Sjournals
Scientific Journals
Scientific Journal of Agricultural (2012) 1(5) 105-111
ISSN 2322-2425

Contents lists available at Sjournals

Scientific Journal of Agricultural

Journal homepage: www.Sjournals.com

Original article

Influence of phosphorus fertilization on gladiolus corm and flower production

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A R T I C L E I N F O

Article history:
Received 18 October 2012
Accepted 25 October 2012
Available online 30 October 2012

Keywords:
Gladiolus
Flowering
Corm
Phosphorus
Influence

A B S T R A C T

The influence of different levels of phosphorus on corm and flower productivity of Gladiolus (*Gladiolus grandiflorus*) was studied at Faculty of Agriculture Rawalakot, Azad Jammu and Kashmir during the year 2010. Corms of similar size and weight were collected from Awan Nursery and Seed Store, Rawalpindi. Sowing was done on 25th April, 2010 with five different phosphorus levels viz. 40, 70, 100, 130, 160 kg ha^{-1}. The experiment was laid out as RCBD (randomized complete block design). Maximum number of leaves (8.68), maximum plant height (156.0), minimum number of days to spike emergence (68.10), minimum number of days to flowering (72.74), maximum spike length (78.73), maximum number of cormels per plant (102.70), maximum weight of corm (67.33) and cormel (3.43), maximum size of corm (7.43) and cormel (2.06) was recorded for P_5. Minimum number of days to sprouting (12.00) was recorded in P_4. Maximum number of plants per corms, florets, spikes and corms per plant were recorded in P_4 andP_5.

1. Introduction

Gladiolus (*Gladiolus grandiflorus)* is an important cut flower crop, popular in many parts of the world due to its beauty and vase life. The inflorescence with variety of colours has made it attractive for use in herbaceous borders, beddings, rockeries, pots and for cut flowers. The genus gladiolus belongs to the family Iridaceae and consists of about 300 species out of which 250 are wild and about 50 of the garden origin. The modern garden has been developed through a succession of crosses involving about 12 Gladiolus species (Buch, 1972).

Fertilizer requirements for rapidly growing gladiolus vary with climatic conditions, irrigation method and soil type (Wilfret, 1980). In sandy soil, it is necessary to provide fertilizer frequently, especially during the rainy season. In some heavier soils, little or no fertilizer is required for flower production (Stuart and McClellan, 1951).

Phosphorus is most often the limiting element in soils. It is absorbed primarily as the monovalent phosphate anion ($H_2PO_4^-$) and less rapidly as the divalent anion ($H_2PO_4^{-2}$). The soil pH control the relative abundance of these two forms, H_2PO_4 being favored below pH 7 and HPO_4^{-2} above pH 7. Phosphate deficient plants are stunted and in contrast to those lacking nitrogen, are often dark green in colour. Maturity is often delayed compared to plants containing abundant phosphate. Phosphorus is an essential part of many sugar phosphates involved in photosynthesis, respiration and other metabolic processes and it is also part of nucleotides (as in RNA and DNA) and of the phospholipids present in the membrane. It also plays an essential role in energy metabolism because of its presence in ATP, ADP, AMP and pyrophosphate (PPi) (Salisbury and Ross, 1992).

Phosphorus is an essential component of cell structures, mainly as nucleic acids and phospholipids. It is especially critical in establishing the enzymatic machinery in energy storage and transfer, which in many cases involves membrane processes. Not surprisingly, phosphorus deficiency results in a loss in cell integrity (Ratnayake *et al*., 1978).

Phosphorus effected growth of gladiolus and it is observed that phosphorus produced the tallest plants with longest spikes and most florets spike^{-1}. Phosphorus also increases number of leaves clump^{-1} (Pandey *et al*., 2000).

