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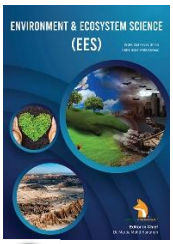

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RESEARCH ARTICLE

IMPACT OF PINCHING ON GROWTH AND YIELD OF MARIGOLD (*Tagetes erecta L.*)

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ABSTRACT

Marigold, a member of the Asteraceae family, is a popular ornamental plant grown throughout the world, including Nepal. The color and size of the flowers on marigold plants vary. Marigold plants can reach a height of 5 feet, but pinching procedures can lower this, allowing the intercultural operation to continue. *Tagetes erecta L.* is one of the most well-known marigold varieties in Nepal. Pinching is a technique for breaking apical dominance and redirecting energy to increase blossom production. Different experiments including treatments like no pinch, single pinch, and double pinches were reviewed to evaluate the effect of pinching on the growth and yield of marigolds. The effect of pinching on marigold growth and yield was investigated by comparing parameters such as plant height, number of branches per plant, number of flowers per plant, and flower size of pinched and unpinched (healthy) plants. The height of the unpinched plant was found to be 25% higher than that of the pinched. When plants are pinched, their apical dominance is broken, which encourages the plant to generate lateral branches and become bushy Because the majority of the nutrition is dislocated from the apical region of the plant when it is pinched; no pinched plants have fewer branches than pinched plants. Pinching stimulates cell division, cell size, leaf area, and photosynthetic compound production, which affects branch formation and, as a result, flower production. According to the results from various trials, double pinching resulted in the highest increase in plant height, number of branches, number of flowers per plant, and bloom size when compared to no pinching.

KEYWORDS

branches, flowers, growth, marigold, pinching

1. INTRODUCTION

Marigold species are gorgeous ornamental plants that are grown for aesthetic, medicinal, and loose flower purposes, and serve as a better cut flower option when major cut flowers are unavailable. Marigold is a member of the Asteraceae family and is known in Nepal as *Sayapatri.* Marigold flowers are being commercially grown in 32 districts across Nepal on 157 hectares of land. Marigold flowers are produced in large quantities in districts like Chitwan, Makawanpur, and Sindhuli, Kathmandu, Bhaktapur, and Lalitpur (FAN, 2018). Marigolds come in a variety of kinds, but *Tagetes* spp. is the most widespread in the globe due to its superior quality (Singh et al., 2018). Marigold is an annual flowering plant that can reach a height of 5 feet when grown in typical, acceptable conditions. Marigold has a wide range of adaptations, making it easy to cultivate from hill to Terai. Marigolds have a unique color, and while most people love and grow yellow and orange kinds, other colors such as white, red, and variegated are now available. Marigolds can be cultivated at any time of year and in every season, but they flower and grow profusely when grown in sunny settings (Sheoran et al., 2022). Marigold plant that many uses, including the treatment of muscle pains, itching, ear difficulties, piles, eye disease, and blood purifiers (Poudel et al., 2017). Marigold production in Nepal is lower than in other industrialized countries, owing to a lack of quality seeds and manure in time (Meena et al., 2015). Oil extracted from marigold has an insecticidal property as well as it can be grown in fields as a trap crop against root nematodes (Pandey et al., 2021).

