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Effect of enriched biochar on seedlings growth of jackfruit

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Abstract
Biochar is a carbon rich product being used in production of many horticultural crops; the production of quality planting material is the key to enhance the yield and quality of the crops. The study on use of biochar for the production of quality seedlings of jackfruit was undertaken with view of minimizing the cost of production of seedlings in eight treatments with three replication. The application of soil, sand and organic biochar in the ratio of 2:1:1 to a rooting media was found to enhance the germination percentage (100%), rate of germination (1.63) and seedling vigour (3667). The growth attributes such as seedling height (64.67 cm), girth (8.07 mm), number of leaves (7.13), leaf area (123.44 cm^2) and root attributes like root length (31.67 cm), root volume (18.30 ml) and root biomass (18.0 g) at 120 days after germination was found to be maximum in T_2. The benefit cost ratio (1.97:1) was observed maximum in same potting mixture.

Keywords: Biochar, germination attributes, FYM, Growth attributes, CHB

Introduction
A success of a jackfruit nursery lies on raising good quality rootstock for grafting. Propagation media is one of the most important input for better seedling production. Media not only acts as a growing place but also as a source of nutrient for plant growth (Ramteke *et al*., 2015) [9]. Hence, it is of prime importance to standardize the suitable media composition for commercial production of jackfruit seedling for grafting. Generally, soil + FYM + sand are used as a potting mixture for production of seedling as a rootstock. Due to the higher cost of sand and FYM, the cost incurred in production of rootstocks will be more. On this background a search for alternatives for replacement of sand and FYM partially by some other easily available components as a growing media constitute an immediate requirement.
Biochar is a carbon rich product being used in production of many horticultural crops; In recent years, addition of biochar to the agricultural soil has emerged a feasible strategy to enhance crop productivity and soil fertility (Major *et al*., 2010) by increasing the net soil surface area (Chan *et al*., 2008) [5] which consequently improves the soil water retention and soil aeration (Baronti *et al*., 2014) [1].
Hence the present study is aimed at standardizing the potting mixture by using enriched biochar as one of the component to obtain quality planting material of jackfruit by reducing the growth period and facilitate the production of quality planting material reasonably at the earliest without waiting for long.

Material and Methods
The experiment on production of quality jackfruit seedlings through enriched biochar in potting mixture was conducted in shade house at College of Horticulture, Bengaluru which is situated at a latitude of N13^{0}5'25.472" and at a longitude of E77^{0}33'40.605" with an altitude of 930 meters above the sea level.

Biochar preparation
The coconut husk biochar (CHB) was used in present investigation. It was prepared by using drum method. The biochar was ground to pass through 0.2 mm sieve and used for chemical analysis.

Characterization of biochar
The biochar collected after the production was enriched with cow urine, cowdung slurry and considered as organic biochar, and the one enriched with 19:19:19, 19:19:19 + Zn and B as

inorganic biochar. After soaking for 24 hours, they were analyzed for physical and chemical parameters according to the standard procedure.

For further research biochar enriched with cow dung slurry as a organic biochar and 19:19:19+Zn and B as a inorganic biochar was used because, it showed the best results compared to other treatment with respect to nutrient content.

Media preparation

Table 1: Quantity of biochar applied to the each treatment

Treatment details	Quantity of biochar
T_1: 2:1:1 (Soil: Sand: FYM) T_6: 2:1 (Soil: FYM)	No biochar added
T_2: 2:1:1 (Soil: Sand: Biochar organic) T_4: 2:1:1 (Soil: FYM: Biochar organic)	250 g of enriched biochar with cowdung slurry in 1 kg potting mixture
T_3: 2:1:1 (Soil: Sand: Biochar inorganic) T_5: 2:1:1 (Soil: FYM: Biochar inorganic)	250 g of enriched biochar with 19:19:19 + Zn and B in 1 kg potting mixture
T_7: 2:1 (Soil: Biochar organic)	333 g of enriched biochar with cowdung slurry in 1 kg potting mixture
T_8: 2:1 (Soil: Biochar inorganic)	333 g of enriched biochar with 19:19:19 + Zn and B in 1 kg potting mixture

Eight treatments with three replications were examined in this study: T_1: 2:1:1 (Soil: Sand: FYM) control, T_2: 2:1:1 (Soil: Sand: Biochar organic), T_3: 2:1:1 (Soil: Sand: Biochar inorganic), T_4: 2:1:1 (Soil: FYM: Biochar organic), T_5: 2:1:1 (Soil: FYM: Biochar inorganic), T_6: 2:1 (Soil: FYM), T_7:2:1(Soil: Biochar organic) and T_8:2:1 (Soil: Biochar inorganic). Jackfruit seeds were sown in the month of August and was studied until the seedlings attain graftable thickness.

