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RESEARCH PAPER

Effect of planting methods and pinching techniques on the growth, flowering, and seed production of African Marigold (*Tagetes erecta* L.)

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Key Message: The research study demonstrated that the bed planting method significantly enhances the growth and flowering of African Marigold compared to the ridge planting method. The study also highlighted the positive impact of pinching techniques on plant characteristics, resulting in shorter plants with more lateral branches and a higher number of flowers.

Abstract

This research study aimed to assess the impact of different planting methods (ridge and bed planting) and pinching techniques on the growth, flowering, and seed production of African Marigold (*Tagetes erecta* L.). The experiments were conducted at the Floricultural Research Substation in Multan, Pakistan. The ridge planting method (T1) and bed planting method (T2) were employed, along with pinching treatments (T1) at a height of 30 cm compared to a control group (T2). Various growth, floral development, flower weight measurements, and seed metrics were systematically recorded and analyzed. The results demonstrated that bed planting significantly influenced Marigold plant growth, leading to taller plants, more leaves, and a higher population compared to ridge planting. Bed planting also accelerated floral development, with earlier spike emergence, quicker floret opening, and a greater number of florets plant^{-1}. Pinching resulted in shorter plants and promoted more lateral branches and a higher number of flowers plant^{-1} compared to the control group. The pinched plants displayed reduced single fresh and dried flower weights, but the control group consistently produced heavier flowers. Additionally, pinching contributed to a reduction in the number of seeds flower^{-1} but increased the average seed yield plant^{-1} compared to the control group. These findings provide valuable insights into optimizing planting methods and employing pinching techniques to enhance the growth, flowering, and seed production of African Marigold. The study emphasizes the importance of selecting appropriate cultivation practices to maximize the economic returns for flower growers and traders in the floriculture industry.

Keywords: Bed planting, Floral development, Pinching techniques, Ridge planting, Seed metrics, *Tagetes erecta* L.

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Introduction

Marigold (*Tagetes erecta* L.), also known as "African marigold," belongs to the Asteraceae family. This charming flower has been gaining recognition for its extensive adaptability and a growing popularity contributing to its high status in the commercial flower market. Originating from Central and South America, especially Mexico, marigold can be grown in all seasons, especially as a main crop in rainy and winter seasons. Additionally, marigold is planted to control soil nematodes. Marigold holds a significant presence as a widely cultivated flower in Pakistan, capturing the attention of gardeners and flower cultivators due to broad adaptability. The marigold traits such as flowering, short duration and marketable flowers, a diverse range of appealing colors, shapes, and sizes, along with excellent longevity, have garnered keen interest from flower growers. Although marigold blooms can be found across the country, but its large-scale commercial cultivation is primarily concentrated in a few regions. Different agro-techniques, including planting methods and pinching, significantly influence the growth and flowering behaviors in marigold (Bhardwaj et al., 2001). Pinching treatment involves the removal of the apical portion to promote the number of side branches that is positively correlated with the yield of flowers in African marigold.

A popular annual flower crop for garden beautification and commercial use, marigold is a hardy and vigorous plant with dark green foliage and large double globular flowers (Nain et al., 2016). It can be grown in sandy loam, well-drained soil in almost all seasons, except in very hot summers. Its appealing features, including productive flowering habit, brief blooming duration, charming color, well-defined shape, optimal size, impressive shelf life, and easy transportability, make it a magnet for flower growers and traders. Besides ornamental, medicinal, and industrial uses, marigold also helps control soil nematodes (Nain et al., 2016).

Commercial cultivation of marigold is gaining momentum in many states. Pinching leads to the removal of the terminal

section of shoots, promoting the earlier emergence of side branches and encouraging the production of a greater quantity of high-quality, uniformly sized flowers. Without the pinching treatment, the plant tends to grow taller, yet its lateral spread is comparatively reduced, ultimately leading to a limited yield (Badge et al., 2015). Implementing pinching treatment at various intervals can successfully accomplish the dual goals of achieving optimal plant spread and flowering. This approach ensures a consistent and prolonged supply of flowers to the market, thereby maximizing economic returns over an extended period (Badge et al., 2015). In recent years, marigold cultivation in Pakistan has become highly remunerative in traditional floriculture due to various commercial uses. Marigold is commonly known as a versatile crop, promising a golden harvest. More flowers result from increasing the number of branches that bear flowers. This is done by limiting upward growth and encouraging side shoots through careful pinching of the apical buds. These side shoots stand a greater chance of bearing flowers, ultimately contributing to increased flower yield (Sasikumar et al., 2015).

Marigold holds a prominent position among global commercial flower crops, being cultivated in over half of the world's nations. Marigold flowers had a wide range of applications in making garlands, floral decorations, flower baskets, religious offerings, bedding, potting, and various products (Swaroop et al., 2007). It serves as a promising source for natural products and pharmaceutical components, thus making it suitable for various purposes such as pigment extraction, meal production, natural colorant preparation, and oil extraction. These applications offer farmers opportunities to enhance their income. The growing interest in marigold cultivation by various industries is attributed to its potential for value addition (Sasikumar et al., 2015). The quantity of flowers produced is primarily influenced by the number of flower-bearing branches, a factor controlled by restricting vertical plant growth and promoting side shoots through apical bud pinching. These side shoots provide more opportunities to bear flowers, contributing to higher flower yield (Sunitha et al., 2007). Therefore, this research aimed to evaluate the effects of Ridge planting method (T1) and Bed planting method (T2) on African Marigold growth and flowering to optimize resource used and increase plant population per unit area. Additionally, the research explored the impact of pinching techniques on the vegetative and reproductive characteristics of African Marigold.

