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Interactive effects of nitrogen and phosphorus on flowering, yield and economics of *Chrysanthemum morifolium* Ramat.) cv. Snowball

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Abstract

A field experiment was conducted during the winter season of 2009-10 at the Research Farm of the Department of Horticulture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, to evaluate the effect of different levels of nitrogen and phosphorus on flowering and yield of chrysanthemum (*Chrysanthemum morifolium* Ramat.) cv. Snowball. The experiment was laid out in a factorial randomized block design comprising four nitrogen levels (0, 40, 60 and 80 kg N ha⁻¹) and three phosphorus levels (0, 100 and 150 kg P₂O₅ ha⁻¹) with three replications. Nitrogen and phosphorus significantly influenced all flowering and yield attributes. Application of 60 kg N ha⁻¹ (N₂) resulted in the highest number of flowers per plant (8.02), flower size (15.56 cm), flower weight (25.72 g) and flower yield (22.91 t ha⁻¹). Among phosphorus levels, application of 100 kg P₂O₅ ha⁻¹ (P₁) recorded superior performance for all flowering and yield parameters. The treatment combination N₂P₁ (60 kg N ha⁻¹ + 100 kg P₂O₅ ha⁻¹) proved to be the most effective, producing the highest number of flowers per plant (9.11), flower weight (27.25 g) and flower yield (28.17 t ha⁻¹), along with maximum economic returns. The study demonstrated that balanced application of nitrogen and phosphorus markedly enhances flowering, productivity and profitability of chrysanthemum cv. Snowball, and the combined application of 60 kg N ha⁻¹ and 100 kg P₂O₅ ha⁻¹ is recommended under Allahabad agro-climatic conditions.

Keywords: *Chrysanthemum morifolium*, flower yield, nitrogen fertilization, phosphorus fertilization, nutrient management, Snowball

Introduction

Chrysanthemum (*Chrysanthemum morifolium* Ramat.) is one of the most important ornamental crops cultivated worldwide for cut flowers, loose flowers and decorative purposes. Owing to its wide range of colours, forms and sizes, it occupies a prominent position in the floriculture industry and is extensively used for garlands, floral arrangements and religious offerings (Gune *et al.*, 2019) [10]. Besides its ornamental importance, *C. morifolium* is also recognized as a medicinal plant owing to its diverse pharmacological properties and its long history of cultivation and utilization in Asia (Karik and Tunturk, 2019; Kumar *et al.*, 2020) [13, 14].

Chrysanthemum is a heavy feeder and requires adequate nutrient supply because of its shallow root system, which limits nutrient extraction from deeper soil layers (Gu *et al.*, 2022; Hosseinzadeh *et al.*, 2015) [9, 11]. Although floral quality is largely governed by genotype, environmental conditions and nutrient management play a crucial role in determining plant growth, flower production and quality. Therefore, appropriate fertilizer management is essential for realizing the yield potential of chrysanthemum (Shahrajabian *et al.*, 2019) [22].

Plant nutrition directly influences crop physiology and productivity, and the judicious application of fertilizers is one of the most important agronomic practices affecting plant growth, flowering and yield (Li *et al.*, 2019; Chaitra *et*

al., 2018) [15, 6]. Among the essential nutrients, nitrogen (N) is a key constituent of amino acids and nucleic acids and promotes vegetative growth and photosynthetic activity, whereas phosphorus (P) plays an important role in energy transfer, enzymatic reactions and metabolic processes. Adequate supply of these nutrients enhances flower initiation, development and overall crop productivity.

Previous studies have demonstrated that growth, yield and quality of chrysanthemum are markedly influenced by nitrogen, phosphorus and other nutrient sources. Optimum doses of nitrogen and phosphorus have been reported to improve flower production in different chrysanthemum cultivars, while balanced NPK nutrition through conventional fertilization and fertigation enhances inflorescence characteristics, nutrient uptake and soil fertility status (Rajan *et al.*, 2019; Choudhary *et al.*, 2022) [19, 7]. Likewise, different nitrogen and phosphorus levels have been found effective in improving growth and flower quality in chrysanthemum and other ornamental crops (Matsumura *et al.*, 2020) [16].

The cultivar 'Snowball', developed by the Indian Agricultural Research Institute, New Delhi, is widely cultivated in the central plains of India and is valued for its large white flowers and high market demand. However, information on the optimum nitrogen and phosphorus requirements of this cultivar under Allahabad agro-climatic conditions is limited. Therefore, the present investigation

was undertaken to evaluate the effect of different levels of nitrogen and phosphorus on flowering and flower yield of chrysanthemum cv. Snowball and to identify the optimum nutrient combination for maximizing productivity and economic returns.

