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Effect of Growing Media on Seed Germination and Seedling Growth of Miracle Fruit (*Synsepalum dulcificum* Schumach and Thonn. Daniell)

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Abstract

Miracle fruit (*Synsepalum dulcificum*), a tropical shrub known for its unique taste-modifying properties and medicinal potential, faces significant propagation challenges due to its recalcitrant seed nature. This study aimed to evaluate the effect of different potting media on seed germination and seedling growth to standardize an efficient propagation medium. Five media combinations were tested viz. T_1 (control- soil)), T_2 (soil + cocopeat + FYM @ 2:1:1), T_3 (soil + cocopeat + vermicompost @1:1:1), T_4 (sawdust) and T_5 (sawdust + vermicompost @ 1:1) under a completely randomized design with three replications. Results revealed that seeds sown in T_5 significantly outperformed other treatments in terms of earliest germination (12.00 days), highest germination percentage (53.33%), seedling height (7.51 cm at 90 DAS), root length (16.66 cm), and seedling weight (0.8 g). Meanwhile, seeds sown in T_3 showed superiority in vegetative growth traits such as number of branches (3.83), number of leaves (4.17), and stem girth (0.2 cm). The positive effects of T_5 and T_3 are attributed to the enhanced aeration, moisture retention, and nutrient supply provided by vermicompost, cocopeat, and sawdust. These findings highlight the significance of media composition in improving germination and early seedling vigour and suggest that vermicompost-based substrates, especially when combined with sawdust or cocopeat, are ideal for seed propagation in miracle fruit.

***Key words*:** *Synsepalum dulcificum*, Propagation media, Sawdust, Seed germination, Seedling growth, Vermicompost

Miracle fruit *(Synsepalum dulcificum)* is a tropical evergreen shrub native to West Africa, belonging to the family Sapotaceae. The fruit is a small ellipsoid red berry and possesses a unique taste-modifying property due to the presence of a glycoprotein miraculin [1]. This glycoprotein can temporarily alter taste perception by converting sour taste into a sweet sensation. Besides its sweetening property, the fruit has various sanative properties like anti-diabetic, anti-cancerous, anti-hyperuricemic, anti-hemorrhoids, and so on.

Even though miracle fruit possesses various pharmacological properties, its commercial cultivation is rare. The primary constraint for commercial cultivation is propagation. While seeds are a common method, they are recalcitrant and must be sown immediately after extraction. Studies have shown that storing seeds at low temperatures (10°C or 4°C) reduces their viability to just 7 days, and storage at 0°C is highly detrimental. Although a storage temperature of 25°C can extend the shelf life to 28 days, it results in minimal germination [2]. Propagation through cuttings is another option, but rooting is difficult. Therefore, these propagation challenges severely limit commercial scalability.

The production of quality seedlings depends on the type of media used for seed propagation. Studies show that different potting media influence seed germination and seedling growth differently. For promoting seed germination, sawdust medium was found to be efficient in miracle fruit, whereas soil medium enhanced seedling growth. Germination was more rapid in sawdust medium (26.5 ± 7.9 days) compared to soil (31.9 ± 11.2 days) [3]. In acid lime cv. Kagzi, soil + cocopeat (1:1) media exhibited the highest germination percentage (63.27% at 45 DAS) and took minimum days for germination (30.33 days for 50% germination) [4]. Soil + sand + FYM (1:1:1) resulted in the highest germination rate (74.8%) and seedling growth parameters in khirni [5]. The media containing soil+ sand+ vermicompost (1:1:2) resulted in highest germination (95.5%) and survival rates (82.25%)) for germination and seedling growth of different mango cultivars [6]. Keeping these findings in mind the present study was conducted to standardize an efficient media for seed propagation of miracle fruit.

MATERIALS AND METHODS

Experimental site

The study was conducted at the Department of Fruit Science, College of Agriculture, Kerala Agricultural University, Vellanikkara, Thrissur, Kerala. The experimental site is geographically positioned at 10°54′N latitude and 76°28′E longitude, with an altitude of 22.25 meters above mean

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sea level. The area falls under a humid tropical climate zone, experiencing abundant rainfall predominantly during the monsoon season.

