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Growth and Corm Production of *Gladiolus grandiflorus* L. 'Essential' Under Different NPK Regimes

Mohsin Bashir [1], Imran Khan [2*], Rashid Waseem Khan Qadri [1], Mohsin Tanveer [2,3], Muhammad Zain [2] and Iftikhar Ahmad [1]

[1] Institue of Horticultural Sciences, University of Agriculture Faisalabad, Pakistan

[2] Department of Agronomy, University of Agriculture Faisalabad, Pakistan

[3] School of Land and Food, University of Tasmania, Hobart Australia

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*Corresponding author's email: drimran@uaf.edu.pk

Abstract

Gladiolus is very popular and highly demanded cut flower worldwide however imbalance nutrition reduces its production, additionally irrational combination of nutrient further kindled the situation. The current study was conducted to ascertain the effects of different combinations of N, P and K on growth, floral development, and N, P and K uptake by gladiolus leaves. N, P and K was applied as; whole NPK (10: 20: 10 g m^{-2}), N (20 g m^{-2}), P (10 g m^{-2}), K (10 g m^{-2}), N+P (20: 10 g m^{-2}), N+K (20: 10 g m^{-2}), P+K (10:10 g m^{-2}). Among treatments, better growth in term of higher sprouting percentage, plant height, leaf area was observed under whole NPK application while stem length and spike length was significantly higher under P+K. Further, we found whole NPK application resulted in higher floret fresh and dry weight whereas maximum floret diameter was under P+K. We found that K played significant role in the floret development while P was important for attaining higher corm weight. Higher leaf chlorophyll contents and N uptake was under whole NPK application. Alone P application showed maximum P uptake and higher K uptake was under P+K treatment. Our results concluded that balanced fertilization (NPK) is better for sustainable gladiolus production.

Keywords: Chlorohpyll, Fertilization, Florets, Gladiolus, Growth, NPK.

INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.) is a bulbous plant which is commercially cultivated as cut flower throughout world. Due to its excellent vase life and captivating colors, it has great economic value in global trade in landscaping (Bose *et al*., 2003). The production demand of cut flowers has also been accelerated manifolds in the past decade and it is expected to spring up further around the globe. It has a pivotal position among commercial flower which has high demand in international arena and in domestic markets (Halder *et al*., 2007). Intensive cut flower production requires high level of fertilization. Imbalance fertilization may reduce gladiolus flower production and may also result in soil and environmental pollution. Gladiolus productivity hinges upon the amounts, forms and frequency of application of plant nutrients (Zafar, 2007).

Gladiolus requires well balanced fertilizers application for optimum growth and quality production. There are evidences that with increasing N application resulted in better growth with concomitant increase in higher flower spike length, corm weight and size and number of cormels per plant stalk length and number of florets stalk^{-1} in gladiolus (Shah *et al.*, 1984; Lehri *et al.*, 2011). Nonetheless, in another study it was found that nitrogen dose of 50 kg ha^{-1} produced the highest corm yield (17.71 g plant^{-1}), whereas higher dose of nitrogen (100 and 150 kg ha^{-1}) fertilizer produced the lowest cormel yield (Pant, 2005). Further P significantly increases the fresh and dry weights of flowers, plant height and flower numbers plant^{-1} in feverfew (*Tanacetum parthenium*) (Saharkhiz and Omidbaigi, 2008). Inadequacy of P and K results in small leaves and small floral bracts of pale color with scant plant height, number of leaves plant^{-1}, number of plants cluster^{-1} and number of racemes plant^{-1} in *Globba rosae* 'Gagnep' (Ruamrungsri *et al*., 2007). Potassium another major macronutrient and most important cation in higher plants, is crucial for enzyme activation, protein synthesis and photosynthesis (Marschner, 1995).

