*Bangladesh Agron. J. 2019, 22(2): 113-127*

# EFFECT OF BIOCHAR APPLICATION AS A SOIL AMENDMENT ON GROWTH AND YIELD OF SESAME (*Sesamumindicum*L.)

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**(Received:** 19 February 2020, **Accepted:** 26 April 2020**)**

**Keywords:**Biochar, growth, yield, *Sesamumindicum*

## Abstract

The experiment was conducted to study the effect of biochar on growth and yield of sesame. In the experiment, the treatment consisted of three varieties, *viz.,* $V_1$ = BARI Til-2, $V_2$ = BARI Til-3 and $V_3$ = BARI Til-4, and five levels of biochar*viz.,* $B_0$= control (no biochar application), $B_1$= 2 t $ha^{-1}$, $B_2$= 4 t $ha^{-1}$, $B_3$= 6 t $ha^{-1}$ and $B_4$= 8 t $ha^{-1}$. The experiment was laid out in two factors randomized complete block design (RCBD) with three replications.Variety, application of different levels of biochar and their interaction showed statistically significant variation in plant height, number of leaves plant$^{-1}$at 55 and 80 DAS and at harvest, capsules plant$^{-1}$, seeds capsule$^{-1}$, 1000-seed weight, seed yield, stover yield, biological yield and harvest index.The highest plant height (70.34, 110.95 and 109.84 cm at 55 and 80 DAS and at harvest respectively), number of leaves plant$^{-1}$ (80.47, 116.70 and 94.54 at 55, 80 DAS and at harvest, respectively), number of branches plant$^{-1}$ (3.60), capsules plant$^{-1}$(80.47), number of seeds capsule$^{-1}$(56.02),seed yield(1.07tha$^{-1}$)andharvestindex(36.46%)were observed in the variety BARI Til-4 cultivated with the application of biochar @ 6 t $ha^{-1}$ ($V_3 \times B_3$) and the lowest one was observed in variety BARI Til-2 with no biochar application ($V_1 \times B_0$).Biochar is effective for increasing growth and yield of sesame.

## Introduction

Sesame (*Sesamumindicum* L.) is one of the important edible oilseed cultivated in Bangladesh. Its oil content generally varies from 46-52% and protein between 20-26%. The oil is used foredible purpose (73%), hydrogenation (8.3%) and industrial purpose (4.2%) in the manufacture of paints, pharmaceuticals and insecticides. Sesame oil is also used in soap, cosmetics and skincare. It has antiviral, antibacterial, antifungal and antioxidant properties (Ray, 2009). A hundred grams of sesame seed provide 592 calories energy. Sesame oil is the poor man's substitute for “ghee”. Sesame as an industrial crop which is potent economically and highly nutrient, per 36 grams of seed contains 206.2 kal, copper 1.48 mg, Mn 0.88 mg, tryptophan 0.12 g, Ca 351 mg, Mg 126.36 mg, Fe 5.24 mg, P 226.44 mg, Zn 2.8 mg, B1 vitamin 0.28 mg and fiber 4.24 g (Ray, 2009). Sesame oil contains oil that ranges between 40 to 50% that is edible and has long shelf life more than one year without any deterioration due to its content of sesamol antioxidant, rich in unsaturated fats especially oleic acid and linoleic acid (Sharar*et al*., 2000).It contains 6.0 -6.2 % nitrogen, 2.0 - 2.2 percent phosphorus and 1.0 -1.2 percent potash. It can be used as manure. The cake is edible and is eaten avidly by working classes. It is also a valuable and nutritious feed for milch cattle.

Sesame is one of the most important oil crops in Bangladesh and grown in all regions. Total area coverage of sesame is 33,974.57 hectors with an annual production of 31,232 metric tones during fiscal year 2017-18 (BBS, 2019). The yield of sesame is much lower in the farmer's field as compared to the researchfield. Mian*etal*.(2002)stated that sesame yield is very low in Bangladesh due to a lack of proper management practices. The yield of sesame can be increased by nutrient management, which is very important for yield improvement of the crop.

Biochar is a soil amendment.It provides a better and more nourishing environment for plant roots. It must be mixed thoroughly within the soil. If it is just placed under the soil, it can interfere with the movement of water or air and the growth of the plant roots can be affected (Davis and Wilson, 2012).Biochar is a pyrolyzed biomass produced under limited oxygen or oxygen absent conditions. The specific intention of biochar application to soil is to improve its agronomic and biochemical quality (Sun and Lu, 2013; Liu *et al*., 2014), and to enhance carbon sequestration (Lehmann and Rondon, 2006). The use of biochar can be an effective tool for sustainable agriculture in the long term, increasing soil carbon sequestration (C abatement strategy), fertility and productivity (soil quality) and reducing greenhouse gas emissions (Jeffery *et al*., 2013). It can increase soil aeration (Laird, 2008) and reduce soil emissions of $N_2O$, a greenhouse gas (Spokas*et al*., 2010).The addition of biochar as amendment materials to agricultural soils is receiving much attention due to the apparent benefits of biochar to soil quality and enhanced crop yields, as well as the potential to gain carbon credits by active carbon sequestration (Major, 2010). Considering the low yield of sesame obtained in most growing areas as the reason of the non-application of fertilizers and the poor fertility status of soil.Application of biochar can increase growth and yield of sesame and also improve soil fertility(Wacal*et al*., 2019). In this scenario,theinvestigation was conducted to study the effect of biocharapplication as a soil amendment on growth and yield of sesame.

## Materials and Methods

The experiment was conducted at the Agronomy research field of theSher-e-Bangla Agricultural University, Dhaka, Bangladeshfrom March to June 2017.Geographically the experimental field was located at 23° 77′ N latitude and 90° 33' E longitudes at an altitude of 9 m above the mean sea level.The morphological, physical and chemical characteristics before and after harvesting of sesame of the experimental plot soil have been presented in Table 1.The weather condition during the study period (March-June) hasbeen presented in Table 2.

