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The Effect of Growing Media on the Growth and Yield of Marigold (Tagetes erecta L.)

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ABSTRACT

This study evaluated the effects of different organic growing media on soil properties, vegetative growth, and reproductive performance of marigold (Tagetes erecta L.). The experiment was conducted from February to May 2024 in Kupang City, Indonesia, using a randomized complete block design with nine growing media treatments and three replications. The results showed that the soil–cow dung compost mixture significantly improved marigold growth and yield compared with most other treatments. Plants grown in this medium exhibited the greatest plant height (81.54 cm at 5 weeks after planting), stem diameter (1.20 mm), number of flowers (14.44 plant^{-1}), flower diameter (71.85 mm), and flower fresh weight (21.89 g). Overall, this study demonstrates the effectiveness of compost-based growing media in improving soil quality and biomass allocation, providing practical insights for sustainable marigold production in tropical dryland environments.

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INTRODUCTION

Ornamental horticulture represents an increasingly important sector of global agriculture due to its economic value, aesthetic significance, and contribution to sustainable urban and peri-urban landscapes. Among ornamental species, marigold (Tagetes erecta L.) is widely cultivated because of its vibrant flower color, broad adaptability to different agro-ecological conditions, and multifunctional uses in landscaping, religious ceremonies, natural pest control, and cosmetic and pharmaceutical industries. The rising demand for marigold flowers, particularly in tropical and subtropical regions, highlights the need for cultivation strategies that can improve growth performance and flower quality while maintaining environmental sustainability.

The growing medium is a fundamental factor influencing ornamental plant productivity, as it determines root anchorage, water availability, aeration, nutrient supply, and microbial activity in the rhizosphere. In tropical dryland regions, conventional soil-based growing media are often characterized by low soil organic carbon, weak aggregate stability, and limited nutrient retention capacity, which constrain plant growth and reproductive development. Consequently, the incorporation of organic amendments into soil has been widely promoted as a sustainable approach to enhance soil quality and crop performance.

Organic-based growing media such as composted animal manures, biochar, rice husk derivatives, and other agricultural residues have received increasing attention over the past decade. Numerous studies have demonstrated that organic amendments can significantly improve soil organic carbon content, cation exchange capacity, aggregate stability, and microbial biomass, thereby enhancing nutrient availability and root growth. Improvements in soil physical and chemical properties are closely linked to enhanced vegetative growth and reproductive development in ornamental crops, including increased flowering intensity, flower size, and biomass allocation.

Despite these advances, most previous studies have focused on single organic materials or specific crop systems, limiting the understanding of how different organic-based growing media compare within a unified experimental framework. In addition, relatively few studies have examined the functional mechanisms by which organic substrates influence soil properties and biomass allocation in ornamental plants under tropical dryland conditions. This gap is particularly evident in marigold cultivation, where substrate selection plays a critical role in determining flower yield and quality, yet systematic comparative evaluations remain scarce.

Cow dung compost has emerged as a promising organic amendment due to its high organic carbon content, balanced nutrient composition, and positive effects on soil physical, chemical, and biological properties. Recent studies indicate that composted animal manures can improve soil fertility, enhance nutrient use efficiency, and stimulate plant growth through improved root soil interactions and microbial activity. However, comparative evidence evaluating cow dung compost alongside other commonly used organic substrates such as poultry manure, bokashi, biochar, and plant-based residues remains limited, particularly for ornamental species grown under dryland tropical conditions.

Therefore, the objective of this study was to comparatively evaluate the effects of different organic-based growing media on soil characteristics, vegetative growth, and reproductive performance of marigold (Tagetes erecta L.) under tropical dryland conditions. We hypothesized that growing media enriched with composted organic materials would outperform non-composted or inert substrates by improving soil quality and enhancing biomass allocation toward reproductive organs. The findings of this study are expected to contribute to the optimization of sustainable growing media for ornamental horticulture and to provide practical recommendations for marigold production in resource-limited environments.

