Research Article

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# Effect of different growing media on seed germination and growth performance of (*Calendula officinalis*)

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## ABSTRACT

Calendula (*Calendula officinalis)* cultivation often faces challenges related to seed germination and early plant growth, which can be influenced by the choice of growing media. This study aims to identify sustainable methods to improve Calendula's seed germination, growth, and flowering performance using different growing media. The experiment was laid out in a Completely Randomized Design (CRD) with three replications and six treatments: $T_0$ (Soil (Top Soil), Garden Soil), $T_1$ (Compost manure + Bagasse + Soil), $T_2$ (Coconut husk + Thermacoal + Soil), $T_3$ (Compost manure + Thermacoal + Soil), $T_4$ (Coconut husk + Bagasse + Soil), and $T_5$ (Vermicompost + Perlite + Soil). Parameters studied included seed germination (%), germination index, number of leaves per plant, days to flower initiation, flower diameter, flower fresh weight, flower dry weight, number of flowers per plant, plant height, and root length. Germination ranged from 28% to 97%, with soil-based and coconut husk + bagasse media showing superior performance. Vermicompost + perlite enhanced flowering traits, flower biomass, and plant height, while coconut husk + bagasse resulted in the poorest floral development. Root growth remained unaffected across treatments. Overall, vermicompost + perlite proved to be the most effective medium for promoting seed germination, vegetative growth, and flowering, emphasizing the importance of appropriate substrate selection for sustainable Calendula cultivation.

**Keywords**: Calendula, Vermicompost, Compost manure, Coconut husk, Bagasse, Soil, Thermacoal, Perlite.

## INTRODUCTION

*Calendula officinalis* L., commonly known as pot marigold or common marigold, belongs to the family Asteraceae and originates from the Mediterranean region. It produces distinctive orange to yellow inflorescences (Dzida et al., 2016) and is widely used in traditional medicine systems such as Ayurveda, Unani, and Homeopathy (Singh et al., 2011). Its pharmacological properties include diaphoretic, analgesic, antiseptic, and anti-inflammatory effects, and it is applied in the treatment of gynecological disorders, gastrointestinal and oral inflammations, eye diseases, skin injuries, and burns. Additionally, it has been reported to aid in poor eyesight and menstrual irregularities (Akhtar et al., 2011). Agronomically, the species grows well in sunlight, tolerates various soils, and flowers within a relatively short time after sowing (El-Sayed et al., 2018). Beyond its medicinal value, *C. officinalis* is also cultivated as an ornamental crop in open fields and greenhouses for cut flowers and potted plants (Kareem et al., 2014; Khalid et al., 2012). In India, calendula ointments are traditionally used to treat skin damage, gangrene, wounds (Givol et al., 2019), acne, scars, herpes, ulcers, frostbite, insect bites, carbuncles, dermatitis, boils, oral sores and toothache (Dhingra et al., 2022).

The therapeutic properties of *C. officinalis* are largely attributed to its bioactive constituents, including carotenoids, flavonoids, saponins, sterols, phenolic acids, and lipids, which collectively contribute to its

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anti-inflammatory, analgesic, and antiseptic activities (Ashwlayan et al., 2018). Extracts and balms prepared from calendula flowers are frequently used in traditional systems such as Ayurveda and Unani (Arora et al., 2013). Studies further highlight its antioxidant potential, showing inhibitory effects on lipid peroxidation and lipoxygenase activity (Khairnar et al., 2013). Moreover, its antibacterial and anti-inflammatory properties have been particularly useful in oral healthcare, where it has been shown to reduce gingival inflammation and inhibit periodontopathic bacteria (Ashwlayan et al., 2018; Khairnar et al., 2013).

Plant growth and productivity are strongly influenced by the choice of growing media, which provide physical support, water, and aeration. Common substrates include soil, vermicompost, farmyard manure, cocopeat, leaf mold, and rice husk. Organic matter has been reported to enhance marigold growth by improving vegetative traits such as plant height, stem diameter, and shoot biomass, as well as floral characteristics including flower number, size, and quality (Elhindi, 2012; Shadanpour et al., 2011). It also improves nutrient availability, particularly $Fe^{2+}$, $Mg^{2+}$, and $NH_4^+$, which are vital for chlorophyll biosynthesis and enzyme activity (Elhindi, 2012). Organic fertilizers, applied either to soil or as foliar sprays, have been shown to promote growth, flowering, root development, and dry matter accumulation (Ezz EL-Din & Hendawy, 2010; Ram et al., 2014). In particular, cow manure vermicompost at 40% significantly increased marigold growth (Rahbar et al., 2013). Effective media also provide anchorage, water retention, and root aeration (Abad et al., 2002). Cocopeat improves porosity and water-holding capacity. Perlite and vermiculite enhance aeration and drainage, while vermicompost contributes macro- and micronutrients, humic acids, growth hormones, and beneficial microbes, thereby improving yield and quality (Atiyeh et al., 2001).

Compost manures also play a vital role in soil fertility and crop yields by improving soil structure, enhancing microbial activity, and supplying essential nutrients. Chicken manure is widely used in peri-urban vegetable production, while composts are increasingly valued for their positive effects on agricultural soils (Bonanomi et al., 2014). In organic horticulture, composts are primarily applied to increase nitrogen availability (Pinto et al., 2017). Fresh composts release inorganic nitrogen more rapidly than mature ones, improving immediate nutrient supply (Antil et al., 2011), though they may also increase risks of nutrient leaching and nitrogen immobilization if mismanaged (Brito et al., 2012). Composting stabilizes organic waste, reduces pathogen loads, and limits weed seed viability (Gómez-Brandón et al., 2008). Although short-term effects of compost on crop growth are sometimes inconsistent, repeated applications are widely recognized to enhance soil fertility and long-term productivity (Erhart et al., 2005).

