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Influence of NPK doses on growth and yield of Spider Lily

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Abstract
The investigation was carried out to study the effect of various levels of N, P and K on spider lily. All the growth parameters were significantly influenced by the different levels of nitrogen, phosphorus and potassium. The individual application of nitrogen 250 kg ha^{-1}, phosphorus 100 kg ha^{-1} and potassium 100 kg ha^{-1}, as well as their combinations, particularly nitrogen 250 kg ha^{-1} + phosphorus 100 kg ha^{-1}, recorded maximum plant height, leaf length, number of leaves, plant spread and leaf area. In case of flower bud yield, number of flower buds per plant, number of flower buds per plot, per hectare and number of flower bundles per hectare were recorded maximum under the individual application of nitrogen 250 kg ha^{-1}, phosphorus 100 kg ha^{-1} and potassium 100 kg ha^{-1} along with their combinations (nitrogen 250 kg ha^{-1} + phosphorus 100 kg ha^{-1} and nitrogen 250 kg ha^{-1} + phosphorus 100 kg ha^{-1} + potassium 100 kg ha^{-1}).

Keywords: Nitrogen, phosphorus, potash, flowering, spider lily

Introduction
Spider lily is a bulbous flowering plant. This genus has its origin in South America and Africa. *Hymenocallis* is derived from two Greek words; hymen meaning membrane and kallos meaning beauty, referring to the membranous beauty of its delicate flowers. Spider lily is cultivated for its evergreen leaves and the fragrant white flowers that are of special attraction because of the membranous corona and the sweet fragrance of the flowers. It is suitable for growing in the field as well as in pots. These look attractive even when not in flowering as in tropical and subtropical climates mostly the leaves remain green. Also as cut flower it is attractive but the flowers do not last long. Certain species are used for loose flower production and *Hymenocallis littoralis* is being grown on commercial scale in Gujarat (Saurashtra region) for production of loose flowers as the flowers are supplied to Mumbai daily packed in gunny bags. Its loose flowers are used for worshippings, garland making, bridal car decorations, mandaps, pandal and stage decorations. *Hymenocallis littoralis* is commercially important and is being cultivated on large scale in western India, specially in Gujarat and Maharashtra and it occupies a premium position in the flower market of Mumbai.

Materials and Methods
The experiment was laid out in a statistical FRBD design with two replications and twenty-seven treatment combinations and was carried out at Hindu Hrudaysamrat Balasaheb Thackeray Udhyan, Department of Floriculture and Landscape Architecture, Faculty of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during July 2022 to May 2023. The spacing maintained for spider lily was 120 × 45 cm. The gross cropped area measured 4.80 m × 2.25 m = 10.8 m^2, while the net cropped area was 3.6 m × 1.8 m = 6.48 m^2. The treatments consisted of three levels each of nitrogen (200, 250 and 300 kg ha^{-1}), phosphorus (50, 100 and 150 kg ha^{-1}) and potassium (50, 100 and 150 kg ha^{-1}). Nitrogen was applied in the form of urea in four split doses: at the time of clipping and subsequently at 90, 180 and 270 days after clipping. Similarly, phosphorus (in the form of single super phosphate) and potassium (in the form of potash) were also applied in four equal split doses at the time of clipping and subsequently at 90, 180 and 270 days after clipping.

Plant height was measured from the base of the plant to the tip of the longest leaf on five randomly selected plants per plot and average height was recorded at 120 days after clipping. Average leaf length was worked out with the help of measuring tape from randomly selected five plants of each plot after 120 DAC. The number of leaves per plant was counted from five randomly selected plants by recording all leaves emerging from the bulb centre at 120 DAC. Plant spread was measured at 120 DAC in both East-West and North-South directions using a meter scale and the average spread was calculated. Leaf area was measured from randomly selected ten leaves from tagged plant of each plot. Out of them, five leaves were selected randomly for recording the observations on self-recording leaf area meter at 120 DAC and average leaf area was worked out.

The number of flower buds per plant was recorded by picking of flowers from randomly selected five plants in a plot at flowering and averaged. The number of flower buds per plot per year was estimated by multiplying the number of buds per plant by 20 plants per plot during the 8-month flowering period. The flowers harvested from each observational plant were multiplied by the number of plants per hectare to determine the number of flower buds per hectare per year. The number of flower bundles per hectare was calculated by dividing the total number of buds per hectare per year by 50, assuming each bundle contained 50 buds.

