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INFLUENCE OF DIFFERENT ORGANIC AMENDMENTS ON THE MORPHOLOGICAL AND GROWTH CHARACTERISTICS OF ANTIRRHINUM MAJUS L

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Abstract
This study was conducted to assess the effects of various potting media amendments with differing compositions on the growth and flowering of Antirrhinum majus L. Statistical analysis of physiological data indicated that the different media combinations significantly influenced plant performance compared to the control. Each treatment included 10 plants with three replications, and multiple growth parameters were evaluated under the various potting formulations.
The results showed marked improvements in both vegetative and reproductive growth when a leaf mold–based potting medium was combined with farmyard manure. Among the tested combinations, the medium containing farmyard manure, leaf mold, topsoil, and silt (T_4; 1:0.5:0.5:1) and the higher pH medium with farmyard manure and silt (T_3) were less effective. In contrast, combinations that included silt with topsoil or leaf mold positively influenced plant growth and flowering. These findings suggest that leaf mold is an effective and reliable potting medium for promoting optimal growth and flowering in Antirrhinum majus L.

1. INTRODUCTION

Antirrhinum majus L. is a member of the Scrophulariaceae family and originates from the Mediterranean region. It is also classified under the Plantaginaceae family[1]. A total of 36 species, along with approximately 20,000 cultivars, have been identified for this species[2]. Due to its hinged flowers, it is commonly known as Snapdragon. When the sides of the flowers are pinched, they close and open like a dragon's mouth. The cultivars of this species are divided into different types based on their flowering responses and growth measurements, which depend on temperature and day length[3]. Globally, horticultural crops are cultivated in more than 140 countries[4]. Among flowering plants, ornamental flowers have the highest demand worldwide[5]. *Antirrhinum majus* contains pigments, amino acids, cinnamic acids, oils, anthocyanidins, flavones, aurones, flavanones, flavanols, and many othercompounds. It also exhibits pharmacological and biological effects2. Chemically, A. majus consists of 2.15–4.69% soluble sugars, 2.79–5.69% free amino acids, and 0.22–0.27% carotenoids. The application of amino acids, such as tryptophan and phenylalanine, either individually or in combination, increases the concentration of these biochemical compounds6. Furthermore, the plant contains aurones, cinnamic acids, flavanols, flavones, and flavanones7. The dwarf variety of A. majus is considered the most suitable for growth in different container media8. Growing flower crops, compared to traditional crops, is more economically viable for farmers and is becoming an increasingly selective choice.

The potting medium plays a crucial role in the growth and propagation of flowering plants. For container cultivation of ornamental plants, peat and common soil are the most widely used potting media9. However, peat is non-reusable, expensive, and poses a threat to sustainability. A nutrient-rich organic medium serves as a cost-effective and environmentally friendly alternative. Organic potting media can reduce irrigation rates and costs10. Peat is widely used in nurseries for growing floral potted varieties11. However, environmentalists identify it as a sustainability threat due to its high carbon dioxide emissions, which contribute significantly to greenhouse gas emissions12. Sustainable organic media alternatives are needed to align with the Sustainable Development Goals (SDGs). Selecting the right combination of growth media is essential, and the cost requirement is approximately 4–6% of total production expenses13. Certain potting media have also been found to prevent plant diseases12. For instance, studies have shown that tomato southern blight occurrences were significantly lower in compost, swine manure, and green manure treatments compared to synthetic fertilizer-treated soils. Organic materials and waste residues provide a wide range of plant-beneficial nutrients14 and are strongly recommended as renewable resources for pot production, helping to mitigate environmental degradation. Possible mechanism of action of organic amendments is depicted in Figure 1.