It was found that K significantly influenced the days to spike emergence and first floret opening in gladiolus (Butt, 2005). Canopy potassium application was also reported to increase SSC (soluble solids concentration) in 'Thompson Seedless' (Feliziani *et al*., 2013). Mukesh *et al*. (2001) reported that application of NPK (50: 10: 20 g m^{-2}) resulted in higher floret diameter, corm weight, number of corms per plant in *Gladiolus grandiflorus*. Younis *et al*. (2006) found that N along with P and K has synergetic effect on bloom distribution in dahlias, while Barman *et al.* (1998) reported that effect of N and K were much more pronounced than those of P on number, size and weight of corms and cormels. Pant (2005) further substantiated that P at 100 kg ha^{-1} and N at 0 kg ha^{-1} produced the highest cormel yield (25 g plant^{-1}), whereas N at 150 kg ha^{-1} and P at 0 kg ha^{-1} produced the lowest cormel yield (1.95 g plant^{-1}). Malvi *et al.* (2011) concluded that optimum N supply increase optimum P and K uptake while excessive N application reduce the uptake of P and K. Though it is well know that N, P and K are important nutrient however information pertaining to effect of their different combinations on gladiolus growth and reproductive development in relation to N, P and K uptake from soil is not well documented and reported. Therefore, the current study was conducted to ascertain effect of different NPK levels on growth, floret and corm development in *Gladiolus grandiflorus*.

MATERIALS AND METHODS

Experimental site

Experiment was conducted during 2013 in Floriculture Research Area, Institute of Horticultural Sciences University of Agriculture, Faisalabad, Pakistan (31.25° N, 73.09° E, and 184 m above sea level). The soil of the experimental site belongs to the Lyallpur soil series (Aridisol-fine-silty, mixed, hyper thermic Ustalfic, Haplargid in the USDA classification and Haplic Yermosols in the FAO classification). Soil analysis was checked and is given in Table 1.

Experimental design and treatments

The experiment was carried out in Randomized Completly Block Design (RCBD) and repli-

Table 1. Analysis of physical and chemical properties of soil from experimental site.

Properties	Soil depth	
	0-15 (cm)	15-30 (cm)
Texture	Loam	Loam
pH	8.30	8.10
EC (dS m^{-1})	0.42	0.37
Exchangeable Sodium (mmol/100g)	0.90	0.70
Organic matter (%)	0.51	0.54

Table 2. Following treatments used in the experiment.

NPK application treatments	Treatment description	Treatment code
Whole NPK	NPK was applied at the rate of 10:20:10 g m^{-2}	NPK
Alone nitrogen application	N was applied at the rate of 10 g m^{-2}	N
Alone phosphorous application	P was applied at the rate of 20 g m^{-2}	P
Alone potassium application	K was applied at the rate of 10 g m^{-2}	K
Nitrogen and phosphorous	N+P was applied at the rate of 10:20 g m^{-2}	N+P
Nitrogen and potassium	N+K was applied at the rate of 10:10 g m^{-2}	P+K
Phosphorous and potassium	P+K was applied at the rate of 10:20 g m^{-2}	P+K

N: Nitrogen, P: Phosphorous, K: Potassium.

cated four times. Corms were planted during first week of October and plant to plant distance was maintained at 7.5 cm and row to row distance was 100 cm. NPK was applied in different combination (Table 2). Phosphorus and potassium based treatments were applied as a whole at the time of planting while nitrogenous fertilizer was applied in three splits, first at the time of planting, second at three leaf stage while third dose was applied at six leaf stage. Nitrogen (N) was applied in form of urea (46 % N), phosphorous (P) and potassium was applied as single super phosphate (18 % P) and sulphate of potash (50 % K). All fertilizers were supplied in granular form by broadcast method in an area of 1 m^2 as per treatments.

Observations

Growth indices

Data pertaining to growth indices such as; sprouting percentage (%), plant height (cm), leaf area (cm^2), stem length (cm), spike length (cm) were measured. Sprouting percentage (%) was taken by the given formula

Sprouting percentage (%)= (Total numbers of corm sprouted)/(Total number od corm sown)× 100

Floral and corm indices

Floral indices was measured by measuring number of florets per stem, floret fresh weight (g), floret dry weight (g), floret diameter (cm) and vase life (days). While, corm development was estimated by measuring numbers of cormels per clump, diameter of a cormel (cm) and weight of cormels per clump (g).

