the following equation:
   Harvest index (HI) % = grain yield / biological yield * 100

III. Results and Discussion

First: Results

The results showed the significant effect of the two study factors and their interaction on the studied traits of barley crop. The significant effect of the two study factors was observed individually on plant height (cm) and no significant effect of their interaction on this trait was recorded. Treatment C3 (0.75 g charcoal. kg soil^{-1}) recorded the highest rate of plant height (53.8 cm) compared to treatment C1 (zero charcoal) recorded the lowest rates of (39.5 cm) which did not differ significantly from treatment C2 (0.50 g charcoal. kg soil^{-1}) resulting a rate of plant height of (41.7 cm). The treatment with a planting depth of 5 cm (D2) resulted the highest rates (59.9 cm), fluctuated to the other two treatments, a planting depth of 10 cm (D3) and zero (D1) recording rates of (43 and 31.9) cm, respectively (Table 1).

A highly significant effect was found for both charcoal levels and planting depths on the flag leaf area (cm^2), and no significant effect was recorded for the interaction on this trait. The result of table (2) observed the charcoal level C3 recorded the highest rate of leaf area (25.04 cm^2) compared to the treatment C2 recorded a rate of leaf area (21.67 cm^2). The lowest flag leaf area was resulted by the treatment C1 (14.40 cm^2). Also, the 5 cm planting depth treatment (D2) recorded the highest rates for the leaf area trait (27.54 cm^2), which was significantly superior to the 10 cm planting depth recorded (21.54 cm^2), and the surface planting treatment (D1) recorded the lowest rates for this trait (17.04 cm^2).

The results in Table (3) recorded a highly significant effect for the two study factors, individually, and a significant effect for their interaction in the tillers per plant, as the charcoal levels C3 and C2 (which

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 1 (2024) PP 397-405
https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

did not differ significantly) recorded the highest branching rate (6.856 and 6.711) respectively, compared to treatment C1 resulted the lowest rates (5.800). The 5 cm planting depth treatment (D2) produced the highest rates for this trait with a rate of (7.289 tillers), which differed significantly from the 10 cm planting depth treatment (D3) Contributed at a rate of (6.411 tillers), which differed significantly from the zero planting depth treatment (D1) recorded the lowest rates of (5.667). The combination of the interaction treatment (C2*D2) observed the highest rate of the number of tillers, which reached (8.067 tillers) differed significantly from the combination (C1*D1) produced the lowest rates for this trait (5.533 tillers).

The number of spikes produced was significantly affected by the two study factors alone, but there was no significant effect of the interaction between the two factors (Table 4), as the charcoal level treatment (C2 and C3) yielded the highest rate of the number of spikes compared to the charcoal level treatment (C1) produced the lowest rates were (5.31, 5.30 and 4.42) spikes per plant, respectively. The same trend was showed with the planting depth treatments, as the 5 cm depth (D2) and the 10 cm depth (D3) recorded the highest rate for this trait compared to zero planting depth (D1) resulted the lowest rate (5.78, 5.14 and 4.11 spikes), respectively.

The results did not show a significant effect of the study factors and their interaction on the trait of number of seeds per spike (Table 5).

The results of Table (6) showed that the charcoal levels significantly affected the trait of 100-grain weight, as the C2 level logged the highest rate for this trait (4.568 g) differed significantly from the charcoal level treatment C3 and C1 resulting the lowest rate for 100-grain weight (3.942 and 3.757 g), respectively. The results also showed a highly significant effect of the plowing depth treatment on the rate of 100-grain weight, as treatment D2 resulted the highest rate for this trait (4.871 g) differed significantly from treatments D3 and D1recorded the lowest rate for this trait (3.977 and 3.420 g), respectively. No significant effect of the interaction between the two factors was resulted in this trait.

The trait of yield in kg per half square meter (Table 7) showed its significant effect by the two study factors and their interaction. The charcoal levels had a significant effect on this trait, as treatment C2 gave the highest grain yield (1.058 kg), which differed significantly from both treatments C3 and C1 recorded a grain yield rate of (0.777 and 0.670 g), respectively. On the other hand, the planting depth had a highly significant effect on this trait, as the plowing depth treatment D2 recorded the highest grain yield rate (1.107 kg), as it did not differ significantly from the 10 cm plowing depth treatment (D3) giving a yield rate of (0.813 kg), while the zero plowing depth treatment D1 recorded the lowest rates for this trait (0.585 kg). The interaction between the two factors also had a significant effect on the grain yield trait, as the combination (C2*D2) yielded the highest rate (1.670 kg) contrasted to the combination (C1*D1) produced the lowest seed yield rate (0.520 kg).

