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Integrated use of NPK fertilizer with FYM influences growth, floral attributes, soil fertility and nutrient uptake of gladiolus in an Inceptisol of semi-arid tropics

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ABSTRACT

Various combinations of farmyard manure (FYM), nitrogen (N), phosphorous (P) and potassium (K) were evaluated to optimize their levels for growth, yield and nutrient uptake of *Gladiolus hybridus* Hort. cv. Trader Horn grown under open field conditions. The field trials were conducted during two cropping seasons (2013-14 & 2014-15) in a randomized block design with three replications. The treatments consisted of three levels of FYM (0, 5 and 10 t ha^{-1}); four levels, each of N (0, 100, 200 and 300 kg ha^{-1}), P and K (0, 40, 80 and 120 kg ha^{-1}), respectively. The results showed substantial improvement in morphological and floral characteristics of gladiolus with increasing levels of FYM and NPK dosage. The nutrient consortium, FYM 10 t ha^{-1} and 300, 120 and 120 kg NPK ha^{-1} (T_1) were found to be most effective in enhancing plant height (142.0 cm), number of leaves (8.9), spike length (115.1 cm), rachis length (72.0 cm), florets per spike (17.4) and spike yield m^{-2} (19.1). These experiments also showed that balanced application of N, P and K significantly promoted the soil fertility and plant nutrient uptake.

Key words: *Gladiolus* hybrids, manure, floral traits, plant nutrient uptake.

INTRODUCTION

Gladiolus (*Gladiolus hybridus* Hort.) is one of the most commercially exploited open field grown bulbous cut flower, where soil nutrient status and its management through fertilizer and manures play a major role in quality spike production. Among the bulbous ornamentals, *Gladiolus* is one of the leading geophytes in international cut flower trade for its fascinating spikes in various forms and sizes with markings and blends of elegant colours (Mukhopadhyay, 13). It is widely used as a cut flower, for garden display, flower arrangements, bouquets and does quite well in pots. In spite of considerable acreage under gladiolus (11,160 ha) with a production of 54.6 lakh cut spikes, a meagre 13 ha area (Saxena *et al.*, 17) is under nutrient supervision, where mining of nutrients from soil operating a disturbance in soil sustainable strategy. As, gladiolus is heavy feeder of primary nutrients and responds positively to the applied nutrients (Kumar and Misra, 10), soil reserves alone are not sufficient thus making it necessary to supply the deficit quantity through external sources. Apart from chemical fertilizers, organic manures like FYM are good complementary sources of nutrients, which improves the efficiency of the applied mineral nutrients and enrich physical and biological properties of soil (Goulding *et al.*, 6). A judicious and combined use of these organic and inorganic sources of plant nutrients is essential to maintain soil health, augment the nutrient use efficiency and to economize the use of costly fertilizer inputs. Hence, the present investigation was aimed to come out with an optimized site specific nutrient dose for cut flower production in gladiolus.

MATERIALS AND METHODS

The experiment on gladiolus was carried out during 2013-14 and 2014-15 at research farm of ICAR-IARI, New Delhi. Seventy-two plots were laid out with each gross plot size of 4 × 2.5 m^2 and quality grade corms (3.5-4.0 cm dia.) were dibbled at a spacing of 50 × 15 cm. Initial soil samples from several spots (0-15 cm soil depth) were collected from the experimental field before start of the experiment. Composite soil sample was processed and analyzed for various physico-chemical properties.

The experiment was laid out in a randomized block design with 24 treatments and three replications. Selected combinations of FYM (0, 5 and 10 t ha^{-1}) and NPK fertilizers each at four levels (0, 1, 2 and 3) corresponds to 0, ½ RDF, RDF, 1 ½ RDF (where recommended dose of fertilizers (RDF) equals to

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200, 80 and 80 kg N, P and K ha^{-1}) respectively, were randomized in each plot before dibbling of corms. Well decomposed FYM (at moisture content 30%, total N - 0.4%, total P - 0.2% and total K - 0.5%), half dose of N and entire dose of P and K were added as a basal dose while the remaining N was applied in three splits, *i.e.* at 3rd leaf, spike emergence and harvesting stages as per the treatment combinations. The fertilizer sources were urea, di-ammonium phosphate, single superphosphate and muriate of potash to meet the requirements of different treatment combinations. All the recommended cultural operations were carried out throughout the crop growth period. Soil samples were collected from each treatment after crop harvest and analyzed for alkaline $KMnO_4$-N, Olsen's-P and NH_4OAc-K. Total N, P and K content in plant tissue was analyzed as per the standard procedures of (Jackson, 8); and nutrient uptake (kg ha^{-1}) by the crop was computed by multiplying tissue nutrient concentration with dry weight.

