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Effect of different organic substances and bio-fertilizers on seed germination and seedling parameters of papaya (*Carica papaya* L.) under shade net condition

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Abstract
The present investigation entitled "Effect of different organic substances and bio-fertilizers on seed germination and seedling parameters of papaya (*Carica papaya* L.) under shade net condition" was conducted during 2024-25 at Horticulture Nursery, Department of Fruit Science, College of Agriculture, IGKV, Raipur (C.G.). A total of thirteen treatments, including an untreated control, were arranged in a Completely Randomized Design (CRD) with three replications. Among all the, treatments studied under present research, treatment T_9 involving (Castor cake @ 10 g +VAM @ 5 g+ *Trichoderma harzianum* @ 5 ml) showed the most promising results, indicating their potential for use in sustainable and effective papaya seedling production under protected conditions. This treatment (T_9) recorded the earliest germination (9.89 days), highest germination percentage (82.21%), emergence rate (49.78%). It also led to notable improvements in seedling growth parameters with the maximum height of the seedling (25.21 cm), fresh weight of seedling (14.89 g), dry weight of seedling (2.13 g), seedling vigor index-I (2072.51) and seedling vigor-II (213.74) were recorded superior under T_9, indicating enhanced seedling performance.

Keywords: Papaya, bio-fertilizers, organic media, *Trichoderma harzianum*, vam fungi, germination and growth

Introduction
Papaya (*Carica papaya* L.) belongs to the family *Caricaceae*, stands as the sole species within the genus *carica*, with a diploid chromosome no. 2n=18. Papaya is a tropical fruit native to central and South America (Hofmeyr, 1945) [12] and is now grown in many tropical and sub-tropical countries. Papaya is cultivated in many tropical countries including India, where it is grown in States like Andhra Pradesh, Karnataka, Kerala, Orissa, Tamil Nadu, Chhattisgarh and West Bengal. Papaya contains a milky latex that contains the proteolytic enzyme papain, which contains 72.2% protein. In India, papaya is being cultivated in an area of 148 thousand hectares having annual production of 5989 thousand metric tons of fruits with productivity of 39.96 mt/ha (*Anon*, 2022) [2]. Papaya is commercially propagated by seed and seed germination in papaya is known to be slow and incomplete, papaya seeds contain inhibitors in the sarcotesta (outer seed coat) and seed coat that slow and inhibit germination, the gelatinous sarcotesta contains inhibitors, mainly phenolic compounds that slow germination (Meena *et al*., 2017) [15]. In today's condition increasing price of chemicals and fertilizers, nursery media preparation is having costly day by day because of the use of this expensive media and germination promoting chemicals also it is out of reach of the farmers so the use of organics and biofertilizers in germination and growing media preparation is essential for papaya nursery (Kumar & Abraham, 1943) [14].
Neem cake (*Azadirachta indica* L.) is considered as the rich source of plant nutrient (5.2% N, 1.0% P and 1.4% K) Neem cake powder, a byproduct of neem oil extraction, is an organic and eco-friendly soil amendment and pest repellent. It also promotes seed germination and plant growth by stimulating root development, increasing nutrient uptake and enhancing plant immunity.

The natural compounds in neem cakes protect plants from pests and diseases and help them resist environmental stressors like drought, heat and cold, the compounds in neem cakes stimulate the growth of beneficial microorganisms like bacteria and fungi, which helps to break down the soil organic matter. This process improves soil structure and fertility, making it easier for plant roots to access nutrients and water (Aneesa, 1997) [1].

Castor cake (*Ricinus communis*) is a rich source of N (4.37%), P (1.85%), K (1.4%) and micro-nutrients considered as good value manure. It helps in mineralization process of plant nutrients during decomposition; Castor oil cake is an organic by-product of castor seed oil production. Castor cake is used as a neutral fertilizer. It enhances the fertility of soil, also has traces of nutrients like manganese, zinc and copper thus making a balanced fertilizer. They provide slow and steady nourishment, stimulation, protection from soil nematodes and insects. It improves the physical, chemical and biological properties of the soil. The Castor cake has insecticidal properties and naturally pest repellent. It can be used in organic farming. It improves the physical, chemical and biological properties of the soil (Gadhesariya and Malam, 2017) [10].

