

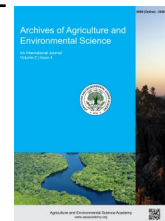


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ORIGINAL RESEARCH ARTICLE



Efficacy of different nitrogen doses and pinching nodes on performance of African marigold (*Tagetes erecta* L. cv. Karma-555)

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ABSTRACT

Marigold cultivation holds substantial religious value and commercial potential worldwide; however, suboptimal nitrogen management and improper pinching practices often limit flower yield and quality. This study aimed to identify the optimal nitrogen dose and pinching node for improved growth and yield of marigold. The experiment was conducted at the Institute of Agriculture and Animal Science, Tribhuvan University, Lamjung Campus, Nepal, using a two-factorial Randomized Complete Block Design with three replications. Treatments included three nitrogen levels (150, 200, and 250 kg ha⁻¹) and three pinching regimes (no pinching, pinching at the 2nd node, and pinching at the 4th node). The interaction of 200 kg N ha⁻¹ with pinching at the 2nd node produced the highest number of primary branches (16.67). The maximum number of flowers per plant (58.08) was recorded at 200 kg N ha⁻¹, while pinching at the 2nd node resulted in the highest flower count (65.15). Flower weight was not significantly influenced by pinching treatments. A positive correlation was observed between the number of primary branches and flower number per plant. The findings indicate that the combined application of 200 kg N ha⁻¹ and pinching at the 2nd node enhances lateral branching and maximizes flower yield. This integrated practice can be recommended as an efficient practical approach for improving both productivity and quality in marigold cultivation under similar agro-ecological conditions.

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INTRODUCTION

The floriculture sector has witnessed rapid expansion in recent years, driven by increasing demand for ornamental plants in landscaping, cultural practices, natural pigments, and medicinal applications (Baskaran & Abirami, 2017; Ruamrungsri *et al.*, 2021). Among ornamental crops, African marigold (*Tagetes erecta* L.) is considered one of the most commercially important species due to its prolific flowering, vibrant yellow–orange inflorescences, and wide adaptability across diverse agro-climatic conditions (Patel *et al.*, 2020). In Nepal, marigold—locally known as ‘Sayapatri’—holds substantial socio-cultural and economic significance, particularly during the Tihar festival, where demand for flowers rises sharply, encouraging seasonal commer-

cialization (Rathore *et al.*, 2011; Adhikari *et al.*, 2020). Beyond its ornamental value, marigold is widely utilized in essential oil extraction, natural dye production, integrated pest management, and pharmaceutical applications due to its bioactive compounds with cytotoxic and anti-inflammatory properties (Pandey *et al.*, 2021b). Despite its importance, the productivity and quality of marigold are often constrained by inefficient agronomic practices, particularly improper nutrient management and inadequate canopy regulation (Adhikari *et al.*, 2020; Afsaneh *et al.*, 2022). Nitrogen, a primary macronutrient, plays a pivotal role in chlorophyll synthesis, amino acid formation, and overall plant metabolism, thereby directly influencing vegetative growth and flowering (Rani *et al.*, 2018). Adequate nitrogen supply enhances photosynthetic pigments, floral biomass, and essential oil

content, whereas deficiency reduces flower size and number, and excess application may lead to delayed flowering, excessive vegetative growth, and reduced quality (Patel et al., 2020; Ze-wide et al., 2012; Ruamrungsri et al., 2021). Therefore, optimizing nitrogen levels is essential for achieving a balance between vegetative and reproductive growth (Afsaneh et al., 2022). In addition to nutrient management, canopy manipulation through pinching is a crucial horticultural practice that influences plant architecture and yield (Chauhan et al., 2016; Nain et al., 2017). Pinching removes the apical meristem, suppresses apical dominance, and promotes lateral branching, thereby increasing the number of potential flowering sites (Napoli et al., 1998; Nain et al., 2017). Previous studies have reported that appropriate pinching enhances branching, improves flower size, and increases yield in marigold (Sasikumar et al., 2015; Singh et al., 2015; Shah et al., 2018; Sheoran et al., 2022). At the physiological level, pinching alters hormonal regulation, including jasmonic acid signaling and ethylene-mediated pathways, which can delay or modify flowering responses (Guan et al., 2021; Chen et al., 2021). However, the effectiveness of pinching varies depending on genotype, environmental conditions, and its interaction with nutrient availability (Inaba et al., 2010; Cao et al., 2022). Although several studies have independently examined the effects of nitrogen fertilization and pinching, their interactive influence on growth and yield remains insufficiently explored, particularly under specific agro-ecological conditions and for newly introduced high-performing cultivars (Pandey et al., 2021a; Singh et al., 2017a, b). Existing recommendations are largely generalized and often derived from studies on other cultivars, limiting their applicability to cv. Karma-555, which is characterized by its dense growth habit and high flowering potential (Pandey et al., 2021a). This highlights a critical research gap in developing integrated nutrient and canopy management strategies for maximizing productivity and resource-use efficiency of African marigold (Souri et al., 2018; Rajput et al., 2020; Afsaneh et al., 2022). Addressing this gap, the present study evaluates the combined effects of different nitrogen doses and pinching nodes on the growth, flowering characteristics, and yield of African marigold cv. Karma-555 under mid-hill conditions of Nepal. The novelty of this research lies in its integrative approach to simultaneously optimize nitrogen management and pinching position for a specific high-yielding cultivar. The study aims to identify the most effective combination of nitrogen dose and pinching node to enhance branching, improve flower yield and quality, and provide a scientifically grounded recommendation for sustainable and profitable marigold cultivation.