Table 1.Soil characteristics of experimental farm of Sher-e-Bangla AgriculturalUniversity (before and after harvesting of sesame)

**A. Morphological characteristics of the experimental field**

| Morphological features | Characteristics |
|---|---|
| Location | Farm, SAU, Dhaka |
| AEZ | Modhupur tract (28) |
| General soil type | Shallow red brown terrace soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |
| Flood level | Above flood level |
| Drainage | Well drained |
| Cropping pattern | N/A |

Source:Soil Resource Development Institute (SRDI), Farmgate, Dhaka, Bangladesh

**B. Physical and chemical properties of the initial soil**

| Physical and chemical properties of the initial soil characteristics | Value |
|---|---|
| Practical size analysis | |
| Sand (%) | 16 |
| Silt (%) | 56 |
| Clay (%) | 28 |

| | |
|---|---|
| Silt + Clay (%) | 84 |
| Textural class | Silty clay loam |
| pH | 5.56 |
| Organic matter (%) | 1.00 |
| Total N (%) | 0.06 |
| Available P (µ g/g soil) | 42.64 |
| Available K (meq/100 g soil) | 0.13 |

Source: Soil Resource Development Institute (SRDI), Farmgate, Dhaka, Bangladesh

**C. Chemical properties of the soil after harvesting of sesame (treatment wise averageresult)**

| Treatment | pH | OC (%) | Total N (%) | Available P (µg $g^{-1}$soil) | Exchangeable K (meq 100$g^{-1}$soil) |
|---|---|---|---|---|---|
| $B_0$ | 6.09 | 0.40 | 0.039 | 14.52 | 0.23 |
| $B_1$ | 5.84 | 0.48 | 0.048 | 17.59 | 0.26 |
| $B_2$ | 5.96 | 0.58 | 0.057 | 21.13 | 0.30 |
| $B_3$ | 6.04 | 0.64 | 0.064 | 25.58 | 0.36 |
| $B_4$ | 5.89 | 0.70 | 0.073 | 29.29 | 0.40 |

Source: Department of Soil Scienece, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh

Table 2. Monthly average temperature, relative humidity and total rainfall of theexperimental site during the period from March 2017 to June 2017

| Month | Air temperature (°C) | | Relative humidity (%) | Total rainfall (mm) |
|---|---|---|---|---|
| | Maximum | Minimum | | |
| March | 33.6 | 20.4 | 67 | 100 |
| April | 36.5 | 23.9 | 73 | 228 |
| May | 37.0 | 25.9 | 73 | 188 |
| June | 36.1 | 26.5 | 80 | 414 |

Source: Bangladesh Agricultural Research Council (Climate Information Management System), Dhaka, Bangladesh

Three sesame varieties *viz.*,BARI Til-2, BARI Til-3 and BARI Til-4 were used as planting material. Seeds of all the varieties were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur-1701.The treatment consisted of three sesame varieties, *viz.,* $V_1$ = BARI Til-2, $V_2$ = BARI Til-3, $V_3$ = BARI Til-4 and five levels of biochar*viz.,* $B_0$= Control (no biochar application), $B_1$= biochar @ 2 t $ha^{-1}$, $B_2$= biochar @ 4 t $ha^{-1}$, $B_3$= biochar @ 6 t $ha^{-1}$ and $B_4$= biochar @8 t $ha^{-1}$. The experiment was laid out in two factors randomized complete block design (RCBD) with three replications.There were 15 treatment combinations and 45unit plots. The unit plot size was 3.60 $m^2$ (1.8 m×2.0 m). The blocks and unit plots were separated by 0.50 m and 0.3 m spacing respectively.Therecommended doses of Urea, TSP, MoP, Gypsum, Zinc sulfate and Boric acid as per BARI (2014) @125, 150, 50, 110, 5 and10 kg $ha^{-1}$ were applied in the soil of each plot. All fertilizers were applied as basal dose except urea,whichwas applied in 2 splits.Seeds were sown in the furrow on 28March 2017. Different intercultural operations such as thinning, weeding, irrigation,drainageand plant protection measures were done when needed.The crop was harvested at 87 DASwhen about 80% of the pods became matured. Samples were collected from each plot leavingundisturbed plants in the center. The sample bundles were sun-dried by spreading those on the threshing floor. The seeds were separated, cleaned and dried in the sun for 3 to 5 consecutive days for achieving safe moisture of seed.The dried seeds and straw were cleaned and weighed. Ten plants were collected randomly from each plotto measure average data of plant height (cm), number of leaves plant$^{-1}$(no.), capsules plant$^{-}$

[1](no.),seeds capsule$^{-1}$ (no.), weight of 1000 seeds (g),seed yield (t ha$^{-1}$), stover yield (t ha$^{-1}$), biological yield (t ha$^{-1}$) and harvest index (%). Biological yield and harvest index were calculated with the following formula;

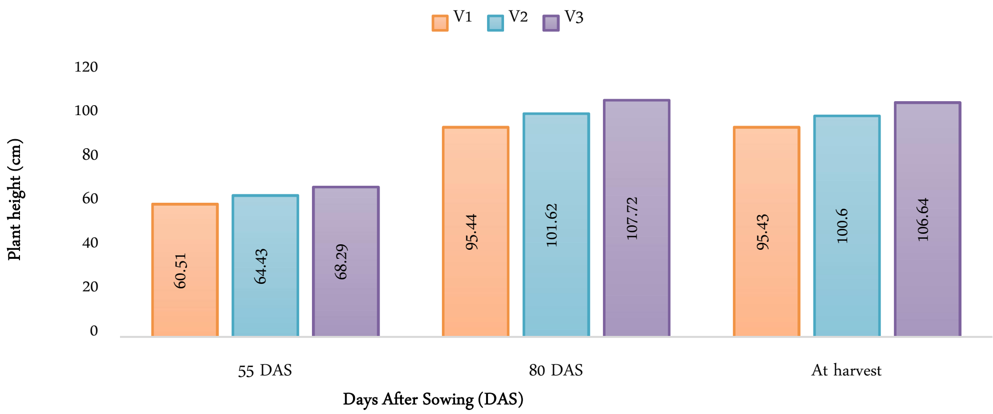
Biological yield = Grain yield + Stover yield.Harvest index (%) $= \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program Statistix 10 and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of significance.

## Results and Discussion

**Plant height**

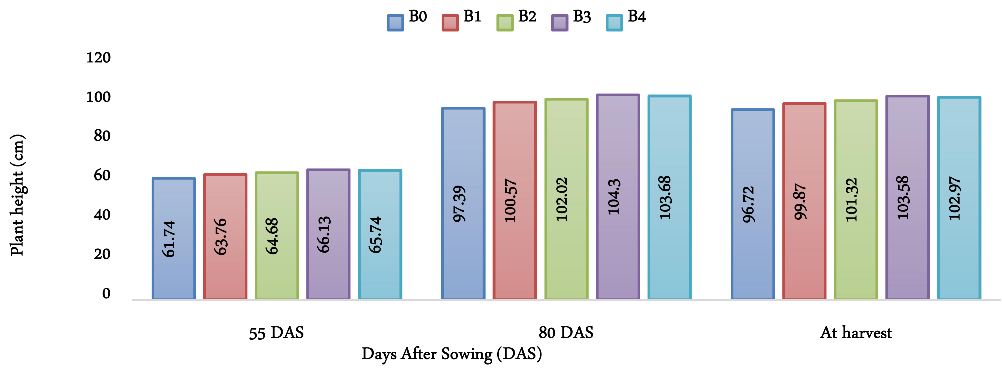
Varieties showed statistically significant variation in respect of plant height of sesame (Figure1). Among the varietiesBARI Til-4 ($V_3$) showed the highest plant height (68.29, 107.72 and 106.64 cm at 55, 80 DAS and at harvest, respectively). The lowest plant height (60.51, 95.44 and 95.43 cm at 55, 80 DAS and at harvest, respectively) was observed in the BARI Til-2 ($V_1$). Variations in plant height among sesame varieties had been reported extensively (Ghungarde*et al*., 1992).