Materials and Methods

The experiment was conducted during the winter season of 2009-10 at the Research Farm of the Department of Horticulture, Sam Higginbottom Institute of Agriculture, Technology and Sciences (SHIATS), Allahabad, Uttar Pradesh, India. The experimental site is situated at 25.8°N latitude and 81.5°E longitude at an altitude of 78 m above mean sea level and falls under the sub-humid Yamuna-Ganga alluvial plains agro-climatic zone. The region experiences a subtropical climate with hot summers and cool winters. The average annual rainfall is about 900-1000 mm, most of which is received during the monsoon period (July-September).

Before the commencement of the experiment, composite soil samples were collected from a depth of 12-15 cm from different locations of the experimental field and analyzed for their physicochemical properties. The soil was nearly neutral in reaction (pH 7.1) with an electrical conductivity of 0.82 dS m⁻¹ and organic carbon content of 0.48%. The available nitrogen, phosphorus and potassium contents of the soil were determined by the alkaline permanganate method (Subbiah and Asija, 1956) [23], Olsen's colorimetric method (Olsen *et al.*, 1954) [17] and flame photometric method (Jackson, 1958) [12], respectively.

The experiment was laid out in a factorial randomized block design comprising four levels of nitrogen (0, 40, 60 and 80 kg N ha⁻¹) and three levels of phosphorus (0, 100 and 150 kg P₂O₅ ha⁻¹), resulting in twelve treatment combinations with three replications (Table 1). A uniform dose of potassium at 100 kg K₂O ha⁻¹ was applied to all treatments. Rooted cuttings of chrysanthemum cv. 'Snowball' were transplanted on 30 October 2009. Nitrogen, phosphorus and potassium were applied through urea (46% N), single super phosphate (16% P₂O₅) and muriate of potash (60% K₂O), respectively. Half of the nitrogen and the entire doses of phosphorus and potassium were applied as basal, while the remaining nitrogen was top-dressed at 20 days after transplanting. Standard agronomic practices, including gap filling, irrigation, weeding and plant protection measures, were followed uniformly in all the treatments.

Observations were recorded on number of flowers per plant, flower size (cm), flower weight (g), flower yield per plot (kg) and flower yield (t ha⁻¹). Flower diameter was measured using a Vernier caliper and flower weight was determined using an electronic balance. Flower yield per hectare was calculated from the plot yield.

The data were subjected to analysis of variance (ANOVA) for a factorial randomized block design following Fisher (1950) [8], and treatment means were compared using the critical difference (CD) test at the 5% level of significance.

Results and Discussion

Flowering and Yield Attributes

Nitrogen, phosphorus and their interaction significantly influenced the flowering and yield attributes of chrysanthemum cv. Snowball (Table 2). Among the

treatment combinations, N₂P₁ (60 kg N ha⁻¹ + 100 kg P₂O₅ ha⁻¹) recorded the highest number of flowers per plant (9.11), flower size (20.65 cm), flower weight (27.25 g) and flower yield (28.17 t ha⁻¹), followed by N₂P₂ (60 kg N ha⁻¹ + 150 kg P₂O₅ ha⁻¹), which produced 8.23 flowers per plant, flower size of 19.28 cm, flower weight of 25.75 g and flower yield of 25.63 t ha⁻¹. The lowest values for all the traits were recorded in the control treatment (N₀P₀), which produced 4.52 flowers per plant, flower size of 13.53 cm, flower weight of 21.33 g and flower yield of 10.08 t ha⁻¹ (Table 2).

The heatmap further illustrated the differential response of the twelve treatment combinations and clearly demonstrated the superiority of N₂P₁ across all the measured traits (Fig. 1). Treatments receiving 60 kg N ha⁻¹ in combination with phosphorus generally exhibited higher values for flowering and yield attributes compared with the other treatments, whereas the control treatment consistently recorded the lowest performance.

The increase in the number of flowers with nitrogen and phosphorus application may be attributed to enhanced vegetative growth, increased photosynthetic area and greater translocation of assimilates towards reproductive organs. Phosphorus plays an important role in energy transfer reactions and cell division, thereby promoting flower initiation and development (Rao *et al.*, 1992; Baboo and Sharma, 1997) [20, 4]. Similar findings were reported by Amit *et al.* (2004) [3] in chrysanthemum and by Agrawal *et al.* (2002) [2] and Pushkar *et al.* (2008) [18] in marigold.

