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EFFECT OF GRADED LEVELS OF NITROGEN AND PHOSPHORUS ON GROWTH AND YIELD OF GLADIOLUS (*GLADIOLUS GRANDIFLORUS* L.) CV. WHITE PROSPERITY IN COASTAL A.P., INDIA

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Abstract

A study was conducted to evaluate the effect of graded doses of nitrogen and phosphorus on growth and yield of gladiolus at Horticultural College and Research Institute, Venkataramannagudem in 2012-13. The spike yield was maximum with nitrogen dose of 300 kg ha^{-1}, phosphorus dose of 200 ha^{-1} both individually and in combination. The total weight of corm per plant was maximum with the treatment combination of nitrogen at 400 kg ha^{-1} plus phosphorus at 200 kg ha^{-1}. The vegetative parameters like plant height, number of leaves, leaf area, dry weight of leaves, dry weight of flower, growth parameters like leaf area index (LAI), crop growth rate (CGR), net assimilation rate (NAR) and the uptake of nitrogen and phosphorus was recorded highest with a dose of nitrogen at 300 kg ha^{-1} plus phosphorus at 200 kg ha^{-1}. Even though, the fertilizer dose of nitrogen at 400 kg ha^{-1} plus phosphorus at 200 kg ha^{-1} was good at initial crop growth stages, the same was not continued in the later stages with respect to the growth parameters.

Key words : Gladiolus, nitrogen, phosphorus, spike and corm.

Introduction

In the growing towns and cities of coastal Andhra Pradesh, utility of cut flowers and search for easily available modern cut flowers is at increasing trend. Any attempt to encourage cut flower production in the region not only helps the florists and consumers to get fresh and quality cut flowers regularly, but also helps the small and marginal farmers in the region to improve their economic condition. Agro techniques of these flower crops have to be standardized with respect to coastal Andhra Pradesh conditions in general and Venkataramannagudem in particular.

Gladiolus belongs to the family Iridaceae. The crop is a native to South Africa and was introduced into India during early part of 19th century (Apte, 1959). Different agro-techniques play an important role in the growth and development of gladiolus crop and among them nutrition is one of the utmost important aspects, which directly influences spike yield and quality. Gladiolus being highly responsive crop to nutrition, requires large doses of macro nutrients *viz*., nitrogen, phosphorus and potassium (Shankar and Dubey, 2005).

Materials and Methods

The soils of Venkataramannagudem area are red loams, which are graded as high in nitrogen (186 kg ha^{-1}), high in phosphorus (32.5 kg ha^{-1}) and medium to high in potassium (215 kg ha^{-1}). The area receives an average of 900 mm rain fall, a major proportion of which is received during June to October *i.e.* by S-W monsoon. The experiment on the effect of graded levels of nitrogen and phosphorus on growth, yield and quality of gladiolus was conducted at Horticultural College and Research Institute, Venkataramannagudem (A.P.), India with an objective of finding out the best combination of nitrogen and phosphorus dose that would result in superior performance in respect of growth, yield and quality of gladiolus flowers. The experiment was conducted with four levels of nitrogen (100, 200, 300 and 400 kg ha^{-1}) and four levels of phosphorus in terms of P_2O_5 (100, 150, 200 and 250 kg ha^{-1}) making sixteen treatment combinations in Factorial Randomised Block Design with three replications. The net plot size was 2.7 m × 1.8 m with a spacing of 30 cm × 20 cm.

Table 1: Plant height (cm) as influenced by nitrogen, phosphorus and their interactions in gladiolus cv. White prosperity