$V_1$ = BARI Til-2, $V_2$ = BARI Til-3, $V_3$ = BARI Til-4; (LSD $_{(0.05)}$ 0.865, 1.255 and 1.24 at 55, 80 DAS and at harvest, respectively).

Fig. 1. Effect of varieties on plant height of sesame at different days after sowing.

The plant height of sesame was significantly influenced by different levels of biochar application (Figure 2) (Wacal*et al*., 2019). At 55, 80 DAS and at harvest, the highest plant height (66.13, 104.30, and 103.58 cm, respectively) was recorded in the application of biochar@ 6 t ha$^{-1}$ ($B_3$) which was statistically similar with the application of biochar@ 8 t ha$^{-1}$ ($B_4$) where the lowest was measured at 55, 80 DAS and harvest (61.74, 97.39 and 96.72 cm, respectively) in control ($B_0$).




$B_0$ = Control, $B_1$ = 2 t $ha^{-1}$, $B_2$ = 4 t $ha^{-1}$, $B_3$ = 6 t $ha^{-1}$, $B_4$ = 8 t $ha^{-1}$; ($LSD_{(0.05)}$ 1.476, 1.622 and 1.601 at 55, 80 DAS and at harvest respectively).

Fig. 2. Effect of different levels of biochar on plant height of sesame at different days after sowing

Table 3. Interaction effect of varieties and different levels of biochar on plant height of sesame at different days after sowing (DAS)

| Interaction | Plant height (cm) | | |
|---|---|---|---|
| | 55 DAS | 80 DAS | Harvest |
| $V_1 \times B_0$ | 58.19 g | 91.78 h | 91.77 i |
| $V_1 \times B_1$ | 60.11 fg | 94.81 g | 94.81 h |
| $V_1 \times B_2$ | 60.99 f | 96.20 g | 96.19 h |
| $V_1 \times B_3$ | 61.67 f | 97.28 g | 97.27 gh |
| $V_1 \times B_4$ | 61.58 f | 97.12 g | 97.11 gh |
| $V_2 \times B_0$ | 61.67 f | 97.27 g | 96.30 h |
| $V_2 \times B_1$ | 63.67 f | 100.43 f | 99.42 fg |
| $V_2 \times B_2$ | 64.58 e | 101.87 ef | 100.85 ef |
| $V_2 \times B_3$ | 66.36 de | 104.67 de | 103.62 de |
| $V_2 \times B_4$ | 65.84 cd | 103.85 de | 102.81 de |
| $V_3 \times B_0$ | 65.37 cd | 103.11 ef | 102.08 ef |
| $V_3 \times B_1$ | 67.50 bc | 106.46 cd | 105.39 cd |
| $V_3 \times B_2$ | 68.46 ab | 107.98 b | 106.90 bc |
| $V_3 \times B_3$ | 70.34 a | 110.95 a | 109.84 a |
| $V_3 \times B_4$ | 69.79 a | 110.08 ab | 108.9 ab |
| CV (%) | 1.933 | 2.806 | 2.773 |
| $LSD_{(0.05)}$ | 6.37 | 7.31 | 6.55 |
| LS | NS | ** | ** |

Figures in a column followed by different letter(s) differ significantly whereas figures having common letter(s) do not differ significantly from each other as adjusted by LSD.

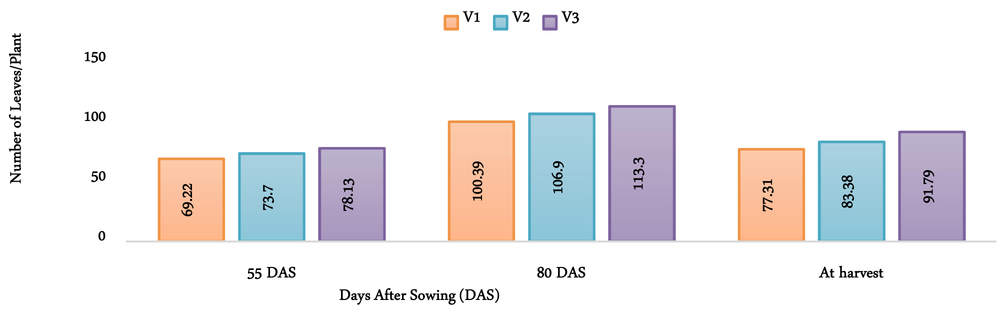
CV= Coefficient of variation, LS= Level of significance, $LSD_{(0.05)}$ = Least significant difference, NS= Non Significant, **= Significant at 1% level of Probability.

$V_1$ = BARI Til-2, $V_2$ = BARI Til-3, $V_3$ = BARI Til-4; $B_0$ = Control, $B_1$ = 2 t $ha^{-1}$, $B_2$ = 4 t $ha^{-1}$, $B_3$ = 6 t $ha^{-1}$, $B_4$ = 8 t $ha^{-1}$.

Van Zwieten*et al*. (2010) reported a nearly 30-40 percent increase in wheat height when biochar was applied @ 10 t $ha^{-1}$ to acidic soil. Wacal*et al.* (2016) found that the plant height of sesame was significantly influenced by the biocharapplication.The interaction effect between varieties and different levels of biochar exerted a significant effect on plant height at 80 DAS and harvest (Table 3). The highest plant height (110.95 and 109.84 cm at 80 DAS and harvest, respectively) was observed in the variety BARI Til-4 cultivated with the application of biochar@ 6 t ha$^{-1}$ ($V_3 \times B_3$). The lowest plant height (91.78 and 91.77 cm at 80 DAS and at harvest, respectively) was observed in the Variety BARI Til-2 with no biochar application ($V_1 \times B_0$).

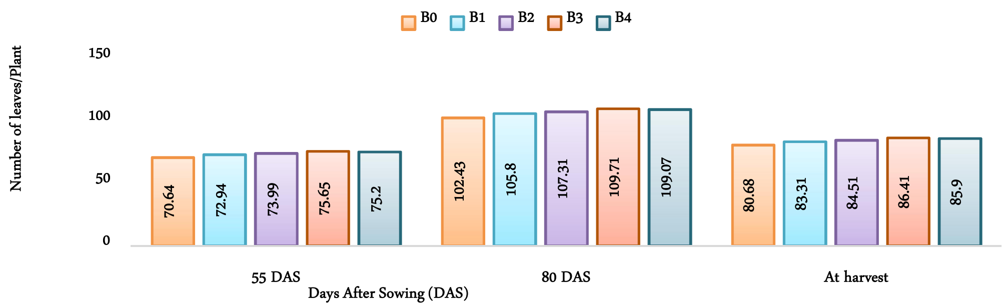
**Number of leavesplant$^{-1}$**

Varieties showed a significant variation in the number of leaves plant$^{-1}$ of sesame (Figure 3). Among the different varietiesBARI Til-4 ($V_3$) showed the highest number of leaves plant$^{-1}$(78.13,113.30 and 91.79 at 55, 80 DAS and at harvest, respectively). The lowest number of leaves plant$^{-1}$(69.22, 100.39 and 77.31 at 55, 80 DAS and at harvest, respectively) was producedby the varietyBARI Til-2 ($V_1$). Leaves plant$^{-1}$of sesame was significantly influenced by different levels of biochar application(Figure4). At 55, 80 DAS and at harvest, the highest number of leaves plant$^{-1}$ (75.65, 109.71 and 86.41, respectively) was recorded in the application of biochar @ 6 t ha$^{-1}$ ($B_3$)and the lowest was achieved with control ($B_0$) (70.64, 102.43 and 80.68,respectively).




