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Impact of various media on shoot and root growth parameters of jackfruit (*Artocarpus heterophyllus* Lam.) under protected condition

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Abstract
The present investigation entitled "Impact of various media on shoot and root growth parameters of jackfruit (*Artocarpus heterophyllus* Lam.) under protected condition" was carried out during the year 2022-2023 at Centre of Excellence on Protected Cultivation and Precision Farming, Department of Fruit Science, College of Agriculture, IGKV, Raipur (C.G.). The experiment was employed in Completely Randomized Design having seven treatments, which replicated thrice. The various media treatments were evaluated to analysed shoot and root growth parameters of jackfruit seedlings under the shade-net condition. The different treatments were *viz.* T_0: Control- Soil + FYM 3:1), T_1 - soil + vermi-compost (1:1), T_2 - soil + vermi-compost (2:1), T_3 - soil + vermi-compost + rice husk (2:1:1), T_4 - soil + vermi-compost + saw dust (2:1:1), T_5 – soil + vermi-compost + coco-peat (2:1:1) and T_6 - soil + vermi- compost + rice husk + coco-peat (1:1:1:1).
The observations concerning shoot growth parameters and *i.e.* seedling height (cm), number of leaves per seedling, fresh and dry weight of seedling, survival percentage and root growth parameters *viz*. root length (cm), fresh and dry weight of seedling were recorded at 30 days intervals upto 120 days after sowing during the investigation.
The results of study showed that the shoot and root growth parameters of jackfruit seedlings were significantly enhanced and recorded maximum under the treatment T_6 (soil + vermi- compost + rice husk + coco-peat (1:1:1:1) as compared to all other treatments tested under the present investigation.

Keywords: Various media, shoot, root growth parameters, jackfruit, *Artocarpus heterophyllus* Lam.

Introduction
The Jackfruit (*Artocarpus heterophyllus* Lam.) belongs to the family Moraceae. It is indigenous to India and the plant bears the largest fruit among fruit bearing plants. It is a quite heavy yielder. The fruit is known as "poor man's food" in the eastern, Southern and Western Ghats of India. Jackfruit is a dicotyledonous compound fruit of the jack tree, which grow in many of the tropical countries of South-East Asia, but is particularly abundant in India and Bangladesh. Jackfruit is widely grown in the Southern states *viz*., Kerala, Tamil Nadu, Karnataka and Andhra Pradesh. It is also cultivated in other states like Assam, Bihar, Orissa, Maharashtra and West Bengal. The total area under jackfruit cultivation in India is around 187,000 hectares with the production volume of 1877,000 metric tonnes per hac and a productivity of 10.03 metric tonnes. (Anon., 2022) [1]. In Chhattisgarh, the total area covered under jack fruit is 10483 hectares of land with an annual production of 204666 metric tonnes and a productivity of 19.52 metric tonnes (Anon., 2022) [1]. In Chhattisgarh, it is mainly grown in the districts of Raigarh, Kondagaon, Jagdalpur, Rajnandgaon, Kabirdham, Mahasamund, Bilaspur and Korea. The astonishing growth in area is proof that growers are willing to accept this fruit in exchange for huge financial returns.
Immature fruit can be used as a vegetable. The ripe fruit has high nutritive value and contains minerals, vitamin A and C. The edible pulp is a rich source of carbohydrates (23.4%) and also contains protein (0.6%), fat (0.6%), minerals (0.9%), fibber (1.8%) and ash (0.5%) The seeds contain fat (0.4%), fiber (1.5%) and ash (1.5%) and the seeds are also rich source of starch (38.4%) as well as proteins (11.05%). (Purseglove, 1968) [15]. The viability of jackfruit seeds lost very quickly even one or two weeks delay in sowing will lead to poor germination.

Jackfruit seeds are recalcitrant in nature. The recalcitrant seeds impose serious storage problems due to their desiccation and chilling sensitivity. Storage above critical level of time leads to loss of viability.

Media plays an important role in seed germination and seedling vigour of jackfruit and other fruit crops. Coco-peat, Vermi-compost and Rice hulls proved very good result in shoot and root growth parameters of jackfruit and other fruit crops.