THEORETICAL REVIEW

Growing media play an important role in ornamental plant production because they influence root development, nutrient availability, water retention, and soil aeration. Previous studies reported that the physical and chemical properties of growing media strongly affect vegetative growth, flowering capacity, and biomass accumulation in ornamental crops, including marigold (Tagetes erecta L.). Organic-based substrates are increasingly preferred because they improve soil structure, microbial activity, and nutrient dynamics while reducing dependence on synthetic inputs.

Organic amendments such as compost, manure, bokashi, rice husk ash, and biochar are widely used to improve soil fertility and sustainability in horticultural production systems. Compost-based materials increase soil organic carbon, cation exchange capacity, and water-holding capacity, thereby improving nutrient availability and root growth. Several studies also demonstrated that integrating organic materials into growing media can improve vegetative and reproductive performance of ornamental plants under tropical conditions.

Marigold (Tagetes erecta L.) is highly responsive to growing media composition because of its rapid growth and high nutrient demand during flowering. Previous research showed that organic amendments significantly affect plant height, stem diameter, flower number, flower diameter, and flower fresh weight. However, comparative studies involving multiple organic growing media under tropical dryland conditions remain limited. Therefore, this study was conducted to compare different organic-based growing media and identify the most effective substrate for improving marigold growth and flower yield.

METHODOLOGY

Experimental Site and Plant Material

The experiment was conducted from February to May 2025 in Lasiana Subdistrict, Kelapa Lima District, Kupang City, East Nusa Tenggara Province, Indonesia (10°10′ S, 123°35′ E). The study area represents a tropical dryland environment characterized by relatively low soil organic matter and seasonal rainfall variability.

Marigold (*Tagetes erecta* L.) seeds of uniform size and viability were used as planting material. Seedlings were established directly in polybags to minimize transplanting stress and ensure uniform early growth.

Experimental Design and Treatments

The experiment was arranged in a randomized complete block design (RCBD) with nine growing media treatments and three replications. Each experimental unit consisted of five plants, resulting in a total of 135 plants. From each experimental unit, three plants were selected as observation samples to represent treatment performance.

The growing media treatments consisted of soil alone (control) and soil mixed with different organic or inorganic amendments at a ratio of 2:1 (w/w). The treatments included soil (P0), soil mixed with river sand (P1), soil mixed with cow manure (P2), soil mixed with broiler chicken manure (P3), soil mixed with rice husk ash (P4), soil mixed with sawdust (P5), soil mixed with cow dung compost (P6), soil mixed with broiler chicken bokashi (P7) and Soil and coconut shell biochar (P8).

The 2:1 ratio was selected to maintain adequate soil volume for root anchorage while allowing the functional effects of each amendment on soil quality and plant growth to be expressed, consistent with standard pot-based horticultural experiments.

Preparation of Growing Media and Crop Management

Topsoil classified as Vertisol was air-dried, sieved (2 mm), and homogenized prior to mixing. All organic amendments were air-dried to a stable moisture content and thoroughly mixed with soil according to the assigned treatments. The prepared growing media were placed into polybags (15 × 30 cm), each containing 3 kg of substrate.

Marigold seeds were sown directly into the polybags. All treatments received uniform crop management practices, including regular irrigation to maintain soil moisture near field capacity and manual weed control. No additional inorganic fertilizers were applied during the experiment to ensure that plant responses were primarily attributable to the growing media treatments.

Chemical Characterization of Soil and Growing Media

Initial soil and growing media were analyzed prior to planting to characterize their chemical properties and to provide baseline information for interpreting plant growth responses to the applied growing media (**Table S1**).

Table 1. Baseline chemical properties of the soil used in the experiment.

Parameter	Value	Unit
Organic carbon	0.97	%
Total nitrogen	0.26	%
Available phosphorus	23.44	mg kg^{-1}
Exchangeable potassium	0.83	cmol(+) kg^{-1}
pH (H_2O, 1:2.5)	6.72	–

Note: Soil analyses were performed prior to planting.

Soil organic carbon was determined using the Walkley–Black method, total nitrogen using the Kjeldahl method, available phosphorus using the Bray I method, and exchangeable potassium using ammonium acetate extraction. Soil pH was measured in a soil–water suspension (1:2.5, w/v).