MATERIALS AND METHODS

Location of experiment

The research was conducted at Sundarbazar-07, Lamjung district, Gandaki province, Nepal from July, 2024 to October 2024 and same date on 2025. This location was situated at 28° 07'32" North latitude, 84°24'45" East longitude with an elevation of 614 meters above sea level in the eastern region of

Gandaki province, Nepal.

Experimental design

The experiment laid out in a Randomized Complete Block Design. There were nine treatments. Each treatment replicated 3 times. Altogether, there were 27 plots. First factor was different doses of nitrogen (150 kg/ha, 200 kg/ha, 250 kg/ha) and second factor was (pinching node (control, 2nd node and 4th node). There were 12 plants in each plots maintaining 45×45 cm distance between two rows and two plants. The seedlings were planted in 4×3 cm rows and the area of one plot was 2.43 m² (i.e.1.8 m length and 1.35 m breadth). The distance between two replications was 50 cm and the distance between two plots was 22.5 cm.

Experimental material

Seedling trays, seedling preparation materials (cocopeat, vermicompost), Karma-555 varieties of African marigold, Farm Yard manures, NPK fertilizers, staking tools, plant protection materials.

Treatment details

Combination: Treatments pattern as N₁P₀:T₁, N₂P₀:T₂, N₃P₀:T₃, N₁P₁:T₄, N₂P₁:T₅, N₃P₁:T₆, N₁P₂:T₇, N₂P₂:T₈ and N₃P₂:T₉. Where, pinching, N₁: 150 kg nitrogen per hectare, N₂: 200 kg nitrogen per hectare, N₃: 250 kg nitrogen per hectare, P₀: Control, P₁:2nd node pinching, P₂: 4th node pinching.

Details of cultural operations

Nursery raising and aftercare

Karma-555 seeds, carefully selected for germination, were sown at a depth of 0.5 mm in a 1:1 mixture of cocopeat and vermicompost. The trays were covered with a moistened jute sack until germination, then placed in a warm, well-lit area with consistent moisture through light water spray. After 25 days, seedlings were ready for transplanting, ideally in a location with direct morning sunlight and filtered afternoon light.

Field preparation and fertilizer application

The experimental field was prepared one week before transplanting through deep plowing and leveling with a rotavator. Farmyard manure at a rate of 20 t/ha incorporated into the soil during the initial land preparation. For each treatment, half of the nitrogen and the full doses of phosphorus and potassium were applied before transplanting, following the Floriculture Association of Nepal's recommendation (i.e., 200:80:80 kg NPK per hectare) using urea, diammonium phosphate, and muriate of potash. Since nitrogen was used as a treatment variable, different doses of nitrogen (i.e., 150 kg/ha, 200 kg/ha, and 250 kg/ha) were applied. Treatment variables for nitrogen and pinching nodes were randomly assigned. Beds were elevated 15 cm above the ground for proper drainage and flood prevention. The nitrogen treatment was split, with half applied in two doses: ¼ at 30 days after planting and ¼ at 50 days after planting.

Transplanting of seedling

Twenty-five-day-old seedlings were transplanted into the raised beds of the experimental plot in the evening on August 15th. The transplantation process was carefully timed to minimize transplant shock and ensure the seedlings adjusted well to their new environment. Following transplantation, light irrigation was immediately applied to help the seedlings settle into the soil, maintain moisture levels, and support early root establishment.

Cultural operation

All essential inter-cultural practices, such as staking, weeding, hoeing, and earthing up, were carried out consistently throughout the growing season. Weeding was done to remove unwanted plants that competed for nutrients and water. Watering was applied as needed to maintain proper soil moisture, ensuring the plants stayed hydrated. Staking was used to support the plants and prevent them from bending or breaking as they grew. Earthing up was performed by piling soil around the base of the plants to improve stability and encourage better root development. All these tasks were done at the appropriate times to promote healthy plant growth.