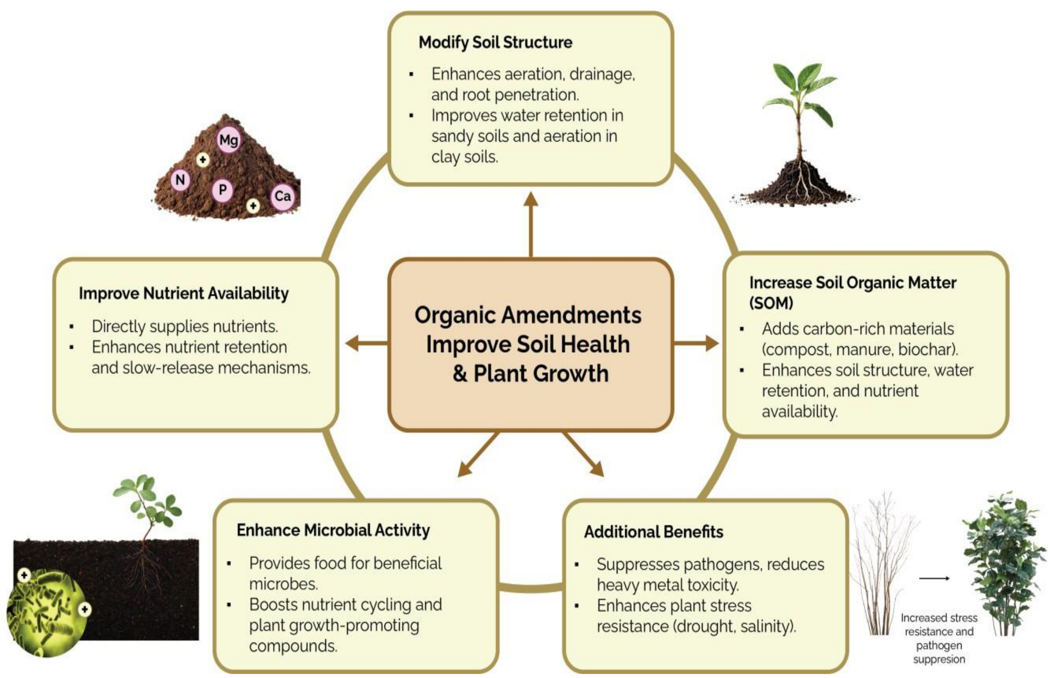


Figure 1. Mode of action of organic amendments in soil ecosystem.

In Pakistan, various organic and raw materials, such as sawdust, sludge, and spent mushroom compost, are used as potting media for different plants[15]. The present study aims to determine the impact of different organic amendments on the growth of *Antirrhinum majus* and to identify the most effective organic amendment for its cultivation.

2. METHODOLOGY

The present research was conducted at the Edible Landscape Area, Department of Horticulture, Bahauddin Zakariya University, Multan, during 2018. The study aimed to assess the effects of different potting media on the growth of *A. majus*. Seeds were purchased from a nursery and sown in various growth media. The pots used for the experiment were 9 inches in size and filled with substrates according to different treatments. Three-week-old *A. majus* seedlings were transplanted in January 2018, with each pot containing one plant.

2.1. Design and Treatment Application

The experiment was laid out according to a Completely Randomized Design with three replications and six treatments. Water was applied to seedlings as needed throughout the growth period. Weeding was performed manually to ensure clean pots. The different treatments used in this study are shown in Table 1. After applying the treatments, seedlings were transplanted, and the pots were irrigated.

Table 1. Composition of different treatments

T_0	**Control (silt)**
T_1	Leaf mold + topsoil + silt (0.5:0.5:1)
T_2	Silt + leaf mold + topsoil (2:0.5:0.5)
T_3	Farmyard manure + silt (1:2)
T_4	Silt + leaf mold + topsoil + farmyard manure (1:0.5:0.5:1)
T_5	Leaf mold + topsoil+ Farmyard manure (0.5:0.5:1)

2.2. Physical Parameters Studied

The following observations were recorded during the experiment: number of leaves, flowers, shoots, plant diameter, number of seed pods, shoot length, root length, fresh stem weight, dry stem weight, fresh root weight, and dry root weight. Parameters were measured from three randomly selected plants per replication, and their averages were calculated. This process was repeated for all treatments. Plant diameter was determined using vernier calipers from a marked portion of the stem. To measure dry weight, roots from six randomly selected plants per treatment were dried in an oven at 60°C for 48 hours. After drying, they were weighed using a balance, and the averages were computed.

