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Enhancing Growth and Flowering of French Marigold (Tagetes Patula l.) Through Pinching and Phosphorus in Protected Shade House Horticulture.

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Abstract

An experiment was conducted at Ornamental Horticulture Nursery, Department of Horticulture, The University of Agriculture Peshawar, Pakistan, from October 2024 to January 2025 on the performance of marigolds in response to pinching and phosphorous in a shed house. A Randomized Complete Block Design (RCBD) with a split-plot arrangement comprised of two factors with three replications. Factors of the experiment were, i.e., phosphorous levels and pinching stages. The performance of marigold in response to different phosphorus levels, i.e., 0, 1%, and 2%, while pinching stages, i.e., 1, 2, and 3 bud stages, including un-pinched plants (control) was evaluated. Experimental results indicated a significant effect of the phosphorus and pinching stages on the growth and flower production of marigolds. Among the phosphorus applications, 2% of phosphorus resulted in better growth and production of marigold. The maximum plant height (21.72 cm), number of branches per plant (8.25), stem diameter (2.58 mm), number of leaves per plant (38.8), leaf fresh weight (0.24 g), leaf chlorophyll content (29.91 SPAD), days to flowering (67.25), number of flowers per plant (6.00), flower diameter (38.62 mm), and flower fresh weight (1.04 g) were recorded in plant of marigold that received 2% phosphorus. Whereas in pinching stages, maximum plant height (22.88 cm), number of branches per plant (8.22), stem diameter (2.34 mm), number of leaves per plant (39.55), leaf fresh weight (0.19 g), leaf chlorophyll content (27.52 SPAD), number of flowers per plant (8.00), flower diameter (38.34 mm), and flower fresh weight (0.94 g) were observed in plants pinched at 3 bud stages. It is concluded that phosphorus at the rate of 2% and pinching at the 3-bud stage could be recommended for better growth and flower production of French marigold (Tagetes patula) in a shed house during autumn/winter in Peshawar conditions.

Key Words: French marigold; Tagetes patula; phosphorus nutrition; pinching stages; protected horticulture, shade house cultivation, off-season flowering

Introduction

Floriculture is the fast growing sector of Horticulture with more than 120 countries dealing in this sector worldwide (Ahmad and Rab, 2020). Marigold is one of the popular ornamental annuals. Marigold (Tagetes spp L.), a member of family Asteraceae. It is an important annual flower crop

native to Central America. The two most frequent species of marigold are African marigold and French marigold. The most famous are African marigold and French marigold, botanically known as Tagetes erecta and Tagetes patula respectively. It is a native of Central and South America, especially Mexico. It is grown as an ornamental crop, a potted plant, and as part of landscape garden. French marigolds are used as cut or loose flowers, as well as potted plants (Murali et al., 2019).

Marigold, a hardy annual herb native to Southern Europe, thrives in temperate climates worldwide. The marigold can reach a height of 50-80 cm and have mid-green, lanceolate leaves ranging in length from 5 to 17 cm. The leaves and stems are covered with tiny hairs. The leaf's margins may have wavy or scant teeth. The plant, which may reach heights of one to five feet, is widely grown in tropical regions such as Asia, India, and China (Singh et al., 2020).

They have a compact, dwarf (35 to 40 cm), and bushy growth habit. This is popular among growers due to its vast range of attractive colors, shapes, sizes, and good keeping quality. The flowers are small, single or double, and borne on stems that are similarly long. They can be deep scarlet, rusty red, primrose, yellow, golden yellow, orange, or a combination of other colors (Pratibha et al., 2018). The leaves are dark green and pinnate-shaped and have a taproot. The leaf blade length is less than 2 inches. The leaves are curved, with sharp teeth on the edge. The flowers are tubular, single, or clustered in panicles, with a diameter of 7 to 10 cm. They come in a variety of colors, including white, yellow, orange, golden yellow, golden orange, cadmium orange, deep orange, and bright orange (Shetty et al., 2015).

Marigolds require a mild climate (14.5 ºC - 28.6 °C) for optimal development and flowering, while higher temperatures can impact flower production. This plant can be located in a place that is exposed to full sun and some leaves must be pruned to induce the flower (Zahara et al., 2024). Marigold has been adapted to different types of soil conditions and is growing successfully in different types of soil. However, the ideal soil for marigold growth is deep, fertile, sandy loam, friable, well-drained, and almost neutral in reaction (pH 7.0–7.5). It should also have a strong water-holding capacity (Ahmed et al., 2017).

