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BIOCHAR BOOST: UNLOCKING THE OPTIMUM PRIMING CONCENTRATION FOR CLUSTER BEAN SEEDS

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ABSTRACT

A laboratory experiment was conducted to identify the optimum concentration of biochar for seed priming in cluster bean at the Department of Seed Science and Technology, University of Agricultural Sciences, Raichur during *Kharif* 2024–25. The experiment was laid out in a Completely Randomized Design with seven treatments and four replications. Treatments included control (no priming), hydropriming and seed priming with biochar at 1%, 3%, 5%, 7% and 9%. Seed priming with 5% biochar significantly improved seed quality parameters, recording the highest seed germination (94.25%), lowest hard seed percentage (4.88%), seedling length (21.43 cm), seedling dry weight (20.70 mg), seedling vigour index-I (2020) and II (1952). Seeds primed with higher concentrations (7% and 9%) showed slightly lower performance, while the control recorded the lowest values and the highest hard seed percentage (9.83%). The findings indicate that 5% biochar is the most effective concentration for seed priming to enhance germination, reduce hard seeds and improve seedling growth and vigour under laboratory conditions.

***Keywords* :** Cluster bean, Seed priming, Biochar, Seed germination and Seedling vigour.

Introduction

Cluster bean is an important leguminous crop of the family Fabaceae. It is recognized as a drought tolerant crop that thrives well in arid and semi-arid regions widely cultivated for its tender pods used as vegetable and fodder. The seeds are rich in protein, fiber and hydrocolloids and guar gum extracted from the endosperm is extensively used in food, pharmaceutical, paper and textile industries (Singh *et al*., 2020). Besides its industrial significance, the crop plays a vital role in sustainable agriculture through nitrogen fixation and as a source of green manure.

Despite its multiple uses, the productivity of cluster bean is often affected by poor seed quality, low germination percentage and uneven seedling emergence (Kumar *et al*., 2017). Seed germination and early seedling growth are critical phases that determine crop stand and yield potential to overcome this problem presowing seed priming as to be done with biochar have been developed to enhance seed performance. Biochar priming involves soaking seeds in a solution containing biochar extract, which improves nutrient availability, enhances microbial activity and stimulates seed metabolism, leading to improved germination and seedling vigour (Accinelli., 2023).

Materials and Methods

The laboratory experiment was conducted in Department of Seed Science and Technology, University of Agricultural Sciences, Raichur, Karnataka, India during 2024–25 to identify the optimum concentration of cotton biochar for seed priming in cluster bean of Naveen variety. The experiment was laid out in a Completely Randomized Design (CRD) with four replications.

The experiment consisted of seven treatments with four replications to identify the optimum biochar concentration for seed priming in cluster bean. Treatment T_1 served as the control with no seed priming, while T_2 consist hydropriming with distilled water. Treatments T_3, T_4, T_5, T_6, and T_7 involved seed priming with biochar at concentrations of 1%, 3%, 5%, 7%, and 9%, respectively. Cotton stalk biochar solutions of different concentrations were prepared by dissolving 1, 3, 5, 7, and 9 g of biochar in 100 ml of distilled water. Cluster bean seeds were soaked in the respective biochar solutions at 1:1 seed to solution ratio for 20 hours at room temperature (25 ± 2°C). After the priming period, the seeds were removed, spread uniformly on blotting paper and air-dried under shade for 12 hours to restore their original moisture content. The dried, primed seeds were then used for assessing seed quality parameters. The observations recorded on seed germination (%), hard seed (%), seedling length (cm), seedling dry weight (mg) and seedling vigour index –I and II.

Seed Germination (%): The standard germination test was conducted with four replications of 100 seeds each by the between-paper method. Rolled towels were incubated in a walk-in seed germination chamber maintained at 25 ± 2°C and 90 ± 5% relative humidity. Final count was recorded on the 8th day. Normal seedlings were counted and expressed as percentage germination (ISTA, 2013).

Hard seed (%): The hard seed test was carried out simultaneously with the standard germination test in four replications of 100 seeds each. After soaking in water, seeds that failed to imbibe water were considered hard seeds. The number of hard seeds from each replication was counted.

Seedling Length (cm): Seedling length was calculated by summing shoot and root lengths. Mean seedling length was expressed in centimeters (ISTA, 2013).

Seedling dry weight (mg): Ten seedlings used for length measurement were placed in butter paper bags and dried in a hot air oven at 70 ± 2°C for 24 hours. After cooling in a desiccator for 20 minutes, seedlings were weighed using an electronic balance. Mean seedling dry weight was expressed in milligrams (ISTA, 2013).

Seedling vigour index I: Calculated by multiplying seed germination (%) with seedling length (cm) and expressed as a whole number (Abdul Baki and Anderson, 1973).

SVI I = Seed germination (%) × Seedling length (cm)

Seedling vigour index II: Calculated by multiplying seed germination (%) with seedling dry weight (mg) and expressed as a whole number (Abdul Baki and Anderson, 1973).