Plant growth monitoring

Five plants were selected from each replication for recording observations in each treatment. The growth parameters were recorded at 30 days interval from the date of germination till the attainment of graft able thickness. Germination and growth attributes such as initiation of germination, germination percentage, rate of germination, seedling vigour index, seedling height, girth, number of leaves, leaf area, root length, root biomass and seedling biomass were recorded at 30 days interval from days of germination.

Results and Discussion

Table 2: Effect of enriched biochar on germination attributes of jack

Treatments	Initiation of germination (days)	Germination percentage (%)	Rate of germination	Seedling vigour
T_1	18.67	93.33	1.62	2395.26
T_2	18.33	100.00	1.63	3667.00
T_3	18.33	100.00	1.63	2700.00
T_4	18.67	100.00	1.62	2367.00
T_5	18.67	100.00	1.61	2467.00
T_6	18.67	96.67	1.61	2030.02
T_7	19.00	93.33	1.61	1757.13
T_8	18.67	96.67	1.61	1965.10
S.Em ±	NS	NS	NS	0.11
CD @ 5%	NS	NS	NS	0.33

Note:

T1: 2:1:1 (Soil: Sand: FYM) control
T2: 2:1:1 (Soil: Sand: Biochar organic)
T3: 2:1:1 (Soil: Sand: Biochar inorganic)
T4: 2:1:1 (Soil: FYM: Biochar organic)
T5: 2:1:1 (Soil: FYM: Biochar inorganic)
T6: 2:1 (Soil: FYM)
T7: 2:1(Soil: Biochar organic)
T8: 2:1 (Soil: Biochar inorganic)

There was no significant difference observed among the treatments with regard to days for the first germination, germination percentage and rate of germination. Significantly maximum seedling vigour (3667) was observed in T_2 [2:1:1 (Soil: Sand: Biochar organic)] and was followed by T_3 [2:1:1 (Soil: Sand: Biochar inorganic)] with seedling vigour (2700). The minimum seedling vigour (1757.13) was recorded in T_7 [2:1 (Soil: Biochar organic)].

Biochar contains organic compounds that may impact on plant germination and growth of seedling. The presence of small quantities of toxic components in biochar may induce a hormeotic response, which has a positive influence on lowering the levels of chemical which show inhibitory effect on seedling germination or plant growth of wheat (Solaiman *et al*., 2012) [11].

Table 3: Effect of enriched biochar on seedling height (cm) of jack

Treatments	Days after germination			
	30	60	90	120
T_1: 2:1:1 (Soil: Sand: FYM) control	16.83	32.07	50.93	61.03
T_2: 2:1:1 (Soil: Sand: Biochar organic)	18.47	33.00	53.51	64.67
T_3: 2:1:1 (Soil: Sand: Biochar inorganic)	17.53	32.27	51.30	64.07
T_4: 2:1:1 (Soil: FYM: Biochar organic)	16.67	30.23	51.07	58.97
T_5: 2:1:1 (Soil: FYM: Biochar inorganic)	16.73	31.57	51.27	59.73
T_6: 2:1 (Soil: FYM)	15.70	30.20	50.21	58.40
T_7: 2:1 (Soil: Biochar organic)	13.70	26.53	47.66	57.03
T_8: 2:1 (Soil: Biochar inorganic)	15.30	28.97	48.00	58.00
S.Em ±	0.46	1.11	0.41	1.37
CD@ 5%	1.33	3.33	1.22	4.10

The maximum seedling height of 18.47, 33.00 and 64.67 cm was recorded in T_2 [2:1:1 (Soil: Sand: Biochar organic)] and was on par with T_3 [2:1:1 (Soil: Sand: Biochar inorganic)] with seedling height of 17.53, 32.27 and 64.07 cm at 30, 60 and 120 days after germination respectively. The significantly maximum seedling height of 53.51 cm was noticed in T_2 [2:1:1 (Soil: Sand: Biochar organic)] at 90 days after germination. The minimum seedling height of 13.70, 26.53, 47.66 and 57.03 cm was found in T_7 [2:1(Soil: Biochar organic)] at 30, 60, 90 and 120 days after germination respectively, as shown in Table 3.