$V_1$ = BARI Til-2, $V_2$ = BARI Til-3, $V_3$ = BARI Til-4; (LSD $_{(0.05)}$ 0.769, 1.159, and 0.735 at 55, 80 DAS and at harvest, respectively).

Fig. 3. Effect of varieties on number of leaves plant$^{-1}$ of sesame at different days after sowing (DAS).




$B_0$ = Control, $B_1$ = 2 t ha$^{-1}$, $B_2$ = 4 t ha$^{-1}$, $B_3$ = 6 t ha$^{-1}$, $B_4$ = 8 t ha$^{-1}$; (LSD $_{(0.05)}$ 0.990, 1.496 and 0.956 at 55, 80 DAS and at harvest, respectively).

Fig. 4. Effect of different levels of biochar on number of leaves plant$^{-1}$of sesame at different days after sowing (DAS)

The interaction effect between varieties and different levels of biochar exerted a significant effect on the number of leaves at all DAS (Table 4). The highest number of leaves (80.47, 116.70 and 94.54 at 55, 80 DAS and harvest, respectively) was observed in the variety BARI Til-4 cultivated with the application of biochar@ 6 t ha$^{-1}$($V_3 \times B_3$)at harvest. The lowest number of leaves (66.55,96.54 and 74.35

at 55, 80 DAS and harvest, respectively) was observed in variety BARI Til-2 with no biocharapplication ($V_1 \times B_0$) at 55 DAS, 80 DAS and harvest.

Table 4. Interaction effect of varieties and different levels of biochar on number of leaves plant$^{-1}$ of sesame at different days after sowing (DAS)

| Interaction | Number of leaves plant$^{-1}$ | | |
|---|---|---|---|
| | 55 DAS | 80 DAS | Harvest |
| $V_1 \times B_0$ | 66.57 j | 96.54 i | 74.35 i |
| $V_1 \times B_1$ | 68.77 i | 99.76 h | 76.80 h |
| $V_1 \times B_2$ | 69.77 hi | 101.17 h | 77.92 gh |
| $V_1 \times B_3$ | 70.56 h | 102.33 h | 78.80 gh |
| $V_1 \times B_4$ | 70.44 hi | 102.17 h | 78.67 gh |
| $V_2 \times B_0$ | 70.55 h | 102.31 h | 79.82 g |
| $V_2 \times B_1$ | 72.84 g | 105.67 g | 82.41 f |
| $V_2 \times B_2$ | 73.89 fg | 107.17 fg | 83.59 ef |
| $V_2 \times B_3$ | 75.92 de | 110.10 de | 85.89 e |
| $V_2 \times B_4$ | 75.32 ef | 109.23 ef | 85.22 d |
| $V_3 \times B_0$ | 74.79 ef | 108.43 ef | 87.86 d |
| $V_3 \times B_1$ | 77.21 cd | 111.97 cd | 90.71 c |
| $V_3 \times B_2$ | 78.32 bc | 113.60 bc | 92.01 bc |
| $V_3 \times B_3$ | 80.47 a | 116.70 a | 94.54 a |
| $V_3 \times B_4$ | 79.84 ab | 115.80 ab | 93.80 ab |
| CV (%) | 1.721 | 2.591 | 2.345 |
| $LSD_{(0.05)}$ | 5.46 | 9.54 | 5.42 |
| LS | ** | ** | ** |

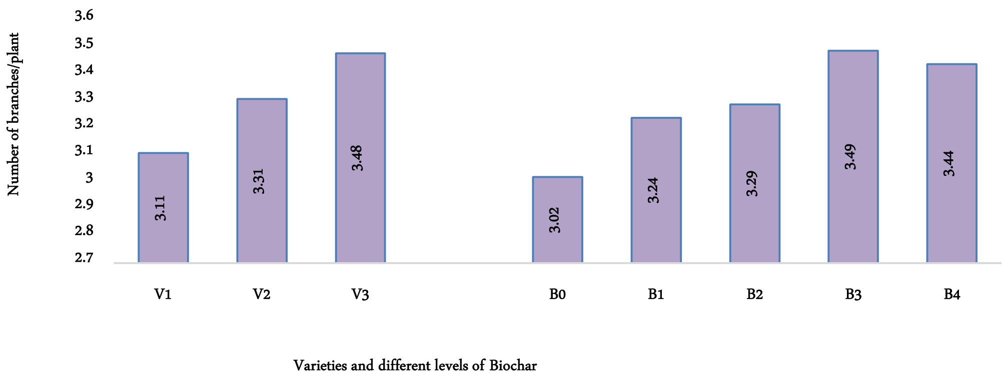
Figures in a column followed by different letter(s) differs significantly whereas figures having common letter(s) do not differ significantly from each other as adjusted by LSD.

CV= Coefficient of variation, LS= Level of significance, $LSD_{(0.05)}$ = Least significant difference, **= Significant at 1% level of Probability.

$V_1$ = BARI Til-2, $V_2$ = BARI Til-3, $V_3$ = BARI Til-4; $B_0$ = Control, $B_1$ = 2 t ha$^{-1}$, $B_2$ = 4 t ha$^{-1}$, $B_3$ = 6 t ha$^{-1}$, $B_4$ = 8 t ha$^{-1}$.

**Number of branches plant$^{-1}$**

Varieties showed a significant variation in the number of branches plant$^{-1}$ of sesame (Figure5). BARI Til-4($V_3$) showed the highest number of branches plant$^{-1}$ (3.48)whereasthe lowest number of branches plant$^{-1}$ (3.11) was observed in variety BARI Til-2 ($V_1$). Variation in the number of branches plant$^{-1}$ due to variety was also reported by Asharani*et al.*(1992).Branches plant$^{-1}$ was significantly influenced by different levels of biochar application at different DAS of sesame (Figure5) (Wacal*et al.*, 2019). The highest number of branches plant$^{-1}$ (3.49) was recorded in the application of biochar@ 6 t ha$^{-1}$ ($B_3$) which was statistically similar to the application of biochar@ 8 t ha$^{-1}$($B_4$) and the lowest number of branches plant$^{-1}$(3.02) was achieved with control ($B_0$).



