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Effect of nitrogen, phosphorus and potassium levels on growth and flowering of annual chrysanthemum cv. PDKV Bijli Super

SM Raghatate and DM Panchbhai

Abstract
A field experiments were carried out to study the effect of nitrogen, phosphorus and potassium levels on growth and flowering of annual chrysanthemum cv. PDKV Bijli super, at Experimental field, Department of Floriculture & Landscape Architecture, Dr. PDKV, Akola (M. S.) during the winter season of 2018-2019 and 2019-2020. The experiments were laid out in factorial randomized block design with twenty seven treatment combinations and replicated thrice. The treatments comprised of three levels of each, Nitrogen (100, 150 and 200 kg ha^{-1}), Phosphorus (50, 75 and 100 kg ha^{-1}) and Potassium (50, 75 and 100 kg ha^{-1}) in twenty seven different combinations. Results of the two years experiment revealed that, growth parameters *viz*., plant height, stem diameter, number of primary branches $plant^{-1}$ and plant spread were recorded maximum with an application of nitrogen 200 kg ha^{-1}, phosphorus 100 kg ha^{-1} and potassium 100 kg ha^{-1}. Whereas, flowering parameters *viz*., days to first flower bud initiation, days to fully opened flower, days to 50 percent flowering and days to first harvesting were delayed with an application of nitrogen 200 kg ha^{-1}, phosphorus 100 kg ha^{-1} and potassium 100 kg ha^{-1}. However, the duration of flowering was found maximum with an application of nitrogen 200 kg ha^{-1}, phosphorus 100 kg ha^{-1} and potassium 100 kg ha^{-1}.

Keywords: Nitrogen, phosphorus, potassium, seed yield, annual chrysanthemum

1. Introduction
Annual chrysanthemum (*Chrysanthemum coronarium* L.) is considered to be the most important cultivated commercial loose flower crop grown all over India. It belongs to the family asteraceae and originated in Southern Europe. The species is also referred to as *Leucanthemum coronarium* or *Glebionis coronarum*. It is winter season annual propagated through seeds. Annual chrysanthemum is commercially grown in the states of India are Maharashtra, Tamilnadu, Karnataka, Andhra Pradesh, Uttar Pradesh, Telangana, Punjab and Haryana. Annual chrysanthemum is also known as 'Crown Daisy' or 'Garland chrysanthemum'. In India the annual chrysanthemum flower is also locally called as 'Bijli' in Maharashtra, 'Babbona' in Haryana, 'Guldhak' in Punjab, 'Gendi' in Uttar Pradesh and 'Market' in Delhi. It has also a medicinal value. It has antioxidant, anti-inflammatory, antimutagenic, antimicrobial, antifungal, antiangiogenic, antiatherosleorosis and nematicidal properties. Leaves are used as expectorant, bitter and stomachic. The essential oil fraction of *chrysanthemum coronarium* have many enzyme inhibitory activities. It also has a cytotoxic activity. The volatile oil components in the flowers are responsible for the pleasant fragrance. The essential oil of annual chrysanthemum is abundant in terpenoids, sterols, flavonoids, polyacetalynes etc. (Dokuparthi *et al*., 2015) [4]. Nitrogen, phosphorus and potassium are the important macronutrients and play a vital role in growth and flowering of plant. Nitrogen acts as an essential part in the biosynthesis of nucleic acids and it is an important constituents of chlorophyll, proteins and amino acids thereby enhancing the rate of photosynthesis. Normally plants need phosphorus for metabolic regulation, cellular bioenergetics and among the key component of essential biomolecular including DNA, RNA, ATP, phospholipids and sugar phosphates. Potassium helps in efficient use of water and develops more resistant against drought, disease and pest and as a result plants grow stronger. Hence, the application of nitrogen, phosphorus and potassium play an important role in growth and development of plant and flowering, so keeping all these things in view the present investigation had been carried out to study the effect of nitrogen, phosphorus and potassium levels on growth and flowering of annual chrysanthemum.

Materials and Methods

An investigation entitled "Effect of nitrogen, phosphorus and potassium levels on growth and flowering of annual chrysanthemum cv. PDKV Bijli Super" at Experimental field, Department of Floriculture & Landscape Architecture, Dr. PDKV, Akola (M.S.) during the winter season of the year 2018-2019 and 2019-2020. The soil of experimental site was sandy loam in texture. The experiment was laid out in factorial randomized block design with twenty seven different treatment combinations and replicated thrice. The treatments comprised of three levels of each, Nitrogen *viz*., N_1 (100 kg ha^{-1}), N_2 (150 kg ha^{-1}) and N_3 (200 kg ha^{-1}), Phosphorus *viz*., P_1 (50 kg ha^{-1}), P_2 (75 kg ha^{-1}) and P_3 (100 kg ha^{-1}) and Potassium *viz*., K_1 (50 kg ha^{-1}), K_2 (75 kg ha^{-1}) and K_3 (100 kg ha^{-1}). The spacing between row to row and plant to plant was 45 x 30 cm and plot size was 2.25 x 1.80 m (4.05 m^2). The half dose of nitrogen was given in the form of urea at the time of planting and remaining half dose of nitrogen was given 30 days after transplanting. Full dose of phosphorus and potassium were given in the form of single super phosphate and muriate of potash, respectively at the time of transplanting. The observations were recorded in respect of growth parameters *viz*., plant height, stem diameter, number of primary branches $plant^{-1}$ and plant spread and in respect of flowering parameters *viz*., days to first flower bud initiation, days to fully opened flower, days to 50 percent flowering, days to first harvesting and duration of flowering. The data obtained on various parameters was statistically analyzed as per methods suggested by Panse and Sukhatme (1967) [13].