Pinching is a technique that involves practices that helps to break apical dominance. Pinching in plants like Marigold is important to improve both quantitative and qualitative properties (Patade et al., 2020). Pinching is a horticultural practice that diverts the flow of energy and nutrients from a single stem system to a multi stem system. More the number of side branches, more the plant gains a bushy appearance as a result, time and money lost in intercultural operations will be reduced thus supporting greater benefit from less investment (B.C. et al., 2020). Pinching can be done manually with a normal hand or with the help of a sharp cutter. Collect the plant with a forefinger and pinch the top portion of the stem with the thumb and first two fingers. Pinching affects a variety of physiological processes in the plant, including vegetative growth arrest and increased deposition of a photosynthetic chemical, resulting in an increase in yield (Sahu and Biswal, 2020). Plant height and leaf area were reduced by the quality of pinching, but plant dry matter and flower count were raised (Santi et al., 2021). For small-scale farming, lodging is not a big issue, but when plants are cultivated on a large scale, lodging causes significant losses. Thus, pinching helps to overcome such a problem as a result stalking cost is reduced (Abbas, 2018). The energy is diverted downwards by pinching the tip allowing for more branch creation these number of branches is directly connected to the number of flowers produced (Prakash et al., 2016). Pinching creates an environment for better use of the hormones in the plant that finally supports in overall growth and development of the plant and increases growth and yield parameter (El-Shayeb et al., 2021).

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Even though marigold is the highest-grossing flower, there is very little research on it in Nepal. It is no surprise that marigold productivity in Nepal is lower than in other nations like Mexico and India. In fact, there are no commercially available Marigold cultivars in Nepal,but few occassionaly grown cultivars are MSGY, MSNY7, Calcuttia orange, Marigold garland orange. Trend of growing hybrid seed is getting popular among the cities areas but most of the farmers still grow the native marigold germplasm, which has a low yield. The Khumaltar Horticulture Research Division has released a set of best practices for offseason marigold cultivation (FAN, 2018). However, effective cultivation procedures, such as planting distance, pinching, and the application of growth regulators, can enhance the economic output and quality of marigold flowers. Pinching is linked to a higher number of smaller flowers and a longer flowering period.

Marigold has high demand throughout the year especially during festivals. Nepalese flowers are unable to meet the demand. As a result, a large quantity of marigold flower garland, estimated to cost over Rs. 8.1 million was imported from India. To address these issues, a study has been carried on marigold to standardize pinching frequency, and their interaction impact to increase the availability of appropriate quality flower in Nepal. The objective of this study was to evaluate current marigold cultivation practices and investigate the impact of pinching on plant final growth and yield.

2. Materials and Methods

This review was conducted utilizing secondary data from various journals like Springers, Elsevier, MDPI, Google Scholar, Research Gate, and technical reports, all of which were shared with the authors. The review was divided into two key sections: causes and mitigation, with subtopics designed in between. Despite the vast number of articles found for each subtopic, few articles were found relevant. The data from those selected articles were used.