Results and discussion

Growth parameters

In the study, various growth parameters such as plant height (cm), leaf length (cm), number of leaves per plant, plant spread (cm) and leaf area (cm^2) were significantly influenced by the different treatment levels of N, P and K.

Effect of Nitrogen

At 120 DAC**,** treatment N_2 (250 kg N/ha) recorded maximum plant height (75.64 cm), leaf length (66.27 cm), number of leaves per plant (82.67), plant spread (91.76 cm) and leaf area (219.03 cm^2), which were found at par with treatment N_3 during 2022-2023. In contrast, minimum plant height (69.07 cm), leaf length (60.42 cm), number of leaves per plant (75.82), plant spread (84.10 cm) and leaf area (197.32 cm^2) were observed under treatment N_1 (200 kg N/ha)**.** Application of 250 kg N/ha in spider lily ensures optimal nitrogen availability, enhancing chlorophyll synthesis, photosynthetic efficiency and active cell division, which collectively result in superior plant height, leaf length, leaf production, plant spread and leaf area. On the other hand, 200 kg N/ha remains insufficient to meet the crop's nitrogen demand, ultimately leading to comparatively reduced vegetative growth.

The findings of the present study are in agreement with Koladiya and Dhaduk (1995) [7] in spider lily, Ghule *et al.* (2003) [5] in spider lily, who recorded a significant increase in the number of leaves under 200 and 300 kg N/ha compared to 100 kg N/ha. Barad *et al.* (2010) [1] in gerbera also confirmed that 20 g N/m^2 resulted in higher plant height. Beneficial responses to nitrogen were further supported by Sharma *et al.* (2013) [13] in *Barleria cristata*. Patel *et al.* (2017) [11] in bird of paradise (*Strelitzia reginae*) and Verma and Kumar (2018) [9] in snapdragon also highlighted the positive influence of higher nitrogen levels on vegetative growth. Sahu *et al.* (2021) [3] in chrysanthemum noted that increasing nitrogen levels significantly enhanced plant height and number of branches at 200 kg N/ha. Recently, Patil (2023) [11] in tuberose recorded the highest number of leaves with 150 kg N/ha (N_3), while Verma *et al.* (2023) [9] in gomphrena confirmed the positive effect of higher nitrogen levels on vegetative growth.

Effect of phosphorus

At 120 DAC, treatment P_2 (100 kg P/ha) consistently recorded maximum plant height (76.55 cm), leaf length (66.61 cm), number of leaves per plant (84.39), plant spread (92.63 cm) and leaf area (221.42 cm^2) and was closely followed by treatment P_3 (150 kg P/ha) during 2022-2023. In contrast, the minimum plant height (69.48 cm), leaf length (61.66 cm), number of leaves per plant (75.68), plant spread (85.11 cm) and leaf area (199.59 cm^2) were observed under treatment P_1 (50 kg P/ha)**.** The superior vegetative performance under 100 kg P/ha can be attributed to enhanced root proliferation, increased ATP-mediated energy transfer, improved nutrient uptake and greater photosynthetic efficiency. Conversely, the suboptimal growth observed under 50 kg P/ha may be due to restricted root activity, lower metabolic energy availability and reduced nutrient utilization.

The present findings align closely with those of Ghule *et al.* (2003) [5] in spider lily, Karetha (2006) [6] in gaillardia. Barad *et al.* (2010) [1] in gerbera also recorded higher plant height with 10 g/m^2 P application. Supporting these trends, Dorajeerao *et al.* (2012) [2] in garland chrysanthemum reported that 100 kg P/ha significantly enhanced the number of leaves per plant (108.81) compared to the minimum (94.57) under no phosphorus application. Further evidence is provided by Sharma *et al.* (2013) [13] in *Barleria cristata*, Patel *et al.* (2017) [11] in bird of paradise (*Strelitzia reginae*) and Verma *et al.* (2018) [9] in snapdragon, who also reported favourable responses to phosphorus levels in enhancing vegetative growth.