Biochemical indices of *Gladiolus grandiflorus*

Biochemical indices of gladiolus were leaf chlorophyll content (SPAD) value, N, P and K contents in leaves (meq. L^{-1}). Total chlorophyll contents were determined following the method of Arnon (1949). A leaf sample of 0.1 g was ground and placed in 15 mL centrifuge tube, along with 10 mL of miscible liquids by 95.5 % acetone and absolute ethyl alcohol in 1:1 ratio. Then covered with black plastic bag and kept at dark place until the sample changed into white. Total

chlorophyll contents were measured using a UV-visible spectrophotometer. Total nitrogen percentage was determined by using the method described by the van Lierop (1976) method. For measuring nitrogen percentage first leaves were passed through digestion procedure and then nitrogen content was measured by Kjeldhal method (Nelson and Sommers 1973). Phosphorus was determined by spectrophotometer using standard curve. Potash was measured with flame photometer.

Statistical analysis

The collected data was analyzed statistically according to Fisher's analysis of variance technique and treatment means were compared according to least significant test at 5% level of probability (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Growth indices

In present study, *G. grandiflorus* growth was examined in terms of sprouting percentage (SP), plant height (PH), leaf area (LA), stem length (StL) and spike length (SpL) in response to NPK application. Results indicated that all the growth related traits varied significantly under the influence of NPK and their different combinations (Fig. 1).

Results indicated that growth of *G. grandiflorus* was considerably influenced by different nutrient treatments. Among treatments, higher SP, PH and LA was observed when whole NPK was applied however, higher values of StL and SpL was observed under combined application of P and K. It was further noted that SP was 90% (data not shown) under alone P application, however alone N, alone K and N+K application showed least and significantly same SP. Similarly, least LA was observed under N+K application. Minimum plant height (35.00 cm) was attained by *G. grandiflorus*

