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ARAŞTIRMA MAKALESİ RESEARCH ARTICLE

Effects of Potting Mixtures on the Germination and Seedling Growth of Marigold (*Tagetes erecta*)

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Abstract

The study was conducted at the Agriculture Faculty Farm of the Department of Horticulture, Nangarhar University, Afghanistan during the spring season of 2019, aiming to determine the effects of different potting mixtures on the germination and seedling growth of marigold (*Tagetes erecta*). Among 12 explored treatments, T_7 (soil + coarse sand + rotten wheat straw + FYM) had the highest seed germination (80%). T_3 (soil + coarse sand + rice husk + FYM) and T_9 (soil + coarse sand + forest soil + FYM) exhibited higher seedling growth, as well as plant fresh and dry weights. In contrast, T_2 (soil + coarse sand+ saw dust + FYM) and T_{10} (soil + coarse sand+ poultry manure+ FYM) exhibited no germination while T_{11} (forest soil + rice husk + wheat husk + poultry manure) resulted in minimal plant growth and mass production. The results of this study not only illuminate the most effective potting mixtures for successful marigold cultivation but also emphasize the significance of utilizing organic waste to promote sustainability and minimize environmental repercussions within the horticulture. Furthermore, they provide valuable guidance to gardeners, farmers, and marigold enthusiasts, demonstrating the potential for sustainable practices benefiting both plant growth and environmental well-being. Subsequent research can delve into additional potting mixtures and environmental variables, advancing marigold cultivation practices and contributing to sustainable agriculture and environmental preservation. A comprehensive understanding of potting mixtures' influence in early plant development can lead to improved marigold germination, waste reduction, and a more ecologically conscious approach to horticulture, ultimately enhancing marigold production.

Keywords: *Tagetes erecta*, Germination, Plant growth, Traditional growth medium

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1. Introduction

Marigold (*Tagetes erecta*), a member of the *Asteraceae* family, is native to Mexico and other parts of Central and South America. There are around 33 species in the genus *Tagetes*, which includes annual and perennial plants, and several hundred different cultivars are grown all over the world. Marigold is considered one of the oldest cultivated flowering plants and holds significant socio-cultural importance in Asian communities (Ahmad et al., 2011). It is mostly planted as a decorative crop for its flowers, which are sold in large quantities as loose flowers, used as specialty cut flowers, and used for garlands and decorations at different religious and social events. Furthermore, xanthophylls, which are utilized as natural food additives to improve the color of egg yolks and poultry skin, are a rich natural resource in marigold (Bosma et al., 2003).

Several factors, both directly and indirectly, have impacts on the germination and seedling growth of marigold. Low-quality seeds, inadequate soil conditions, insufficient water availability and agricultural pests are among the main causes of low-quality marigold production. In particular, poor soil can result in the loss of more than half the flower yield. High-quality propagation media are frequently used in developed countries to assure favorable germination and healthy seedling growth. However, accessing to these commercial media can be difficult or prohibitively expensive in Afghanistan and other less developed countries. As a solution, we recommend utilizing readily available plant and animal waste as a potting medium. The use of this approach not only aids the prevention of environmental damage but also enables farmers to reduce unnecessary costs. Additionally, the cultivation and promotion of marigold in the country will help in the creation of optimal agricultural and propagation media for other ornamental plants.

There are two types of potting media available for container or pot seedlings: soil-based and organic-based. Organic-based media are made up of organic materials such as bagasse, coco peat, peat, peat moss, perlite, vermiculite, leaf litter, or any other organic material, while soil-based media are predominantly made up of soil. However, in many local nurseries, affordable access to these organic materials is limited, leading growers to prepare their own potting medium utilizing readily available and cost-effective sources (Sardoei, 2014); (Çiçek and Yücedağ, 2021). A good potting medium should serve a number of functions. First of all, it needs to give the plant enough support and anchorage. It should also serve as a storage area for water and nutrients, allowing oxygen to reach the roots and permitting gaseous exchange between the roots and the atmosphere outside the root substrate. The potting media must be permeable in order to allow for root aeration and drainage while still having the capacity to hold onto water and nutrients. Of course, oxygen is necessary for all living cells to survive (Abad et al., 2002); (Yücedağ and Çiçek, 2023). The creation of high-quality flowering plants is thought to depend heavily on the composition and nutritional content of the potting media.