Effect of potassium

At 120 DAC, treatment K_2 (100 kg K/ha) consistently outperformed all other treatments, producing the maximum plant height (77.60 cm), leaf length (67.09 cm), number of leaves per plant (83.83), plant spread (92.99 cm) and leaf area (218.24 cm^2) during 2022-2023, followed by treatment K_1 (50 kg K/ha)**.** In contrast, the minimum plant height (69.07 cm), leaf length (60.79 cm), number of leaves per plant (76.04), plant spread (85.30 cm) and leaf area (203.57 cm^2) were recorded under treatment K_3 (150 kg K/ha)**.** Application of 100 kg K/ha provided the optimal potassium supply necessary for maintaining osmotic balance, enhancing photosynthetic efficiency, facilitating assimilate translocation and supporting nutrient uptake, resulting in maximum plant height, leaf length, number of leaves, plant spread and leaf area. In contrast, 150 kg K/ha induced nutrient antagonism, mild osmotic stress and reduced photosynthetic activity, ultimately suppressing vegetative growth in spider lily.

The results of the present investigation are in close conformity with those reported by Sahu *et al.* (2021) [3] in chrysanthemum, who observed that the application of potassium at 150 kg ha^{-1} resulted in significantly higher plant height (41.50 cm), while the minimum (39.10 cm) was recorded under 200 kg ha^{-1} and further noted that potassium

application at 150 kg ha^{-1} (K_2) significantly increased the number of leaves per plant (68.7), whereas the minimum (59.5) was observed under 100 kg ha^{-1} (K_1). These findings are further supported by Verma *et al.* (2023) [9] in gomphrena.

Table 1: Effect of NPK doses on plant height, leaf length, number of leaves per plant, plant spread and leaf area of spider lily at 120 DAC.

Treatment	Plant height (cm)	Leaf length (cm)	Number of leaves per plant	Plant spread (cm)	Leaf area (cm^2)
Nitrogen (kg N/ha)					
N_1-200	69.07	60.42	75.82	84.10	197.32
N_2-250	75.64	66.27	82.67	91.76	219.03
N_3-300	74.33	65.24	81.23	91.15	215.80
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.71	0.61	0.89	0.87	2.76
CD at 5%	2.08	1.77	2.60	2.54	8.02
Phosphorus (kg P/ha)					
P_1-50	69.48	61.66	75.68	85.11	199.59
P_2-100	76.55	66.61	84.39	92.63	221.42
P_3-150	73.02	63.25	79.65	89.26	211.43
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.71	0.61	0.89	0.87	2.76
CD at 5%	2.08	1.77	2.60	2.54	8.02
Potassium (kg K/ha)					
K_1-50	72.36	64.05	79.84	88.71	210.62
K_2-100	77.60	67.09	83.83	92.99	218.24
K_3-150	69.07	60.79	76.04	85.30	203.57
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.71	0.61	0.89	0.87	2.76
CD at 5%	2.08	1.77	2.60	2.54	8.02
Interactions					
N x P	Sig.	Sig.	Sig.	Sig.	Sig.
N x K	NS.	NS.	NS.	NS.	NS.
P x K	NS.	NS.	NS.	NS.	NS.
N x P x K	NS.	NS.	NS.	NS.	NS.

Interaction effect of nitrogen x phosphorus

At 120 DAC, the treatment combination N_2P_2 (250 kg N/ha + 100 kg P/ha) recorded maximum plant height (78.52 cm), leaf length (69.62 cm), number of leaves per plant (87.19), plant spread (95.55 cm) and leaf area (230.62 cm²) during 2022-2023 and was statistically at par with N_3P_2 (300 kg N/ha + 100 kg P/ha). In contrast, the minimum plant height (62.86 cm), leaf length (59.42 cm), number of leaves per plant (68.35), plant spread (77.09 cm) and leaf area (176.23 cm²) were observed under the N_1P_1 (200 kg N/ha + 50 kg P/ha) treatment.