Data on various parameters like plant height, number of shoots per plant, number of leaves per shoot, spike and rachis length, diameter of 3rd fully open floret, duration of flowering, number of florets per spike and spike yield were recorded. Data of both the years were pooled, analyzed and presented in tabular form. Statistical analysis was performed using SAS 9.3 (SAS, 17). The treatment differences were determined by ANOVA procedure in a randomized block design ($P \leq 0.05$).

RESULTS AND DISCUSSION

The soil of experimental site was sandy loam in texture and taxonomically categorized under the great group typic Haplustepts (old alluvium). The initial soil had $pH_{1:2.5}$ 8.13, $EC_{1:2.5}$ 0.32 dSm^{-1}, 179 kg ha^{-1} alkaline $KMnO_4$-N, 20.4 kg ha^{-1} Olsen's P, 167 kg ha^{-1} NH_4OAc-K and 0.46% organic carbon. DTPA-extractable micronutrients were in sufficiency range. The data presented in Table 1 clearly indicate that different treatment combinations of FYM and NPK fertilizers significantly influenced the vegetative characters studied. A composite dose of FYM 10 t ha^{-1} and 300, 120 and 120 kg N, P and K ha^{-1} (T_1) was found to be more effective in enhancing the vegetative attributes like plant height, number of shoots per plant and leaves per shoot.

All the treatments improved the plant height in comparison to control (127.1 cm). However, T_1 ($F_{10}N_3P_3K_3$) was found to be the highest (142.0 cm) and was on par with $F_{10}N_3P_2K_3$ (T_5) and $F_{10}N_3P_2K_2$ (T_8). The increased plant height at higher doses may be attributed to stimulatory action of sufficient supply of plant nutrients in terms of cell division and cell enlargement. The least determined height in control could be because of the unavailability of sufficient nutrients at critical crop stages for its luxuriant growth. Similar results in gladiolus were reported earlier (Khan and Ahmed, 9).

Number of shoots per plant (1.4) failed to show statistical disparity beyond 200, 80 and 80 kg NPK ha^{-1} irrespective of FYM dose. It may be probably due to the cumulative effect of optimistic dose on the process of cell division, assisted in assured emergence of more shoots per mother corm up to a certain level. These findings are in accordance with (Gupta *et al.*, 7 and Chaudhary *et al.*, 2). However, minimum number of shoots and leaves was observed in T_{10} (1.2) and T_{21} (8.0), respectively. The highest number of leaves (8.9) was recorded in plants treated with combination of FYM 10 t ha^{-1} and 300, 120 and 120 kg N, P and K ha^{-1} (T_1). This marked increase in leaf number with higher doses of nutrients may be due to the increased availability of nutrients, alleviating activation of apical meristems and enhanced the biosynthesis of carbohydrates and proteins, which leads to the proliferation of leaf primordium (Kumar and Misra, 11; Gajhbhiye *et al.*, 5). Important quality assessment characters like spike and rachis length were found maximum with the application of higher doses of NPK and FYM *i.e.* in $F_{10}N_3P_3K_3$ (T_1) (115.1 and 72.0 cm) followed by $F_{10}N_3P_2K_3$ (T_5) and $F_{10}N_3P_2K_2$ (T_8) whereas minimum spike (101.4 cm) and rachis length (59.6 cm) was observed in control (Table 1). This might be due to greater uptake of nutrients into the plant system, which assured a rapid growth of stems by mobilization of nutrients toward the developing spikes. Similar beneficial effects of higher doses of primary nutrients on spike and rachis length were reported earlier (Kumar *et al.*, 12; Chouhan *et al.*, 3).