While soil is traditionally considered an ideal medium for plant growth, its limitations include susceptibility to pathogens such as root-knot nematodes and other soilborne diseases. Sustainable alternatives such as potting media provide improved aeration, drainage, and water retention, thereby enhancing root and shoot development (Utobo et al., 2017). For ornamental and medicinal crops like *C. officinalis*, the use of renewable substrates is particularly relevant, as reliance on non-renewable garden topsoil is unsustainable for long-term floricultural production (Marianthi, 2006). Although *C. officinalis* has been extensively studied for its medicinal and ornamental uses, little attention has been given to the role of sustainable growing media in improving its germination, vegetative growth, and flowering performance. To address this gap, the present study was conducted to evaluate the influence of different potting media on the seed germination and growth responses of *Calendula officinalis*, with the objective of identifying effective and sustainable substrates for its cultivation.

## MATERIALS AND METHODS

The present research was conducted at the Department of Horticulture, Sindh Agriculture University Tandojam during the winter of 2024-2025 to evaluate the effects of different growing media on the germination and growth of *Calendula officinalis*. Further details of the experiment are given as below.

### Experimental Design and Treatment

The experiment was laid out in a Completely Randomized Design (CRD) with three replications. Each replication consisted of one pot containing 20 seeds of the calendula variety 'Costa'. Thus, a total of 60 seeds were sown per treatment. Six growing media were tested in equal ratios (1:1:1). $T_0$ = Soil (Top Soil) Garden Soil, $T_1$= Compost manure + Bagasse + Soil (1:1:1), $T_2$= Coconut husk + Thermacoal + Soil (1:1:1), $T_3$= Compost manure + Thermacoal + Soil (1:1:1), $T_4$= Coconut husk + Bagasse + Soil (1:1:1), $T_5$= Vermicompost + Perlite + Soil (1:1:1).

### Growth Conditions

The experiment was conducted under open-field conditions with average daytime temperatures of 18–25 °C and night temperatures of 8–12 °C. Relative humidity ranged between 55–65%. Pots were irrigated uniformly as required to maintain adequate moisture, avoiding both drought and waterlogging. No additional fertilizers were applied, ensuring that growth responses reflected the properties of the respective media. Weeds were manually removed when necessary.

**Data Collection and Methodology**

Data on growth and flower related attributes were recorded for further statistical analysis. Parameters were recorded on the seed germination (%), germination index, number of leaves per plant, days to flower initiation, number of flowers per plant, flower fresh weight (g), flower dry weight (g), flower diameter (cm) and plant height (cm).

**Seed Germination (%)**

The seed germination percentage was determined by counting the number of germinated seeds out of the total number of seeds sown and expressed it as a percentage.

**Germination Index (GI)**

The germination index was calculated following the standardized method outlined by the Association of Official Seed Analysts (AOSA, 1983).

$$GI = \sum \frac{Gt}{Dt}$$

Where:

- Gt = Number of seeds germinated on day t
- Dt= Number of days after sowing (day t)

**Number of Leaves per Plant**

The number of leaves per plant was counted at a set growth interval and averaged across all plants in each pot.

**Days to Flower Initiation**

The number of days from sowing to the first appearance was recorded for each plant. The average was calculated across all flower replicates.

**Number of Flowers per Plant**

The number of flowers per plant was counted at a set growth interval and averaged across all plants in each pot.

**Flower Fresh Weight (g)**

Flower fresh weight was measured by taking the random samples using an electronic weighing balance and the values were expressed in grams.

**Flower Dry Weight (g)**

Dry flower weight was measured by drying flower samples at 60°C for 24 hours and weighing using an electronic balance.

**Flower Diameter (mm)**

The flower diameter was measured at the widest point using a vernier caliper and recorded in millimeters.

**Plant Height (cm)**

Plant height was measured using measuring tape from the soil surface to the highest point of the plant and recorded in centimeters.

**Statistical Analysis**

Data were subjected to analysis of variance (ANOVA) appropriate for a Completely Randomized Design (CRD) using Statistics 8.1 software (Statistix, 2006). Treatment means were compared using the Least Significant Difference (LSD) test at the 5% probability level ($P \leq 0.05$).

**Chemical Analysis**

The chemical analysis of treatments is given in the following table.

**Table 1. Chemical analysis of growing media for pH, EC, Organic Matter (%), and Nitrogen (%).**

| Sr. No. | Treatments | EC dS/m | pH | OM % | N % |
|---|---|---|---|---|---|
| 01 | $T_0$ = Soil (Top Soil) Garden Soil | 2.27 | 8.6 | 0.25 | 0.013 |
| 02 | $T_1$= Compost manure + Bagasse + Soil (1:1:1) | 6.23 | 8.8 | 0.47 | 0.024 |
| 03 | $T_2$= Coconut husk + Thermacoal + Soil (1:1:1) | 8.41 | 8.7 | 0.37 | 0.018 |
| 04 | $T_3$= Compost manure + Thermacoal + Soil (1:1:1) | 10.08 | 8.8 | 0.25 | 0.013 |
| 05 | $T_4$= Coconut husk + Bagasse + Soil (1:1:1) | 9.25 | 8.7 | 0.45 | 0.023 |
| 06 | $T_5$= Vermicompost + Perlite + Soil (1:1:1) | 7.10 | 8.9 | 0.60 | 0.030 |

## RESULTS

**Seed Germination (%)**

The impact of various growing media calendula seed is presented in (Figure 1). The results indicate that the maximum (96.667%) seed germination of Calendula was observed in $T_0$ Soil (Top Soil) Garden Soil, and $T_4$ Coconut husk + Bagasse + Soil (1:1:1) and $T_1$= Compost manure + Bagasse + Soil (1:1:1) which resulted 96.66 % and 93.33%. The seed germination further decreased (90.00% and 36.66%) with $T_3$= Compost manure + Thermacoal + Soil (1:1:1) and $T_5$= Vermicompost + Perlite + Soil (1:1:1). However, the minimum (28.33%) seed germination was recorded with $T_2$= Coconut husk + Thermacoal + Soil (1:1:1).