2.3. Statistical Analysis

The collected data were statistically analyzed using a one-way analysis of variance (ANOVA). Treatment means were compared using the Least Significant Difference (LSD) test at a 5% (0.05) probability level. The data were processed using the statistical software GraphPad Prism 8.4.2.

3. RESULTS & DISCUSSION

The present investigation provides novel insights into the effects of diverse organic amendments on the morphological and developmental traits of *Antirrhinum majus* L. (snapdragon). The results clearly indicate that the formulation and composition of potting media have a substantial impact on various aspects of plant growth, including leaf production, shoot formation, floral production, stem diameter, and biomass accumulation. These findings contribute to the expanding corpus of research indicating that organic amendments exert a positive impact on plant growth, primarily through enhancements in soil structure, nutrient bioavailability, and microbial dynamics[16].

Vegetative growth parameters, including leaf number and shoot proliferation, exhibited significant responses to varied organic treatments. Our analysis, as shown in Fig. 2A, revealed that the number of leaves observed in T0 (control, silt) was 82.4 ± 16.8. The T1 treatment {leaf mold + topsoil + silt (0.5:0.5:1)} showed a significant increase in the number of leaves (96 ± 8.5) compared to the control treatment. In the T2 treatment (silt + leaf mold + topsoil (2:0.5:0.5)), the number of leaves also increased significantly (109.4 ± 4). However, the T3 treatment (farmyard manure + silt (1:2)) resulted in a statistically significant decrease in the number of leaves (39.2 ± 2.00) compared to the control. Similarly, the T4 treatment (silt + leaf mold + topsoil + farmyard manure (1:0.5:0.5:1)) also showed a significant decrease in the number of leaves (70.1 ± 5.5) relative to the control treatment. On the other hand, the T5 treatment (leaf mold + topsoil + farmyard manure (0.5:0.5:1)) exhibited the most significant increase in the number of leaves (111.8 ± 23.7) compared to control plants. Among the treatments, the highest number of leaves in *Antirrhinum majus* plants was observed in T5, followed by T2 and then T1. Notably, the highest leaf count was observed in plants cultivated in treatment T5, comprising a combination of leaf mold, topsoil, and farmyard manure. This synergistic blend appears to optimize nutrient availability and enhance soil structural properties, thereby fostering robust vegetative growth [17]. This observation aligns with existing literature, which underscores the pivotal role of organic matter in enhancing soil physical properties, including aeration, water retention, and root penetration, thereby facilitating robust vegetative growth [18]. Our results revealed that the number of shoots observed in T0 (control) was 11.1 ± 3.43. A significant increase in the number of shoots was observed with the T1 treatment (14.3 ± 2.32) and T2 treatment (14.1 ± 2.48) compared to the control plants. Conversely, the T3 (6.73 ± 0.11) and T4 (6.73 ± 0.61) treatments showed a statistically significant decrease in the number of shoots compared to the control. The T5 treatment also resulted in a decrease (11.3 ± 1.9), but this reduction was statistically non- significant compared to the control. The maximum number of shoots in *Antirrhinum majus* plants was recorded in the T1 and T2 treatments, while the T3, T4, and T5 treatments reduced the number of shoots compared to the control (Fig. 2B). Consistent with this finding, shoot production exhibited a similar trend, with treatments T5 and T2 demonstrating superior performance relative to the control. This suggests that organic amendments create a more conducive environment for shoot emergence and development, ultimately contributing to enhanced plant growth and productivity [19]. The enhanced vegetative growth exhibited by plants in organically amended treatments is attributable to the gradual and sustained release of essential nutrients. Organic materials, specifically composts and farmyard manure, are recognized as repositories of macronutrients and micronutrients that are vital for plant metabolic processes[20]. In contrast to synthetic fertilizers, which provide nutrients in a readily available yet transient form, organic amendments release nutrients gradually, thereby ensuring a consistent and sustained supply throughout the plant's growth cycle[21].

