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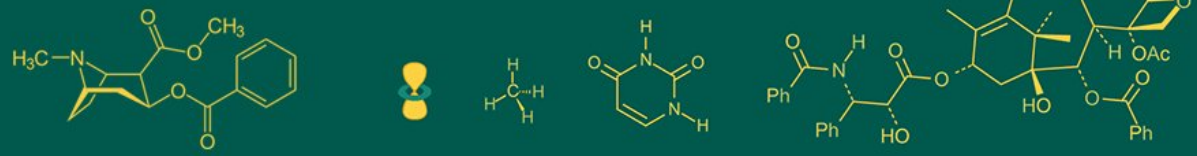

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Suryakant
Research Scholar College of Horticulture and Research Station, Saja, Bemetara. MGUVV, Durg, Chhattisgarh, India

Bhawna Panda
Assistant Professor, Department of Fruit Science, Mahant Bisahu Das College of Horticulture and Research Station, Gaurella-Pendra-Marwahi. MGUVV, Durg, Chhattisgarh, India

Sonal Upadhyaya
Assistant Professor, Department of Genetics and Plant Breeding, Mahant Bisahu Das College of Horticulture and Research Station Gaurella-Pendra-Marwahi. MGUVV, Durg, Chhattisgarh, India

Mukesh Verma
Research Scholar College of Horticulture and Research Station, Saja, Bemetara. MGUVV, Durg, Chhattisgarh, India

Corresponding Author:
Suryakant
Research Scholar College of Horticulture and Research Station, Saja, Bemetara. MGUVV, Durg, Chhattisgarh, India

Effect of various soilless growing media on seed germination of acid lime under protected structure

Suryakant, Bhawna Panda, Sonal Upadhyaya and Mukesh Verma

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Abstract
The current investigation entitled "Effect of various soilless growing media on seed germination of acid lime under protected structure" Was carried out during the year 2024-25 at Government Horticulture Nursery Lalpur, Districts Gaurella-Pendra-Marwahi, Departments of Fruit Science, College of Horticulture and Research Station Saja, Bemetara (C.G.), Mahatma Gandhi University of Forestry, Durg (C.G). The experiments was conducted in completely randomized design (CRD) comprising of 14 treatments.

The observations will be recorded after sowing of acid lime seed. Physical composition of acid lime seed before sowing and Growth parameters of acid lime seed after germination of recorded at 30, 60 and 90 DAS. Seed weight (gm) and Seed size (mm). Seed germination percentages were recorded at 30 DAS. Length of roots (cm), were recorded at 90 DAS. Length of shoots (cm), were recorded at 90 DAS. Root to Shoot ratio, were recorded at 90 DAS. Number of leaves per plant (cm) were recorded at 30, 60 and 90 DAS. Height of plants (cm), were recorded at 30, 60 and 90 DAS. Survival percentage of plants (%), were recorded at 90 DAS.

The result indicated that the best soilless growing media on physical composition of acid lime seed before sowing and growth parameters of acid lime seed after germination. However, (T_{11}) Vermiculite + cocopeat (1:1), showed the best result over all parameters likes, seed weight (g), seed size (mm) seed germination percentages, length of root (cm), length of shoot (cm), root to shoot ratio, number of leaves per plants, height of plants and survival percentage of plants.

Keywords: Acid lime, soilless growing media, cocopeat, sawdust, sphagnum moss, vermiculite

Introduction

Acid Lime (*Citrus aurantifolia* Swingle) is the third most important citrus fruit crop in India after mandarin and sweet orange. Commonly known as Kagzi lime, Sour lime, Key lime, or Mexican lime, it belongs to the family Rutaceae and has a chromosome number of 2n = 18. (Anon., 2015) [3]. Commercial cultivation is mainly practiced in tropical and subtropical regions. The fruits of acid lime have remarkable therapeutic and nutritional value. The trees are medium sized, hardy, and semi-vigorous, with an upright growth habit, loose and irregular crown, and light green foliage. They bear numerous thorns. The fruits are typically round to oblong, greenish yellow at maturity, with highly acidic juice. The seeds are poly embryonic, an important trait for propagation. Acid lime enjoys high market demand both as fresh fruit and for its refreshing processed juice. Citrus fruits are unique due to their diversity in shape and wide adaptability to different climatic conditions. Acid lime cultivation is best suited to tropical and subtropical climates, with an optimum temperature range of 20 °C to 35 °C. The crop performs well in well-drained, fertile soils with a pH between 6.0-7.0 (Chin and Roberts, 1980) [14]

