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OPTIMIZATION OF N, P AND K TO ENHANCE THE PRODUCTIVITY AND QUALITY OF *GLADIOLUS GRANDIFLORAS* CV ESSENTIAL UNDER SEMI-ARID CONDITIONS OF PAKISTAN

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Abstract

Field experiments were conducted to optimize the primary nutrient levels to improve the quality and productivity of floral and cormel aspects of gladiolus in semi-arid climate of Pakistan. NPK levels were standardized (data not shown) in first experiment before the actual experiment. Results showed that application of 10-20-10 g/m^2 (NPK-1) improved plant height, leaf area and sprouting percentage from rest of the treatments. About 8.49 and 10.20% longer stems and spikes, respectively and 0.41% higher chlorophyll contents were recorded at 20-20-00 g/m^2 (NPK-7) over control. Compared with control, cormels diameter was enhanced by two-folds while weight of cormels clump^{-1} was improved by 73.41% at 30-30-30 g/m^2 (NPK-4). Furthermore, 15, 30 and 25% higher N, P and K contents in leaves were noticed at 30-30-30 (NPK-4) and 20-00-20 g/m^2 (NPK-6), respectively. Additionally, fresh and dry weight and diameter of florets as well as prolonged vase life were noticed at 10-20-10 g/m^2 (NPK-1) in gladiolus cut flower, and further increase in nutrition remained non-significant. Conclusively, NPK-1 proved an optimal level to enhance quality and yield of *Gladiolus grandifloras* cv. Essential under semi-arid conditions.

Introduction

Gladiolus (*Gladiolus grandiflorus* L.) is one of the most renowned cut flowers cultivated commercially as perennial bulbous plant which belongs to Iridaceae (Bai *et al.* 2009). It is a corm, originated from the base of the sheath foliage. Its multitudinous varieties and majestic inflorescence with disparate enchanting colors has made this flower attractive for employ in herbaceous borders, beddings, cut flowers and for pots as well. Such a beauty and famousness has created a lead role for gladiolus in world trade among other cut flowers.

Robust and healthy, corms and cormels production necessitates many things, of which balance nutrient supply is a crucial one. According to Halder *et al.* (2007) chemical fertilizers have important roles in growth aspects, flowers quality and cormel production of gladiolus. Addition in concentration of N application enhanced corm production of gladiolus and it gave more spike weight, flower diameter and size when NPK was applied at 50-10-20 g/m^2 (Mukesh *et al.* 2001). Cormel production of gladiolus was much better at high levels of phosphorous fertilizer than nitrogenous fertilizer (Pant 2005).

Furthermore, when potassium was used in combination with nitrogen it increased the flowering and spike length, also levels of K affects significantly the first floret opening and days to spike emergence in gladiolus (Butt 2005). Hence, optimization of macronutrients is necessary to enhance the floral production of high quality. Till now, very little work has been done on this

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aspect of gladiolus production under semi-arid climate of Pakistan. The present study was, therefore, conducted to optimize the macronutrients N, P and K levels to enhance the quality and yield of *Gladiolus grandiflorus* L. The results of this study will be a tool for horticulturists and gladiolus producers to get maximum output of high quality through effective management of nutritional aspect of flower production not only of this region but also for other regions with similar climatic conditions.

Materials and Methods

The top soil (0 - 20 cm) of the experimental site was collected and passed through 2 mm sieve and different soil properties were determined according to Sparks (1996). The soil was naturally loamy with an organic matter content of 0.51%, pH 8.1, EC 0.42 dS/m, nitrogen 0.0352%, available phosphorus 4.3 mg/kg, available potassium 110 mg/kg and bulk density of 1.40/cm^3. The relative proportions of micronutrients in the soil were as follows: B (1.02 mg/kg), Mn (20.4 mg/kg), Fe (10.1 mg/kg), Cu (1.9 mg/kg) and Zn (1.1 mg/kg) of soil.