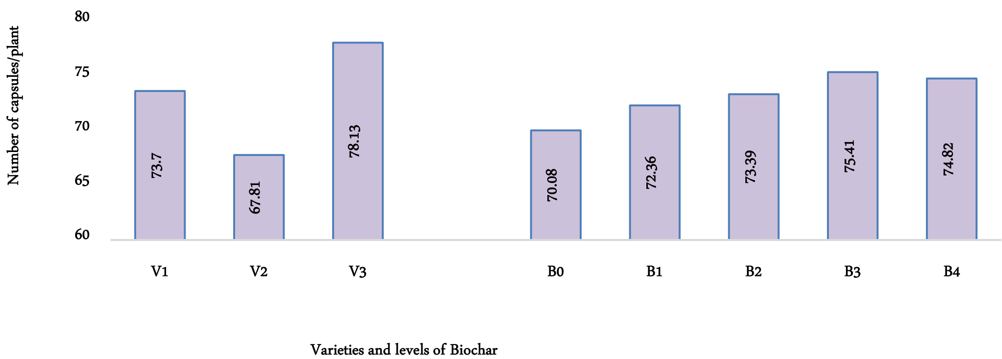

$V_1$ = BARI Til-2, $V_2$ = BARI Til-3, $V_3$ = BARI Til-4; (LSD $_{(0.05)}$ 0.047). $B_0$ = Control, $B_1$ = 2 t ha$^{-1}$, $B_2$ = 4 t ha$^{-1}$, $B_3$ = 6 t ha$^{-1}$, $B_4$ = 8 t ha$^{-1}$; (LSD $_{(0.05)}$ 0.061).

Fig. 5. Effect of varieties and different levels of biocharon number of branches plant$^{-1}$ of sesame.

The interaction effect between varieties and different levels of biochar exerted a significant effect on the number of leaves (Table 5). The highest number of leaves (3.60) was observed in the variety BARI Til-4 cultivated with the application of biochar@ 6 t ha$^{-1}$ ($V_3 \times B_3$). The lowest number of leaves (2.73) was observed Variety BARI Til-2 with no biocharapplication ($V_1 \times B_0$) at 55 DAS, 80 DAS and harvest.

**Number of capsulesplant$^{-1}$**

The number of capsulesplant$^{-1}$ showed significant variation due to the effects of sesame variety (Figure6).The highest number of capsules plant$^{-1}$ (78.13) was obtained from the varietyBARI Til-4 ($V_3$). The lowest number of capsulesplant$^{-1}$(73.70) was found in the variety BARI Til-3 ($V_2$).The number of capsules plant$^{-1}$ was significantly influenced by different levels of biochar application of sesame (Figure6). It was remarked from the present study that the increasing rate of biochar significantly increased the number of capsules plant$^{-1}$. Application of biochar@ 6 t ha$^{-1}$ ($B_3$) treatment produced a maximum number of capsules plant$^{-1}$ (75.41) which was statistically similar result with the application of biochar@ 8 t ha$^{-1}$ ($B_4$). The lowest number of capsules plant$^{-1}$(70.08) was achieved with control ($B_0$).



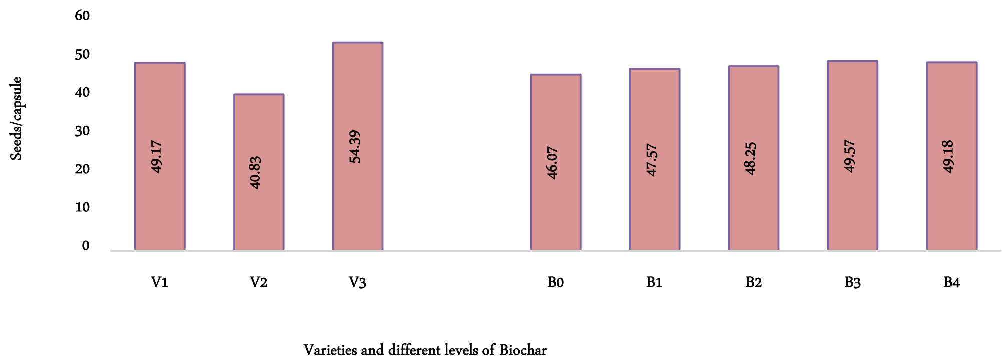

$V_1$ = BARI Til-2, $V_2$ = BARI Til-3, $V_3$ = BARI Til-4; (LSD $_{(0.05)}$ 0.897).$B_0$ = Control, $B_1$ = 2 t ha$^{-1}$, $B_2$ = 4 t ha$^{-1}$, $B_3$ = 6 t ha$^{-1}$, $B_4$ = 8 t ha$^{-1}$; (LSD $_{(0.05)}$ 1.159).

Fig.6. Effect of varieties on number of capsules plant$^{-1}$ of sesame.

The interaction effect between varieties and different levels of biochar exerted a significant effect on the number of capsules plant$^{-1}$(Table 5). The highest capsule plant$^{-1}$ (80.47) was observed in the variety BARI Til-4 cultivated with the application of biochar@ 6 t ha$^{-1}$($V_3 \times B_3$) which was statistically similar result BARI Til-4 cultivated with the application of biochar@ 8 t ha$^{-1}$($V_3 \times B_4$). The lowest number of capsules per plant(70.55) was observed in the variety of BARI Til-2 with no biochar application ($V_1 \times B_0$).

**Number of seeds capsule$^{-1}$**

Sesame varieties showed a significant variation in the number of seedscapsule$^{-1}$ (Figure7). Among the different varieties BARI Til-4 ($V_3$)showed the highest number of seedscapsule$^{-1}$(54.39). The lowest number of seedscapsule$^{-1}$(49.17) was recorded in varietyBARI Til-3 ($V_2$). Genetically controlled character might be increased the vegetative growth and development of sesame that lead to the highest number of seedscapsule$^{-1}$(Deshmukh*et al.*,1990).Results presented in Figure 7 on number of seeds capsule$^{-1}$influenced by different levels of biochar application were statistically significant. The highest number of seedscapsule$^{-1}$(49.57) was recorded in application of biochar@6 t ha$^{-1}$ ($B_3$) which was statistically similar to application of biochar@ 8 t ha$^{-1}$ ($B_4$). The lowest number of seeds capsule$^{-1}$(46.07) was recorded by control ($B_0$).