The use of natural stimulants and biological fertilizers in place of chemical fertilizers has drawn considerable attention recently, both from an ecological and health perspective (Hu and Barker, 2004); (Mohammadipour and Souri, 2019); (Souri and Bakhtiarizade, 2019). Raw crop residue or processed byproducts can also be used as soil amendments and growth media in agriculture (Neel et al., 1978). Yüksel (2012) investigated the impact of municipal solid waste compost on Xerofluvent soil properties. Accordingly, municipal solid waste compost had a positive impact on the physical properties of the soils, particularly hydraulic conductivity, bulk density, saturation percentage, and field capacity, with a more pronounced effect as compost rates increased. The composting of sugarcane bagasse yields a valuable substrate that can be used as a potting media, especially for ornamentals like pelargoniums (Najarian and Souri, 2020). Margenot et al. (2018), suggested that sawdust and biochar may be readily available and more affordable alternatives for cultivating marigold. Utilizing manure, wood chips, and paper waste with volcanic mixture as a growth medium for croton, Cordyline, and chrysanthemum have demonstrated promising results (Khomami et al., 2019).

The traditional nursery potting medium in the majority of less developed countries is topsoil dug up from farmland and amended with poultry manure (PM). Barlas et al. (2018) revealed that a treatment consisting of 25% cow manure vermicompost and 75% soil is the most effective for enhancing the nutritional concentration of plants. Anwar et al. (2013) examined the effects of several soilless and soil-based media on marigold growth, yield, and flower quality under controlled condition. According to their findings, a combination of peat compost and soil, along with poultry manure in pots, might be a profitable media of marigold production. Atiyeh et al. (2000) demonstrated that applying hog manure vermicompost to marigold and tomato enhanced the growth rate that vermicompost had more positive effect on germination rate in tomato than that in marigold. According to

Bachman and Metzger (2008), a 20% v/v hog manure vermicompost mixture with growth medium increased the root and shoot dry matter, leave area, and shoot-to-root rates in tomato and marigold plants, but had little or no impact on the growth rates of pepper and santeria. Amending the soil with 4% chicken manure compost killed majority of the raspberry plants. However, plant mortality was decreased and growth restored when the chicken manure compost was combined with vermicomposted pig solids, but not with bark or yard composts. Plant growth in soils containing a mixture of chicken manure mixed with 20% vermicomposted pig wastes looked similar to that of plants grown in the unfertilized control. Çiçek (2021), exploring the effects of bat guano and vermicompost on the growth, quality and photosynthetic pigments of the marigold, revealed that their all doses were found to be higher than the control group and the most suitable dose for marigold plant was 6% of bat guano. According to Dede et al. (2006), poultry manure provides nitrogen necessary for plant growth-highest stem thickness. Sahu et al. (2022) examined the soil properties as affected by fly ash on performance of marigold.

Considering the results of several studies exploring the effects of different potting media on different plants growth and production, we established our own potting mixtures using nearby and conveniently accessible animal and plant residues. Thus, we hoped to lessen our reliance on traditional potting media and advance a more environmentally friendly method of plant production. The findings of our study have improved the knowledge of how locally sourced resources can be used to promote effective and sustainable plant cultivation techniques.

2. Material and Method

The present study was conducted at the Agriculture Faculty Farm of the Department of Horticulture, Nangarhar University, Afghanistan during spring season of 2019 to find out the effects of different potting mixtures on the germination and growth of marigold seedlings. The pot experiment was designed in a Completely Randomized Design (CRD) with three replications and included 12 treatments. *i.e.* soil + coarse sand (4:2), soil + coarse sand + saw dust + FYM (2:1:2:1), soil + coarse sand + rice husk + FYM (2:1:2:1), soil + coarse sand + paddy straw + FYM (2:1:2:1), soil + coarse sand + wheat husk + FYM (2:1:2:1), soil + coarse sand + sugarcane bagass + FYM (2:1:2:1), soil + coarse sand + rotted wheat straw + FYM (2:1:2:1),soil + coarse sand + well-rotted leaves + FYM (2:1:2:1), soil + coarse sand + forest soil + FYM (2:1:2:1), soil + coarse sand + poultry manure + FYM (2:1:2:1), forest soil + rice husk + wheat husk + poultry manure (2:2:1:1), forest soil + paddy straw + wheat straw + sugarcane bagass (2:1:1:2), and each treatment included 10 seeds.