Plant materials and seed preparation

Fully ripened miracle fruits (*Synsepalum dulcificum*) were harvested from five-year-old trees maintained at the Agricultural Research Station, Mannuthy, Thrissur, Kerala during November 2024. The seeds were extracted from the pulp, cleaned, and immediately used for sowing to ensure viability. No chemical or mechanical pretreatments were applied.

Treatment details

Five different potting media were formulated as follows:

T_1: Soil (control)
T_2: Soil + cocopeat + Farmyard Manure (2:1:1 by volume)
T_3: Soil + cocopeat + vermicompost (1:1:1 by volume)
T_4: Sawdust
T_5: Sawdust + vermicompost (1:1 by volume)

The media were filled in 5" × 7" sized polybags and the extracted seeds were sown at a depth of 2–3 cm.

Experimental design

The study was laid out in a Completely Randomized Design (CRD) with three replications per treatment. Each replication consisted of ten seeds, and all treatments were maintained under polyhouse with regular irrigation and weeding.

Observations recorded

Seed parameters such as seed weight, seed length and seed diameter were measured prior to sowing. After sowing, germination parameters including time taken for germination and germination rate were recorded. Germination rate was calculated using the formula:

$$\text{Germination rate (\%)} = \frac{\text{No. of seeds germinated}}{\text{No. of seeds sown}} \times 100$$

Growth parameters such as height of seedling, number of branches, number of leaves, girth of seedling at 10 cm height, average root length and weight of seedling were also recorded. The observations were taken at 15 days intervals for three months. Average root length and weight of seedling were recorded at the end of experiment.

Statistical analysis

The experimental data recorded for different parameters were analyzed using Analysis of Variance (ANOVA) under a Completely Randomized Design (CRD). The significance of the results was tested at the 5% probability level. Statistical computations were carried out with the help of KAU GRAPES (General R-based Analysis Platform Empowered by Statistics) software, version 1.0.0 [7].

RESULTS AND DISCUSSION

The results revealed notable variations among the treatments in terms of seed germination and seedling growth characteristics, and are as shown below:

Effect of media on germination parameters

The time taken for germination varied significantly among the treatments (Table 1). The earliest germination was recorded in seeds sown in T_5 (sawdust + vermicompost @ 1:1), with an average of 12.00 days, which was on par with T_3 (soil + cocopeat + vermicompost @ 1:1:1) and T_2 (soil + cocopeat + FYM @ 2:1:1), which took 12.66 days and 13.66 days, respectively. The improved performance of these treatments may be attributed to the presence of organic amendments such as vermicompost and FYM, particularly when combined with cocopeat. These components are known to enhance aeration, moisture retention, and nutrient availability, thereby creating favourable conditions for early seedling emergence. Our findings are consistent with a study where a potting mixture of vermicompost, cocopeat, and perlite resulted in the earliest germination (8.3 days) and enhanced seedling vigour in *Carica papaya* [8]. Furthermore, sawdust also contributed positively, with a previous study on miracle fruit reporting that germination was more rapid in sawdust medium (26.5 ± 7.9 days) compared to soil (31.9 ± 11.2 days) [3], indicating its effectiveness in supporting faster seed emergence due to better aeration and water drainage. In contrast, delayed germination was observed in T_1 (control-soil) and T_4 (sawdust), with mean germination times of 23.00 days and 19.00 days, respectively. These results suggest that while sawdust alone has limited nutritional capacity, its combination with nutrient-rich amendments like vermicompost significantly enhances germination performance.