Climatic conditions of Kashmir are well suited for the production of quality flowers because of its soil and other required conditions (Ahmed and Gull, 2002). Rawalakot Valley lies at altitude of between 1800 and 2000 m and latitude of 33-36^0 in Northern Pakistan, under the foot hills of Himalaya. The climate of the area is temperate, sub-humid with annual rainfall ranging from about 500-2000 mm, most of which is irregular, with intensive storms during monsoon and winter. The mean annual temperature ranges from a minimum of 0 ^{0}C to maximum of 30 ^{0}C accompanied by severe cold and snowfall in winter (Abbasi and Khan, 2004). Although some work has been done on different aspects of gladiolus but very little or no work is being done on influence of different fertilizers on growth and development of gladiolus in Rawalakot conditions. Keeping in view, present study was carried out to find out the influence of different levels of phosphorous on growth and development of gladiolus.

2. Materials and methods

The present study was carried out at Faculty of Agriculture Rawalakot, Azad Jammu and Kashmir, during the year 2010 to investigate the response of gladiolus to different doses of phosphorous. Corms of similar size and weight were selected for this experiment, on the basis of their performance, in other areas. There were six treatments with three replications. Eighteen plots of similar size and width were made. The size of one bed was 3 m^2. The Row-Row was kept 60 cm and Plant-Plant was 23 cm. There were 18 beds with two rows per bed and with 10 plants in one row. The distance between any two beds was kept 30.48 cm. The experiment was laid out according to randomized complete block design (RCBD). Single Super Phosphate was used as source of phosphorus. Following rates of phosphorus was applied as different treatments:

P_0 = Control
P_1 = 40 kg ha^{-1}
P_2 = 70 kg ha^{-1}
P_3 = 100 kg ha^{-1}
P_4 = 130 kg ha^{-1}
P_5 = 160 kg ha^{-1}

Results obtained were statistically analyzed and results exhibiting significant differences were subjected to LSD Test for comparisons of their means (Steel *et al.,* 1997).

3. Results and discussion

3.1. Days to sprouting

A perusal of Table 1 showed that the effect of different fertilizer treatments on days to sprouting was significant. The maximum days (19.00) to sprouting were counted for P_0 (control) while minimum days (12.00) to sprouting were counted for P_4 followed by (12.83) days to sprouting for P_5 . P_2 and P_3 were at par in response for number of days to sprouting. These results identified that all treatments had significant effect on days taken to sprouting as compared to control, with increasing levels of phosphorus number of days to sprouting decreases. This might be due to the reason that as phosphorus is an integral part of plant reproductive system as a component of genetic memory system: ribonucleic acid and deoxyribonucleic acid. Specifically, the role of phosphorus in the structure of these two compounds directly or indirectly controls every biochemical reaction occurring in the plants. Phosphorus storage occurs in seeds to prepare them for germination and early growth prior to extensive root development (Follet *et al*., 1981).

These results supported various researchers conducted work on gladiolus. Same results have been found in earlier a study which indicates minimum days to sprouting with phosphorus applications (Bawaja *et al.*, 2001).

Table 1
Vegetative characteristics.

Phosphors levels	Days to sprouting	Plant per corm	Leaves per plant	Plant height (cm)
P0	19.00^{a}	1.52^{d}	6. 40^{d}	128.4^{f}
P1	15.40^{b}	2.13^{c}	6.59^{d}	138.7^{e}
P2	13.17^{c}	2.76^{b}	7.66^{c}	142.2^{d}
P3	13.17^{c}	2.84^{b}	7.89^{bc}	146.3^{c}
P4	12.00^{d}	3.47^{a}	8.27^{ab}	151.8^{b}
P5	12.83^{cd}	3.57^{a}	8.68^{a}	156.0^{a}

3.2. Number of plants corm^{-1}

An examination of the above arrangements led to the conclusion that P_5 and P_4 showed the superiority over all other treatments with (3.57) and (3.47) number of plants corm^{-1} followed by (2.84) and (2.76) plants corm^{-1}for P_3 and P_2 . P1 produced (2.13) plants corm^{-1} while minimum number (1.52) of plants corm^{-1} were counted for P_0 (control) which attained the lowest position. This may probably be due to the cumulative effect of phosphorus on the process of cell division and balanced nutrition. Results of other scientists working on gladiolus confirmed the results of these studies which shows the maximum number of plants corm^{-1} with phosphorus applications (Miroiu *et al*., 2008)