The superior vegetative performance observed under the 250 kg N/ha + 100 kg P/ha combination may be attributed to optimum nutrient availability, improved photosynthetic activity and better root-shoot coordination. In contrast, the lowest values under 200 kg N/ha + 50 kg P/ha were likely due to combined nitrogen and phosphorus deficiencies, resulting in reduced metabolic activity and poor vegetative growth. Although the higher nutrient combination (300 kg N/ha + 150 kg P/ha) supplied greater nutrient availability, diminishing returns and nutrient imbalance restricted further improvement, resulting in growth statistically comparable to the optimum dose. These findings are supported by Dorajeerao *et al.* (2012) [2], who reported in chrysanthemum that maximum plant height (120.08 cm) occurred under N_3P_3 (200:200 N:P kg/ha) and the minimum (89.70 cm) under N_0P_0 (0:0 N:P kg/ha). Comparable results were reported by Sharma *et al.* (2013) [13] in *Barleria cristata*. Further support is provided by Kumar and Kumar (2014) [8], who noted that the application of 300 kg N + 200 kg P resulted in the highest plant height (62.87 cm), number of primary branches (25.20), number of leaves (160.07) and significant plant spread (29.60 cm) in china aster.

Table 2: Interaction effects of N x P doses on plant height, leaf length, number of leaves per plant, plant spread and leaf area of spider lily at 120 DAC

N x P	Plant height (cm)	Leaf length (cm)	Number of leaves per plant	Plant spread (cm)	Leaf area (cm^2)
N_1P_1	62.86	59.42	68.35	77.09	176.23
N_1P_2	73.30	61.53	81.03	88.19	209.9
N_1P_3	71.05	60.33	78.06	87.03	205.83
N_2P_1	73.65	63.26	79.39	89.21	212.7
N_2P_2	78.52	69.62	87.19	95.55	230.62
N_2P_3	74.75	65.94	81.44	90.53	214.63
N_3P_1	71.92	60.47	79.3	89.05	209.84
N_3P_2	77.81	69.53	84.94	94.16	223.74
N_3P_3	73.26	65.73	79.46	90.23	213.84
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) ±	1.24	1.05	1.55	1.51	4.78
CD at 5%	3.60	3.07	4.50	4.40	13.90

Interaction effects of N x K, P x K and N x P x K

Data presented in Table 1 revealed that, the interaction effects of N × K, P × K and N × P × K combinations on plant height, leaf length, number of leaves per plant, plant spread, leaf area of spider lily were found to be non-significant during both the years of experimentation.

Flower bud yield parameters

During study, various flower bud yield parameters, such as the number of flower buds per plant, number of flower buds per plot, number of flower buds per hectare and number of flower bundles per hectare were significantly influenced by the different treatment levels of N, P and K**.**

Effect of nitrogen

Application of 250 kg N/ha (N_2) resulted in the maximum number of flower buds per plant (307.38), number of flower buds per plot per year (6,147.50), number of flower buds per hectare per year (56,91,970.25) and the highest number of flower bundles per hectare (113,839.41). In contrast, the minimum number of flower buds per plant (249.22), number of flower buds per plot per year (4,984.34), number of flower buds per hectare per year (46,15,004.52) and number of flower bundles per hectare (92,300.09) were recorded under the application of 200 kg N/ha (N_1)**.** The superior performance at 250 kg N/ha may be attributed to an adequate nitrogen supply, which is essential for promoting vegetative growth, protein synthesis and chlorophyll formation, all of which support flower bud initiation and development. At 200 kg N/ha, comparatively lower nitrogen availability may have restricted these physiological processes, resulting in reduced flower bud production. In contrast, 250 kg N/ha provided optimal nutrient availability, enhancing overall growth and flowering without causing nutrient imbalance.

The present findings are in close agreement with those of Barad *et al.* (2010) [1], who reported that the application of

20 g N/m² significantly improved flowering in Gerbera cv. Sangria, producing approximately 8.7 flowers per plant, equivalent to about 4.83 lakh flowers per hectare. Similar results were recorded by Dorajeerao *et al.* (2012) [2] in garland chrysanthemum and by Nain (2023) [10] in tuberose.