The germination rate also varied significantly among the treatments. The highest germination percentage was observed in seeds sown in T_5 (sawdust + vermicompost @ 1:1) at 53.33%, which was statistically on par with seeds sown in T_1 (control-soil) at 46.66% and T_3 (soil + cocopeat + vermicompost @ 1:1:1) with 43.33%. The lowest germination rate was recorded in seeds sown in T_2 (soil + cocopeat + FYM @ 2:1:1, 20.00%). This outcome is likely due to the presence of farmyard manure (FYM), as a study on the rapid growth of mango nursery plants found that FYM, at any level, led to complete seedling death within 3-4 months of germination. This undesirable effect was attributed to the potting medium having an unfavourably high electrical conductivity (EC) [9].

Table 1 Effect of growing media on germination parameters of seed

Treatments	Time taken for germination (days)	Germination rate (%)
T_1	23.00^{c}	46.66^{a}
T_2	13.66^{a}	20.00^{c}
T_3	12.66^{a}	43.33^{ab}
T_4	19.00^{b}	33.33^{b}
T_5	12.00^{a}	53.33^{a}
SE (m)	0.71	3.94
CD @ 5%	2.25	12.42

Effect of media on seedling growth parameters

Seedling growth is significantly influenced by the composition of the growing medium (Table 2), which affects nutrient availability, moisture retention, and aeration. Among the treatments, seedlings grown in T_5 (sawdust + vermicompost @ 1:1) recorded the highest seedling height (7.51 cm at 90 DAS), indicating its superior support for seedling vigour. Moderate growth was observed in seedlings in T_3 (soil + cocopeat + vermicompost @ 1:1:1, 6.43 cm at 90 DAS) and T_2 (soil + cocopeat + FYM @ 2:1:1, 6.4 cm at 90 DAS). In contrast, seedlings in T_4 (sawdust alone) showed reduced growth (5.62 cm at 90 DAS). The lowest height was recorded in seedlings grown in T_1 (control-soil) at 5.13 cm (90 DAS), emphasizing the need for organic amendments to enhance seedling development. This positive influence of organic

amendments is further supported by a study where 1000 ppm sawdust vermicompost extract significantly increased plant height (15.33 cm) in *Syngonium podophyllum*, confirming the potential of sawdust-based vermicompost in enhancing vegetative growth [10].

Branch formation at 120 days after sowing (DAS) differed markedly among media, with seedlings in T_3 (soil + cocopeat + vermicompost @ 1:1:1) producing the highest number of branches (3.83), followed by seedlings in T_2 (soil + cocopeat + FYM @ 2:1:1) and T_5 (sawdust + vermicompost @ 1:1), which were statistically on par, each generating two branches. In contrast, seedlings grown in T_1 (control-soil) produced only one branch and those in T_4 (sawdust alone) produced none, indicating the importance of organic amendments in shoot development. The number of leaves per seedling showed a similar trend, with T_3 (soil + cocopeat + vermicompost @ 1:1:1) recording the highest count of 4.17 at 90 DAS, which was on par with T_1 (control-soil) at 3.93 and T_5 (Sawdust + vermicompost @ 1:1) at 3.69. In contrast, seedlings in T_4 (sawdust alone) showed the lowest (2.72) number of leaves. Stem girth also followed a comparable pattern, with seedlings in T_3 (soil + cocopeat + vermicompost @ 1:1:1) showing the highest girth (0.2 cm at 10 cm height), followed by those in T_1 (control-soil) and T_5 (sawdust + vermicompost @ 1:1) which both recorded 0.17 cm girth at 10 cm height, and the lowest was recorded in T_4 (sawdust alone, 0.1 cm at 10 cm height). These findings are consistent with previous research in jamun, where the soil + cocopeat + vermicompost (1:1:1) medium resulted in improved vegetative growth, with a higher number of leaves (55.75) and greater stem girth (7.58 mm), highlighting the efficiency of this medium in promoting seedling vigour [11]. This is further supported by observations in acid lime, where soil + vermicompost (1:1) medium was observed to produce a greater number of leaves (16.47), demonstrating the beneficial role of vermicompost-based media in improving overall seedling performance [4].

