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# Impact of Various Levels of Biochar on Growth and Yield of Chickpea (*Cicer arietinum* L.)

**Rajeev Varma, D [a++], Anand Naik [b#], Mallikarjun Reddy [b#*], Bellakki, M. A [b†], Balanagoudar, S. R [c‡] and Siddaram [b#]**

*[a] UAS Raichur, India.*
*[b] College of Agriculture Kalaburagi, India.*
*[c] College of Agriculture Raichur, India.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

An experiment was conducted during the rabi season of 2021-2022 at the College of Agriculture, Kalaburagi. The study aimed to assess the impact of biochar on various growth and yield parameters of chickpeas. Results indicated that the treatment involving 100% of the recommended dose of fertilizer (RDF) and biochar applied at 4 t ha-1 significantly enhanced grain yield, stover yield, and harvest index of chickpea. Additionally, plant height, number of branches per plant, dry matter production, number of pods per plant, and 100-seed weight were also notably higher under

*++ M.Sc. (Soil Science);*
*# Assistant Professor;*
*† Professor;*
*‡ Associate Professor;*
**Corresponding author: E-mail: mreddy390@uasraichur.edu.in;*

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this treatment compared to others. In conclusion, the application of 100% RDF along with biochar at 4 t ha-1 demonstrated superior performance in increasing both grain and stover yield of chickpea. These findings underscore the potential of biochar as a beneficial soil amendment in enhancing crop productivity, particularly in chickpea cultivation.

*Keywords: Biochar; grain yield; stover yield and harvest index.*

## 1. INTRODUCTION

"Biochar is a carbon-rich substance, produced by the thermal decomposition of organic compounds at a relatively high temperature (<700 °C) under a limited supply of oxygen. It contains more than 60 per cent carbon and is rich in various nutrients and trace elements essential for crop growth. Biochar is a term generally used for the plant biomass-derived materials contained within the black carbon. In recent years, biochar has emerged as an organic amendment with mineral nutrient elements and holds a promise to improve the soil quality and yield of crops. The biochar is found to have a positive impact on soil fertility, increasing in crop yield without causing a hazard to the soil and water environment" (Venkatesh et al., 2018). Moreover, its production and utilization on a commercial basis seems to be an attractive avenue and a sustainable method of carbon sequestration in agriculture. Effectiveness in retaining most nutrients and keeping them available to plants is the most unique characteristic of the biochar than the other organic matter (leaf litter, compost and manures) and improve the crop yield by decreasing environmental pollution due to nitrogen. "Returning biochar to the field can quickly improve soil carbon storage, nitrogen content and soil fertility" (Venkatesh et al., 2018; Chavan et al., 2023). "It can also reduce the emission of greenhouse gases and improve crop yields. Biochar has a stable and long-term potential in carbon sequestration. Chickpea (*Cicer arietinum* L.), also known as Gram or Bengal gram is the third most important pulse crop after bean (*Phaseolus vulgaris* L.) and pea (*Pisum sativum* L.). On average chickpea seeds contain 23% protein, 63% total carbohydrates, 5% fat, 6% crude fibre and 3% ash and are also rich in calcium, iron and niacin" (Mula et al., 2011). Chickpea seeds, leaves and straw are used in many ways for human consumption. Malic and oxalic acids collected from green leaves are prescribed for intestinal disorders. Stover forms an excellent fodder for cattle. The present study was taken up to investigate the Promotional effects of biochar on the growth and yield of Chickpea. Biochar with its higher porous structure and larger surface area is expected to be the perfect form to withhold and increase the uptake of nutrients in plants.

