RESPONSE OF GLADIOLUS TO COMBINED APPLICATION OF NITROGEN, PHOSPHORUS, POTASSIUM AND SULFUR IN GREY TERRACE SOILS OF GAZIPUR, BANGLADESH

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Abstract

Modern agricultural practices are mostly directed toward high application of commercial fertilizers to achieve high yield. Cut flowers of gladiolus (*Gladiolus sp.*) are highly exhaustive and responsive to inorganic fertilizers. An approach was made to introduce combined application of inorganic fertilizer for better growth and yield of gladiolus. Hence an investigation on gladiolus was carried out in floriculture research field of Horticulture Research Centre, BARI, Gazipur during Rabi season of 2010-2011 and 2011-2012 to find out the suitable combination of nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) for yield maximization of gladiolus. The trial consisted sixteen treatments which comprising four levels each of N (0, 100, 150 and 200 kg ha^{-1}), P (0, 50, 75 and 100 kg ha^{-1}), K (0, 100, 150 and 200 kg ha^{-1}) and S (0, 20, 30 and 40 kg ha^{-1}) including farmers practice and reference dose. Blanket dose of cow dung was used as 5 tons ha^{-1}. Results revealed that the treatment T_5= $N_{200}P_{75}K_{150}S_{30}$ contributed to obtain highest plant height (1225 mm), number of effective leaves (14.98), length of spike (1041 mm) and rachis (623 mm), number of florets per spike (17.04), floret diameter (78.4 mm) and weight of individual spike (124.4 g). The lowest yield and yield contributing characters of gladiolus were recorded in T_1= $N_0P_0K_0S_0$ treatment. Therefore, the combination of $N_{200}P_{75}K_{150}S_{30}$ along with 5 tons cow dung ha^{-1} may be considered as suitable dose for gladiolus cultivation in grey terrace soils of Gazipur, Bangladesh.

Keywords: Combined fertilizer (N, P, K and S), gladiolus yield and yield contributing parameters, grey terrace soil

Introduction

Gladiolus (*Gladiolus sp.*) is an important flower found everywhere throughout the world. It has innumerable cultivars owing to its versatile colors and varieties having keeping quality of flower. It has great economic value for cut flower trade and much valued by the aesthetic world for beauty and loving people because of its prettiness and unparallel elegance. For its attractiveness and assortment of colors, gladiolus captured the domestic and world market economy. Due to its aesthetic value for mankind and economic importance, the area and production of gladiolus flower crops increased substantially day by day like tuberose. But unfortunately the growers even do not have any recommended doses of integrated fertilizer package. Even in most cases, the farmers do not use any chemical fertilizers. As a result, the growers are not getting desired and expected yield of flowers. Cut flowers of gladiolus are highly exhaustive and responsive to inorganic fertilizers (Afifty 2003, Sunutha *et al.,* 1998 and Potti *et al*, 1986). It can be uptake huge amount of nutrients (macro and micro) from native soil. So it is required higher doses of chemical as well as organic fertilizers in balance proportion for ensuring higher flower production. Nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) are contributed to get higher floret production of gladiolus specially increasing N fertilization appreciably multiplied the plant growth, number of leaves per plant, spike length and number of florets $spike^{-1}$ (Lehri *et al.,* 2011 and Shah *et al.,* 1984). Therefore, the present study was under taken to find out the suitable combined package of nitrogen, phosphorus, potassium and sulfur for yield maximization of gladiolus in grey terrace soil of Gazipur, Bangladesh.

Materials and Methods

The field experiment was conducted at floriculture research farm of Horticulture Research Centre, BARI, Gazipur during Rabi season of 2010-2011 and 2011-2012 to find out the suitable combination of nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) for yield maximization of gladiolus. The experiment field, Gazipur (24° 0′ 13″ N latitude and 90° 25′ 0″ E longitude) which lies at an elevation of 8.4 m above the sea level. The field was medium high land with clay loam soil and it belongs to Chhiata series (Soil taxonomy: Udic Rhodustalf) under the agroecological zone Madhupur Tract (AEZ-28).