Results and Discussion

Growth parameters

Effect of nitrogen levels

The data presented in table 1 (a), pooled results revealed that, the application of nitrogen significantly influenced the growth parameters. Significantly maximum plant height (103.56 cm), stem diameter (20.03 mm), number of primary branches $plant^{-1}$ (29.47) and plant spread (47.00 cm) were recorded in the treatment N_3. However, significantly minimum plant height (94.98 cm), stem diameter (16.30 mm), number of primary branches $plant^{-1}$ (23.92) and plant spread (37.40 cm) were recorded in the treatment N_1. This might be due to nitrogen as an elementary constituent of amino acid, nucleic acid, proteins, proteids, nucleotides, chlorophyll, and numerous substances such as alkaloids, is an important constituent of enzymes. Thus higher dose of nitrogen would have improved cell division, which resulted in better growth of annual chrysanthemum. The similar results were reported by Chopde *et al.* (2015) [2] in annual chrysanthemum, Satar *et al*. (2016) [15] in annual chrysanthemum and Nikam *et al.* (2018) [11] in annual chrysanthemum.

Effect of phosphorus levels

The pooled results presented in the table 1 (a) shown that, the application of phosphorus significantly increased the plant height (100.42 cm), stem diameter (18.73 mm), number of primary branches $plant^{-1}$ (27.47) and plant spread (43.56 cm) recorded in the treatment P_3. Whereas, significantly minimum plant height (96.84 cm), stem diameter (17.16 mm), number of primary branches $plant^{-1}$ (25.19) and plant spread (39.39 cm) were recorded in the treatment P_1. This might be due to phosphorus application improved growth due to stimulation in root growth which helps in better root development and subsequently leading to more absorption of water and mineral nutrients in soil which ultimately enhanced the plant growth. Similar results were recorded by Satar *et al.* (2016) [15] in Annual chrysanthemum and Rajan *et al.* (2019) in chrysanthemum.

Effect of potassium levels

The pooled results from the Table 1 (a) indicated that, an application of potassium significantly increased the plant height (100.03 cm), stem diameter (18.57 mm), number of primary branches $plant^{-1}$ (27.21) and plant spread (43.05 cm) were recorded with an application of the treatment K_3. However, significantly lowest plant height (97.47 cm), stem diameter (17.42 mm), number of primary branches $plant^{-1}$ (25.60) and plant spread (40.11 cm) were recorded under the treatment K_1. This might be due to potassium increases protein synthesis which might have been responsible for the growth of annual chrysanthemum with the increase level of potassium. The similar results were in close conformity with the findings of Karetha *et al.* (2011) [6] in gaillardia, Kumar and Moon (2014) [8] in African marigold, Shinde *et al.* (2014) in African marigold and Nikam *et al.* (2018) [11] in annual chrysanthemum.

Interaction effects

Interaction effect between nitrogen and phosphorus

The pooled results from the Table 1 (b & f) revealed that, the plant height, stem diameter, number of primary branches $plant^{-1}$ and plant spread were significantly influenced due to interaction between nitrogen and phosphorus levels. The treatment combination N_3P_3 recorded significantly highest plant height (105.45 cm), stem diameter (20.67 mm), number of primary branches $plant^{-1}$ (30.56) and plant spread (49.51 cm). Whereas, significantly lowest plant height (93.80 cm), stem diameter (15.62 mm), number of primary branches $plant^{-1}$ (23.10) and plant spread (36.08 cm) were recorded with the application of treatment combination N_1P_1. It might be due to nitrogen, which is one of the major key elements for the plant growth and increase in nitrogen supply accelerates the synthesis of chlorophyll and amino acids which enhanced the vegetative growth. Beneficial effects of phosphorus on the growth were probably being the resultant of the increased synthesis of metabolites in the presence of directly applied phosphorus is found in nucleic acids and is involved through ATP in activation of amino acids for the synthesis of proteins. Similar results are also reported by Dorajeerao *et al.* (2012) [5] in annual chrysanthemum and Tembhare *et al.* (2015) [16] in China aster.

Interaction effect between nitrogen and potassium

The pooled results depicted in Table 1 (c & g), in respect of plant height, stem diameter, number of primary branches $plant^{-1}$ and plant spread were significantly influenced due to the interaction of nitrogen and potassium levels. The treatment combination N_3K_3 significantly increased the plant height (104.74 cm), stem diameter (20.42 mm), number of primary branches $plant^{-1}$ (30.13) and plant spread (48.66 cm). However, minimum plant height (93.45 cm), stem diameter (15.46 mm), number of primary branches $plant^{-1}$ (22.83) and plant spread (35.83 cm) were recorded in the treatment combination N_1K_1. The results obtained in this investigation are in close agreement with the findings of Nikam *et al*. (2018) [11] in annual chrysanthemum and Shinde *et al*. (2019) in African marigold.

