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EFFECT OF APPLIED BIOCHAR ON PRODUCTIVITY OF LINSEED

Neha Kumari[1], Asha Kumari Sinha[1*], Shashi Bhushan Kumar[1], Dhirendra Kumar Shahi[1], Nargish Kumari[2], Satish Kumar Pandey[2] and Khushboo Jyotsana Baxla[1]

[1]Department of Soil Science, Birsa Agricultural University, Kanke, Ranchi - 834 006, Jharkhand, India.

[2]Department of Agronomy, Birsa Agricultural University, Kanke, Ranchi - 834 006, Jharkhand, India.

*Corresponding author E-mail : ashasinhabau@gmail.com

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ABSTRACT

This research paper investigates the impact of biochar application on crop yield and soil quality, focusing on its nutrient-enriching and soil-structuring properties. The experiment was conducted with varying level of biochar application on sandy loam soil in linseed crop to study the effect of biochar on growth and yield of linseed crop. The experimental results revealed that significantly higher values of growth parameters *viz*., number of branches per plant and yield attributes *viz*., number of capsules per plant, number of seeds per capsule, seed weight per plant along with higher seed yield (16.76 q/ha) and straw yield (33.51 q/ha) were recorded with application of cob rind biochar 3 t/ha + RDF in every season. Increase in pH, water holding capacity, cation exchange capacity of soil favoured the more availability of nutrients and increased the nutrients uptake and their translocation to economically important parts, may also be attributed to the better uptake of essential nutrients. However, significantly higher nutrient uptake by plant, available N, P, K in soil after harvest were also realized with the application of cob rind biochar 3 t/ha + RDF in every season. Moreover, highest net return (Rs. 50770/ha) and B:C ratio (2.22) was observed with the application of cob rind biochar 3 t/h+RDF at the time of initiation of the project. Based on the results, it could be concluded that higher production from linseed along with improved soil fertility can be obtained by the application of cob rind biochar 3 t/ha + RDF in every season.

Key words : Linseed, Biochar, Yield parameters, Productivity.

Introduction

Linseed (*Linum usitatissimum* L.) also known as flaxseed, is one of the most versatile and useful crops which belongs to the family Linaceae. It is a native to the region extending from the Eastern Mediterranean to India. It is known as Ousahalu in Telugu , Javas or Alashi in Marathi, Alsi in Hindi and Agasi/ Akshiin (Kannada). It is one of the oldest plant species cultivated for oil and fiber. Among *Rabi* oilseed crops in India, linseed occupy the second position *i.e.*, next to rapeseed-mustard in areas as well as production. India is the 4th largest linseed growing country in the world. It is grown mainly for seeds which is used for extracting oil as well as fibre, which is used for manufacturing of linen. The seed contains a good percentage of oil varying from 33% to 47% in different accessions of linseed crop. World production of linseed in 2016 was 27.94 lakh tons harvested from 27.78 lakh ha area (FAOSTAT, 2017). In India, it is grown in an area of 326.01 thousand ha with production of 173.62 thousand tons and productivity of 545 kg/ha whereas in Jharkhand, it is grown in about 52.07 thousand ha with production of 29.68 thousand tonnes and productivity of 570 kg/ha (P.C. Report, 2018-19, AICRP on linseed).

Agricultural waste is often considered as a liability since there is a lack of means to convert it into a valuable resource. An emerging issue in the agricultural sector is the management of crop residues, which can lead to significant problems in crop handling due to their accumulation. Many farmers resort to burning crop residues, resulting in the loss of valuable biomass and nutrients, as well as the release of harmful gases like CO_2, methane and nitrous oxide, contributing to global warming. Maintaining an adequate level of organic matter in the soil is crucial for preserving the soil's physical, chemical, and biological integrity, and for supporting agricultural productivity. A deficiency of organic matter leads to a substantial decline in soil fertility. To address this, converting organic waste into biochar using the pyrolysis process is seen as a promising solution. This approach not only helps sequester carbon naturally in the soil but also reduces farm waste and improves soil quality. Proposing biochar as a soil amendment introduces a novel method to combat human-induced climate change while simultaneously enhancing soil productivity.

