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Effect of Different Growing Media Compositions on Seed Germination and Seedling Growth of Papaya (*Carica papaya* L.) cv. Pusa Nanha

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Abstract: Papaya (*Carica papaya* L.) is a fast-growing, herbaceous tropical fruit crop belonging to the family Caricaceae. Indigenous to Central America and Southern Mexico, it is now widely cultivated in tropical and subtropical regions, with India ranking among the leading producers worldwide. Among the various cultivars grown in India, Pusa Nanha is a dwarf, gynodioecious papaya variety specifically developed for a high-density plantation system. The present study was conducted to enhance seed germination and seedling growth of papaya using various combinations of growing media. The experiment was laid out in a Randomized Complete Block Design (RCBD) consisting of thirteen treatments with three replications. The treatments comprised various combinations of vermicompost, farmyard manure (FYM), leaf litter, and cocopeat. The result of the study revealed that the growing media combination T_{13} (Vermicompost + FYM + Leaf litter) showed superior performance over all other treatments, recording the fastest initial germination (16.14 days), highest germination per cent (82.10 %) and maximum survival per cent (90.11 %). Additionally, this combination also produced seedlings with superior growth characteristic, including the maximum plant height (58.14 cm), shoot diameter (16.34 mm), thickest root diameter (11.26 mm), highest number of leaves (24.41), longest root length (31.24 cm), maximum shoot fresh and dry biomass (102.20 g and 30.19 g, respectively), maximum root fresh and dry biomass (28.17 g and 9.66 g, respectively) and maximum total fresh and dry biomass (130.24 g and 39.85 g, respectively).

Keywords: Papaya • Seedling • Germination • Vermicompost • Leaf litter • Cocopeat

Introduction

Papaya (*Carica papaya* L.) is one of the most important fruit crops of the tropical and sub-tropical regions and is often referred to as the "Wonder Fruit of the Tropics". Commonly known as papaw or pawpaw, it is native to Central America and Southern Mexico. Papaya is ideally suited for cultivation in kitchen gardens, home backyards, as well as in commercial orchards. It belongs to the family Caricaceae, which consists of 32 species, among which *Carica papaya* is the only species cultivated for its edible fruits (Ray 2002). Papaya is a short-lived, fast-growing, large herb, having a single straight or sometimes branched stem reaching 2-10 m in height. Fruits are melon-like, oval to nearly round or elongated in shape 15-50 cm long and 10-20 cm thick, and weighing up to 9 kg (Khadijah *et al* 2020). Nutritionally, papaya contains 2500 I.U. of vitamin A and 85 mg of vitamin C per 100 g of pulp, along with significant amounts of calcium and other essential minerals. Medicinally, it has been traditionally used in the treatment of stomach ulcers, diphtheria, and various other ailments (Bal 1997). In India, papaya holds a significant position in fruit production, with several improved varieties cultivated across different agro-climatic zones. Among these, Pusa Nanha is a prominent cultivar developed by the Indian Agriculture Research Institute (IARI), characterized by its dwarf growth habit, early bearing, and suitability for high-

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density planting. Papaya is primarily propagated through seeds; however, considerable variability in germination and seedling growth has been observed (Dayeswari *et al* 2017). Seeds are the product of successful pollination and fertilization in flowers, where the zygote formed develops into a mature seed. They serve as a storehouse of food reserves essential for supporting the initial growth of emerging seedlings (Sharma 2005). Propagation by seeds is the principal mode of reproduction in nature and remains one of the most efficient and widely adopted methods for the propagation of cultivated crops (Hartmann *et al* 2002). Papaya seeds are enclosed in a gelatinous outer layer (sarcotesta), which often delays germination and induces dormancy. Removing this layer before drying helps improve germination. Although freshly extracted seeds generally show low germination due to dormancy, drying them increases their germination potential. Under favorable conditions, papaya seeds typically germinate within two weeks. The initial stages of plant growth, particularly seed germination and seedling establishment, play a critical role in determining the success of papaya cultivation. The choice of an appropriate growing medium has a significant influence on germination rate, seedling vigor, and subsequent plant development. Growing media not only provide physical support but also supply essential nutrients, regulate moisture, and ensure adequate aeration for optimal root growth (Anjanawe *et al* 2013 and Monika *et al* 2021). Despite papaya's widespread cultivation, limited systematic research has been undertaken to optimize growing media compositions specifically specific to the Pusa Nanha cultivar for improved germination and seedling growth. Understanding the interaction between different media components, such as vermicompost, farmyard manure, cocopeat, and leaf litter is crucial for developing sustainable nursery practices and enhancing crop productivity. Given the economic importance of papaya and the necessity for high-quality planting material, this study aims to evaluate the effect of different growing media compositions on seed germination and seedling growth of papaya (*Carica papaya* L.) cv. Pusa Nanha. The findings of this research will contribute to formulating efficient propagation techniques and optimizing nursery management practices for papaya growers.