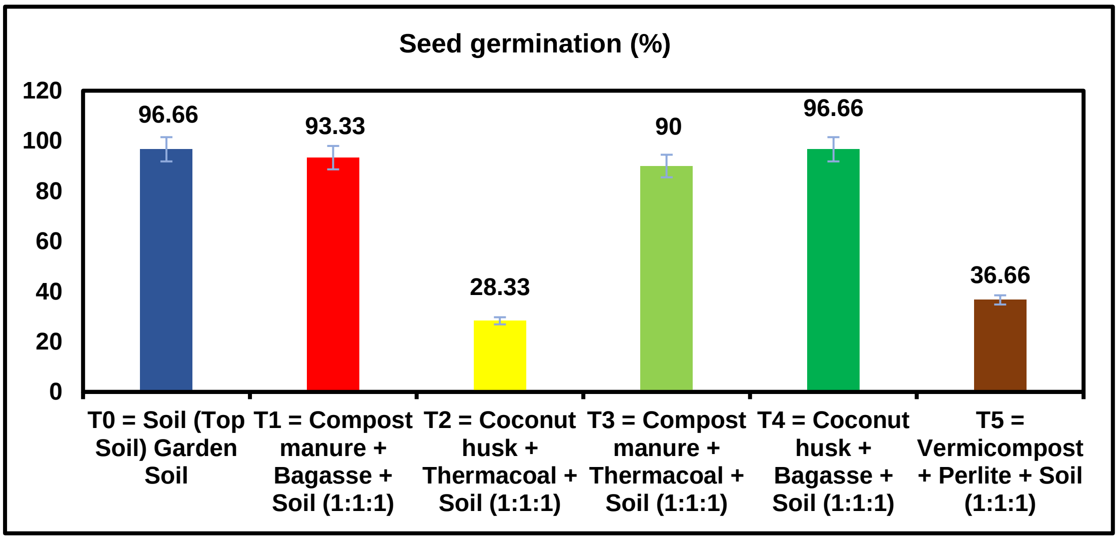


Figure 1. Seed germination (%) of Calendula affected by different growing media.

**Germination Index (GI)**

The effect of different growing media on Calendula the germination index of is presented in (Figure 2). The maximum (4.53) germination index of Calendula was observed in $T_0$ Soil (Top Soil) Garden Soil, followed by $T_4$ Coconut husk + Bagasse + Soil (1:1:1) and $T_1$= Compost manure + Bagasse + Soil (1:1:1) resulting in 4.13 and 4.06. The germination index further decreased (3.56 and 1.91) with $T_3$= Compost manure + Thermacoal + Soil (1:1:1) and $T_2$= Coconut husk + Thermacoal + Soil (1:1:1). However, the minimum (1.40) germination index was recorded with $T_5$= Vermicompost + Perlite + Soil (1:1:1).

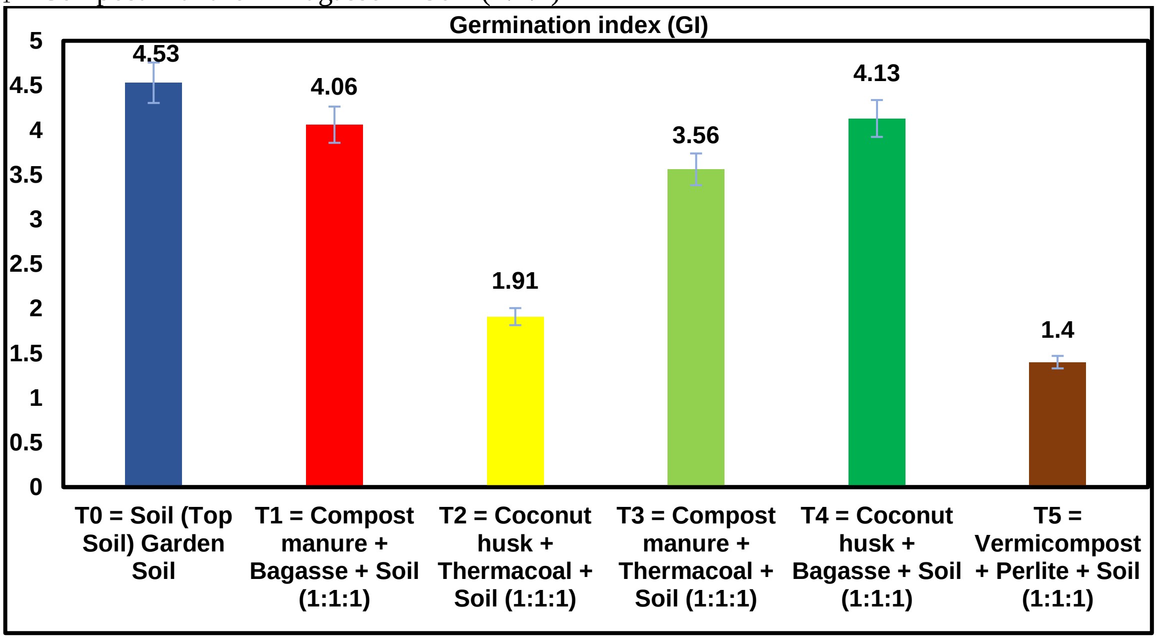


Figure 2. Germination index (GI) of Calendula as affected by different growing media

**Number of Leaves per Plant**

The effect of different growing media on the number of leaves per plant of Calendula is presented in (Figure 3). The results showed that the maximum number of leaves per plant (109.00) number of leaves per plant of Calendula was observed in $T_0$ Soil (Top Soil) Garden Soil, followed by $T_2$= Coconut husk + Thermacoal + Soil (1:1:1) and $T_3$= Compost manure + Thermacoal + Soil (1:1:1) resulted in 76.99 and 70.77. The number of leaves per plant further decreased (62.99 and 56.33) with $T_5$= Vermicompost + Perlite + Soil (1:1:1) and $T_4$= Coconut husk + Bagasse + Soil (1:1:1). However, the minimum (53.22) number of leaves per plant was recorded when $T_1$= Compost manure + Bagasse + Soil (1:1:1).