In the study, parameters associated with seed germination and seedling growth were evaluated. Daily observations to assess characteristics related to seed emergence in the study. These characteristics comprised emergence percentage, mean daily emergence, and emergence speed performed, which were defined according to Gairola et al.'s (2011) guidelines. The seed emergence parameters were computed using the following equations (Eq. 1, 2, and 3).

$$\text{Emerging percentage } \% = \text{number of emerged seeds} / \text{total number of seeds} \times 100 \quad \text{(Eq. 1).}$$

$$\text{Mean daily emerging} = \text{total number of emerged seeds} / \text{total number of days} \quad \text{(Eq. 2).}$$

$$\text{Speed of emerging} = n1/d1 + n2/d2 + n3/d3 + ----------- \quad \text{(Eq. 3).}$$

Where, n = number of emerged seeds, d = number of days.

At the end of the experiment, various parameters related to seedling growth were assessed. These parameters included plant height (measured in centimeters), the count of leaves, the number of stems, as well as the fresh and dry weights of both roots and shoots. Following the harvesting of the plants, they were carefully uprooted and thoroughly rinsed with flowing tap water to eliminate any soil particles. The plants were subsequently divided into their respective root and shoot components. Using a digital top-loading weighing balance, we determined the fresh weights (FW) of both the roots and shoots. The root and shoot segments were then subjected to a 4-days drying period at 65°C, after which the dried samples were weighed to ascertain their respective dry weights (Root and shoot). Statistical analysis of the data was conducted using Minitab version 15 (Minitab Inc., Philadelphia, USA). The mean values were evaluated through one-way analysis of variance (ANOVA) and differences between groups were assessed using Kruskal-Wallis and Tukey's honest significant differences test ($p < 0.05$).

3. Results and Discussion

3.1. Influence of potting media on germination percentage, daily emerging and speed of emerging

The study revealed that the maximum seed germination percentage (80%) was observed in T_7 (soil + coarse sand + rotted wheat straw + FYM) and T_1 (soil + coarse sand), followed by 76% in T_8 (soil + coarse sand + well-rotted leaves + FYM) and 70% in T_3 (soil + coarse sand + rice husk + FYM). These results indicate the potential effectiveness of the potting media used in these treatments. On the other hand, the minimum germination percentage (25%) was recorded in T_{11} (forest soil + rice husk + wheat husk + poultry manure) (**Hata! Başvuru kaynağı bulunamadı.** 1). It should be noted that treatments T_2 (soil + coarse sand + sawdust + FYM), T_5 (soil + coarse sand + wheat husk + FYM), and T_{10} (soil + coarse sand + poultry manure + FYM) did not exhibit any germination, suggesting that the potting media used in these treatments may have hindered or failed to support seed germination. Regarding the daily emerging values of marigold cultivars in different potting media treatments, the highest value (2.40) was recorded in T_3 (soil + coarse sand + rice husk + FYM), followed by 2.13 in T_1 (soil + coarse sand), 2.00 in T_9 (soil + coarse sand + forest soil + FYM), and 1.92 in T_4 (soil + coarse sand + paddy straw + FYM). The minimum daily emerging value (0.18) was observed in T_{11} (forest soil + rice husk + wheat husk + poultry manure) (***Hata! Başvuru kaynağı bulunamadı.***). In terms of emerging speed, the maximum values (0.53) were obtained in T_7 (soil + coarse sand + rotted wheat straw + FYM) and T_1 (soil + coarse sand), respectively. The minimum emerging speed value (0.26) was recorded in T_{11} (forest soil + rice husk + wheat husk + poultry manure) (***Hata! Başvuru kaynağı bulunamadı.*** *1*). Organic matter plays a crucial role in creating a favorable environment for seed germination and subsequent plant growth. Rotted wheat straw, a form of organic matter, contains essential nutrients and beneficial microorganisms that contribute to improved soil fertility and moisture retention (Hubbe et al., 2010) (Locke and Altland, 2012). Studies have shown that the addition of organic matter in potting media enhances seed germination, as it improves soil structure, water-holding capacity, and nutrient availability (Önemli, 2004); (Zulfiqar et al., 2022). Moreover, the incorporation of farmyard manure (FYM) in potting media has been reported to positively influence seed germination, plant growth and increased biomass production. FYM is rich in organic nutrients, such as nitrogen, phosphorus, and potassium, which are essential for seedling establishment and vigor (Vaithiyanathan and Sundaramoorthy, 2016). It also aids in enhancing soil microbial activity, leading to improved nutrient cycling and availability (Kumar et al., 2021). Coarse sand promotes the movement of water through the medium and allows excess water to drain, preventing the accumulation of moisture around the seeds, which can hinder germination (Kaur et al., 2020). This improved drainage and aeration are critical for the successful germination of seeds.