Interaction effect between phosphorus and potassium

The data presented in Table 1 (d & h), the pooled results indicated that, the results in respect of growth parameters significantly influenced due to interaction effect of phosphorus and potassium levels. The significantly superior plant height (101.56 cm), stem diameter (19.24 mm), number of primary branches plant^{-1} (28.16) and plant spread (45.18 cm) were noted in the treatment combination P_3K_3. However, significantly lowest plant height (95.48 cm), stem diameter (16.57 mm), number of primary branches plant^{-1} (24.40) and plant spread (38.07 cm) were recorded in the treatment combination P_1K_1. Similar results are found in close conformity with the results of Kumar and Moon (2014) [8] in African marigold and Saeed and Amin (2019) [14] in rose.

Interaction effect between nitrogen, phosphorus and potassium

The pooled data presented in Table 1 (e & i) revealed that, growth parameters were influenced due to interaction of nitrogen, phosphorus and potassium. Significantly superior plant height (106.76 cm), stem diameter (21.20 mm), number of primary branches plant^{-1} (31.47) and plant spread (52.06 cm) were recorded under the treatment combination $N_3P_3K_3$. However, significantly lowest plant height (92.60 cm), stem diameter (15.00 mm), number of primary branches plant^{-1} (22.27) and plant spread (35.00 cm) were recorded under the treatment combination $N_1P_1K_1$. The combine application of higher doses of nitrogen, phosphorus and potassium increased plant height might be due to nitrogen promotes rapid growth as a constituent of protein and nucleic acid. This rapid growth is because of higher concentration of nitrogen, which has tendency to increase plant growth and potassium enhances synthesis and translocation of carbohydrate, whereas phosphorus encourages cell walls and growth of plant. This result are in close conformity with the result of Ahmad *et al.* (2010) [1] in marigold and Karetha *et al.* (2011) [6] in gaillardia.

Flowering parameters

Effect of nitrogen levels

The data depicted in the Table 2 (a) revealed that, the application of nitrogen significantly influenced the flowering parameters. During the year 2018-2019 and 2019-2020, the flowering parameters *viz*., days to first flower bud initiation (54.16 and 54.19 days, respectively), days to fully opened flower (17.46 and 18.75 days, respectively), days to 50 percent flowering (72.07 and 74.22 days, respectively) and days to first harvesting (93.00 and 93.18 days, respectively) were delayed significantly with the treatment N_3. Whereas, the minimum days to first flower bud initiation (47.29 and 47.01 days, respectively), days to fully opened flower (12.99 and 13.64 days, respectively), days to 50 percent flowering (63.22 and 64.40 days, respectively) and days to first harvesting (83.07 and 81.92 days, respectively) were recorded in the treatment N_1. The late induction of flower bud might be due to more synthesis of protein and protoplasm from carbohydrates deciding to less accumulation of stored vegetative parts. Since the nature of protoplasm hydrated, plants become succulent and as resulted in delayed in flowering parameters. The results are in close conformity with the results of Kumar *et al.* (2003) [7] in China aster and Tembhare *et al*. (2016) in China aster.

Effect of phosphorus levels

The data furnished in the Table 2 (a) indicated that, significantly delayed in flowering parameters during the year 2018-2019 and 2019-2020, *viz*., days to first flower bud initiation (52.15 and 52.01 days, respectively), days to fully opened flower (16.11 and 17.25 days, respectively), days to 50 percent flowering (69.37 and 71.48 days, respectively) and days to first harvesting (89.81 and 89.85 days, respectively) were recorded with the treatment P_3. Whereas, the minimum days to first flower bud initiation (49.36 and 49.36 days, respectively), days to fully opened flower (14.46 and 15.33 days, respectively), days to 50 percent flowering (66.18 and 67.70 days, respectively) and days to first harvesting (86.14 and 85.59 days, respectively) were noted in the treatment P_1. This might be due to phosphorus is an essential component of protoplasm and chlorophyll materials, which caused conversion of photosynthates and phospholipids resulting adequate vegetative growth and ultimately resulted in delayed in flowering. The results of the present investigation are supported by the findings of Kumar *et al.* (2003) [7] in China aster and Tembhare *et al.* (2016) in China aster.

Effect of potassium levels

The data from the Table 2 (a) indicated that, flowering parameters significantly influenced due to the potassium levels. The significantly highest days to first flower bud initiation (51.50 and 51.42 days, respectively), days to fully opened flower (15.70 and 16.76 days, respectively), days to 50 percent flowering (68.66 and 70.63 days, respectively) and days to first harvesting (89.14 and 88.81 days, respectively) were recorded with an application of the treatment K_3. Whereas, significantly minimum days to first flower bud initiation (49.88 and 49.76 days, respectively), days to fully opened flower (14.78 and 15.69 days, respectively), days to 50 percent flowering (66.85 and 68.44, respectively) and days to first harvesting (86.81 and 86.48 days, respectively) were observed in the treatment K_1. The late flower bud initiation was observed in the higher level of potassium. Potassium increases protein content of plants which in turn improves vegetative growth which might have been responsible for delay in first flower bud initiation and ultimately resulted in delayed in flowering. Similar results were reported by Pal and Ghosh (2010) [12] in African marigold and Badge *et al.* (2019) [3] in annual chrysanthemum.

