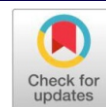


Original Research Article

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Vermicompost based media influenced dry matter partition of African marigold seedlings



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ABSTRACT

This research investigates the effect of vermicompost-based media on the dry matter partitioning in African marigold (*Tagetes erecta*) seedlings. The study aimed to assess how different species of vermicompost in the growing medium influence the growth and development of marigold seedlings, with a focus on dry matter distribution among various plant parts. Six different vermicompost-based growth media were tested along with a control. Parameters such as germination percent, seedling vigour index II, plant height, number of leaves, stem girth, leaf area, stem and root biomass, overall dry weight and physiological parameters like net assimilation rate (NAR), relative growth rate (RGR), leaf area ratio (LAR), stem elongation rate (SER), leaf expansion rate (LER) were measured to determine the impact of vermicompost on seedling performance. The results demonstrated that medium containing cocopeat and vermicompost produced from *Eisenia fetida* (2:1 v/v) gave the best results, suggesting that this medium can optimize growth conditions for marigold seedlings. This study provides insights into the potential of using organic-based media for improving seedling production and offers practical recommendations for the sustainable production of African marigold seedlings.

Keywords: African marigold, growing medium, vermicompost, cocopeat, sand, seedling growth, and dry matter partitioning.

I. Introduction

The marigold, a member of the Asteraceae family, is a highly adaptable flower crop that is cultivated in both tropical and subtropical regions worldwide. The African marigold, *Tagetes erecta*, is one of the most popular garden flowers and a major cash crop worldwide. It has a long history of use in medicine, is effective against insects, and holds enormous promise for the perfume business [8]. African marigold is commercially propagated by seeds. It is essential to use an appropriate medium or substrate when growing marigolds from seed to guarantee the development of strong, homogeneous seedlings. How well and how productively plants are re-established in the main field depends on the quality of the seedlings cultivated in the nursery. The traditional method of nursery management in open-field situations in India, which relies solely on the whims of nature, is estimated to result in the death of 15–20% of seedlings. Standardising the nursery raising procedure is essential for providing healthy and robust seedlings to farmers. If the environment for their growth is ideal, seedlings can be kept growing robust and healthy. When it comes to young plants, a balanced media combination is usually the key to ensuring

their continued growth and development.

Many nurseries now employ soilless platforms to grow their seedlings. The most widely used commercial medium consists of cocopeat, perlite, and vermiculite (3:1:1 v/v). But the production process is expensive, and extra nutrients are needed to meet nutritional requirements. The viability of using vermicompost as a component of growing media to produce horticultural seedlings in nurseries has been outlined by numerous scientists [3,8,12]. As a commonly available, nutrient-rich organic fertiliser, it reduces the cost of plant protection chemicals while also promoting plant growth and protecting seedlings from microbial diseases. The fundamental objective of horticultural nurseries is to produce seedlings with certain morphological and physiological traits that guarantee crop performance after transplanting [6], and plant morphological parameters play a key role in determining post-transplant success.

Dry matter partitioning is the distribution of biomass among various plant structures like roots, stems, and leaves, and it is closely tied to functional traits such as photosynthetic efficiency, nutrient uptake, and water use. Understanding DMP helps elucidate how plants allocate resources in response to environmental conditions, developmental stages, and competitive interactions. While morphology (e.g., leaf area, stem height, root length) provides information on structural characteristics, it does not directly reflect the physiological processes driving growth and resource use.

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Therefore, in this investigation, both morphological parameters and dry matter partitioning were used as important factors in evaluating plant development and growing medium compatibility. We were unaware of any data pertaining to the effect of different growing media on the distribution of dry matter in African marigold seedlings. The goal of this study was to test the effects of vermicompost on the development of African marigold seedlings when cultivated in a variety of different growing conditions.