Treatment	30 DAP					60 DAP					90DAP				
	P_1	P_2	P_3	P_4	Mean	P_1	P_2	P_3	P_4	Mean	P_1	P_2	P_3	P_4	Mean
N_1	24.00	24.23	25.42	25.43	24.77	45.50	50.86	51.82	53.63	50.45	70.25	72.12	73.25	74.32	72.48
N_2	26.32	27.50	28.00	28.46	27.57	56.42	60.00	61.00	61.33	59.68	74.96	77.38	83.83	85.34	80.37
N_3	26.42	28.50	30.00	33.92	29.71	56.96	62.56	74.32	64.89	64.68	75.00	88.12	106.6	93.25	90.74
N_4	27.82	27.25	31.32	29.23	28.90	60.21	59.26	67.08	64.08	62.15	81.00	76.96	97.01	91.65	86.65
Mean	26.14	26.87	28.68	29.26	27.73	54.77	58.17	63.55	60.98	59.24	75.30	78.64	90.17	86.14	82.56
	SEm±			**CD at 5%**		**SEm±**			**CD at 5%**		**SEm±**			**CD at 5%**	
N	0.33			0.96		0.60			1.74		0.54			1.58	
P	0.33			0.96		0.60			1.74		0.54			1.58	
N × P	0.66			1.92		1.20			3.48		1.08			3.16	

Table 2: Number of leaves as influenced by nitrogen, phosphorus and their interactions in gladiolus cv. White prosperity

Treatment	30 DAP					60 DAP					90DAP				
	P_1	P_2	P_3	P_4	Mean	P_1	P_2	P_3	P_4	Mean	P_1	P_2	P_3	P_4	Mean
N_1	3.40	3.47	3.55	3.60	3.50	5.26	5.33	5.46	5.56	5.40	7.75	8.36	8.68	8.96	8.43
N_2	3.60	4.12	4.34	4.26	4.08	5.98	6.50	7.52	7.20	6.80	9.12	9.26	12.56	10.68	10.40
N_3	3.87	4.26	4.42	4.40	4.23	6.24	7.40	8.33	7.92	7.47	9.20	12.25	13.45	12.80	11.92
N_4	4.12	3.76	4.65	4.24	4.19	6.96	5.80	7.60	6.98	6.83	10.21	9.16	12.62	11.00	10.74
Mean	3.74	3.90	4.24	4.12	4.00	6.11	6.25	7.22	6.91	6.62	9.07	9.75	11.82	10.86	10.37
	SEm±			**CD at 5%**		**SEm±**			**CD at 5%**		**SEm±**			**CD at 5%**	
N	0.10			0.31		0.14			0.41		0.19			0.56	
P	0.10			0.31		0.14			0.41		0.19			0.56	
N × P	0.20			N.S.		0.28			0.82		0.38			1.12	

Table 3 : Leaf area (cm^2) as influenced by nitrogen, phosphorus and their interactions in gladiolus cv. White prosperity.

Treatment	30 DAP					60 DAP					90DAP				
	P_1	P_2	P_3	P_4	Mean	P_1	P_2	P_3	P_4	Mean	P_1	P_2	P_3	P_4	Mean
N_1	161.20	172.90	177.80	179.00	172.70	540.10	590.00	619.20	635.20	596.10	780.60	796.70	806.34	835.60	804.83
N_2	179.80	185.00	194.90	196.10	188.90	678.40	698.80	780.10	745.60	725.70	915.30	932.60	956.40	930.00	933.61
N_3	180.90	193.10	201.200	197.20	193.10	695.30	775.60	894.50	814.30	794.90	914.10	946.20	1120.90	993.20	993.66
N_4	183.80	180.80	194.90	184.20	185.90	712.90	643.10	781.10	736.10	718.30	926.20	898.90	959.90	928.70	928.49
Mean	176.40	182.90	192.20	189.10	185.15	656.70	676.90	768.70	732.80	708.70	884.10	893.60	960.90	921.90	915.14
	SEm±			**CD at 5%**		**SEm±**			**CD at 5%**		**SEm±**			**CD at 5%**	
N	1.19			3.44		2.01			5.82		5.94			17.18	
P	1.19			3.44		2.01			5.82		5.94			17.18	
N × P	2.38			6.88		4.03			11.65		11.88			34.37	

Table 4: Dry weight (g) of leaves as influenced by nitrogen, phosphorus and their interactions in gladiolus cv. White prosperity

