IMPACT OF VARIOUS LEVELS OF BIOCHAR ON GROWTH AND YIELD OF CHICKPEA (*Cicer arietinum* L.)

ABSTRACT

An experiment titled "Effect of different levels of biochar on growth and yield of chickpea (Cicer arietinum)" 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 chickpea. Results indicated that the treatment involving 100% recommended dose of fertilizer (RDF) along with 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 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.

Key Words: Biochar, Grain yield, Stover yield and Harvest index.

Introduction

Biochar is a carbon-rich substance, produced by thermal decomposition of organic compounds at a relatively high temperature (<700 °C) under 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 hold a promise to improve the soil quality and yield of crops. The biochar is found to have a positive impact on soil fertility, resulting in an increase in crop yield without causing a hazard to soil and water environment. Moreover, its production and utilizations on a commercial basis is 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 are the most unique characteristics 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. Retuning biochar to the field can quickly improve soil carbon storage, nitrogen content and soil fertility. It can also reduce the emission of greenhouse gases and improve crop yields.

Comment [A1]:
In general, the writing has fulfilled the rules of science. The research methodology has not been fully described. The data from the research results is quite complete, but the data from the research results are not supported by specific statistical analysis. The discussion of the research results is also still very minimal,
References are very few and do not meet the requirements of international journals. A minimum of 20 references need to be added..

In the Results and Discussion section, the author should present the results per sub, such as:
- Plant height,
- Number of branches,
- Dry matter production,
- Grain yield, stover yield and harvest index, and
- Economic costs

Information like this that is urgently needed by readers.

Biochar has a stable and a 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 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 promotionary effects of biochar on growth and yield of Chickpea. Biochar with its higher porous structure and larger surface area are expected to be the perfect forms to withhold and increase the uptake of nutrients in plants.

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 17^{o} 34$^{'}$ N latitude and 76^{o} 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 were replicated thrice. The treatments were consisting of different levels of recommended dose of fertilizers and biochar application produced from *Prosopis juliflora* wood. The details of treatments included for the study are given in table 1. Recommended dose of NPK fertilizers was 25:50:00 kg ha^{-1} 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, 60 days after sowing and also at the time of harvest. Plant height was measured from the ground level up to tip of 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.

Comment [A2]:
•In the method section, it is necessary to add about biochar (the bucket of raw materials, how to make and the characteristics of biochar used in this research

•Research variables, need to be presented and how the measurement method is

•Analysis method; Statistical analysis, it is important to present, to strengthen claims

Table 1: The details of treatments included for the study are as follow

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

Farm yard 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

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 (Table 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

Comment [A3]:
The author should provide complete information on the results of his research. It is recommended that the results and discussions be made per sub-chapter, such as:
- Plant height,
- Number of branches,
- Dry matter production,
- Grain yield, stover yield and harvest index, and
- economic costs.

Thus, complete scientific information about the impact of biochar levels on chickpea growth and yield was obtained

Comment [A4]: Please provide an explanation as to why this treatment level displays the best plant height compared to other treatments

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**

Comment [A5]: What statistical analysis is the basis for, that of the 8 treatments tested, the T8 treatment (100% RDF + Biochar 4 t ha-1 is the best

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**

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 (Table 5 and 6). The increase in number of pods per plant with the biochar addition was due to increased availability of soil bounded nutrients through chelation and their absorption by the plants. 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 test weight of chickpea. Seed and stover yield of chickpea have positive relationship with plant growth parameters. Higher seed and stover yield were recorded with 100 % RDF + biochar @ 4 t ha^{-1} 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 characters 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.

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 higher cost of cultivation was observed with 100 % RDF + biochar @ 4 t ha^{-1}. This was due to external supply of inorganic fertilizers and application of biochar source. The lowest cost of cultivation was observed in absolute control followed by Biochar @ 2 t ha^{-1}. Further, 100 % RDF was recorded the lower cost of cultivation due to no external supply of biochar. Among the different treatments, 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 was observed in the absolute control (Table 7). Application of 50 % RDF + biochar @ 2 t ha^{-1} recorded higher benefit cost ratio compared to all other treatments. This might be due to higher economic yield obtained as a result of better utilization of nutrients through application of biochar in combination with chemical fertilizers.

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**

Comment [A6]:
The results of the analysis in Table 7 should be explained, what is the urgency?

The basis of analysis to determine the treatment that is more economically beneficial, what is the B/C Ratio? Which treatment is more beneficial?

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.

Comment [A7]: The claim that the treatment of 100% RDF + biochar 4 t ha-1, is not supported by the results of its economic cost analysis

The conclusion needs to be reformulated

Referance

Comment [A8]:
•Please add a minimum of 20 references
•References about soil improvement biochar are numerous, please add those that are in accordance with this study

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