II. Materials and Methods

The trial was carried out during the 2021-22 academic year at the Advanced Training Centre of Soilless System for Production of Various Crops, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari. The experiment was laid out in a Completely Randomized Design (CRD) with four repetitions. The experiment employed seven different permutations of treatments. Table I provides information on the composition of different media used in the experiment. A total of 3360 seedlings, or 120 for each repetition, were grown for this study.

Specified growth media for each treatment were made, and trays were filled. Seeds of the African marigold variety Double Orange were sown (one seed in each cell) at a depth of roughly 10 mm in various growing media. The plots were immediately watered after sowing, and a black polythene covering was placed on top and left in place for four days. Once the seedlings began to emerge from the media, polythene mulch was removed. While in the nursery, plants were given only regular and consistent watering, and no further nutrients were supplemented.

Table 2.1: Composition of the growing media

Treatments	Media composition
T ₁	Control (Cocopeat + Vermiculite + Perlite 3:1:1 v/v)
T ₂	Cocopeat + Vermicompost produced from <i>Eisenia fetida</i> (2:1 v/v)
T ₃	Cocopeat + Vermicompost produced from <i>Eudrilus eugeniae</i> (2:1 v/v)
T ₄	Cocopeat + Vermicompost produced from <i>Lampito mauritii</i> (2:1 v/v)
T ₅	Sand + Vermicompost produced from <i>Eisenia fetida</i> (2:1 v/v)
T ₆	Sand + Vermicompost produced from <i>Eudrilus eugeniae</i> (2:1 v/v)
T ₇	Sand + Vermicompost produced from <i>Lampito mauritii</i> (2:1 v/v)

Ten randomly selected seedlings from each repeat were measured at weekly intervals beginning one week after germination and continuing through the fourth week to determine the average value. Primary data were used to determine the stem elongation rate (SER), leaf expansion rate (LER), relative growth rate (RGR) and its components, net assimilation rate (NAR), and leaf area ratio (LAR) for each time period, specifically the second, third, and fourth weeks after germination. Seedling vigour index II and survival rate were determined when the experiment was complete. All of the experimental parameters were subjected to an ANOVA, and means were separated by the LSD at a 5% level of significance. Seed germination percent: Final count of the emerged seedlings was done with respect to each tray when germination was completed, and a calculation was made in relation to the number of sown seeds, and a percentage was obtained by the use of the formula below (ISTA, 1999).

$$\text{Germination (\%)} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds}} \times 100$$

Ten randomly selected seedlings from each repetition were used to measure morphological and physiological parameters, and were recorded at weekly intervals beginning one week after germination and continuing through the fourth week to

determine the average value. Plant height was measured from the base to the shoot apex with the help of a measuring scale. The number of leaves was counted after the emergence of true leaves. Total plant leaf area was measured through a destructive method with the help of a digital leaf area meter (*Biovis*). Stem girth of seedlings was measured with the help of *Vernier calliper* i.e., initially stem diameter was measured by holding *Vernier calliper* at mid portion of the stem, and later the obtained value was multiplied with the approximate value of π (pi), which is about 3.14.

$$\text{Girth} = \pi \times \text{Diameter}$$

To determine the Stem elongation rate ($\text{cm}^{-1} \text{ day}^{-1}$), from each replication, 10 seedlings were tagged randomly. Each week, the stem length of tagged seedlings was recorded with the help of a measuring scale, and it was computed with the help of the following formula.

$$\text{SER} = \frac{\Delta L}{\Delta t}$$

Where,

ΔL = change in length, it can be calculated by the following formula

$$\Delta L = L_1 - L_0$$

L_0 = initial stem length

L_1 = new stem length

Δt = time interval (in days)

Leaf expansion rate ($\text{cm}^{-2} \text{ day}^{-1}$) was measured through a destructive method with the help of a digital leaf area meter (*Biovis*), and it was computed with the help of the following formula.