In India, the major lime-producing states include Andhra Pradesh, Maharashtra, Gujarat, Karnataka, Tamil Nadu, Assam, Bihar, Rajasthan, and Madhya Pradesh, among others. According to the Government of India (Third Advance Estimates, 2023-24), the total area and production of acid lime in India is about 318 thousand hectares and 3886 thousand MT. In Chhattisgarh, the crop is grown over 12.328 thousand hectares with a production of 88.675 MT, (Anonymous, 2022-23) [4]. In Chhattisgarh, citrus cultivation is concentrated in districts such as Sarguja, Balodabazar, Raipur, Mungeli, Balod, Bilaspur, Rajnandgaon, Gariyaband and Surajpur (Department of Agriculture and Cooperation, Chhattisgarh, 2012-

2017) [8]. Botanically, acid lime trees are typically evergreen shrubs or small trees with glossy, oval leaves. Many species possess thorns. The flowers are white, fragrant, and generally five-petaled. The fruits are classified as a modified berry called a hesperidium, characterized by segmented juicy vesicles. The rind is leathery and dotted with numerous oil glands (Kadam *et al*., 2010) [10].

Acid lime (*Citrus aurantifolia* Swingle) is commercially propagated through seeds, while other methods such as grafting, budding, and air-layering are also practiced. However, propagation encounters several challenges due to the recalcitrant nature of seeds, which results in poor storage life, loss of viability, and lack of uniformity in seedlings (Chaudhary *et al*., 2020) [16]. In India, Kagzi lime is predominantly propagated by seeds, as it breeds true to type owing to a high degree of nucellar embryony (39-60%). Seed propagation is considered the most economical and convenient method. Kagzi lime seeds exhibit polyembryony, producing more than one embryo per seed. Yet, their recalcitrant nature causes low germination (27-58%) and a very short storage period, posing difficulties for nurserymen (Chatopadhya and Mohanta, 1998) [15]. Germination in kagzi lime is generally slow and irregular, which remains a major limitation. The presence of growth inhibitors and the mechanical resistance of the seed coat to radicle emergence are considered the two principal factors hindering germination. For raising seedlings, freshly extracted seeds should be sown in raised seedbeds to ensure better establishment (Patel *et al*., 2017) [22]. Seed germination usually requires around three weeks. A critical problem in kagzi lime propagation is the high mortality of seedlings at the primary stage. This is attributed mainly to inhibitory compounds present in the seed coat, which act as a barrier and delay early germination (Jadhav *et al*., 2019) [17]

Acid lime (*Citrus aurantifolia* Swingle) is a popular citrus fruit crop that can be successfully cultivated using soilless growing media. These media provide several advantages over traditional soil-based cultivation, including improved water use efficiency, higher crop yields, and reduced incidence of soil-borne disease (Baiyeri and Mbah, 2006) [6]. Soilless media are crucial in horticulture as they create an optimal environment for plant growth by ensuring better control over moisture, nutrients, and pH. Substrates such as peat, coconut coir, and perlite enhance drainage, aeration, and water retention, thereby promoting healthier root development and faster plant growth. They also minimize the risk of soil-borne pests and diseases, reducing the need for chemical pesticides (Noble and Coventry, 2005) [19]. Soilless cultivation systems are highly versatile, making them suitable for controlled environments like greenhouses and urban farming. Moreover, they contribute to sustainability by conserving water and lowering chemical inputs, thus serving as an efficient option for modern agriculture (Bartczak *et al.*, 2007) [7]. Growing media play a vital role not only in seed germination but also in the subsequent growth and development of seedlings. Among various substrates, vermiculite is particularly effective as it provides ample oxygen and water to plant roots, offers sufficient nutrient and water storage, balances the physical, chemical, and biological requirements for healthy growth, is lightweight, and ensures uniform plant development (Atefe *et al.*). Similarly, cocopeat enhances water holding capacity, nutrient availability, infiltration rate, porosity, and hydraulic conductivity of the medium (Savithri *et al*., 2014) [26]. The incorporation of sand and vermiculite further improves aeration and moisture conservation. When vermiculite is combined with peat or other composted organic materials like sawdust, it forms an excellent medium for plant propagation and growth (Maher *et al*., 2008) [18].