Average of two years data revealed that full dose ($F_{10}N_3P_3K_3$) of NPK and FYM showed significant influence on the number of florets per plant and diameter of the third fully open floret. T_1 ($F_{10}N_3P_3K_3$) leads with 17.4 florets and 12.2 cm diameter, while minimum (15.2 and 11.1 cm) was recorded in control. Abundant availability of nutrients at elevated levels might have shown a positive influence on mobilization of nutrient reserves to put forth vegetative growth which lead to more assimilation of food reserves. The accumulated reserves could have been diverted for flower bud differentiation and resulted in more number of florets per spike. These findings are supported with differential applications of N, P, K and FYM on number of florets by Khan and Ahmad (9) and Chouhan *et al.* (3). An increase in floret size might be due to maximum turgidity and loosening of cell wall material which is a prerequisite of cell expansion caused by potassium levels (Zubair, 19). Maximum

Table 1. Effect of FYM and NPK on vegetative and floral attributes of gladiolus cv. Trader Horn.

Treatment	Plant height (cm)	No. of shoots	No. of leaves	Spike length (cm)	Rachis length (cm)	No. of florets/ spike	Florets open at a time	Duration of flowering (days)	Dia. of floret (cm)	No. of spikes m^{-2}
$F_{10}N_3P_3K_3$	141.9^{a}	1.4^{a}	8.9^{a}	115.1^{a}	72.03^{a}	17.4^{a}	5.9^{a}	14.8^{cdef}	12.2^{a}	19.1^{a}
$F_{10}N_2P_1K_2$	134.5^{bcdef}	1.3^{bcde}	8.5^{bcdef}	107.9^{bcdefg}	66.7^{defghij}	16.0^{efghi}	5.1^{fg}	14.0^{gh}	11.9^{abc}	17.6^{bcde}
$F_{10}N_2P_3K_2$	134.7^{bcdef}	1.3^{bcd}	8.5^{bcdef}	108.1^{bcdefg}	67.4^{bcdefgh}	16.2^{cdefgh}	5.2^{defg}	13.8^{hi}	12.1^{ab}	17.7^{bcd}
$F_{10}N_0P_2K_2$	132.3^{cdefg}	1.3^{defg}	8.3^{defg}	106.3^{cdefgh}	64.8^{ghijkl}	15.7^{ghij}	4.8^{hij}	14.6^{efgh}	11.8^{abcd}	16.9^{def}
$F_{10}N_3P_2K_3$	139.8^{ab}	1.4^{a}	8.8^{ab}	112.3^{ab}	70.7^{ab}	17.1^{ab}	5.5^{bc}	14.6^{efgh}	12.2^{a}	18.80^{a}
$F_{10}N_0P_0K_0$	134.2^{bcdef}	1.3^{efgh}	8.2^{efg}	105.2^{fgh}	63.3^{kl}	15.6^{ghij}	4.7^{ij}	14.4^{fgh}	11.7^{abcd}	16.7^{efg}
$F_{10}N_3P_1K_1$	136.4^{abcde}	1.4^{abc}	8.7^{abcd}	109.2^{bcdef}	67.7^{bcdefg}	16.4^{bcdefg}	5.3^{cdef}	14.1^{gh}	12.1^{a}	18.3^{abc}
$F_{10}N_3P_2K_2$	136.9^{abcd}	1.4^{abc}	8.78^{abc}	111.2^{abcd}	69.2^{abcde}	16.8^{abcd}	5.6^{b}	14.2^{fgh}	12.1^{ab}	18.3^{abc}
$F_5N_3P_3K_1$	136.4^{abcde}	1.4^{a}	8.73^{abcd}	110.6^{abcde}	68.5^{bcdef}	16.9^{abc}	5.4^{bcd}	15.6^{ab}	12.1^{ab}	18.8^{a}