3.3. Number of leaves plant^{-1}

The results shows that P_5 produced maximum number of leaves (8.68) followed by P_4 (8.27). The minimum number of leaves per plant (6. 40) and (6.59) were produced by P_0 and P_1. This may be due to the effect of phosphorus because, when phosphorus is limiting, the most striking effects are a reduction in leaf expansion and leaf surface area, as well as then number of leaves. The increase in number of leaves plant^{-1} with higher doses of phosphorus may be due to activating apical meristems, enhancing the biosynthesis of proteins and carbohydrates and leads to an enhancing for the initiation of leaves primordial and consequently produced more leaves. Results of other scientists working on gladiolus confirmed the results of these studies that maximum numbers of leaves plant^{-1} increases with phosphorus application (Sharma *et al*., 2003).

3.4. Plant height (cm)

It is evident from the Table 1 that the P_5 produced maximum plant height i.e. (156.0cm) followed by P_4 (151.8cm) while minimum plant height was recorded in P_0 (128.4cm). Remaining treatments gave the intermediate results. The increase in plant height with increasing level of phosphorus levels was might be due to the fact that phosphorus is known to stimulate root growth and is connected with the early maturity of crops. 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. These results are in line with the results (Zubair and Wazir, 2007) who found maximum plant height with higher level of phosphorus application i.e. 100 and 200 kg ha^{-1}. Similarly it was also reported that phosphorus produced the tallest plants with longest spikes and most floret per spike (Pandey *et al*., 2000).

3.5. Days to spike emergence

A perusal of Table 2 showed that the effect of different fertilizer treatments on days to spike emergence was significant. The maximum days to spike emergence (78.82) were recorded for P_0 (control) and P_1 (78.20) while minimum days (68.10) were recorded for P_5 followed by P_4 (71.10 days). Increase in energy level enhanced biochemical processes due to phosphorus application might be the main reason for significant decrease in number of days to spike emergence with increasing levels of phosphorus. Phosphorus storage takes place in seeds and prepares them for germination and early growth prior to extensive root development. Phosphorus is an important constituent of DNA that is known as genetic memory unit of all living things. It is also a component of RNA, the compound that reads the DNA genetic code to build proteins and other compounds essential for plant structure, seed yield, and genetic transfer. The structures of both DNA and RNA are linked together by phosphorus bonds. Phosphorus is a vital component of ATP, known as energy unit of plants. ATP forms during photosynthesis, has phosphorus in its structure, and processes from the beginning of seedling emergence, growth and maturity (Schachtman *et al*., 1998). Same results have been found those minimum days to spike emergence with phosphorus applications (Mohapatra *et al*., 2005).

Table 2
Reproductive characteristics

Phosphors levels	Days to spike emergence	Days to flowering	No. of florets per spike	No. of spikes/ plant	Spike length (cm)
P0	78.82^{a}	84.00^{a}	14.59^{c}	1.11^{d}	61.33^{f}
P1	78.20^{a}	83.67^{a}	16.48^{b}	1.56^{c}	67.00^{e}
P2	74.80^{b}	81.63^{b}	16.00^{b}	1.96^{b}	70.00^{d}
P3	73.90^{c}	80.10^{c}	18.48^{a}	1.77^{bc}	71.67^{c}
P4	71.10^{d}	75.00^{d}	19.03^{a}	2.70^{a}	75.33^{b}
P5	68.10^{e}	72.74^{e}	19.15^{a}	2.77^{a}	78.73^{a}

3.6. Number of spikes $plant^{-1}$

Number of spikes per plant shows significant results. The maximum numbers of spikes per plant were produced by P_5 (2.77) followed by P_4 (2.70) while minimum number of spikes were recorded in P_0 which was 1.11 spikes per plant. The increase in plant height with increasing level of phosphorus levels was might be due to the fact that phosphorus is known to stimulate root growth and is connected with the early maturity of crops. 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.