Cocopeat, a by-product of coconut husk derived from the processing of coconut shells, is a lightweight, sterile, and inert growing medium. It has the ability to retain moisture, suppress weeds, and provide adequate aeration for plant roots (Abad *et al*., 2005) [1]. Sawdust, a wood residue obtained from sawmilling operations, is a coarse and dry material that can be utilized as a growing medium, mulch, or soil amendment. Its incorporation improves soil structure, enhances water holding capacity, and suppresses weed growth (Sawan and Eissa, 1996) [25]. Similarly, sphagnum moss, a type of peat moss obtained from the partial decomposition of sphagnum plants, is highly acidic, sterile, and absorbent. It effectively retains moisture, suppresses weeds, and provides sufficient aeration for root development (Evans and Stamps, 1996) [9].

Materials and Methods

The study was conducted during 2024-25 at the Government Horticulture Nursery Lalpur, Districts Gaurella-Pendra-Marwahi. College of Horticulture and Research Station, Saja, Bemetara, Chhattisgarh. The experiment followed a Completely Randomized Design (CRD) with three replications and 14 treatments. Comprising nine treatments combinations T_5 = Cocopeat + Sand (1:1) T_6 = Cocopeat + Sawdust (1:1) T_7 = Cocopeat + Sphagnum Moss (1:1) T_8 = Sawdust + Sand (1:1) T_9 = Sawdust + Sphagnum Moss (1:1) T_{10} = Sphagnum Moss + Sand (1:1) T_{11} = Vermiculite + Cocopeat (1:1) T_{12} = Vermiculite + Sawdust (1:1) T_{13} Vermiculite + Sphagnum Moss (1:1). Acid lime seeds were sown in polybags size (6 × 4 cm) with a total number of plants 420 maintained throughout the study. The optimum temperature and relative humidity of sowing in acid lime seeds (25-30°C, 80-90 % relative humidity).

Observations were recorded at 30, 60, 90 days. Physical composition of acid lime seed before sowing (Seeds weight (g)), (Seeds size (mm)) and growth parameters of acid lime seed after sowing. (Seeds germinations percentages (%)), (Height of plants (cm)). The data were analyzed statistically using ANOVA as per Panse and Sukhatme (1985) with treatment means compared at the 5% significance level.

Results and Discussions

1. Seeds weight (g) before sowing

The maximum seed weight of (0.55g) was recorded in T_{11} = (Vermiculite + Cocopeat (1:1)), followed by T_7 = (90.52g) and at par T_2 = (0.50g) whereas the minimum seed weight of (0.28g) was recorded in T_0 = (control). The results of this study revealed that the effect of seed weight influenced some of the seedlings' growth parameters. Seed weight influence was, however, not statistically significant on the local mango studied. Although heavy seeds produced more seedlings per seed, longer stem heights, higher seedling dry weights, and more leaves, there was no statistical significance compared with medium and light seeds. Olorunmaiye *et al.*, (2010) [20]. Variation in seed weight clearly influences germination in *Carica papaya.* Heavy seeds germinate earlier and achieve greater germination percentage than small seeds under both laboratory and greenhouse conditions. Khan and Shankar (2001) [13].