The production of flowers, a paramount parameter in the cultivation of ornamental plants, was markedly influenced by the composition of potting media. The number of flowers is presented in Fig. 2C. Our study revealed that the number of flowers in T0 (control) was 30.5 ± 7.67. A significant increase in the number of flowers was observed with the T1 (44.5 ± 17.7), T2 (40.8 ± 15.7), T4 (46.3 ± 2.51), and T5 (53.9 ± 5.09) treatments compared to the control plants. However, the T3 treatment showed a statistically significant decrease (20.8 ± 1.89) in the number of flowers compared to the control. The highest number of flowers in *Antirrhinum majus* plants was observed with the T5 treatment, followed by T4, T1, and then T2.

Treatment T5 yielded the highest flower count, with treatments T4 and T2, which also incorporated organic amendments, exhibiting similarly elevated floral production. These findings suggest that organic matter exerts a profound influence on reproductive growth, potentially mediated by enhanced nutrient uptake efficiency and optimized plant physiological functions[22]. Consistent with this observation, previous research has demonstrated that organic amendments can stimulate the biosynthesis of floral regulatory hormones, including cytokinins and gibberellins, which play a critical role in promoting flower formation and overall plant vigor [23].

Our analysis revealed that the number of seed pods in T0 (control) was 14.8 ± 3.01. The number of seed pods significantly increased with the T1 treatment (19.3 ± 4.91) and the T2 treatment (22.3 ± 0.76) compared to the control plants. However, the T3 (3 ± 0.87) and T4 (6.67 ± 1.04) treatments showed a statistically significant decrease in the number of seed pods compared to the control. The T5 treatment (14.8 ± 1.61) did not show any change in the number of seed pods compared to the control treatment. The highest number of seed pods was observed in the T2 treatment, while the lowest was recorded in the T3 treatment (Fig. 2E).