Effect of phosphorus

The data pertaining to the number of flower buds per plant, number of flower buds per plot per year, number of flower buds per hectare per year and number of flower bundles per hectare in spider lily, as influenced by phosphorus application, were found to be statistically significant and presented in Table 3. The application of 100 kg P/ha (P_2) recorded the maximum number of flower buds per plant (309.10), number of flower buds per plot per year (6,181.96), per hectare per year (57,23,872.65) and flower bundles per hectare per year (114,477.45), followed by the application of 150 kg P/ha (P_3). In contrast, the minimum number of flower buds per plant (261.74), number of flower buds per plot per year (5,234.77), per hectare per year (48,46,870.46) and flower bundles per hectare per year (96,937.41) was observed under 50 kg P/ha (P_1). The best performance under 100 kg P/ha (P_2) may be attributed to the crucial role of phosphorus in energy transfer through ATP, nucleic acid synthesis, and cell division all of which are essential for flower bud initiation and development. Adequate phosphorus availability at this level enhances these physiological and metabolic processes, thereby promoting better flowering. In contrast, the lower phosphorus dose of 50 kg/ha limits nutrient availability, restricting energy metabolism and cellular activities required for flower formation, ultimately resulting in fewer flower buds. These findings are in agreement with those of Barad *et al.* (2010) [1] in gerbera, who reported that the application of 10 g of phosphorus per m² produced approximately 7.9 flowers per plant in winter (4.44 lakh flowers/ha) and 19.5 flowers per plant annually (10.85 lakh flowers/ha). Similar results were also documented by Dorajeerao *et al.* (2012) [2] in chrysanthemum.

Effect of potassium

The data presented in Table 2 indicated that, the effect of different doses of potassium on the number of flower buds per plant, number of flower buds per plot per year, per hectare per year and the number of flower bundles per hectare was statistically significant.

The application of 100 kg K/ha (K_2) recorded the maximum number of flower buds per plant (317.04), number of flower buds per plot per year (6,340.97), number of flower buds per hectare per year (58,71,111.34) and number of flower bundles per hectare (117,422.22), followed by K_1 (50 kg K/ha). In contrast, the minimum number of flower buds per plant (248.90), number of flower buds per plot per year (4,978.18), number of flower buds per hectare per year (46,09,305.09) and number of flower bundles per hectare (92,186.10) was observed under the highest potassium level of 150 kg K/ha (K_3). The best performance under 100 kg K/ha can be attributed to the fact that this dose facilitates balanced nutrient uptake and maintains physiological homeostasis, thereby supporting efficient metabolic activities essential for flowering. Optimal potassium availability promotes enzyme activation, osmoregulation, translocation of photosynthates and overall reproductive development. However, the higher dose of 150 kg K/ha likely induced nutrient imbalances by antagonizing the uptake of essential cations such as calcium and magnesium, leading to physiological stress and reduced flower bud formation, ultimately resulting in lower flowering compared with the optimal potassium dose.

These findings align with those of Barad *et al.* (2010) [1], who reported that the application of potassium @ 20 g/m² (K_1) increased gerbera yield from 21.65 to 24.55 flowers per plant, enhancing annual production to approximately 13.64 lakh flowers per hectare.

Table 3: Effect of N, P and K on number of flower buds per plant, per plot, per hectare per year and number of flower bundles per hectare per year in spider lily.

Treatment	Number of flower buds per plant per year	Number of flower buds per plot per year	Number of flower buds per hectare per year	Number of flower bundles per hectare per year
Nitrogen (kg N/ha)				
N_1-200	249.22	4984.34	4615004.52	92300.09
N_2-250	307.38	6147.50	5691970.25	113839.41
N_3-300	295.79	5915.86	5477490.66	109549.81
'F' test	Sig.	Sig.	Sig.	Sig.
SE (m) ±	2.64	52.95	49032.89	980.65
CD at 5%	7.69	4984.34	4615004.52	92300.09
Phosphorus (kg P/ha)				
P_1-50	261.74	5234.77	4846870.46	96937.41
P_2-100	309.10	6181.96	5723872.65	114477.45
P_3-150	281.55	5623.98	5213722.32	104274.45
'F' test	Sig.	Sig.	Sig.	Sig.
SE (m) ±	2.64	52.95	49032.89	980.65
CD at 5%	7.69	153.94	142536.54	2850.73
Potassium (kg K/ha)				
K_1-50	286.42	5728.53	5304049.01	106080.98
K_2-100	317.04	6340.97	5871111.34	117422.22
K_3-150	248.90	4978.18	4609305.09	92186.10
'F' test	Sig.	Sig.	Sig.	Sig.
SE (m) ±	2.64	52.95	49032.89	980.65
CD at 5%	7.69	153.94	142536.54	2850.73
Interactions				
N x P	Sig.	Sig.	Sig.	Sig.
N x K	NS.	NS.	NS.	NS.
P x K	NS.	NS.	NS.	NS.
N x P x K	Sig.	Sig.	Sig.	Sig.