Interaction effect

The interaction effect of these flowering parameters were found to be non-significant.

Duration of flowering (days)

Effect of nitrogen levels

The pooled data furnished in the Table 2 (a) revealed that, significantly superior duration of flowering was recorded in the treatment N_3 (60.01 days). Whereas, significantly lowest duration of flowering was noticed in the treatment N_1 (52.27 days). The maximum flowering duration was recorded with the highest application of nitrogen, might be due to an increased vegetative growth of plants at higher nitrogen level that might have enhanced turgidity of flowers by increasing the rate of photosynthesis and other metabolic activities which turn might have increased flowering duration in annual chrysanthemum. These results were in line with the findings of Chopde *et al.* (2015) [2] in annual chrysanthemum and Mali *et al.* (2016) [10] in annual chrysanthemum.

Effect of phosphorus levels

The data depicted in Table 2 (a), the pooled results revealed that, the highest duration of flowering was recorded with an application of treatment P_3 (57.55 days) and significantly lowest duration of flowering was observed in the treatment P_1 (54.14 days). Similar results have been recorded by Maheta *et al*. (2016) [9] and Tembhare *et al.* (2016) in China aster.

Effect of potassium levels

The pooled results from the Table 2 (a) indicated that, significantly maximum duration of flowering recorded in the treatment K_3 (57.27 days). However, significantly minimum duration of flowering was observed in the treatment K_1 (54.72 days). Similar results were reported by Badge *et al.* (2019) [3] in annual chrysanthemum.

Interaction effect

Interaction effect between nitrogen and phosphorus

The data from the Table. 2 (b), pooled results revealed that, the interaction between nitrogen and phosphorus levels significantly influenced the duration of flowering. The treatment combination N_3P_3 noted significantly maximum flowering duration (61.44 days). Whereas, significantly minimum duration of flowering was recorded with the treatment combination N_1P_1 (50.66 days). The findings of the present investigation are in conformity with the results of Kishore *et al.* (2010) in African marigold and Maheta *et al.* (2016) [9] in China aster.

Interaction effect between nitrogen and potassium

The pooled results from the Table 2 (c) indicated that, significantly the highest duration of flowering was recorded with the treatment combination N_3K_3 (60.88 days). However, significantly lowest flowering duration was observed in the treatment combination N_1K_1 (50.27 days). Similar results were reported by Badge *et al.* (2019) [3] in annual chrysanthemum.

Interaction effect between phosphorus and potassium

The pooled results from Table 2 (d) revealed that, significantly superior duration of flowering was observed with the application of treatment combination P_3K_3 (58.66 days). Significantly lowest duration of flowering was produced in the treatment combination P_1K_1 (52.88 days). Similar results have been reported by Kumar and Moon (2014) [8] in African marigold.

Interaction effect between nitrogen, phosphorus and potassium

The pooled data from the Table 2 (e) exhibited that, the interaction effect between nitrogen, phosphorus and potassium levels significantly influenced the duration of flowering. Significantly maximum duration of flowering was recorded with the application of treatment combination $N_3P_3K_3$ (62.83 days). Whereas, significantly lowest duration of flowering was recorded with the treatment combination $N_1P_1K_1$ (49.16 days). The findings of the present investigation are in conformity with the results of Sharma *et al.* (2006) in chrysanthemum and Maheta *et al.* (2016) [9] in China aster.

Table 1(a): Effect of nitrogen, phosphorus and potassium levels on growth parameters of annual chrysanthemum

Treatments	Plant height (cm)			Stem diameter (mm)			Number of primary branches plant^{-1}			Plant spread (cm)		
	2018-2019	2019-2020	Pooled	2018-2019	2019-2020	Pooled	2018-2019	2019-2020	Pooled	2018-2019	2019-2020	Pooled
Nitrogen (N)												
N_1-100 kg ha^{-1}	93.43	96.53	94.98	16.19	16.41	16.30	23.54	24.30	23.92	37.65	37.16	37.40
N_2-150 kg ha^{-1}	96.61	99.63	98.13	17.71	17.97	17.84	25.74	26.37	26.06	41.23	40.13	40.68
N_3-200 kg ha^{-1}	102.03	105.09	103.56	19.87	20.17	20.03	29.52	29.68	29.47	47.50	46.49	47.00
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig	Sig	Sig
SE(m) ±	0.08	0.07	0.07	0.06	0.05	0.05	0.06	0.06	0.05	0.11	0.11	0.07
CD at 5%	0.24	0.21	0.19	0.17	0.15	0.14	0.17	0.18	0.14	0.33	0.33	0.22
Phosphorus (P)												
P_1-50 kg ha^{-1}	95.97	98.37	96.84	17.03	17.28	17.16	24.88	25.49	25.19	39.71	39.08	39.39
P_2-75 kg ha^{-1}	97.84	100.97	99.41	18.14	18.43	18.29	26.51	27.08	26.80	42.59	41.67	42.13
P_3-100 kg ha^{-1}	98.91	101.92	100.42	18.60	18.84	18.73	27.14	27.79	27.47	44.09	43.03	43.56
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig	Sig	Sig
SE(m) ±	0.08	0.07	0.07	0.06	0.05	0.05	0.06	0.06	0.05	0.11	0.11	0.07
CD at 5%	0.24	0.21	0.19	0.17	0.15	0.14	0.17	0.18	0.14	0.33	0.33	0.22
Potassium (K)												
K_1-50 kg ha^{-1}	95.93	99.01	97.47	17.29	17.54	17.42	25.34	25.88	25.60	40.46	39.77	40.11
K_2-75 kg ha^{-1}	97.57	100.76	99.17	18.02	18.33	18.18	26.33	26.94	26.64	42.38	41.47	41.92
K_3-100 kg ha^{-1}	98.57	101.48	100.03	18.46	18.68	18.57	26.89	27.53	27.21	43.55	42.55	43.05
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE(m) ±	0.08	0.07	0.07	0.06	0.05	0.05	0.06	0.06	0.05	0.11	0.11	0.07
CD at 5%	0.24	0.21	0.19	0.17	0.15	0.14	0.17	0.18	0.14	0.33	0.33	0.22
Interaction (N X P)												
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE(m) ±	0.14	0.13	0.12	0.10	0.09	0.08	0.10	0.11	0.08	0.20	0.20	0.13
CD at 5%	0.42	0.37	0.33	0.29	0.26	0.24	0.29	0.31	0.24	0.58	0.57	0.38
Interaction (N X K)												
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE(m) ±	0.14	0.13	0.12	0.10	0.09	0.08	0.10	0.11	0.08	0.20	0.20	0.13
CD at 5%	0.42	0.37	0.33	0.29	0.26	0.24	0.29	0.31	0.24	0.58	0.57	0.38
Interaction (P X K)												