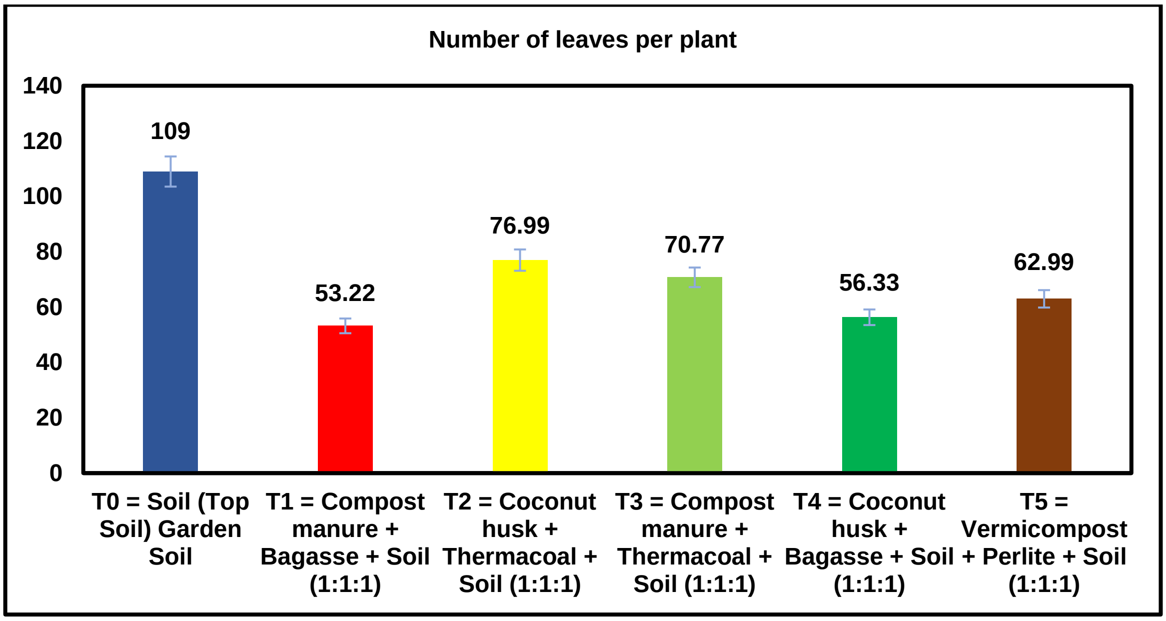


Figure 3. Number of leaves per plant of Calendula as affected by different growing media

**Days to flowers initiation:** The result regarding days to flower initiation of Calendula treated with different growing media are presented in (Figure 4). The data showed that the maximum days to flower initiation (119.33) of Calendula was observed with $T_4$= Coconut husk + Bagasse + Soil (1:1:1), followed by $T_2$= Coconut husk + Thermacoal + Soil (1:1:1) and $T_3$= Compost manure + Thermacoal + Soil (1:1:1), resulting in 103.67 and 100.33. The days to flowers initiation further decreased (95.66 and 79.66) with $T_1$= Compost manure + Bagasse + Soil (1:1:1) and $T_0$ = Soil (Top Soil) Garden Soil. However, the minimum (76.00) days to flowers initiation were recorded with $T_5$= Vermicompost + Perlite + Soil (1:1:1).

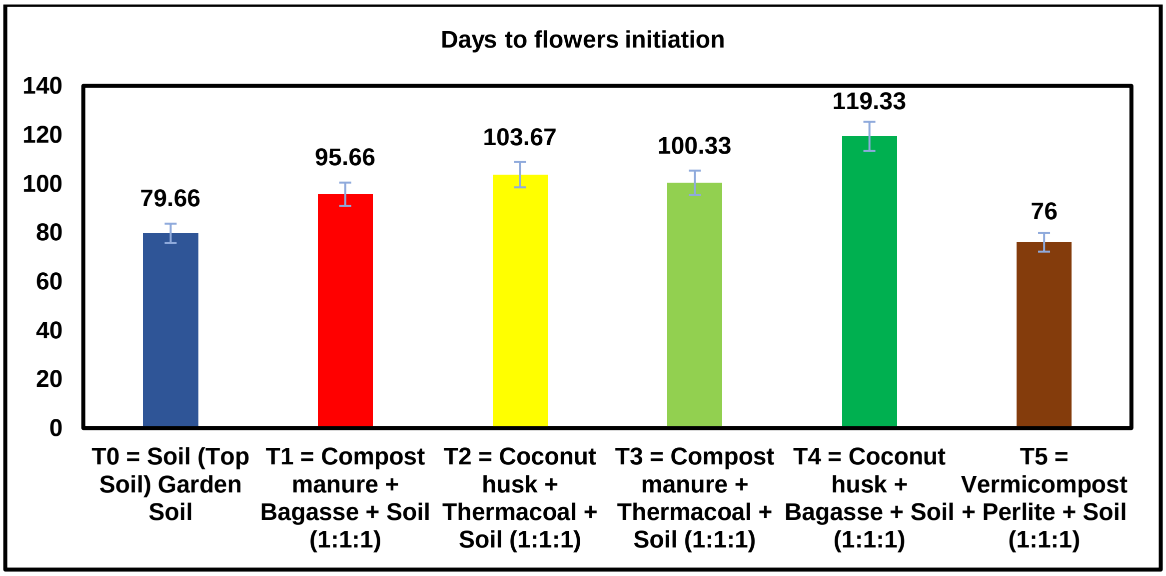


Figure 4. Days to flowers initiation of Calendula as affected by different growing media