Coir dust, also known as coco-peat, is a by-product of coir manufacturing and a by-product of coconut processing that has been proposed as a possible alternative to peat in growth media due to its suitable physical and chemical properties. Due to environmental concerns and diminishing peat soil supplies, coco-peat has been considered a viable replacement for peat in horticulture in recent years (Yau *et al*. 1998) [19].

Soil / Sand and Farm yard manure are the traditional practicing media alone and in combination. Whereas with the combination of farm yard manure, it improves the soil structure, fertility and often prevent nutrient deficiencies. Traditional practicing media does not produce higher yield, whereas the most economical treatment for seedling production is traditional practicing media like soil, sand and farm yard manure in 1:1:1 ratio.

Rice hulls are the sheaths of rice grains, a waste product of rice processing. Rice hulls or husks have been used as a component of potting medium with locally obtained peat for many years (Miller and Jones, 1995). Several nurseries have used composted, screened and hammer-milled rice hulls in place of composted bark (Landis and Morgan, 2009) [6].

Vermi-composting is described as "bioxidation and stabilization of organic material involving the joint action of earthworms and mesophilic micro-organisms". Under appropriate conditions, worms eat agricultural waste and reduce the volume by 40 to 60%. Vermi-compost produced by the activity of earthworms is rich in macro and micro nutrients, vitamins, growth hormones, enzymes such as proteases, amylases, lipase, cellulase and chitinase and immobilized microflora. Reduced use of water for irrigation, reduced pest attack, reduced termite attack, reduced weed growth; faster rate of seed germination and rapid seedlings growth and development; greater numbers of fruits per plant and greater numbers of seeds per year are only some of the beneficial effects of the vermi-compost usage in agricultural production.

Saw dust plays an important role as media due to positive physical properties such as bio-degradability at an acceptable rate, low superficial specific gravity, high porosity, high water retention, moderate drainage and high bacterial tolerance elevated the usage of sawdust as a plant growth medium in seed germination for better seedling growth.

Material and Methods

The present experiment has been carried out during the year 2022-23 at Research Farm of Centre of Excellence on Protected Cultivation and Precision Farming, Department of Fruit Science, College of Agriculture, IGKV, Raipur (C.G.). The topography of the area was uniform with proper drainage. The experimental field is located at an altitude of 298.15 meters above mean sea level 21.25^0 North latitude and 81.62^0 E longitudes. The experiment was designed under Completely Randomized Design with three replications.

The treatments were as follows:- T_0 - (Control- Soil + FYM 3:1), T_1 - Soil + Vermi-compost (1:1), T_2 - Soil + Vermi-compost (2:1), T_3 - Soil + Vermi-compost + Rice husk (2:1:1), T_4 - Soil + Vermi-compost + Saw dust (2:1:1), T_5 – Soil + Vermi-compost + Coco-peat (2:1:1) and T_6 - Soil + Vermi- compost + Rice husk + Coco-peat (1:1:1:1). The data observed during the investigation were analysed statistically by the method of analysis of variance.

The observations concerning various shoot and root growth parameters were recorded at one month intervals up to 120 days after sowing during the investigation.

Results and Discussion

Shoot growth characteristics

The shoot growth characteristics like seedling height (cm), number of leaves per seedling, fresh weight of seedling (g) and dry weight of seedling (g), were observed at 60, 90 & 120 days after sowing, which are described under following heads:

Seedling height (cm)