2. Seeds size (mm) before sowing

The maximum seed size of 5.8 mm was recorded in T_{11} = (Vermiculite + Cocopeat (1:1)), followed by T_7 = 5.7 (mm) and at par T_2 = 5.6 (mm) whereas the minimum seed weight of 4.4 (mm) was recorded in T_0 = (control). Seed size,

generally assessed by its length and breadth, is an important factor influencing germination and subsequent seedling growth in fruit crops. Larger seeds usually contain well developed embryos along with greater nutrient reserves, which promote quicker germination, stronger root proliferation, and enhanced shoot growth compared to smaller seeds. In citrus species, for instance, larger seeds have been reported to produce more vigorous seedlings with higher survival rates. Singh and Srivastava, (2010) [27]. In mango and jamun, bigger seeds germinated earlier and established more successfully under nursery conditions. Sharma *et al.*, (2013) [29].

3. Seeds germination percentages (%) after sowing

The germination percentage of seeds was recorded at 30 DAS. The results of the present investigation indicated that soilless growing media had a significant influence on seed germination. The maximum germination (93%) was observed in T₁1 = (Vermiculite + Cocopeat (1:1)), followed by T_7 = (92%) and at par T_2 = (90%). The minimum germination percentage (58%) was recorded in T_0 (Control). The highest germination percentage (93%) was recorded in T_{11} = Vermiculite + Cocopeat (1:1). This may be attributed to the stimulatory effect of Vermiculite + Cocopeat along with the favourable influence of the medium on seed germination. The results revealed that the maximum seed germination (90.00 %) was observed cocopeat + vermicompost (2:1) the lowest germination was recorded under control (40.00%). Singh *et al.*, (2017) [28]. in Kagzi lime, where they observed maximum seed germination (91%) in soilless media containing (cocopeat + perlite) the lowest germination recorded under control (53%). Kalalbandi *et al.*, (2003) [11]

4. Height of plants (cm)

It was observed that the soilless growing media had a significant effect on the seedling height. The maximum heights of plants 11.8 cm, 21.3 cm, and 32.4 cm were recorded under T_{11} = Vermiculite + cocopeat (1:1), followed by T_7 = 11.2 cm, 20.4 cm, 31.1 cm and at par T_2 = 10.5 cm, 18.8 cm, 28.6 cm while the minimum heights of 7.1 cm, 12.2 cm, and 18.7 cm were recorded in T_0 (control) at 30, 60, and 90 DAS, respectively. in Rangpur lime. The maximum plant height (11.97 cm) at 120 DAS was observed under soilless growing media, whereas the minimum plant height (7.92 cm) was recorded in the control at 120 DAS. Singh *et al.*, (2017) [28]

in pistachio, where the maximum seedling height and internode length were recorded under cocopeat + vermicompost (1:1). Patil *et al.* (2018) [23] also reported a maximum plant height of 82.60 cm when jamun seeds were treated with (cocopeat + sand + vermicompost) prior to sowing. Ozguven *et al.*, (1995) [21]. In acid lime. The enhanced height growth in such media demonstrates the potential of soil-less culture as a sustainable alternative to traditional soil-based nursery practices. The maximum height of plants (14.77 cm) at 90 DAS was observed under soilless growing media (Vermicompost + sand + cocopeat) whereas the minimum height of plant (6.82 cm) was recorded in the control at 90 DAS. Kumari *et al.*, (2018) [12].