The experiment was consisted with sixteen treatments comprising four levels each of N (0, 100, 150 and 200 kg ha^{-1}), P (0, 50, 75 and 100 kg ha^{-1}), K (0, 100, 150

and 200 kg ha^{-1}) and S (0, 20, 30 and 40 kg ha^{-1}) along with blanket dose of cow dung 5 t ha^{-1}. The treatment combinations were viz. $T_1 = N_0P_0K_0S_0$ (control); $T_2 = N_0P_{75}K_{150}S_{30}$; $T_3 = N_{100}P_{75}K_{150}S_{30}$; $T_4 = N_{150}P_{75}K_{150}S_{30}$; $T_5 = N_{200}P_{75}K_{150}S_{30}$; $T_6 = N_{150}P_0K_{150}S_{30}$; $T_7 = N_{150}P_{50}K_{150}S_{30}$; $T_8 = N_{150}P_{100}K_{150}S_{30}$; $T_9 = N_{150}P_{75}K_0S_{30}$; $T_{10} = N_{150}P_{75}K_{100}S_{30}$; $T_{11} = N_{150}P_{75}K_{200}S_{30}$; $T_{12} = N_{150}P_{75}K_{150}S_0$; $T_{13} = N_{150}P_{75}K_{150}S_{20}$; $T_{14} = N_{150}P_{75}K_{150}S_{40}$; $T_{15} = N_{100}P_{50}K_{100}S_0$ (Farmers' practice) and $T_{16} = N_{375}P_{150}K_{250}S_{20}$ (Reference dose).

The field experiment was laid out in randomized block design having three replications. The unit plot size was 1 m x 0.9 m with the spacing of 250 mm x 150 mm. Gladiolus (*Gladiolus sp.*) planting material corms were sown on 18th November, 2010 and 23rd November, 2011. All P, K, S and cow dung except N were applied and mixed up well with the soils during final land preparation. Nitrogen was applied in three equal installments. First one third of N at 30 days, second top dress at 45 days and remaining one third of N was applied at 60 days of sowing, respectively. Intercultural operations like weeding, irrigation, pesticides etc were done as and when required. At different stages, opened and bloomed flowers were cut timely for recording field data. Five plants from each plot were randomly selected for data collection. All data were computed and analyzed statistically adjusting with LSD test at 5% level of significance through STAR software (Version 2.0.1). Soil samples at 0-150 mm were collected before establishing the experiment and dried in the air through passing a 2-mm sieve and it were analyzed for soil pH and organic matter by Nelson and Sommers (1982) method; total N by Microkjeldahl method (Bremner and Mulvaney, 1982); exchangeable K by 1N NH_4OAc method (Jackson, 1973); exchangeable Ca and Mg by 1 M NH_4OAc method (Gupta, 2004); available P by Olsen and Sommers (1982) method; available S by turbidity method using $BaCl_2$ (Fox *et al*., 1964); available Zn by DTPA method (Lindsay and Norvell, 1978); available B by azomethine-H method (Page *et al*., 1982). The soil nutrient statuses are presented in the Table 1.

Table 1. Fertility status of initial soil of the experimental field at Joydebpur

Location	pH	OM	Ca	Mg	K	Total N %	P	S	B	Zn
			meq/100g				µg/g			
Joydebpur	6.2	1.1	1.5	0.7	0.18	0.065	10	12	0.1	1.0
Critical level	-	-	2.0	0.8	0.20	0.12	14	14	0.2	2.0

