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EFFECT OF NURSERY GROWING MEDIA FOR QUALITY SEEDLING PRODUCTION OF MARIGOLD, CALENDULA, DIANTHUS, AND SALVIA

Dweepjyoti Sarkar[1], Preeti Hatibarua[2], Ruchika Borbaruah[3]*, Madhumita Choudhury Talukdar[2], Dharmendra Naikwad[4] and Dhruba Jyoti Nath[5]

[1]Agricultural Development Officer, Department of Agriculture, Majuli, Government of Assam-785106, India

[2] Department of Horticulture, Assam Agricultural University, Jorhat, Assam-785013

[3]Department of Floriculture and Landscaping, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal-741252, India

[4]Section Officer Horticulture, Horticulture sub division, Central PWD, Ministry of Urban Development, Government of India

[5]Department of Plant Pathology, Assam Agricultural University, Jorhat, Assam-785013, India

*Corresponding author E-mail: ruchikab2018@gmail.com

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ABSTRACT

The expanding ornamental nursery industry relies on the growth medium as a critical factor influencing seed germination, seedling emergence, development, and quality. This document examines appropriate nursery growth mediums for the production of healthy and disease-free seedlings of four ornamental plant species *viz.* Marigold cv. Inca Orange, Calendula cv. Bon Bon Mix, Dianthus cv. Idea Select Mix, and Salvia cv. Vista Mix. The experimental treatments comprised four distinct media blends utilized in plastic plug trays maintained under greenhouse conditions in Assam, namely: M_1: Cocopeat (60): Vermiculite (20): Perlite (20), M_2: Cocopeat (60): Vermicompost (40), M_3: Cocopeat (60): Vermicompost (40): Microbial consortia (10 g/kg media), M_4: Traditional nursery (Soil: Sand: FYM in a 1:1:1 v/v ratio). Among the four-nursery medium M_3, there was a notable increase in seedling production characterized by earlier seedling emergence (3.16, 3.18, 4.10, and 2.84 DAS for marigold, calendula, dianthus, and salvia), seedling height, a greater number of leaves per seedling, as well as an increased quantity of roots per seedling, extended root length, and elevated fresh and dry root weight (0.42, 0.38, 0.38, 0.46 g fresh weight and 0.13, 0.14, 0.12, 0.15 g dry weight). This ultimately resulted in enhanced seedling fresh and dry weight (1.57 g, 1.57 g, 1.64 g, 1.31 g fresh weight and 0.40 g, 0.38 g, 0.37 g, 0.34 g dry weight), alongside increased chlorophyll content (1.57, 1.45, 1.54, and 1.56 mg g^{-1} fresh weight), and ultimately resulted in improved in seedling vigor in M_3.

Keywords **:** nursery media, marigold, calendula, dianthus, salvia, microbial consortia

Introduction

Floriculture represents an escalating agro-industry in India. Its floriculture market is currently experiencing a compounded annual growth rate (CAGR) of 20. 1% from 2019 to 2024 (Kumar *et al*., 2024). The availability of diverse and conducive agro-climatic conditions, inexpensive and abundant labor, a well-established knowledge base, vast research network and traditions makes India in advantageous position to produce flowers year-round. Among the frequently cultivated flowers in India, the most significant include marigold, aster, chrysanthemum, rose, carnation, jasmine, crossandra, tuberose, gladiolus, orchid, and others, which are extensively cultivated in states such as Tamil Nadu, Karnataka, Andhra Pradesh, West Bengal, Bihar, Rajasthan, Delhi, Uttar Pradesh, and Maharashtra (Thakur *et al*., 2023). Within this category of ornamental plants, annual species such as marigold, pot marigold, dianthus, and salvia, which thrive in subtropical climates, are well-suited for farming in Assam. Nevertheless, the nursery production in the state has not yet reached a standardized level.

Marigold (*Tagetes minuta* L.) is a highly favored annual flowering plant in Assam, flourishing in warm environments with full sunlight and exhibiting moderate resilience to drought once it has been established. It is classified within the Asteraceae family and commercially propagated via seeds. It is extensively cultivated as an ornamental flower, loose or cut flower, bedding, pot or landscape plant. The visually appealing and vividly colored flowers are utilized in the creation of garlands, religious offerings, exhibitions, and various decorations. Its petals are edible and serve as a source of commercial lutein (Sharma *et al*., 2024; Manzoor *et al*., 2022). In addition, chemical compounds known as 'thiopenes' extracted from roots of *Tagetes minuta* L. function as mosquito repellents (Walia and Kumar, 2020), while alpha-terthienyl derived from its root exhibits nematicidal, insecticidal, antiviral, and cytotoxic properties (Sachin and Homraj, 2021). Consequently, the integration of marigold as an intercrop and trap crop alongside species such as Coconut (Nath *et al*., 2019), tomato (Kalaiselvam and Devaraj, 2011), and white cabbage (Jankowska *et al*., 2009) are proved advantageous and in trend. Another notable annual plant in the region is Calendula (*Calendula officinalis*), commonly referred to as pot marigold, belongs to the Asteraceae family. This species is native to Southern Europe and is also propagated commercially via seeds. Calendula is cultivated in garden beds, as potted plants, as cut flowers, and in window boxes. The alcoholic extract from its leaves and flowers possesses antimicrobial properties and is employed in the treatment of varicose ulcers and skin lesions (Ullah *et al*., 2023). Furthermore, the petals are edible and exhibit anti-helminthic and anticancer attributes (Pires *et al*., 2018). One additional widely recognized winter annual is Sweet William (*Dianthus barbatus* L.), which is a triploid (3x) species exhibiting various forms and colors, classified within the family Caryophyllaceae. It is commercially cultivated through seeds and is commonly utilized as a bedding plant for landscaping purposes, as well as for pot plants and cut flower production. This species serves as an alternative to *Dianthus chinensis* in the treatment of menostasis, gonorrhea, cough, and has emmenagogue and diuretic properties (Xing *et al*., 2015). Another prevalent annual ornamental from the Lamiaceae family is *Salvia splendens*. This plant is also propagated by seeds and has a long-standing application in traditional medicine for combating fever, rheumatism, perspiration, sexual dysfunction, and chronic bronchitis or various mental disorders (Miraj and Kiani, 2016). It is regarded as an important ornamental crop for landscaping, with some varieties being utilized for the extraction of diverse culinary aromas. These plants exhibit drought resistance and flourish in sunny environments, making them suitable for the warm climate of Assam.