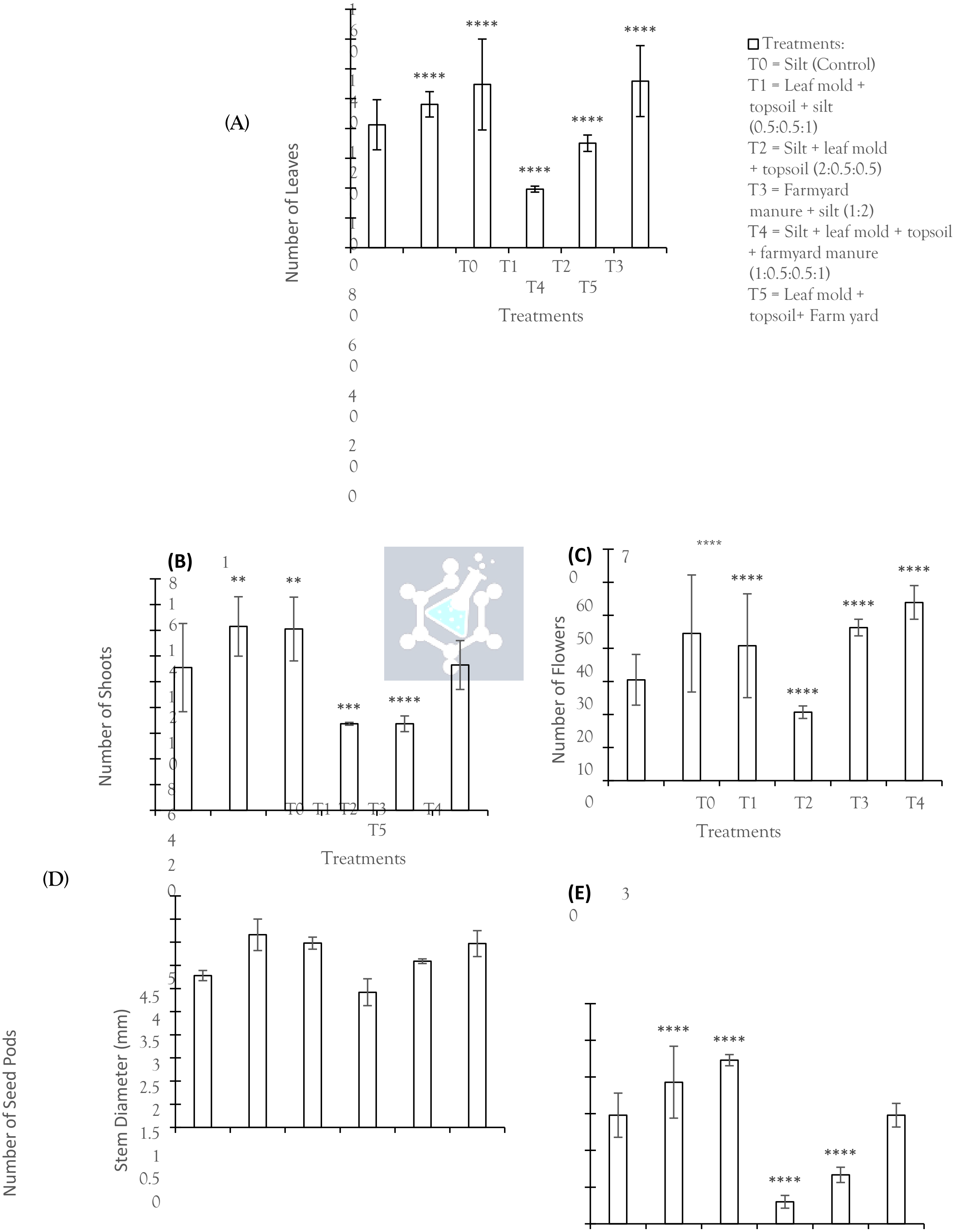
Our study showed that the stem diameter in T0 (control) was 3.28 ± 0.11 mm. The stem diameter increased to 4.16 ± 0.35 mm in the T1 treatment, while the T2 treatment showed a slight increase (3.98 ± 0.13 mm). The T3 treatment resulted in a decrease in stem diameter (2.92 ± 0.29 mm). In the T4 treatment, the stem diameter was 3.59 ± 0.05 mm, whereas the T5 treatment also showed a slight increase (3.98 ± 0.28 mm). However, these increases and decreases in stem diameter were not statistically significant compared to the control plants. The maximum stem diameter was observed in the T1 treatment, while the minimum was recorded in the T3 treatment (Fig. 2D). Statistical analysis for stem length is shown in Fig. 3A. The analysis revealed that the stem length in T0 (control) was 67.1 ± 6.25 cm. The T1 treatment did not show any significant difference (67.7 ± 8.82 cm) compared to the control. However, the T2 treatment resulted in a significant increase in stem length (68.7 ± 1.13 cm) compared to the control plants. Conversely, the T3 (42.1 ± 3.47 cm), T4 (58.5 ± 8.63 cm), and T5 (62.6 ± 5.82 cm) treatments showed a significant decrease in stem length compared to the control plants. The maximum stem length was observed in the T2 treatment, while the minimum stem length was recorded in the T3 treatment.

