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Dr. RA Gurjar
Scientist (Horticulture),
KVK, NAU, Navsari, Gujarat, India

Dr. SL Chawla
Associate Professor
Department of Floriculture and Landscape Architecture, ACH, NAU, Navsari, Gujarat, India

Dr. DP Patel
Assistant Professor
Department of NRM,
College of Forestry,
NAU, Navsari, Gujarat, India

Dr. MA Patel
Assistant Professor
Department of Floriculture and Landscape Architecture, ACH, NAU, Navsari, Gujarat, India

Dr. Sudha Patil
Assistant Professor
Department of Floriculture and Landscape Architecture, ACH, NAU, Navsari, Gujarat, India

Corresponding Author:
Dr. RA Gurjar
Scientist (Horticulture),
KVK, NAU, Navsari, Gujarat, India

Interaction effect of nitrogen and phosphorus levels in chrysanthemum (*Dendranthema grandiflora* Tzvelev) var. Ratlam selection

Dr. RA Gurjar, Dr. SL Chawla, Dr. DP Patel, Dr. MA Patel and Dr. Sudha Patil

Abstract
An experiment conducted in the field at the Floriculture Research Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, for three years (2014-15, 2015-16, and 2016-17) to understand how the chrysanthemum 'Ratlam Selection' plant responds to different levels of nitrogen and phosphorus. The experiment was set up in Randomized Block Design with Factorial Concept (RBD). There were nine different combinations with factors of nitrogen and phosphorus with three replication up to three years and combined the data to make results more accurate and to get a better overall picture. For each factor, three different levels were set up. For nitrogen, it was 100, 125, and 150 kg/ha. For phosphorus, it was 50, 75, and 100 kg/ha. After combining the data from all three years, treatment of nitrogen and phosphorus (N_3P_3), resulted significantly maximum weight of 10 flowers, flowers per plant, flower yield per plant, whereas maximum flower yield per plot and per hectare was recorded in N_3P_3 which was found at par with N_3P_2 and N_2P_3. It is observed that using 150 kg/ha of nitrogen and 100 kg/ha of phosphorus (N_3P_3) recorded most economically viable treatment for chrysanthemum production with maximum B:C ratio (1.78).

Keywords: Chrysanthemum, fertilizers interaction, flowering, nitrogen, phosphorus, Ratlam selection

Introduction
Chrysanthemum, known as 'Shatapatri' in Sanskrit language, holds cultural significance and is referred to as 'Guldaudi' in Hindi and 'Sevanti' in Gujarati and Marathi (Gurjar *et al*., 2022) [8].The cultivation of flowers has deep historical roots within India's rich heritage. In contemporary times, the demand for cut flowers has surged, attributed to evolving lifestyles and shifting consumer preferences. The term 'Chrysanthemum' originates from the Greek words 'chryso,' meaning gold and 'anthemom,' meaning flower. Scientifically classified as Dendranthema grandiflora Tzvelev, Chrysanthemum belongs to the Asteraceae family. Renowned for its diverse array of colors, shapes, shades, and impressive longevity, Chrysanthemum holds a prominent place among the most beloved flowers cultivated in India. It thrives as an excellent choice for bedding, potted plants and ornamental floral compositions due to its strikingly attractive blossoms. While its flowering period spans a relatively short 2 to 3 months, the aesthetic and commercial value it carries remains high. This is reflected in its favorable market prices. Notably, its robust flowers possess a remarkable capacity for preservation, allowing easy transport to distant markets. Standard varieties yield flowers on sturdy, elongated stems, characterized by their enduring quality. These attributes collectively render it exceptionally well-suited for ornamental displays. Additionally, spray variety flowers find utility as individual blossoms in traditional adornments like garlands, venis, and gajaras.
Several factors influence the growth and flower production of chrysanthemums. The cultivation of chrysanthemums holds significant potential in Gujarat due to the region's favorable soil and climatic conditions. Nutrients are pivotal for the metabolic processes of plants and play a crucial role in determining crop growth and yield. The primary nutrients, namely nitrogen (N), phosphorus (P), and potassium (K), are of paramount importance. Nitrogen is a vital component of nucleic acids, which is essential for promoting vegetative growth, plant development and expansion (Gupta and Prashad, 1991) [5]. Phosphorus participates in numerous physiological processes, including cell division, the formation of meristematic tissue, photosynthesis and the metabolism of carbohydrates, fats and proteins (Sharma *et al*., 2006) [14]. The fundamental impact of nitrogen and phosphorus on plant growth is likely due to enhanced metabolic transport, photosynthesis, and cell multiplication (Tripathi, 1989) [19].