Interaction effect of nitrogen x phosphorus

The data presented in Table 4 showed that the interaction effects of nitrogen and phosphorus doses had a significant influence on the number of flower buds per plant, number of flower buds per plot and per hectare per year and number of flower bundles per hectare.

During the experimentation, treatment combination N_2P_2 (250 kg N/ha + 100 kg P/ha) produced a significantly maximum number of flower buds per plant (332.74), number of flower buds per plot per year (6,654.70), number of flower buds per hectare per year (61,61,586.73) and flower bundles per hectare per year (123,231.73). This treatment was statistically at par with N_3P_2 (300 kg N/ha + 100 kg P/ha)**.** In contrast, the minimum number of flower buds per plant (211.27), number of flower buds per plot per year (4,225.43), number of flower buds per hectare per year (39,12,328.72) and flower bundles per hectare per year (78,246.57) were recorded under the treatment combination N_1P_1 (200 kg N/ha + 50 kg P/ha)**.** The superior performance of N_2P_2 combination can be attributed to the complementary roles of nitrogen and phosphorus. Nitrogen enhances vegetative growth, protein synthesis and chlorophyll formation, while phosphorus is essential for energy transfer (ATP), nucleic acid synthesis and strong root development. Together, these nutrients improve metabolic efficiency, promote nutrient uptake and facilitate optimal flower bud initiation and development. Conversely, lower nutrient availability under 200 kg N/ha and 50 kg P/ha limited physiological activity and reduced flowering potential.

These results are in agreement with the findings of Dorajeerao *et al.* (2012) [2] in garland chrysanthemum, who reported that the treatment combination N_2P_1 (150:100 kg N:P/ha) produced the maximum number of flowers per plant (30.52 and 47.31) and per hectare (6.86 t and 11.49 t) during the kharif season, while the lowest per plant (14.45 and 22.39) and per hectare (1.09 t and 1.83 t) yields were recorded under the N_0P_0 (00:00 kg N:P/ha) treatment during kharif and rabi seasons.

Table 4: Interaction effect of different N x P doses on, number of flower buds per plant, per plot per, per hectare per year and number of flower bundles per hectare per year.

N x P	Number of flower buds per plant per year	Number of flower buds per plot per year	Number of flower buds per hectare per year	Number of flower bundles per hectare per year
N_1P_1	211.27	4225.43	3912328.72	78246.57
N_1P_2	276.48	5529.60	5119856.64	102397.13
N_1P_3	259.90	5198.00	4812828.20	96256.56
N_2P_1	293.33	5866.60	5431884.94	108637.70
N_2P_2	332.74	6654.70	6161586.73	123231.73
N_2P_3	296.06	5921.20	5482439.08	109648.78
N_3P_1	280.61	5612.27	5196397.71	103927.95
N_3P_2	318.08	6361.57	5890174.58	117803.49
N_3P_3	288.69	5773.73	5345899.69	106917.99
'F' test	Sig.	Sig.	Sig.	Sig.
SE (m) ±	4.58	91.72	84927.46	1698.54
CD at 5%	13.33	266.63	246880.53	4937.61

Interaction effects of N x K and P x K

The data presented in Table 3 revealed that, an interaction effects of N x K and P x K was found non - significant.

2.6 Interaction effects of N x P x K

The interaction effects of nitrogen, phosphorus and potassium (NPK) were found significant and presented in table 5. The maximum number of flower buds per plant (397.35), number of flower buds per plot per year (7,946.90), number of flower buds per hectare per year (73,58,034.71) and flower bundles per hectare per year (1,47,160.69) were recorded in the treatment combination $N_2P_2K_2$ (250:100:100 kg NPK/ha), followed by the treatment combination $N_3P_2K_2$ (300:100:100 kg NPK/ha). In contrast, minimum number of flower buds per plant (158.12), number of flower buds per plot per year (3,162.30), number of flower buds per hectare per year (29,27,973.57) and flower bundles per hectare per year (58,559.47) were observed in the treatment combination $N_1P_1K_3$ (200:50:150 kg NPK/ha).