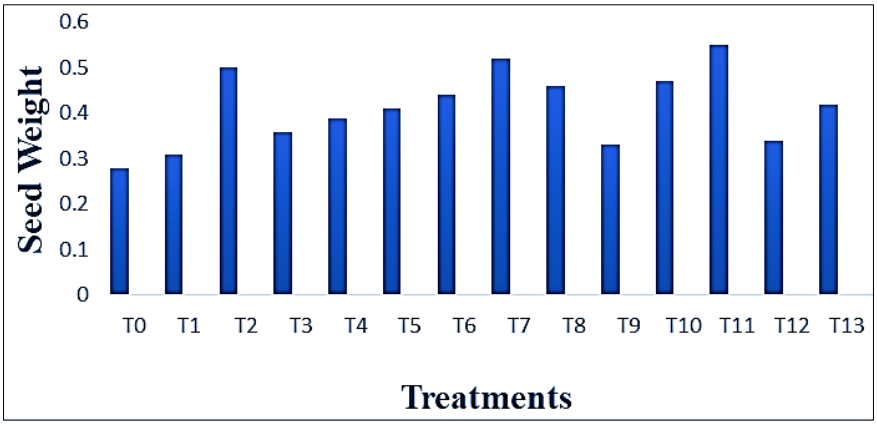

Fig 1: Seed weight (gm) before sowing

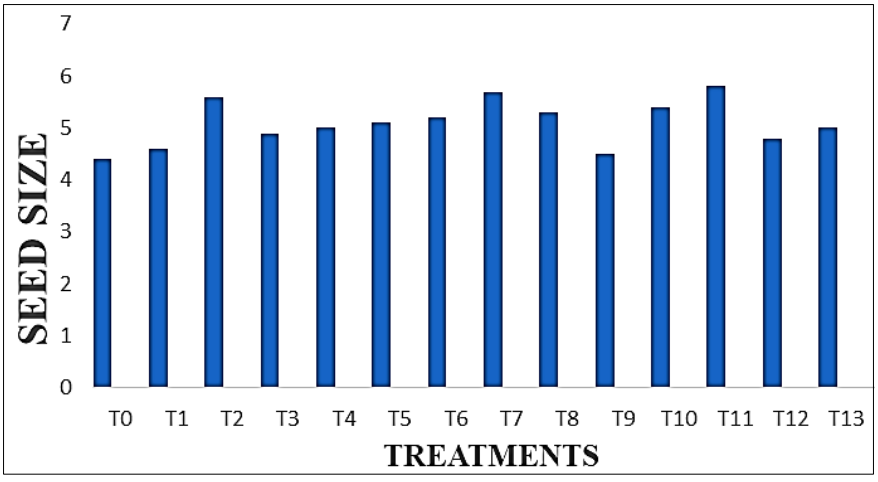

Fig 2: Seed size (mm) before sowing

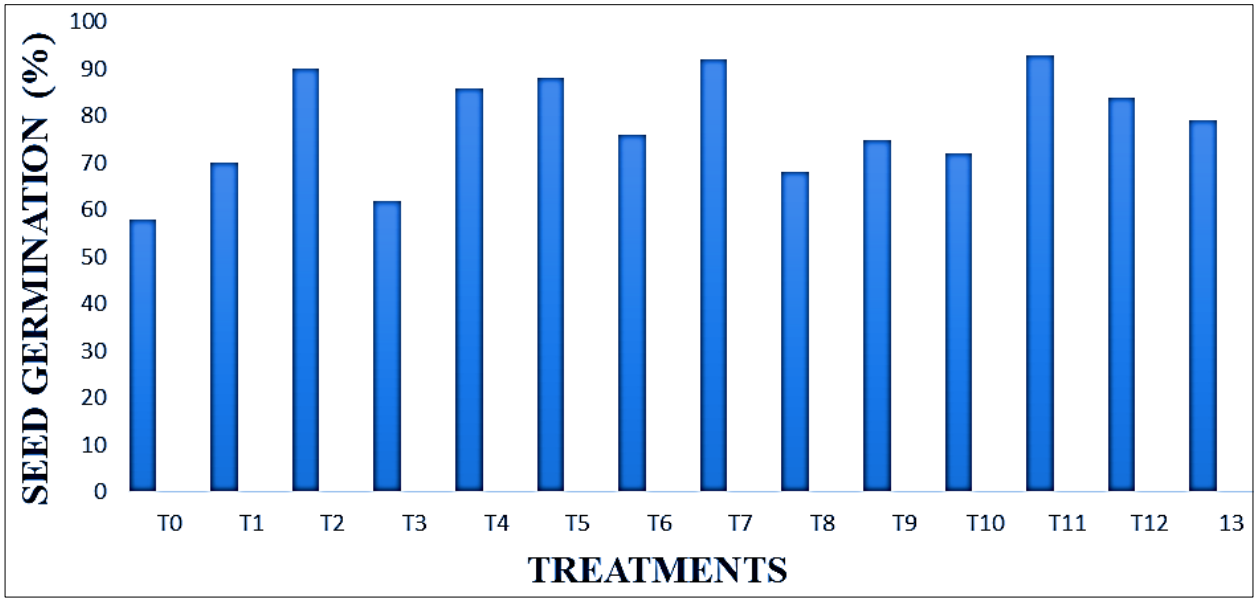

Fig 3: Effect of various soilless growing media on seed germination percentages.

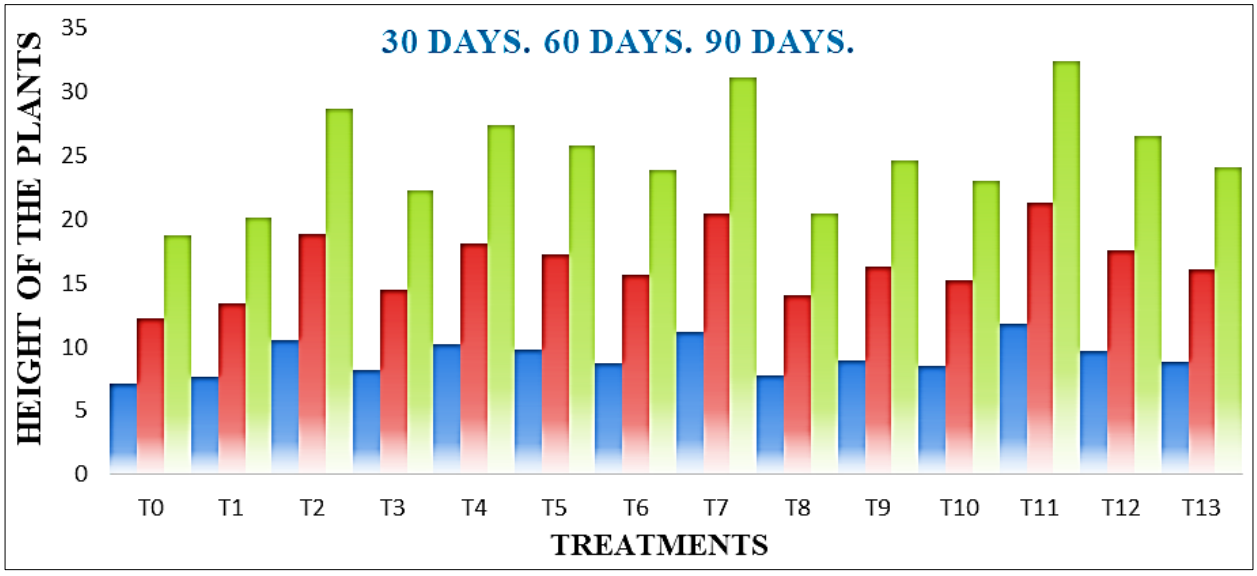

Fig 4: Effect of various soilless growing media on height of plant (cm).

Table 1: Seed weight (gm) before sowing

Treatments	Media	Average
T_0	Soil (control)	0.28
T_1	Sand	0.31
T_2	Cocopeat	0.50
T_3	Sawdust	0.36
T_4	Sphagnum moss	0.39
T_5	Cocopeat + sand (1:1)	0.41
T_6	Cocopeat + sawdust (1:1)	0.44
T_7	Cocopeat + sphagnum moss (1:1)	0.52
T_8	Sawdust + sand (1:1)	0.46
T_9	Sawdust + sphagnum moss (1:1)	0.33
T_{10}	Sphagnum moss + sand (1:1)	0.47
T_{11}	Vermiculite + cocopeat (1:1)	0.55
T_{12}	Vermiculite + sawdust (1:1)	0.34
T_{13}	Vermiculite + sphagnum moss (1:1)	0.42
	SE m±	0.007
	CD at 5%	0.021
	CV	3.014