**Flower Diameter (mm)**

The result regarding flower diameter of Calendula treated with different growing media are presented in (Figure 5). The data showed that the maximum flower diameter (158.05 mm) flower diameter of Calendula was observed with $T_5$= Vermicompost + Perlite + Soil (1:1:1), followed by $T_0$ = Soil (Top Soil) Garden Soil and $T_2$= Coconut husk + Thermacoal + Soil (1:1:1) which resulted in 150.15 mm and 127.37 mm. The flower diameter further decreased (119.59 mm and 10.57 mm) with $T_1$= Compost manure + Bagasse + Soil (1:1:1) and $T_3$= Compost manure + Thermacoal + Soil (1:1:1). However, the minimum diameter of flower (42.29 mm) was recorded with $T_4$= Coconut husk + Bagasse + Soil (1:1:1).

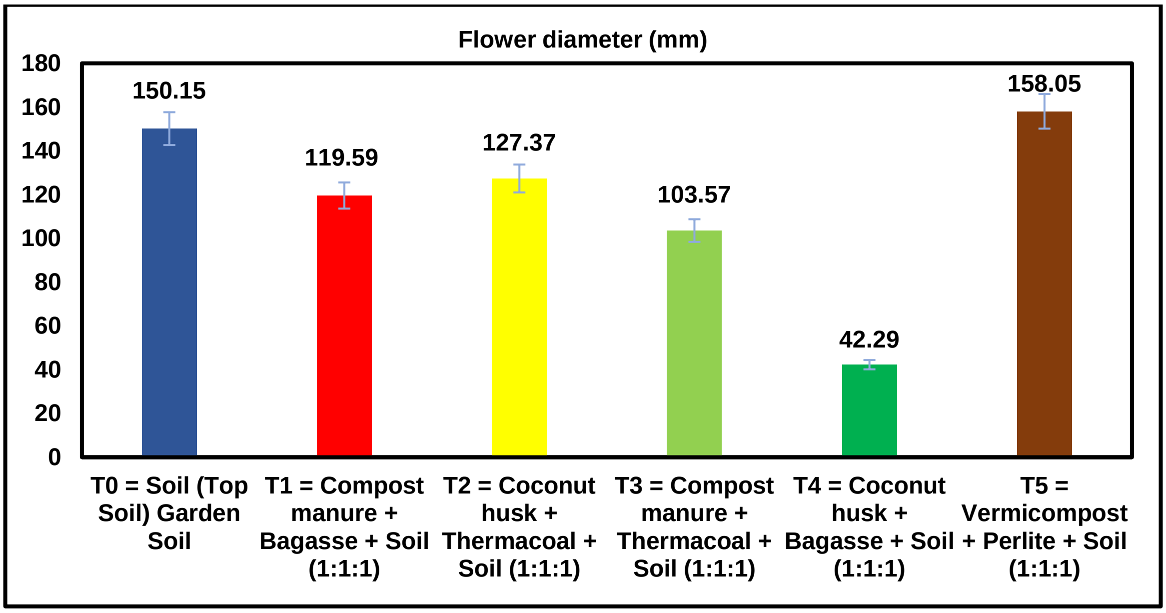


Figure 5. Flower diameter (mm) of Calendula as affected by different growing media

**Flower Fresh Weight (g)**

The results regarding the freshly harvested flower of Calendula treated with different growing media presented in (Figure 6). The data showed that the maximum flower fresh weight (24.42 g) flower fresh weight of Calendula was observed with $T_5$= Vermicompost + Perlite + Soil (1:1:1), followed by $T_1$= Compost manure + Bagasse + Soil (1:1:1) and $T_2$= Coconut husk + Thermacoal + Soil (1:1:1) resulting in 18.47 g and 15.54 g. The flower fresh weight further decreased (15.16 g and 14.10 g) with $T_0$ = Soil (Top Soil) Garden Soil and $T_3$= Compost manure + Thermacoal + Soil (1:1:1). However, the minimum (3.88 g) flower fresh weight was recorded with $T_4$= Coconut husk + Bagasse + Soil (1:1:1).

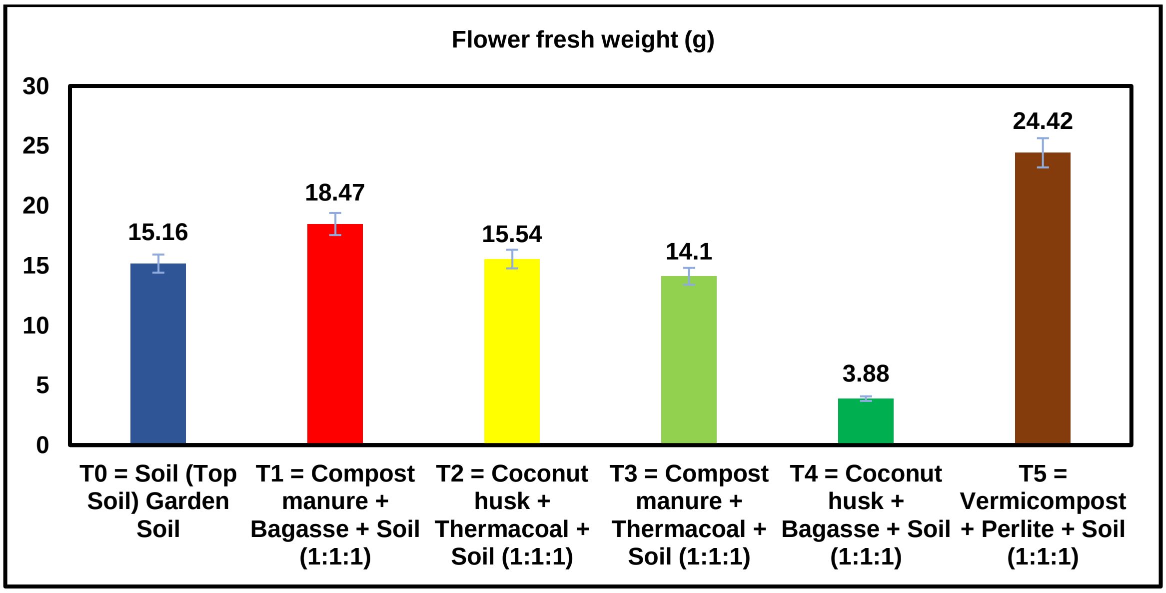


Figure 6. Flower fresh weight (g) of Calendula as affected by different growing media