Materials and Methods

Experimental Area and Material: A field experiment was conducted at the College of Horticulture, VCSG UUHF Bharsar, Pauri Garhwal, Uttarakhand, India during 2021. The experimental site is located in the lower Shivalik mountain range of the Himalayas, at an altitude of 1950 m above MSL with a longitude of 78.99°E and latitude of 30.056°N. The seeds of papaya cv. Pusa Nanha were procured from IARI, Pusa, New Delhi, in 10 g air-tight polythene packets. The experiment was laid out in a Randomized Complete Block Design with thirteen treatments and three replications consists of different growing media, including farmyard manure (FYM), leaf litter, cocopeat, vermicompost and their combinations in various proportions: FYM + leaf litter (1:1), leaf litter + cocopeat (1:1), cocopeat + vermicompost (1:1), vermicompost + FYM (1:1), FYM + leaf litter + cocopeat (1:1:1), leaf litter + cocopeat + vermicompost (1:1:1), cocopeat + vermicompost +FYM (1:1:1) and vermicompost + FYM + leaf litter (1:1:1), along with control. All the seeds were sown in black polythene bags measuring 15 cm in length and 10 cm in diameter with a 200-gauge thickness. These bags were filled with the respective growing media mixtures as per the treatment combinations. In each replication, 15 polybags were filled for every treatment and placed under naturally ventilated conditions. The observations for different treatments were recorded at a 30 days interval.

Days taken for initial germination

The duration from the date of sowing to the emergence of the first radicle was considered as the time taken for the initiation of seed germination.

$$Mean\ daily\ germination = \frac{Total\ number\ of\ germinated\ seed}{Total\ number\ of\ days}$$

Seed germination per cent

$$Germination\ (\%) = \frac{Number\ of\ seed\ germinated}{Number\ of\ seeds\ kept\ for\ germination} \times 100$$

Statistical analysis

The statistical analysis for each observed parameter in the study was performed using MS-Excel, OPSTAT software. The data obtained during the investigation were analyzed by using standard statistical procedure in the Randomized Complete Block Design (RCBD).

Results and Discussion

The results of the present findings indicate that the number of days for initial germination, germination per cent, and survival per cent were significantly influenced by the compositions of the growing media (Table 1). The treatment T_{13} (Vermicompost + FYM + Leaf litter) recorded the minimum number of (16.14) days for initial germination, the highest seed germination per cent (82.10 %) and the maximum survival per cent (90.11 %). This improved performance is due to the combined effect of vermicompost, FYM and leaf litter, which together enhance the physical and chemical properties of the organic medium. The organic matter enhances moisture availability, nutrient retention and porosity of the growing medium, resulting in earlier seedling emergence and improved plant growth (Garhwal *et al* 2014). (Bachman and Metzger, 2007; Hossain *et al*., 2016, and Jarvan *et al* 2017) also revealed that vermicompost provides bioactive compounds that promote germination, seedling strength, and overall plant development. Furthermore, the well-decomposed organic matter increased the respiration rate at an optimum level, which is favourable for seed sprouting. The enhanced aeration in the root zone also helped to reduce the effect of damping off disease in seedlings. Overall, the improved physical and biological conditions provided by the combination of vermicompost, FYM and leaf litter had a positive effect on seedling growth, which ultimately enhanced survival (Hyder *et al* 2015).

Table 1: Effect of different growing media compositions on germination parameters

Treatments	Treatment details	Days taken for initial germination	Germination per cent (%)	Survival per cent (%)
T_1	Control	24.000	58.243	64.067
T_2	FYM	23.000	61.177	72.167
T_3	Leaf litter	22.000	64.243	75.400
T_4	Cocopeat	25.327	51.200	34.397
T_5	Vermicompost	21.253	66.107	76.033
T_6	FYM + Leaf litter (1:1)	19.000	72.590	81.767
T_7	Leaf litter + Cocopeat (1:1)	20.857	67.827	78.000
T_8	Cocopeat + Vermicompost (1:1)	20.327	70.073	79.367
T_9	Vermicompost + FYM (1:1)	18.807	74.437	83.870
T_{10}	FYM + Leaf litter + Cocopeat (1:1:1)	18.343	76.947	85.133
T_{11}	Leaf litter + Cocopeat + Vermicompost (1:1:1)	16.700	81.660	89.120
T_{12}	Cocopeat + Vermicompost +FYM (1:1:1)	17.583	79.033	86.993
T_{13}	Vermicompost + FYM + Leaf litter (1:1:1)	16.147	82.107	90.113
$SE_{(d)}$		0.258	0.258	0.344
$C.D_{(0.05)}$		0.535	0.535	0.714