Table 2: Seed size before sowing

Treatments	Media	Average
T_0	Soil (control)	4.4
T_1	Sand	4.6
T_2	Cocopeat	5.6
T_3	Sawdust	4.9
T_4	Sphagnum moss	5.0
T_5	Cocopeat + sand (1:1)	5.1
T_6	Cocopeat + sawdust (1:1)	5.2
T_7	Cocopeat + sphagnum moss (1:1)	5.7
T_8	Sawdust + sand (1:1)	5.3
T_9	Sawdust + sphagnum moss (1:1)	4.5
T_{10}	Sphagnum moss + sand (1:1)	5.4
T_{11}	Vermiculite + cocopeat (1:1)	5.8
T_{12}	Vermiculite + sawdust (1:1)	4.8
T_{13}	Vermiculite + sphagnum moss (1:1)	5.0
	SE m±	0.065
	CD at 5 %	0.191
	CV	2.218

Table 3: Effect of various soilless growing media on seed germination percentages.

Treatments	Media	Average
T_0	Soil (control)	58
T_1	Sand	70
T_2	Cocopeat	90
T_3	Sawdust	62
T_4	Sphagnum moss	86
T_5	Cocopeat + sand (1:1)	88
T_6	Cocopeat + sawdust (1:1)	76
T_7	Cocopeat + sphagnum moss (1:1)	92
T_8	Sawdust + sand (1:1)	68
T_9	Sawdust + sphagnum moss (1:1)	75
T_{10}	Sphagnum moss + sand (1:1)	72
T_{11}	Vermiculite + cocopeat (1:1)	93
T_{12}	Vermiculite + sawdust (1:1)	84
T_{13}	Vermiculite + sphagnum moss (1:1)	79
	SE m±	**0.655**
	CD at 5 %	**1.906**
	CV	**1.454**

Table 4: Effect of various soilless growing media on height of plant (cm).

Treatments	Media	Height of plants (cm)		
		30 DAYS	60 DAYS	90 DAYS
T_0	Soil (control)	7.1	12.2	18.7
T_1	Sand	7.6	13.4	20.1
T_2	Cocopeat	10.5	18.8	28.6
T_3	Sawdust	8.2	14.5	22.3
T_4	Sphagnum moss	10.2	18.1	27.4
T_5	Cocopeat + sand (1:1)	9.8	17.2	25.8
T_6	Cocopeat + sawdust (1:1)	8.7	15.6	23.9
T_7	Cocopeat + sphagnum moss (1:1)	11.2	20.4	31.1
T_8	Sawdust + sand (1:1)	7.8	14.0	20.4
T_9	Sawdust + sphagnum moss (1:1)	8.9	16.3	24.6
T_{10}	Sphagnum moss + sand (1:1)	8.5	15.2	23.0
T_{11}	Vermiculite + cocopeat (1:1)	11.8	21.3	32.4
T_{12}	Vermiculite + sawdust (1:1)	9.7	17.6	26.5
T_{13}	Vermiculite + sphagnum moss (1:1)	8.8	16.1	24.1
S.Em (±)		0.539	0.058	0.298
CD (5%)		1.569	0.168	0.869
CV (%)		10.403	2.652	2.002

Conclusion

The present investigation entitled was undertaken to study the physical composition of seeds before sowing and the subsequent growth parameters after germination. The study revealed significant variations among the different soilless growing media. Seed weight and seed size showed direct influence on seed germination and early seedling vigour. Among the tested media, certain combinations exhibited superior performance in terms of seed weight, seed size, seed germination percentage, length of shoot, length of

shoot, root-to-shoot ratio, number of leaves per plants, height of plants and survival percentage of plant and number of days to be ready for planting were found significantly superior over other treatments under T_{11} (Vermiculite + cocopeat (1:1))

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