Mustard cake (*Brassica* spp.) fertilizer is a rich source of essential nutrients required for plant growth, including nitrogen, phosphorus, potassium, sulphur, calcium and magnesium. It also contains micronutrients such as iron, manganese, zinc and copper. Its low carbon-to-nitrogen ratio makes it a good source of nitrogen for plants. Mustard cake fertilizer for flowering plants is a better alternative to synthetic fertilizers as it is economical, eco-friendly and has no adverse effects on the environment or human health. It also provides a wider range of nutrients than most synthetic fertilizers. Mustard cake is a slow-release bio fertilizer it does not give any negative impact on plant growth and development (Tandon, 1992) [23].

Arbuscular Mycorrhiza fungi uptake many different nutrients, but the ratio of nitrogen to phosphorus in a system has been shown to be a strong driver of the growth benefit AM fungi provide to host plants (Dutt *et al*., 2013) [7]. It is also well established that, like many taxonomically distinct soil beneficial microbes, AM fungi prime plant defense systems in shoots. During the initiation of root colonization by an AM fungus jasmonic acid responses occur but typically do not result in changes in plant secondary chemistry until plants are challenged by an antagonist (Farschian *et al*., 2018) [8]. Arbuscular mycorrhiza fungi (AMF) are mutualistic association existing between fungi and roots of many higher plants. AM association have been shown to reduce damage caused by soil-borne plant pathogens (Clark and Zeto, 1996) [5]. Papaya is known to exhibit a strong growth response to colonization by AM fungi.

Trichoderma spp. produce or release a variety of compounds that induce localized and systemic resistance response in plants. Hence, balanced nutrition including organic, bulky organic manures and a few bio-fertilizers is the key factor to enhance plant growth, yield and fruit quality. *Trichoderma spp*. are endophytic plant symbionts that are widely used as seed treatments to control diseases and to enhance plant growth and yield. Although some recent work has been published on their abilities to alleviate abiotic stresses, specific knowledge of mechanisms, abilities to control multiple plant stress factors, their effects on seed and seedlings is lacking. We examined the effects *T. harzianum* on germination of seed sown to protected structure The consistent response to varying stresses suggests a common mechanism through which the plant-fungus association enhances tolerance to a wide range of abiotic stresses as well as biotic stress (Fatemeh *et al*. 2010) [9].

Materials and Methods

The present investigation entitled "Effect of different organic substances and bio-fertilizers on seed germination and seedling parameters of papaya (*Carica papaya* L.) under shade net condition" was conducted at Horticultural Nursery, Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur during the year 2024-25. In this study, the effects of organic products and bio fertilizers caster cake, neem cake, mustard cake, *Trichoderma harzianum* and *arbuscular mycorrhiza* fungi at various concentrations were examined for seed germination and seedling vigor of papaya seedlings. The experiment was carried out by employing completely randomized design with three replications. The media Soil, Sand and FYM in the ratio of 1:1:1 was used commonly for each treatment. The details of treatments of the present investigation are *viz*. T_0: Control (Potting media only), T_1 Neem cake @ 10 g, T_2 Caster cake @ 10 g, T_3 Mustard cake @ 10 g, T_4 Neem cake @ 10 g + VAM @ 5 g, T_5 Neem cake @ 10 g + *Trichoderma harzianum* @ 5 ml, T_6 Neem cake @ 10 g + VAM @ 5 g + *Trichoderma harzianum* @ 5 ml, T7 Caster cake @ 10 g + VAM @ 5 g, T8 Caster cake @ 10 g + *Trichoderma harzianum* @ 5 ml, T_9 Caster cake @ 10 g +VAM @ 5 g+ *Trichoderma harzianum* @ 5 ml, T_{10} Mustard cake @ 10 g +VAM @ 5 g, T_{11} Mustard cake @ 10 g + *Trichoderma harzianum* @ 5 ml, T_{12} Mustard cake @ 10 g + VAM @ 5 g + *Trichoderma harzianum* @ 5 ml after that Black poly bags measuring 6" × 5" with a thickness of 200 gauge were used for sowing. The growing media consisting of soil, farmyard manure (FYM) and sand in a ratio of 1:1:1, was filled into the bags after applying different treatments as mentioned above. Thereafter seeds of papaya was sown in depth of 2.5 cm in polybags. After sowing the seeds, the polybags were arranged as per the treatments allocated. The observations recorded on Days taken to start germination, Rate of emergence (%), Germination percentage (%), maximum height of the seedling height, fresh weight of seedling, dry weight of seedling, Seedling Vigor index-I and Seedling Vigor index-II, the experimental data were statistically analyzed by following standard procedures of Panse and Sukhante, 1985 [17].