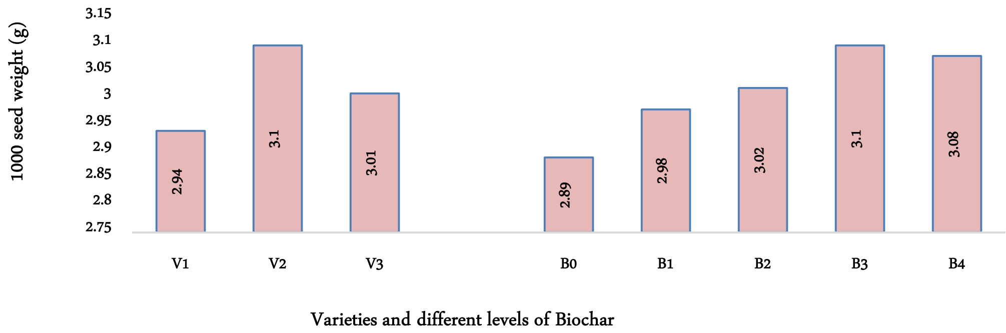

$V_1$ = BARI Til-2, $V_2$ = BARI Til-3, $V_3$ = BARI Til-4; (LSD $_{(0.05)}$ 0.897).$B_0$ = Control, $B_1$ = 2 t ha$^{-1}$, $B_2$ = 4 t ha$^{-1}$, $B_3$ = 6 t ha$^{-1}$, $B_4$ = 8 t ha$^{-1}$; (LSD $_{(0.05)}$ 0.1.159).

Fig.7. Effect of varieties on number of seeds capsule$^{-1}$ of sesame.

The interaction effect between varieties and different levels of biochar showed a significant effect on seeds capsule$^{-1}$at harvest (Table 5). The highest seeds capsule$^{-1}$(56.02) was observed in the variety BARI Til-4 cultivated with the application of biochar@ 6 t ha$^{-1}$($V_3 \times B_3$) which was statistically similar to the result obtained from $V_3 \times B_4$. The lowest seeds capsule$^{-1}$(47.07) was observed in theVariety BARI Til-2 with no biocharapplication ($V_1 \times B_0$).

**Weight of 1000 seeds**

Varieties showed a significant variation on thousand seed weight (Figure8). BARI Til-3 ($V_2$)showed the highest thousand seed weight (3.10g)whereasthe lowest thousand seed weight (2.94 g) was recorded in variety BARI Til-2 ($V_1$). Results showed that the weight of 1000 seeds was significantly influenced by different levels of biochar application (Figure8). The highest weight of 1000 seeds (3.10 g) was recorded in application of biochar@ 6 t ha$^{-1}$ ($B_3$) which was statistically similar with application of biochar@ 8 t ha$^{-1}$ ($B_4$) whereas the lowest weight of 1000 seeds (2.89 g) was achieved by control ($B_0$). Wacal*et al.* (2016) found that 1000-seed weight was significantly influenced by biochar application.




$V_1$ = BARI Til-2, $V_2$ = BARI Til-3, $V_3$ = BARI Til-4; (LSD $_{(0.05)}$ 0.041).$B_0$ = Control, $B_1$ = 2 t ha$^{-1}$, $B_2$ = 4 t ha$^{-1}$, $B_3$ = 6 t ha$^{-1}$, $B_4$ = 8 t ha$^{-1}$; (LSD $_{(0.05)}$ 0.052).

Fig.8. Effect of varieties and different levels of biocharon 1000 seed weightof sesame

The interaction effect between varieties and different levels of biochar showed a significant effect on the weight of 1000 seeds at harvest (Table 5). The highest weight of 1000 seeds (3.18g) was observed in the BARI Til-3 cultivated withthe application of biochar @ 6 t ha$^{-1}$($V_2 \times B_3$). The lowest 1000-seed weight (2.81 g)was observed in the variety BARI Til-2 with no biocharapplication ($V_1 \times B_0$).

Table 5. Interaction effect of varieties and different levels of biochar on yield attributes of sesame

| Interaction | Branches plant$^{-1}$ (no.) | Capsules plant$^{-1}$ (no.) | Seeds capsule$^{-1}$ (no.) | 1000 seeds weight (g) |
|---|---|---|---|---|
| $V_1 \times B_0$ | 2.73 h | 70.55 h | 47.07 h | 2.81 i |
| $V_1 \times B_1$ | 3.07 f | 72.84 g | 48.59 g | 2.90 gh |
| $V_1 \times B_2$ | 3.13 f | 73.89 fg | 49.29 fg | 2.94 f-h |
| $V_1 \times B_3$ | 3.33 de | 75.92 de | 50.64 e | 3.02 c-f |
| $V_1 \times B_4$ | 3.27 e | 75.32 d-f | 50.25 ef | 3.00 d-f |
| $V_2 \times B_0$ | 2.93 g | 64.91 k | 39.09 k | 2.97 e-h |
| $V_2 \times B_1$ | 3.27 e | 67.01 j | 40.35 j | 3.06 c-e |
| $V_2 \times B_2$ | 3.33 de | 67.98 ij | 40.93 ij | 3.10 a-c |
| $V_2 \times B_3$ | 3.53 ab | 69.84 hi | 42.06 i | 3.18 a |
| $V_2 \times B_4$ | 3.47 bc | 69.30 hi | 41.73 i | 3.16 ab |
| $V_3 \times B_0$ | 3.40 cd | 74.79 e-g | 52.06 d | 2.89 hi |
| $V_3 \times B_1$ | 3.40 cd | 77.21 cd | 53.75 c | 2.98 e-g |
| $V_3 \times B_2$ | 3.40 cd | 78.32 bc | 54.52 bc | 3.02 c-f |
| $V_3 \times B_3$ | 3.60 a | 80.47 a | 56.02 a | 3.10 a-c |
| $V_3 \times B_4$ | 3.60 a | 79.84 ab | 55.58 ab | 3.08 b-d |
| CV (%) | 8.52 | 2.008 | 1.256 | 0.091 |
| $LSD_{(0.05)}$ | 0.105 | 4.53 | 6.51 | 2.54 |
| LS | ** | ** | ** | ** |

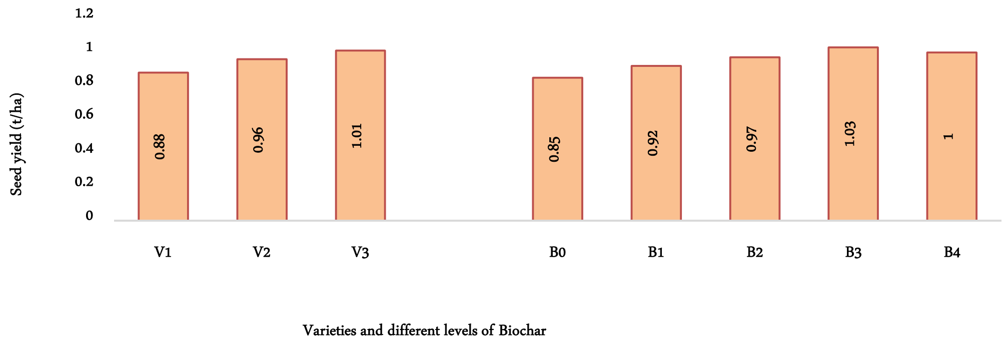
Figures in a column followed by different letter(s) differs significantly whereas figures having common letter(s) do not differ significantly from each other as adjusted by LSD.