Treatment	30 DAP					60 DAP					90DAP				
	P_1	P_2	P_3	P_4	Mean	P_1	P_2	P_3	P_4	Mean	P_1	P_2	P_3	P_4	Mean
N_1	2.62	2.86	3.05	3.28	2.95	6.92	7.43	8.93	10.07	8.338	8.00	8.520	9.97	11.12	9.40
N_2	3.52	4.50	5.08	7.60	5.17	10.76	11.37	13.47	16.08	12.92	12.03	13.08	17.06	18.52	15.17
N_3	5.10	5.62	9.30	8.54	7.14	11.71	12.63	19.70	19.31	15.83	13.92	15.50	22.43	21.19	18.26
N_4	6.40	6.82	9.03	8.02	7.56	14.62	15.13	18.46	17.92	16.53	17.97	18.20	22.08	20.15	19.60
Mean	4.41	4.95	6.61	6.86	5.70	11.00	11.64	15.14	15.84	13.40	12.98	13.82	17.88	17.74	15.60
		SEm±		CD at 5%			SEm±		CD at 5%			SEm±		CD at 5%	
N		0.14		0.42			0.28		0.81			0.22		0.64	
P		0.14		0.42			0.28		0.81			0.22		0.64	
N × P		0.29		0.84			0.56		1.62			0.44		1.29	

Results and Discussion

Plant height (cm)

Plant height showed significant differences among the different graded levels of nitrogen and phosphorus and their interactions at 30, 60 and 90 days after planting (table 1). The mean plant height increased from 27.73 cm at 30 DAP to 82.56 cm at 90 DAP. At 90 DAP, N_3 (90.74 cm) recorded maximum height followed by N_4 (86.65 cm) and among phosphorus levels, P_3 registered the highest (90.17 cm) followed by P_4 (86.14 cm). Among interaction effects, N_3P_3 recorded the highest plant height (106.6 cm) which was followed by N_4P_3 (97.01 cm) and the minimum (72.48 cm) was found in N_1, P_1 (75.30 cm) and N_1P_1 (70.25 cm).

The increased plant height obtained at higher doses on different days after planting revealed that nitrogen had an encouraging effect on plant height as it forms an important constituent of chlorophyll, proteins and amino acids, which can be also confirmed by the data on nitrogen content. This might had resulted in better photosynthesis. Phosphorus stimulates generation of rootlets and nurture the roots. It is also an important constituent in energy rich compounds and thus an indispensable element in energy metabolism. This is involved in the synthesis of growth stimulating compounds, absorption of nutrients, cell division and cell growth which might result in vigorous growth. On the other hand, plants with low levels of nitrogen and phosphorus were under developed and shorter in stature. These results are in confirmation with the findings of Shaukat *et al.* (2012), Kumar and Misra (2011), Patel *et al.* (2010), Mahgoub *et al.* (2006) in gladiolus.

Number of leaves

The data on number of leaves produced at different stages of crop growth as influenced by graded levels of nitrogen and phosphorus and their interactions are presented in table 2. The mean number of leaves increased from 4.0 at 30 DAP to 10.37 at 90 DAP. The differences among the values of number of leaves were found significant at all stages of crop growth except at 30 DAP.

At 90 DAP, N_3 registered maximum number of leaves per plant (11.92) which was on par with N_4 (10.74) followed by N_2 (10.40). P_3 recorded the highest number of leaves (11.82) per plant followed by P_4 (10.86) and the lowest (8.43) was recorded by N_1 and P_1 (9.07). Among the interactions, N_3P_3 recorded highest number of leaves (13.45) which was at par with N_3P_4 (12.80), N_4P_3 (12.62) and N_2P_3 (12.56) followed by N_3P_2 (12.25). Number of leaves per plant was recorded at minimum

Table 5 : Dry weight (g) of stem and flower at final harvest as influenced by nitrogen, phosphorus and their interactions in gladiolus cv. White prosperity.