Table 4: Effect of enriched biochar on seedling girth (mm) of jack

Treatments	Days after germination			
	30	60	90	120
T_1: 2:1:1 (Soil: Sand: FYM) control	3.68	4.70	5.58	7.56
T_2: 2:1:1 (Soil: Sand: Biochar organic)	3.91	5.16	5.83	8.07
T_3: 2:1:1 (Soil: Sand: Biochar inorganic)	3.79	5.10	5.80	7.93
T_4: 2:1:1 (Soil: FYM: Biochar organic)	3.56	4.05	5.20	7.40
T_5: 2:1:1 (Soil: FYM: Biochar inorganic)	3.62	4.14	5.38	7.59
T_6: 2:1 (Soil: FYM)	3.53	4.02	5.17	7.27
T_7: 2:1 (Soil: Biochar organic)	3.47	3.91	5.03	7.09
T_8: 2:1 (Soil: Biochar inorganic)	3.51	3.95	5.09	7.14
S.Em ±	NS	0.25	0.16	0.03
CD@ 5%	NS	0.74	0.44	0.07

The data presented in the Table 4 reveals that, there was no significant differences for seedling girth was observed on 30 days after sowing. However, the maximum seedling girth of 5.16 and 5.83 mm was observed in T_2 [2:1:1 (Soil: Sand: Biochar organic)] and was statistically on par with T_3 [2:1:1 (Soil: Sand: Biochar inorganic)] having the seedling girth of 5.10 and 5.80 at 60 and 90 days after germination respectively. Significantly maximum seedling girth of 8.07 mm was noticed in T_2 at 150 days after germination. The minimum seedling girth of 3.91, 5.03 and 7.09 mm was found in T_7 [2:1 (Soil: Biochar organic)] at 60, 90 and 120 days after germination respectively.

Table 5: Effect of enriched biochar on number of leaves of jack

Treatments	Days after germination			
	30	60	90	120
T_1: 2:1:1 (Soil: Sand: FYM) control	3.00	5.27	5.97	6.87
T_2: 2:1:1 (Soil: Sand: Biochar organic)	3.00	4.67	5.93	7.13
T_3: 2:1:1 (Soil: Sand: Biochar inorganic)	3.00	4.73	5.60	7.11
T_4: 2:1:1 (Soil: FYM: Biochar organic)	3.00	4.37	4.57	7.07
T_5: 2:1:1 (Soil: FYM: Biochar inorganic)	3.00	4.67	5.30	7.03
T_6: 2:1 (Soil: FYM)	3.00	4.47	4.67	7.03
T_7: 2:1 (Soil: Biochar organic)	3.00	4.67	4.87	6.18
T_8: 2:1 (Soil: Biochar inorganic)	3.00	4.80	5.07	6.60
S. Em ±	NS	NS	NS	NS
CD@ 5%	NS	NS	NS	NS

The data on number of leaves per seedling are presented in the Table 5. There was no significant difference observed among the treatments with regard to number of leaves.

Table 6: Effect of enriched biochar on leaf area (cm^2) of jack

Treatments	Days after germination	
	90	120
T_1: 2:1:1 (Soil: Sand: FYM) control	95.63	106.49
T_2: 2:1:1 (Soil: Sand: Biochar organic)	106.56	123.44
T_3: 2:1:1 (Soil: Sand: Biochar inorganic)	100.46	118.13
T_4: 2:1:1 (Soil: FYM: Biochar organic)	82.13	99.93
T_5: 2:1:1 (Soil: FYM: Biochar inorganic)	88.46	103.35
T_6: 2:1 (Soil: FYM)	79.59	93.43
T_7: 2:1 (Soil: Biochar organic)	77.88	92.43
T_8: 2:1 (Soil: Biochar inorganic)	79.39	92.77
S.Em ±	0.25	0.30
CD@ 5%	0.74	0.89

The maximum leaf area (106.56 and 123.44 cm^2) was noticed in T_2 [2:1:1 (Soil: Sand: Biochar organic)] and was followed by T_3 [2:1:1 (Soil: Sand: Biochar inorganic)] with leaf area (100.46 and 118.13 cm^2) at 90 and 120 days after germination respectively. The minimum leaf area of 77.88 and 92.43 cm^2 was recorded in T_7 [2:1 (Soil: Biochar organic)] at 90 and 120 days after germination respectively as shown in Table 6.