**= Significant at 1% level of Probability.

$V_1$ = BARI Til-2, $V_2$ = BARI Til-3, $V_3$ = BARI Til-4; $B_0$ = Control, $B_1$ = 2 t ha$^{-1}$, $B_2$ = 4 t ha$^{-1}$, $B_3$ = 6 t ha$^{-1}$, $B_4$ = 8 t ha$^{-1}$.

**Seed yield**

BARI Til-4 ($V_3$) gave the highest yield (1.01 t ha$^{-1}$) (Figure 9). On the contrary, the lowest seed yield (0.88 t ha$^{-1}$) was observed with variety BARI Til-2 ($V_1$).Variation in seed yield of sesame due to variety was also reported by many researchers (Asharani*et al.*, 1992). Seed yield of sesamewas significantly influenced by the application of different levels of biochar (Figure9). The highest seed yield (1.03 t ha$^{-1}$) was recorded in application of biochar@6 t ha$^{-1}$ ($B_3$) which was statistically similar to application of biochar@ 8 t ha$^{-1}$ ($B_4$) while the lowest seed yield (0.85 t ha$^{-1}$) was achieved by control ($B_0$). Wacal*et al.* (2016) found that the seed yield of sesame was significantly influenced by the biochar application.Ndor*et al*. (2015) found that the application of 10 tha$^{-1}$ of sawdust and rice husk biochar produced the highest seed weight of sesame.



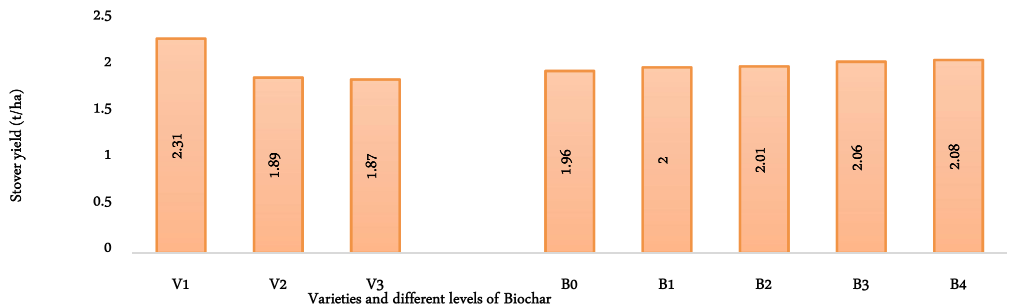

$V_1$ = BARI Til-2, $V_2$ = BARI Til-3, $V_3$ = BARI Til-4; (LSD $_{(0.05)}$ 0.014).$B_0$ = Control, $B_1$ = 2 t ha$^{-1}$, $B_2$ = 4 t ha$^{-1}$, $B_3$ = 6 t ha$^{-1}$, $B_4$ = 8 t ha$^{-1}$; (LSD $_{(0.05)}$ 0.019).

Fig.9. Effect of varieties and different levels of biocharon seed yield of sesame.

The interaction effect between varieties and different levels of biochar showed a significant effect on seed yield at harvest (Table 6). The highest seed yield (1.07 t ha$^{-1}$) was observed in the variety BARI Til-4 cultivated with the application of biochar@ 6 t ha$^{-1}$($V_3 \times B_3$) which was statistically similar to the result obtained from $V_3 \times B_4$. The lowest seed yield (0.75 t ha$^{-1}$) was observed in the variety BARI Til-2 with no biocharapplication ($V_1 \times B_0$).

**Stover yield**

Different varieties showed significant variations in respect of the stover yield of sesame (Figure 10). Among the different varieties BARI TIl-2 ($V_1$) showed the highest stover yield (2.31 t ha$^{-1}$).




$V_1$ = BARI Til-2, $V_2$ = BARI Til-3, $V_3$ = BARI Til-4; (LSD $_{(0.05)}$ 0.033). $B_0$ = Control, $B_1$ = 2 t ha$^{-1}$, $B_2$ = 4 t ha$^{-1}$, $B_3$ = 6 t ha$^{-1}$, $B_4$ = 8 t ha$^{-1}$; (LSD $_{(0.05)}$ 0.043).

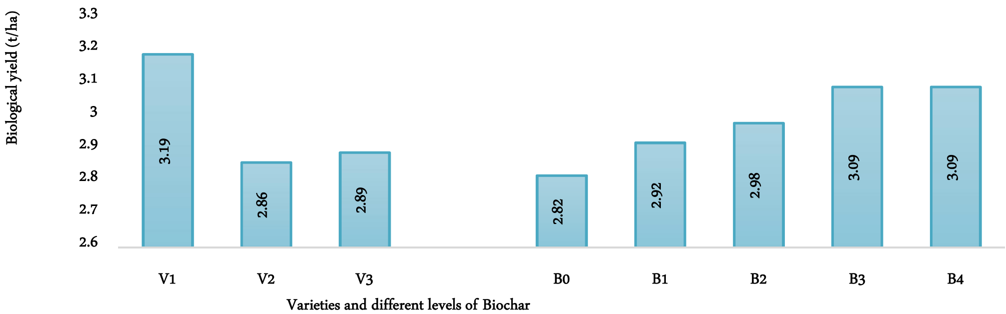
Fig.10. Effect of varieties and different levels of biocharon stover yield of sesame.

The lowest stover yield (1.87 t ha$^{-1}$) was observed with BARI Til-3 ($V_2$) which was statistically similar to $V_3$ (BARI Til-4). Stover yield of sesame varied significantly due to different levels of biochar applications (Figure 10). The highest stover yield (2.08 t ha$^{-1}$) was observed from application of biochar@ 8 t ha$^{-1}$ ($B_4$) which was statistically similar to $B_3$ while the lowest stover yield (1.96 t ha$^{-1}$) from control ($B_0$).

The interaction effect between varieties and different levels of biochar showed a significant effect on strove yield (t ha$^{-1}$) at harvest (Table 6). The highest stover yield (2.42 t ha$^{-1}$) was observed in the variety BARI Til-2 cultivated with the application of biochar@ 8 t ha$^{-1}$ ($V_1 \times B_4$). The lowest stover yield (1.83 t ha$^{-1}$) was observed in the variety BARI Til-4 with 2 t ha$^{-1}$biochar application ($V_3 \times B_1$).

**Biological yield**

Different varieties showed significant variations in respect of the biological yield of sesame (Figure 11). Among the different varieties BARI Til-2 ($V_1$) showed the highest biological yield (3.19 t ha$^{-1}$).The lowest biological yield (2.86 t ha$^{-1}$) was observed with $V_2$ (BARI Til-3) which was statistically similar with BARI Til-4 ($V_3$).The biological yield was significantly influenced by different levels of biochar application (Figure 11). The maximum biological yield (3.09 t ha$^{-1}$) was recorded in application of biochar @ 6 and 8 t ha$^{-1}$ ($B_3$ and $B_4$) and the minimum biological yield (2.82 t ha$^{-1}$) was achieved by control ($B_0$). The application of 6 to 8 t C ha$^{-1}$ increased rice biomass by 17 percent while the presence of 135t C ha$^{-1}$ of biochar enhanced the growth by 43 percent (Lehmann *et al.*, 2003).