Results and Discussions

Days taken to start germination

As per the result of present investigation (Table 1.1) it is clearly indicated that the minimum days taken to start germination (9.89 days) was registered under the treatment T_9 (Castor cake @ 10 g +VAM @ 5 g+ *Trichoderma harzianum* @ 5 ml), which was found statistically at par with the treatment T_{12} (Mustard cake @ 10 g +VAM @ 5 g+ *Trichoderma harzianum* @ 5 ml) having days taken to start germination of 10.36 days under the present study. Moreover, the treatment T_8 & T_{11} and T_6 & T_{10} and T_6 and T_7 having respective days taken to start germination of 13.72

& 13.81 and 11.86 & 12.26 and 11.86 & 11.31 were perceived non-significant difference with each other at 5% level of significance under the present investigation. However, the maximum days taken to start germination (16.03 days) was documented under the treatment T_0 (control). The earliest germination observed in treatment T_9 might be due to the crucial importance of castor cake, VAM and *Trichoderma harzianum* in key stages of germination process the first is stimulating root growth with better colonization of papaya roots in soil microbiota and the second is the production and activating the reverse food mobilization system in roots of seeds. The result of present investigation was closely agreement with the findings reported by Devi *et al*. (2019) [6] and Singh *et al*. (2002) [21] in jackfruit.

Rate of emergence (%)

As per the data displayed in Table 1.1., observed that the highest rate of emergence (49.78%) was recorded under the seeds treated with (T9) Castor cake @ 10 g + VAM @ 5 g + *Trichoderma harzianum* @ 5 ml, which was found significantly superior from rest of the other treatments tested under the present investigation. Furthermore, the treatments T_7 & T_6 and T_{11} & T_5 and T_8 & T_4 having respective rate of emergence of 45.78 & 44.30 and 36.67 & 35.47 and 38.36 & 38.51% were registered statistically at par with each other at 5% level of significance. The lowest rate of emergence (29.3%) was observed under treatment control (T_0). The increased rate of papaya seedlings emergence may be attributed to the stimulatory effect of castor cake, VAM, and *Trichoderma harzianum* on enzyme production, which plays a vital role during the initial stages of germination. The results of the present investigation are also similar with the findings reported by Ashish *et al*. (2021) [3] and Baghel *et al*. (2022) [4] in papaya.

Germination percentage (%)

The results of present trial indicated that the maximum germination percentage (82.21%) was confirmed under the treatment T_9 (Castor cake @ 10 g + VAM @ 5 g + *Trichoderma harzianum* @ 5 ml) which was found significantly superior from other treatments tested under the present investigation. Moreover, the treatments T_6 & T_{10} and T_4 & T_8 and T_{11} & T_5 having respective germination percentage of papaya seeds 66.69 & 66.41 and 64.14 & 63.13 and 60.31 & 60.09% were observed statistically at par with each other at 5% level of significant under the study. However, the minimum germination percentage (54.21%) was registered under the treatment control (T0). The enhanced germination percentage of papaya seeds might be due to the involvement of bio-fertilizer *Trichoderma harzianum* stimulating alpha-amylase activity, which facilitates the breakdown of starch into simple carbohydrates. This process releases chemical energy that supports embryo activation. The present results are in close conformity with the outcomes reported by Raizada *et al*. (2023) [20] and Gupta *et al*. (2023) [11] in papaya seeds.

Height of the seedling (cm)

The data observed at 60 days after sowing, clearly showed that the supremacy of treatment T9 (Castor cake @ 10 g + VAM @ 5 g + *Trichoderma harzianum* @ 5 ml) recorded maximum seedling height which was found statistically similar with T_{12} (Mustard cake @ 10 g +VAM @ 5 g + *Trichoderma harzianum* @ 5 ml) having the seedling height of 24.68 cm. The treatments T_{12}, T_6 & T_7 and T_6, T_7 & T_{10} with average seedling height of 24.68, 24.01, 23.80 and 24.01, 23.80 & 23.52 cm respectively were also showed non-significant differences with each other at 5% level of significance. The minimum seedling height (17.33) was confirmed under the treatment T_0 (control). The increase in seedling height of papaya plants may be attributed due to enhanced photosynthetic efficiency, which provides the energy required for the plant's metabolic activities. *Trichoderma* perform the process of biological fixation as well as work to strengthen the growth of the root and vegetative system of plant. Similar results were observed by Devi *et al*. (2019) [6] in papaya, Shrivastava *et al*. (2021) [22] in papaya.