When biochar was enriched with cow dung slurry, the availability of nutrients will be more to the plants. Hence, the increase in plant height and girth was noticed. The results were in conformity with the observation made by Changxun *et al*. (2016) [6] after application of biochar to red soil increased growth attributes of *Poncirus trifoliate*. Biochar application can increase soil fertility and nutrient retention to a greater extent than uncharred organic matter (Lehmann *et al*., 2006) [7].

Biochar usually has the potential of activating soil microorganisms and increasing the water retention capacity of the soil thereby increasing photosynthetic rate and consequent increase in growth of citrus plants (Changxun *et al*., 2016) [6]. This might be the reason for increase in leaf area of the plants.

Table 7: Effect of enriched biochar on root parameters and seedling biomass of jack after 120 days of germination

Treatments	Root length (cm)	Root volume (ml)	Root biomass (g)	Seedling biomass (g)
T_1: 2:1:1 (Soil: Sand: FYM) control	25.67	17.30	16.67	46.00
T_2: 2:1:1 (Soil: Sand: Biochar organic)	31.67	18.30	18.00	46.33
T_3: 2:1:1 (Soil: Sand: Biochar inorganic)	27.00	18.00	17.33	46.00
T_4: 2:1:1 (Soil: FYM: Biochar organic)	23.67	16.00	16.30	44.33
T_5: 2:1:1 (Soil: FYM: Biochar inorganic)	24.67	16.00	16.30	45.33
T_6: 2:1 (Soil: FYM)	21.00	15.30	15.83	44.33
T_7: 2:1 (Soil: Biochar organic)	18.83	12.70	14.33	42.33
T_8: 2:1 (Soil: Biochar inorganic)	20.33	15.30	15.50	43.00
S.Em ±	0.62	0.55	0.5	0.78
CD@ 5%	1.87	1.67	2.4	2.36

Data on root length and volume per seedling is presented in Table 7. The maximum root length of 31.67 cm and 18.30 ml was noticed in T_2 [2:1:1 (Soil: Sand: Biochar organic)] and was followed by T_3 [2:1:1 (Soil: Sand: Biochar inorganic)] with root length of 27.00 cm and 18.00 ml at 120 days after germination. The minimum root length of 18.83 cm and 12.70 ml was recorded in T_7 [2:1 (Soil: Biochar organic)].

Cavalcante *et al*. (2012) stated that, the root system is in direct contact with the substrate and thus the positive or negative effects of the growth medium can influence the performance of yellow passion fruit seedlings. Therefore, the activated biochar when added to growing media showed beneficial effects in the production of passion fruit seedlings (Barros *et al*., 2017) [2].

The data on root and seedling biomass is presented in Table 7. The maximum root biomass was 18.00 g and 46.33 g found in T_2 [2:1:1 (Soil: Sand: Biochar organic)].The minimum root biomass of 14.33 g and 42.33 g was recorded in T_7 [2:1 (Soil: Biochar organic)].

The increase in root and seedling biomass might be due to the

application of enriched biochar with cow dung slurry which helps in altering the soil physical structure (bulk density) and modifies the soil chemical properties (pH, CEC and nutrient supply) as quoted by Carter *et al*. (2013) [13] in lettuce. Crop yields increases in combination of biochar with organic fertilizers (Schmidt and Noack, 2000) [10].

Conclusion

In organic and inorganic combinations of enriched biochar, the biochar enriched with cow dung slurry and 19: 19: 19 (NPK) + zinc and boron were recorded maximum nutrient contents compared to other combinations. The potting mixture consisting of soil: sand: biochar organic in the ratio 2:1:1 was found superior over other combinations with respect to seedling germination and growth parameters including root attributes and seedling biomass jack. Hence, the potting mixture consisting of soil: sand: biochar organic in the ratio 2:1:1 may be adopted by nurserymen for commercial production of quality seedling materials by excluding FYM.

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