3. Results and Discussion

3.1 Impact of Pinching on Height of Plants

There are several reports on the effect of pinching on the height of marigold plants. Because of the apical dominance displayed by unpinched plants at maturity (75.49cm) compared to pinched plants (50.03cm), marigold plants grew to a greater height (75.49cm) if not pinched (Baskaran & Abirami, 2017). The height difference between unpinched and pinched stems was (52.50cm to 39.80cm) when the terminal section of the stem was removed. This was attributable to the collapse of apical dominancy (Sahu & Biswal, 2020). Plant height is reduced to 29.86 cm from double pinching compared to 41.85 cm when the plant is not pinched (Ahmade, 2019). Fifty (full form) DAT, the maximum height of a no-pinched marigold was 60.73 cm, whereas the maximum height of a pinched marigold was 51.15 cm (Rajput et al., 2020). The florists practice pinching on other species for the same reason of benefit. The height of a pinched ornamental pepper plant was found to be 25% lower than that of a non-pinched ornamental pepper plant (Mutlu and Agan, 2015) . Carnation plants that were double pinched grew to a height of 86.24 cm; single pinching grew to a height of 92.89 cm; but, when the plant was left unpinched, it grew to a height of 107.84 cm (Rai and Fatmi, 2020). When pinched 30 DAT, chrysanthemum plants grew to a height of 103.93 cm, while no-pinch plants grew to a height of 110.33 cm (Nagdeve et al., 2021). Chrysanthemum heights ranged from 60 cm (no pinching) to 45 cm (thrice pinching). The apical section of the plant was repeatedly removed, causing these oscillations (Ehsanullah et al., 2021). Along with pinching, paclobutrazol at 30 and 45 ppm was found to be responsible for drastically lowering plant height (Santi et al., 2021). Without pinching, Gomphrena (botanical name) plants reach a height of 73.53 cm (Sendhil Nathan et al., 2019). This might be due to the auxin accumulation at the tip portion. The pinched Aster plant grew to a height of 81.85 cm, whereas the unpinched Aster grew to a height of 86.83 cm. This fluctuation in height was caused by a combination of pinching and plantation spacing (Khobragade et al., 2012). Plants that were not pinched grew taller. It is possible that the maximum height of an unpinched plant is related to the limited transfer of nutrients to the lateral branches, which supports continued vegetative growth and auxin production for greater height. When the tips of plants are pinched, the auxin produced in the top region is dispersed to the bottom portion, resulting in a reduction in plant height and a bushier appearance. Similar results were found by (Sahu and Biswal, 2020; Rajput et al., 2020). Repeated pinching develops multiple side branches, which diminishes plant height, according to the data in table 1 reported by (Meena et al., 2015). IAA is important for elongating the plant's height upwards, but when the apical meristem is disrupted, the growth of side branches is accelerated (Biswas et al., 2019). When the terminal bud was removed from the plants during the pinching process, the plants became stressed, and the plants required time to recover from this situation, causing growth to be impeded. Pinching momentarily decreases auxin, removing apical dominance (Uddin et al., 2015).

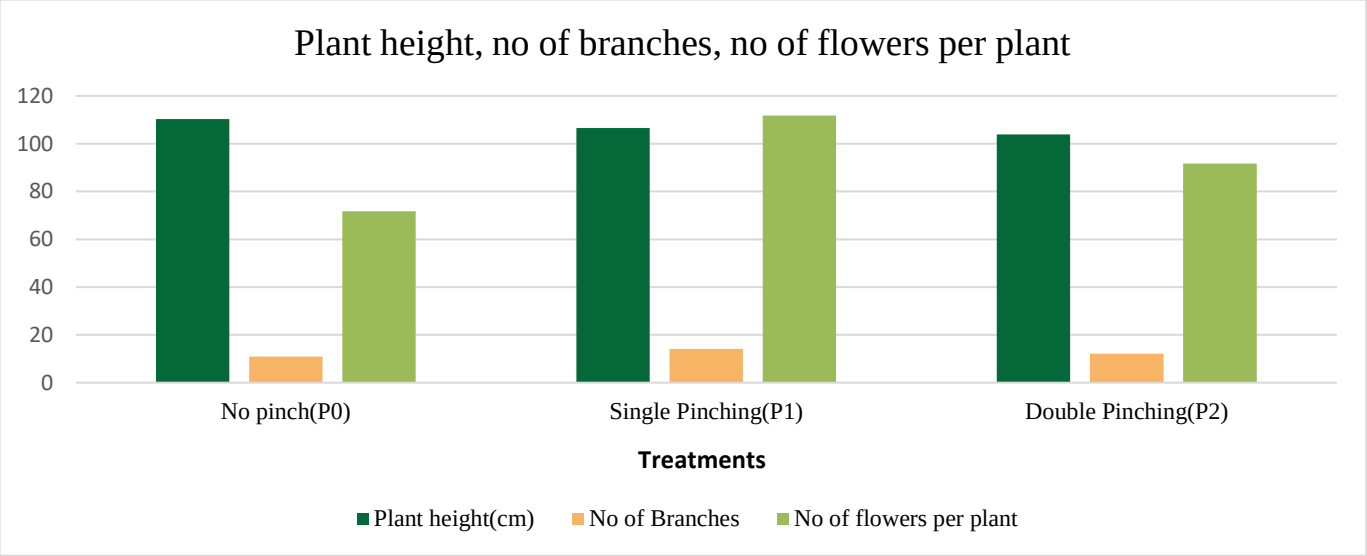

Figure 1: Effect of Pinching in plant height, no of branches per plant, and no of flower per plant on annual chrysanthemum (Source: Nagdeve et al., 2021)