The enhancement in flower size and flower weight under optimum nutrient supply could be attributed to improved cell division and cell elongation, resulting in larger and heavier flowers. Nitrogen promotes leaf development and photosynthetic efficiency, leading to greater accumulation of carbohydrates, while phosphorus contributes to energy metabolism and membrane integrity, thereby favouring flower development (Santosh and Datta, 2006) [21]. Similar observations were reported by Baboo and Singh (2003) [5] and Acharya and Dashora (2004) [1].

The higher flower yield observed under N₂P₁ and N₂P₂ treatments may be due to the cumulative effect of increased flower number, flower size and flower weight, which collectively enhanced the productivity of chrysanthemum. Improved nutrient availability under these treatments might have promoted photosynthetic activity and efficient partitioning of assimilates towards the developing flowers, resulting in higher yields. Similar results have been reported by Rao *et al.* (1992) [20], Baboo and Sharma (1997) [4], Amit *et al.* (2004) [3], Agrawal *et al.* (2002) [2], Baboo and Singh (2003) [5], Acharya and Dashora (2004) [1], Pushkar *et al.* (2008) [18] and Santosh and Datta (2006) [21].

Correlation among Flowering and Yield Attributes

Pearson's correlation analysis revealed significant positive associations among all the flowering and yield attributes of chrysanthemum (Table 3). Flower yield exhibited the strongest positive correlation with flower size ($r = 0.981$, $p < 0.001$), followed by flower weight ($r = 0.902$, $p < 0.001$) and number of flowers per plant ($r = 0.881$, $p < 0.001$). Similarly, flower size was strongly associated with flower weight ($r = 0.912$, $p < 0.001$) and number of flowers per plant ($r = 0.833$, $p < 0.001$). The positive and significant

correlations among these traits indicate that improvements in flower size, flower weight and number of flowers collectively contributed to enhanced flower yield in chrysanthemum.

Economics

The economic analysis indicated substantial variation among the treatment combinations (Table 4). The treatment N₂P₁ recorded the highest gross return (₹2,81,700 ha⁻¹), net return (₹2,40,950 ha⁻¹) and benefit-cost ratio (5.91), followed by N₂P₂, which recorded a net return of ₹2,14,800 ha⁻¹ and a benefit-cost ratio of 5.18. The control treatment (N₀P₀) recorded the lowest gross return (₹1,00,800 ha⁻¹), net return (₹65,800 ha⁻¹) and benefit-cost ratio (1.88). The higher economic returns obtained under N₂P₁ may be attributed to its superior flower yield and improved flowering characteristics, demonstrating that the application of 60 kg N ha⁻¹ and 100 kg P₂O₅ ha⁻¹ was the most

profitable nutrient management practice for chrysanthemum cv. Snowball under the experimental conditions.

Table 1: Treatment combinations used in the experiment

Treatment	N (kg ha ⁻¹)	P ₂ O ₅ (kg ha ⁻¹)	Symbol
T ₀	0	0	N ₀ P ₀
T ₁	0	100	N ₀ P ₁
T ₂	0	150	N ₀ P ₂
T ₃	40	0	N ₁ P ₀
T ₄	40	100	N ₁ P ₁
T ₅	40	150	N ₁ P ₂
T ₆	60	0	N ₂ P ₀
T ₇	60	100	N ₂ P ₁
T ₈	60	150	N ₂ P ₂
T ₉	80	0	N ₃ P ₀
T ₁₀	80	100	N ₃ P ₁
T ₁₁	80	150	N ₃ P ₂

Table 2: Effect of nitrogen and phosphorus levels on flowering and yield attributes of chrysanthemum cv. Snowball

Treatment	Number of flowers plant ⁻¹	Flower size (cm)	Flower weight (g)	Flower yield (t ha ⁻¹)
N ₀ P ₀	4.52	13.53	21.33	10.08
N ₀ P ₁	6.27	14.33	22.67	13
N ₀ P ₂	5.02	14.91	22.67	12
N ₁ P ₀	5.28	13.87	21.67	11.83
N ₁ P ₁	6.45	15.2	23.08	14.25
N ₁ P ₂	5.63	15.13	22.83	12.5
N ₂ P ₀	6.73	14.75	24.17	14.92
N ₂ P ₁	9.11	20.65	27.25	28.17
N ₂ P ₂	8.23	19.28	25.75	25.63
N ₃ P ₀	5.72	14.58	21	13.5
N ₃ P ₁	7.98	15.18	22.83	15.58
N ₃ P ₂	7.27	15.77	24.42	15.25
S.Em.± (N)	0.052	0.081	0.067	0.162
CD (P=0.05) (N)	0.152	0.237	0.196	0.474
S.Em.± (P)	0.045	0.07	0.058	0.14
CD (P=0.05) (P)	0.132	0.205	0.17	0.41
S.Em.± (N×P)	0.09	0.14	0.116	0.281
CD (P=0.05) (N×P)	0.263	0.41	0.34	0.821