French marigold is primarily propagated by seed, though cuttings may also be used. The crop can be grown in three seasons: rainy (June–July), winter (August–September), and summer (January–February). Optimum spacing for French marigold ranges from 20 × 20 cm to 20 × 15 cm for proper plant establishment and growth (Singh et al., 2020).

The shading effect of crops resulted in various changes on both crop microclimate and crop activity. Presently, progressive farmers are adopting commercial protected cultivation of high value vegetables and flowers. Shade nets are used to improve the thermal temperature and protect a variety of horticultural crops from abiotic variables such as excessive wind speed, searing insolation, and damage from birds and rodents. Shade netting clearly reduces light intensity compared to normal field conditions, and the capacity to alter different spectral aspects that alter light quality has a significant effect on plant development and growth (Lenka., 2020).

The process of pinching involves removing a few leaves and the apical bud. It might be due to the fact that by removal of the apical portion more energy might have been to promote the number of side branches. The amount of side branches directly correlates with flower output in marigold. Pinching delays the flowering but increases the number of flowers. Pinching is mostly used to promote branching for bushy growth, increase flower and seed yield, and/or promote branching. To pinch, use your thumb and forefinger to remove the top growth of plants (Abbas et al., 2025).

Proper fertilizer combination promotes strong plants with more shoots and leaves, leading to better flower result and a longer flowering period. Optimal cultural techniques are essential for producing outstanding flowers. These nutrients promote vegetative growth and help plants open flowers during the flowering season. In gladiolus and marigold, phosphorus promotes early, uniform, and abundant flowering by supporting energy transfer and reproductive development,

while calcium enhances stem strength, floret integrity, and postharvest longevity, together improving overall flower quality and marketability (Polara et al., 2015; Ahmad and Rab, 2019). Among essential nutrients, phosphorus is most important for plant growth and flowering. They contribute significantly to increased flower and seed yield in ornamentals. Flowering can be increased with increased levels of P application. Along with the effect of fertilizer dose on yield and quality of marigold flower, the adoption of suitable high yielding varieties also plays an important role to maximize flower yield per unit area (Polara et al., 2015).

Considering the demonstrated role of phosphorus in enhancing vegetative growth and flower production French Marigold (Tagetes patula L.), a research was designed with the following objectives:

- To find the effect of phosphorus levels on the growth and production of French marigold.
- To evaluate the effect of pinching stages on the growth and production of French marigold.
- To study the interaction between phosphorus levels and pinching stages on the growth and production of French marigold

Materials and Methods

Experimental Site and Design

The study was conducted at Ornamental Horticulture Nursery, The University of Agriculture Peshawar from during off-season October 2024 to January 2025. Peshawar, Pakistan. A randomized complete block design (RCBD) with a split-plot arrangement was employed, replicated three times. The experiment evaluated two factors:

- Factor A: phosphorus application (main- plot) i.e. 0, 1%, 2% Levels.
- Factor B: Pinching (Sub-plot), Control, Single bud, 2 buds, 3 buds Stages.

Data Collection

- **Growth Parameters:** Plant height (cm), number of branches plant^{-1}, stem diameter (mm), number of leaves plant^{-1}, leaf fresh weight (g).
- **Physiological Parameter:** Leaf chlorophyll content (SPAD value).
- **Floral Parameters:** Days to flowering (from sowing), number of flowers plant^{-1}, flower diameter (mm), flower fresh weight (g).

Statistical Analysis:

Data were analyzed using STATISTIX 8.1 with two-way ANOVA for RCBD split-plot design. Treatment means were separated using LSD test at $p \leq 0.05$ or 0.01 (Khan et al., 2025).

Result

Figure 1 shows the data regarding plant height (cm), number of branches per plant, stem diameter (mm), number leaves per plant, leaf fresh weight(g), leaf chlorophyll content (SPAD), as effected by different doses of phosphorus and various stages of pinching. The statistical analysis revealed that different phosphorous levels and pinching stages had a significant effect on all observed parameters of marigold, including plant height. Maximum height (21.72 cm) was noted with phosphorus application at 2%, while the minimum plant height (20.32 cm) was recorded with no application of phosphorus (control). In case of pinching, un-pinched plants achieved the maximum height of (22.88 cm), pinched at the two-bud stage while minimum height (19.99 cm) that was statistically similar to the plants pinched at single and 3 bud stages (Figure 1 (A). The highest number of branches per plant (8.25) was observed in plants treated with phosphorus at a rate of 2%. In contrast, the lowest number of branches per plant (4.50) was recorded in control plants. The data (Figure 1 (B)) indicated that pinching plants at the three-bud stage produced the highest average number of branches per plant (8.22). While un-pinched plants yielded the least branches per plant (3.88). Figure 1(C) show the maximum stem diameter of (2.58 mm) was observed in