A preliminary trial was conducted during 2008 - 2009 at Floriculture Research Area in Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan (31°25´N, 73°04´E) before actual trial to standardize the NPK level to improve vegetative and floral aspects of gladiolus. An exotic variety of gladiolus named "Essential" was assessed to check its adaptability under semi-arid conditions of Pakistan. The climate of this region is semi-arid and subtropical. The weather of this region ranges between 4.4°C (in January) and 48°C (in June) with mean annual rainfall about 200 - 250 mm and falls in semi-arid region. Most of the rainfall in this region occurs during monsoon (July-August) (Ashraf *et al.* 2016). The planting material was obtained from Green Works Pvt. Ltd., Lahore, Pakistan (an importer, representing Stoop flower Bulb Company of Holland in Pakistan). The data for various vegetative and floral parameters were collected (results not presented here) and analyzed by practicing standard statistical techniques as were employed in actual experiment.

On the basis of results from preliminary trial, actual trial was also conducted on the same location during the year 2009 - 2010. Treatments were arranged in randomized complete block design (RCBD) in triplicate. The following treatments were applied to each experimental unit; NPK-1 (10-20-10 g/m^2), NPK-2 (10-10-10 g/m^2), NPK-3 (20-20-20 g/m^2), NPK-4 (30-30-30 g/m^2), NPK-5 (00-20-20 g/m^2), NPK-6 (20-00-20 g/m^2), NPK-7 (20-20-00 g/m^2). The corms were stored in cold store at 2 ± 1ºC to ensure that corms are not in dormant conditions. Each treatment was disjointed by an additional ridge to control the leaching of fertilizers after irrigation to minimize experimental error. Corms were planted on 3rd October with plant × plant and row × row distance of 7.5 cm and 100 cm, respectively. Phosphorous and potassium based fertilizers were applied at planting time while nitrogen was applied in three splits, 1/3rd at planting time, and other two splits were applied at 3rd and 6th leaf stage as per mentioned in treatments. Moreover, standard agronomic and management practices were adopted regarding irrigation, weed removal and others cultural practices for each treatment.

Data regarding growth characteristics such as sprouting percentage, plant height (cm), leaf area (cm), stem length (cm) and spike length (cm) of the gladiolus were recorded during the growing season of crop. Leaf chlorophyll contents were measured with a chlorophyll meter (SPAD-502 plus Konica Minolta, Japan).

Sprouting % was measured as follows:

$$\text{Sprouting \%} = \frac{\text{Total number of corms sprouted}}{\text{Total number of corms sown}} \times 100$$

Parameters concerning with corm and floral characteristics as number of cormels/clump, cormels diameter (cm), cormels weight/clump, number of florets/stem, fresh and dry weight of floret, diameter of floret (mm) and vase life (days) were calculated at maturity. Nitrogen contents (meq/l) in the leaves were measured by using the method described by van Lierop (1976). Spectrophotometer using standard curve was practiced to measure phosphorous while potash contents (meq/l) in leaves were determined by flame photometer.

Data were analyzed by using statistics 8.1 (Analytical, Tallahassee, Florida, USA). When F values were significant, the Tuckey's test was used for comparing treatments means. Graphs for experimental data were generated by using SigmaPlot 9.0 (Systat Software, Inc., San Jose California USA).

Results and Discussion

N, P and K significantly ($p \leq 0.05$) affected vegetative growth of gladiolus (Table 1). Highest sprouting %, plant height and leaf area were noticed in NPK-1. On the other hand, minimum sprouting % was observed in NPK-4, while tallest plants and maximum leaf area were observed in NPK-5. Furthermore, NPK-7 significantly improved stem and spike length while reduced stem and spike length were measured in NPK-2 and NPK-6, respectively which is statistically at par with other treatments. It was perceived that sufficient amount of N and P was required for improvement in stem and spike length while K in comparatively less quantity proved best for a good marketable stem length (Table 1). Saleem *et al.* (2012) found variations sprouting % with same variety *Gladiolus grandifloras* cv. "Essential" with different levels of macronutrients under similar climatic conditions. Increased growth may be due to nutrient availability and their uptake. N in combination with P and K increased the plant height but N + P had more prominent effect. Saleem *et al.* (2010) also reported that the higher concentration of phosphorous promoted plant

Table 1. Effect of different NPK levels on vegetative growth of *Gladiolus grandifloras.*