**Flower Dry Weight (g)**

The results regarding the flower dry weight of calendula treated with different growing media are presented in (Figure 7). The data showed that the maximum flower dry weight (6.47 g) flower dry weight of Calendula was observed with $T_0$ = Soil (Top Soil) Garden Soil, followed by $T_2$= Coconut husk + Thermacoal + Soil (1:1:1) and $T_5$= Vermicompost + Perlite + Soil (1:1:1) resulting in 6.32 g and 6.20 g. The flower dry weight further decreased (5.46 g and 4.95 g) with $T_1$= Compost manure + Bagasse + Soil (1:1:1) and $T_3$= Compost manure + Thermacoal + Soil (1:1:1). However, the minimum (2.34 g) flower dry weight was recorded with $T_4$= Coconut husk + Bagasse + Soil (1:1:1).

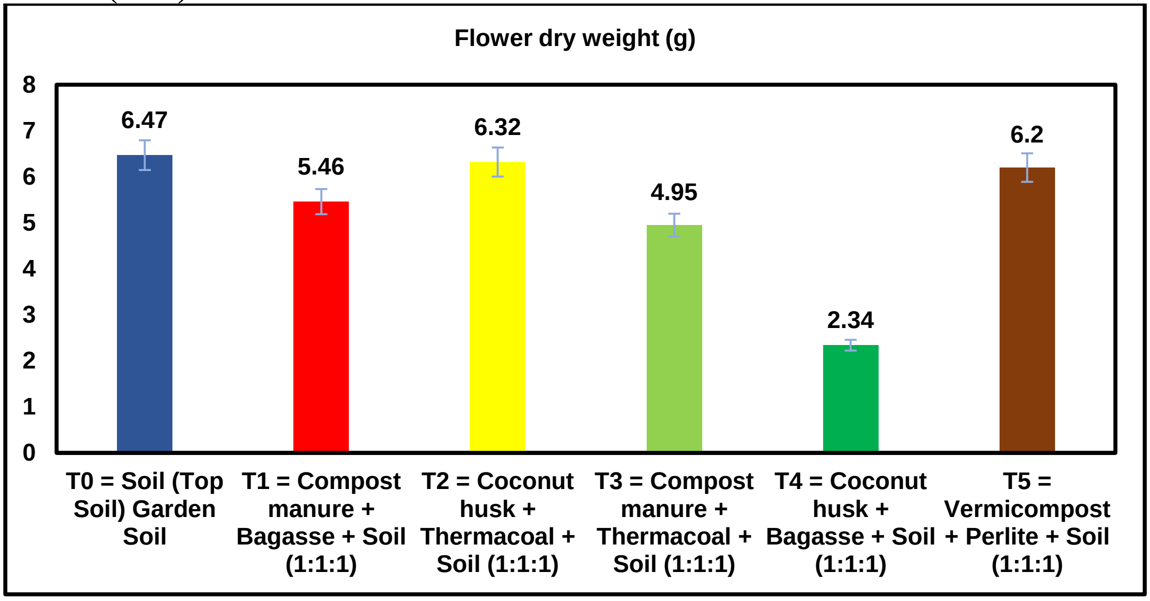


Figure 7. Flower dry weight (g) of Calendula as affected by different growing media

**Number of Flowers per Plant**

The effect of different growing media on the number of flowers per plant of Calendula is presented in (Figure 8). The showed that the maximum number of flowers plant$^{-1}$ (13.77) number of flowers per plant of Calendula was observed with $T_0$ = Soil (Top Soil) Garden Soil, followed by $T_5$= Vermicompost + Perlite + Soil (1:1:1) and $T_3$= Compost manure + Thermacoal + Soil (1:1:1) resulting in 12.77 and 9.22. The number of flowers per plant further decreased (7.77 and 7.66) with $T_1$= Compost manure + Bagasse + Soil (1:1:1) and $T_2$= Coconut husk + Thermacoal + Soil (1:1:1). Despite this, the minimum number (3.00) of flowers per plant was obtained from $T_4$= Coconut husk + Bagasse + Soil (1:1:1).