With the escalating demand for ornamental plants in both urban and rural regions of India, the pressure on nurseries has intensified. However, the production of flower seedlings using traditional methods induces stress in the plants. To address the constraints associated with soil-based production systems (such as soil-borne pests and other chemical and biological variabilities), the utilization of soilless growing media can significantly enhance seedling production under controlled conditions. Growing media is a critical factor that affects seed germination, seedling emergence, growth, and overall quality of seedlings in a nursery (Mathowa *et al*., 2016). The quality of seedlings produced in a nursery impacts their re-establishment in the field and the subsequent productivity of an orchard (Mahmoud *et al*., 2019). Growing media can comprise organic substances such as peat, compost, tree bark, coconut (*Cocos nucifera* L.) coir, and poultry feathers, or inorganic substances such as clay, perlite, vermiculite, and mineral wool. In addition to growing media, a revolutionized use of microbial consortia has emerged as a trend in nursery production. This primarily encompasses nitrogen-fixing bacteria such as *Azotobacter, Bacillus, Clostridium, and Klebsiella*; phosphate-solubilizing bacteria such as *Azospirillum Bacillus, Pseudomonas, Rhizobium*, alongside newly identified endophytes and other microorganisms. Its integration into nursery practices for bedding ornamental annuals may lead to enhanced seed germination, improved root growth, increased efficiency of nutrient absorption, suppression of diseases, greater resilience to stress, and a decreased dependence on chemical inputs, as evidenced by numerous experimental investigations conducted on various other crops and plants (Rasool *et al*., 2024; Mellidou and Karamanoli, 2022; Abdul *et al*., 2007). These benefits play a significant role in producing robust, healthy, and high-quality bedding plants that are ready for transplantation and successful establishment in diverse landscapes or gardens.

The importance of quality ornamental seedling production cannot be over-emphasized. Therefore, standardization of processes for large-scale seed production, improving the germination of seeds, and other resources could help to overcome the prohibitive cost of these seedlings within the state of Assam. Therefore, a polyhouse experiment was conducted to determine the optimal growing media supplemented with pre-sowing microbial consortia to yield quality and robust seedlings on portrays.

Materials and Methods

The current study was undertaken in the Experimental Farm, Dept of Horticulture, Assam Agricultural University, Jorhat (26.47°N latitude and 94.12°E longitude; 86.8 m above msl). The aim of this study was to standardize the most suitable nursery media for Marigold (Inca Orange), Calendula (Bon Bon Mix), Dianthus (Ideal Select Mix) and Salvia (Vista Mix). The experiment was carried out as Randomized Block Design, comprising four-nursery media composition i.e., Cocopeat, Vermiculite and Perlite at 60:20:20 ratio (M_1); Cocopeat and Vermicompost at 60:40 ratio (M_2); Cocopeat and Vermicompost at 60:40 ratio with Microbial consortia of *Azotobacter, Azospirullum* and Phosphate Solubilizing Bacteria (PSB) (10 g/kg media) (M_3); and Conventional nursery (Soil: Sand: FYM at 1:1:1 v/v) (M_4). One seed of each four ornamental in per cell of the pro-trays under protected conditions in the second week of October 2018.

Physico-chemical estimations of growing media

Various physico-chemical estimations of growing media performed during the experiment are as follows:

pH: The pH of media-water suspension was determined by systronic pH meter using combined glass and calomel electrode. Soil (20g) was mixed with 410 mL distilled water in 1:2 ratio and moved intermittently for 30 minutes. After this suspension was left undisturbed for 1 hr. In supernatant the combination electrode was put and pH was recorded.

Water holding capacity: Maximum water holding capacity of the soil was determined by using Keen's Raczkowaski brass cup as described by Black,1965.

Electrical conductance (EC): EC of soil-water suspension was determined by systronic conductivity meter. Soil sample (20g) was mixed in 40 mL distilled water. The suspension was stirred intermittently for 1/2hr and kept for 30minutes without any disturbance for complete dissolution of soluble salt. The soil was allowed to settled then conductivity cell inserted in solution to record the EC value.