$$\text{LER} = \frac{\Delta A}{\Delta t}$$

Where,

ΔA = change in length, it can be calculated by the following formula

$$\Delta A = A_1 - A_0$$

A_0 = Leaf area of plant at time t_1

A_1 = Leaf area of plant at time t_2

Δt = time interval ($t_1 - t_0$) in days

t_0 = initial week

t_1 = subsequent week

To measure the distribution of biomass among various plant structures, seedlings were separated into different parts (stem, root, and leaf), and the fresh weight of each part was calibrated with the help of an electronic balance. Then, the same were bagged in a brown envelope and oven dried to constant weight at $65^\circ\text{C} \pm 1$. From these, dry weight was measured with the help of an electronic balance. Later, root-shoot ratio and root-weight ratio were calculated by using the following formula.

$$\text{Root shoot ratio} = \frac{\text{Dry weight of root}}{\text{Dry weight of shoot}}$$

$$\text{Root weight ratio} = \frac{\text{Dry weight of root}}{\text{Dry weight of seedling}}$$

Primary data were used to determine the relative growth rate (RGR) and its components, net assimilation rate (NAR), and leaf area ratio (LAR) for each time period and are calculated as per the formula given by Gardener *et al.*, 1985.

$$\text{Net Assimilation Rate} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\log_e A_2 - \log_e A_1}{A_2 - A_1} \dots\dots\dots (\text{g m}^{-2} \text{ day}^{-1})$$

Where,

W_1 = dry weight of plant at time t_1

W_2 = dry weight of plant at time t_2

A_1 = total leaf area of plant at time t_1

A_2 = total leaf area of plant at time t_2

t_1 = initial week

t_2 = subsequent week

$$\text{Relative Growth Rate} = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1} \dots\dots\dots (\text{g g}^{-1} \text{ day}^{-1})$$

Where,

W_1 = dry weight of plant at time t_1 ,

W_2 = dry weight of plant at time t_2

t_1 = initial week

t_2 = subsequent week

$$\text{Leaf Area Ratio} = \frac{\text{Total plant leaf area}}{\text{Dry weight of plant}} \dots\dots\dots (\text{cm}^2 \text{ g}^{-1})$$

Seedling vigour index II and survival rate were determined at the end of the investigation. Seed vigour index II was calculated by multiplying average seedling dry weight and germination percentage as described by Abdul-Baki and Anderson (1973) and Reddy and Khan (2001). For calculating survival percentage, one protrait from each repetition of treatment was kept undisturbed, and it was calculated with the help of the following formula.

$$\text{Survival percentage} = \frac{\text{No. of survived plants}}{\text{Total no. of germinated seeds}} \times 100$$

Table 2.2: The physical properties of all media were measured before sowing the seed using standard procedures (AOAC, 1984)

Treatment	BD (g/cc)	PD (g/cc)	WHC (%)	pH	Porosity (%)
T ₁	0.359	2	191.3	7.042	82.05
T ₂	0.329	1.72	384.61	7.073	80.87
T ₃	0.329	1.67	333.33	6.85	80.29
T ₄	0.412	1.818	433.33	7.54	77.33
T ₅	1.388	2.5	32.3	7.89	44.48
T ₆	1.565	2.53	28.81	7.55	38.14
T ₇	1.482	2.61	25.4	8.15	43.21

Table 2.3: Details of nutrient content of vermicompost produced by different species i.e., *Eisenia fetida*, *Eudriluseugeniae* and *Lampitomauritii*

Parameters	<i>E. fetida</i>	<i>E. eugeniae</i>	<i>L. mauritii</i>
Organic Carbon (%)	11.41	11.66	12.10
CN ratio	5.59	6.34	10.61
Total Nitrogen (%)	2.04	1.84	1.14
Total Phosphorus (%)	2.39	2.28	1.47
Total Potassium (%)	1.61	1.48	1.25
Total Calcium (%)	0.31	0.28	0.22
Total Magnesium (%)	0.15	0.15	0.13
Total Sulphur (ppm)	364	312	202
Total Fe (%)	1.01	0.94	0.53
Total Mn (ppm)	496	519	332
Total Zn (ppm)	370	340	183
Total Cu (ppm)	96	96	74