The results for stem fresh weight are shown in Fig. 3B. The stem fresh weight in T0 (control) was observed as 15.8 ± 3.99 g. The stem fresh weights in the T1 (21.9 ± 5.14 g), T2 (22.6 ± 2.48 g), and T4 (24.7 ± 3.05 g) treatments increased significantly compared to the control plants. The T5 treatment showed a highly significant increase in stem fresh weight (43.07 ± 3.13 g) compared to the control.

However, the T3 treatment showed a significant decrease (8.27 ± 1.17 g) in stem fresh weight compared to the control plants. The maximum stem fresh weight was observed in the T5 treatment, while the minimum was recorded in the T3 treatment. Our study revealed that the stem dry weight in T0 (control) was 4.28 ± 0.92 g. Stem dry weights increased with the T1 (5.72 ± 1.09 g), T2 (5.73 ± 0.61 g), T4 (4.91 ± 0.57 g), and T5 (9.28 ± 0.91 g) treatments; however, this increase was not statistically significant compared to the control. The T3 treatment showed a non-significant decrease in stem dry weight (1.67 ± 0.24 g) compared to the control plants. The maximum stem dry weight was observed in the T5 treatment, while the minimum was recorded in the T3 treatment (Fig. 3C). The stem diameter and strength exhibited significant improvements in treatments incorporating organic amendments, with T5 and T2 demonstrating particularly notable enhancements. This observation suggests that the inclusion of organic matter plays a pivotal role in promoting the development of robust plant structures, a critical determinant of floral production and ornamental plant longevity [24]. Moreover, organic amendments may exert a suppressive effect on soilborne diseases, thereby indirectly contributing to the maintenance of healthier and more productive plants [25].

A noteworthy observation was the divergence in growth responses between above-ground and below-ground plant components. Specifically, while above-ground growth parameters exhibited significant enhancements in response to organic amendments, root growth metrics, including length and weight, displayed a declining trend across all treatments relative to the control. This finding contrasts with existing literature, which has consistently reported positive effects of organic amendments on root biomass[26]. A potential explanation for this discrepancy lies in the increased above-ground growth observed in this study, which may have led to elevated nutrient demand and concomitant reductions in energy allocation to root expansion. Additionally, the high organic matter content in the soil may have modified soil physical properties, including compaction and aeration levels, thereby influencing root architecture and morphology[27]. Our study revealed that the root length observed in T0 (control) plants was 40.7 ± 17.1 cm. However, root lengths significantly decreased in the T1 (20.9 ± 1.94 cm), T2 (27.8 ± 5.79 cm), T3 (24.9 ± 0.38 cm), T4 (18.8 ± 5.01 cm), and T5 (23.6 ± 1.13 cm) treatments compared to the control. The shortest root length was observed in the T4 treatment (Fig. 3D). The root fresh weights of control and treated plants are shown in Fig. 2E. The fresh root weight observed in T0 (control) was 2.57 ± 0.33 g. A significant decrease in fresh root weight was observed with the application of T1 (1.93 ± 0.21 g), T2 (2.21 ± 0.15 g), T3 (1.23 ± 0.09 g), T4 (1.43 ± 0.15 g), and T5 (1.79 ± 0.10 g) treatments. Among all treatments, the lowest fresh root weight was recorded in the T3 treatment (Fig. 3E). We obtained similar results for root dry weight as for root fresh weight. The dry root weight for T0 (control) was 0.94 ± 0.17 g. The application of T1 (0.67 ± 0.11 g), T2 (0.72 ± 0.08 g), T3 (0.29 ± 0.03 g), T4 (0.38 ± 0.04 g), and T5 (0.5 ± 0.05 g) significantly reduced root dry weights compared to the control. Among all treatments, the lowest root dry weight was recorded in the T3 treatment (Fig. 3F).

Despite the noted diminution in root growth, total plant biomass exhibited a significant increase in organically amended treatments, with treatment T5 demonstrating the most substantial enhancement. The attendant augmentation in shoot and flower biomass suggests that plants effectively utilized available nutrients to optimize their overall growth performance[28]. This finding highlights the critical importance of selecting a judicious combination of organic amendments to strike a balance between root and shoot development, thereby ensuring optimal plant health and productivity[29].