$F_5N_0P_0K_0$	127.4^{g}	1.2^{h}	8.18^{fg}	104.5^{fgh}	62.4^{lm}	15.5^{hij}	4.8^{hij}	14.6^{efg}	11.3^{de}	16.0^{g}
$F_5N_2P_2K_1$	133.6^{bcdefg}	1.4^{abc}	8.57^{abcdef}	108.2^{bcdefg}	66.1^{efghijk}	16.2^{cdefgh}	5.2^{defg}	15.4^{abcd}	11.9^{abcd}	18.3^{abc}
$F_5N_1P_2K_1$	130.4^{defg}	1.3^{def}	8.37^{cdefg}	105.8^{efgh}	64.7^{ghijkl}	15.6^{hij}	5.0^{gh}	14.7^{cdefg}	11.6^{bcde}	17.0^{def}
$F_5N_3P_3K_2$	135.4^{abcdef}	1.4^{a}	8.74^{abcd}	111.4^{abc}	70.3^{abc}	16.7^{abcdef}	5.4^{bcde}	16.0^{a}	12.2^{a}	19.1^{a}
$F_5N_2P_2K_0$	132.3^{cdefg}	1.2^{fgh}	8.56^{abcdef}	107.2^{bcdefg}	66.3^{efghijk}	15.9^{fghij}	5.0^{gh}	14.6^{efg}	11.8^{abcd}	16.5^{fg}
$F_5N_2P_3K_3$	133.1^{cdefg}	1.4^{ab}	8.63^{abcde}	108.9^{bcdef}	67.3^{cdefghi}	16.6^{bcdef}	5.2^{defg}	15.2^{bcde}	11.8^{abcd}	18.4^{ab}
$F_5N_1P_2K_2$	131.6^{cdefg}	1.3^{cde}	8.48^{bcdef}	106.4^{cdefg}	63.7^{jkl}	15.7^{ghij}	5.1^{fg}	14.6^{efgh}	11.5^{bcde}	17.4^{cde}
$F_0N_2P_0K_2$	129.6^{fg}	1.2^{fgh}	8.59^{abcdef}	106.0^{defgh}	64.4^{hijkl}	16.1^{defghi}	4.6^{jk}	15.2^{bcde}	11.8^{abcd}	16.40^{fg}
$F_0N_3P_2K_1$	138.0^{abc}	1.4^{a}	8.85^{ab}	111.9^{ab}	69.6^{abcd}	17.1^{ab}	5.5^{bc}	15.5^{abc}	12.2^{a}	18.86^{a}
$F_0N_2P_1K_1$	132.2^{cdefg}	1.4^{abc}	8.63^{abcde}	105.9^{defgh}	64.3^{hijkl}	16.2^{cdefgh}	5.1^{fg}	14.2^{fgh}	11.9^{abcd}	18.26^{abc}
$F_0N_2P_2K_3$	134.7^{bcdef}	1.4^{a}	8.67^{abcd}	108.0^{bcdefg}	68.8^{abcde}	16.7^{abcde}	5.4^{bcd}	14.9^{bcdef}	12.2^{a}	18.66^{a}
$F_0N_0P_0K_0$	127.0^{g}	1.2^{gh}	8.00^{g}	101.4^{h}	59.6^{m}	15.2^{j}	4.4^{k}	13.2^{i}	11.1^{e}	16.13^{fg}
$F_0N_1P_1K_1$	129.3^{fg}	1.3^{defg}	8.33^{defg}	103.5^{gh}	62.2^{lm}	15.3^{ij}	4.9^{ghi}	14.2^{fgh}	11.5^{cde}	16.93^{def}
$F_0N_2P_2K_2$	133.5^{bcdefg}	1.4^{abc}	8.73^{abcd}	106.1^{cdefgh}	65.5^{fghijkl}	16.1^{defghi}	5.1^{efg}	14.8^{cdef}	12.0^{abc}	18.26^{abc}
$F_0N_1P_1K_2$	129.9^{efg}	1.3^{cde}	8.34^{defg}	104.9^{fgh}	64.1^{ijkl}	15.6^{ghij}	5.0^{gh}	14.7^{defg}	11.7^{abcde}	17.46^{cde}
LSD (5%)	6.63	0.06	0.42	5.32	3.26	0.73	0.25	0.73	0.58	0.87

F = FYM (0, 5 and 10 t ha^{-1}); Number 0, 1, 2 and 3 represents NPK at four levels. (N: 0,100, 200 and 300 kg ha^{-1}), (P and K each of 0, 40, 80 and 120 kg ha^{-1}), respectively.

flower diameter was obtained with full dose of NPK (Dubey *et al*., 4); NPK and FYM (Shankar and Dubey, 18), and this could be due to steady decomposition of FYM coupled with inorganic sources which release the nutrients throughout the crop growth period thus helps in improved assimilation.