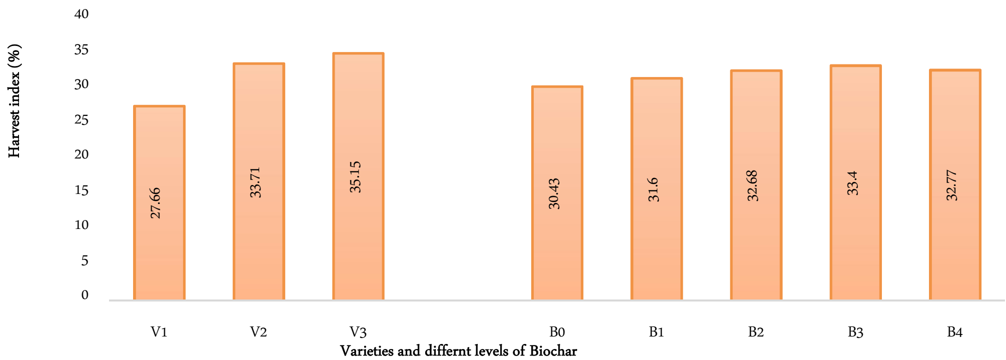

$V_1$ = BARI Til-2, $V_2$ = BARI Til-3, $V_3$ = BARI Til-4; (LSD $_{(0.05)}$ 0.041).$B_0$ = Control, $B_1$ = 2 t ha$^{-1}$, $B_2$ = 4 t ha$^{-1}$, $B_3$ = 6 t ha$^{-1}$, $B_4$ = 8 t ha$^{-1}$; (LSD $_{(0.05)}$ 0.052).

Fig.11. Effect of varieties and different levels of biocharon biological yield of sesame.

The interaction effect between varieties and different levels of biochar showed a significant effect on biological yield at harvest (Table 6). The highest biological yield (3.37 t ha$^{-1}$) was observed in the variety BARI Til-2 cultivated with the application of biochar @ 8 t ha$^{-1}$ ($V_1 \times B_4$) which was statistically similar to $V_1 \times B_3$. The lowest biological yield (2.73 t ha$^{-1}$) was observed in the variety BARI Til-3 with no biochar application ($V_2 \times B_0$).

**Harvest index**

Different varieties showed significant variations in respect of the harvest index of sesame (Figure12). BARI Til-4 ($V_3$) showed the highest harvest index (35.15 %). On the contrary, the lowest harvest index (27.66 %) was observed with BARI Til-2 ($V_1$).The harvest index was significantly influenced by different levels of biochar application (Figure12). It stated from the presentstudy that the highest harvest index (33.40 %) was recorded in application of biochar @ 6 t ha$^{-1}$ ($B_3$) and the lowest harvest index (30.43%) was achieved by control ($B_0$).




$V_1$ = BARI Til-2, $V_2$ = BARI Til-3, $V_3$ = BARI Til-4, (LSD $_{(0.05)}$ 0.486). $B_0$ = Control, $B_1$ = 2 t ha$^{-1}$, $B_2$ = 4 t ha$^{-1}$, $B_3$ = 6 t ha$^{-1}$, $B_4$ = 8 t ha$^{-1}$, (LSD $_{(0.05)}$ 0.682).

Fig.12. Effect of varieties and different levels of biochar on harvest index of sesame.

The interaction effect between varieties and different levels of biochar showed a significant effect on harvest indexat harvest (Table 6).

Table 6. Interaction effect of varieties and different levels of biochar on yield and harvest indexof Sesame

| Interaction | Seed yield (t ha$^{-1}$) | Stover yield (t ha$^{-1}$) | Biological yield (t ha$^{-1}$) | HI (%) |
|---|---|---|---|---|
| $V_1 \times B_0$ | 0.75 j | 2.17 d | 2.92 cd | 25.78 g |
| $V_1 \times B_1$ | 0.83 i | 2.32 bc | 3.15 b | 26.38 g |
| $V_1 \times B_2$ | 0.92 g | 2.26 c | 3.18 b | 28.90 ef |
| $V_1 \times B_3$ | 0.98 de | 2.36 ab | 3.34 a | 29.24 e |
| $V_1 \times B_4$ | 0.94 e-g | 2.42 a | 3.37 a | 28.02 f |
| $V_2 \times B_0$ | 0.87 h | 1.86 gh | 2.73 f | 31.91 d |
| $V_2 \times B_1$ | 0.94 e-g | 1.87 f-h | 2.81 ef | 33.57 c |
| $V_2 \times B_2$ | 0.97 d-f | 1.86 f-h | 2.83 de | 34.35 bc |
| $V_2 \times B_3$ | 1.03 bc | 1.95 e | 2.98 c | 34.50 bc |
| $V_2 \times B_4$ | 1.01 cd | 1.93 ef | 2.94 c | 34.24 bc |
| $V_3 \times B_0$ | 0.94 fg | 1.86 gh | 2.80 ef | 33.62 c |
| $V_3 \times B_1$ | 0.98 de | 1.83 h | 2.80 ef | 34.85 b |
| $V_3 \times B_2$ | 1.02 c | 1.91 e-g | 2.93 c | 34.78 b |
| $V_3 \times B_3$ | 1.07 a | 1.87 f-h | 2.94 c | 36.46 a |
| $V_3 \times B_4$ | 1.06 ab | 1.89 e-h | 2.95 c | 36.05 a |
| CV (%) | 0.033 | 0.074 | 0.091 | 1.088 |
| $LSD_{(0.05)}$ | 6.67 | 7.85 | 6.54 | 2.01 |
| LS | ** | * | * | * |

Figures in a column followed by different letter(s) differs significantly whereas figures having common letter(s) do not differ significantly from each other as adjusted by LSD.

CV= Coefficient of variation, LS= Level of significance, $LSD_{(0.05)}$= Least significant difference, *= Significant at 5% level of Probability, **= Significant at 1% level of Probability.

$V_1$ = BARI Til-2, $V_2$ = BARI Til-3, $V_3$ = BARI Til-4; $B_0$ = Control, $B_1$ = 2 t ha$^{-1}$, $B_2$ = 4 t ha$^{-1}$, $B_3$ = 6 t ha$^{-1}$, $B_4$ = 8 t ha$^{-1}$.

The highest harvest index (36.46%) was observed in the variety BARI Til-2 cultivated with the application of biochar @ 8 t ha$^{-1}$ ($V_3 \times B_3$) which was statistically similar to $V_3 \times B_4$. The lowest harvest index (25.78%) was observed in the variety BARI Til-2 with no biochar application ($V_1 \times B_0$).

## Conclusion

The results in this study indicated that the sesame variety BARI Til-4 performed better with the application of biochar@ 6 t ha$^{-1}$in respect of growth and yield properties compared to other treatment combinations.

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