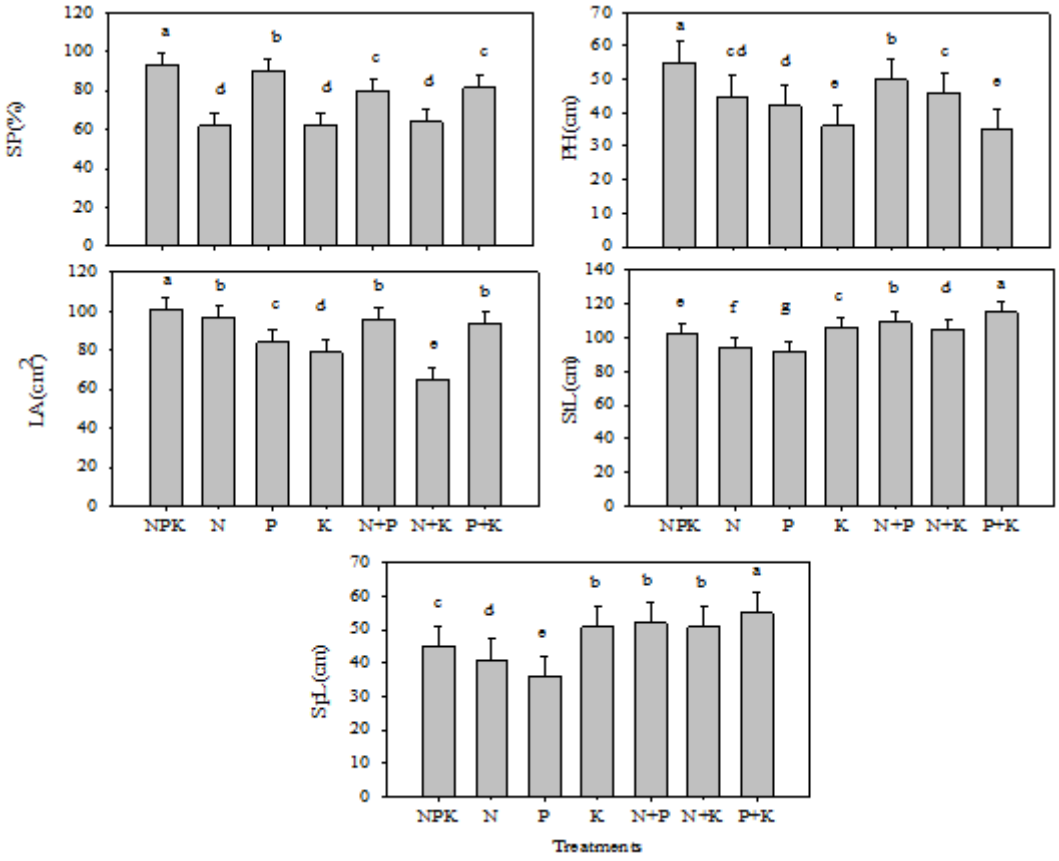

Fig. 1. Effect of different levels of NPK on sprouting percentage (SP), plant height (PH), leaf area (LA), stem length (StL) and spike length (SpL) of *Gladiolus grandiflorus* L. Vertical bars above mean denote LSD value (P< 0.05) of four replicates. NPK (10:20:10 g m^{-2}), N (10 g m^{-2}), P (20 g m^{-2}), K (10 g m^{-2}), N+P (10:20 g m^{-2}), N+K (NK 10:10 g m^{-2}), P+K (10:20 g m^{-2}).

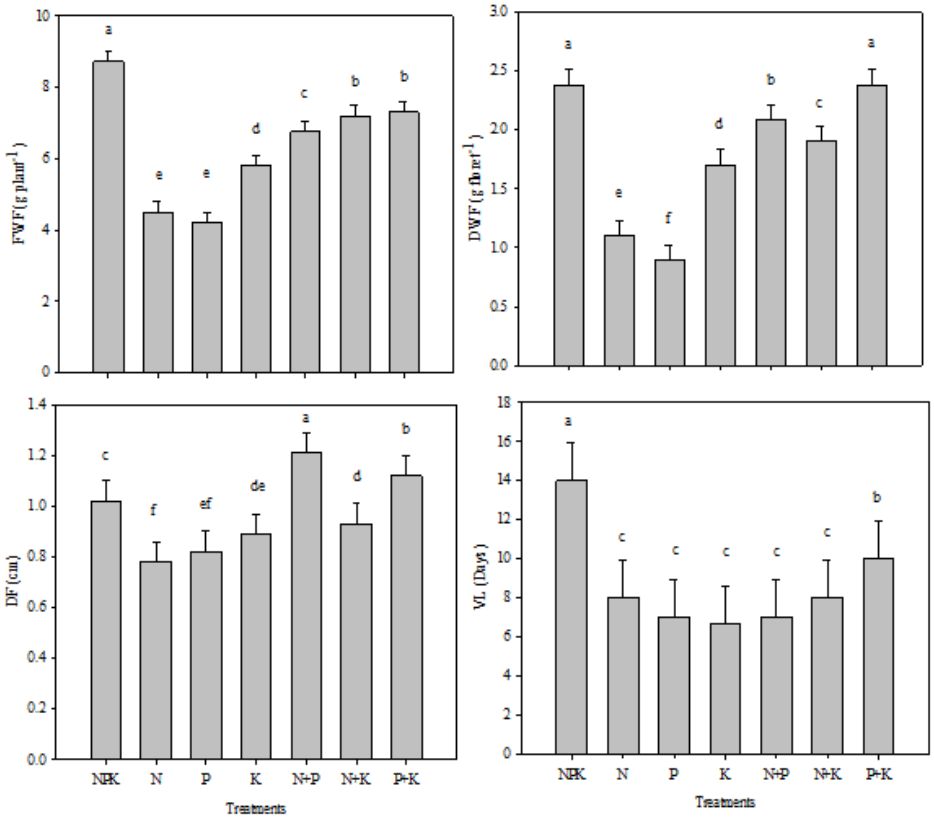

Fig. 2. Effect of different levels of NPK on fresh weight of floret (FWF), dry weight of floret (DWF), diameter of floret (DF) and vase life (VL) of *Gladiolus grandiflorus* L. Vertical bars above mean denote LSD value (P< 0.05) of four replicates. NPK (10:20:10 g m^{-2}), N (10 g m^{-2}), P (20 g m^{-2}), K (10 g m^{-2}), N+P (10:20 g m^{-2}), N+K (NK 10:10 g m^{-2}), P+K (10:20 g m^{-2}).

when alone K and P+K were applied.