Double pinched chrysanthemum plant gained a height of 103.93 cm whereas no pinched gained a height of 110.33 cm (Figure 1). Similarly, number of branches and number of flowers were more in pinched than no pinched plants. Plants with double nipping grew to a minimum height of 85.73 cm and yielded 233.02 g/plant (Mane et al., 2021).

3.2 Impact of Pinching on Branches Per Plant

When marigold plants were doubly pinched 50 DAT, the number of branches increased significantly (21.50) when compared to no pinching (Poudel et al., 2017). Marigold plants that have been pinched at 60 DAT develop a higher number of branches per plant (22.99), compared to plants that have not been pinched, which produce 12.98 branches (Meena et al., 2015). Plants that were pinched at 1-foot height produced more branches (12.41) than those that were not pinched (Naafe, 2022). When chrysanthemum plants were pinched at 30 DAT, the pinched plants developed 20.73 branches compared to 15.46 in the unpinched plants (Salve et al., 2016). Single pinching at 20 DAT resulted in the greatest number of main branches (4.69), secondarybranches (23.74), plant spread (27.62 cm), leaf area (23.86 cm2), and stem diameter at 90 DAT (1.50 cm), all of which were significantly higher than the other treatments. This was followed by a 30-day single pinching therapy (Gaidhani et al., 2020). Plants that were pinched at the 3rd node stage had more lateral branches per plant (3.55) than those that were pinched at the 2nd node stage (3.49), while plants that were not pinched had the lowest lateral branches (2.01).

The cytokinin is stimulated when the apical bud is removed, which encourages lateral branching (Naafe, 2022).

Plants pinched 50 DAT produce a large number of branches, which could be related to enhanced cell division, cell size, leaf area, and photosynthetic activity. These results were the findings of (Poudel et al., 2017). Plants planted at a closer spacing produce a smaller number of branches this is due to greater competition for light and other nutrients (Kumar and Singh, 2011). A reported that plants utilized the produced photosynthetic compound as a result there occurs more lateral growth in the form of side branches (Biswas et al., 2019). More the number of lateral branches there arises a relation between source and sink. Because apical dominance is broken by pinching, auxiliary buds are formed in greater numbers, resulting in an increase in the number of branches (Ullah et al., 2019). By removing the terminal buds, auxin concentration is reduced, which inhibits upward plant growth, and lateral buds begin to sprout, resulting in an increase in the number of branches per plant, i.e., 6 branches per plant (Ali et al., 2021).

Table 1: Effect of pinching on height, number of branches, and number of flowers per plant in marigold.

Treatments	Plant Height in cm	Number of branches per plant	Number of flowers per plant
P1	52.97	12.98	28.90
P2	48.00	19.28	31.97
P3	47.11	22.99	34.91
SEM	0.39	0.17	0.27
CD (0.05)	1.11	0.50	0.77

Note: P1= no pinching, P2=Pinching at 30 DAT, P3=Pinching at 60DAT (Source: Meena et al., 2015)

Double pinched marigold plant gained a height of 47.11 with 22.99 number of branches and 34.92 flowers in the same experiment it was found no pinching plant gained a height of 52.97 cm with 12.98 branches and 28.90 numbers of flowers. Pinching causes plants to lose their apical dominance as a result energy will be diverted to increase cell division and cell size in the pinched portion of plant, resulting in the development of additional branches (Ullah et al., 2019).