plants treated with a phosphorus application rate of 2%, whereas the minimum stem diameter of (1.79 mm) was recorded in control plants. Statistical analysis (4.3a) demonstrated that pinching at different growth stages significantly influenced stem diameter. The maximum stem diameter of (2.34 mm) was recorded in plants pinched at the three-bud stage, while the minimum stem diameter of (1.97 mm) was observed in un-pinched plants. The more number of leaves per plant (33.83) was observed in plants treated with a phosphorus application rate of 2%, whereas the minimum number of leaves (31.58) was noted in control plants. Statistical analysis (4.4a) demonstrated that pinching at different growth stages significantly influenced number of leaves per plant. The maximum number of leaves per plant (39.55) was recorded in plants pinched at the three-bud stage, while the minimum number of leaves per plant (24.00) was observed in unpinched plants (Figure 1 (D). The optimum leaf fresh weight (0.24g) were weight in plants treated with a phosphorous application rate of 2%. While minimum leaf fresh weight (0.12g) were recorded in control plants. The maximum leaf fresh weight (0.19g) was recorded in plants pinched at 3 bud stage which are statistically similar to plants pinched at single bud stage. While, the minimum leaf fresh weight (0.13g) was observed in unpinched plant which is statistically similar to plants pinched at two bud (Figure 1 (E)). The heights leaf chlorophyll content (29.91) were recorded in plants treated with a phosphorous application rate of 2%. While minimum leaf chlorophyll content (23.18) were recorded in control plants. The maximum leaf chlorophyll content (27.52) was recorded in plants pinched at 2 and 3 bud stage. While, the minimum leaf chlorophyll content (24.97) was observed in unpinched plant shown in Figure 1 (F).