Fresh weight of seedling (g)

As per the result observed under the trial showed that different organic products and biofertilizers impacted the fresh weight of papaya seedlings. At 60 DAS, maximum fresh weight of papaya seedlings (14.89 g) was reported under the treatment T_9 (Castor cake @ 10 g + VAM @ 5 g + *Trichderma harzianum* @ 5 ml), which was statistically at par with T_{12} (14.42 g). The result revealed that the treatments T_7, T_4, T_{11} & T_{10} and T_2 & T_3 and T_3 & T_1 with fresh weights of seedlings of 12.98, 12.94, 12.93 & 12.65 & 11.47 & 11.12 and 11.12 & 10.80 g, respectively were also found statistically equal with each other at 5% level of significance.

However, the minimum fresh weight of seedlings (9.84 g) was confirmed under control (T_0). The increased fresh weight of the seedling may be the consequence of greater water and nutrient uptake capacity, mobilization and transportation by gibberellin as opposed to cytokinin, which has led to increased production of photosynthetic products and translocation into different plant parts. The outcomes of present trial support the findings of Verma *et al*. (2008) [24] in aonla, Parasanna *et al*. (2012) [18] in mango and Devi *et al*. (2019) [6] and in papaya.

Dry weight of seedling (g)

A preview of data presented in Table 1.2. showed that the treatment T_9 (Castor cake @ 10 g + VAM @ 5 g + *Trichderma harzianum* @ 5 ml) had the maximum dry weight of seedlings (2.13 g) which was found superior from all other treatments of the present investigation. However, the treatments T_7 & T8 and T_{10} & T_{11} and T_3 & T_1 with average dry weight of seedling of 1.63 & 1.59 and 1.23 & 1.18 and 0.92 & 0.87 g, respectively were found statistically at par with each other at 5% level of significance. Further the significant differences were observed among the treatments T_{12}, T_6, T_4, T_5 & T_2 with dry weights of seedling of 1.81, 1.72, 1.46, 1.10 & 1.01 g, respectively. The minimum dry weight of seedling (0.78 g) was reported under the treatment control (T_0). the increased dry weight of papaya seedling might be due to higher fresh weight of papaya, which in turn led to a higher dry weight. This outcome aligns with the research conducted by Verma *et al*. (2008) [24] in aonla, Parasanna *et al*. (2012) [18] and Devi *et al*. (2019) [6] in Papaya.

Seedling vigor index-I

As per the results of present investigation at 60 DAS the superiority of treatment, T_9 (Castor cake @ 10 g + VAM @

5 g + *Trichderma harzianum* @ 5 ml), recorded highest seedling vigor index-I (2072.51) which was significantly different from rest of the other treatments evaluated under study. Moreover, the non-significant differences were observed between the treatments T_7 & T_{10} and T_5 & T_11 having the respective seedling vigor index-I of 1587.22 & 1561.96 and 1215.62 & 1226.70 under the trial. The seedling vigor index-I was enrolled minimum (939.45) under the plants treated with control (T_0). The increased seedling vigor index-I of papaya plants may be the result of different organic cakes with bio fertilizers like *Vesicular arbuscular mycorrhiza* and *Trichoderma harzianum*, which increases seedling length and germination percentage. The seed treated with castor cake, VAM and *Trichoderma* had the highest percentage of germination and recorded the maximum plant height. The present results are in conformity with the findings observed by Panchal *et al*. (2014) [16] in sapota, Kumar and Arora (2007) [13] in peach, Devi *et al*. (2019) [6].