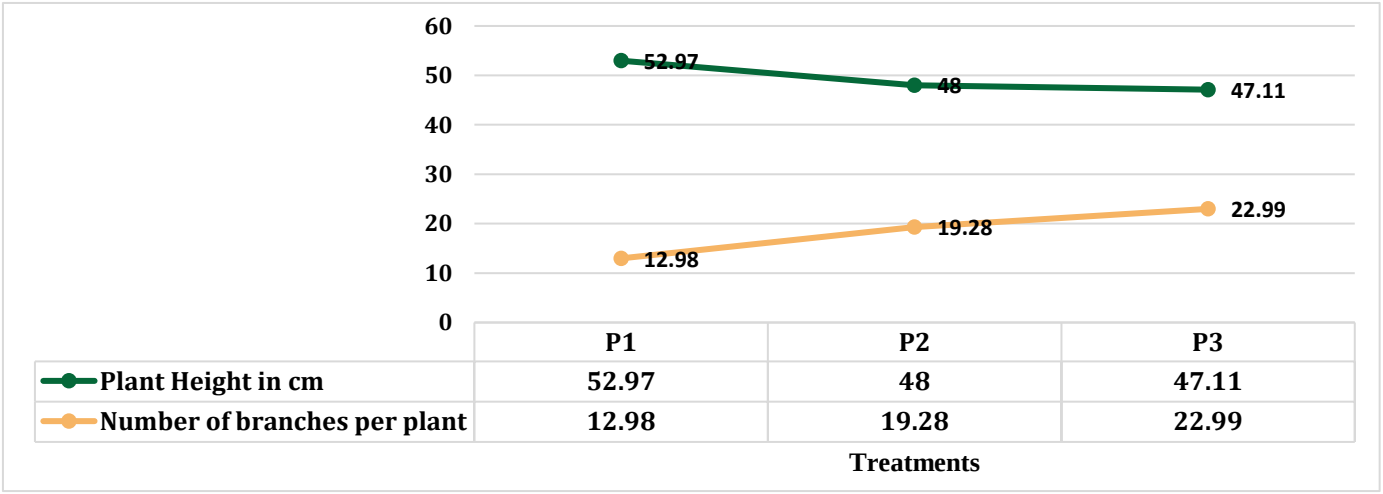

Figure 1: Effect of pinching on the number of branches and plant height

Note: P1= no pinching, P2=Pinching at 30 DAT, P3=Pinching at 60DAT (Source: Meena et al., 2015)

3.3 Impact of Pinching on Floral Size and Production

The interaction of plants with the surrounding environment plays a dramatic role in influencing the size of the flower. Pinching reduced the flower's size since more branches require more nutrients. Pinching increases floral diameter: a pinched flower has a diameter of 4.58 cm, but an unpinched blossom has a diameter of 3.45 cm (Ehsanullah et al., 2021). Sunflower plants that were allowed to blossom without being pinched produced larger flowers, whereas pinched plants produced small but many flowers (Cheema, 2018).

Pinching at 60 DAT results in a higher number of flowers (31.97) due to increased number of branches seen as a result of previous pinching (Meena et al., 2015). Along with pinching, the planting season has a positive effect on flower output, as (37.27) blooms were obtained when planted on October 15 rather than November 15 (Meena et al., 2015). Because of the distribution of auxin in the plant stem to develop more side branches in contrast to bud creation in a single stem, flower occurrence is delayed in the event of pinched ones (Sheoran et al., 2022). In the case of the pinched plant, flower output increased by three times as compared to the unpinched plant (Baskaran & Abirami, 2017). Pinching 2 (Full form) WAT revealed 51.71 blooms, as well as a long blossom stalk (Sheoran et al., 2022). At 20 DAT, chrysanthemum plants that were pinched produced the most blooms (111.74), whereas those that were not pinched produced 71.67 blossoms (Nagdeve et al., 2021). (Salve *et al.,* 2016) found that when chrysanthemum plants were pinched, they produced 112.85 flowers per plant, while unpinched plants produced 92.33 flowers per plant. Pinched Zinnia plants produce 16.11 blooms per plant, while unpinched plants produce 11.77 blooms per plant (Ullah et al., 2019). Calendula plants when pinched yield 14.2 flowers per plant which in turn increases the yield of the plant (Kumar and Singh, 2011). Pinching distributes the energy to develop different side growth. Since more the number of side branches more will be the floral buds which intimately increases flower size and production.