Table 3: Correlation coefficients among flowering and yield attributes of chrysanthemum cv. Snowball

Character	Flowers	Flower size	Flower weight	Yield
Flowers	1	0.833***	0.854***	0.881***
Flower size	0.833***	1	0.912***	0.981***
Flower weight	0.854***	0.912***	1	0.902***
Yield	0.881***	0.981***	0.902***	1

***Significant at $p < 0.001$

Table 4: Economics of nitrogen and phosphorus application in chrysanthemum cv. Snowball

Treatment	Flower yield (t ha ⁻¹)	Gross return (₹ ha ⁻¹)	Cost of cultivation (₹ ha ⁻¹)	Net return (₹ ha ⁻¹)	B:C ratio
N ₀ P ₀	10.08	1,00,800	35,000	65,800	1.88
N ₀ P ₁	13	1,30,000	38,500	91,500	2.38
N ₀ P ₂	12	1,20,000	39,250	80,750	2.06
N ₁ P ₀	11.83	1,18,300	36,500	81,800	2.24
N ₁ P ₁	14.25	1,42,500	40,000	1,02,500	2.56
N ₁ P ₂	12.5	1,25,000	40,750	84,250	2.07
N ₂ P ₀	14.92	1,49,200	37,250	1,11,950	3.01
N ₂ P ₁	28.17	2,81,700	40,750	2,40,950	5.91
N ₂ P ₂	25.63	2,56,300	41,500	2,14,800	5.18
N ₃ P ₀	13.5	1,35,000	38,000	97,000	2.55
N ₃ P ₁	15.58	1,55,800	41,500	1,14,300	2.75
N ₃ P ₂	15.25	1,52,500	42,250	1,10,250	2.61

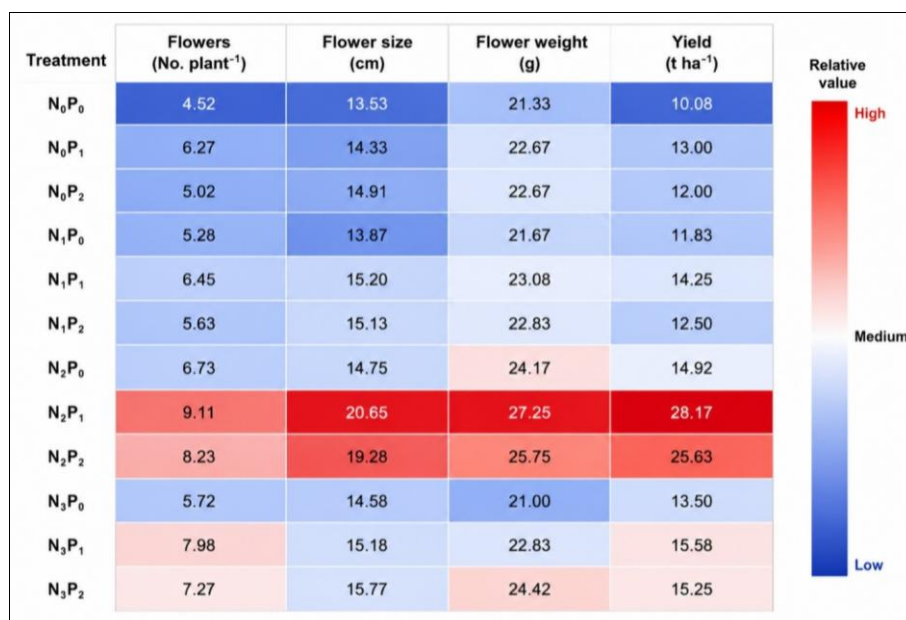


Fig 1: Heatmap showing the performance of different nitrogen and phosphorus treatment combinations for flowering and yield attributes of chrysanthemum cv. Snowball.