Treatment	Dry weights of stem (g)					Dry weights of flower (g)				
	P_1	P_2	P_3	P_4	Mean	P_1	P_2	P_3	P_4	Mean
N_1	2.33	2.45	2.72	2.98	2.62	0.04	0.05	0.05	0.05	0.05
N_2	3.26	3.86	4.42	4.78	4.08	0.05	0.05	0.06	0.05	0.05
N_3	4.05	4.20	4.84	5.03	4.53	0.06	0.06	0.08	0.07	0.07
N_4	4.53	4.67	5.46	5.24	4.97	0.06	0.07	0.06	0.06	0.06
Mean	3.54	3.79	4.36	4.50	4.05	0.05	0.06	0.06	0.06	0.06
	SEm±			CD at 5%		SEm±			CD at 5%	
N	0.11			0.33		0.0004			0.001	
P	0.11			0.33		0.0004			0.001	
N × P	0.22			N.S.		0.0008			0.002	

Table 6 : Total dry weight of plant and spike at harvest as influenced by nitrogen, phosphorus and their interactions in gladiolus cv. White prosperity

Treatment	Total dry weight of plant (g)					Dry weight of spike at final harvest (g)				
	P_1	P_2	P_3	P_4	Mean	P_1	P_2	P_3	P_4	Mean
N_1	10.87	11.56	13.00	14.39	12.45	2.38	2.50	2.77	3.03	2.67
N_2	14.90	18.22	22.60	25.24	20.24	3.31	3.91	4.48	4.83	4.13
N_3	17.90	23.05	28.93	27.4	24.32	4.11	4.26	4.91	5.10	4.59
N_4	22.76	20.80	27.89	26.48	24.48	4.59	4.74	5.52	5.30	5.04
Mean	16.60	18.40	23.10	23.38	20.37	3.60	3.85	4.42	4.57	4.10
	SEm±			CD at 5%		SEm±			CD at 5%	
N	0.16			0.46		0.11			0.33	
P	0.16			0.46		0.11			0.33	
N × P	0.32			0.92		0.22			N.S.	

(7.75) in N_1P_1, which was on par with N_1P_2 (8.36) and N_1P_3 (8.68). These findings are in accordance with Javid *et al.* (2005) in zinnia (*Zinnia elegans*) cv. Giant Dahlia Flowered Blue Point Series, Devi and Singh (2010) in tuberose, Kumar and Misra (2011) and Shaukat *et al.* (2012) in gladiolus.

Leaf area (cm^2)

There were significant differences in leaf area due to the graded levels of nitrogen and phosphorus and their interaction at different stages of crop growth (table 3). The mean leaf area increased from 185.85 cm^2 at 30 DAP to 915.14 cm^2 90 DAP. At 90 DAP maximum leaf area was obtained by N_3 (993.66 cm^2) followed by N_2 (933.61 cm^2), P_3 (960.90 cm^2) followed by P_4 (921.90 cm^2) and N_3P_3 (1120.90 cm^2) followed by N_3P_4 (993.20 cm^2). The corresponding minimum values were recorded by N_1 (804.83 cm^2), P_1 (884.10 cm^2) and N_1P_1 (780.6 cm^2) followed by N_1P_2 (796.70 cm^2).

A comparative examination of leaf area and number of leaves per plant indicated that more the number of leaves per plant more was the leaf area both being lesser at lower nutrient doses as compared to higher nutrient doses. The number of leaves per plant and leaf area was constantly increasing in the plants receiving N_3P_3. As compared to higher levels of nitrogen and phosphorus significant increase in both these parameters was found to record only up to this level clearly establishing the optimum degree of these levels under local agro-cllimatic conditions. Similar findings were reported by Shaukat *et al.* (2012), Kumar and Misra (2011), Patel *et al.* (2010), Mahgoub *et al.* (2006), Haitbura and Misra (1999), Parthiban and Khadar (1991) in gladiolus.

Dry weight of leaves (g) at 30, 60 and 90 DAP

Dry weight of leaf differed significantly due to nitrogen, phosphorus as well as their interaction at all growth stages except at 30 DAP (table 4). The mean dry weight of leaves increased from 5.70 g at 30 DAP to 15.60 g at 90 DAP. At 60 DAP the highest dry weight of leaves was obtained with N_4 (16.53 g), which was on par with N_3 (15.83 g), but significantly different from N_2 (12.92 g). The dry weights of leaves at 90 DAP was maximum in N_4 (19.60 g), which was on par with N_3 (18.26 g) and among phosphorus levels highest dry weight of leaves was obtained in P_3 (17.88 g), which was on par with P_4 (17.74 g). The combination of N_3P_3 registered the highest leaf dry weight (22.43 g), which was on par