Harvesting

The harvesting of marigold flowers was conducted when the blooms reached their full maturity, typically 60-70 days after transplanting. Flowers were carefully hand picked early in the morning to preserve their freshness and quality. This timing helped prevent wilting due to high daytime temperatures. Harvesting was done every 2-3 days to ensure that flowers were picked at their peak bloom, maximizing both yield and market value. Harvested flowers were then carried to lab for further data measurement (i.e. fresh weight of flower, dry weight of flower and pedicel length of flower, diameter of a flower). The harvested flowers were placed in baskets and handled with care.

Details of observations

Data were collected from five plants randomly selected from each plot, and observations were made on the following parameters. Plant height at 30 and 45 days after transplantation, Number of primary branches per plant, Number of flowers per plant, Fresh weight, dry weight of flower.

Statistical analysis

Data entry and management was done in Excel-2019 and analysis was done in R programming language version 4.3.2.

RESULTS AND DISCUSSION

Different nitrogen doses showed a significant effect in primary branches ($p < 0.05$) and number of flowers per plants ($p < 0.001$). The highest number of primary branches was recorded in 200 kg nitrogen/ha (10.23) followed by 250 kg nitrogen/ ha (9.66) and 150 kg nitrogen/ha (9.05). Similarly, the highest flower number

was recorded in 200 kg nitrogen/ha (58.08) followed by 250 kg nitrogen/ ha (53.26) and 150 kg nitrogen/ha (49.26) (Tables 1-3). Different nitrogen doses did not show any significant effect in plant height at 30 days and 45 days after transplanting, fresh weight and dry weight of flower. Pinching at different node showed a statistically significant result in different parameter. Primary branches, flower number, fresh weight of flower and dry weight of flower were statistically significant at $p < 0.001$. The plant height at 30 days was statistically significant at $p < 0.001$ and plant height at 45 days was statistically significant at $p < 0.05$. The maximum plant height at 30 days after transplanting was observed in control (no pinching) (49.07 cm) followed by 4th node pinching (39.37 cm) and 2nd node pinching (31.04 cm). Also, maximum plant height at 45 days after transplanting was observed in control (no pinching) (81.49 cm) followed by 4th node pinching (77.04 cm) and 2nd node pinching (73.60 cm). The interaction of different nitrogen doses and pinching nodes was found significant only for primary branches. Highest number of primary branches was observed in the combination of 200 kg nitrogen and pinching at 2nd node after transplanting. A positive correlation between number of primary branches and flower number per plant was observed as shown in figure 1.

In the present study, pinching second node after transplanting twenty-five days old sapling was found most effective in terms of adequate plant height, number of primary branches, number of flowers and its quality due to its optimal balance between vegetative growth and reproductive development. Also, early apical dominance removal with adequate vegetative growth, leading to maximum branching and flower production (Jadhav et al., 2017; Verma et al., 2015). It enhances both plant structure and yield compared to pinching at other nodes. Application of 200 kg nitrogen per hectare in marigold strikes the best balance between vegetative growth and reproductive performances without causing negative effects of over-fertilization like excessive vegetative growth and delayed flowering, lodging, nutrient toxicity or luxury consumption (Jadhav et al., 2017; Peralta-Sánchez et al., 2020, 2023). The negative effect of low dose of fertilizer result in weak growth, reduced branching, early senescence, and poor flower yield and quality due to insufficient nutrient supply for essential physiological functions (Ruamrungsri et al., 2021). The fresh and dry weights of flowers was found highest at second node pinched plant. This is due to better nutrient translocation, improved photosynthetic efficiency and partitioning and adequate source sink relationship. Second node pinched plant delayed apical growth and redirected nutrients toward developing flower buds. This concept is supported by Ahmed et al. (2017), who found that strategic pruning and nutrient management in marigold increased biomass allocation to reproductive organs, improving flower quality and longevity. A positive correlation between number of primary branches and flower number per plant was observed. Increased primary branches enhance axillary bud outgrowth, improving light capture and resource distribution, which can lead to greater plant spread and higher flower yield (Napoli et al., 1998).

Table 1. Effects nitrogen doses on the performance of African marigold (*Tagetes erecta* L. cv. Karma 555).

Treatments	Plant height at 30 days	Plant height at 45 days	Primary branches	Flower number	Fresh weight of flower (g)	Dry weight of flower (g)
150 kg/ha	40.72 ^a	76.44 ^a	9.05 ^b	49.26 ^c	11.59 ^a	6.39 ^a
200 kg/ha	41.93 ^a	76.91 ^a	10.23 ^a	58.08 ^a	11.80 ^a	6.55 ^a
250 kg/ha	42.84 ^a	78.78 ^a	9.66 ^{ab}	53.26 ^b	11.12 ^a	6.12 ^a
LSD (0.05)	3.12	6.17	0.81	3.24	1.03	0.75
SEM	1.04	2.06	0.27	1.08	0.35	0.25
F-test	ns	ns	*	***	ns	ns
CV%	7.47	7.98	8.49	6.06	9.03	11.86
Grand Mean	41.83	77.38	9.65	53.60	11.50	6.35

CV=Coefficient of variation, LSD=Least significant difference, SEM=Standard error of mean difference, ns= non-significant, Means with same letter in column are not significantly different at $p=0.05$, *Significant at 5% ($p<0.05$), **Significant at 1% ($p<0.01$), ***significant at ($p<0.001$).