CEC: Cation exchange capacity was determined by neutral normal ammonium acetate saturation method (Black, 1965). Down weight of soil was treated with neutral normal ammonium acetate solution which saturated the soil surface with ammonium ions and the excess ammonium ions present on non-exchangeable sites were washed with alcohol. Then the soil was subjected to distillation and based on ammonia released CEC was computed.

Porosity %: Total porosity of soil was determined by using the values of particle density and bulk density (Black, 1965)

Seedling characteristics: The characteristics monitored during the experiment are Seedling emergence (%), Days to 2-True leaf stage, Days to transplanting, Seedling height (cm), Leaf area (cm^2), Leaf number per plant, Leaf area index (LAI) by Evans, 1972, Root length (cm), root fresh weight (g), Root dry weight (g), Number of roots, Seedling fresh weight (g), Seedling dry weight (g) and Seedling growth index / seedling vigour index (SVI) as suggested by Abdul Baki and Anderson (1973).

Chlorophyll content (mg/g fw): Chlorophyll estimation was done from fresh leaf samples. The absorbance of the extract was measured at 645 and 663 nm wavelength filters in UVV spectrophotometer for the determination of total chlorophyll content according to the method developed by Singh and Singh and Singh (1977) as below:

Total chlorophyll in mg/gm tissue

$$= \frac{20.2 \times (D.645) + 8.02 \times (D.663) \times V}{1000 \times W}$$

Where,

V = Final volume of extract (mL)

W =Weight of sample taken (g)

D.645 = O.D. at 645

D.663 = O.D. at 663

Statistical analysis

The experiment was carried out in completely randomized design (CRD) at 5% level of significance with three replications. IBM-SPSS (www.spss.com.hk/ software/ statistics/data analysis) software was used to analyses the recorded data.

Results

Marigold

Different nursery growing media had considerable effect on seedling emergence and subsequent growth in Inca marigold. Among the four treatments, the optimal seedling attributes were noted in M_3 [Cocopeat (60): Vermicompost (40): Microbial consortia (10 g/kg media)]. Marigold seeds planted in trays within greenhouse conditions in M_3 experienced the shortest duration for emergence (3. 16 days), the least time for the formation of 2 true leaves and 4 true leaves (11. 50

and 28. 81 days), indicating the fewest days required to achieve a transplantable stage during both the first and second years, as well as in the combined data. The cumulative data for marigold seedlings demonstrated (Table 1. and Table 2.) the highest seedling height (8. 65 m), increased leaf area (6. 29 cm2), leaf production (4. 27 leaves/seedling), root production (38. 23 roots/seedling), root length (9. 39 cm), along with the highest fresh and dry weight of roots (0. 42 and 0. 13 g) and maximum seedling fresh weight (1. 57 g) when cultivated in M_3. Consequently, this led to a heightened seedling vigor index of 2267. 54 in M_3. Nonetheless, no notable difference in the turgidity values of seedlings grown in any substrate within greenhouse trays was observed under the conditions of Assam. Biochemically, a significantly higher chlorophyll content (1. 57 mg g^{-1} FW) was found in seedlings grown in M_3 (Fig. 1).

Calendula

In Calendula (Bon Bon Mix), during the years 2018-19 and 2019-20, as well as in the combined data, the optimal seedling performance was recorded in the treatment M_3 [Cocopeat (60): Vermicompost (40): Microbial consortia (10 g/kg media)]. Seeds germinated in the M_3 treatment exhibited the quickest emergence (3. 18 days), resulting in the least time taken (11. 47 and 27. 63 days) for the formation of two leaves and progressing to the transplanting phase, specifically to the four-leaf stage (Table 1.). Furthermore, calendula seedlings cultivated in M_3 achieved the highest measurements in seedling height (9. 34 cm), leaf area (7. 12 cm²), leaf count (5. 06 leaves/plant), leaf area index (1. 39), root length (8. 96 cm), and number of roots per seedling (33. 97). This particular combination of cocopeat, vermicompost, and microbial consortia effectively nurtured the seedlings, leading to maximum root fresh and dry weights of 0. 38 and 0. 14 g, respectively, along with the greatest seedling fresh and dry weights of 1. 57 and 0. 38 g (Table 2.), respectively, which resulted in the highest seedling vigour index of 2221. 35. However, no significant differences were observed in the turgidity values. Biochemically, the M_3 treatment also demonstrated a significantly elevated chlorophyll content of 1. 45 mg/g FW (Fig 1.).

Dianthus

Seeds of Dianthus (Ideal Select Mix) sown in media M_3, M_2 and M_4 exhibited the earliest seedling emergence (4.10, 4.37 and 4.50 days in the pooled data) within the polyhouse conditions in trays, and these results were at par. Additional seedling traits like the least duration for the formation of 2 true leaves (9. 71 days), the formation of 4 true leaves or the transplantable stage (28. 21 days), the tallest seedling height (8. 43 cm), leaf area (5. 61 cm2), leaf area index (1. 22), root length (9. 12 cm), and production of leaves and roots (8. 28 leaves per seedling and 39. 06 roots per seedling), all enhanced by nursery media M_3. This media also achieved the highest root fresh and dry weight (0. 38 and 0. 12 g) and seedling fresh and dry weights (1. 64 and 0. 37 g), leading to a peak turgidity of 79. 90% and an exceptional seedling vigor index of 2184. 28 (Table 2.). Furthermore, plants cultivated in media M_3 achieved the significantly highest chlorophyll content (1. 54 mg g^{-1} FW in the pooled data analysis) (Fig. 1).