The results obtained under the study showed, that the treatment T_6 (soil + vermi- compost + rice husk + coco-peat 1:1:1:1) recorded the maximum seedling height (25.31, 36.55 and 48.67 cm) at 60, 90 and 120 days after sowing, respectively. However, the treatments T_5, T_3, T_4, T_2 and T_1 having respective average seedling height of 24.64, 23.74, 23.19, 22.43 and 21.63 cm at 60 DAS & the treatments T_5, T_3, T_4, T_2 and T_1 having respective seedling height of 35.74, 35.34, 34.84, 33.47 and 32.63 cm at 90 DAS & the treatments T_3, T_4, T_2 and T_1 having respective seedling height of 46.31, 45.41, 44.52 and 42.33 cm at 120 DAS were also registered statistically equivalent with each other under the present experiment. While, the minimum seedling height (20.13, 31.22 and 41.19 cm) at 60, 90 and 120 days after sowing was seen under the treatment T_0 (Control- Soil + FYM 3:1).. Increase in seedling height of jackfruit might be due to the to the action of the balanced nutrition and improved soil physico-chemical properties provided by the combination of all four organic amendments. The mixture enhanced nutrient availability, aeration, water holding capacity and fungal/microbial activity in the soil to a greater extent than individual or paired amendments. Similar finding were also reported by Prajapati *et al*. (2017) [14] in acid lime, Parmar *et al.* (2019) [12] in custard apple and Lad *et al.* (2020) [5] in mango.

Number of leaves per seedling

It is clear from the results obtained under the present investigation, the treatment T_6 (soil + vermi-compost + rice husk + coco-peat 1:1:1:1) recorded maximum number of leaves per seedling (4.90, 12.30 & 14.25) at 60, 90 and 120 days after sowing, respectively. However, the treatments T_5, T_3 and T_4 having number of leaves per seedling 4.56, 3.94 and 3.84 respectively at 60 DAS & the treatments T_3, T_4, T_1 and T_2 and T_5, T_3 and T_4 having respective number of leaves per seedling 10.67, 10.35, 9.59 and 9.33 and 11.74, 10.67 and 10.35 at 90 DAS & the treatments T_5, T_3 & T_4 and T_4,T_2 & T_1 having respective number of leaves per seedling 13.84, 13.36 & 12.41 and 12.41, 11.51 & 10.69 at DAS 120 were also registered statistically equivalent with each other tested under the present experiment. While, the minimum number of leaves per seedling (3.50, 8.70 and 10.31) was registered under the treatment T_0 (Control- Soil + FYM 3:1) during

same intervals of observation. The increase in the number of leaves per seedling of jackfruit might be due to the influence of soil moisture and ambient temperature and nutrition supplied from the growth media can influence number of leaves. Nutrients are the key factors for executing many metabolic activities and also hormonal balance within the plant. The variation in number of leaves of the seedlings on different growing media thus obviously appears to be due to different physical and chemical properties of the growing media. Investigation is also supported by Parasana *et al.* (2013) [11] in mango, Parmar *et al.* (2019) [12] in custard apple and Nainar *et al*. (2021) [9] in acid lime.

Fresh weight of seedling (g)

The maximum fresh weight of seedling (63.26 g) was certified under treatment T_6 (soil + vermi- compost + rice husk + coco-peat 1:1:1:1). However the treatments T_5, T_3 and T_4 having respective fresh weight of seedlings 61.56, 59.75 and 58.56 g were noticed non-significant differences with each other under 5% level of significance. While the minimum fresh weight of seedling (50.13 g) was observed under the treatment T_0 (Control- Soil + FYM 3:1). The increase in fresh weight of seedlings of jackfruit might be due to balanced nutrition and favorable soil properties from vermi-compost, rice husk and coco-peat in T_6 promoted optimal plant growth and bio-mass accumulation. This facilitated greater synthesis of metabolites and cell multiplication, increasing seedling fresh weight. In addition, the treatment T_6, with a balanced mixture of vermi-compost, rice husk and coco-peat added organic matter and nutrients to the soil while also improving soil structure and aeration. This created optimal growing conditions for root development and uptake of water and nutrients. The results obtained in the present study are supported by the works of Malakar *et al*. (2019) [7] in acid lime, Singh *et al*. (2020) [18] in papaya, Nainar *et al*. (2021) [9] in acid lime and Jyoti *et al.* (2022) [4] in jackfruit.