Table 2 Effect of growing media on seedling growth parameters

Treatments	Height of seedling (90 DAS) (cm)	Number of branches (120 DAS)	Number of leaves (90 DAS)	Girth of seedling at 10 cm height (cm)	Root length (cm)	Weight of seedling (g)
T_1	5.13^{d}	1.00^{c}	3.93^{a}	0.17^{ab}	15.16	0.61^{b}
T_2	6.40^{b}	2.00^{b}	3.33^{b}	0.13^{bc}	12.33	0.39^{c}
T_3	6.43^{b}	3.83^{a}	4.17^{a}	0.20^{a}	16.10	0.77^{ab}
T_4	5.62^{c}	0.00^{d}	2.72^{c}	0.10^{c}	13.83	0.39^{c}
T_5	7.51^{a}	2.00^{b}	3.69^{ab}	0.17^{ab}	16.66	0.80^{a}
SE (m)	0.12	0.075	0.172	0.012	1.18	0.06
CD @ 5%	0.40	0.075	0.541	0.039	*NS*	0.18

The average root length of seedlings varied between 12.33 cm in T_2 (soil + cocopeat + farmyard manure) and 16.66 cm in T_5 (sawdust + vermicompost 1:1), though the differences were not statistically significant. In contrast to root length, seedling weight varied with media composition. Seedlings in T_5 (sawdust + vermicompost @ 1:1) showed the highest weight (0.8 g), followed by T_3 (soil + cocopeat + vermicompost @ 1:1:1) at 0.77 g. These findings indicate the positive influence of nutrient-rich and well-aerated media on seedling growth. While T_1 (control-soil) produced a moderate seedling weight of 0.61 g, its performance improved with amendments. Conversely, T_2 (soil + cocopeat + farmyard manure @ 2:1:1) and T_4 (sawdust alone), with weights below 0.4 g, were the least effective media. These results align with previous research that a sawdust-vermicompost blend significantly enhanced nutrient release and mineralization, leading to improved overall plant vigour [12].

The superior seedling growth observed in T_5 (sawdust + vermicompost 1:1) and T_3 (soil + cocopeat + vermicompost 1:1:1) can be attributed to the beneficial effects of vermicompost and sawdust on soil health and seedling development. Vermicompost has been reported to significantly enhance soil fertility by increasing organic carbon, available macronutrients (N, P, K), micronutrients, and cation exchange capacity (CEC), while reducing bulk density, thereby promoting better nutrient uptake and plant growth [13]. It also contains hormone-like substances such as auxins, cytokinins, and gibberellins that promote root formation, increase biomass, and improve overall seedling vigour [14]. Sawdust possesses favourable physical properties, including low bulk density, high porosity, good water retention, and moderate drainage, which make it a valuable component of plant growth media [15]. Beyond these attributes, its incorporation into compost has been shown to enhance temperature regulation, reduce N_2O emissions, and reshape the microbial community by decreasing denitrification and ureolysis while promoting nitrogen fixation [16]. A key factor contributing to the favourable effect of the sawdust culture medium was its slightly acidic pH, a condition essential for successful germination in *Synsepalum dulcificum* [17]. This chemical property, combined with the medium's light and porous physical structure, promoted the easy emergence of the hypocotyl in contrast to the denser soil.

CONCLUSION

The study demonstrated that growing media significantly influences seed germination and seedling growth in miracle fruit. Among the treatments, T_5 (sawdust + vermicompost @ 1:1) excelled in parameters such as earliest germination (12.00 days), highest germination percentage (53.33%), seedling height (7.51 cm at 90 DAS), root length (16.66 cm), and seedling weight (0.8 g), highlighting the beneficial effects of combining nutrient-rich and well-aerated components. T_3 (soil + cocopeat + vermicompost @ 1:1:1) showed superiority in vegetative traits such as branch number (3.83), leaf count (4.17), and stem girth (0.2 cm), indicating its effectiveness in enhancing shoot development. These findings underscore the importance of integrating organic amendments like vermicompost with structurally favorable materials such as sawdust or cocopeat to optimize both germination and early seedling vigour in miracle fruit.

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