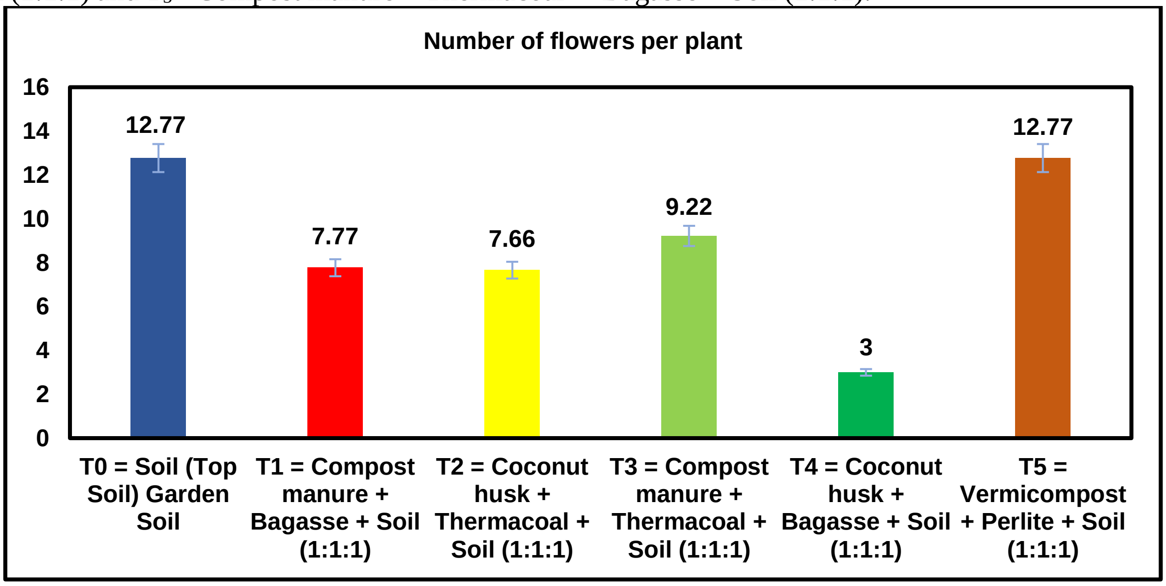


Figure 8. Number of flowers per plant of Calendula as affected by different growing media

**Plant Height (cm)**

The result regarding plant height of Calendula treated with different growing media presented in (Figure 9). The data showed that the maximum plant height (25.83 cm) for Calendula was observed with $T_5$= Vermicompost + Perlite + Soil (1:1:1), followed by $T_0$ = Soil (Top Soil) Garden Soil and $T_2$= Coconut husk + Thermacoal + Soil (1:1:1) which resulted in 18.48 cm and 16.53 cm. The plant height further decreased (14.75 cm and 13.48 cm) with $T_1$= Compost manure + Bagasse + Soil (1:1:1) and $T_3$= Compost manure +

Thermacoal + Soil (1:1:1). However, the minimum plant height of 7.66 cm was recorded with $T_4$= Coconut husk + Bagasse + Soil (1:1:1).

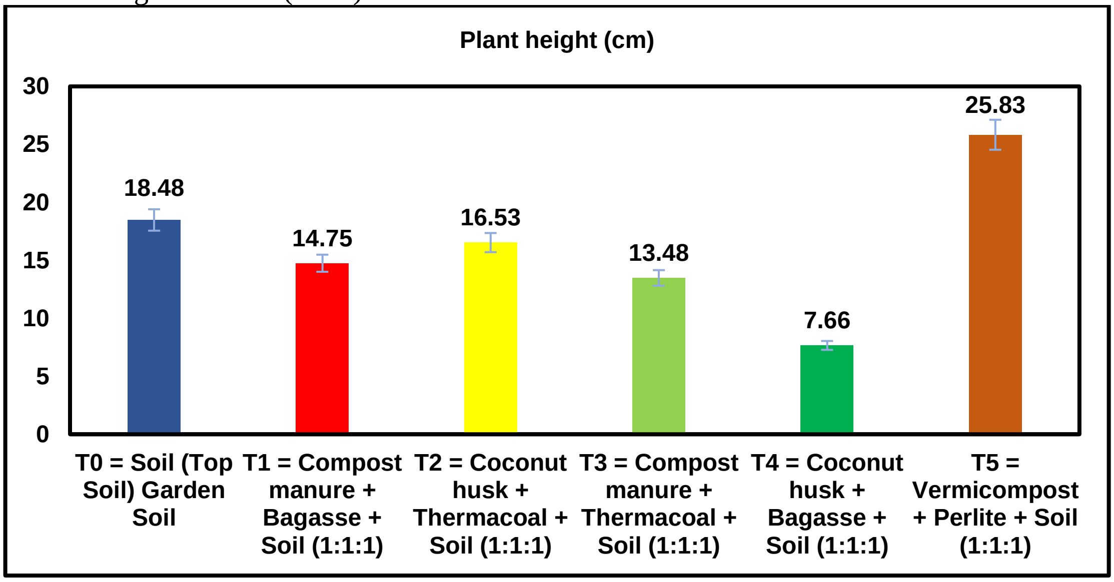


Figure 9. Plant height (cm) of Calendula as affected by different growing media

**Root Length (cm)**

The results regarding the root length of Calendula treated with different growing media presented in (Figure 10). The data showed that the maximum root length (23.88 cm) for Calendula was observed with $T_5$= Vermicompost + Perlite + Soil (1:1:1), followed by $T_2$= Coconut husk + Thermacoal + Soil (1:1:1) and $T_4$= Coconut husk + Bagasse + Soil (1:1:1), which resulted 22.22 cm and 22.16 cm. The root length further decreased (21.55 cm and 20.21 cm) with $T_1$= Compost manure + Bagasse + Soil (1:1:1) and $T_0$ = Soil (Top Soil) Garden Soil. However, the minimum root length of 9.33 cm was recorded with $T_3$= Compost manure + Thermacoal + Soil (1:1:1).