The ability of florets opening at one time was recorded maximum in T_1, *i.e.* $F_{10}N_3P_3K_3$ (5.9) while minimum was noticed in control (4.4). Higher uptake of NPK from soil available and external applied nutrients might have helped in carbohydrate and sugar metabolism which leads to synchronous opening of florets at a time. These results are in conformity with Chaudhary *et al*. (2) and Dubey *et al*. (4). The application of various doses of nutrients significantly affected the duration of flowering. T_{13} ($F_5N_3P_3K_2$) was found to be the best with respect to the longest flowering duration (16 days) which was at par with T_9 ($F_5N_3P_3K_1$) and T_{15} ($F_5N_2P_3K_3$) with 15.6 and 15.2 days, respectively. High dose of NPK and FYM might have encouraged vigorous vegetative growth with more photosynthetic area for greater production and mobilization of photosynthates and prevention of chlorophyll degradation. Thus, sufficient amount of nutrient (N, P, and K) availability ultimately delayed the reproductive phase thereby improving duration of flowering. These findings are in line with application of NPK in gladiolus as reported by Atta-Alla *et al*. (1).

Number of spikes m^{-2} is directly correlated with number of shoots per plant. The highest spike yield m^{-2} (19.1) was obtained from the treatment receiving

10 t ha^{-1} FYM + 300, 120 and 120 kg NPK ha^{-1}, whereas the lowest spike yield was recorded in T_{10} and T_{21} (control). This increase in yield is probably due to effective utilization of applied nutrients, increased sink capacity and nutrient uptake by the crop.

Post harvest soil available N, P and K were favourably influenced by FYM and NPK levels. Mean alkaline $KMnO_4$-N, Olsen's-P and NH_4OAc-K content indicated a considerable increase in post harvest soil N, P and K in parallel to the increment in fertilizer dose (Table 2). This implied that, not all the N, P and K, supplied through FYM and NPK fertilizer application were utilized by gladiolus. The highest values of soil available nutrients in respective plots can be ascribed to accumulation of these nutrients as gladiolus could not utilize them for completion of life cycle. Gladiolus has the ability to utilize stored carbohydrate reserves in the corm to support its growth and development apart from externally applied nutrients which resulted in residual effects of N, P and K. Similar findings were reported by Kumar and Misra (11).

The treatments containing high soil available nutrients have shown a physiological advantage in nutrient uptake in contrast to low fertile plots due to their easy availability and high absorption capacity. The total plant N uptake significantly varied from 112 to 214.8 kg ha^{-1}, P uptake ranged from 11.6 to 27.7 kg ha^{-1} and K uptake was recorded in between 92.5 to 188 kg ha^{-1} (Table 2) considering two years in response to variation in nutrient dose. These

Table 2. Effect of FYM and NPK on soil available NPK and plant uptake of gladiolus cv. Trader Horn.