Salvia

Among the four types of sowing media, the best seedling performance of Salvia-Vista Mix cultivar were observed in M_3 media, which consists of Cocopeat (60%), Vermicompost (40%), and Microbial consortia (10 g/kg media). Salvia seeds planted in trays under greenhouse conditions within M_3 demonstrated the shortest duration for emergence (2. 84 days), the quickest development of two true leaves (9. 12 days), and attained the transplantable stage in the least time (28. 16 days) during both the first and second years, as well as the cumulative data (Table 1.). Additionally, this media effectively supported seedlings, resulting in the highest recorded seedling height (6. 22 cm), leaf area (5. 85 cm²), leaf production (6. 95 leaves/seedling), leaf area index (1. 08), root length (9. 44 cm), root production (65. 38 roots/seedling), and ultimately, the highest root and seedling fresh and dry weights (Table 2.). Nonetheless, no significant differences were noted in the turgidity values of the seedlings. Biochemically, leaves of salvia grown in M_3 exhibited the significantly highest chlorophyll content (1. 58 mg g^{-1}FW). Furthermore, the highest seedling vigor index of 2239. 91 was recorded in M_3 (Fig. 1).

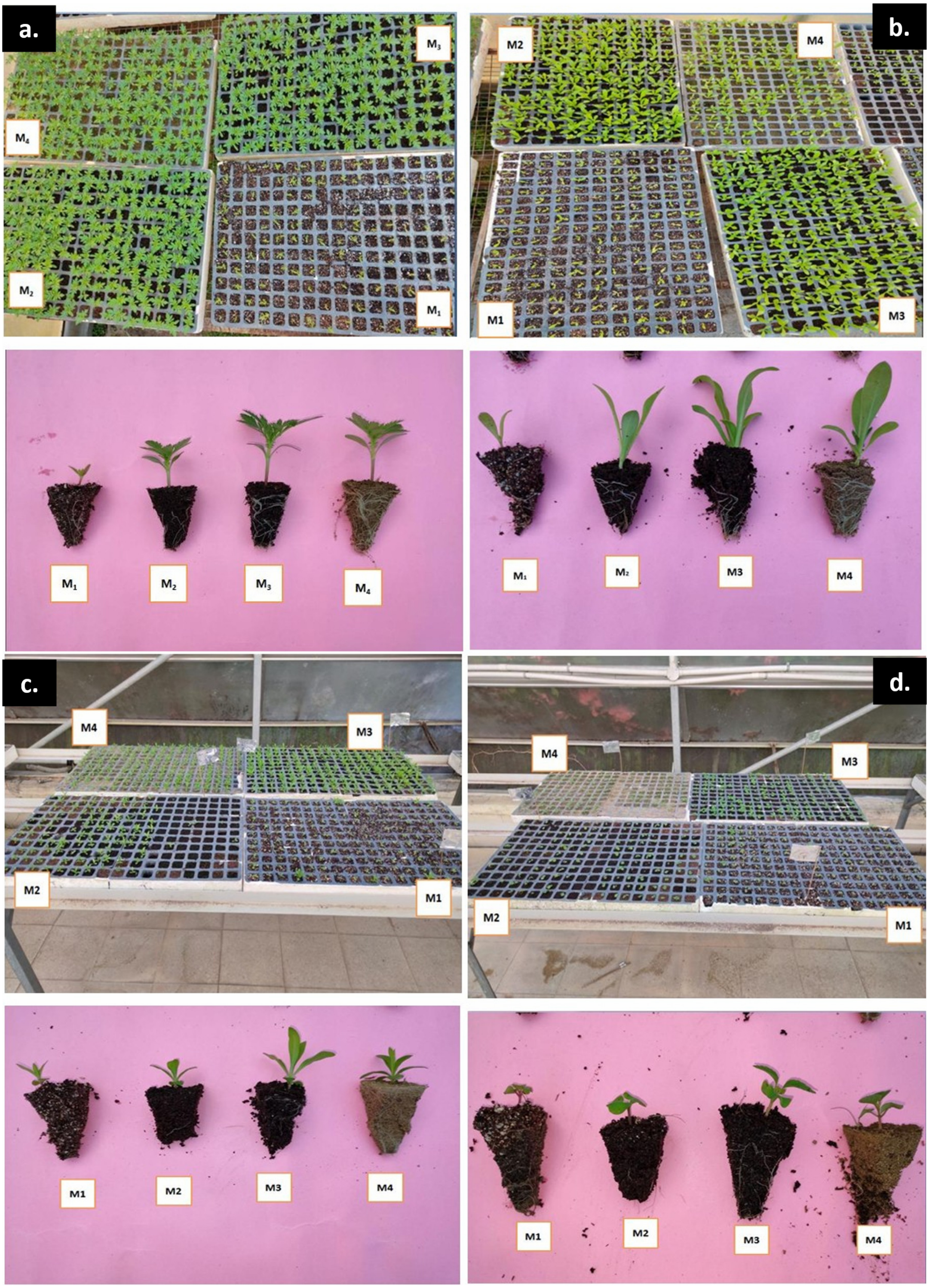

Fig. 1 : Seedlings of a. Marigold, b. Calendula, c. Dianthus and d. Salvia in different media compositions