The chemical properties of the organic and inorganic amendments used for growing media preparation were determined prior to the experiment and are provided as supplementary information (**Table S2**)

Table 2. Selected chemical properties of organic and inorganic amendments used as components of growing media prior to the experiment.

Amendment	Organic C (%)	Total N (%)		P (%)	K (%)	
River sand	0.83	0.07	0.13		0.05	5.32
Cow manure	9.26	0.87	0.28		1.05	6.32
Broiler chicken manure	10.38	1.06	0.74		0.92	6.83
Rice husk ash	2.47	1.45		0.27	0.42	6.78
Sawdust	0.98	1.32		0.94	1.05	–
Cow dung compost	18.72	1.11		0.76	0.97	7.30
Broiler chicken bokashi	16.11	1.50	0.73		0.82	7.10
Coconut shell biochar	23.30	0.23	0.16		0.12	5.69

Notes: Organic C = organic carbon content; N = total nitrogen; P = total phosphorus; K = total potassium. pH was measured in a soil–water suspension (1:2.5, w/v). "–" indicates parameter not determined.

Source: Chemistry and Soil Laboratory, Faculty of Agriculture, Nusa Cendana University, Kupang, Indonesia (2025).

Growth and Yield Measurements

Plant height (cm) was measured weekly from 2 to 5 weeks after planting (WAP) from the soil surface to the apical meristem. Stem diameter (mm) was measured at 20 cm above the soil surface using a digital caliper at the same observation intervals.

The number of flowers per plant was recorded at final harvest (8 WAP) by counting all fully developed flowers. Flower diameter (mm) was measured at 6, 7, and 8 WAP across the widest part of fully opened flowers using a digital caliper. Flower fresh weight (g) was determined immediately after harvest using an analytical balance. All measurements were performed on three representative plants per experimental unit.

Statistical Analysis

All data were subjected to analysis of variance (ANOVA) appropriate for an RCBD to evaluate the effects of growing media treatments. Prior to analysis, data were tested for normality and homogeneity of variance. When significant treatment effects were detected ($p < 0.05$), mean separation was performed using the least significant difference (LSD) test at the 5% probability level. Statistical analyses were conducted using standard statistical software.

RESULTS

Plant Height

Plant height of marigold was significantly affected by growing media treatments at all observation times ($p < 0.05$). Differences among treatments became more pronounced from 3 to 5 weeks after planting (WAP), indicating a cumulative effect of growing media composition on vegetative growth (**Table 3**).

Table 3. Effect of different growing media on plant height of marigold (*Tagetes erecta* L.) at different weeks after planting (WAP**).**

Treatment	**2 WAP (cm)**	**3 WAP (cm)**	**4 WAP (cm)**	**5 WAP (cm)**
Soil	15.74 bcd	28.37 cd	45.30 bc	70.48 de
Soil + river sand	14.34 abc	26.09 bcd	41.31 abc	62.56 bcd
Soil + cow manure	12.58 ab	21.78 abc	34.61 ab	51.21 ab
Soil + broiler chicken manure	15.38 abcd	31.32 de	50.86 bc	70.22 cde
Soil + rice husk ash	17.76 cde	33.21 def	52.77 bc	69.96 cde
Soil + sawdust	10.79 a	16.91 a	27.37 a	42.08 a
Soil + cow dung compost	21.94 e	39.74 f	65.24 c	81.54 e
Soil + broiler chicken bokashi	19.98 de	36.38 ef	60.20 c	76.32 de
Soil + coconut shell biochar	12.51 ab	20.90 ab	34.20 a	55.16 abc
HSD ($p \leq 0.05$)	**4.59**	**7.46**	**14.44**	**15.27**

Values followed by the same letter within the same column are not significantly different according to the HSD test at $p \leq 0.05$. WAP = weeks after planting.

Stem Diameter

Stem diameter of marigold was significantly affected by growing media treatments at most observation times, particularly at 2, 3, and 5 weeks after planting (WAP) (**Table 4**). Differences among treatments were not significant at 4 WAP.