Dry weight of seedling (g)

The maximum dry weight of seedlings of Jackfruit (5.20 g) was confirmed under the superiority of treatment T_6 (soil + vermi- compost + rice husk + coco-peat 1:1:1:1), which was found significantly superior from rest of other the treatments tested under the present investigation. However the treatments T_5 & T_3 and T_4 & T_2 having respective dry weight of seedlings 4.85 & 4.53 and 3.73 & 3.61 g were recorded statistically *at par* with each other at 5% level of significance under the present investigation. The minimum dry weight of seedlings (2.73 g) was noticed under the treatment T_0 (Control- Soil + FYM 3:1).

The increase in dry weight of jackfruit seedlings in treatment T_6 might be owing to optimal nutrition and soil conditions provided by vermi-compost, rice husk, coco-peat promoted vigorous plant growth and greater accumulation of dry matter. This facilitated enhanced photosynthesis and metabolism, driving cellular multiplication and expansion which increased seedling dry weight. The present result corroborates with the findings of Patel *et al*. (2017) [13] in custard apple, Prajapati *et al*. (2017) [14] and Nainar *et al*. (2021) [9] in acid lime and Salamat *et al*. (2021) [17] in jackfruit.

Survival percent of seedling

It has been observed that the maximum survival percentage of jackfruit seedlings (73.30) were noticed under the excellency of treatment T_6 (Soil + vermi- compost + rice husk + coco-peat 1:1:1:1). However, the treatments T_5, T_3, T_4 and T_2 having respective survival percentage of seedlings 71.97, 70.12, 66.93 and 63.17 were also registered statistically equivalent with each other tested under the present experiment. While the minimum survival percent of seedling (59.83) was registered under the treatments T_0 (Control-Soil + FYM 3:1). Among the different combination of vermi-compost, rice husk and coco-peat, the treatment T_6 provided balanced nutrition and ideal soil physical properties, which promoted vigorous plant growth and health. The robust seedlings were more resilient to stresses, leading to higher survival rate. The results emphasize the role of soil amendments in boosting survival through improved soil health. Similar findings were reported by Parmar *et al.* (2019) [12] in custard apple, Gawankar *et al*. (2020) [2] in jackfruit, Singh *et al.* (2020) [18] and Sahu *et al.* (2022) [16] in papaya.

Root growth characteristics

The root growth characteristics were observed for the following variables *i.e.* root length (cm), fresh weight of roots (g) and dry weight of roots (g), which has been presented under following heads:

Root length (cm)

The maximum root length (26.20 cm) was registered under the superiority of treatment T_6 (soil + vermi- compost + rice husk + coco-peat (1:1:1:1), which showed significantly superior among all other treatments. However, the treatments T_5, T_3, T_4 and T_2 having respective root length of 25.59, 24.61, 23.41 and 22.57 cm, respectively were also registered statistically *at par* with each other. Similarly the treatments T_4, T_2 and T_1 having respective root length of 23.41, 22.57 and 20.56 cm were found statistically similar with each other under the present investigation. While the minimum root length (19.50 cm) was registered under the treatment T_0 (Control- Soil + FYM 3:1). In the treatment T_6 balanced mix of soil, vermi-compost, rice husk and coco-peat provided optimal nutrition and structure for robust root growth compared to the other treatments with fewer components as observed by Patel *et al*. 2017 [13] in custard apple. This might be the reason for improved germination and vigour characteristics that is reflected in terms of root length. The maximum root length observed in treatment T_6 was due to most suitable environment for root system expansion in jackfruit seedlings. Through evenly supplementing nutrients and improving soil conditions with the balanced mixture of vermi-compost, rice husk and coco-peat (T_6) facilitated robust root elongation. The present result is in close conformity with the findings of Meena *et al.* (2017) [8] in papaya and Prajapati *et al*. (2017) [14] in acid lime and Nayak *et al*. (2022) [10] in papaya.