The biological yield is an important trait for barley crop as it is an excellent fodder crop, and therefore the results in Table (8) showed that this trait was significantly affected significantly by the two study factors, but their interaction had no significant effect, as treatment C2 gave the highest biological yield rate (15.71 kg), which fluctuated significantly from both treatments C3 and C1 giving the lowest rate for this trait (14.35 and 13.77 kg), respectively. The planting depth also had a significant effect on this trait, as the 5 cm planting depth treatment (D2) produced the highest rate of the biological yield (15.85 kg), which fluctuated significantly from the 10 cm planting depth treatment (D3) recording a rate of (14.59 kg), and the lowest yield was resulted by the zero planting depth treatment (D1) produced (13.77 kg).

The harvest index is an important trait because it is an indicator of the efficiency of food conversion of the plant. The higher this index is, the more it gives an indicator of the nutritional efficiency of the plant in converting carbohydrate products into grains. The two study procedures and their interaction had a significant effect on this trait (Table 9). The charcoal levels had a significant effect on the harvest index, and treatment C2 recorded the highest rate (6.57%) fluctuated to the two charcoal level

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 1 (2024) PP 397-405
https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

treatments C3 and C1, as they resulted the lowest rate of the harvest index (5.33 and 4.83%), respectively. Also, the planting depths have a highly significant effect on the harvest index trait. Treatment D2 recorded the highest rate of this trait (6.86%), and the D3 and D1 treatments gave a rate of the harvest index of (5.46 and 4.39%), respectively. The interaction between the two factors showed a significant effect on this trait, as the combination (C2*D2) recorded the highest rate of the harvest index trait (9.60%) compared to the combination (C2*D1) and the combination (C1*D1), which recorded the lowest rate of the harvest index trait (4.10 and 4.11%), respectively.

Second: Discussion

The results showed the expected behavior and trend of using charcoal to enhance plant growth by improving the qualities and properties of the soil, increasing its fertility, and providing quantities of water, which results in providing a good source for seed growth and seedling emergence (Gamage et al., 2016; Lehmann and Joseph, 2015). The plant height increased when the level of charcoal used increased (Table 1). The planting depth also had an effect in determining the significance of the response of the studied traits, as the agricultural depth of 5 cm exceeded the depth of 10 and zero cm, despite the availability of moisture due to the use of charcoal. The highest plant height was at the agricultural depth of 5 cm. Also, the trend of the flag leaf area was similar to the drift of the plant height (Table 2). The same is true for the number of branches, as the development is similar to the factors, which are individual (Table 3), as the level (0.75 g charcoal. kg soil-1) and the depth of 5 cm exceeded the rest of the levels and planting depths. It was also noted that the combination C2*D2 delivered the highest rate of branches, and this may It is illuminated on the basis that the best depth for seed germination is between 3 to 6 cm and under a good level of charcoal, which drove to hold good amounts of water throughout the period of seed growth and emergence and throughout the period of plant growth and worked to enhance the properties and fertility of the soil, including improving the acidity and salinity of the soil, as Rekaby et al. (2019) indicated that the acidity and salinity of the soil improved by using charcoal, and there is a direct and indirect effect of charcoal by improving the chemical, physical and biological properties of the soil as a result of providing some nutrients, especially carbon (Major et al., 2010 and Abdilpour et al., 2019). The yield and its components were affected by the studied factors (Tables 4, 6 and 7), especially at the second level of charcoal and a planting depth of 5 cm. This may be attributed to the fact that the roots at this depth can easily obtain the available water and nutrients compared to depths of 10 and zero cm. Here, water may evaporate easily and nutrients are scarce, which ultimately affects the production of the number of spikes per unit area, which negatively affects the total grain yield (Jadoua and Baqer, 2012). This was also reflected in the biological yield (Table 8) and the harvest index (Table 9), as the increase in the number of branches, plant height and flag leaf area were positively reflected in increasing the biological yield of the plant and increasing the number of spikes produced and the weight of a thousand seeds and the grain yield were reflected in increasing the harvest index (Jadoua and Baqer, 2012). The results of this study agreed with the findings of (Jadoua and Baqer, 2012 and Aqila and Boubaker, 2019).