Materials and Methods

The experiments were conducted at the Floricultural Research Substation in Multan to investigate the effects of different planting methods and pinching on the growth and flowering of African Marigold. In Experiment 1, corms measuring 6 × 8 cm were used in Ridge planting method (T1) and Bed planting method (T2), with a corm-to-corm distance of 4 inches maintained for both methods. The row-to-row distance for Ridge planting was set at 2 feet, and the plot size for both methods was 5.25 × 3.25 meters. Cultural practices were consistently applied to ensure uniformity across treatments. In Experiment 2, conducted at the dedicated research area for floriculture and landscaping, two treatments were employed: T1 involved pinching marigold plants when they reached a height of 30 cm, while T2 served as a control group. The experiment was replicated three times for result reliability. After the pinching procedure, data was recorded at a 15-day interval, and all cultural practices were diligently performed uniformly across treatments. Vegetative and reproductive characteristics were systematically recorded for subsequent analysis and interpretation.

Data were recorded for growth parameters such as plant height (cm), number of lateral branches plant^{-1}, number of leaves plant^{-1} and plant population acre^{-1}, floral development parameters such as spike emergence (days), number of days taken to first floret opening, number of florets plant^{-1}, number of flowers plant^{-1}, flower weight measurements such as single fresh weight of flower (g) and single dried weight of flower (g), as well as seed metrics such as number of seeds flower^{-1} and seed yield plant^{-1} (g).

Results

Effect of planting methods on plant growth

The impact of ridge planting (T1) and bed planting (T2) methods on the growth of Marigold plants was investigated in this study. The results revealed significant differences between the two planting techniques (Table 1). In the ridge planting method (T1), Marigold plants exhibited a mean height of 65.5 cm, with an average of 9.5 leaves plant^{-1}, and a plant population of 80,000 acre^{-1}. On the other hand, the bed planting method (T2) demonstrated significantly enhanced growth parameters, with Marigold plants reaching an average height of 80.08 cm, having a higher number of leaves plant^{-1} (10.5), and a substantially increased plant population of 320,000 acre^{-1} (Table 1).

Table 1 Effect of ridge planting and bed planting methods on plant growth of Marigold

Treatments	Plant height (cm)	Number of leaves per plant	Plant population/acre
Ridge planting method (T1)	65.5^{b}	9.5^{b}	80000^{b}
Bed planting method (T2)	80.08^{a}	10.5^{a}	320000^{a}

Effect of planting methods on floral development

The results demonstrated significant variations in various parameters related to floral growth (Table 2). In the ridge planting method (T1), Marigold plants exhibited a mean spike emergence time of 90.75 days, with the first floret opening took place on an average, after 105.75 days. The number of florets per plant was observed to be 12.50. In contrast, the bed planting method (T2) exhibited a more rapid floral development, as indicated by a reduced spike emergence time of 75.20 days and a shorter duration of 98.25 days for the first floret opening. Furthermore, Marigold plants subjected to the bed planting method (T2) produced a higher number of florets per plant (16.40) (Table 2).

Table 2 Effect of ridge planting and bed planting methods on floral development of Marigold

Treatments	Spike emergence (days)	No. of days taken to first floret opening	No. of florets/plant
Ridge planting method (T1)	90.75[a]	105.75[a]	12.50[b]
Bed planting method (T2)	75.20[b]	98.25[b]	16.40[a]

Effect of pinching on plant growth

The results revealed significant differences in plant height, number of lateral branches per plant, and number of flowers per plant among the two treatments (Table 3). Marigold plants subjected to pinching (T1) exhibited a mean height of 90.33 cm, significantly lower than the control group (T2) with an average height of 135.15 cm. However, the pinched plants displayed a more increase in lateral branches (32.00 per plant) compared to the control group with 21.50 lateral branches per plant (Table 3). Furthermore, the number of flowers per plant was significantly higher in the pinching treatment (T1) at 168.25, compared with the control group (T2) where the average number of flowers per plant was 118.35.

Table 3 Effect of pinching on plant height (cm), number of lateral branches/ plant and number of flowers/ plant of Marigold

Treatments	Plant height (cm)	Number of lateral branches per plant	Number of flowers per plant
Pinching (T1)	90.33[b]	32.00[a]	168.25[a]
Control (T2)	135.15[a]	21.50[b]	118.35[b]

Effect of pinching on flower weight measurements

The study investigated the impact of pinching (T1) on flower weight measurements in Marigold plants and compared the results with the control group (T2). The findings indicated significant differences in both the single fresh weight and single dried weight of flowers between the two treatments (Table 4). Marigold plants subjected to pinching (T1) displayed a mean single fresh flower weight of 5.65 g, which was lower than the control group (T2) with a fresh flower weight of 7.20 g. Similarly, in the dried flower weight measurements, the pinched plants (T1) exhibited a lower mean of 1.13 g compared to the control group (T2) with a dried flower weight of 1.44 g. These results suggested that pinching method may contribute to a reduction in both fresh and dried flower weights, the control group consistently produced heavier flowers across both treatments.