III. Results and Discussion

Table 3.1: Effect of growing media on seed germination and seedling growth parameters

Treatments	Germination (%)	Plant height (cm)	Number of leaves per plant	Stem girth (cm)	Plant leaf area (cm ²)	Seedling vigour index-II
T ₁	93.72	14.46	7.35	0.79	21.34	22.63
T ₂	95.32	24.65	11.30	1.21	116.70	88.19
T ₃	94.96	24.25	11.00	1.15	111.96	85.5
T ₄	94.13	24.47	10.65	1.14	111.26	84.61
T ₅	91.85	17.11	8.20	0.86	39.95	41.03
T ₆	78.09	14.59	7.75	0.80	28.84	18.88
T ₇	79.96	14.97	7.80	0.88	28.24	26.84
Mean	89.72	19.21	9.15	0.91	65.47	52.52
SEm ±	1.36	0.43	0.22	0.022	1.83	1.43
CD at 5 %	4.01	1.27	0.66	0.066	5.41	4.21
CV %	3.04	4.55	4.93	4.59	5.62	5.45

The seeds sown in T₂ media gave the highest germination percentage. This is attributed to the synergistic benefits of both components, as cocopeat is excellent at retaining moisture while still allowing for adequate aeration. This is crucial for seed germination, as seeds need consistent moisture to activate enzymes, trigger germination processes and it helps in maintaining a stable environment for germination when it mixed with vermicompost by retaining moisture. The nutrients from the vermicompost are slowly released to nourish the seeds as they sprout. Similar results have been reported on other crops such as papaya [3] and chilli [15].

The growth responses of African marigold vary with the growing medium. All vegetative parameters of African marigold seedlings were significantly affected by the various growing media treatments. Cocopeat and vermicompost (*Eisenia fetida*) mixed at a ratio of 2:1 v/v (T₂) outperformed all other treatments in terms of plant height (24.65cm), number of leaves per plant (11.30), stem girth (1.21cm), plant leaf area (116.70 cm²), and seedling vigour index (88.19), likely because the media allowed for greater nutrient uptake by the young plants. Plant growth-promoting chemicals such as NAA, cytokinins, and gibberellins are amplified in worm castings, leading to enhanced seedling height, expanded foliage due to a faster photosynthetic rate, and subsequent vegetative growth. Since nitrogen is the most important nutrient for promoting plant growth, it is likely that the higher nitrogen and micronutrient (Ca, Mg, Fe, S, and Zn) content of vermicompost (*E. fetida*) played a role in the increased vegetative growth of seedlings. There is a lot of concordance between our findings and those of [2,20].

Table 3.2: Effect of growing media on shoot and root growth parameters

Treatments	Fresh weight of leaves (mg)	Fresh weight of stem (mg)	Fresh weight of root (mg)	Dry weight of leaves (mg)	Dry weight of stem (mg)	Dry weight of root (mg)	Dry weight of seedling (mg)	Root shoot ratio	Root weight ratio
T ₁	1228.00	520.80	591.75	124.75	49.62	67.00	241.37	0.384	0.277
T ₂	4673.75	2217.15	1545.25	525.25	234.50	165.50	925.25	0.217	0.178
T ₃	4439.75	2180.82	1466.25	511.00	227.75	161.50	900.25	0.219	0.179
T ₄	4433.25	2144.77	1464.00	510.75	227.00	161.00	898.75	0.218	0.179
T ₅	1631.75	721.17	643.75	263.25	84.65	98.75	446.65	0.284	0.221
T ₆	1268.00	610.15	519.00	129.25	52.85	59.75	241.85	0.328	0.246
T ₇	1688.00	624.27	601.00	196.75	57.42	69.75	323.92	0.278	0.218
Mean	2766.07	1288.44	975.85	323	133.39	111.89	568.29	0.275	0.215
SEm ±	82.46	28.53	28.25	5.16	2.41	1.85	9.43	0.007	0.004
CD at 5 %	242.51	83.92	83.08	15.18	7.10	5.46	27.75	0.021	0.014
CV %	5.96	4.42	5.79	3.19	3.61	3.32	3.32	5.23	4.59