Fresh weight of roots (g)

Fresh weight of roots was influenced significantly under different media treatments tested under the present investigation. The treatment T_6 (soil + vermi- compost + rice husk + coco-peat 1:1:1:1) registered maximum fresh weight of roots (10.18 g), which showed significantly superior among rest of the other treatments tested under the present study. However, the treatments T_5, T_3, T_4 & T_2 and T_4, T_2 & T_1 having respective fresh weight of roots of 17.42, 16.67, 14.84 & 14.56 g and 14.84, 14.56 & 12.63 g were also

documented statistically *at par* with each other at 5% level of significance under the present study. The minimum fresh weight of roots (10.64 g) was perceived under the treatment T_0 (control- Soil + FYM 3:1) at 120 days after sowing. The increase in fresh weight of roots of jackfruit seedlings might be due to the influence of balanced soil, vermi-compost, rice husk and coco-peat in treatment T_6 provided the best conditions for robust Jackfruit root growth and maximum fresh weight. The Similar result was also reported by Hota *et al*. (2018) [3] in jamun. By mixing vermi-compost, rice husk and coco-peat, (T_6) uniformly supplemented nutrients and improved soil properties to promote vigorous root development. Similar findings were documented by Meena *et al.* (2017) [8] in papaya, Patel *et al*. (2017) [13] in acid lime and Lad *et al*. (2020) [5] in mango.

Dry weight of roots (g)

The maximum dry weight of root (3.80 g) was gathered under the treatment T_6 (Soil + vermi- compost + rice husk + coco-peat 1:1:1:1), which showed significantly superior among all other treatments. Howevere the treatments T_3 & T_4 and T_2 & T_1 having respective dry weight of roots 3.64 & 3.33 g and 2.93 & 2.84 g were statistically *at par* with each other at 5% level of significance under the present experiment. The minimum dry weight of roots (2.50 g) was detected under the treatment T_0 (control- Soil + FYM 3:1) at 120 days after sowing. Increase in dry weight of roots of jackfruit seedlings might be due to to diverse substrate in T_6 with balanced soil, vermi-compost, rice husk and coco-peat provided optimal nutrition and structure for robust Jackfruit root growth and maximum dry weight accumulation. The diverse substrate in T_6 was superior for root development and dry matter accumulation and optimized conditions to support the highest dry root weight in jackfruit seedlings. The present result is supported by the findings of Patel *et al*. (2017) [13] in custard apple, Hota *et al*. (2018) [3] in jamun and Sahu *et al*. (2022) [16] in papaya.

Table 1: Effect of various media on seedling height (cm), number of leaves per seedling and girth of stem (mm) of jackfruit under protected condition

Notations	Treatment details	Seedling height (cm)			Number of leaves per seedling		
		60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	90 DAS
T_0	Soil + FYM (Control 3:1)	20.13^{a}	31.22^{a}	41.19^{a}	3.50^{a}	8.70^{a}	10.31^{a}
T_1	Soil+ Vermi-compost (1:1)	21.63^{ab}	32.63^{ab}	42.33^{ab}	3.64^{a}	9.59^{ab}	10.69^{ab}
T_2	Soil+ Vermi-compost (2:1)	22.43^{abc}	33.47^{abc}	44.52^{abc}	3.73^{a}	9.33^{ab}	11.51^{ab}
T_3	Soil + Vermi-compost + Rice husk (2:1:1)	23.74^{bc}	35.34^{bc}	46.31^{bc}	3.94^{ab}	10.67^{bcd}	13.36^{cd}
T_4	Soil + Vermi-compost + Saw dust (2:1:1)	23.19^{abc}	34.84^{bc}	45.41^{abc}	3.84^{ab}	10.35^{abc}	12.41^{bc}
T_5	Soil + Vermi.-compost + Coco-peat (2:1:1)	24.64^{bc}	35.74^{bc}	47.84^{c}	4.56^{bc}	11.74^{cd}	13.84^{cd}
T_6	Soil + Vermi-compost + Rice husk + Coco-peat (1:1:1:1)	25.31^{c}	36.55^{c}	48.67^{c}	4.90^{c}	12.30^{d}	14.25^{d}
	SE (m) ±	1.02	1.10	1.45	0.26	0.63	0.72
	C.D. at 5%	3.10	3.33	4.40	0.78	1.92	2.19

1. DAS- Days after sowing
2. The superscript letter indicates that the treatment means with the same letters are *at par* at 5% level of significance, while the means with different letters are significantly different at 5% level of significance. These letters have been affixed based on CD-value comparison of treatment means.