Numerous studies conducted by various researchers have extensively documented the positive impact of biochar on plant growth and soil quality across multiple crops. Biochar has been found to enhance soil organic carbon levels, increase water retention capacity, improve cation exchange capacity, adjust pH levels and enhance the availability of nutrients.

Materials and Methods

The field experiment was conducted at Research Farm of Department of Soil Science, Birsa Agricultural University, Ranchi, Jharkhand during Rabi, 2021-22. This experiment was started during the *Rabi* season in 2018. Geographically, Ranchi is located at a longitude of 85°19' E, altitude of 23°17' N and an altitude of 625 m above mean sea level. This site has a tropical climate characterized by hot and wet summers and mild winters. The temperature during summers can rise up to 42°C. The monsoon season lasts from July to September and the state receives an average annual rainfall of 1450mm. The texture of soil is sandy loam soil with pH of 5.4 and EC ,the contents of organic carbon, Available nitrogen (AN), phosphorous (AP), potassium (AK) were 0.24 dS/m, 0.43%,191.30 kg/ha, 14.56 kg/ha, 152.4 kg/ha, respectively. The experiment comprising 7 treatments viz., T_1: RDF, T_2: RDF+ 1.0 t/ha biochar at the time of initiation of the project, T_3: RDF+ 1 t/ha biochar in every season, T4: RDF+ 2.0 t/ha biochar at the time of initiation of the project , T_5: RDF+ 2.0 t/ha biochar in every season, T_6: RDF + 3.0 t/ha biochar at the time of initiation of the project, T_7: RDF+ 3.0 t/ha biochar in every season was laid out in randomized block design with three replications. The biochar was made from maize stone under 350 - 500°C for four hours in the absence or limited supply of oxygen, with contents of organic carbon, nitrogen, phosphorous, potassium of 94.0, 0.32, 0.16 and 1.08%, respectively and had a pH of 7.06.

As per the treatments entire dose of nitrogen, phosphorus and potassium was applied in the form of urea, single super phosphate and muriate of potash (MOP). The biochar, were applied in furrows as basal in respective treatments just before sowing. The linseed variety 'Divya' was sown on November 8, 2021 at row spacing of 30 cm using seed rate of 25 kg per hectare The growth and yield attributes were recorded from the five tagged plants in each plot. Seed and straw yield were recorded from the net plot area and converted into kilogram per hectare. The costs involved in all cultivation operations, ranging from preparatory tillage to harvesting, were calculated and this encompassed expenses related to inputs such as seeds, fertilizers, biochar, irrigation, etc., for each treatment. The calculation was based on the current local charges. To determine the gross realization in rupees per hectare, seed and straw yields from each treatment, along with local market prices, were taken into account. For each treatment, the net return was calculated by subtracting the total cost of cultivation from the gross returns. Furthermore, the benefit-to-cost ratio (B: C) was computed by dividing the gross return by the cost of cultivation.

Results and Discussion

Growth and yield

The results revealed that different treatments manifested significant influence on growth and yield of linseed. The treatment T_7 (Biochar 3 t/ha + RDF) in every season recorded significantly the highest number of primary branches per plant (5.45) and secondary branches per plant (19.34) at harvest (Table 1). This might be due to addition of nutrients through biochar. It may also attributed to better uptake of essential nutrients because of improvement in physical and chemical properties of soil, which favored the more availability of nutrients thereby increased the nutrients uptake and its translocation to economic parts which resulted in improvement in number of primary branches per plant. Similar findings were also reported by Kamara *et al*. (2014), Partey *et al*. (2014), Gokila and Basker (2017), Coumaravel *et al*. (2015), Imran *et al*. (2014) and Cornelissen *et al*. (2013). An appraisal of data (Table 2) indicated that significantly the most number of capsules per plant (24.85), number of seed per capsule (5.80), seed weight per plant (6.68 g) were recorded with the treatment T7 (Biochar 3 t/ha + RDF) in every season). A scrutiny of data (Table 3) further revealed that application of biochar 3 t/ha + RDF (T_7) established its superiority by producing significantly the highest seed yield (1676 kg/ha) and straw yield (3351 kg/ha). The beneficial effects of biochar on yield and yield attributes seems to be due to the addition of greater quantities of biochar, as

Table 1 : Effect of biochar application on number of branches per plant.