Table 7: Leaf area index as influenced by nitrogen, phosphorus and their interactions in gladiolus cv. White prosperity

Treatment	30 DAP					60 DAP					90DAP				
	P_1	P_2	P_3	P_4	Mean	P_1	P_2	P_3	P_4	Mean	P_1	P_2	P_3	P_4	Mean
N_1	0.26	0.28	0.29	0.29	0.28	0.90	0.98	1.03	1.05	0.99	1.30	1.32	1.34	1.39	1.33
N_2	0.29	0.30	0.32	0.32	0.30	1.13	1.16	1.30	1.24	1.20	1.52	1.55	1.59	1.55	1.55
N_3	0.32	0.30	0.32	0.32	0.31	1.15	1.29	1.49	1.29	1.30	1.52	1.57	1.80	1.60	1.62
N_4	0.30	0.30	0.32	0.30	0.30	1.18	1.07	1.30	1.22	1.19	1.50	1.40	1.59	1.54	1.50
Mean	0.28	0.30	0.31	0.30	0.30	1.09	1.12	1.28	1.20	1.17	1.46	1.46	1.58	1.52	1.50
		SEm±			**CD at 5%**		**SEm±**			**CD at 5%**		**SEm±**			**CD at 5%**
N		0.01			0.02		0.01			0.04		0.01			0.03
P		0.01			N.S.		0.01			0.04		0.01			0.03
N × P		0.02			N.S.		0.02			0.08		0.02			0.06

with N_4P_3 (22.08 g) and N_3P_4 (21.19 g). The lowest dry weight of leaves was recorded by N_1 (9.40 g), P_1 (12.98 g) and N_1P_1 (8.0 g).

Dry weight of stem at 90 DAP

The data on dry weight of stem at 90 DAP as influenced by various levels of nitrogen and phosphorus are presented in table 5. The highest dry weight of stem was registered in N_4 (4.97 g), P_4 (4.50 g) and N_4P_3 (5.46 g) whereas, the lowest dry weight was recorded by N_1 (2.62 g), P_1 (3.54 g) and N_1P_1 (2.33 g).

Dry weight of florets at 90 DAP

The dry weights of flower significantly differed due to various levels of nitrogen and phosphorus and their interaction (table 5). The maximum dry weight of the flower (0.07 g) was recorded in N_3 among nitrogen levels which was on par with N_4 (0.06 g) and P_3 (0.065 g) among phosphorus levels. With respect to interactions, N_3P_3 recorded the height dry weight of the flower (0.078g).

Dry weight of whole plant and spike at final harvest

The data on total dry weight of whole plant as influenced by various levels of nitrogen and phosphorus are presented in table 6. The highest dry weight of whole plant was registered in N_4 (24.48 g), P_4 (23.38 g) and N_4P_3 (27.89 g) whereas, the lowest dry weight was recorded by N_1 (12.45 g), P_1 (16.60 g) and N_1P_1 (10.87 g). N_4 was on par with N_3 (24.32 g) and P_4 was on par with P_3 (23.10 g).

The highest dry weight of spike was registered in N_4 (5.04 g), P_4 (4.57 g) and N_4P_3 (5.52 g) whereas, the lowest dry weight was recorded by N_1 (2.67 g), P_1 (3.60 g) and N_1P_1 (2.38 g). N_4 was on par with N_3 (4.59 g) and P_4 was on par with P_3 (4.42 g).

Leaf area index

The mean values of leaf area index showed an increase from 0.30 at 30 DAP to 1.50 at 90 DAP (table 7). Leaf area index was maximum in N_3 (0.31) followed by N_2 (0.30) and minimum in N_1 (0.28). The P and interactions of nitrogen and phosphorus did not show significant influence on the leaf area index at 30 DAP.

At 90 DAP, the maximum leaf area index was observed in N_3 (1.62) followed by N_2 (1.55). The effect of phosphorus was found to be highest at P_3 level (1.58) followed by P_4 (1.52) and among the interactions combination of N_3P_3 recorded the highest leaf area index (1.80) followed by N_3P_4 (1.60). The lowest values were recorded by N_1 (1.33), P_1 (1.46) and N_1P_1 (1.30).