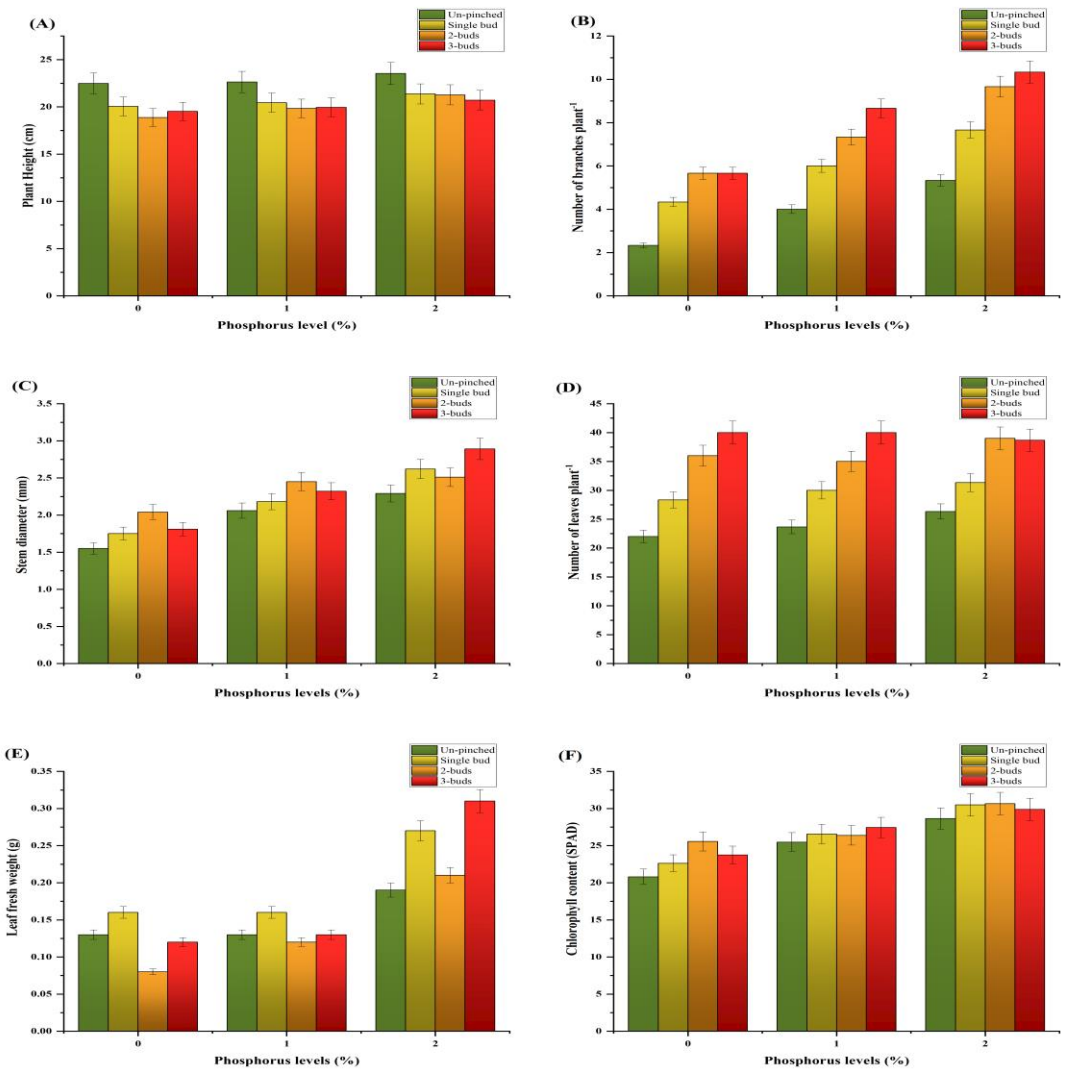

Fig 1. Plant height(cm), number of branches per plant, stem diameter(mm), number leaves per plant, leaf fresh weight(g), leaf chlorophyll content (SPAD), as effected by different doses of phosphorus and various stages of pinching

Figure 2 show the data regarding, days to flowering, flowers per plant, flower diameter (mm) and flower fresh weight (g), as effected by different doses of phosphorus and various stages of pinching. The statistical analysis revealed that different phosphorous levels and pinching stages had a significant effect on all observed parameters of marigold (Figure 2 A). The most days to flowering (67.25) were recorded in plants treated with a phosphorous application rate of 2%. While minimum days to flowering (60.16 days) were recorded in control plants. The maximum days to flowering (69.77 days) was recorded in plants pinched at 3 bud stage. While, the minimum days to flowering (50.11 days) was observed in unpinched plant. The heights number of flowers per plant (6.00) were recorded in plants treated with a phosphorous application rate of 2%. While minimum number of flowers per plant (4.58) were recorded in control plants. The maximum number of flowers per plant (8.00) was recorded in plants pinched at 3 bud stage. While, the minimum number of flowers per plant (3.22) was observed in unpinched plant (Figure 2 (B)). French marigold plants gained maximum flower diameter (38.62mm) with phosphorus application at 2%, while the minimum flower diameter (34.94mm) was recorded with no

application of phosphorus (control). In case of pinching plants pinched at single bud stage achieved the maximum flower diameter (38.34mm), while plant pinched at 3 bud stage exhibited minimum flower diameter (34.02mm) Figure 2 (C). French marigold plants gained maximum fresh flower weight (1.04g) with phosphorus application at 2%, while the minimum fresh flower weight (0.60g) was recorded with no application of phosphorus (control). In case of pinching plants pinched at 3 bud stage achieved the maximum fresh flower weight (0.94g), while unpinched plant exhibited minimum flower diameter (0.65g) Figure 2 (D).