Conclusion and Suggestions

The use of charcoal has modified the soil properties and improved the growth of barley plants, which gave a good biological yield that was reflected in the production of high grain and fodder yields, and the best planting depth is the depth that lies within the rhizosphere of the roots of the plant seedlings, i.e. at a depth of 5 cm.

Suggestions

1- Paying attention to such studies and using charcoal as an important element to provide water and improve soil properties for planting strategic crops.
2- Repeating this experiment on a larger scale with the addition of other levels of charcoal and studying its effect on the yield.

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 1 (2024) PP 397-405

https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

IV. References

Abdipour M, M Hosseinifarahi M, Najafian S (2019) Effects of Humic Acid and Cow Manure Biochar (CMB) in Culture Medium on Growth and Mineral Concentrations of Basil Plant. International Journal of Horticultural Science and Technology , 6(1):27–38.

Antal, M.J. and M. Grenli (2003). The art, science, and technology of charcoal production. Industrial and Engineering Chemistry Research, 42(8) 1619-1640.

Aqila, Najah Ali Suleiman and Boubaker, Idris Hussein. 2019. The effect of planting depth and grain size on the germination and differentiation of barley seedlings Hordeum vulgar L. Alexandria Journal of Scientific Exchange. 4 (3). 293-299.

Atkinson, C.J.; J.D. Fitzgerald and N.A. Hipps (2010). Potential mechanisms for achieving agricultural benefits from biochar application to temperate soils a review. Plant and Soil 337 1-18.

Burrell, L.D.; F. Zehetner; N. Rampazzo; B. Wimmer and G. Soja (2016). Long- term effects of biochar on soil physical properties. Geoderma, 282 96-102.

Downie, A.; A. Crosky and P. Munroe (2009). Physical properties of biochar. In Lehmann J, Joseph S (eds) Biochar for environmental management science and technology'. Earthscan, London, pp 13-32.

Gamage, D.V.; R.B. Mapa; R.S. Dharmakeerthi and A. Biswas (2016). Effect of rice- husk biochar on selected soil properties in tropical Alfisols. Soil Research, 54(3) -310.

Grando, S.(2002).food barley grains Lang overdue attention ICARDA .caravan 16.

Jaber, Faleh Saeed, 1997. Documents of the Loaf and Grain Symposium, Arab Union for Food Industries. Ministry of Trade. Baghdad, September 11-9 .

Jadoua, Khadir Abbas and Baqer, Haider Abdul Razzaq.(2012). The effect of planting depths on the characteristics of the yield and its components for six wheat varieties. Iraqi Journal of Agricultural Sciences. 43 (1). 25-37.

Jeffery, S.; F.G. Verheijen; M. Vandervelde and A.C. Bastos (2011). A quantitative review of the effects of biochar application to soils on crop productivity using meta- analysis. Agriculture, ecosystems and environment, 144(1) 175-187.

Kalra, G.S. and S.D., Dhiman. (1977). Determination of leaf area of wheat plants by rabid method. Journal of the India Botanical Society. 58:261-264.

Lehmann, J. and S. Joseph (2015). Biochar for environmental management an introduction. In Lehmann, J., Joseph, S. (Eds.), Biochar for Environmental Management Science, Technology and Implementation, 2nd ed. Earthscan from Routledge, London, pp.1-1214.

Lech, B., and K. Kolasinka (2004). Germination vigor and response to simulate water deficit germination of hulled and hulless spring barley .27th ISTA Congress – Seed Symposium .pp. 64.

Li, F.; X. Cao; L. Zhao; J. Wang and Z. Ding (2014). Effects of mineral additives on biochar formation carbon retention, stability, and properties. Environmental science and technology, 48(19) 11211-11217.

University of Thi-Qar Journal of agricultural research
Thi-Qar Journal of agricultural research
ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 1 (2024) PP 397-405
https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

Major J, Rondon M, Molina D, Riha S, Lehmann J (2010). Maize yield and nutrition during 4 years after biochar application to a Colombian savanna oxisol. Plant and Soil 333:117–128.

Naeem MA, Khalid M, Aon M, Abbas G, Tahir M, Amjad M, Murtaza B, Yang A, Akhtar SS (2017) Effect of wheat and rice straw biochar produced at different temperatures on maize growth and nutrient dynamics of a calcareous soil. Arch. Agron. Soil Sci., 63:2048–2061.