Additionally data pertaining to StL and SpL indicated that these growth indices were significantly influenced and reduced to 91 cm and 36 cm respectively when alone N was applied as compared to P+K which gave maximum StL (115 cm) and SpL (55 cm) (Data not shown). Similar results have been reported by Khan and Ahmad (2004) who found higher SP, PH and LA of gladiolus plants when balanced amount of NPK is available. We found higher SP, PH, LA under NPK application could be related to availability of N, P and K which played significant role in growth.

N is reported to be significantly increased LA might be due to better cell division, this could further resulted in a significant increase in photosynthetic activity thus increase growth (Kumar *et al.,* 1988). Further, Haitbura and Misra (1999) substantiated that 30 g N m^{-2} is best for enhancing vegetative growth of gladiolus. Likewise P also played significant role in increasing fresh and dry weight of flowers, plant height and flower numbers per plant in feverfew (*Tanacetum parthenium*) (Saharkhiz and Omidbaigi, 2008). We found higher SpL and StL under P+K application however under N application these traits were least developed. Our results are in divergent with the finding of Bhattacharjee (1981) who reported that increasing dose of N increased SpL. These results are also supported by previous studies in which maximum spike length with phosphorus application of 30 gm per m^{-2} (Rajiv *et al.*, 2003). In addition phosphorus fertilizer acts to regulate many enzymatic reactions which are leading to enhancement of plant metabolism and formation of new cells and consequently increasing stem length.

Floral and corm related indices

Floral and corm performance examined by examining fresh weight of floret (FWF), dry weight of floret (DWF), diameter of floret (DF), vase life (VL), number of floret per stem (NFS), weight of cormels per clump (WCC), diameter of clump (DC) and number of cormels per clump