Table 1: Effect of different organic substances and bio-fertilizers on seed germination and of papaya (*Carica papaya* L.) under shade net condition

S. No.	Treatments	Days taken to start germination	Rate of emergence (%)	Germination percentage (%)
1.	T_0-control (Potting media only)	16.03^{h}	29.30^{a}	54.21^{a}
2.	T_1-Neem cake @ 10 g	15.44^{g}	30.15^{a}	56.70^{b}
3.	T_2-Castor cake @ 10 g	15.09^{fg}	33.68^{b}	56.84^{b}
4.	T_3-Mustard cake @ 10 g	15.22^{g}	29.45^{a}	56.09^{b}
5.	T_4-Neem cake @ 10 g + VAM @ 5 g	12.61^{d}	38.51^{d}	64.14^{d}
6.	T_5-Neem cake @ 10 g + *Trichoderma harzianum* @ 5 ml	14.65^{f}	35.47^{c}	60.09^{c}
7.	T_6-Neem cake @ 10 g + VAM @ 5 g + *Trichoderma harzianum* @ 5 ml	11.86^{bc}	44.30^{f}	66.69^{e}
8.	T_7-Castor cake @ 10 g + VAM @ 5 g	11.31^{b}	45.78^{fg}	70.00^{f}
9.	T_8-Castor cake @ 10 g + *Trichoderma harzianum* @ 5 ml	13.72^{e}	38.36^{d}	63.13^{d}
10.	T_9-Castor cake @ 10 g +VAM @ 5 g+ *Trichoderma harzianum* @ 5 ml	9.89^{a}	49.78^{h}	82.21^{h}
11.	T_{10}-Mustard cake @ 10 g +VAM @ 5 g	12.26^{cd}	42.53^{e}	66.40^{e}
12.	T_{11}-Mustard cake @ 10 g + *Trichoderma harzianum* @ 5 ml	13.81^{e}	36.67^{c}	60.31^{c}
13.	T_{12}-Mustard cake @ 10 g +VAM @ 5 g + *Trichoderma harzianum* @ 5 ml	10.36^{a}	46.60^{g}	78.62^{g}
SEm±		0.18	0.60	0.81
CD at 5%		0.54	1.70	1.63

Note: Treatments distribution with the similar lowercase letter are considered statistically equivalent at the 5% significance level. Conversely, treatments assigned different letters are significantly different from each other at the 5% significance level. These letters have been assigned based on the comparison of treatment means using the critical difference value.

Table 2: Effect of different organic substances and bio-fertilizers on Height of seedlings of papaya (*Carica papaya* L.) under shade net condition

S. No.	Treatments	Height of seedlings		
		30 DAS	45 DAS	60 DAS
1.	T_0-control (Potting media only)	5.41^{a}	8.34^{a}	17.33^{a}
2.	T_1-Neem cake @ 10 g	6.12^{bc}	9.54^{bc}	19.12^{b}
3.	T_2-Castor cake @ 10 g	6.37^{cd}	9.73^{cd}	19.41^{bc}
4.	T_3-Mustard cake @ 10 g	5.79^{b}	9.41^{b}	18.03^{a}
5.	T_4-Neem cake @ 10 g + VAM @ 5 g	7.13^{ef}	10.91^{f}	22.51^{f}
6.	T_5-Neem cake @ 10 g + *Trichoderma harzianum* @ 5 ml	6.49^{d}	9.82^{d}	20.23^{cd}
7.	T_6-Neem cake @ 10 g + VAM @ 5 g + *Trichoderma harzianum* @ 5 ml	8.43^{gh}	12.68^{h}	24.01^{gh}
8.	T_7-Castor cake @ 10 g + VAM @ 5 g	8.12^{g}	12.47^{h}	23.80^{gh}
9.	T_8-Castor cake @ 10 g + *Trichoderma harzianum* @ 5 ml	7.01^{e}	10.72^{ef}	21.33^{e}
10.	T_9-Castor cake @ 10 g +VAM @ 5 g+ *Trichoderma harzianum* @ 5 ml	9.07^{i}	13.96^{j}	25.21^{i}
11.	T_{10}-Mustard cake @ 10 g +VAM @ 5 g	7.46^{f}	11.34^{g}	23.52^{g}
12.	T_{11}-Mustard cake @ 10 g + *Trichoderma harzianum* @ 5 ml	6.67^{d}	10.61^{e}	20.34^{d}
13.	T_{12}-Mustard cake @ 10 g +VAM @ 5 g + *Trichoderma harzianum* @ 5 ml	8.66^{h}	13.54^{i}	24.68^{hi}
SEm±		0.12	0.10	0.31
CD at 5%		0.34	0.27	0.93

Note: Treatments distribution with the similar lowercase letter are considered statistically equivalent at the 5% significance level. Conversely, treatments assigned different letters are significantly different from each other at the 5% significance level. These letters have been assigned based on the comparison of treatment means using the critical difference value.