Results and Discussion

Different combinations of nitrogen, phosphorus, potassium and sulfur contributed significant role on yield and yield attributes of gladiolus during the consecutive two years (2010-11 and 2011-12) (Table 2, 3 and 4). The plant height was noticeably differed due to different treatment combinations. The average (over two years) plant height ranged from 828.1 to 1225 mm. The highest plant height (1298 mm and 1152 mm) was recorded from the T_5 ($N_{200}P_{75}K_{150}S_{30}$ kg ha^{-1}) treatment which was statistically significant with others treatment combination during 2010-11 and 2011-12 closely followed by treatment T_4 ($N_{150}P_{75}K_{150}S_{30}$ kg ha^{-1}). The lowest plant height (920.2 mm in 2010-11 and 736 mm in 2011-12) was recorded from control (T_1) treatment (Table 2). The average number of effective leaves per plant and length of spike varied from 79.1 to 149.8 and 666.9 to 1041 mm, respectively. The maximum number of effective leaves per plant (16.70 in 2010-11 and 13.25 in 2011-12) was found in the treatment T_5 ($N_{200}P_{75}K_{150}S_{30}$ kg ha^{-1}) which was showed significantly different with the other treatment combination but closely similar to T_4 ($N_{150}P_{75}K_{150}S_{30}$ kg ha^{-1}) treatment. The highest length of spike was observed similar trend as effective leaves per plant. Both characters- effective leaves per plant and spike length were recorded lowest values from control T_1 treatment (Table 2). The above yield contributing characters indicated that the nutrient nitrogen was more pronounced than the nutrient phosphorus, potassium and sulfur. Plant might be absorbed higher amounts of nitrogen however enhanced the growth characters. These results are supported by the findings of Lehri *et al*. (2011); Chaungrahvy (2002); Shah and Seth (2002) and Deswai, *et al*. (2001). They reported that the highest N application (170 kg ha^{-1}) which contributed highest plant height, maximum numbers of effective leaves per plant and spike length.

Length of rachis was varied significantly due to addition of different levels of NPKS fertilizer in soil. Applied combined of four nutrient elements- nitrogen, phosphorus, potassium and sulfur where nitrogen played a significant role in increasing length of rachis. But phosphorus, potassium and sulfur either in their combinations or their single application which functioned moderately on the length of rachis as compared to nitrogen fertilizer. The longest rachis (678.5 mm in 2010-11 and 567.5 mm in 2011-12) was recorded from T_5 ($N_{200}P_{75}K_{150}S_{30}$ kg ha^{-1}) treatment which was closely followed by the treatment T_4 ($N_{150}P_{75}K_{150}S_{30}$ kg ha^{-1}), T_8 ($N_{150}P_{100}K_{150}S_{30}$ kg ha^{-1}) and statistically significant over the other treatment. The control and the farmers' dose produced the shortest rachis (398 mm) and (476.9 mm). In both the years while the reference dose T_{16} ($N_{375}P_{150}K_{250}S_{20}$ kg ha^{-1}) exerted the rachis length (635.5 mm and 423.8

Table 2. Effects of combined application of N, P, K and S on plant height, number of effective leaves and length of spike of gladiolus