Table 4. Effect of different growing media on stem diameter of marigold (*Tagetes erecta* L.) at different weeks after planting (WAP).

Treatment	**2 WAP (mm)**	**3 WAP (mm)**	**4 WAP (mm)**	**5 WAP (mm)**
Soil	0.32 bc	0.51 bc	0.78	1.17 c
Soil + river sand	0.33 bc	0.51 bc	0.74	1.07 abc
Soil + cow manure	0.27 ab	0.39 ab	0.61	0.80 ab
Soil + broiler chicken manure	0.39 c	0.66 cd	0.87	1.16 c
Soil + rice husk ash	0.40 cd	0.61 cd	0.88	1.15 c
Soil + sawdust	0.22 a	0.30 a	0.58	0.77 a
Soil + cow dung compost	0.50 c	0.82 e	0.90	1.20 c

Soil + broiler chicken bokashi	0.49 de	0.72 de	0.87	1.12 bc
Soil + coconut shell biochar	0.25 ab	0.42 ab	0.65	1.06 abc
HSD ($p \leq 0.05$)	**0.09**	**0.15**	**ns**	**0.34**

Values followed by the same letter within the same column are not significantly different according to the HSD test at $p \leq 0.05$. WAP = weeks after planting; ns = not significant

Number of Flowers per Plant

The number of flowers per plant was significantly affected by growing media treatments, as shown in **Figure 1**.

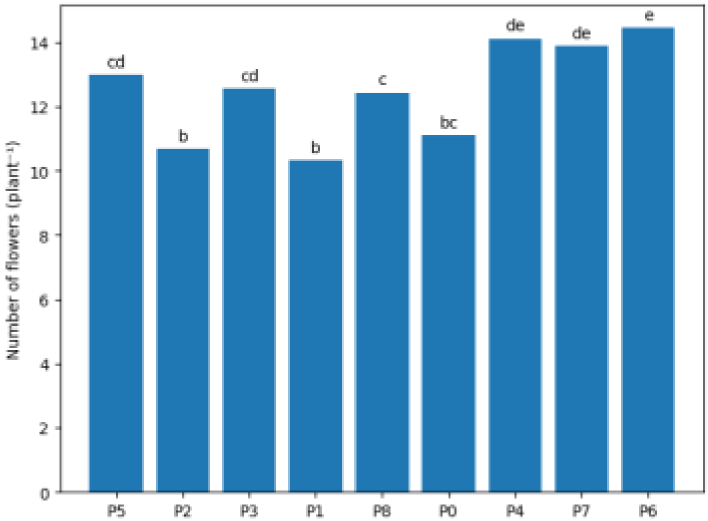

Figure 1. Effect of different growing media on the number of flowers per plant of marigold (Tagetes erecta L.).

Bars represent mean values. Bars sharing the same letter are not significantly different according to the HSD test at $p \leq 0.05$ (HSD = 1.32). P0 = soil; P1 = soil + river sand; P2 = soil + cow manure; P3 = soil + broiler chicken manure; P4 = soil + rice husk ash; P5 = soil + sawdust; P6 = soil + cow dung compost; P7 = soil + broiler chicken bokashi; P8 = soil + coconut shell biochar.

Diameter of Flower Buds

Flower bud diameter was significantly affected by growing media treatments, reflecting differences in reproductive organ development among treatments (**Figure 2**).

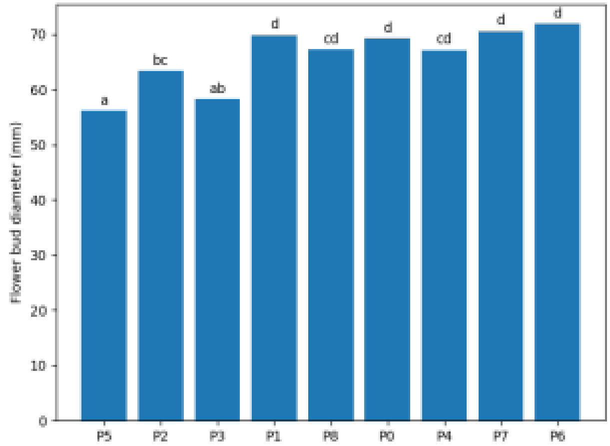

Figure 2. Effect of different growing media on flower bud diameter of marigold (*Tagetes erecta* L.).