The fertilizer combination $N_2P_2K_2$ (250:100:100 kg NPK/ha) produced the maximum number of flower buds per plant, per plot and per hectare per year. This balanced supply of nitrogen, phosphorus and potassium supports essential physiological processes like vegetative growth, energy transfer, enzyme activation and nutrient translocation needed for flower bud development. In contrast, the treatment combination $N_1P_1K_3$ (200:50:150 kg NPK/ha) recorded the minimum number of flower buds. Lower nitrogen and phosphorus levels in this treatment limited vital metabolic activities. Additionally, excessive potassium (150 kg/ha) may have caused nutrient imbalances by interfering with the uptake of other essential nutrients. These factors together reduced flower bud formation under the lower N and P but higher K dose.

Barad *et al.*, (2010) [1] recorded that the synergistic combination of $N_2P_2K_1$ (i.e., 20:10:20 NPK g/m^2) amplified this effect tripling flower counts to over 24 flowers per plant and boosting yield to approximately 13.64 lakh flowers per hectare.

Table 5: Interaction effects of nitrogen x phosphorus x potassium on number of flower buds per plant, per plot, per hectare per year and number of flower bundles per hectare per year in spider lily.

N x P x K	Number of flower buds per plant per year	Number of flower buds per plot per year	Number of flower buds per hectare per year	Number of flower bundles
$N_1P_1K_1$	216.24	4324.80	4004332.32	80086.65
$N_1P_1K_2$	259.46	5189.20	4804680.28	96093.61
$N_1P_1K_3$	158.12	3162.30	2927973.57	58559.47
$N_1P_2K_1$	279.97	5599.30	5184391.87	103687.84
$N_1P_2K_2$	303.52	6070.40	5620583.36	112411.67
$N_1P_2K_3$	245.96	4919.10	4554594.69	91091.89
$N_1P_3K_1$	265.62	5312.40	4918751.16	98375.02
$N_1P_3K_2$	284.63	5692.50	5270685.75	105413.72
$N_1P_3K_3$	229.46	4589.10	4249047.69	84980.95
$N_2P_1K_1$	299.04	5980.70	5537530.13	110750.60
$N_2P_1K_2$	307.85	6157.00	5700766.30	114015.33
$N_2P_1K_3$	273.11	5462.10	5057358.39	101147.17
$N_2P_2K_1$	314.69	6293.70	5827336.83	116546.74
$N_2P_2K_2$	397.35	7946.90	7358034.71	147160.69
$N_2P_2K_3$	286.18	5723.50	5299388.65	105987.77
$N_2P_3K_1$	303.32	6066.40	5616879.76	112337.60
$N_2P_3K_2$	323.48	6469.50	5990110.05	119802.20
$N_2P_3K_3$	261.39	5227.70	4840327.43	96806.55
$N_3P_1K_1$	289.85	5796.90	5367349.71	107346.99
$N_3P_1K_2$	309.12	6182.40	5724284.16	114485.68
$N_3P_1K_3$	242.88	4857.50	4497559.25	89951.19
$N_3P_2K_1$	327.33	6546.50	6061404.35	121228.09
$N_3P_2K_2$	346.01	6920.20	6407413.18	128148.26
$N_3P_2K_3$	280.90	5618.00	5201706.20	104034.12
$N_3P_3K_1$	281.81	5636.10	5218464.99	104369.30
$N_3P_3K_2$	322.04	6440.70	5963444.13	119268.88
$N_3P_3K_3$	262.22	5244.40	4855789.96	97115.80
'F' test	Sig.	Sig.	Sig.	Sig.
SE (m) ±	7.94	158.87	147098.67	2941.97
CD at 5%	23.09	461.83	427609.62	8552.19

Conclusion

On the basis of data vegetative growth parameters plant height, leaf length, number of leaves, plant spread and leaf area measured at 120 days after planting were significantly enhanced with the application of 250 kg N/ha, 100 kg P/ha, 100 kg K/ha and their combined application of 250 kg N/ha + 100 kg P/ha. Similarly, flower yield attributes, including number of flower buds per plant, per plot and per hectare, as well as the number of flower bundles, recorded their highest values under the application of 250 kg N/ha, 100 kg P/ha, 100 kg K/ha and the combined nutrient doses of 250 kg N/ha + 100 kg P/ha and 250 kg N/ha + 100 kg P/ha + 100 kg K/ha. Overall, study confirms that balanced and adequate doses of nitrogen, phosphorus and potassium are essential for maximizing both vegetative growth and flower bud yield in spider lily.

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