Treatments	Primary branch/plant	Secondary branch/plant
T_1: RDF	3.45	14.54
T_2: RDF+1.0ton/ha biochar (Once- At the time of starting the project	4.55	15.62
T_3: RDF+1.0 ton/ha biochar (Every season)	4.78	17.05
T_4: RDF+2.0 ton/ha biochar (Once- At the time of starting the project)	4.64	16.04
T_5: RDF+2.0 ton/ha biochar (Every season)	5.38	18.32
T_6: RDF+3.0 ton/ha biochar (Once- At the time of starting the project)	4.68	16.68
T_7: RDF+3.0 ton/ha biochar (Every season)	5.45	19.34
CD (P=0.05)	**0.79**	**2.43**
CV (%)	9.50	8.16

Table 2 : Effect of biochar application on yield parameters of Linseed.

Treatments	Capsules/ plant	Seeds/capsule	1000 seed weight (g)
T_1: RDF	19.20	4.49	6.28
T_2: RDF+1.0ton/ha biochar (Once- At the time of starting the project	20.48	4.87	6.37
T_3: RDF+1.0 ton/ha biochar (Every season)	23.26	5.35	6.57
T_4: RDF+2.0 ton/ha biochar (Once- At the time of starting the project)	21.36	4.96	6.43
T_5: RDF+2.0 ton/ha biochar (Every season)	23.96	5.70	6.60
T_6: RDF+3.0 ton/ha biochar (Once- At the time of starting the project)	22.40	5.20	6.53
T_7: RDF+3.0 ton/ha biochar (Every season)	24.85	5.80	6.68
CD (P=0.05)	**3.49**	**0.59**	**NS**
CV (%)	8.84	6.45	5.22

Table 3 : Effect of biochar application on seed yield and straw yield of Linseed.

Treatments	Seed yield (q/ha)	Straw yield (q/ha)	Harvest Index
T_1: RDF	13.57	26.93	33.49
T_2: RDF+1.0 ton/ha biochar (Once- At the time of starting the project	14.69	30.71	32.36
T_3: RDF+1.0 ton/ha biochar (Every season)	16.09	32.41	33.18
T_4: RDF+2.0 ton/ha biochar (Once- At the time of starting the project)	15.24	30.80	33.10
T_5: RDF+2.0 ton/ha biochar (Every season)	16.32	33.51	32.75
T_6: RDF+3.0 ton/ha biochar (Once- At the time of starting the project)	15.84	32.41	32.83
T_7: RDF+3.0 ton/ha biochar (Every season)	16.76	33.51	33.34
CD (P=0.05)	**1.27**	**3.99**	**NS**
CV(%)	8.57	7.11	5.19

it improves soil nutrients, enhances cation exchange capacity, reduces soil acidity and promotes soil structure. Additionally, biochar enhances nutrient use efficiency, water-holding capacity and carbon sequestration. Biochar also improves soil physical properties by enhancing its own micro-porous structure and amending the soil's chemical properties through its stronger adsorption capacity and abundance of nutrient elements. Similar

Table 4 : Effect of biochar application on nutrient uptake by linseed crop.

Treatments	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)
T_1: RDF	49.50	12.05	35.57
T_2: RDF+1.0 ton/ha biochar (Once- At the time of starting the project	56.39	13.39	40.60
T_3: RDF+1.0 ton/ha biochar (Every season)	63.07	12.73	39.29
T_4: RDF+2.0 ton/ha biochar (Once- At the time of starting the project)	57.20	12.06	42.53
T_5: RDF+2.0 ton/ha biochar (Every season)	69.14	13.13	44.18
T_6: RDF+3.0 ton/ha biochar (Once- At the time of starting the project)	61.48	12.56	39.31
T_7: RDF+3.0 ton/ha biochar (Every season)	72.24	16.67	50.97
CD (P=0.05)	**7.18**	**3.99**	**5.34**
CV (%)	7.83	8.48	7.18

Table 5 : Effect of biochar application on economics of Linseed.