SVI II = Seed germination (%) × Seedling dry weight (mg)

Results and Discussion

The results showed that different concentration of biochar seed priming had shown significant differences for seed germination (%) hard seed (%), seedling length (cm), seedling dry weight (mg) and seedling vigour indices I and II which are presented in Tables 1 and 2.

Biochar priming significantly influenced germination (Table 1). Seeds primed with 5% biochar (T_5) recorded the highest germination (94.25%), followed by 7% biochar (T_6, 93.25%), while control seeds (T_1) recorded the lowest (85.50%). The improvement in germination is attributed to enhanced water retention and nutrient availability, which facilitates enzymatic activation and mobilization of stored reserves. Similar results were reported by Khadem *et al*. (2014) in wheat and Jatav and Mishra (2018) in soybean, where biochar priming enhanced germination through improved moisture and metabolic activation.

Biochar priming reduced hard seed percentage. The lowest hard seed content was observed in 5% biochar (T_5, 4.88%), whereas control seeds (T_1) showed the highest (9.83%). The decrease in hard seeds suggests improved seed coat permeability, enhancing water imbibition. A slight increase at higher concentrations (7% and 9%) may result from overexposure. Similar observations were reported by Suthar and Singh (2022) in chickpea and Kiruthiga *et al*. (2019) in finger millet. 5% biochar (T_5) produced the longest seedlings (21.43 cm), on par with 7% (T_6, 20.73 cm). Control seedlings were shortest (T_1, 16.53 cm). Marginal declines beyond 5% indicate that excessive biochar may induce osmotic stress or accumulate inhibitory compounds. Similar trends were reported in finger millet by Kiruthiga *et al*. (2019) and in rice by Ramachandran and Kavitha (2022).

Seed priming with 5% biochar (T_5, 20.70 mg) produced the highest dry weight, followed by 7% (T_6, 20.30 mg), while control seedlings (T_1, 15.70 mg) had the lowest. Enhanced biomass accumulation results from efficient nutrient release, water uptake, and metabolic activation. These findings are in agreement with Kumari *et al*. (2020) in green gram, Suthar and Singh (2022) in chickpea and Uddin *et al*. (2021) in mustard.

5% biochar priming (T_5, 2020) recorded the highest SVI I, followed by 7% (T_6, 1930), with control seeds showing the lowest value (T_1, 1410). Improvement in SVI I reflects enhanced germination coupled with increased seedling length, consistent with results in finger millet by Kiruthiga *et al*. (2019) and in rice by Zhang *et al*. (2021). Maximum SVI II was observed in 5% biochar (T_5, 1952), followed by 7% (T_6, 1893), and the lowest in control (T_1, 1343). Enhancement in SVI II indicates better biomass accumulation and metabolic activity, similar to reports in green gram by Kumari *et al*. (2020) and in Brassica juncea by Uddin *et al*. (2021).

Table 1: Effect of biochar seed priming on seed germination, hard seeds and seedling length of cluster bean

Treatment	Seed germination (%)	Hard seed (%)	Seedling length (cm)
T_1: Control (No priming)	85.50 (67.45)	9.83 (17.92)	16.53
T_2: Hydropriming	88.75 (70.28)	8.09 (16.30)	17.80
T_3: Seed priming with biochar at 1%	90.50 (71.97)	6.83 (14.96)	18.60
T_4: Seed priming with biochar at 3%	92.00 (73.70)	5.68 (13.67)	19.75
T_5: Seed priming with biochar at 5%	94.25 (76.21)	4.88 (12.70)	21.43
T_6: Seed priming with biochar at 7%	93.25 (74.80)	5.83 (13.80)	20.73
T_7: Seed priming with biochar at 9%	91.25 (72.86)	6.81 (14.93)	19.40
Mean	90.80 (72.33)	6.85 (14.90)	19.18
S.Em. ±	0.73	0.19	0.40
CD @ 1 %	2.18	0.78	1.57

Table 2: Effect of biochar seed priming seedling dry weight and seedling vigour indices of cluster bean

Treatment	Seedling dry weight (mg)	Seedling vigour index-I	Seedling vigour index-II
T_1 : Control (No priming)	15.70	1410	1343
T_2: Hydropriming	17.30	1578	1536
T_3: Seed priming with biochar at 1%	18.40	1682	1666
T_4: Seed priming with biochar at 3%	19.30	1820	1776
T_5: Seed priming with biochar at 5%	20.70	2020	1952
T_6: Seed priming with biochar at 7%	20.30	1930	1893
T_7: Seed priming with biochar at 9%	19.40	1772	1771
Mean	18.73	1745	1705
S.Em. ±	0.21	28.70	30.88
CD @ 1 %	0.83	84.30	123.63

Conclusion

Biochar priming at 5% concentration consistently improved germination, seedling growth, and vigour in cluster bean. Concentrations above 5% did not offer additional benefits and in some cases slightly reduced performance, emphasizing the importance of optimizing biochar levels for effective seed priming.

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