Achieving sustainable flower production necessitates effective fertilizer management to achieve both high ornamental value and cost reduction in production (Zhang *et al*., 2012) [20]. Despite its popularity, limited research has been conducted on the optimal application of nitrogen and phosphorus, particularly in the agro-climatic conditions of southern Gujarat, specifically for the chrysanthemum variety Ratlam Selection. This variety boasts adaptability to diverse soil and climate conditions, produces abundant marketable flower bunches, exhibits an attractive light pink-yellow color and shape, and possesses commendable shelf life. As a result, there is a need to standardize the nutrient requirements to enhance yields and ensure the quality of cut flowers. Consequently, this experiment was conducted to address these aspects.

Materials and Methods

The purpose of this experiment was to investigate how different amounts of nitrogen and phosphorus interact with Chrysanthemum var. Ratlam Selection in terms of its growth and the flowers it produces. The study took place at the Floriculture Research Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari over three years: 2014-15, 2015-16, and 2016-17. The area where the experiment was conducted had consistent features and allowed water to drain effectively.

The soil in this area was deep and moderately drained clayey soil. It falls under the category of deep black soils, primarily composed of montmorillonite clay minerals. This type of soil has good water retention abilities, making it suitable for cultivating chrysanthemums.

The experiment's layout followed a Randomized Block Design with a Factorial Concept. This involved nine different treatment combinations, each consisting of two factors: nitrogen and phosphorus. For nitrogen, there were three levels (100, 125, and 150 kg/ha), and for phosphorus, there were also three levels (50, 100, and 150 kg/ha). Each treatment combination was replicated three times.

The plots used for the experiment were of specific sizes. The gross plot size was 3.6 m x 3.0 m, accommodating 90 plants, while the net plot size was 0.9 m x 2.4 m, holding 24 plants. The plants were spaced at intervals of 30 cm x 30 cm. During field preparation, well-decomposed farmyard manure was added at a rate of 10 t/ha. Additionally, half of the prescribed nitrogen dose, along with the full phosphorus dose according to the treatments, and potash at a rate of 100 kg/ha were applied as a common basal treatment. The remaining half of the nitrogen dose was administered 45 days after transplanting, following the specific treatments.

Various observations were made during the experiment, including measurements related to plant growth, flowering, and yield. The nutrient content in both the soil and the plants was also assessed. These observations were recorded at appropriate stages and were subjected to statistical analysis using the method outlined by Panse and Sukhatme (1995) [11].

Results and Discussion

The combined data (shown in Table-1) reveals that the interaction between nitrogen and phosphorus didn't have a significant impact on certain aspects related to plant growth, such as plant height, plant spread, the number of branches per plant, and flower-related parameters like days until the first flower opens, flower diameter, and how long the flowers last in a vase. These outcomes match the findings from Sudha Patil and colleagues in 2020 [18].

However, when it comes to the flowering and quality of chrysanthemums, the interaction between nitrogen and phosphorus did have an effect (as shown in Table-1). Based on our results, the treatment combining N3 (nitrogen at 150 kg/ha) and P3 (phosphorus at 100 kg/ha) had a significant impact on flowering parameters. This treatment showed noticeable results in terms of the weight of ten flowers, the number of flowers per plant, and the flower yield per plant. The N_3P_2 treatment, which involved applying nitrogen at 150 kg/ha and phosphorus at 75 kg/ha, followed closely. On the other hand, the lowest values were observed in the N1P1 treatment, where nitrogen was applied at 100 kg/ha and phosphorus at 50 kg/ha. This disparity could be attributed to the balanced combination of nitrogen, phosphorus, and potassium. This balanced approach seemed to stimulate plant growth, which in turn, facilitated the synthesis of essential compounds like peptide bonds, proteins and carbohydrates, all of which are vital for flower development (Boodly and Meyer, 1965) [2]. The improved growth due to the application of fertilizers, as seen in our study, aligns well with previous findings from Chawla and associates in 2018 regarding tuberose [4], Chawla *et al*. in 2007 concerning chrysanthemums [3], and Gurjar R.A. *et al*. in 2021 [6].

The growth we observed can be attributed to the higher levels of nitrogen present. Nitrogen tends to increase both the number and size of leaf cells, leading to an overall boost in leaf production. This aligns with what Meyer and colleagues reported in 1973 [10]. Potassium, on the other hand, contributes to the creation and movement of carbohydrates, while phosphorus supports the development of cell walls and the lengthening of the plant (Henry, 1982) [9].