Table 2. Effect of pinching nodes on the performance of African marigold (*Tagetes erecta* L. cv. Karma 555).

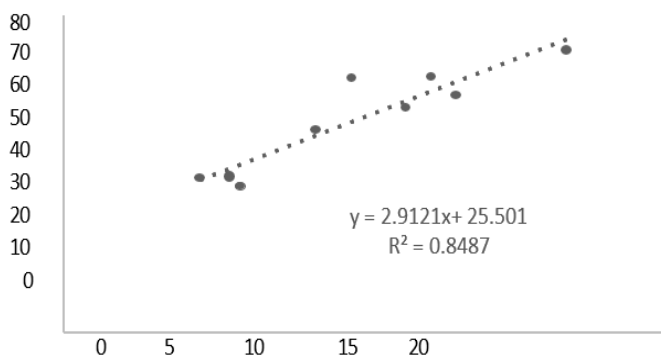
Treatments	Ph 30	Ph 45	Primary branches	Flower number	Fresh weight of flower (g)	Dry weight of flower (g)
Control	49.07 ^a	81.49 ^a	5.28 ^c	38.33 ^c	13.41 ^a	8.34 ^a
2 nd node	31.04 ^b	73.60 ^b	13.95 ^a	65.15 ^a	10.99 ^b	5.50 ^b
4 th node	39.37 ^b	77.04 ^{ab}	9.74 ^b	57.33 ^b	10.12 ^b	5.22 ^b
LSD	3.12	6.17	0.81	3.24	1.03	0.75
SEM	1.04	2.06	0.27	1.08	0.35	0.25
F-test	***	*	***	***	*	*
CV %	7.47	7.98	8.49	6.06	9.03	11.86
Grand Mean	41.84	77.38	9.65	53.60	11.50	6.35

Ph 30= Plant height at 30 days in cm, Ph 45= Plant height at 45 days in cm, CV=Coefficient of variation, LSD=Least significant difference, SEM=Standard error of mean difference, Means with same letter in column are not significantly different at $p=0.05$, *Significant at 5% ($p<0.05$), **Significant at 1% ($p<0.01$), ***significant at ($p<0.001$).

Table 3. Interaction effect of nitrogen doses and pinching nodes on the primary branches African marigold (*Tagetes erecta* L. cv. Karma 555).

Treatment Nitrogen doses (Kg/ha)	Pinching Nodes		
	Control	2 nd node	4 th node
150	5.84 ^e	13.00 ^b	8.33 ^d
200	4.50 ^e	16.67 ^a	9.53 ^d
250	5.50 ^e	12.17 ^{bc}	11.13 ^c
LSD	1.41		
SEM	0.47		
F-Value	***		
CV %	8.49		
Grand Mean	9.65		

CV=Coefficient of variation, LSD=Least significant difference, SEM=Standard error of mean difference, Means with same letter in column are not significantly different at $p=0.05$, *Significant at 5% ($p<0.05$), **Significant at 1% ($p<0.01$), ***significant at ($p<0.001$).

**Figure 1.** Correlation and regression between primary branches and flower number (Y axis= Flower number, X axis=Primary branches; X axis=Primary branches, Y axis= Flower number).

Conclusion

Eventually, the results obtained clearly indicate that the combined application of 200 kg nitrogen per hectare with pinching of second node after transplanting offers the most effective strategy for improving growth and flower yield in African mari-

gold cv. Karma-555. These results hold practical significance for commercial marigold cultivation farmers worldwide and can be applied to other floricultural crops with similar growth habits as African marigold. Future studies may investigate the effects of slow-release nitrogen sources or integrated nutrient management in combination with different pinching intervals and pinching intensities at different climatic zones across different marigold cultivars to enhance yield and quality attributes of marigold.

DECLARATIONS

Author contribution statement: Conceptualization: K.R. and A.S.; Methodology: K.R. and A.S.; Software and validation: K.R. and A.S.; Formal analysis and investigation: K.R., A.S. and M.R.; Resources: K.R.; Data curation: K.R.; Writing—original draft preparation: K.R. and A.S.; Writing—review and editing: K.R. and A.S.; Visualization: K.R.; Supervision: S.K.M.; Project administration: S.K.M.; Funding acquisition: K.R. and A.S. All authors have read and agreed to the published version of the manuscript.

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Ethics approval: This study was conducted in view of the institutional ethical guidelines and does not harm the human participants.

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