Table 1: Effect of nursery media on seedling emergence (Days) (%), days to 2-true leaf stage, days to transplanting, seedling height (cm), Leaf area (cm^2), Leaf number and LAI of Marigold, Calendula, Dianthus and Salvia

Treatment	Seedling emergence (Days)			Days to 2 leaf stage			Days to transplanting			Seedling height (cm)			Leaf area (cm2)			Leaf number			LAI		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Marigold																					
M_1	4.95	5.28	5.12	14.28	14.31	14.30	33.14	33.81	33.47	4.98	4.32	4.65	2.20	2.84	2.52	3.66	3.66	3.83	0.96	0.96	0.96
M_2	3.73	4.07	3.90	12.90	12.97	12.93	30.12	30.12	30.12	6.98	6.32	6.65	5.20	6.55	5.88	3.59	3.87	3.79	1.10	1.25	1.18
M_3	2.99	3.33	3.16	11.45	11.55	11.50	28.48	29.15	28.81	8.98	8.31	8.65	5.80	6.79	6.29	4.10	4.26	4.27	1.20	1.32	1.26
M_4	4.01	4.01	4.01	13.18	13.25	13.21	29.62	31.62	30.62	5.99	5.32	5.65	4.60	5.01	4.80	4.00	3.78	3.89	1.01	1.03	1.02
S. Ed.±	**0.22**	**0.21**	**0.20**	**0.14**	**0.16**	**0.15**	**0.51**	**0.54**	**0.48**	**0.12**	**0.12**	**0.12**	**0.08**	**0.24**	**0.11**	**0.26**	**0.20**	**0.21**	**0.02**	**0.04**	**0.02**
CD (5%)	**0.76**	**0.73**	**0.69**	**0.44**	**0.49**	**0.47**	**1.58**	**1.66**	**1.47**	**0.36**	**0.36**	**0.36**	**0.25**	**0.75**	**0.33**	**0.21**	**0.33**	**0.21**	**0.06**	**0.14**	**0.07**
Calendula																					
M_1	5.12	5.25	5.18	14.25	14.45	14.35	32.43	31.76	32.10	5.13	5.47	5.30	3.58	3.60	3.59	4.36	4.40	4.38	1.20	1.18	1.10
M_2	3.90	4.07	3.98	12.90	13.23	13.07	29.08	28.41	28.75	7.15	7.48	7.32	5.67	5.69	5.68	4.76	4.86	4.81	1.37	1.23	1.26
M_3	3.09	3.26	3.18	11.49	11.45	11.47	27.99	27.27	27.63	9.31	9.37	9.34	7.11	7.13	7.12	5.27	4.86	5.06	1.38	1.39	1.39
M_4	4.15	4.35	4.25	13.15	13.45	13.30	30.06	30.02	30.04	6.28	6.61	6.45	6.23	6.26	6.24	4.71	4.71	4.71	1.22	1.24	1.23
S. Ed.±	**0.20**	**0.21**	**0.20**	**0.16**	**0.13**	**0.14**	**0.50**	**0.52**	**0.50**	**0.25**	**0.23**	**0.24**	**0.17**	**0.17**	**0.17**	**0.28**	**0.22**	**0.24**	**0.10**	**0.10**	**0.10**
CD (5%)	**0.70**	**0.72**	**0.71**	**0.50**	**0.41**	**0.42**	**1.54**	**1.61**	**1.54**	**0.79**	**0.70**	**0.73**	**0.52**	**0.51**	**0.52**	**0.85**	**0.67**	**0.75**	**NS**	**NS**	**NS**
Dianthus																					
M_1	5.62	4.95	5.28	13.07	11.91	12.49	33.47	32.43	32.95	4.32	4.95	4.63	1.87	2.12	1.99	4.00	4.63	4.31	0.86	0.90	0.88
M_2	4.67	4.07	4.37	11.47	10.50	10.98	29.78	28.78	29.28	6.32	6.91	6.62	4.87	5.08	4.97	6.00	6.63	6.31	1.08	1.12	1.10
M_3	4.03	3.87	4.10	10.33	9.08	9.71	28.81	27.60	28.21	8.25	8.61	8.43	5.47	5.76	5.61	8.00	8.56	8.28	1.18	1.25	1.22
M_4	4.71	4.28	4.50	11.57	10.89	11.23	29.95	29.95	29.95	5.29	5.64	5.46	4.27	4.58	4.42	6.00	5.59	5.79	0.89	0.96	0.93
S. Ed.±	**0.23**	**0.34**	**0.28**	**0.20**	**0.26**	**0.21**	**0.47**	**0.66**	**0.47**	**0.10**	**0.39**	**0.23**	**0.08**	**0.21**	**0.13**	**0.10**	**0.47**	**0.27**	**0.03**	**0.04**	**0.04**
CD (5%)	**0.79**	**1.17**	**0.97**	**0.61**	**0.79**	**0.65**	**1.44**	**2.04**	**1.44**	**0.31**	**1.19**	**0.70**	**0.25**	**0.65**	**0.39**	**0.31**	**1.46**	**0.82**	**0.11**	**0.12**	**0.11**
Salvia																					
M_1	4.62	4.12	4.37	12.50	11.88	12.19	33.48	31.88	32.68	3.00	3.37	3.18	2.10	2.38	2.24	4.21	4.77	4.49	0.34	0.37	0.36
M_2	3.73	3.04	3.18	9.80	9.53	9.67	30.02	30.18	30.11	5.84	5.99	5.92	3.13	3.72	3.43	4.55	5.32	4.93	0.48	0.51	0.50
M_3	2.93	3.06	2.84	9.21	9.03	9.12	28.63	27.70	28.16	6.11	6.33	6.22	5.67	6.04	5.85	7.00	6.37	6.95	1.00	1.15	1.08
M_4	4.20	4.20	4.20	10.58	9.49	10.04	31.73	30.47	31.10	4.45	4.57	4.51	4.96	5.24	5.10	4.36	4.85	4.61	0.62	0.77	0.70
S. Ed.±	**0.30**	**0.50**	**0.39**	**0.18**	**0.52**	**0.34**	**0.52**	**1.27**	**0.89**	**0.09**	**0.13**	**0.10**	**0.06**	**0.34**	**0.20**	**0.08**	**0.45**	**0.26**	**0.01**	**0.06**	**0.03**
CD (5%)	**1.04**	**1.20**	**1.36**	**0.55**	**1.59**	**1.03**	**1.60**	**3.93**	**2.75**	**0.27**	**0.40**	**0.32**	**0.20**	**1.04**	**0.61**	**0.26**	**1.39**	**0.79**	**0.03**	**0.18**	**0.10**