'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE(m) ±	0.14	0.13	0.12	0.10	0.09	0.08	0.10	0.11	0.08	0.20	0.20	0.13
CD at 5%	0.42	0.37	0.33	0.29	0.26	0.24	0.29	0.31	0.24	0.58	0.57	0.38
Interaction (N X P X K)												
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE(m) ±	0.25	0.23	0.20	0.18	0.16	0.15	0.18	0.19	0.15	0.35	0.35	0.23
CD at 5%	0.73	0.65	0.57	0.51	0.46	0.41	0.51	0.55	0.41	1.01	0.99	0.66

Table 1(b): Interaction effect between nitrogen and phosphorus levels on plant height (cm) and stem diameter (mm) of annual chrysanthemum

N X P	Plant height (cm)									Stem diameter (mm)								
	2018-2019			2019-2020			Pooled			2018-2019			2019-2020			Pooled		
	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3
P_1	92.17	94.04	99.73	95.42	97.20	102.48	93.80	95.62	101.11	15.49	16.56	19.04	15.76	16.73	19.38	15.62	16.64	19.21
P_2	93.73	97.35	102.44	96.80	100.31	105.80	95.26	98.83	104.12	16.36	18.07	20.02	16.58	18.33	20.38	16.47	18.20	20.20
P_3	94.37	98.44	103.91	97.37	101.40	107.00	95.87	99.92	105.45	16.73	18.53	20.56	16.91	18.84	20.78	16.82	18.69	20.67
'F' test	Sig			Sig			Sig			Sig			Sig			Sig		
SE(m) ±	0.14			0.13			0.12			0.10			0.09			0.08		
CD at 5%	0.42			0.37			0.33			0.29			0.26			0.24		

Table 1(c): Interaction effect between nitrogen and potassium levels on plant height (cm) and stem diameter (mm) of annual chrysanthemum

N X K	Plant height (cm)									Stem diameter (mm)								
	2018-2019			2019-2020			Pooled			2018-2019			2019-2020			Pooled		
	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3
K_1	91.75	95.48	100.55	95.15	98.46	103.42	93.45	96.97	101.98	15.36	17.20	19.33	15.56	17.40	19.69	15.46	17.30	19.51
K_2	93.71	96.68	102.31	96.80	99.88	105.60	95.25	98.28	103.95	16.31	17.76	20.00	16.67	18.04	20.29	16.49	17.90	20.14
K_3	94.82	97.66	103.22	97.64	100.55	106.26	96.23	99.11	104.74	16.91	18.20	20.29	17.02	18.47	20.56	16.97	18.33	20.42
'F' test	Sig			Sig			Sig			Sig			Sig			Sig		
SE(m) ±	0.14			0.13			0.12			0.10			0.09			0.08		
CD at 5%	0.42			0.37			0.33			0.29			0.26			0.24		

Table 1(d): Interaction effect between phosphorus and potassium levels on plant height (cm) and stem diameter (mm) of annual chrysanthemum

P X K	Plant height (cm)									Stem diameter (mm)								
	2018-2019			2019-2020			Pooled			2018-2019			2019-2020			Pooled		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
K_1	94.04	96.62	97.13	96.93	99.75	100.35	95.48	98.18	98.74	16.44	17.60	17.84	16.69	17.87	18.09	16.57	17.73	17.97
K_2	95.04	98.24	99.42	98.28	101.53	102.46	96.66	99.88	100.94	16.84	18.38	18.84	17.18	18.73	19.09	17.01	18.56	18.97
K_3	96.86	98.66	100.17	99.88	101.62	102.95	98.37	100.14	101.56	17.80	18.47	19.13	18.00	18.69	19.36	17.90	18.58	19.24
'F' test	Sig			Sig			Sig			Sig			Sig			Sig		
SE(m) ±	0.14			0.13			0.12			0.10			0.09			0.08		
CD at 5%	0.42			0.37			0.33			0.29			0.26			0.24		