Table 8: Crop growth rate (CGR) as influenced by nitrogen, phosphorus and their interactions in gladiolus cv. White prosperity

Treatment	30 - 60 DAP					60 - 90 DAP				
	P_1	P_2	P_3	P_4	mean	P_1	P_2	P_3	P_4	mean
N_1	2.66	2.81	3.54	4.05	3.26	2.19	2.29	2.43	2.57	2.37
N_2	4.30	4.09	4.93	4.98	4.57	2.85	3.44	4.87	4.53	3.92
N_3	4.18	4.47	6.05	5.77	5.11	3.85	4.29	5.19	4.47	4.45
N_4	4.84	4.89	5.98	5.78	5.37	4.79	4.80	4.86	5.05	4.87
mean	3.99	4.06	5.12	5.14	4.58	3.42	3.70	4.33	4.15	3.90
	SEm±			CD at 5%		SEm±			CD at 5%	
N	0.02			0.07		0.05			0.14	
P	0.02			0.07		0.05			0.14	
N × P	0.05			0.14		0.10			0.28	

Crop growth rate (CGR) (g m^{-2} day^{-1})

There were significant differences in crop growth rate due to the graded levels of nitrogen and phosphorus and their interaction at different stages of crop growth (table 8). The mean crop growth rate was found to be more (4.58 g m^{-2} day^{-1}) between 30 and 60 DAP and less (3.90 g m^{-2}day^{-1}) between 60 and 90 DAP. During the first phase (30-60 DAP), maximum crop growth rate was recorded by N_4 (5.37 g m^{-2} day^{-1}) followed by N_3 (5.11 g m^{-2} day^{-1}). Among phosphorus levels, P_4 recorded the highest CGR (5.14 g m^{-2} day^{-1}), which was on par with P_3 (5.12 g m^{-2} day^{-1}). With respect to interactions, N_3P_3 had the highest CGR (6.05 g m^{-2} day^{-1}) on par with N_4P_3 (5.98 g m^{-2} day^{-1}) and significantly superior to N_4P_4 (5.78 g m^{-2} day^{-1}). The lowest crop growth rate values were recorded by N_1 (3.26 g m^{-2} day^{-1}), P_1 (3.99 g m^{-2} day^{-1}) and the combination of N_1P_1 (2.66 g m^{-2} day^{-1}).

During the second phase (60-90 DAP), maximum crop growth rate was registered in N_4 (4.87 g m^{-2} day^{-1}), P_3 (4.33 g m^{-2} day^{-1}) and N_3P_3 (5.19 g m^{-2} day^{-1}) followed by N_4P_4 (5.05 g m^{-2} day^{-1}).

Net assimilation rate (NAR) (g m^{-2} day^{-1})

The net assimilation rate (NAR) was found to be more (6.50 g m^{-2} day^{-1}) between 30 and 60 DAP and less (2.86 g m^{-2}day^{-1}) between 60 and 90 DAP (table 9). During the first phase (30-60 DAP), maximum NAR was recorded by N_4 (7.47 g m^{-2} day^{-1}) followed by N_3 (6.88 g m^{-2} day^{-1}). Among phosphorus levels, P_3 recorded the highest NAR (7.23 g m^{-2} day^{-1}) which was on par with P_4 (6.96 g m^{-2} day^{-1}). With respect to interactions, N_3P_3 had the highest NAR (8.60 g m^{-2} day^{-1}). The lowest NAR values were recorded by N_1 (5.21 g m^{-2} day^{-1}), P_1 (5.94 g m^{-2} day^{-1}) and the combination of N_1P_1 (4.48 g m^{-2} day^{-1}). These treatments continued to record greater values of net assimilation rate during the second phase (30-60 DAP) also.