(A)
Number of Leaves
****
****
****
****
****
T0 T1 T2 T3
T4 T5
Treatments
Treatments:
T0 = Silt (Control)
T1 = Leaf mold + topsoil + silt (0.5:0.5:1)
T2 = Silt + leaf mold + topsoil (2:0.5:0.5)
T3 = Farmyard manure + silt (1:2)
T4 = Silt + leaf mold + topsoil + farmyard manure (1:0.5:0.5:1)
T5 = Leaf mold + topsoil+ Farm yard
(B)
Number of Shoots
**
**
***
****
T0 T1 T2 T3 T4
T5
Treatments
(C)
Number of Flowers
****
****
****
****
****
T0 T1 T2 T3 T4
Treatments
(D)
Stem Diameter (mm)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Number of Seed Pods
(E)
****
****
****
****

T0 T1 T2
T3 T4
T5

25

20

15

10

5

0

T0 T1 T2 T3 T4 T5

Treatments

Figure 2. Effect of different treatments on number of leaves, flowers, seed pods and shoots as well as on diameter.

The incorporation of organic amendments in potting media confers considerable economic and environmental advantages. Peat, a ubiquitous component in commercial potting media, is not only expensive but also raises ecological concerns due to its non-renewable nature [30]. The substitution of peat with organic materials, such as leaf mold and farmyard manure, offers a dual benefit: reducing production costs while promoting sustainable agricultural practices[31]. Furthermore, the utilization of locally sourced organic materials can contribute meaningfully to waste management efforts and mitigate reliance on synthetic fertilizers, which often pose environmental pollution risks32. Furthermore, organic amendments have been demonstrated to enhance soil health through the augmentation of microbial activity and the increased availability of essential nutrients. Microorganisms play a crucial role in facilitating nutrient cycling, decomposing organic matter, and suppressing plant pathogens33. The presence of beneficial microorganisms in soils enriched with organic amendments can contribute significantly to long-term soil fertility and resilience, rendering organic amendments a sustainable and environmentally conscious choice for horticultural production34.

1. FUTURE DIRECTIONS

The results of this investigation highlight the necessity for future research endeavors to investigate the long-term consequences of organic amendments on soil health and plant productivity. Furthermore, an in- depth examination of the specific microbial communities associated with diverse organic amendments could yield profound insights into their role in augmenting plant growth and development, thereby informing the development of novel, microbiome-based strategies for sustainable agriculture35. Additionally, studies examining the potential disease-suppressive properties of organic materials would be highly beneficial in promoting sustainable plant cultivation practices and mitigating the reliance on chemical pesticides36. It is recommended that horticultural professionals and growers incorporate organic amendments, including leaf mold, farmyard manure, and compost, into potting media for the cultivation of ornamental plants. The integration of these amendments not only yields improvements in plant growth and flowering but also confers significant environmental benefits by reducing dependence on synthetic inputs 37. By optimizing the formulation of organic potting media, growers can achieve superior plant quality while minimizing production costs and ecological footprint38.

2. CONCLUSION

In conclusion, this investigation unequivocally demonstrates the efficacy of organic amendments in enhancing the growth and flowering of Antirrhinum majus L. The combination of leaf mold, topsoil, and farmyard manure (T5) emerged as the optimal treatment, yielding superior vegetative and reproductive performance. Although root growth exhibited a declining trend, overall plant biomass accumulation was significantly higher in organically amended treatments. The findings underscore the potential of organic amendments as a sustainable and environmentally conscious alternative to conventional potting media, offering economic and ecological benefits. Future research endeavors should focus on the long-term impacts of organic amendments on soil health and plant productivity, thereby providing a scientific foundation for the development of sustainable horticultural practices.

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