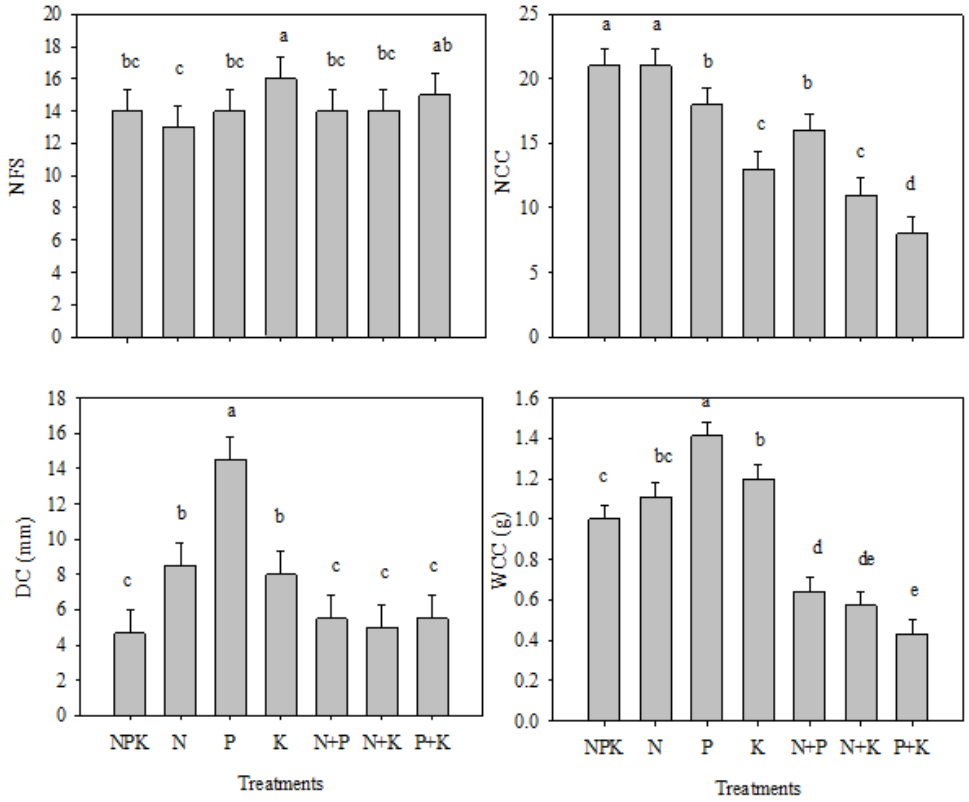

Fig. 3. Effect of different levels of NPK on number of florets per stem (NFS), number of cormels per clump (NCC), diameter of cormel (DC) and weight of cormels per clump (WCC) of *Gladiolus grandiflorus* L. Vertical bars above mean denote LSD value (P< 0.05) of four replicates. NPK (10:20:10 g m^{-2}), N (10 g m^{-2}), P (20 g m^{-2}), K (10 g m^{-2}), N+P (10:20 g m^{-2}), N+K (NK 10:10 g m^{-2}), P+K (10:20 g m^{-2}).

(NCC) was significantly influenced by different NPK treatments. Among NPK treatments, combined application of NPK gave higher FWF (13.32%), DWF (10.3%), and NCC (13.23%) as compared to other treatments, while maximum DF was recorded under combined application of P and K. Maximum NFS were developed when alone K was applied (Fig. 2 and Fig. 3).

Furthermore, it was observed that higher WCC (8.7%) and DC (6.56%) was attained by *Gladiolus* cormels when alone P was applied as compared to other treatments. Similar results have been reported by Sharma *et al.,* (2003), who observed increased floret size and number of florets per spike when P (up to 200 kg ha^{-1}) was applied. Further maximum vase life (VL) was found when NPK was applied followed by P+K application, while remaining all other nutrient treatments gave statistically same and least VL (Fig. 2). According to Pimple *et al.,* (2006), maximum vase life was obtained by applying N and P at 5 g N + 15 g P_2O_5 m^{-2}.

Least attainment of FWF and FDW was observed under P application, nonetheless NFS and DF were least developed under alone N. This might be because of reason that N is essential for vegetative growth traits (Lehri *et al.*, 2011), while P is for important for floret development (Shaoukat *et al.*, 2012). These results are in line with the findings of earlier studies that higher doses of phosphorus produced the more corms weight and cormels yield as compared when no phosphorus was applied (Pant, 2005). Additionally least number of cormels per clumps (NCC) and WCC were recorded under N+K and P+K application respectively (Fig. 3). As we observed a varied repose of these attributes to different N, P and K treatments, our results suggested that application of balanced amount of nutrition is pre-requisite to get higher yield. Similar finding have been reported by Khan and Ahmad (2004) who substantiated that high N application rate along with moderate P and K increased vegetative growth while moderate doses of NPK exhibited more pronounced effect on floral characteristics and corm development of gladiolus.

We found higher FWF, DWF, VL and NCC under NPK application and are in consistent with the findings of Lehri *et al*., (2011) who found that N+P are the essential nutrients for production of cormlets in gladiolus. Further, higher NFS as resulted of alone K application might be associated with positive role of K in floret development (Zubair, 2011). Further K is reported as one of major elements that played significant role in reproductive stage while N played significant role in vegetative growth therefore NFS was least under alone N application as compared to alone K application. These results are in contrast with the findings of Mukesh *et al.*, (2001) who reported that NPK (50: 10: 20 g m^{-2}) in another variety of gladiolus resulted in maximum spike weight, number of flowers $spike^{-1}$, flower diameter and size.

Biochemical indices

Biochemical indices were analyzed by measuring leaf chlorophyll contents (LC), N, P and K uptake. A significant response of these indices was found to different NPK treatments. Maximum LC was found when whole NPK was applied followed by P+K application. Total chlorophyll contents $plant^{-1}$ were increased consistently by the treatments where P alone or in combination with K was applied in sufficient quantity while it decreased significantly when N and K were applied independently in the treatments. Previous studies reported that N is important element for chlorophyll contents (Akram, 2014), however our results suggested that P and K are also important, therefore NPK application resulted in higher chlorophyll contents as compared to other treatments. Further, data related to leaf nitrogen content revealed that whole NPK, alone N, N+P, and N+K gave statistically same and significantly higher N uptake as compared to other NPK application treatments. However, alone P application showed minimum N uptake and assimilation.