Rajkovich, S.; A. Enders; K. Hanley; C. Hyland; A.R. Zimmerman and J. Lehmann, (2012). Corn growth and nitrogen nutrition after additions of biochars with varying properties to a temperate soil. Biol. Fertil. Soils 48 271-284.

Rekaby, S.A, Awad, M.Y.M. Hegab, S.A. and Eissa, M. 2019. Effect of biochar application on barley plants grown on calcareous sandy soils irrigated by saline water. Scientific Journal of Agricultural Sciences. 1 (2): 52-61.

Sinha A. K. and B. P. Ghildyal. 2005. Emergence force of crop seedlings. 0032-079X (Print) 1573-5036 pp. 153- 156. Springer Netherlands.

Vaccari F, Baronti S, Lugato E, Genesio L, Castaldi S, Fornasier F, Miglietta F (2011) Biochar as a strategy to sequester carbon and increase yield in durum wheat. European Journal of Agronomy 34, 231–238.

Waters, D.; L. Van Zwieten; B.P. Singh; A. Downie; A.L. Cowie and J. Lehmann (2011). Biochar in soil for climate change mitigation and adaptation. In Soil Health and Climate Change. Springer Berlin Heidelberg, pp. 345-368.

Table 1: Effect of charcoal level, planting depth and their interaction on plant height cm for barley crop.

	D1	**D2**	**D3**	**Mean**
C1	**28.1**	**53.7**	**36.7**	**39.5**
C2	**26.7**	**56.7**	**41.6**	**41.7**
C3	**40.9**	**69.5**	**50.9**	**53.8**
Mean	**31.9**	**59.9**	**43.0**	
LSD Values	**Depth LSD = 8.68**	**Charcoal LSD = 8.68**	**Interaction LSD = ns**	

C = coal levels where C1 = 0, C2 = 0.5 g coal.kg $soil^{-1}$, C3 = 0.75 g coal.kg $soil^{-1}$
D = planting depth where D1 = 0 cm, D2 = 5 cm, D3 = 10 cm, ns = not significant.

Table 2: Effect of charcoal level, planting depth and their interaction on flag leaf area cm^2 for barley crop.

	D1	**D2**	**D3**	**Mean**
C1	**15.07**	**23.30**	**19.83**	**14.40**
C2	**17.69**	**26.60**	**20.73**	**21.67**
C3	**18.37**	**32.71**	**24.05**	**25.04**
Mean	**17.04**	**27.54**	**21.54**	
LSD Values	**Depth LSD = 2.146**	**Charcoal LSD = 2.146**	**Interaction LSD = ns**	

C = coal levels where C1 = 0, C2 = 0.5 g coal.kg $soil^{-1}$, C3 = 0.75 g coal.kg $soil^{-1}$

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 1 (2024) PP 397-405
https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

D = planting depth where D1 = 0 cm, D2 = 5 cm, D3 = 10 cm, ns = not significant.

Table 3: Effect of charcoal level, planting depth and their interaction on tillers per plant for barley crop.

	D1	**D2**	**D3**	**Mean**
C1	**5.533**	**6.267**	**5.600**	**5.800**
C2	**5.700**	**8.067**	**6.367**	**6.711**
C3	**5.767**	**7.533**	**7.267**	**6.856**
Mean	**5.667**	**7.289**	**6.411**	
LSD Values	**Depth LSD = 0.499**	**Charcoal LSD = 0.499**	**Interaction LSD = 0.865**	

C = coal levels where C1 = 0, C2 = 0.5 g coal.kg $soil^{-1}$, C3 = 0.75 g coal.kg $soil^{-1}$
D = planting depth where D1 = 0 cm, D2 = 5 cm, D3 = 10 cm, ns = not significant.

Table 4: Effect of charcoal level, planting depth and their interaction on number of spikes per plant for barley crop.

	D1	**D2**	**D3**	**Mean**
C1	**3.87**	**4.93**	**4.47**	**4.42**
C2	**3.97**	**6.87**	**5.10**	**5.31**
C3	**4.50**	**5.53**	**5.87**	**5.30**
Mean	**4.11**	**5.78**	**5.14**	
LSD Values	**Depth LSD = 0.820**	**Charcoal LSD = 0.820**	**Interaction LSD = ns**	

C = coal levels where C1 = 0, C2 = 0.5 g coal.kg $soil^{-1}$, C3 = 0.75 g coal.kg $soil^{-1}$
D = planting depth where D1 = 0 cm, D2 = 5 cm, D3 = 10 cm, ns = not significant.