Treatments N-P-K-S (kg ha^{-1})	Plant height(mm)			No. of effective leaves plant^{-1}			Length of spike (mm)		
	2010-11	2011-12	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean
$T_1 = N_0P_0K_0S_0$	920.2e	736k	828.1	8.21d	7.60f	7.91	708.7d	625m	666.9
$T_2= N_0P_{75}K_{150}S_{30}$	1133cd	765.5jk	949	11.58cd	7.95ef	9.77	851.7c	645.5lm	748.6
$T_3= N_{100}P_{75}K_{150}S_{30}$	1198b-d	892.7e-h	1045	14.80a-c	10.05a-f	12.43	1021ab	782.8f-i	901.9
$T_4= N_{150}P_{75}K_{150}S_{30}$	1256ab	1082ab	1169	15.82ab	12.55ab	14.19	1072a	948.8ab	1010
$T_5= N_{200}P_{75}K_{150}S_{30}$	1298a	1152a	1225	16.70a	13.25a	14.98	1106a	975.5a	1041
$T_6= N_{150}P_0K_{150}S_{30}$	1193b-d	856g-i	1025	12.20bc	9.35b-f	10.78	1056ab	737.7h-k	896.9
$T_7= N_{150}P_{50}K_{150}S_{30}$	1215a-c	948.7c-f	1082	13.80a-c	10.75a-f	12.28	1075a	831.5d-g	953.3
$T_8= N_{150}P_{100}K_{150}S_{30}$	1240ab	1055b	1147	14.25a-c	12.35a-c	13.30	1098a	920.5a-c	1009
$T_9= N_{150}P_{75}K_0S_{30}$	1199b-d	825.5h-j	1012	12.33bc	8.75d-f	10.54	1023ab	695.8j-m	859.4
$T_{10}= N_{150}P_{75}K_{100}S_{30}$	1218a-c	966c-e	1092	12.73bc	11.25a-e	11.99	1060a	856.2c-f	958.1
$T_{11}= N_{150}P_{75}K_{200}S_{30}$	1229ab	1025bc	1127	13.05a-c	11.85a-d	12.45	1071a	895.5a-d	983.3
$T_{12}= N_{150}P_{75}K_{150}S_0$	1189b-d	878.7f-i	1034	14.20a-c	9.82a-f	12.01	1001ab	759.5g-j	880.3
$T_{13}= N_{150}P_{75}K_{150}S_{20}$	1196b-d	999.3b-d	1098	15.02a-c	11.35a-e	13.19	1022ab	869.8b-e	945.9
$T_{14}= N_{150}P_{75}K_{150}S_{40}$	1221a-c	920.6d-g	1071	14.98bc	10.45a-f	12.72	1051ab	805.5e-h	928.3
$T_{15}= N_{100}P_{50}K_{100}S_0$	1120d	798.7i-k	959	12.05bc	8.35ef	10.20	950.6bc	667.5k-m	809.1
$T_{16}= N_{375}P_{150}K_{250}S_{20}$	1205a-d	879.3f-i	1042	14.07a-c	8.95c-f	11.51	1068a	714.3i-l	891.2
$LSD_{0.05}$	93.3	83.0	-	3.79	3.43	-	108	86.1	-
CV (%)	4.71	5.39	-	9.85	10.75	-	6.41	6.49	-

Values within a column with a common letter do not differ significantly (p=0.05)

Table 3. Effects of combined application of N, P, K and S on length of rachis, number of florets per spike and length of floret of gladiolus