Table 3: Effect of different organic substances and bio-fertilizers on seedling parameters of papaya (*Carica papaya* L.) under shade net condition

S. No.	Treatments	Fresh weight of seedling (60 DAS)	Dry weight of seedling (60 DAS)	Seedling vigor index-I	Seedling vigor index-II
1.	T_0-control (Potting media only)	9.84[a]	0.78[a]	939.45[a]	32.52[a]
2.	T_1-Neem cake @ 10 g	10.80[b]	0.87[b]	1084.10[c]	45.92[b]
3.	T_2-Castor cake @ 10 g	11.47[c]	1.01[c]	1103.26[c]	59.68[d]
4.	T_3-Mustard cake @ 10 g	11.12[bc]	0.92[b]	1011.30[b]	52.70[c]
5.	T_4-Neem cake @ 10 g + VAM @ 5 g	12.94[c]	1.46[f]	1443.79[f]	103.95[g]
6.	T_5-Neem cake @ 10 g + *Trichoderma harzianum* @ 5 ml	12.10[d]	1.10[d]	1215.62[d]	187.23[e]
7.	T_6-Neem cake @ 10 g + VAM @ 5 g + *Trichoderma harzianum* @ 5 ml	14.16[g]	1.72[h]	1680.70[h]	143.38[j]
8.	T_7-Castor cake @ 10 g + VAM @ 5 g	12.98e[f]	1.63[g]	1587.22[g]	112.00[h]
9.	T_8-Castor cake @ 10 g + *Trichoderma harzianum* @ 5 ml	13.49[f]	1.59[g]	1346.56e	124.36[i]
10.	T_9-Castor cake @ 10 g +VAM @ 5 g+ *Trichoderma harzianum* @ 5 ml	14.89[h]	2.13[j]	2072.51[j]	213.74[l]
11.	T_{10}-Mustard cake @ 10 g +VAM @ 5 g	12.65[e]	1.23[e]	1561.96[g]	93.63[f]
12.	T_{11}-Mustard cake @ 10 g + *Trichoderma harzianum* @ 5 ml	12.93[e]	1.18[e]	1226.70[d]	92.27[ef]
13.	T_{12}-Mustard cake @ 10 g +VAM @ 5 g + *Trichoderma harzianum* @ 5 ml	14.42[gh]	1.81[i]	1940.34[i]	177.68[k]
SEm±		0.18	0.02	20.06	2.01
CD at 5%		0.54	0.05	58.67	5.81

Note: Treatments distribution with the similar lowercase letter are considered statistically equivalent at the 5% significance level. Conversely, treatments assigned different letters are significantly different from each other at the 5% significance level. These letters have been assigned based on the comparison of treatment means using the critical difference value.

Seedling vigor index-II

As per the results of study it can be concluded that the seedling vigor index-II of papaya plants was registered maximum (213.74) under the supremacy of treatment T9 (Castor cake @ 10 g + VAM @ 5 g + *Trichderma harzianum* @ 5 ml), which was higher and superior among all other treatments of present investigation. However, the treatments T_{10} & T_{11} and T_5 & T_{11} having respective seedling vigor index-II of 93.63 & 92.27 and 87.23 & 92.27 were statistically identical with each other under the study. The minimum seedling vigor index-II (32.52) was observed under control plants (T_0). The increase in seedling vigor index-II of papaya plants might be due to the result of increased seedling dry weight brought due to effect of different bio-fertilizer treatments. The present result is in close agreement with the results obtained by Qamber *et al*. (2023) [19] in papaya and Parassana *et al*. (2012) [18] in papaya.

Conclusion

Based on the findings obtained from the present investigation, the following conclusions can be drawn that the application of Castor cake @ 10 g + VAM @ 5 g + *Trichoderma harzianum* @ 5 ml proved to be the most effective treatment for enhancing seed germination, overall plant growth, root development, and seedling vigor in papaya under shade net conditions, as it is economical, eco-friendly and has no antagonistic effects on the environment or human health. It also provides a broader range of nutrients than most artificial fertilizers.

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