Effect of different growing media on growth parameters

An examination of data presented in (Table 2) revealed that the tallest plant height, *viz*., (9.14 cm), (28.20) cm and (58.14) cm; however maximum number of leaves (10.40), (16.40) and (24.41) was recorded under the treatment combination T_{13} (Vermicompost + FYM + Leaf litter at 1:1:1 ratio) at 30, 60 and 90 DAS respectively. The improved growth in both plant and number of leaves could be attributed to the presence of abundant macro- and micro-nutrients, particularly nitrogen, as well as active microbial populations in vermicompost, FYM and leaf litter. These components boost plant growth through various physical, chemical and biological mechanisms. According to (Bhardwaj *et al*., 2024), nutrient uptake, especially nitrogen, plays a key role in the synthesis of amino acids, which are subsequently incorporated into proteins and nucleic acids, thereby influencing crucial biochemical reactions that significantly enhance vegetative growth. Furthermore, the superior nutrient availability in growing media leads to higher chlorophyll production and an increased photosynthetic area in seedlings, which directly contributes to a higher number of leaves (Kaur 2017).

The thickest shoot diameter (16.34 mm) was recorded under the treatment T_{13} (Vermicompost + FYM + Leaf litter). According to (Hota *et al* 2018), the increase in shoot thickness can be attributed to the higher nutrient content in the growing medium, which not only supports plant stability but also improves oxygen diffusion to the roots and facilitates essential gaseous exchange between the roots and the external environment. Such enhancements contribute to healthier and more robust plant development.

It is evident from the data as depicted in (Table 2) that the longest length of root (31.24 cm) and thickest root diameter (11.26 mm) were observed under the treatment T_{13} (Vermicompost + FYM + Leaf litter). The integration of these organic materials, which are abundant in nitrogen, phosphorus and potassium, not only enriches the nutrient profile of the medium but also enhances its physical characteristics. Improved porosity, water-holding capacity, aeration and texture contribute to maintaining favourable temperature conditions, thereby facilitating efficient nutrient uptake. This combined effect of improved physical and chemical properties ultimately leads to enhanced root elongation, increased thickness and overall superior root development (Hyder *et al*., 2015 and Jarvan *et al* 2017).

Table 2: Effect of different growing media compositions on growth parameters

Treatment	Treatment details	Plant height (cm)			Number of leaves			Shoot diameter (cm)	Root length (cm)	Root diameter (mm)
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS			
T_1	Control	3.967	10.910	27.267	4.100	9.110	14.270	7.127	14.947	4.227
T_2	FYM	4.533	13.267	31.263	4.670	11.100	18.240	7.913	18.340	4.927
T_3	Leaf litter	5.000	15.433	34.023	5.103	11.600	19.167	8.533	19.510	5.477
T_4	Cocopeat	3.367	7.660	15.340	3.567	7.603	10.073	3.203	7.787	2.180
T_5	Vermi compost	5.767	16.633	37.837	5.867	12.133	19.737	10.937	20.723	6.033
T_6	FYM + Leaf litter (1:1)	6.800	20.267	46.383	7.900	13.600	21.500	12.803	25.140	7.503
T_7	Leaf litter + Cocopeat (1:1)	6.033	17.600	40.343	6.467	12.533	20.267	11.403	21.793	6.387
T_8	Cocopeat + Vermicompost (1:1)	6.433	18.267	42.883	7.200	13.033	21.133	11.880	23.107	6.833
T_9	Vermicompost + FYM (1:1)	7.067	23.233	50.237	8.633	14.137	22.100	13.193	26.447	8.077
T_{10}	FYM + Leaf litter + Cocopeat (1:1:1)	7.433	24.747	52.823	9.067	14.700	22.540	14.417	27.653	8.783