Where, M_1: Cocopeat (60): Vermiculite (20): Perlite (20); M_2: Cocopeat (60): vermicompost (40); M_3: Cocopeat (60): vermicompost (40): Microbial consortium; M_4: Conventional nursery (soil: sand: FYM); S. Ed.: standard error of the differences; CD: Critical difference

Table 2 : Effect of nursery media on root length (cm), Root fresh weight(g), Root dry weight(g), No of roots per seedling, Seedling fresh weight(g), Seedling dry weight(g) and Turgidity (RWC%) of Marigold, Calendula, Dianthus and Salvia

Treatment	Root length (cm)			Root fresh weight(g)			Root dry weight(g)			No of roots per seedling			Seedling fresh weight(g)			Seedling dry weight(g)			Turgidity (RWC%)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Marigold																					
M_1	4.01	4.70	4.36	0.15	0.22	0.18	0.01	0.01	0.01	8.98	9.89	9.44	0.51	0.54	0.53	0.08	0.11	0.10	77.18	78.18	77.68
M_2	7.02	7.64	7.33	0.30	0.40	0.35	0.09	0.12	0.11	28.98	30.13	29.55	1.49	1.56	1.52	0.36	0.39	0.38	78.61	79.61	79.11
M_3	9.00	9.78	9.39	0.37	0.47	0.42	0.11	0.15	0.13	37.98	38.47	38.23	1.52	1.62	1.57	0.37	0.44	0.40	79.52	80.52	80.02
M_4	3.00	4.13	3.57	0.22	0.28	0.25	0.04	0.04	0.04	17.98	18.74	18.36	0.56	0.66	0.61	0.10	0.13	0.12	77.90	78.57	78.23
S. Ed.±	**0.11**	**0.23**	**0.16**	**0.01**	**0.01**	**0.01**	**0.01**	**0.02**	**0.01**	**0.45**	**0.28**	**0.36**	**0.02**	**0.04**	**0.03**	**0.01**	**0.02**	**0.01**	**1.32**	**1.28**	**1.30**
CD (5%)	**0.35**	**0.70**	**0.50**	**0.01**	**0.04**	**0.02**	**0.01**	**0.05**	**0.03**	**1.40**	**0.85**	**1.12**	**0.06**	**0.11**	**0.08**	**0.02**	**0.05**	**0.03**	**NS**	**NS**	**NS**
Calendula																					
M_1	4.79	4.95	4.87	0.17	0.18	0.18	0.01	0.01	0.01	13.57	14.23	13.90	0.52	0.55	0.54	0.09	0.09	0.09	78.15	78.35	78.25
M_2	5.73	5.80	5.76	0.26	0.27	0.26	0.10	0.10	0.10	28.69	29.36	29.03	1.49	1.54	1.52	0.38	0.38	0.38	79.04	79.05	79.05
M_3	8.96	9.13	9.05	0.37	0.38	0.38	0.13	0.14	0.14	33.64	34.31	33.97	1.57	1.57	1.57	0.38	0.38	0.38	80.66	80.29	80.47
M_4	6.61	6.78	6.70	0.24	0.25	0.24	0.07	0.06	0.06	19.61	20.20	19.91	0.58	0.62	0.60	0.19	0.10	0.14	78.80	78.90	78.85
S. Ed.±	**0.30**	**0.31**	**0.30**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.59**	**0.57**	**0.58**	**0.02**	**0.02**	**0.02**	**0.03**	**0.01**	**0.02**	**1.51**	**1.49**	**1.50**
CD (5%)	**0.92**	**0.95**	**0.94**	**0.04**	**0.04**	**0.04**	**0.03**	**0.02**	**0.03**	**1.81**	**1.77**	**1.79**	**0.08**	**0.06**	**0.06**	**0.10**	**0.02**	**0.06**	**NS**	**NS**	**NS**
Dianthus																					
M_1	8.01	8.31	8.16	0.15	0.16	0.16	0.01	0.01	0.01	9.65	10.23	9.94	0.48	0.54	0.51	0.07	0.08	0.08	76.85	77.68	77.26
M_2	7.05	7.13	7.26	0.30	0.31	0.31	0.09	0.09	0.09	29.64	30.46	30.05	1.46	1.58	1.52	0.35	0.36	0.36	78.28	79.29	78.78
M_3	8.87	9.38	9.12	0.37	0.39	0.38	0.11	0.14	0.12	38.65	39.47	39.06	1.49	1.80	1.64	0.36	0.38	0.37	78.85	80.95	79.90
M_4	6.77	7.11	6.94	0.22	0.23	0.23	0.04	0.04	0.04	18.65	19.74	19.19	0.53	0.64	0.58	0.10	0.09	0.10	77.23	77.90	77.56
S. Ed.±	**0.38**	**0.58**	**0.47**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.45**	**0.50**	**0.47**	**0.02**	**0.12**	**0.06**	**0.01**	**0.01**	**0.01**	**1.24**	**1.95**	**1.58**
CD (5%)	**1.17**	**1.78**	**1.46**	**0.01**	**0.03**	**0.02**	**0.01**	**0.03**	**0.02**	**1.40**	**1.54**	**1.45**	**0.06**	**0.38**	**0.19**	**0.02**	**0.03**	**0.02**	**NS**	**NS**	**NS**
Salvia																					
M_1	5.99	6.44	6.21	0.36	0.39	0.37	0.11	0.12	0.12	23.72	24.57	24.14	0.12	0.13	0.12	0.03	0.05	0.04	77.17	78.02	77.59
M_2	9.08	9.29	9.18	0.28	0.30	0.29	0.08	0.09	0.08	18.65	20.58	19.61	0.13	0.14	0.14	0.03	0.05	0.04	78.59	79.60	79.09
M_3	9.36	9.52	9.44	0.45	0.48	0.46	0.14	0.15	0.14	65.17	65.58	65.38	1.28	1.34	1.31	0.33	0.35	0.34	79.35	80.62	79.99
M_4	4.72	5.08	4.90	0.24	0.27	0.25	0.07	0.08	0.08	16.55	17.48	17.02	0.51	0.57	0.54	0.13	0.13	0.13	77.90	78.56	78.23
S. Ed.±	**0.14**	**0.30**	**0.21**	**0.01**	**0.02**	**0.01**	**0.00**	**0.01**	**0.00**	**0.54**	**1.25**	**0.86**	**0.01**	**0.03**	**0.02**	**0.002**	**0.01**	**0.01**	**1.30**	**1.88**	**1.59**
CD (5%)	**0.42**	**0.92**	**0.66**	**0.02**	**0.06**	**0.04**	**0.01**	**0.02**	**0.01**	**1.67**	**3.85**	**2.65**	**0.03**	**0.09**	**0.06**	**0.007**	**0.03**	**0.02**	**NS**	**NS**	**NS**