Table 1(e): Interaction effect between nitrogen, phosphorus and potassium levels on plant height (cm) and stem diameter (mm) of annual chrysanthemum

N X P X K	Plant height (cm)									Stem diameter (mm)								
	2018-2019			2019-2020			Pooled			2018-2019			2019-2020			Pooled		
	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3
P_1K_1	91.00	92.80	98.33	94.20	96.26	100.33	92.60	94.53	99.33	14.87	15.93	18.53	15.13	16.07	18.87	15.00	16.00	18.70
P_1K_2	91.80	93.26	100.06	95.06	96.60	103.20	93.43	94.93	101.63	15.13	16.20	19.20	15.60	16.40	19.53	15.37	16.30	19.37
P_1K_3	93.73	96.06	100.80	97.00	98.73	103.93	95.36	97.40	102.36	16.47	17.53	19.40	16.53	17.73	19.73	16.50	17.63	19.57
P_2K_1	91.93	96.60	101.33	95.46	99.26	104.53	93.70	97.93	102.93	15.47	17.73	19.60	15.67	17.93	20.00	15.57	17.83	19.80
P_2K_2	94.20	97.93	102.60	97.26	101.26	106.06	95.73	99.60	104.33	16.67	18.33	20.13	17.07	18.67	20.47	16.87	18.50	20.30
P_2K_3	95.06	97.53	103.40	97.66	100.40	106.80	96.36	98.96	105.10	16.93	18.13	20.33	17.00	18.40	20.67	16.97	18.27	20.50
P_3K_1	92.33	97.06	102.00	95.80	99.86	105.40	94.06	98.46	103.70	15.73	17.93	19.87	15.87	18.20	20.20	15.80	18.07	20.03
P_3K_2	95.13	98.86	104.20	98.06	101.80	107.53	96.60	100.33	105.90	17.13	18.73	20.67	17.33	19.07	20.87	17.23	18.90	20.77
P_3K_3	95.66	99.40	105.46	98.26	102.53	108.06	96.96	100.96	106.76	17.33	18.93	21.13	17.53	19.27	21.27	17.43	19.10	21.20
'F' test	Sig			Sig			Sig			Sig			Sig			Sig		
SE(m) ±	0.25			0.23			0.20			0.18			0.16			0.15		
CD at 5%	0.73			0.65			0.57			0.51			0.46			0.41		

Table 1(f): Interaction effect between nitrogen and phosphorus levels on number of primary branches plant^{-1} and plant spread (cm) of annual chrysanthemum

N X P	Number of primary branches plant^{-1}									Plant spread (cm)								
	2018-2019			2019-2020			Pooled			2018-2019			2019-2020			Pooled		
	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3
P_1	22.73	24.00	27.91	23.47	24.67	28.36	23.10	24.33	28.13	36.24	38.44	44.43	35.93	37.78	43.54	36.08	38.11	43.98
P_2	23.76	26.27	29.53	24.47	26.87	29.91	24.11	26.57	29.72	37.82	41.94	48.00	37.42	40.58	47.00	37.62	41.26	47.50

P_3	24.13	26.98	30.31	24.98	27.60	30.80	24.56	27.29	30.56	38.88	43.28	50.07	38.13	42.03	48.94	38.51	42.66	49.51
'F' test	Sig			Sig			Sig			Sig			Sig			Sig		
SE(m) ±	0.10			0.11			0.08			0.20			0.20			0.13		
CD at 5%	0.29			0.31			0.24			0.58			0.57			0.38		

Table 1(g): Interaction effect between nitrogen and potassium levels on number of primary branches plant^{-1} and plant spread (cm) of annual chrysanthemum

N X K	Number of primary branches plant^{-1}									Plant spread (cm)								
	2018-2019			2019-2020			Pooled			2018-2019			2019-2020			Pooled		
	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3
K_1	22.49	25.04	28.40	23.18	25.64	28.84	22.83	25.34	28.62	35.97	39.91	45.47	35.68	38.97	44.64	35.83	39.44	45.06
K_2	23.71	25.82	29.47	24.53	26.47	29.84	24.12	26.14	29.66	37.90	41.42	47.81	37.44	40.23	46.74	37.67	40.82	47.27
K_3	24.42	26.38	29.89	25.20	27.02	30.38	24.81	26.70	30.13	39.07	42.34	49.22	38.35	41.20	48.10	38.71	41.77	48.66
'F' test	Sig			Sig			Sig			Sig			Sig			Sig		
SE(m) ±	0.10			0.11			0.08			0.20			0.20			0.13		
CD at 5%	0.29			0.31			0.24			0.58			0.57			0.38		

Table 1(h): Interaction effect between phosphorus and potassium levels on number of primary branches plant^{-1} and plant spread (cm) of annual chrysanthemum