Treatments	Sprouting (%)	Plant height (cm)	Leaf area (cm^2)	Stem length (cm)	Spike length (cm)
NPK-1	93.00 a	55.50 a	97 a	106 bc	49 b
NPK-2	77.00 b	51.60 abc	67 d	93 e	48 b
NPK-3	82.66 b	54.70 a	91 b	98 d	47 b
NPK-4	52.00 e	49.90 bc	84 c	99 d	42 c
NPK-5	69.66 c	48.60 c	62 e	104 c	43 c
NPK-6	61.33 d	52.30 abc	69 d	109 b	34 d
NPK-7	65 cd	53.70 ab	93 b	115 a	54 a
LSD ($p \leq 0.05$)	5.91	4.35	3.70	3.06	2.60

Values sharing a letter in common with a column do not differ significanlty (LSD $p \leq 0.05$). NPK-1 (10-20-10 g/m^2), NPK-2 (10-10-10 g/m^2), NPK-3 (20-20-20 g/m^2), NPK-4 (30-30-30 g/m^2), NPK-5 (00-20-20 g/m^2), NPK-6 (20-00-20 g/m^2), NPK-7 (20-20-00 g/m^2).

height of cotton owing to their strong and speedy roots development, whereas Kargbo *et al.* (2016) reported that NPK compound fertilizers improved physiological basis of rice performance under field conditions. Moreover, presence of N and P is more important for leaf area development, while K also plays an important role in plant development and involved in various physio-metabolical mechanisms (Ali *et al.* 2016). The results are in accordance with Pathania *et al.* (2000) who argued that initially there is no significant effect of split application of nitrogen on leaf area but at later stages application of nitrogen in split along with phosphorous enhanced leaf area of gladiolus. Moreover, Khan and Ahmad (2004) noticed enhanced plant growth and spike length in *Gladiolus hortulanus* L. cv. 'Wind Song' where K was applied less than N and P (10-10-5 g/pot NPK).

Corm characteristics (number of cormels/clump, diameter of cormels and weight of cormels/ clump) were little affected by the different macronutrients combinations. The results revealed that number of cormels/clump were increased by 29.41% in NPK-5 than control while least number of cormels/clump were recorded in NPK-7. Further, higher values for diameter of cormel and weight of cormels/clump were noticed in NPK-4 whilst the minimum diameter and weight of cormels were recorded in NPK-7, former is statistically similar with NPK-1 and NPK-5. Additionally, maximum leaf chlorophyll contents were recorded at NPK-7 when compared with control while minimum values for leaf chlorophyll contents were obtained in NPK-5 (Table 2). Present results corroborate with the findings of Singh and Ha (1990) who asserted that higher concentration of nitrogen diminished the cormel yield. Diameter of cormels and weight of cormels/clump were maximal at NPK-4 that corresponded with the results of Khan and Ahmad (2004) who noticed an increased corm weight and corm diameter when plants were treated with NPK at 5-5-5 g/ pot.

Table 2. Effect of different NPK levels on cormel characteristics of Gladiolus *grandifloras.*

Treatments	Cormels/ clump	Cormels diameter (mm)	Cormels weight/clump (g)	Leaf chlorophyll content
NPK-1	17 b	5.50 c	0.79 c	72.70 ab
NPK-2	17 b	6.50 c	1.19 b	70 bc
NPK-3	18 b	14.50 b	1.33 ab	64.20 d
NPK-4	13 c	16.83 a	1.37 a	63.70 d
NPK-5	22 a	5.50 c	0.63 cd	62.30 d
NPK-6	11 c	6.00 c	0.58 de	69.87 c
NPK-7	8 d	5.50 c	0.42 e	73.00 a
LSD $p \leq 0.05$	2.23	1.15	0.17	2.81

Values sharing a letter in common with a column do not differ significantly (LSD $p \leq 0.05$). NPK-1 (10-20-10 g/m^2), NPK-2 (10-10-10 g/m^2), NPK-3 (20-20-20 g/m^2), NPK-4 (30-30-30 g/m^2), NPK-5 (00-20-20 g/m^2), NPK-6 (20-00-20 g/m^2), NPK-7 (20-20-00 g/m^2).