The results obtained on total dry weight and individual part wise dry weights recorded at periodic intervals as well as growth indices like LAI, CGR and NAR made it clear that the plants receiving higher levels of nutrients could produce more dry weights as compared to those supplied with lower doses. In most of the parameters, the highest values were recorded by N_3P_3 levels as compared to other lower and higher levels. While the lower levels were failing to fulfil the plants requirements, higher levels could have led to non-synchronous growth functions and ultimately reducing the systems efficiency beyond N_3P_3. This nutrient combination sustained a higher leaf area index until the final stage of the crop indicating that the photosynthetic surface of the plant was maintained higher even after the plant had entered reproductive phase. Similarly crop growth rate and net assimilation rates were found to decline at second phase of crop's life cycle, but the treatment of N_3P_3 was found to record comparatively a better growth rate and assimilation rate, which might form a sufficiently stronger foundation to generate more reproductive structures of better quality. These findings were in confirmation with the results of Patel *et al*. (2010), Mahgoub *et al*. (2006), Yousuf *et al.* (2006), Sharma *et al*. (2003), Waly *et al*. (2001), Vijayakumar *et al*. (1988) in gladiolus and Dorajee Rao (2010) in chrysanthemum.

Spike yield per plot

The highest spike yield per plot (56.34) was recorded by N_4, which was on par with N_3 (54.27) (table 10). Among the phosphorus levels P_3 recorded the highest spike yield (52.92) followed by P_4 (48.78). Among the interactions N_3P_3 registered the highest spike yield per plot (66.60), which was on par with N_4P_3 (62.64) followed by N_4P_4 (57.60). The least spike yield per plot was recorded in N_1 (38.52), P_1 (44.46) and among interactions N_1P_1 registered the least spike yield per plot (36.72).

The spike yield per plot was found to increase with every increase in the nitrogen level up to N_4 level. Supply of phosphorus could bring about an improvement in these parameters up to P_3 level only. Interaction effect was found to be highest at the combination of N_3 and P_3. It can also be pointed out here that the increase in these parameters after N_3 level was not statistically significant. Therefore, it can be summarized that better spike yield per plant and per plot was recorded by the treatments N_3 and P_3 individually and in combination. Insignificant increase at higher doses of nitrogen and decrease at higher doses of phosphorus is indicative of negative interaction among themselves and with other nutrients, which might have led to overall inefficiency of the plant-soil-environment system beyond the combination of N_3P_3 under the local conditions of Venkataramannagudem. This combination could have encouraged the plant to put up more dry matter by increased photosynthetic surface or leaf area leading to better outturn of photosynthates, which might have stimulated more floral buds and leading to a better number of spikes per plant and per plot. Not only more number of floral buds were stimulated but also the expansion of spikes and their axes was found to be more at the said combination of nitrogen and phosphorus, as conformed by the results on spike length and rachis length. Similar results were reported by Khan *et al.* (2012), Shaukat *et al.* (2012) and Dalvi *et al*. (2008) in gladiolus.

Corm yield per plot

The data pertaining to the number of corms produced per plot was significantly influenced by different levels of nitrogen, phosphorus and their interactions (table 10). The maximum number of corms per plot (45.27) among nitrogen doses was registered in N_3, which was on par with N_4 (42.84) and among phosphorus levels highest number of corms per plot (44.73) was recorded in P_3, which was on par with P_4 (41.40). With respect to interactions, the treatment combination of N_3P_3 recorded the highest number of corms per plot (55.08), which was on par with N_4P_3 (48.24) and N_3P_4 (46.8). The least number of corms per plot (36.90) was recorded in N_1, P_1 (37.80) and N_1P_1 (36.00).

The number of corms produced per plot increased as the dose of nitrogen and phosphorus increased up to 300 kg ha^{-1} (N_3) and 200 kg ha^{-1} (P_3), respectively. After this level there was still some marginal increment in the corm yield, but was not significant. This might be due to the fact that there was increase in the supply of photosynthates into corms as the external supply of nutrients was increased up to a threshold level N_3P_3. An increase beyond N_3 and P_3 could not produce significant improvement, which might be due to their toxic effect at higher dosages or negative interactions with other nutrients suppressing their availability and consequently reducing the partitioning of assimilates into the corms and cormels. These results are in conformity with the findings of Khan *et al*. (2012), Shaukat *et al*. (2012), Patel *et al*. (2010), Zubair *et al.* (2006) and Ramesh and Raman (2006) in gladiolus.

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