P X K	Number of primary branches plant^{-1}									Plant spread (cm)								
	2018-2019			2019-2020			Pooled			2018-2019			2019-2020			Pooled		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
K_1	24.09	25.76	26.09	24.71	26.36	26.60	24.40	26.06	26.34	38.35	41.16	41.84	37.80	40.48	41.02	38.07	40.82	41.43
K_2	24.69	26.89	27.42	25.29	27.38	28.18	24.99	27.13	27.80	39.31	43.13	44.68	38.85	42.12	43.44	39.08	42.62	44.06
K_3	25.87	26.91	27.91	26.49	27.51	28.60	26.18	27.21	28.26	41.45	43.46	45.72	40.61	42.40	44.64	41.03	42.93	45.18
'F' test	Sig			Sig			Sig			Sig			Sig			Sig		
SE(m) ±	0.10			0.11			0.08			0.20			0.20			0.13		
CD at 5%	0.29			0.31			0.24			0.58			0.57			0.38		

Table 1(i): Interaction effect between nitrogen, phosphorus and potassium levels on number of primary branches plant^{-1} and plant spread (cm) of annual chrysanthemum

N X P X K	Number of primary branches plant^{-1}									Plant spread (cm)								
	2018-2019			2019-2020			Pooled			2018-2019			2019-2020			Pooled		
	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3
P_1K_1	21.93	23.33	27.00	22.60	23.87	27.67	22.27	23.60	27.33	35.16	37.13	42.76	34.83	36.73	41.83	35.00	36.93	42.30
P_1K_2	22.33	23.53	28.20	23.13	24.20	28.53	22.73	23.87	28.37	35.50	37.53	44.90	35.50	37.06	44.00	35.5	37.3	44.45
P_1K_3	23.93	25.13	28.53	24.67	25.93	28.87	24.30	25.53	28.70	38.06	40.66	45.63	37.46	39.56	44.80	37.76	40.11	45.21
P_2K_1	22.60	25.80	28.87	23.33	26.40	29.33	22.97	26.10	29.10	36.03	41.10	46.36	35.90	39.90	45.66	35.96	40.50	46.01
P_2K_2	24.27	26.67	29.73	24.93	27.27	29.93	24.60	26.97	29.83	38.43	42.66	48.30	37.96	41.13	47.26	38.20	41.90	47.78
P_2K_3	24.40	26.33	30.00	25.13	26.93	30.47	24.77	26.63	30.23	39.00	42.06	49.33	38.40	40.73	48.06	38.70	41.40	48.70
P_3K_1	22.93	26.00	29.33	23.60	26.67	29.53	23.27	26.33	29.43	36.73	41.50	47.30	36.33	40.30	46.43	36.53	40.90	46.86
P_3K_2	24.53	27.27	30.47	25.53	27.93	31.07	25.03	27.60	30.77	39.76	44.06	50.23	38.86	42.50	48.96	39.31	43.28	49.60
P_3K_3	24.93	27.67	31.13	25.80	28.20	31.80	25.37	27.93	31.47	40.16	44.30	52.70	39.20	43.30	51.43	36.68	43.80	52.06
'F' test	Sig			Sig			Sig			Sig			Sig			Sig		
SE(m) ±	0.18			0.19			0.15			0.35			0.35			0.23		
CD at 5%	0.51			0.55			0.41			1.01			0.99			0.66		

Table 2(a): Effect of nitrogen, phosphorus and potassium levels on flowering parameters of annual chrysanthemum

Treatments	Days to first flower bud initiation (days)		Days to fully opened flower (days)		Days to 50 percent flowering (days)		Days to first harvesting (days)		Duration of flowering (days)		
	2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020	Pooled
Nitrogen (N)											
N_1-100 kg ha^{-1}	47.29	47.01	12.99	13.64	63.22	64.40	83.07	81.92	51.93	52.63	52.27
N_2-150 kg ha^{-1}	50.90	50.86	15.39	16.46	68.29	70.33	88.22	88.18	55.70	56.22	55.96
N_3-200 kg ha^{-1}	54.16	54.19	17.46	18.75	72.07	74.22	93.00	93.18	59.37	60.67	60.01
'F' test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE(m) ±	0.17	0.14	0.11	0.09	0.22	0.20	0.24	0.25	0.14	0.17	0.10
CD at 5%	0.47	0.39	0.31	0.26	0.64	0.57	0.68	0.72	0.41	0.48	0.29
Phosphorus (P)											
P_1-50 kg ha^{-1}	49.36	49.36	14.46	15.33	66.18	67.70	86.14	85.59	53.81	54.48	54.14
P_2-75 kg ha^{-1}	50.84	50.70	15.27	16.27	68.03	69.77	88.33	87.85	56.11	57.00	56.55
P_3-100 kg ha^{-1}	52.15	52.01	16.11	17.25	69.37	71.48	89.81	89.85	57.07	58.04	57.55
'F' test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE(m) ±	0.17	0.14	0.11	0.09	0.22	0.20	0.24	0.25	0.14	0.17	0.10
CD at 5%	0.47	0.39	0.31	0.26	0.64	0.57	0.68	0.72	0.41	0.48	0.29