Bars represent mean values. Bars sharing the same letter are not significantly different according to the HSD test at $p \leq 0.05$ (HSD = 5.46).

Flower fresh weight

Flower fresh weight of marigold was significantly affected by growing media treatments, indicating differences in assimilate accumulation and reproductive biomass among treatments (**Figure 3**).

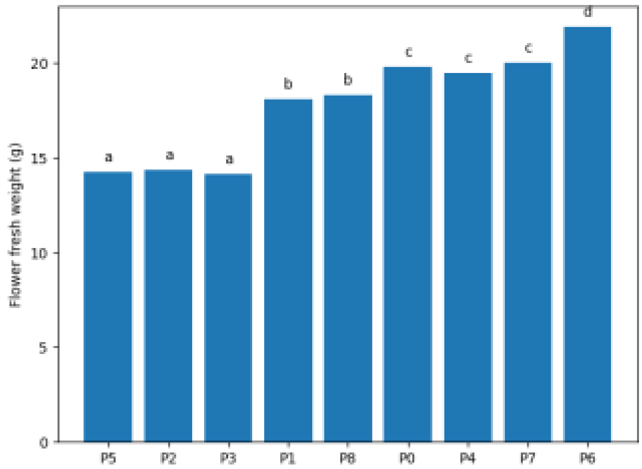

Figure 3. Effect of different growing media on flower fresh weight of marigold (*Tagetes erecta* L.).

DISCUSSION

Integrated effects of growing media on vegetative and reproductive performance

The present study demonstrates that growing media composition plays a critical role in determining both vegetative growth and reproductive performance of marigold (*Tagetes erecta* L.). Treatments that enhanced vegetative traits particularly plant height and stem diameter also consistently resulted in higher reproductive outputs, as reflected by increased flower number, flower bud diameter, and flower fresh weight. This integrated response suggests a strong linkage between early vegetative vigor and subsequent assimilate allocation to reproductive organs, a pattern commonly observed in ornamental crops where flower yield and quality are closely tied to overall plant physiological status.

Among the tested treatments, soil amended with cow dung compost (P6) consistently produced superior performance across almost all measured parameters. Plants grown under this treatment exhibited the greatest plant height and stem diameter during the vegetative phase, followed by the highest number of flowers, largest flower bud diameter, and greatest flower fresh weight at harvest. This consistent superiority across multiple growth stages indicates that cow dung compost created a more favorable root-zone environment that supported sustained nutrient uptake and biomass accumulation throughout the growth cycle.

Mechanistic explanation of compost superiority

The enhanced performance observed under the cow dung compost treatment can be explained by its chemical and functional properties. Compost is widely reported to increase soil organic carbon content, improve soil structure, enhance microbial activity, and provide a more balanced and gradual release of essential nutrients compared with raw organic materials. In the present study, the compost-based medium likely improved water-holding capacity and aeration, thereby promoting root development and nutrient absorption efficiency. Improved root function, in turn, supports greater photosynthetic capacity and assimilate production, which are essential for flower initiation and development.

Recent studies have shown that compost amendments significantly enhance nutrient availability and microbial-mediated nutrient cycling, leading to improved growth and yield in ornamental and horticultural crops [4,5]. Specifically, mature composts supply readily mineralizable nitrogen while simultaneously stabilizing soil pH and increasing cation exchange capacity, conditions that favor balanced uptake of nitrogen, phosphorus, and potassium. These mechanisms are consistent with the superior reproductive performance observed in the compost-treated marigold plants in this study.

Comparison with other organic amendments

Although other organic amendments such as broiler chicken bokashi, rice husk ash, and coconut shell biochar also improved marigold performance relative to the control, their effects were generally intermediate and less consistent than those of cow dung compost. Bokashi-based treatments enhanced both vegetative growth and flower traits, likely due to their contribution of readily available nutrients and stimulation of microbial activity. However, the magnitude of their effect may depend on fermentation quality, maturity level, and nutrient balance, which can vary among batches.