## 2. MATERIALS AND METHODS

The experiment was conducted at ICAR-Krishi Vigyan Kendra, Kalaburagi farm during *rabi* season, 2021-22. Kalaburagi is situated in the North Eastern Dry Zone (Zone-2) of Karnataka between 17º 34' N latitude and 76º 79' E longitude with an altitude of 478 meters above the mean sea level. The soil had a clayey texture, a moderately alkaline pH of 8.10, a low EC of 0.35 dS $m^{-1}$ and a low amount of soil organic carbon (5.53 g $kg^{-1}$). The soil available nitrogen content was low (198.10 kg $ha^{-1}$), phosphorus availability was medium (28.60 kg $ha^{-1}$) and its potassium content was high (370.20 kg $ha^{-1}$). DTPA extractable zinc, iron, copper and manganese contents were 0.28, 2.66, 1.18 and 3.15 mg $kg^{-1}$ respectively. The experiment was laid out in a Randomized Complete Block Design (RCBD) with eight treatments and was replicated thrice. The treatments consisted of different levels of the recommended dose of fertilizers and biochar application produced from *Prosopis juliflora* wood. The details of treatments included in study are given in Table 1. Recommended dose of NPK fertilizers was 25:50:00 kg $ha^{-1}$ and was applied to all the treatments except in absolute control. Certified seeds of chickpea (JG- 11) were selected for sowing. The seeds were sown on November 9, 2021 by hand dibbling at 30 cm x 10 cm spacing and harvested on February 23, 2022. Five plants from the net plot area were selected randomly and tagged to record the periodical biometric observations at 30 and 60 days after sowing and also at the time of harvest. Plant height was measured from the ground level up to the tip of the plant. The observation on seed yield was recorded at harvest. The economics was worked out based on the prevailing market price for the existing year.

**Table 1. The details of treatments included in the study are as follows**

| | |
|---|---|
| $T_1$ | Absolute control |
| $T_2$ | Recommended dose of fertilizer only (25:50:00 kg $ha^{-1}$) |
| $T_3$ | Biochar @ 2 t $ha^{-1}$ |
| $T_4$ | Biochar @ 4 t $ha^{-1}$ |
| $T_5$ | 50 % RDF + Biochar @ 2 t $ha^{-1}$ |
| $T_6$ | 50 % RDF + Biochar @ 4 t $ha^{-1}$ |
| $T_7$ | 100 % RDF + Biochar @ 2 t $ha^{-1}$ |
| $T_8$ | 100 % RDF + Biochar @ 4 t $ha^{-1}$ |

*Note: RDF- Recommended dose of fertilizer*
*Farmyard manure @ 5 t $ha^{-1}$ is common for all the treatments except $T_1$*
*Zinc sulphate (21%) @ 5 kg $ha^{-1}$ is common for all the treatments except $T_1$*

## 3. RESULTS AND DISCUSSION

The results regarding the average plant height, number of branches per plant and total dry matter production of chickpea at various phases of crop have been significantly influenced by the application of different levels of biochar (Tables 2, 3 and 4 respectively). Treatment with 100 % RDF + biochar @ 4 t $ha^{-1}$ application resulted in significantly increased the plant height and number of branches of chickpea plants. Application of biochar resulted in better soil physical environment and also increased availability of nutrients by improving biological activity and also supplied some amount of nutrients directly to crop plants which resulted in higher plant growth, number of branches and biomass production. Similar results were reported by Laxman Rao et al. (2017) and Lehmann et al. (2003).

**Table 2. Plant height at different growth stages of chickpea as influenced by application of biochar**

| Treatments | Plant height (cm) | | |
|---|---|---|---|
| | **30 DAS** | **60 DAS** | **Harvest** |
| $T_1$ - Absolute control | 19.18 | 28.23 | 35.13 |
| $T_2$ - RDF only (25:50:00) | 20.05 | 34.29 | 41.10 |
| $T_3$ - Biochar @ 2 t $ha^{-1}$ | 19.24 | 32.49 | 36.62 |
| $T_4$ - Biochar @ 4 t $ha^{-1}$ | 19.54 | 33.18 | 37.96 |
| $T_5$ - 50 % RDF + Biochar @ 2 t $ha^{-1}$ | 20.03 | 36.84 | 42.11 |
| $T_6$ - 50 % RDF + Biochar @ 4 t $ha^{-1}$ | 20.28 | 38.99 | 46.28 |
| $T_7$ - 100 % RDF + Biochar @ 2 t $ha^{-1}$ | 20.32 | 39.49 | 47.63 |
| $T_8$ - 100 % RDF + Biochar @ 4 t $ha^{-1}$ | 20.45 | 42.18 | 49.32 |
| **S. Em±** | **0.59** | **1.08** | **1.05** |
| **CD @ 5%** | **NS** | **3.28** | **3.19** |