Potassium (K)											
K_1-50 kg ha^{-1}	49.88	49.76	14.78	15.69	66.85	68.44	86.81	86.48	54.37	55.07	54.72
K_2-75 kg ha^{-1}	50.97	50.88	15.36	16.40	68.07	69.88	88.33	88.00	55.78	56.74	56.25
K_3-100 kg ha^{-1}	51.50	51.42	15.70	16.76	68.66	70.63	89.14	88.81	56.85	57.70	57.27
'F' test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE(m) ±	0.17	0.14	0.11	0.09	0.22	0.20	0.24	0.25	0.14	0.17	0.10
CD at 5%	0.47	0.39	0.31	0.26	0.64	0.57	0.68	0.72	0.41	0.48	0.29
Interaction (N X P)											
'F' test	NS	NS	NS	NS	NS	NS	NS	NS	Sig	Sig	Sig
SE(m) ±	0.29	0.24	0.19	0.16	0.39	0.34	0.41	0.44	0.25	0.29	0.18
CD at 5%	-	-	-	-	-	-	-	-	0.70	0.84	0.51
Interaction (N X K)											
'F' test	NS	NS	NS	NS	NS	NS	NS	NS	Sig	Sig	Sig
SE(m) ±	0.29	0.24	0.19	0.16	0.39	0.34	0.41	0.44	0.25	0.29	0.18
CD at 5%	-	-	-	-	-	-	-	-	0.70	0.84	0.51
Interaction (P X K)											
'F' test	NS	NS	NS	NS	NS	NS	NS	NS	Sig	Sig	Sig
SE(m) ±	0.29	0.24	0.19	0.16	0.39	0.34	0.41	0.44	0.25	0.29	0.18
CD at 5%	-	-	-	-	-	-	-	-	0.70	0.84	0.51
Interaction (N X P X K)											
'F' test	NS	NS	NS	NS	NS	NS	NS	NS	Sig	Sig	Sig
SE(m) ±	0.50	0.42	0.33	0.28	0.68	0.60	0.71	0.76	0.43	0.51	0.31
CD at 5%	-	-	-	-	-	-	-	-	1.22	1.45	0.88

Table 2(b): Interaction effect between nitrogen and phosphorus levels on duration of flowering (days)

N x P	Duration of flowering (days)								
	2018-2019			2019-2020			Pooled		
	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3
P_1	50.33	53.33	57.77	51.00	53.44	59.00	50.66	53.38	58.38
P_2	52.22	56.55	59.55	53.00	57.11	60.88	52.61	56.83	60.22
P_3	53.22	57.22	60.77	53.88	58.11	62.11	53.55	57.66	61.44
'F' test	Sig			Sig			Sig		
SE(m) ±	0.14			0.17			0.10		
CD at 5%	0.41			0.48			0.29		

Table 2(c): Interaction effect between nitrogen and potassium levels on duration of flowering (days)

N x K	Duration of flowering (days)								
	2018-2019			2019-2020			Pooled		
	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3
K_1	50.00	54.88	58.22	50.55	55.00	59.66	50.27	54.94	58.94
K_2	52.22	55.55	59.55	53.11	56.22	60.88	52.66	55.88	60.22
K_3	53.55	56.66	60.33	54.22	57.44	61.44	53.88	57.05	60.88
'F' test	Sig			Sig			Sig		
SE(m) ±	0.14			0.17			0.10		
CD at 5%	0.41			0.48			0.29		

Table 2(d): Interaction effect between phosphorus and potassium levels on duration of flowering (days)

P x K	Duration of flowering (days)								
	2018-2019			2019-2020			Pooled		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
K_1	52.55	54.88	55.66	53.22	55.88	56.11	52.88	55.38	55.88
K_2	53.33	56.55	57.44	54.00	57.44	58.77	53.66	57.00	58.11
K_3	55.55	56.88	58.11	56.22	57.66	59.22	55.88	57.27	58.66
'F' test	Sig			Sig			Sig		
SE(m) ±	0.14			0.17			0.10		
CD at 5%	0.41			0.48			0.29		

Table 2(e): Interaction effect between nitrogen, phosphorus and potassium levels on duration of flowering (days)

N x P x K	Duration of flowering (days)								
	2018-2019			2019-2020			Pooled		
	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3
P_1K_1	48.66	52.00	57.00	49.66	52.00	58.00	49.16	52.00	57.50
P_1K_2	49.66	52.33	58.00	50.33	52.33	59.33	50.00	52.33	58.66
P_1K_3	52.66	55.66	58.33	53.00	56.00	59.66	52.83	55.83	59.00
P_2K_1	50.00	56.00	58.66	50.66	56.33	60.66	50.33	56.16	59.66
P_2K_2	53.00	57.00	59.66	54.00	57.66	60.66	53.50	57.33	60.16

P_2K_3	53.66	56.66	60.33	54.33	57.33	61.33	54.00	57.00	60.83
P_3K_1	51.33	56.66	59.00	51.33	56.66	60.33	51.33	56.66	59.66
P_3K_2	54.00	57.33	61.00	55.00	58.66	62.66	54.5	58.00	61.83
P_3K_3	54.33	57.66	62.33	55.33	59.00	63.33	54.83	58.33	62.83
'F' test	Sig			Sig			Sig		
SE(m) ±	0.43			0.51			0.31		
CD at 5%	1.22			1.45			0.88		

Conclusion

The maximum plant growth was recorded with the combine application of nitrogen 200 kg ha^{-1}, phosphorus 100 kg ha^{-1} and potassium 100 kg ha^{-1} and the flowering parameters were delayed with the combine application of nitrogen 200 kg ha^{-1}, phosphorus 100 kg ha^{-1} and potassium 100 kg ha^{-1}.

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