When it comes to different aspects of yield in chrysanthemums, the combined effects of nitrogen and phosphorus were found to significantly influence flower yield per plot and per hectare. The most substantial flower yield per plot (2998.72 g) was achieved with the treatment combining N3 (nitrogen at 150 kg/ha) and P3 (phosphorus at 100 kg/ha). This result was on par with the N_3P_2 treatment (2941.16 g) and N2P3 treatment (2769.61 g), where nitrogen was applied at 150 kg/ha and phosphorus at 75 kg/ha, and nitrogen at 100 kg/ha and phosphorus at 100 kg/ha, respectively. These findings are consistent with the research of Belgaonkar and team in 1996 on annual chrysanthemums [1], Patel *et al*. in 2006 on tuberose [12], and Gurjar *et al*. in 2012 on anthurium [7].

Applying higher doses of fertilizers that were sufficient to enhance vegetative traits accelerated processes like photosynthesis, carbohydrate production, and the accumulation of nutrients in the plant's vegetative parts. This increase in nutrients likely nurtured the plants continuously, extended the flowering period, and consequently led to more harvests, resulting in higher production. Moreover, the balanced application of nitrogen, phosphorus, and potassium seemed to stimulate vegetative growth, which is beneficial for synthesizing essential compounds like peptide bonds, proteins, and carbohydrates that play a critical role in flower development (Boodly and Meyer, 1965) [2]. These findings are in line with the research of Sudha Patil and colleagues in 2020 on gladiolus [18], Shivshankar in 2005 on chrysanthemum var. Shyamal [16], and Shinde in 1992 on marigold [15].

These findings align with the discoveries made by Rao and colleagues in 1992 [13]. Similarly, the highest flower yield per hectare (138.83 quintals/ha) was achieved with the N_3P_3 treatment (nitrogen at 150 kg/ha and phosphorus at 100 kg/ha). This result was statistically comparable to the N_3P_2 treatment (136.16 quintals/ha) and the N2P3 treatment (128.22 quintals/ha), where nitrogen was applied at 150 kg/ha and phosphorus at 75 kg/ha, and nitrogen at 100 kg/ha and phosphorus at 100 kg/ha, respectively. This could be attributed to the combined and coordinated activities of all the essential growth nutrients. These activities play an active role in the enlargement of plant cells and tissues, ultimately leading to enhanced vegetative growth. A similar trend was noted in the research by Sonawane *et al*. in 2008 on China aster [17].

However, when considering the interaction between nitrogen and phosphorus on soil and leaf analysis (as shown in Table 2), no significant effects were observed.

Economic Considerations

When considering the economic aspect (as shown in Table 3), the interaction between nitrogen and phosphorus had a notable impact. The highest benefit-to-cost ratio (B:C ratio) of 1.78 was observed with the N_3P_3 treatment (nitrogen at 150 kg/ha and phosphorus at 100 kg/ha). The superior net returns and B:C ratio in these specific treatment combinations were attributed to the higher flower yield accompanied by good quality. This combination allowed for fetching favorable market prices while maintaining comparatively lower cultivation costs.

Table 1: Interaction Effect of Nitrogen and Phosphorus on Vegetative, Flowering and Yield Parameters of Chrysanthemum var. Ratlam Selection.

Treatment	Plant Height (cm)	Plant Spread (cm)	Number of branches	Days to first floret opening	Flower diameter (cm)	Vase life (Days)	Weight of 10 flowers (g)	Flowers per plant	Flower yield (g) per plant	Flower yield (g) per plot	Flower yield (q) per ha	BC Ratio
N_1 P_1	40.51	23.394	5.85	69.95	3.57	6.22	12.78	32.94	80.55	1659.18	76.81	1.03
N_1 P_2	41.05	24.449	6.52	63.10	4.35	6.93	14.57	36.68	82.83	1784.29	82.61	1.11
N_1 P_3	45.12	27.311	7.73	58.66	5.21	8.18	18.05	46.94	94.56	2115.90	97.96	1.30
N_2 P_1	44.25	25.647	7.16	60.24	4.63	7.58	16.38	39.60	83.03	1935.14	89.59	1.20
N_2 P_2	47.65	27.983	8.32	56.79	5.46	8.82	18.40	47.47	96.22	2168.98	100.42	1.33
N_2 P_3	53.72	28.741	9.17	53.03	5.67	9.69	19.95	52.90	122.09	2769.61	128.22	1.66
N_3 P_1	53.45	28.547	8.70	54.14	5.57	9.22	19.02	49.15	107.65	2467.93	114.26	1.50
N_3 P_2	55.36	29.707	9.73	51.50	5.86	10.16	20.36	53.02	123.36	2941.16	136.16	1.75
N_3 P_3	62.63	33.161	10.86	41.28	6.60	10.78	28.15	56.56	136.24	2998.72	138.83	1.78
S.Em. ±	1.54	0.671	0.21	2.20	0.15	0.23	0.82	1.24	3.87	87.97	4.07	
C.D.@ 5 %	NS	NS	NS	NS	NS	NS	2.35	3.53	11.02	250.14	11.58	
							28.15	56.56	136.24	2998.72	138.83	
							25.80	53.02	125.22	2748.58	127.25	

Table 2: Interaction effect of nitrogen and phosphorus on soil analysis and leaf on chrysanthemum var. Ratlam Selection.