Treatments N-P-K-S (kg ha^{-1})	Length of rachis (mm)			No. of florets spike^{-1}			Length of floret (mm)		
	2010-11	2011-12	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean
$T_1 = N_0P_0K_0S_0$	425.9d	370k	398	10.98c	8.80f	9.89	75.6d	72.1e	73.9
$T_2= N_0P_{75}K_{150}S_{30}$	562.2bc	385.5jk	473.9	13.40bc	9.28ef	11.34	84.1cd	74.5de	79.3
$T_3= N_{100}P_{75}K_{150}S_{30}$	618a-c	465.8d-i	541.9	15.27ab	11.75b-f	13.51	90.2b-d	92.5a-e	91.4
$T_4= N_{150}P_{75}K_{150}S_{30}$	634ab	551.5ab	592.8	16.25ab	15.15ab	15.70	106.8a-d	115.1ab	111
$T_5= N_{200}P_{75}K_{150}S_{30}$	678.5a	567.5a	623	18.62a	15.45a	17.04	127.6a	118a	122.8
$T_6= N_{150}P_0K_{150}S_{30}$	582.5bc	435.3f-k	508.9	15.55ab	11.05c-f	13.30	107.5a-d	86.5b-e	97
$T_7= N_{150}P_{50}K_{150}S_{30}$	612.5a-c	490.2b-g	551.4	16.25ab	12.65a-e	14.45	110.5a-c	97.5a-e	104
$T_8= N_{150}P_{100}K_{150}S_{30}$	627.9ab	545a-c	586.5	16.75ab	14.55a-c	15.65	118.5ab	110.5a-c	114.5
$T_9= N_{150}P_{75}K_0S_{30}$	581.3bc	405.5h-k	493.4	14.35bc	10.20d-f	12.28	107.5a-d	81.5c-e	94.5
$T_{10}= N_{150}P_{75}K_{100}S_{30}$	597.3bc	505.5a-f	551.4	14.95ab	13.35a-d	14.15	110.5ab	100.5a-e	105.5
$T_{11}= N_{150}P_{75}K_{200}S_{30}$	576.6bc	526.5a-d	551.6	15.25ab	14.28a-c	14.77	119.5ab	107.5a-c	113.5
$T_{12}= N_{150}P_{75}K_{150}S_0$	544c	448.5e-j	496.3	13.25bc	11.40c-f	12.33	107.6a-d	87.8b-e	97.7
$T_{13}= N_{150}P_{75}K_{150}S_{20}$	557.3bc	514.5a-e	535.9	14.77b	13.58a-d	14.18	112.5a-c	103.5a-d	108
$T_{14}= N_{150}P_{75}K_{150}S_{40}$	580.7bc	474.7c-h	527.7	14.98ab	12.35a-f	13.67	113.5a-c	95.8a-e	104.7
$T_{15}= N_{100}P_{50}K_{100}S_0$	558.5bc	395.3i-k	476.9	13.28bc	9.65ef	11.47	88.2b-d	77.7de	83
$T_{16}= N_{375}P_{150}K_{250}S_{20}$	635.5ab	423.8g-k	529.7	15.58ab	10.60d-f	13.09	116.5ab	83.5c-e	100
$LSD_{0.05}$	80.74	73.1	-	3.701	3.55	-	33.51	29.4	-
CV (%)	8.27	9.35	-	8.75	9.57	-	8.5	8.74	-

Values within a column with a common letter do not differ significantly (p=0.05)

Table 4. Effects of combined application of N, P, K and S on diameter of floret and weight of individual spike of gladiolus

Treatments N-P-K-S (kg ha^{-1})	Diameter of floret (mm)			Weight of individual spike (g)		
	2010-11	2011-12	Mean	2010-11	2011-12	Mean
$T_1 = N_0P_0K_0S_0$	42.9f	51.1c	47	68.52g	57.35n	62.94
$T_2= N_0P_{75}K_{150}S_{30}$	50.8ef	52.6c	51.7	98.02ef	61.75mn	79.89
$T_3= N_{100}P_{75}K_{150}S_{30}$	61.5b-d	64.5a-c	63	110.6de	83.75f-h	97.18
$T_4= N_{150}P_{75}K_{150}S_{30}$	67.5ab	79.6ab	73.6	120.1b-d	109.30ab	114.7
$T_5= N_{200}P_{75}K_{150}S_{30}$	73.5a	83.3a	78.4	135.2a	113.60a	124.4
$T_6= N_{150}P_0K_{150}S_{30}$	62.9b-d	60.5a-c	61.7	112.8c-e	72.75i-k	92.78
$T_7= N_{150}P_{50}K_{150}S_{30}$	67.8ab	67.5a-c	67.7	119.0b-d	91.25d-f	105.1
$T_8= N_{150}P_{100}K_{150}S_{30}$	69.5ab	77.3a-c	73.4	129.0ab	103.70bc	116.3
$T_9= N_{150}P_{75}K_0S_{30}$	60.2b-e	55.8bc	58	119.1b-d	66.72km	92.9
$T_{10}= N_{150}P_{75}K_{100}S_{30}$	65.2a-c	70.1a-c	67.7	122.0a-d	95.35c-e	108.7
$T_{11}= N_{150}P_{75}K_{200}S_{30}$	66.8ab	74.4a-c	70.6	126.8a-c	101.23bc	114.0
$T_{12}= N_{150}P_{75}K_{150}S_0$	56.8c-e	62.1a-c	59.5	115.6b-d	78.65hi	97.13
$T_{13}= N_{150}P_{75}K_{150}S_{20}$	60.3b-d	72.4a-c	66.4	121.6a-d	98.77cd	110.2
$T_{14}= N_{150}P_{75}K_{150}S_{40}$	63.2b-d	65.5a-c	64.4	128.1ab	88.84e-g	108.5
$T_{15}= N_{100}P_{50}K_{100}S_0$	55.2de	53.5bc	54.4	95.05f	68.95j-m	82.00
$T_{16}= N_{375}P_{150}K_{250}S_{20}$	68.1ab	58.5a-c	63.3	121.1a-d	81.65gh	101.4
$LSD_{0.05}$	9.82	26.4	-	14.99	8.68	-
CV (%)	9.5	7.14	-	7.81	6.69	-