3.2. Influence of potting media on plant growth

In the study, it was observed that different potting media treatments had an impact on the growth of marigold seedlings. The results of the plant height of the marigold cultivar in relation to the different potting media treatments are presented in *Table 1*. At the end of the seedling growth period, the highest plant height recorded was 23.00 cm in T_3 (soil + coarse sand + rice husk + FYM), followed by 17.66 cm in T_9 (soil + coarse sand + forest soil + FYM), and 16.00 cm in both T_8 and T_4. On the other hand, the lowest plant height of 4.50 cm was found in T_{11} (forest soil + rice husk + wheat husk + poultry manure) (*Table 1*). Regarding the number of leaves of the marigold cultivar, an increasing trend was observed depending on the different potting media treatments (*Table 1*). The highest number of leaves (12.00) was determined in T_3 (soil + coarse sand + rice husk + FYM), followed by 10.00 in T_9 (soil + coarse sand + forest soil + FYM), and 9±0.44 in T_4. Conversely, the lowest number of leaves (4.00) was found in T_{11} (forest soil + rice husk + wheat husk + poultry manure) (*Table 1*). FYM improves soil fertility, enhances nutrient availability, and promotes beneficial microbial activity which have beneficial effects of FYM on seed germination, plant growth and biomass production in various crops, including ornamental plants (Bhatt et al., 2023); (Rehman et al., 2023). The inclusion of coarse sand in potting media is known to enhance drainage and prevent waterlogging, thereby facilitating root growth, reducing the risk of seed rot and crucial for plant growth (Rajvanshi et al., 2011).