Treatment	Available N (kg /ha)	Available P_2O_5 (kg /ha)	Available K_2O (kg /ha)	Leaf N	Leaf P	Leaf K
N_1 P_1	267.67	37.41	334.04	3.63	0.44	4.73
N_1 P_2	256.11	38.88	336.80	3.65	0.43	4.81
N_1 P_3	252.71	38.80	339.62	3.71	0.45	4.82
N_2 P_1	249.60	38.01	341.44	3.76	0.43	4.66
N_2 P_2	259.89	39.09	336.00	3.79	0.44	4.70
N_2 P_3	259.07	37.32	335.80	3.83	0.46	4.84
N_3 P_1	250.62	38.22	338.28	3.89	0.42	4.62
N_3 P_2	247.69	36.79	343.30	3.91	0.45	4.66
N_3 P_3	252.80	38.30	342.96	3.95	0.45	4.80
S.Em. ±	8.88	1.46	3.29	0.06	0.01	0.07
C.D.@ 5 %	NS	NS	NS	NS	NS	NS

Table 3: Interaction effect of nitrogen and phosphorus on economics of chrysanthemum var. Ratlam Selection.

Treatment	Flower yield (q/ha)	Gross return (Rs/ha)	Treatment cost (Rs./ ha)	Fix Cost (Rs./ ha)	Variable Cost (Rs./ ha)	Total Cost (Rs/ha)	Net return (Rs/ha)	B:C Ratio
N_1P_1	76.81	3,07,255	6,440	2,66,496	23,984	2,96,921	10,334	1.03
N_1P_2	82.61	3,30,424	7,509	2,65,428	23,778	2,96,715	33,709	1.11
N_1P_3	97.96	3,91,834	8,577	2,64,360	27,872	3,00,809	91,025	1.30
N_2P_1	89.59	3,58,359	6,767	2,66,170	25,641	2,98,577	59,781	1.20
N_2P_2	100.42	4,01,662	7,835	2,65,102	28,527	3,01,464	1,00,198	1.33
N_2P_3	128.22	5,12,890	8,903	2,64,034	35,943	3,08,880	2,04,011	1.66
N_3P_1	114.26	4,57,024	7,093	2,65,844	32,218	3,05,155	1,51,869	1.50
N_3P_2	136.16	5,44,660	8,161	2,64,776	38,061	3,10,998	2,33,662	1.75
N_3P_3	138.83	5,55,319	9,229	2,63,708	38,771	3,11,708	2,43,610	1.78

Purchase cost		Selling Price	
Rooted cutting	Rs. 1 / plant	Flowers	Rs. 40/kg

	NPK kg / ha			Fertilizer kg/ha			Rs /50 kg			Rs / Treatment			
Treatment	**N**	**P**	**K**	**Urea**	**DAP**	**MOP**	**Urea**	**DAP**	**MOP**	**Urea**	**DAP**	**MOP**	**Total**
N_1P_1	100	50	100	175	109	167	300	1100	900	1,049	2,391	3,000	6,440
N_1P_2	100	75	100	154	163	167	300	1100	900	922	3,587	3,000	7,509
N_1P_3	100	100	100	132	217	167	300	1100	900	794	4,783	3,000	8,577
N_2P_1	125	50	100	229	109	167	300	1100	900	1,375	2,391	3,000	6,767
N_2P_2	125	75	100	208	163	167	300	1100	900	1,248	3,587	3,000	7,835
N_2P_3	125	100	100	187	217	167	300	1100	900	1,120	4,783	3,000	8,903
N_3P_1	150	50	100	284	109	167	300	1100	900	1,701	2,391	3,000	7,093
N_3P_2	150	75	100	262	163	167	300	1100	900	1,574	3,587	3,000	8,161
N_3P_3	150	100	100	241	217	167	300	1100	900	1,446	4,783	3,000	9,229

Conclusion

The comprehensive findings from the combined data lead to the conclusion that careful management of nutrients in chrysanthemum cultivation can substantially enhance profitability. Applying N_3P_3 treatment (nitrogen at 150 kg/ha and phosphorus at 100 kg/ha) along with the standard dose of potash at 100 kg/ha demonstrated the most favorable performance, yielding a B:C ratio of 1.78 for Chrysanthemum var. Ratlam Selection. Nitrogen and phosphorous fertilizers stand as vital elements for achieving optimal growth and development in plants. Given that Chrysanthemum var. Ratlam Selection is a nutrient-demanding cut-flower crop, meticulous fertilization is crucial for the optimal development of the plant, its flower stems, and florets.

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