Table 3. Effect of different NPK levels on biochemical characteristics of *Gladiolus grandifloras.*

Treatments	Leaf N contents (%)	Leaf P contents (meq/l)	Leaf K contents (meq/l)
NPK-1	2.38 c	1.37 c	26 c
NPK-2	2.41 c	1.53 b	22.65 d
NPK-3	2.69 ab	1.00 de	27.74 b
NPK-4	2.74 a	0.88 e	22 d
NPK-5	1.70 d	1.10 d	28 b
NPK-6	2.60 b	1.79 a	32.57 a
NPK-7	2.58 b	0.99 de	31 a
LSD $p \leq 0.05$	0.12	0.13	1.63

Values sharing a letter in common with a column do not differ significantly (LSD $p \leq 0.05$). NPK-1 (10-20-10 g/m^2), NPK-2 (10-10-10 g/m^2), NPK-3 (20-20-20 g/m^2), NPK-4 (30-30-30 g/m^2), NPK-5 (00-20-20 g/m^2), NPK-6 (20-00-20 g/m^2), NPK-7 (20-20-00 g/m^2).

As for biochemical characteristics are concerned, highest values for nitrogen % were detected in NPK-4 while lowest were observed in NPK-5, however, phosphorous (P) and potassium (K) contents were different in each treatment but 30.65 and 25.26% more P and K contents were recorded in NPK-6, respectively whereas NPK-4 showed the lowest values for P and K contents (0.88 and 22 meq/l) in the leaves gladiolus. Plants with adequate availability of P had shown better growth and development. It was comprehended that in plants which were not supplied with potassium showed substandard growth of flowers and were more prone to disease attack. Plants with sufficient supply of K produced vigorous and sturdy flowers (Table 3). Ahmad *et al.* (2007) noted that application of N at 100 kg/ha enhanced vegetative growth but medium dose of 67 kg/ha of N enhanced the floral characteristics like flower diameter along with leaf nitrogen percentage in *Zinnia elegans* cv. Giant Dahlia.