Treatments	Cost of cultivation (` /ha)	Gross return (` /ha)	Net return (` /ha)	B:C ratio
T_1: RDF	22888	62918.60	40030.60	1.75
T_2: RDF+1.0 ton/ha biochar (Once- At the time of starting the project	25388	68454.20	43066.20	1.70
T_3: RDF+1.0 ton/ha biochar (Every season)	23245	74708.20	51463.20	2.21
T_4: RDF+2.0 ton/ha biochar (Once- At the time of starting the project)	27888	70784.00	42896.00	1.54
T_5: RDF+2.0 ton/ha biochar (Every season)	23602	75916.20	52314.20	2.22
T_6: RDF+3.0 ton/ha biochar (Once- At the time of starting the project)	30388	73658.20	43270.20	1.42
T_7: RDF+3.0 ton/ha biochar (Every season)	23959	77764.20	53805.20	2.25
CD (P=0.05)		**6790**	**4453**	**0.17**
CV (%)		5.33	5.32	5.28

findings were also reported by Kamara *et al*. (2014), Partey *et al*. (2014), Ndor *et al*. (2015). The increase in seed yield was attributed to remarkable improvement in almost all the growth and yield attributes under these treatments.

Nutrients uptake

The data given in Table 4 showed that application of biochar 3.0 t/ha + RDF (T_7) recorded significantly the highest uptake of nitrogen (72.24 kg/ha), phosphorus (16.67 kg/ha) and potassium (50.97 kg/ha). The application of biochar may have significantly reduced leaching, which would have enhanced nitrogen retention and, in turn, nitrogen intake. Similar findings were reported by uptake Agegnehu *et al*. (2016), Laxman Rao *et al*. (2017). The increase in phosphorus uptake in the biochar-treated soil may be attributed to the ability of biochar to maintain a higher concentration of these nutrients in the soil solution, which reduces their leaching. Similar findings were reported by Agegnehu *et al*. (2016) and Supriyadi *et al*. (2012) The increased cation exchange capacity of biochar resulted in lower losses of potassium from the soil, which in turn led to an increase in its uptake. When biochar was added to the soil its surface oxidation by biotic and abiotic agents resulted in development of negative charges that give ability to biochar to sorbs more cations like potassium which leads to increase in uptake of nutrients easily. Similar findings were reported by Danish *et al*. (2014).

Economics

The data on economics (Table 5) revealed that the maximum net return Rs 50770/ha was realized with treatment T_6 (Biochar 3 t/ha + RDF) at the time of initiation of the project whereas, the lowest net return (Rs 40030/ ha) was realized in the treatment T_1 (RDF) at the time of initiation of the project. The data (Table 5) further indicated that the highest B:C (2.22) was obtained with the treatment T_6 (Biochar 3 t/ha + RDF) at the time of initiation of the project. The highest net return and B:C ratio gained in the treatment T_6 is mainly due to may be due to reduction in labour cost.

Conclusion

Based on the findings obtained from the experiments, it can be reasonably inferred that the positive impacts of biochar on both crop yield and yield attributes are primarily attributed to the application of larger quantities of biochar. This phenomenon is associated with its ability to enhance soil nutrients, increase cation exchange capacity, alleviate soil acidity, and improve overall soil structure. Furthermore, the incorporation of biochar leads to heightened nutrient utilization efficiency, improved water retention capacity and enhanced carbon sequestration. Moreover, the introduction of biochar contributes to the enhancement of soil physical properties, achieved through its micro-porous structure and its role in amending soil chemistry through efficient adsorption and an abundance of nutrient elements.

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