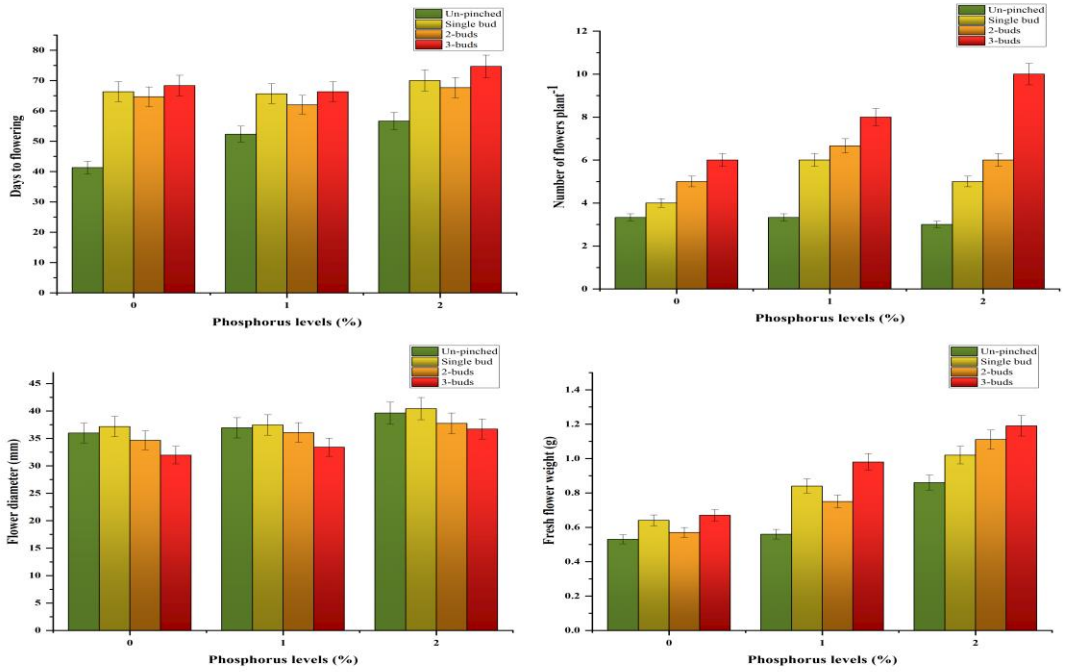

Fig 2. Days to flowering, flowers per plant, flower diameter(mm) and flower fresh weight(g), as effected by different doses of phosphorus and various stages of pinching.

Dicussion

The current experiment showed that the use of phosphorus levels and pinching played major roles in the growth and flowering production of Marigold. Such findings are in line with previously reported outcomes that show that pinching and phosphorus levels are good sessions that improve vegetative and reproductive characters of almost all crops and ornamentals. Phosphorus has important role in transfer of energy and development of roots that might influence the elongation of roots indirectly. That might be the reason that phosphorus resulted in increase in plant height (Rashid et al., 2022). The energy level of an organic compound is increased through the formation of a phosphate ester hence phosphorus enhanced stem diameter of French marigold (Yaseen et al., 2016). This may be attributed to phosphorus being an essential component of cellular structures, such as photo proteins and phospholipids, which are vital constituents of cell membranes. These compounds play a crucial role in maintaining cell integrity and promoting cell division, ultimately enhancing vegetative growth traits including stem diameter (Kendra, 2013). Phosphorus in the protoplasm increases the amount of chlorophyll, which may be the reason for the increase in the number of leaves per plant. (Rahimi et al., 2016). Better vegetative growth results from this, which in turn encourages the conversion of photosynthetic into phospholipids (Rizwan and Ahmad, 2021). By fueling zinc-dependent enzymes, phosphorus promotes energy-demanding processes that enhance flowering quality, spike strength, and reproductive success in gladiolus and marigold

(Ahmad et al., 2020). A sufficient amount of phosphorus is necessary for photosynthetic synthesis and accumulation, which raises biomass production, including leaf fresh weight. Increased phosphorus nutrition in marigold has been linked to rapid growth and increased leaf fresh weight because of improved nutrient absorption and translocation (Khan et al., 2014).

Pinching caused interference in plant architecture by deactivating apical dominance by the removal of the shoot apex, and lateral shoot growth was encouraged. This method shortened the height of the plant but multiplied the number of side branches, which helps to have more flowering places and a more extensive canopy (Abbas et al.,2025). In case of pinching at various stages, significant variation in stem diameter were observed where pinching resulted in more stem diameter as compared to control plants. The accumulation of photosynthesis and extra branches may be the cause of the increase in leaves, which would result in improved growth characteristics. It could be because additional branches entered the vegetative phase and took a long time to become physiologically mature enough to produce flowers (Khan et al., 2025). Pinching had a major impact on the amount of chlorophyll content. In leaf tissues, pinching increases the amount of chlorophyll, which improves photosynthetic translocation from source to sink. Due to their huge photosynthetic area and abundance of leaves, pinched plants have a higher photosynthetic rate and perform better (Halagi et al., 2023). Similar results were also observed by Sharma et al. (2016), that pinched plants produced more flower as compared to non-pinched plants in marigold, as result of cytokinin being stimulated by pinching, the lateral buds begin to expand, increasing the number of blooms.

Conclusions

The study demonstrated that both phosphorus application and pinching significantly influence the growth and flowering performance of marigold under protected horticulture conditions. Among the treatments, phosphorus at 2% consistently enhanced vegetative growth, leaf health, and flowering attributes, including plant height, branching, stem diameter, leaf number and weight, chlorophyll content, flower number, diameter, and fresh weight. Pinching at the 3-bud stage further optimized plant architecture and flower production.

Recommedation

For improved marigold productivity and quality under shed house conditions, it is recommended to apply phosphorus at 2% and perform pinching at the 3-bud stage to maximize growth, flowering, and overall yield.

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