Conclusion

The present study demonstrated that nitrogen and phosphorus significantly influenced the flowering and yield performance of chrysanthemum cv. Snowball. Application of 60 kg N ha⁻¹ and 100 kg P₂O₅ ha⁻¹ proved to be the optimum nutrient combination, resulting in superior flowering attributes, flower yield and economic returns. The treatment combination N₂P₁ (60 kg N ha⁻¹ + 100 kg P₂O₅ ha⁻¹) consistently outperformed the other treatments, indicating that balanced nutrient application is essential for maximizing productivity and profitability in chrysanthemum cultivation. Further increases in nitrogen and phosphorus levels did not result in additional yield benefits and showed a declining trend. Therefore, application of 60 kg N ha⁻¹ and 100 kg P₂O₅ ha⁻¹ along with a uniform dose of 100 kg K₂O ha⁻¹ is recommended for obtaining higher flower yield and economic returns in chrysanthemum cv. Snowball under Allahabad agro-climatic conditions.

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References

- Acharya S, Dashora LK. Effect of nitrogen and phosphorus on growth and flowering of marigold. *Journal of Ornamental Horticulture*. 2004;7(1):75-78.
- Agrawal RP, Singh R, Singh KK. Effect of nitrogen and phosphorus on growth and flower yield of marigold. *Progressive Horticulture*. 2002;34(2):189-192.
- Amit M, Singh K, Kumar S, Singh KP. Effect of nitrogen and phosphorus on growth and flowering of chrysanthemum. *Journal of Ornamental Horticulture*. 2004;7(1):42-46.
- Baboo R, Sharma SK. Effect of nitrogen and phosphorus on growth and flowering of chrysanthemum. *Haryana Journal of Horticultural Sciences*. 1997;26(1-2):24-27.
- Baboo R, Singh R. Response of nitrogen and phosphorus on growth and flower yield of chrysanthemum. *Journal of Ornamental Horticulture*. 2003;6(2):148-151.
- Chaitra R, Krishnappa KS, Prashanth M, Reddy SK. Effect of integrated nutrient management on growth, yield and quality of chrysanthemum. *International Journal of Current Microbiology and Applied Sciences*. 2018;7(5):210-219.
- Choudhary RS, Singh RP, Singh SK. Response of NPK on growth and flowering of chrysanthemum. *Indian Journal of Horticulture*. 2022;79(3):356-362.
- Fisher RA. *Statistical methods for research workers*. 11th ed. Edinburgh: Oliver and Boyd; 1950.
- Gu M, Liu Y, Chen J. Nutrient management in chrysanthemum production. *Journal of Plant Nutrition*. 2022;45(8):1245-1258.
- Gune S, Kumar S, Singh P. Chrysanthemum: A medicinal and ornamental plant. *Medicinal Plants Research*. 2019;9(4):56-68.
- Hosseinzadeh M, Golchin A, Khorasani R. Effect of nitrogen and phosphorus on growth and yield of chrysanthemum. *Journal of Soil Science and Plant Nutrition*. 2015;15(4):987-996.
- Jackson ML. *Soil chemical analysis*. Englewood Cliffs (NJ): Prentice Hall; 1958.
- Karik A, Tunturk S. Chemical composition and pharmacological effects of medicinal chrysanthemum.

- Journal of Ethnopharmacology. 2019;245:112-125.
14. Kumar V, Sharma S, Gupta R. Medicinal chrysanthemum cultivars of China. *Journal of Medicinal Plant Research*. 2020;14(3):45-58.
 15. Li J, Zhang Y, Wang X. Effect of NPK fertilization on chrysanthemum growth and quality. *Journal of Plant Growth Regulation*. 2019;38(2):567-578.
 16. Matsumura Y, Tanaka H, Watanabe H. Optimum fertilizer dose for chrysanthemum flower yield. *Journal of Horticultural Science*. 2020;95(6):789-798.
 17. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular No. 939. Washington (DC): United States Department of Agriculture; 1954.
 18. Pushkar D, Singh B, Sharma AK. Effect of nitrogen and phosphorus on growth and flowering of marigold. *Journal of Agricultural Sciences*. 2008;48(3):245-249.
 19. Rajan R, Singh DK, Verma A. NPK fertigation in chrysanthemum production. *Journal of Horticultural Sciences*. 2019;14(1):67-75.
 20. Rao MM, Reddy BS, Prasad R. Effect of nitrogen and phosphorus on growth and flowering of chrysanthemum. *Journal of Research, APAU*. 1992;20(1):45-50.
 21. Santosh K, Datta S. Effect of NPK on growth and flowering of gladiolus. *Journal of Ornamental Horticulture*. 2006;9(2):112-116.
 22. Shahrajabian MH, Sun W, Cheng Q. Chemical fertilizers and their impact on flower crops. *International Journal of Plant Production*. 2019;13(4):287-298.
 23. Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. *Current Science*. 1956;25:259-260.