**Table 3. Number of branches per plant at different growth stages of chickpea as influenced by application of biochar**

| Treatments | Number of branches $plant^{-1}$ | | |
|---|---|---|---|
| | **30 DAS** | **60 DAS** | **Harvest** |
| $T_1$ - Absolute control | 3.29 | 5.01 | 8.00 |
| $T_2$ - RDF only (25:50:00) | 3.64 | 6.01 | 9.00 |
| $T_3$ - Biochar @ 2 t $ha^{-1}$ | 3.29 | 5.34 | 8.33 |
| $T_4$ - Biochar @ 4 t $ha^{-1}$ | 3.63 | 5.67 | 8.66 |
| $T_5$ - 50 % RDF + Biochar @ 2 t $ha^{-1}$ | 3.96 | 6.67 | 9.66 |
| $T_6$ - 50 % RDF + Biochar @ 4 t $ha^{-1}$ | 4.29 | 8.17 | 11.13 |
| $T_7$ - 100 % RDF + Biochar @ 2 t $ha^{-1}$ | 4.63 | 8.34 | 11.33 |
| $T_8$ - 100 % RDF + Biochar @ 4 t $ha^{-1}$ | 4.96 | 8.66 | 12.00 |
| **S. Em±** | **0.61** | **0.23** | **0.29** |
| **CD @ 5%** | **NS** | **0.70** | **0.89** |

**Table 4. Dry matter production at different growth stages of chickpea as influenced by application of biochar**

| Treatments | Dry matter production (g plant$^{-1}$) | | |
|---|---|---|---|
| | **30 DAS** | **60 DAS** | **Harvest** |
| $T_1$ - Absolute control | 1.70 | 7.95 | 21.28 |
| $T_2$ - RDF only (25:50:00) | 1.86 | 8.81 | 25.06 |
| $T_3$ - Biochar @ 2 t ha$^{-1}$ | 1.71 | 8.12 | 23.36 |
| $T_4$ - Biochar @ 4 t ha$^{-1}$ | 1.78 | 8.30 | 23.74 |
| $T_5$ - 50 % RDF + Biochar @ 2 t ha$^{-1}$ | 1.87 | 8.93 | 28.14 |
| $T_6$ - 50 % RDF + Biochar @ 4 t ha$^{-1}$ | 1.88 | 9.45 | 31.21 |
| $T_7$ - 100 % RDF + Biochar @ 2 t ha$^{-1}$ | 1.92 | 9.54 | 32.22 |
| $T_8$ - 100 % RDF + Biochar @ 4 t ha$^{-1}$ | 1.93 | 9.71 | 34.36 |
| **S. Em±** | **0.08** | **0.09** | **1.15** |
| **CD @ 5%** | **NS** | **0.28** | **3.50** |

**Table 5. Number of pods per plant and test weight of chickpea as influenced by application of biochar**

| Treatments | Number of pods plant$^{-1}$ | Test weight (g) |
|---|---|---|
| $T_1$ - Absolute control | 42.41 | 20.65 |
| $T_2$ - RDF only (25:50:00) | 48.19 | 22.77 |
| $T_3$ - Biochar @ 2 t ha$^{-1}$ | 43.55 | 21.35 |
| $T_4$ - Biochar @ 4 t ha$^{-1}$ | 45.76 | 21.76 |
| $T_5$ - 50 % RDF + Biochar @ 2 t ha$^{-1}$ | 52.73 | 23.22 |
| $T_6$ - 50 % RDF + Biochar @ 4 t ha$^{-1}$ | 57.40 | 24.99 |
| $T_7$ - 100 % RDF + Biochar @ 2 t ha$^{-1}$ | 60.02 | 25.08 |
| $T_8$ - 100 % RDF + Biochar @ 4 t ha$^{-1}$ | 61.94 | 25.73 |
| **S. Em±** | **1.56** | **2.06** |
| **CD @ 5%** | **4.74** | **NS** |

**Table 6. Grain yield, stover yield and harvest index of chickpea as influenced by application of biochar**

| Treatments | Grain yield (kg ha$^{-1}$) | Stover yield (kg ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|
| $T_1$ - Absolute control | 1063 | 1420 | 42.80 |
| $T_2$ - RDF only (25:50:00) | 1326 | 1706 | 43.74 |
| $T_3$ - Biochar @ 2 t ha$^{-1}$ | 1205 | 1562 | 43.60 |
| $T_4$ - Biochar @ 4 t ha$^{-1}$ | 1268 | 1685 | 42.95 |
| $T_5$ - 50 % RDF + Biochar @ 2 t ha$^{-1}$ | 1358 | 1720 | 44.08 |
| $T_6$ - 50 % RDF + Biochar @ 4 t ha$^{-1}$ | 1396 | 1748 | 44.40 |
| $T_7$ - 100 % RDF + Biochar @ 2 t ha$^{-1}$ | 1410 | 1763 | 44.42 |
| $T_8$ - 100 % RDF + Biochar @ 4 t ha$^{-1}$ | 1434 | 1766 | 44.83 |
| **S. Em±** | **24.30** | **14.48** | **0.56** |
| **CD @ 5%** | **73.70** | **43.91** | **NS** |