Values within a column with a common letter do not differ significantly (p=0.05)

mm) which was almost apparent with the treatment T_6 ($N_{150}P_0K_{150}S_{30}$ kg ha^{-1}), T_{12} ($N_{150}P_{75}K_{150}S_0$ kg ha^{-1}) and T_3 ($N_{100}P_{75}K_{150}S_{30}$ kg ha^{-1}) (Table 3). The similar trend in floret number, length and diameter were observed under different combined doses of N, P, K and S. Significantly maximum number of florets per plant (18.62 and 15.45), highest floret length (127.6 mm and 118 mm) and floret diameter (73.5 mm and 83.3 mm) were recorded in T_5 ($N_{200}P_{75}K_{150}S_{30}$ kg ha^{-1}) treatment while the native control treatment showed poor performance in producing floret number, length and diameter during 2010-11 and 2011-12, respectively (Tables 3 and 4). Thèse results are in agreement with the findings of Najjar and Rehalia (2005) and Bhattacharjee (2001). They stated that the maximum number of florets per spike and large flowers were obtained with 175 kg N ha^{-1}. The weight of individual spike was also greatly influenced by the different combination of N, P, K and S. The mean weight of individual spike was varied from 62.94 to 124.4 g due to different treatment. However, the maximum weight of spike was recorded from T_5 ($N_{200}P_{75}K_{150}S_{30}$ kg ha^{-1}) treatment which was significantly similar to T_4 ($N_{150}P_{75}K_{150}S_{30}$ kg ha^{-1}) treatment and 98.08% and 97.31% yield increased over control T_1. This result is in closent ressembles the observations of Chouhan *et al*. (2014); Rajhansa *et al*. (2010); Sharma and Singh (2007) and Deo-Shankar and Dubey (2005).

The reference dose T_{16} ($N_{375}P_{150}K_{250}S_{20}$ kg ha^{-1}) was exhibited moderate result in all the characters but in view of economic point, the treatment combinations T_5 ($N_{200}P_{75}K_{150}S_{30}$ kg ha^{-1}) was found to be superior followed by T_4 ($N_{150}P_{75}K_{150}S_{30}$ kg ha^{-1}) to all other treatment combination and farmers' dose.

Conclusion

Combined application of $N_{200}P_{75}K_{150}S_{30}$ kg ha^{-1} contributed to obtain highest yield of gladiolus followed by $N_{150}P_{75}K_{150}S_{30}$ kg ha^{-1} and $N_{150}P_{100}K_{150}S_{30}$ kg ha^{-1}. So, the economic point of view, combined application of N, P, K and S at 200, 75, 150 and S 30 kg ha^{-1}, respectively along with 5 tons cow dung ha^{-1} might be suitable dose for yield maximization of gladiolus in grey terrace soils of Gazipur, Bangladesh.

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