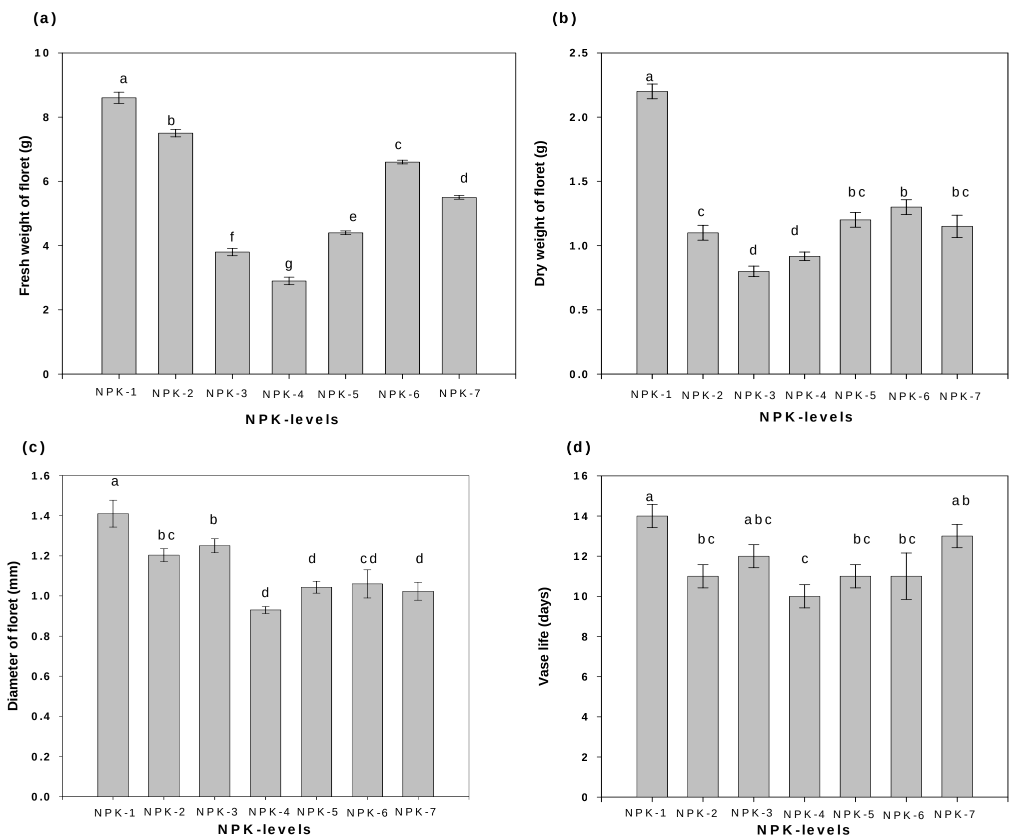

Fig. 1. Effect of different NPK levels on (a) fresh weight of floret, (b) dry weight of floret, (c) diameter of floret and (d) vase life, respectively. NPK-1 (10-20-10 g/m^2), NPK-2 (10-10-10 g/m^2), NPK-3 (20-20-20 g/m^2), NPK-4 (30-30-30 g/m^2), NPK-5 (00-20-20 g/m^2), NPK-6 (20-00-20 g/m^2), NPK-7 (20-20-00 g/m^2). Capped bars above means are S.E. of three replicates.

Floral characteristics (fresh weight, dry weight, diameter of floret and vase life) was not affected by macronutrients application. Maximum fresh and dry weight of floret, diameter and prolonged vase life was noticed in control while minimum fresh weight, diameter of floret and vase life was recorded in NPK-4 while NPK-3 gives minimum dry weight of floret (Fig. 1a-d). Application of N, P and K with an optimal dose yielded heavy florets in iris cultivation (Mahgpub *et al.* 2006). However, results for dry weight of florets are in contrast with the findings of

Saharkhiz and omidbaig (2008) who explained that P significantly enhanced fresh and dry weights of flowers in feverfew (*Tanacetum parthenium*) and its deficiency hampered fresh and dry weight and in poinsettias (*Euphorbia pulcherrima* Willd. ex Klotzsch) (van Iersel 2000). Moreover, NPK-1 proved best in terms of diameter of floret over other tested treatments. These results are confirmed by Pimple *et al.* (2006) who stated that highest floret diameter was obtained when N and P was applied at 10 g N + 12.5 P_2O_5 g/m^2 were applied in gerbera spp. Vase life, indicates shelf life of cut flower, also an important parameter for flower producers. In gladiolus, maximum vase life was established at NPK-1 that is also affirmed by previous reports (Ramzan *et al.* 2010; Lehri *et al.* 2011) who reported that vase life can be increased at some extent by combine application of macro- and micronutrients.

Table 4. Pearson correlation analysis among growth indices and chlorophyll contents of *Gladiolus*.

Growth indices	Sprouting (%)	Plant height	Leaf area	Stem length	Spike length	Cormels/ clump	Cormels diameter	Cormels weight/ clump
Plant height	0.6537							
Leaf area	0.3393	0.7714*						
Stem length	–0.1777	0.2435	0.2864					
Spike length	0.4549	0.4440	0.5757	0.0817				
Cormels/clump	0.5081	–0.2620	–0.3480	–0.5806	–0.0402			
Cormels diameter	–0.2982	–0.0941	0.2807	–0.4921	–0.1327	0.0088		
Cormels wt./clump	0.0538	–0.0553	0.0938	–0.8795**	–0.0258	0.3126	0.8171*	
Leaf chlorophyll content	0.3032	0.6367	0.3731	0.4822	0.3861	–0.5640	–0.6061	–0.4840

*Significant ($p \leq 0.05$) ; **Significant ($p \leq 0.01$).

Further, no significant correlations were observed among the growth indices except plant height vs leaf area ($R^2 \geq$ 77%; positive), stem length vs cormels weight/clump ($R^2 \geq$ 87%; negative) and cormels diameter vs cormels weight/clump ($R^2 \geq$ 81% ; positive) (Table 4).

Overall, present study revealed that combination of NPK-1 (10-20-10 g/m^2) is an overall optimal level of primary macronutrients for healthy crop production under semi-arid conditions. So, *Gladiolus grandifloras* cv. “Essential” can be propagated successfully under semi-arid climate of Pakistan on commercial scale to enhance its share in trade.

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