T_{11}	Leaf litter + Cocopeat + Vermicompost (1:1:1)	8.800	27.817	57.540	10.077	16.100	24.067	16.053	30.947	10.873
T_{12}	Cocopeat + Vermicompost +FYM (1:1:1)	7.910	25.920	54.937	9.600	15.267	23.200	15.150	29.583	9.720
T_{13}	Vermicompost + FYM + Leaf litter (1:1:1)	9.147	28.207	58.140	10.407	16.403	24.417	16.340	31.243	11.260
$SE_{(d)}$		0.192	0.280	0.331	0.189	0.181	0.383	0.236	0.137	0.201
$C.D_{(0.05)}$		0.400	0.581	0.687	0.392	0.375	0.794	0.489	0.285	0.417

Effect of different growing media on shoot, root and total fresh and dry biomass The data presented in (Table 3) clearly indicate that the highest fresh and dry biomass of shoot (102.07 g and 30.19 g, respectively) and the maximum fresh and dry biomass of root (28.17 g and 9.66 g, respectively) were recorded under the treatment T_{13} (Vermicompost + FYM + Leaf litter). This superior performance can be associated with the favourable growth environment provided by the medium, which facilitated proper root system development with minimal coiling in earthen pots. This enhanced root proliferation enabled seedlings to absorb greater quantities of nutrients, consequently promoting vigorous leaf production and higher photosynthetic activity. This combined effect increased fresh biomass, which ultimately contributed to the higher dry matter accumulation (Blouin *et al* 2019).

It is apparent from the data presented in (Table 3) that the treatment T_{13} (Vermicompost + FYM + Leaf litter) gave maximum total fresh biomass (130.24 g) and maximum total dry biomass (39.85 g). It might be due to the fact that the vermicompost, FYM and leaf litter provides proper ventilation by increasing the porosity, improving physical characteristic of the media and this is also considered as a big source of nutrients elements especially nitrogen and phosphorous which simultaneous increase in the total fresh and dry biomass of seedling (Garhwal *et al* 2014 and Blouin *et al* 2019).

Table 3: Effect of different growing media compositions on shoot, root and total fresh and dry biomass

Treatments	Treatment details	Shoot fresh biomass (g)	Shoot dry biomass (g)	Root fresh biomass (g)	Root dry biomass (g)	Total fresh biomass (g)	Total dry biomass(g)
T_1	Control	24.420	6.100	14.467	2.243	38.887	8.343
T_2	FYM	34.813	9.570	16.127	3.107	50.940	12.677
T_3	Leaf litter	40.723	11.277	17.417	3.960	58.140	15.237
T_4	Cocopeat	8.680	1.970	5.113	0.587	13.793	2.557
T_5	Vermicompost	47.967	13.797	19.343	4.607	67.310	18.403
T_6	FYM + Leaf litter (1:1)	69.483	19.747	21.267	6.617	90.750	26.363
T_7	Leaf litter + Cocopeat (1:1)	55.463	15.983	20.367	5.050	75.830	21.033
T_8	Cocopeat +	60.363	17.023	20.967	5.853	81.330	22.877

	Vermicompost (1:1)						
T_9	Vermicompost + FYM (1:1)	81.170	22.353	22.810	7.087	103.980	29.440
T_{10}	FYM + Leaf litter + Cocopeat (1:1:1)	86.723	23.863	24.043	7.647	110.767	31.510
T_{11}	Leaf litter + Cocopeat + Vermicompost (1:1:1)	101.563	29.620	27.623	9.157	129.187	38.777
T_{12}	Cocopeat + Vermicompost +FYM (1:1:1)	92.713	26.827	25.767	8.227	118.480	35.053
T_{13}	Vermicompost + FYM + Leaf litter (1:1:1)	102.073	30.197	28.173	9.660	130.247	39.857
$SE_{(d)}$			0.389	0.479	0.266	0.246	0.403
$C.D_{(0.05)}$			0.808	0.993	0.551	0.512	0.837

Conclusion

Based on the present investigation, it can be concluded that the T_{13} (Vermicompost + FYM + Leaf litter) is the most effective media composition compared to all other the treatments, consistently recording the earliest germination, highest germination per cent, maximum survival rate and superior seedling growth in terms of plant height, number of leaves, shoot diameter, root length, root diameter and biomass accumulation. The combined use of vermicompost, FYM and leaf litter offers a sustainable, eco-friendly and cost-effective alternative for seedling production, providing an optimal growing medium for papaya cultivation. These findings highlight the potential of T_{13} as a recommended medium composition for producing vigorous, healthy and uniform seedlings of papaya cv. Pusa Nanha, thus contributing to increased productivity and more efficient nursery management practices.

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