Seedlings grown in cocopeat + vermicompost made from *Eisenia fetida* at a ratio of 2:1 v/v (T₂) gained more fresh weight of leaves, stem and root, dry weight of leaves, stem and root and total dry weight of seedling than seedlings grown in any other growing media during the first, second, third, and fourth weeks after germination. Besides the favourable effects of cocopeat and vermicompost, this may be attributed to the carbon-to-nitrogen (C/N) ratio of the media as it directly affects nutrient availability. Vermicompost produced from *Eisenia fetida* tends to have a lower C/N ratio, meaning the decomposition of organic matter happens more quickly, making nutrients more readily available for plant uptake. When both cocopeat and vermicompost (*Eisenia fetida*) are combined, the mixture promotes faster growth, leading to higher dry matter production in seedlings by providing both the necessary physical structure and nutrients for growth, consistent with findings by [3,22].

The control group (T₁) had the highest root mass ratio and the highest root-to-shoot ratio. Higher root dry weight relative to shoots may reflect adaptations to specific environmental conditions, such as drought or competition for food, where prioritizing root growth can enhance survival and overall fitness. The results are consistent with those found in [1,3,10,13,14].

Table 3.3: Effect of growing media on physiological growth parameters and survival percent

Treatments	NAR ($\times 10^{-7} \text{ g m}^{-2} \text{ day}^{-1}$)			RGR ($\text{g g}^{-1} \text{ day}^{-1}$)			LAR ($\text{cm}^2 \text{ g}^{-1}$)				SER (cm day^{-1})			LER ($\text{cm}^2 \text{ day}^{-1}$)			Survival percent
	2 nd week	3 rd week	4 th week	2 nd week	3 rd week	4 th week	1 st week	2 nd week	3 rd week	4 th week	2 nd week	3 rd week	4 th week	2 nd week	3 rd week	4 th week	
T ₁	1.84	0.82	1.87	0.199	0.082	0.171	112.42	105.70	96.99	88.31	0.17	0.22	0.33	0.58	0.39	1.73	67.85
T ₂	2.01	0.87	1.35	0.257	0.116	0.180	139.34	120.72	143.38	124.88	0.34	0.65	0.59	2.26	3.93	9.57	98.33
T ₃	2.22	0.91	1.41	0.257	0.112	0.181	136.57	103.96	138.05	123.69	0.33	0.63	0.56	2.15	3.74	9.24	98.21
T ₄	2.17	0.94	1.46	0.258	0.115	0.182	128.20	114.29	126.44	123.79	0.32	0.62	0.55	2.15	3.72	9.16	98.24
T ₅	2.36	0.78	1.21	0.254	0.082	0.122	130.75	94.96	115.89	89.42	0.19	0.35	0.47	1.30	1.81	1.91	94.88
T ₆	2.53	0.67	1.09	0.239	0.065	0.127	111.54	84.42	113.09	119.25	0.16	0.21	0.30	0.65	0.92	2.18	96.59
T ₇	2.52	1.05	1.73	0.196	0.079	0.147	90.55	69.30	81.73	87.44	0.18	0.27	0.34	0.51	0.76	2.34	93.20
Mean	2.23	0.86	1.44	0.237	0.093	0.158	121.33	99.05	116.5	108.11	0.24	0.42	0.44	1.37	2.18	5.16	92.47
SEm ±	0.03	0.01	0.03	0.004	0.002	0.003	3.01	1.58	3.05	1.63	0.006	0.009	0.012	0.029	0.051	0.132	1.74
CD at 5 %	0.11	0.05	0.10	0.011	0.006	0.010	8.85	4.67	8.99	4.81	0.020	0.029	0.037	0.087	0.150	0.389	5.13
CV %	3.47	3.99	4.99	3.36	4.61	4.67	4.96	3.20	5.24	3.02	5.57	4.68	5.70	4.34	4.69	5.12	3.77