Our results revealed that alone P application showed maximum P uptake (1.42 meq. L^{-1}) followed by P+K (1.37 meq. L^{-1}) (Data not shown). However, minimum P (0.92 meq L^{-1}) in leaves was noted under N+K application (Fig. 4).

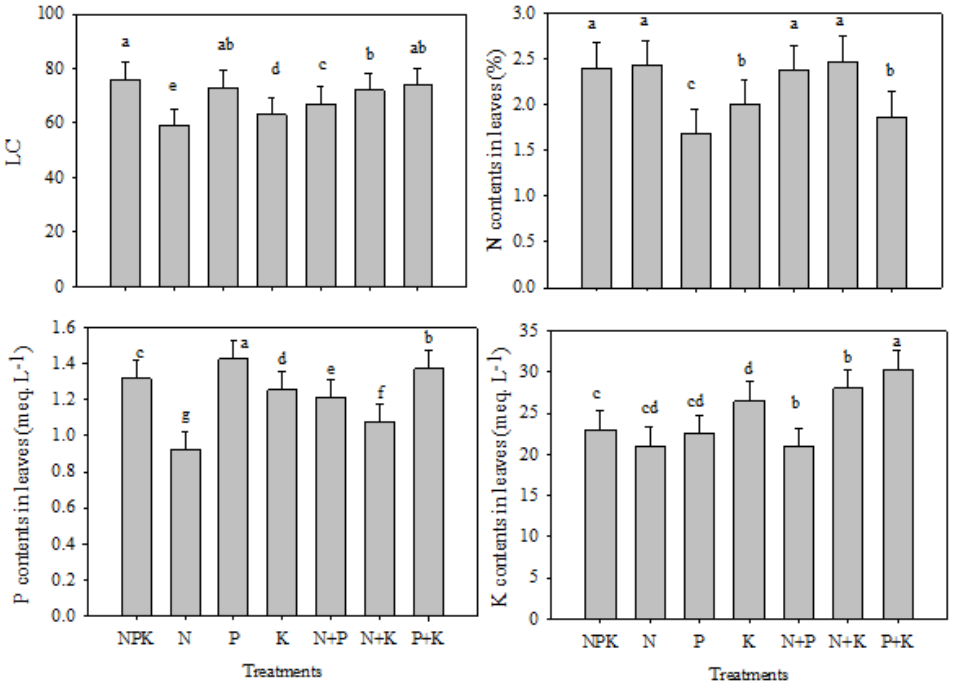

Fig. 4. Effect of different levels of NPK on leaf chlorophyll contents (LC) (mg g^{-1} FW), nitrogen uptake, phosphorous uptake and potassium uptake in the leaves of *Gladiolus grandiflorus* L. Vertical bars above mean denote LSD value (P< 0.05) of four replicates. NPK (10:20:10 g m^{-2}), N (10 g m^{-2}), P (20 g m^{-2}), K (10 g m^{-2}), N+P (10:20 g m^{-2}), N+K (NK 10:10 g m^{-2}), P+K (10:20 g m^{-2}).

Maximum K uptake was recorded in those plants which were fertilized by P+K followed by N+K and NPK treatment, while joint application of N and P gave least K contents in leaves suggested that least K uptake and assimilation was under this treatment. Our results are supported by many findings reviewed by Malvi *et al*., (2011), who concluded that optimum N supply increase optimum P and K uptake while excessive N application reduce the uptake of P and K.

CONCLUSIONS

We found that balanced application of NPK increased growth and yield related indices of *Gladiolus grandiflorus* vigorously. Whole NPK application was better for increasing plant height, leaf area, number of cormels per clumps while P and K application gave maximum floret size. Our study further revealed that P is important for attaining higher corm weight per clump and corm diameter corm while K plays a significant role in the development of florets. Our result further suggested that in order to attain sustainable production of *Gladiolus grandiflorus*, balanced fertilization is necessary. Therefore, optimum use of compound fertilizer would help better towards vigorous growth and maximum flower production in gladiolus.

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