Where, M_1: Cocopeat (60): Vermiculite (20): Perlite (20); M_2: Cocopeat (60): vermicompost (40); M_3: Cocopeat (60): vermicompost (40): Microbial consortium; M_4: Conventional nursery (soil: sand: FYM); S. Ed.: standard error of the differences; CD: Critical difference

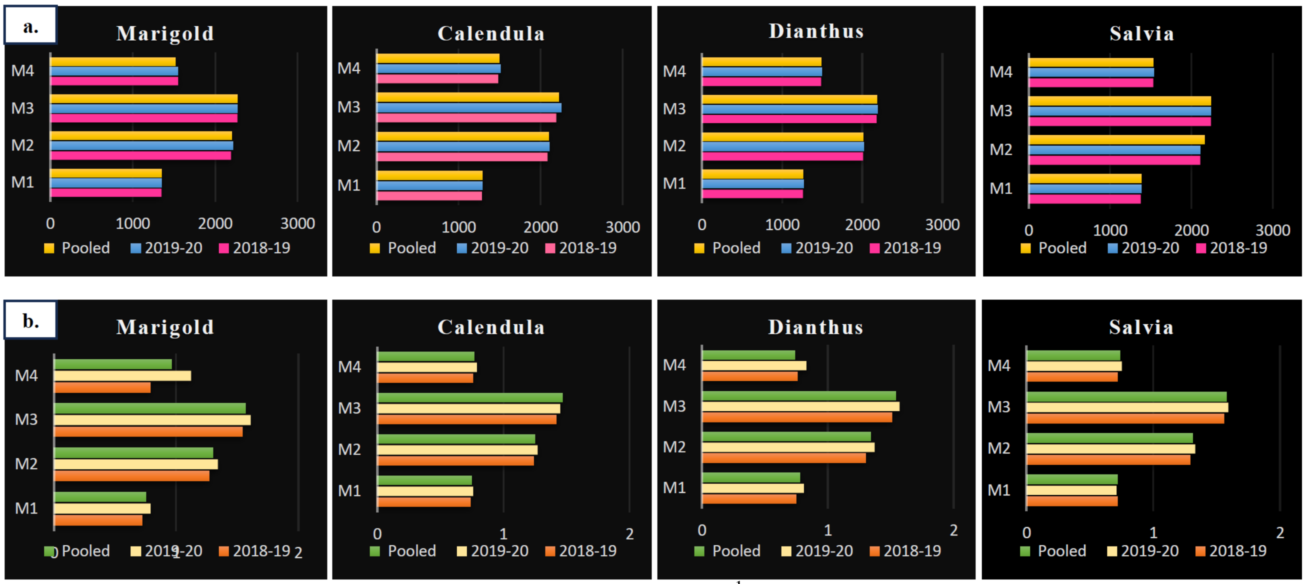

Fig 2.: a. Seedling vigour index and b. Chlorophyll content (mg g^{-1} FW) of Marigold, Calendula, Dianthus and Salvia