The yield and yield parameters, such as the number of pods per plant, the weight of 100 seeds, the seed yield and the stover yield were also altered (Tables 5 and 6). The increase in the number of pods per plant with the biochar addition was due to increased availability of soil bound nutrients through chelation and their absorption by the plants. An Increase in pod yield may be attributable to the improved nutrient and water retention capacity in the biochar-treated soils (Agegnehu et al., 2015). Biochar application did not show any significant influence on the test weight of chickpeas. Seed and stover yield of chickpeas have a positive relationship with plant growth parameters. Higher seed and stover yields were recorded with 100 % RDF + biochar @ 4 t ha$^{-1}$

**Table 7. Cost economics of biochar usage in chickpea cultivation**

| Treatments | Cost of cultivation (Rs. $ha^{-1}$) | Gross returns (Rs. $ha^{-1}$) | Net returns (Rs. $ha^{-1}$) | Benefit cost ratio |
|---|---|---|---|---|
| $T_1$ - Absolute control | 21100 | 58484 | 37384 | 2.77 |
| $T_2$ - RDF only (25:50:00) | 24082 | 72927 | 48845 | 3.03 |
| $T_3$ - Biochar @ 2 t $ha^{-1}$ | 23100 | 66299 | 43199 | 2.87 |
| $T_4$ - Biochar @ 4 t $ha^{-1}$ | 25100 | 69732 | 44632 | 2.78 |
| $T_5$ - 50 % RDF + Biochar @ 2 t $ha^{-1}$ | 24591 | 74682 | 50091 | 3.04 |
| $T_6$ - 50 % RDF + Biochar @ 4 t $ha^{-1}$ | 26591 | 76807 | 50216 | 2.89 |
| $T_7$ - 100 % RDF + Biochar @ 2 t $ha^{-1}$ | 26082 | 77543 | 51461 | 2.97 |
| $T_8$ - 100 % RDF + Biochar @ 4 t $ha^{-1}$ | 28082 | 78893 | 50811 | 2.81 |
| **S. Em. ±** | | | **1336.55** | **0.05** |
| **CD @ 5%** | | | **4053.99** | **0.17** |

which is superior to absolute control. It might be due to a better-balanced absorption of vital nutrients and their translocation to economic sections, as well as an increase in yield attributing characteristics such as number of pods, dry weight per plant and test weight. Major et al. (2010) and Van Zwieten et al. (2010) registered these responses with the demand threshold.

The higher cost of cultivation was observed with 100 % RDF + biochar @ 4 t $ha^{-1}$. This was due to external supply of inorganic fertilizers and the application of biochar sources. The lowest cost of cultivation was observed in absolute control followed by Biochar @ 2 t $ha^{-1}$. Further, 100 % RDF was recorded as the lower cost of cultivation due to no external supply of biochar. Among the different treatments, the application of inorganic fertilizers in combination with biochar has observed the higher gross returns and net returns. The 100 % RDF + biochar @ 4 t $ha^{-1}$ realized the highest gross and net returns. The lower gross and net returns were observed in the absolute control (Table 7). Application of 50 % RDF + biochar @ 2 t $ha^{-1}$ recorded a higher benefit-cost ratio compared to all other treatments. This might be due to the higher economic yield obtained as a result of better utilization of nutrients through the application of biochar in combination with chemical fertilizers (Nartey & Zhao, 2014; Yang et al., 2019).

## 4. CONCLUSION

Application of 100 % RDF + biochar @ 4 t $ha^{-1}$ had the best results across all the treatments. But, considering the economics of the chickpea, the treatment which received 50 % RDF + biochar @ 2 t $ha^{-1}$ had greater overall performance. It indicated that use of biochar in crop production has achieved higher chickpea performance the productivity of chickpea crop.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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