Table 2: Effect of various media on fresh weight of seedling (g), dry weight of seedling (g) and survival percent of jackfruit seedlings of jackfruit under protected condition

Notations	Treatment details	Fresh weight of seedling (g)	Dry weight of seedling (g)	Survival percent of jackfruit seedlings
T_0	Soil + FYM (Control 3:1)	50.13^{a}	2.73^{a}	59.83^{a}
T_1	Soil + Vermi-compost (1:1)	53.46^{ab}	2.91^{a}	62.38^{ab}
T_2	Soil + Vermi-compost (2:1)	56.53^{bc}	3.61^{b}	63.17^{abc}
T_3	Soil + Vermi-compost + Rice husk (2:1:1)	59.75^{cde}	4.53^{c}	70.12^{bcd}
T_4	Soil + Vermi-compost + Saw dust (2:1:1)	58.36^{cd}	3.73^{b}	66.93^{abcd}
T_5	Soil + Vermi-compost + Coco-peat (2:1:1)	61.56^{de}	4.85^{cd}	71.97^{cd}
T_6	Soil + Vermi- compost + Rice husk + Coco peat (1:1:1:1)	63.26^{e}	5.20^{d}	73.30^{d}
	SE (m) ±	1.19	0.20	2.96
	C.D. at 5%	3.61	0.61	8.98

1. DAS- Days after sowing
2. The superscript letter indicates that the treatment means with the same letters are *at par* at 5% level of significance, while the means with different letters are significantly different at 5% level of significance. These letters have been affixed based on CD-value comparison of treatment means.

Table 3: Effect of various media on root length (cm), Fresh weight of roots (g) and Dry weight of roots (g) of jackfruit seedlings under protected condition

Notations	Treatment details	Root length (cm)	Fresh weight of roots (g)	Dry weight of roots (g)
T_0	Soil + FYM (Control 3:1)	19.50[a]	10.64[a]	2.50[a]
T_1	Soil + Vermi-compost (1:1)	20.56[ab]	12.63[ab]	2.84[ab]
T_2	Soil + Vermi-compost (2:1)	22.57[abc]	14.56[bc]	2.93[b]
T_3	Soil + Vermi-compost + Rice husk (2:1:1)	24.61[cd]	16.67[cd]	3.64[cd]
T_4	Soil + Vermi-compost + Saw dust (2:1:1)	23.41[bcd]	14.84[bc]	3.33[c]
T_5	Soil + Vermi-compost + Coco-peat (2:1:1)	25.59[cd]	17.42[cd]	3.72[d]
T_6	Soil + Vermi- compost + Rice husk + Coco-peat (1:1:1:1)	26.20[d]	18.41[d]	3.80[d]
	SE (m) ±	1.23	1.10	0.12
	C.D. at 5%	3.73	3.32	0.35

1. DAS- Days after sowing
2. The superscript letter indicates that the treatment means with the same letters are *at par* at 5% level of significance, while the means with different letters are significantly different at 5% level of significance. These letters have been affixed based on CD-value comparison of treatment means.

Conclusion

In conclusion, the study on shoot growth characteristics, including seedling height, number of leaves per seedling, fresh weight of seedling, and dry weight of seedling, revealed significant insights into the influence of various treatments on jackfruit seedling development. Treatment T_6, comprising soil, vermi-compost, rice husk, and coco-peat in balanced proportions, consistently demonstrated superior performance across all parameters, promoting optimal growth and biomass accumulation. The observed enhancements in seedling characteristics underscore the importance of balanced nutrition and favorable soil conditions facilitated by the combination of organic amendments. These findings align with prior research in similar crops, highlighting the efficacy of integrated organic approaches in fostering robust plant growth. Furthermore, the study on root growth characteristics reaffirmed the benefits of treatment T_6 in promoting root elongation and biomass accumulation, thus reinforcing the role of comprehensive soil amendments in enhancing overall seedling vigor and resilience. These results underscore the significance of holistic soil management practices in sustainable agriculture and underscore the potential for integrated organic approaches to optimize crop productivity and resilience.

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