Table 3 : Physico-Chemical characteristics of the media used in the experiment

Treatments	**pH**		**EC (dS/m)**		**CEC (m eq/100g)**		**Porosity (%)**		**Water Holding Capacity %**	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
M_1 – Cocopeat (60): Vermiculite (20): Perlite (20)	6.59	6.43	0.049	0.048	17.48	17.0 6	61.66	60.16	62.27	60.75
M_2 – Cocopeat (60): vermicompost (40)	5.82	5.68	0.041	0.038	8.83	8.61	56.47	55.09	54.09	52.77
M_3 – Cocopeat (60): vermicompost (40): Microbial consortium	5.59	5.45	0.031	0.034	13.21	12.89	58.62	57.20	52.72	51.44
M_4 – Conventional nursery (soil: sand: FYM)	5.31	5.32	0.023	0.025	4.56	4.44	47.16	46.02	37.4	35.9

Discussion

Growing media affects the germination of seeds and the subsequent emergence and development of seedlings in a nursery (Bhardwaj, 2014), as it serves as a reservoir for moisture and essential plant nutrients (Kazemi and Mohorko, 2017). All seeds require water, oxygen, and appropriate temperature conditions for successful germination. Water is essential for softening the protective seed coat, while oxygen is needed for aerobic respiration to generate energy for both germination and growth. The embryo derives energy by metabolizing its stored food reserves.

In the context of Marigold, Calendula, Dianthus, and Salvia, the M_3 growing media demonstrated excellent water retention capabilities, providing a consistent moisture supply alongside adequate porosity. This allowed for proper moisture retention and gas exchange between the media and the seeds, thus facilitating improved seedling emergence. Comparable findings were reported by Hota and Arulmozhiselvan (2017) concerning tomato plants. Subsequently, true leaves appear shortly after the cotyledons and begin to produce energy through photosynthesis, which nourishes the plant and assists in reaching the transplantable stage promptly, alongside improved physical properties and enhanced levels of nutrients, water, and air in the seedling root zone of M_3 (Bharadwaj, 2013b). The sufficient aeration provided by a combination of cocopeat and vermicompost, along with the substantial nutrient availability enhanced by vermicompost and microbial consortia, including Azotobacter, Azospirillum, and PSB in M_3 media, resulted in taller plants with enhanced leaf production (Nissi, 2018). This increase in leaf surface area ultimately led to a higher Leaf Area Index (Patel *et al.*, 2019). The heightened leaf production of seedlings may correlate with a simultaneous increase in plant height (Moles *et al*, 2009). Additionally, the microorganisms present in the vermicompost and microbial consortia within the M_3 nursery media synthesize plant growth hormones, primarily auxins, gibberellins, and cytokinins. The maximum growth of both roots and shoots may be attributed to the higher availability of auxin in this growing medium, derived from the consortium as well as from the humic acid and humates found in vermicompost (Scaglia *et al*., 2016). Furthermore, the intensive activity of earthworms in vermicompost results in nutrient levels such as nitrogen, phosphorus, and potassium being 5 to 11 times greater than those in ordinary soil. Kiyasudeen *et al*, 2016 also noted that the application of vermicompost enhances both micro and macronutrient content of the media, thereby potentially improving shoot growth, as reflected in the dry and fresh weight of the shoots. Additionally, the incorporation of cocopeat improved the physical and chemical properties of the media by reducing its density and increasing porosity, which encouraged the formation of a greater number of roots with enhanced dry and fresh weight. These findings align with earlier research conducted by Bachman and Metzger (2008), Gupta *et al*. (2023), and Kispotta (2019) on Marigold and cornflower; Tomato; and African and French Marigold. Similarly, Baskaran *et al*. (2004) reported comparable results when utilizing a media combination of coir compost and vermicompost (1:1) for chrysanthemum cuttings. The higher vigor index observed in M_3 is likely attributable to improved germination and seedling height, contributing to an enhanced vigor index. The outcomes of this research are consistent with the findings of Prajapati *et al*. (2017) and Parasana *et al*. (2013).

Conclusion

It could be concluded that the healthy status, and quality nursery seedling production of Marigold (Inca Orange), Calendula (Bon Bon Mix), Dianthus (Ideal Select Mix) and Salvia (Vista Mix) could be dramatically influenced by the component of the growing media. Findings of the current research exhibited that the media substrate of Cocopeat and vermicompost in the ratio of 60:40 along with Microbial consortium (M_3) was particularly suitable for sturdy and healthy nursery seedling production for all four annuals.

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