Treatments	Soil N	Soil P	Soil K	N uptake	P uptake	K uptake
$F_{10}N_3P_3K_3$	255.0^{a}	46.1^{a}	336.0^{a}	214.8^{a}	27.7^{a}	188.0^{a}
$F_{10}N_2P_1K_2$	248.4^{abc}	29.3^{ghi}	320.6^{b}	163.4^{g}	22.2^{d}	137.8^{fg}
$F_{10}N_2P_3K_2$	250.6^{ab}	40.8^{b}	321.2^{b}	187.7^{cd}	22.2^{de}	164.9^{d}
$F_{10}N_0P_2K_2$	242.9^{bcde}	35.6^{d}	312.0^{bcd}	152.8^{i}	22.5^{defg}	125.9^{hij}
$F_{10}N_3P_2K_3$	241.8^{bcde}	28.3^{hijk}	288.1^{fgh}	188.0^{cd}	23.1^{c}	162.1^{cd}
$F_{10}N_0P_0K_0$	239.0^{bcdef}	28.7^{hij}	303.5^{de}	121.2^{jk}	18.2^{l}	105.9^{k}
$F_{10}N_3P_1K_1$	246.5^{abcd}	28.3^{ijk}	305.7^{cd}	185.7cd	25.0^{bc}	160.0^{cd}
$F_{10}N_3P_2K_2$	239.6^{bcdef}	35.2^{d}	311.0^{bcd}	166.9^{g}	21.3^{defg}	137.8^{fg}
$F_5N_3P_3K_1$	246.1^{abcd}	36.3^{d}	283.9^{gh}	195.6^{b}	16.7^{jk}	159.7^{c}
$F_5N_0P_0K_0$	237.7^{cdef}	26.9^{kl}	319.9^{bc}	112.0^{k}	15.6^{n}	99.8^{k}
$F_5N_2P_2K_1$	240.2^{bcdef}	28.6^{hij}	323.8^{ab}	173.6^{f}	20.5^{fgh}	144.1^{ef}
$F_5N_1P_2K_1$	215.4^{g}	30.7^{fg}	299.4^{def}	163.0^{g}	22.5^{def}	128.2^{hi}
$F_5N_3P_3K_2$	229.5^{f}	32.9^{e}	318.4^{bc}	193.6^{cd}	25.1^{b}	171.5^{b}
$F_5N_2P_2K_0$	238.8^{bcdef}	25.6^{lm}	290.5^{efg}	158.1^{g}	18.4^{jkl}	112.6^{ij}
$F_5N_2P_3K_3$	234.8^{def}	44.7^{a}	310.5^{bcd}	178.2^{ef}	20.9^{efgh}	155.3^{cd}
$F_5N_1P_2K_2$	236.1^{def}	27.2^{jk}	261.3^{ij}	151.7^{hi}	19.7^{ij}	132.3^{hij}
$F_0N_2P_0K_2$	242.3^{bcde}	22.6^{n}	274.3^{hi}	148.2^{i}	18.4^{kl}	127.0^{j}
$F_0N_3P_2K_1$	236.5^{def}	36.3^{d}	261.2^{ij}	201.2^{a}	24.2^{b}	159.4^{cd}
$F_0N_2P_1K_1$	232.5^{ef}	24.3^{m}	261.1^{ij}	175.9^{ef}	20.2^{hi}	138.5^{g}
$F_0N_2P_2K_3$	231.5^{ef}	31.8^{ef}	265.4^{i}	194.2^{bc}	21.4^{fgh}	161.8^{cd}
$F_0N_0P_0K_0$	232.4^{ef}	24.5^{m}	267.1^{i}	113.5^{j}	11.6^{op}	92.5^{k}
$F_0N_1P_1K_1$	229.2^{f}	29.9^{gh}	261.2^{ij}	162.6^{gh}	17.7^{m}	136.5^{h}
$F_0N_2P_2K_2$	239.0^{bcdef}	39.0^{c}	260.1^{ij}	181.4^{de}	19.9^{gh}	150.3^{e}
$F_0N_1P_1K_2$	228.8^{f}	27.7^{ijk}	247.7^{j}	155.9^{ghi}	17.9^{kl}	131.4^{hi}
LSD (5%)	11.82	1.60	14.23	9.16	1.075	8.47
S/NS	S	S	S	S	S	S

F = FYM (0, 5 and 10 t ha^{-1}); Number 0, 1, 2 and 3 represents NPK at four levels. (N: 0, 100, 200 and 300 kg ha^{-1}), (P and K each of 0, 40, 80 and 120 kg ha^{-1}), respectively.

results are in conformity with Naik (14) in marigold, where he reported that increased dose of N, P and K improved the nutrient uptake. Moreover, positive interaction between organic (FYM) and inorganic (NPK) nutrients resulted in initial buildup of vigorous growth and higher photosynthetic rate which led to better uptake of nutrients during the crop growth period (Patil and Dhaduk, 15).

It can be concluded that, integrated use of fertilizer NPK with organic FYM significantly increased the growth, flower attributes, soil available NPK and nutrient uptake over their corresponding sole applications in gladiolus. Application of FYM 10 t ha^{-1} and 300, 120 and 120 kg NPK ha^{-1} (T_1) was found to be a balanced optimal dose for sustained productivity and better quality of gladiolus spikes in Inceptisols of Delhi.

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