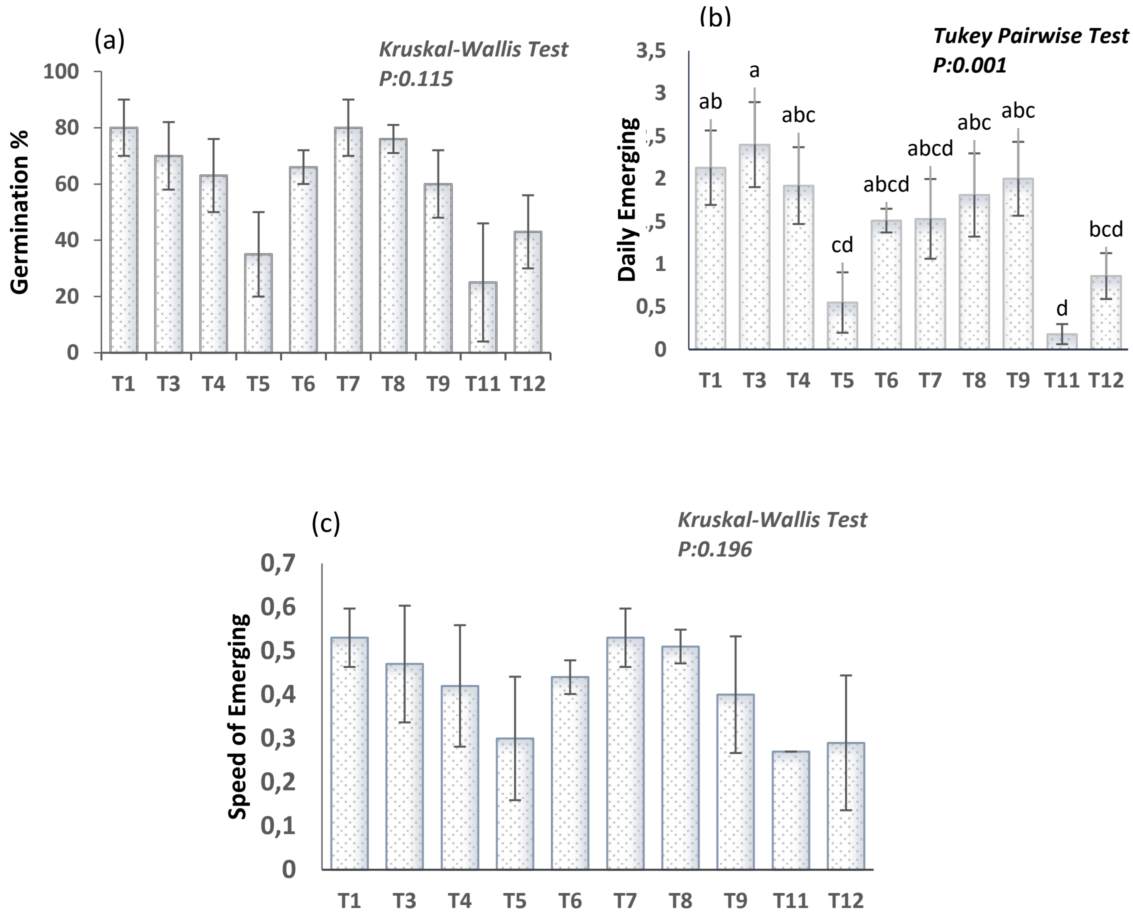

***Figure 1 a: Seed germination of marigold. b: daily emerging of marigold c: speed of emerging of marigold*.**
Different letters represent statistical differences at P≤0.05 (least significant difference test).

3.3. Influence of potting media on plant biomass

Various plant growth and quality characteristics of marigold seedlings depending on different potting media treatments are presented in *Table 1*. Significant differences were observed among the potting media treatments regarding the plant fresh weight of the marigold cultivar. The highest plant fresh weight of 15.00 g was recorded in T_3 (soil + coarse sand + rice husk + FYM), followed by 13.16 g in T_9 (soil + coarse sand + forest soil + FYM) and 12.20 g in T_4 (soil + coarse sand + paddy straw + FYM). Conversely, the lowest value of 4.00 g was observed in T_{11} (forest soil + rice husk + wheat husk + poultry manure) for the marigold cultivar (*Table 1*). Regarding the plant dry weight, there were no significant differences among the different potting media treatments for the marigold cultivar. The highest plant dry weight of 2.10 g was recorded in T_3 (soil + coarse sand + rice husk + FYM), followed by 1.93 g in T_9 (soil + coarse sand + forest soil + FYM) and 1.43 g in T_8 (soil + coarse sand + well-rotted leaves + FYM). The lowest value of 0.41 g was determined in T_{12}(forest soil + paddy straw+ wheat straw+ sugarcane bagass). The data presented for different potting media treatments showed that the maximum root fresh weight of 2.60 g was recorded in T_3 (soil + coarse sand + rice husk + FYM), followed by 1.60 g in T_9 (soil + coarse sand + forest soil + FYM), 1.43 g in T_4 (soil + coarse sand+ paddy straw+ FYM), and 1.43 g in T_8 (peat + soil). The minimum root fresh weight of 0.39 g was recorded in T_{11} (forest soil + rice husk + wheat husk + poultry manure). In terms of root dry weight, the highest value of 0.75 g was determined in T_3 (soil + coarse sand + rice husk + FYM), followed by 0.57 g in T_9 (soil + coarse sand + forest soil + FYM). The lowest value of 0.14 g was found in T_{11} (forest soil + rice husk + wheat husk + poultry manure) (*Table 1*). The presence of silica in rice husk, the improved drainage and aeration provided by coarse sand, and the organic nutrients and microbial activity from FYM and forest soil likely contributed to the observed increased plant growth. Forest soil contains a variety of organic matter and microorganisms that contribute to nutrient cycling and soil fertility (Peguero et al., 2022); (Sardans et al., 2019). The inclusion of forest soil in T_9 may have enhanced nutrient availability and microbial activity, leading to increased plant growth, biomass and dry weight. Rice husk in potting media has been reported to have positive effects on plant growth. Rice husk contains silica, which contributes to improved plant structural integrity, resistance to pests and diseases, and enhanced root development (Vijay et al., 2018). The presence of silica in the potting media used in T_3 might have promoted the growth of marigold plants, resulting in increased plant growth and mass production. The specific combination of forest soil, rice husk, wheat husk, and poultry manure used in T11 may have created unfavorable conditions for marigold germination and growth. The presence of potentially unfavorable physical properties, phytotoxic compounds, and nutrient imbalances could collectively contribute to the observed minimum germination percentage, plant height, leaf production, and fresh and dry weight (Agarwal et al., 2023). Forest soil is known to have varying characteristics depending on its composition and location. It often contains a high amount of organic matter and can be rich in nutrients. However, in some cases, forest soil can also have physical properties such as compaction or high acidity, which may impede root development and nutrient uptake, resulting in reduced plant height, leaf production, fresh and dry weight. The presence of forest soil in T_{11} may have contributed to the observed minimum plant height, number of leaves, plant fresh and dry weight, likely due to unfavorable physical properties, phytotoxic compounds, and nutrient imbalances.