3.4 Impact of Pinching on Floral Size

Pinching produces more vegetative growth in the form of side branches, and these side branches produce higher flowers in upcoming days (Nagdeve et al., 2021). The said that plant grown in November produces a greater number of flowers per plant (Mohanty et al.,2015). Marigold plants when double pinched produce a more number of flowers per plant, greater size flowers and this flower remain for a longer period (Baskaran and Abirami, 2017). Pinching diverts the energy from the vegetative part to the floral parts which in turn increases flower yield (Dali et al., 2019; Salve et al., 2016). The maximum flower diameter in the China aster was measured in the absence of pinching. This could be due to the developing side branches sharing energy during pinching treatment (Gaidhani et al., 2020). With spacing and pinching, the maximum number of blooms per plant was 67.14. The number of flowers may be connected to vegetative development characteristics such as the number of branches and stem diameter. As a result, the plant's organic reserves were higher, allowing for enhanced floral development and, as a result, an increase in the number of flowers (Nagdeve et al., 2021). The increased number of flowers per plant (31.80) in African marigolds could be attributed to the production of a large number of laterals at an early stage of growth, which had enough time to accumulate carbohydrate for proper flower bud differentiation due to increased reproductive efficiency and

photosynthesis restriction. These were the findings of (Kalaimani et al., 2017). Pinching at 30 days after transplanting in Gaillardia revealed the maximum diameter of fully blown flower (7.76cm). In the absence of pinching, the minimum diameter of a fully opened flower was 6.11 cm. The increase in bloom diameter could be attributed to single pinching at an earlier stage, which causes robust branching and hence favors the development of larger flowers (Moon et al., 2017). According to pinching increased the number of flowers per plant by breaking apical dominance, which accelerated branching and shifted plant metabolites from vertical to horizontal growth, resulting in a substantial improvement in yield-contributing characteristics and hence more flowers per plant (Yaseen et al., 2020).

Table 2: Effect of pinching on flower number and flower diameter in marigold

Treatments	Number of Flowers Per Plant	Flower Diameter (Cm)
Control	6.44b	3.45b
Pinched	9.93a	4.58a
LSD<=0.05	0.95	0.57

Note: Source (Ehsanullah et al., 2021)

Marigold species are gorgeous ornamental plants that are grown for aesthetic, medicinal, and loose flower purposes. They are popular over the world. Marigolds can be cultivated at any time of year and in every season in Nepal, but they flower and grow profusely when grown in sunny settings. Plants that were not pinched grow tall. It's possible that the maximum height of not pinched plant is related to the limited transfer of nutrients to the lateral branches, which supports continued vegetative growth and auxin production for greater height. When the tips of plants are pinched, the auxin produced in the top region is dispersed to the bottom portion, resulting in a reduction in plant height and a bushier appearance. Plants pinched at 50 DAT produce a large number of branches, which could be related to enhanced cell division, cell size, leaf area, and photosynthetic activity. Pinching at 60 DAT results in a higher number of flowers due to increased number of branches. Along with pinching, the planting season also has a positive effect on flower output.

From the discussion above, we may extrapolate that pinching significantly improves bloom production, as well as branching per plant, blossom size, and flower diameter. The use of pinching in conjunction with optimum spacing, planting season, and variety is advantageous to flower-growing farmers, allowing them to increase their output also benefiting large economic returns. Marigolds that have been pinched produce more flowers from the same unit than those that have not been pinched.

Conflict of Interest

The authors declare that there is no conflict of interest for the publication of the manuscript.

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