Table 5: Effect of charcoal level, planting depth and their interaction on number of seeds per spike for barley crop.

	D1	**D2**	**D3**	**Mean**
C1	**42.00**	**35.70**	**41.87**	**39.86**
C2	**39.20**	**42.43**	**39.40**	**40.34**
C3	**41.03**	**35.63**	**36.90**	**37.86**
Mean	**40.74**	**37.92**	**39.39**	
LSD Values	**Depth LSD = ns**	**Charcoal LSD = ns**	**Interaction LSD = ns**	

C = coal levels where C1 = 0, C2 = 0.5 g coal.kg $soil^{-1}$, C3 = 0.75 g coal.kg $soil^{-1}$
D = planting depth where D1 = 0 cm, D2 = 5 cm, D3 = 10 cm, ns = not significant.

Table 6: Effect of charcoal level, planting depth and their interaction on 100-seed weigh (g) for barley crop.

	D1	**D2**	**D3**	**Mean**
C1	**3.080**	**4.517**	**3.673**	**3.757**
C2	**3.690**	**5.643**	**4.370**	**4.568**
C3	**3.490**	**4.453**	**3.887**	**3.943**
Mean	**3.420**	**4.871**	**3.977**	
LSD Values	**Depth LSD = 0.482**	**Charcoal LSD = 0.482**	**Interaction LSD = ns**	

C = coal levels where C1 = 0, C2 = 0.5 g coal.kg $soil^{-1}$, C3 = 0.75 g coal.kg $soil^{-1}$

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 1 (2024) PP 397-405
https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

D = planting depth where D1 = 0 cm, D2 = 5 cm, D3 = 10 cm, ns = not significant.

Table 7: Effect of charcoal level, planting depth and their interaction on grain yield (kg. 50 cm^2) for barley crop.

	D1	**D2**	**D3**	**Mean**
C1	**0.520**	**0.791**	**0.699**	**0.670**
C2	**0.591**	**1.670**	**0.913**	**1.058**
C3	**0.644**	**0.859**	**0.828**	**0.777**
Mean	**0.585**	**1.107**	**0.813**	
LSD Values	**Depth LSD = 0.202**	**Charcoal LSD = 0.202**	**Interaction LSD = 0.350**	

C = coal levels where C1 = 0, C2 = 0.5 g coal.kg $soil^{-1}$, C3 = 0.75 g coal.kg $soil^{-1}$
D = planting depth where D1 = 0 cm, D2 = 5 cm, D3 = 10 cm, ns = not significant.

Table 8: Effect of charcoal level, planting depth and their interaction on biological yield (kg. 50 cm^2) for barley crop.

	D1	**D2**	**D3**	**Mean**
C1	**12.65**	**14.83**	**13.83**	**13.77**
C2	**14.54**	**17.38**	**15.19**	**15.71**
C3	**12.95**	**15.34**	**14.75**	**14.35**
Mean	**13.38**	**15.85**	**14.59**	
LSD Values	**Depth LSD = 1.221**	**Charcoal LSD = 1.221**	**Interaction LSD = ns**	

C = coal levels where C1 = 0, C2 = 0.5 g coal.kg $soil^{-1}$, C3 = 0.75 g coal.kg $soil^{-1}$
D = planting depth where D1 = 0 cm, D2 = 5 cm, D3 = 10 cm, ns = not significant.

Table 9: Effect of charcoal level, planting depth and their interaction on harvest index (%) for barley crop.

	D1	**D2**	**D3**	**Mean**
C1	**4.11**	**5.33**	**5.04**	**4.83**
C2	**4.10**	**9.60**	**6.00**	**6.57**
C3	**4.96**	**5.66**	**5.36**	**5.33**
Mean	**4.39**	**6.86**	**5.46**	
LSD Values	**Depth LSD = 1.077**	**Charcoal LSD = 1.077**	**Interaction LSD = 1.866**	

C = coal levels where C1 = 0, C2 = 0.5 g coal.kg $soil^{-1}$, C3 = 0.75 g coal.kg $soil^{-1}$
D = planting depth where D1 = 0 cm, D2 = 5 cm, D3 = 10 cm, ns = not significant.