The net assimilation rate is a complex physiological parameter related to photosynthesis and respiration that measures the rate at which dry biomass rises per unit of leaf area. The age of the plant and the environment in which it grows are also important factors. When seedlings are grown in T₁ media and don't reach the target dry weight by the end of their second week of life, it could be because of a lack of nutrients in the growing medium. As a result, the net assimilation rate was also reduced because the numerator (plant dry weight) was less. In the third week, the net assimilation rate ($1.0510^{-7} \text{ g m}^{-2} \text{ day}^{-1}$) was highest for T₇ (Sand + Vermicompost produced from *Lampitoma mauritii* 2:1 v/v). Enhanced photosynthetic efficiency causes plants to amass more dry matter per unit of leaf area between the second and third week of plant development, when the rate of net assimilation is highest. The maximum net assimilation rate ($1.8710^{-7} \text{ g m}^{-2} \text{ day}^{-1}$) was found in T₁ (Cocopeat+Vermiculite+Perlite 3:1:1 v/v) seedlings in the fourth week of growth. It's possible that this is because there is less respiratory tissue present (stem and leaf area, table 3.1), allowing for greater photosynthate accumulation per unit of leaf area.

The relative growth rate (RGR) is a helpful statistic for evaluating the impact of various environmental conditions on the development of seedlings. RGR was significantly higher in the first four weeks post-germination for African marigold seedlings cultivated on cocopeat and vermicompost-based media.

For both cocopeat and vermicompost, the faster relative growth rate of the seedlings can be attributed to the former's higher nutrient content, which stimulated photosynthetic activity, leading to an increase in plant stored material and the leaf area ratio. The results of this study agree with [11,18] almost exactly. The parameters such as stem elongation rate, leaf expansion rate, and leaf area ratio are important traits that are directly linked to the photosynthetic potential of plants and provide insight into the plant's resource-use strategy, particularly its efficiency in using water and nitrogen. The seedlings grown in T₂ media exhibited significantly higher stem elongation rate, leaf expansion rate, and leaf area ratio than the control. This may be attributed to moisture retention capacity of cocopeat and presence of relatively higher content of nitrogen and plant growth regulators (such as auxins, gibberellins, and cytokinins) in a more plant-available form in vermicompost from *Eisenia fetida* than other two species (Table 2.2), which enhanced photosynthetic rate and resulted in the faster stem growth and larger leaves. The findings of [18] about *Cucumis sativus* are validated by these data.

Seedlings grown in a medium containing cocopeat and vermicompost produced from *Eisenia fetida* have a higher survival percentage because the combination of these materials creates an optimal environment for seedling growth. The benefits of improved nutrient availability, better moisture retention, aeration, disease resistance, and microbial health all contribute to stronger, more resilient seedlings.

These factors help seedlings establish themselves, grow healthier, and withstand environmental stresses, ultimately leading to higher survival rates. [3] has also reported that the combined effect of cocopeat and vermicompost gave maximum survival percent in papaya.

Future scope of study: Future research could focus on testing the effectiveness of the best-performing vermicompost-based medium for African marigold seedlings in real field conditions, assessing its impact on flowering, yield, and plant health. Investigating the nutrient availability and microbial activity within different vermicompost types may offer a better understanding of their growth-enhancing properties. Expanding this approach to other ornamental and horticultural plants could help determine its broader applicability. Additionally, evaluating the economic feasibility and environmental benefits of using vermicompost-based media on a larger scale would support its practical use by growers. Further studies might also explore combining vermicompost with other organic or biofertilizer inputs to improve seedling quality and stress tolerance.

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