Table 4 Effect of pinching on flower weight measurements of Marigold

Treatments	Single fresh weight of flower (g)	Single dried weight of flower (g)
Pinching (T1)	5.65[b]	1.13[b]
Control (T2)	7.20[a]	1.44[a]

Effect of pinching on seed metrics

The results revealed significant variations in both the number of seeds per flower and the average seed yield per plant between the two treatments (Table 5). Marigold plants subjected to pinching (T1) exhibited a lower (125.55) mean number of seeds per flower, compared to the control group (T2) with a higher average of 145.50 seeds per flower (Table 5). However, the pinched plants demonstrated a higher average seed yield per plant (100.45 g), whereas the control group yielded an average of 82.68 g of seeds per plant. These results suggested that pinching may lead to a reduction in the number of seeds per flower, it contributes to an overall increase in the average seed yield per plant compared to the control group.

Table 5 Effect of pinching on seed metrics of Marigold

Treatments	Number of seed/ flower	Average seed yield/ plant (g)
Pinching (T1)	125.55[b]	100.45[a]
Control (T2)	145.50[a]	82.68[b]

Discussion

Pinching is a vital horticultural technique employed to disrupt apical dominance in plants, particularly in species like Marigold, with benefits for both quantity and quality (Patade et al., 2020). This practice involves redirecting the flow of energy and nutrients from a single stem system to a multi stem system. The increased number of side branches contributes to a bushy appearance, thereby reducing the time and costs associated with intercultural operations. This, in turn, maximizes benefits while minimizing investments (B.C. et al., 2020). Manual pinching can be done using a regular hand cutter. The process involves securing the plant with the forefinger and then pinching the top section of the stem between the thumb and the first two fingers. The impact of pinching extends to various physiological processes within the plant, inducing the arrest of vegetative growth and promoting the accumulation of photosynthetic chemicals, ultimately leading to enhanced yield (Sahu & Biswal, 2020).

The application of pinching techniques has demonstrated a dual effect on plant characteristics. While it led to a reduction in plant height and leaf area, there was a prominent increase in both plant dry matter and flower count (Santi et al., 2021). Although lodging might not be a significant concern for small-scale farming operations, its implications become more pronounced when cultivation is done on a large scale resulting in considerable losses. Pinching proves to be a valuable strategy in addressing this issue, effectively reducing stalking costs (Abbas, 2018). The downward diversion of energy achieved through pinching of tip facilitates the creation of additional branches that directly influence the number of flowers produced (Prakash et al., 2016). This process not only mitigates lodging-related losses but also establishes an environment conducive to optimal hormone utilization within the plant. Consequently, this enhanced hormonal regulation supports overall growth and development, leading to improved growth parameters and increased yield (Makinde et al., 2016).

Our findings suggest that bed planting method positively influences Marigold plant growth, resulting in taller plants, more leaves, and a higher population compared to the ridge planting method. Bed planting method accelerates the floral development of Marigold plants, resulting in earlier spike emergence, quicker floret opening, and a greater number of florets per plant compared to the ridge planting method. Our findings also suggest that while pinching may result in shorter Marigold plants, it promotes the development of more lateral branches and a higher number of flowers per plant compared to the control group. Pinched plants exhibit reduced height due to the removal of the apical portion during pinching, whereas unaltered control plants display greater height as they have not undergone any pinching. Our findings are in line with the findings of Singh et al. (2015). Singh et al. (2019) reported that maximum plant spread, number of branches, duration of flowering, number of flowers per plant, size of flower, weight of single flower, flower yield per plant and seed yield per plant were observed in the double pinching treatment. The flower yield was maximum in double pinching with two times more yield than the control.

During the study, a greater number of flowers was produced in pinching treatments. This phenomenon can be attributed to the enhanced branching resulting from early pinching, which increases the development of larger auxiliary shoots. These shoots, in turn, contribute to a higher number of flowers, thereby increasing the overall flower yield. These findings align with the observations of Pushkar and Singh (2012) in marigold, where pinching at 20 days after transplanting proved to be more effective in augmenting the yield of marigold flowers.

Conclusion

The bed planting method proved to be superior, resulting in taller plants, more leaves, and a substantially higher population compared to the ridge planting method. Bed planting also accelerated floral development, with earlier spike emergence, quicker floret opening, and a greater number of florets per plant. Additionally, pinching techniques were shown to influence plant characteristics, with pinched plants exhibiting shorter stature, more lateral branches, and a higher number of flowers per plant compared to the control group. Although pinching led to a reduction in both fresh and dried flower weights, it contributed to an overall increase in the average seed yield per plant. This information is crucial for flower growers seeking to optimize their cultivation practices to enhance both floral production and seed yield.

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