Table 1: Influence of different potting mixtures on seedling growth of marigold.

Treatments	Leaf numb. (unit)	Plant			Root	
		Hieght(cm)	Fresh Weight(g)	Dry Weight(g)	Fresh Weight(g)	Dry Weight(g)
T_1= soil + coarse sand.	8.67^{DE}	12.67^{c}	10.00^{D}	1.10^{c}	1.18^{c}	0.41^{DE}
T_3= soil + coarse sand+ rice husk + FYM.	12.00^{A}	23.00^{a}	15.13^{A}	2.10^{a}	2.17^{a}	0.75^{A}
T_4= soil + coarse sand+ paddy straw+ FYM.	9.33^{CD}	9.33^{bc}	12.2^{B}	1.43^{b}	1.54^{bc}	0.51^{BC}
T_6= soil + coarse sand+ sugarcane bagass+ FYM.	6.67^{FG}	6.67^{c}	9.83^{D}	1.03^{c}	1.20^{c}	0.41^{D}
T_7= soil + coarse sand+ rotted wheat straw+ FYM.	8.00^{EF}	8.00^{bc}	11.47^{C}	1.13^{c}	1.28^{bc}	$0.76B^{CD}$
T_8= soil + coarse sand+ well-rotted leaves+ FYM.	8.00^{EF}	8.00^{bc}	11.83^{BC}	1.43^{b}	1.47^{bc}	$0.52A^{BC}$
T_9= soil + coarse sand+ forest soil+ FYM.	10.00^{BC}	10.00^{b}	13.17^{A}	1.93^{a}	1.61^{b}	0.57^{AB}
T_{11}= forest soil + rice husk + wheat husk + poultry manure.	4.00^{G}	4.00^{d}	4.00^{E}	0.45^{d}	0.39^{d}	0.14^{F}
T_{12}= forest soil + paddy straw+ wheat straw+ sugarcane bagass.	4.13^{G}	4.67^{d}	4.13^{E}	0.42^{d}	0.44^{d}	0.15^{EF}
LSD	0.004*	***	0.003*	*	**	*

Different letters in each column is indicated significant difference at at $P \leq 0.05$ (least significant difference test). **: $P \leq 0.01$, *: $P \leq 0.05$, tested by Kruskal-Wallis Test and Tukey Pairwise Comparisons.

4. Conclusions

The study revealed that T_7 (soil + coarse sand + rotted wheat straw + FMG) showed the highest germination rate of 80%. In addition, T_3 (soil + coarse sand + rice husk + FMG) and T_9 (soil + coarse sand + forest soil + FMG) exhibited higher plant fresh and dry weights with significant seedling growth. In contrast, T_{11} (forest soil + rice husk + wheat husk + chicken manure) resulted in minimal plant growth and production, likely due to unfavorable physical properties, the presence of phytotoxic compounds, and nutrient imbalances. These findings contribute to our understanding of the best potting mixtures that facilitate successful germination and seedling growth of the marigold production. By identifying the most effective potting mixtures, this research offers valuable guidance for gardeners, farmers and enthusiasts interested in marigold cultivation. It allows them to make informed decisions regarding the selection of appropriate potting mixture that promote optimal germination, vigorous seedling growth and ultimately better marigold yields. Future work may build on these findings, investigating additional potting mixtures and their impact on marigold growth, while considering other environmental factors to further improving marigold cultivation practices. Overall, this research highlights the importance of understanding the impact of potting mixtures in the early stages of plant development and demonstrates the potential for improving marigold production through the application of appropriate growing strategies. By optimizing germination and seedling growth, it can pave the way for sustainable and successful marigold cultivation, which can benefit the farming community and contribute to the overall progress of horticultural practices.

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Ethical Statement

There is no need to obtain permission from the ethics committee for this study.

Conflicts of Interest

We declare that there is no conflict of interest between us as the article authors.

Authorship Contribution Statement

Concept: Dawlatzai, A., Sadat, M. I., Omari, M. G.; Design: Dawlatzai, A., Sadat, M. I., Omari, M. G.; Data Collection or Processing: Dawlatzai, A., Sadat, M. I., Omari, M. G.; Statistical Analyses: Dawlatzai, A., Sadat, M. I., Omari, M. G.; Literature Search: Dawlatzai, A., Sadat, M. I., Omari, M. G.; Writing, Review and Editing: Dawlatzai, A., Sadat, M. I., Omari, M. G.

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