Biochar and ash-based amendments are known to improve soil physical properties and nutrient retention, but their immediate nutrient-supplying capacity is often limited compared with compost. Several recent studies have emphasized that biochar is more effective when combined with nutrient-rich organic inputs such as compost, as this combination couples short-term nutrient availability with long-term soil carbon stabilization [5,10,11]. The present findings align with this concept, as biochar-based treatments alone did not outperform compost in terms of flower yield and quality.

Relationship between vegetative growth and flower yield

The strong correspondence observed between vegetative parameters (plant height and stem diameter) and reproductive traits (flower number, diameter, and fresh weight) highlights the importance of early growth conditions in determining final ornamental quality. Stem diameter, in particular, is often associated with vascular capacity and assimilate transport efficiency, which are crucial for supporting developing flowers. Treatments that promoted thicker stems generally produced larger and heavier flowers, suggesting improved translocation of photosynthates to reproductive sinks.

This relationship has been reported in previous studies on marigold and other ornamental species, where improved substrate fertility and structure resulted in greater vegetative vigor and, consequently, enhanced flower yield and quality [12,13,14,15]. The present study reinforces this concept by demonstrating that substrate-driven improvements in early growth stages have lasting effects on reproductive performance.

Agronomic implications for marigold cultivation

From a practical perspective, the results indicate that cow dung compost mixed with soil at the tested ratio is a highly effective growing medium for marigold production, particularly under pot or container-based cultivation systems. The consistent improvement in flower number and fresh weight suggests that this treatment can enhance both aesthetic quality and market value of marigold flowers. Given the widespread availability of cow dung compost in many agricultural regions, its use represents a cost-effective and environmentally sustainable strategy for improving ornamental crop production.

Limitations and future research directions

Despite the clear trends observed, several limitations of this study should be acknowledged. First, the experiment was conducted under pot conditions and over a single growing season, which may limit extrapolation to field-scale production or different climatic conditions. Second, although basic chemical properties of the growing media were analyzed, detailed assessments of soil microbial activity and nutrient mineralization dynamics were not included. These parameters could provide deeper insight into the biological mechanisms underlying the observed plant responses.

Future research should therefore focus on multi-season and field-based evaluations, as well as on integrating microbial and soil carbon fraction analyses to better elucidate the interactions between organic amendments, soil processes, and marigold physiology. Additionally, combining compost with biochar or other stabilizing amendments may offer synergistic benefits that warrant further investigation.

CONCLUSIONS AND RECOMMENDATIONS

This study demonstrates that growing media composition plays a crucial role in determining the vegetative growth and reproductive performance of marigold (Tagetes erecta L.) under tropical dryland conditions. Among the tested treatments, the soil–cow dung compost mixture consistently produced superior results across all growth and yield parameters, including plant height, stem diameter, number of flowers, flower diameter, and flower fresh weight. The enhanced performance of this treatment was closely associated with improved soil organic carbon content and favorable pH conditions, which likely promoted nutrient availability and efficient biomass allocation from vegetative to reproductive organs. Other organic-based growing media, such as broiler chicken bokashi and rice husk ash, showed moderate improvements but did not outperform cow dung compost. These findings highlight the effectiveness of compost-based substrates as sustainable alternatives to conventional soil media for ornamental crop production. From a practical perspective, the use of cow dung compost mixed with soil offers a cost-effective and environmentally friendly strategy to improve marigold growth and flower yield in tropical dryland environments. Future studies should focus on multi-season and field-scale evaluations, as well as detailed assessments of soil biological activity, to further validate and optimize the use of organic growing media in ornamental horticulture.

FURTHER STUDY

Future research is recommended to explore the long-term effects of different growing media combinations on marigold (Tagetes erecta L.) under varying environmental conditions, including nutrient optimization, water management, and the integration of organic and inorganic substrates to enhance both yield and flower quality.

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