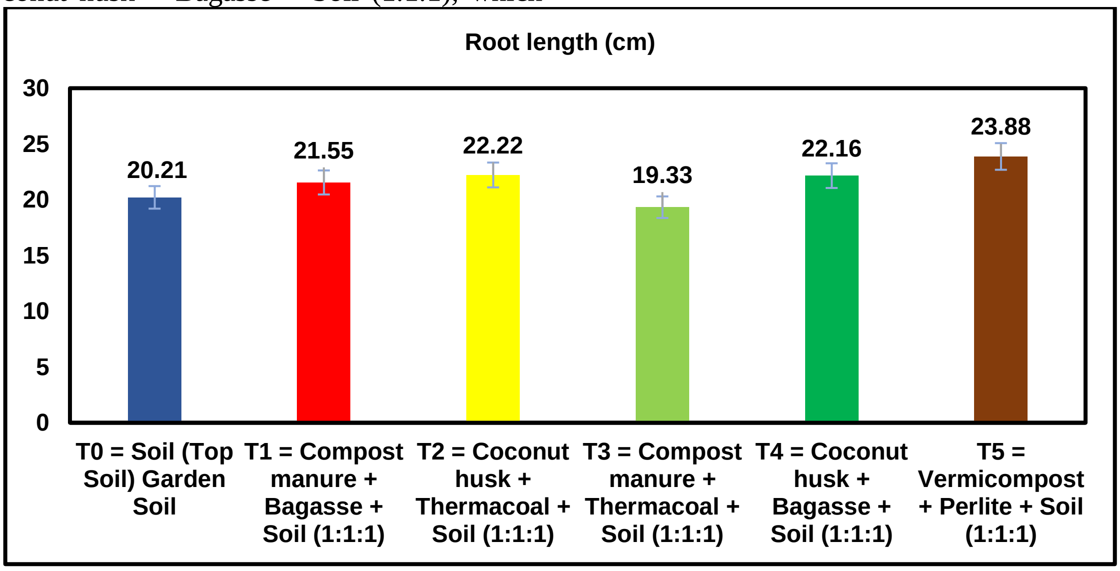


Figure 10. Root length (cm) of Calendula as affected by different growing media

The analysis of variance indicated that different growing media had significant effects ($P<0.05$) on seed germination, germination index, number of leaves per plant, plant height, days to flower initiation, flower diameter, flower fresh weight, flower dry weight, and number of flowers per plant. Root length, however, was not significantly influenced ($P>0.05$). Treatment means were separated using the LSD test at the 5% probability level.

**DISCUSSION**

Seed germination and early growth are critical stages in a plant's life cycle, shaping subsequent development and productivity. *Calendula officinalis*, an ornamental and medicinal species valued for its colorful flowers and pharmacological properties, is widely cultivated under diverse conditions (Dzida et al., 2016). The choice of growing medium plays a decisive role by influencing the physical, chemical, and biological environment that governs seedling emergence, root architecture, nutrient uptake, and ultimately plant performance. Thus, identifying sustainable substrates is essential for improving both cultivation efficiency and environmental outcomes.

In the present study, topsoil-based media and coconut husk + bagasse supported high germination percentages (up to 96.66%). Comparable findings were reported in marigold by Hassan et al. (2018), were compost enhanced germination, albeit to a lesser extent. Variations between species and substrate quality likely explain the differences. Germination index (GI) was also greatest in topsoil, consistent with Zhao et al. (2020), who demonstrated that substrates enriched with organic matter promote uniform and vigorous seedling emergence. In contrast, vermicompost + perlite showed low GI, probably due to perlite's low nutrient contribution, despite its aeration benefits.

Vegetative growth parameters also reflected substrate composition. Maximum leaf number (109 leaves per plant) was observed in topsoil, corroborating Sharma et al. (2019), who reported enhanced vegetative growth in nutrient-rich substrates. Meanwhile, vermicompost + perlite accelerated flowering (76 days), supporting Kumar et al. (2017), who emphasized the role of vermicompost in improving nutrient availability and stimulating reproductive transitions. These contrasting outcomes suggest that nutrient density favors vegetative development, while the balanced nutrient release in vermicompost can promote earlier reproductive onset.

Floral traits were also influenced by substrate type. Topsoil yielded the largest flower diameter, whereas vermicompost + perlite produced the heaviest flowers (fresh weight). Similar results were reported by Ali et al. (2016), where nutrient availability enhanced floral biomass in ornamentals. The greater fresh weight in vermicompost-amended media is attributable to its supply of both macro- and microelements, improving physiological vigor and biomass accumulation. Flower dry weight followed the same pattern, as shown by Hossain et al. (2019), highlighting the long-term role of nutrient-rich substrates in supporting sustained biomass production. Flower number was likewise highest in topsoil, consistent with Naseem et al. (2021), who reported that balanced nutrient environments support greater reproductive output.

Plant height was maximized in vermicompost + perlite, while root length was greatest in coconut husk + thermacoal. Jha et al. (2020) similarly reported that vermicompost improved shoot elongation, whereas organic residues like coconut husk enhanced aeration and root penetration. This suggests a complementary role of nutrient supply and physical structure in shaping plant architecture. Beyond crop performance, the sustainability dimension of substrate choice is increasingly important. Recent studies highlight that integrating vermicompost with other eco-friendly substrates can reduce reliance on synthetic fertilizers and improve soil health. For example, soil + cocopeat + vermicompost combinations improved flowering and postharvest nutrient retention in Calendula, enhancing both yield and soil fertility (Mehar et al., 2022). In tomato, vermicompost blended with cocopeat produced higher nutrient concentrations in leaves and fruits compared to conventional media, underscoring its agronomic and environmental benefits (Erdal & Aktas, 2025). Vermi-liquids derived from vermicompost have also been shown to outperform inorganic nutrient solutions in hydroponic systems, improving biomass accumulation and nutrient uptake while reducing chemical inputs (Rehman et al., 2024). These findings collectively suggest that vermicompost-based media not only optimize growth and flowering in Calendula but also offer a more sustainable alternative, minimizing environmental impact and promoting circular resource use.

## CONCLUSIONS

The present study demonstrates that seed germination and growth traits of *Calendula officinalis* are significantly influenced by growing media. Among the tested substrates, vermicompost + perlite + soil ($T_5$) consistently enhanced flowering and vegetative performance, including greater flower diameter (158.05 mm), flower fresh weight (24.42 g), plant height (25.83 cm), and root length (23.88 cm). These results highlight the practical significance of using vermicompost-based media as an eco-friendly alternative to conventional soil, offering improved flowering, biomass production, and resource efficiency. By integrating organic waste recycling into horticultural practice, vermicompost + perlite emerges as a sustainable potting medium that supports both high productivity and reduced environmental impact in Calendula cultivation.

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