3.7. Spike length (cm)

It is evident from the table 2 that the effect of different levels of phosphorus on spike length of gladiolus was significant. The maximum spike length (78.73cm) was recorded for P_5 followed by P_4 which gave (75.33cm) spike length. P_0 (Control) showed the least response for spike length (61.33cm). From the above table it is clear that with increasing levels of phosphorus spike length also increased. This might be due to the reason that supplying additional phosphorus when soils are deficient can significantly increase the ability of the crop to produce protein. When there will be more protein in the tissues the growth will be more and rapid. Phosphorus is an important constituent of DNA that is known as genetic memory unit of all living things. It is also a component of RNA, the compound that reads the DNA genetic code to build proteins and other compounds essential for plant structure, seed yield, and genetic transfer. Phosphorus is a vital component of ATP, known as energy unit of plants. ATP forms during photosynthesis, has phosphorus in its structure, and processes from the beginning of seedling emergence, growth and maturity (Schachtman *et al*., 1998). These results are also supported by previous studies in which maximum spike length with phosphorus application of 30gm per m^{-2} (Rajiv *et al*., 2003).

3.8. Number of flowers spike^{-1}

It is clear from the table 2 that the effect of different fertilizer treatments on number of flowers plant^{-1}was significant. The minimum numbers (14.59) of flowers spike^{-1}were recorded for P_0 (control) while maximum numbers (19.15), (19.03) and (18.48) of flowers spike^{-1} were recorded for P_5, P_4 and P_3 respectively. These three treatments showed no significant differences among each other and statistically gave the same results. More number of flowers with higher level of phosphorus application may be due to maximum vegetative growth that depends upon the availability of the more nutrients. A healthy plant or spike with maximum number of leaves and leaf initials and terminated by a vegetative growing point produced more photosynthates and developed into an inflorescence. The secondary crown-extension axis so formed may later terminate in a second inflorescence and this series continue the process. The mechanism of flower bud initiation and development indirectly it is closely related to the well flourished vegetative growth (Robertson and wood, 1954). Results of these studies revealed that P_5 provide the favorable conditions in which a gladiolus plant can utilize maximum nutrients. These results are also supported by the earlier researches that plant height, leaf area, floret life, number of flowers per spike all increased with increasing levels of both phosphorus and nitrogen (Haokip and Sing, 2005). The phosphorus up to 200 kg ha^{-1} increased floret size and number of florets per spike (Sharma *et al.*, 2003).

3.9. Number of days to Flowering

The effect of different fertilizer treatments on number of days to flowering was significant. The maximum number (84.00) and (83.67) of days to flowering were counted for P_0 (control) and P_1 while minimum number (72.74) of days to first blooming were counted for P_5 followed by P4 (75.00). The decrease in number of days to flowering with increasing levels of phosphorus is due to the fact that phosphorus plays very important role in reproductive phases of the crops and enhances their growth. In addition flowers production is correlated with the phosphorus amount absorbs by the root system. These results are similar to the results of many other researchers. Same results have been found which reflects minimum number of days to flowering with phosphorus applications (Rajiv *et al*., 2003).

3.10. Number of corms plant^{-1}

Observations of Table 3 showed highly significant differences among treatments for number of corms plant^{-1}. The maximum number of corms (4.18) and (4.11) plant^{-1} were recorded for P_5 and P_4 respectively. These two treatments have no significant differences among each other and were statistically alike. P_0 produced least number of corms, i.e. 1.22.

It is obvious that with increasing levels of phosphorus there will be more number of corms because phosphorus plays very important role in reproductive growth of plant on being an integral part of plant reproductive system as a component of genetic memory system: ribonucleic acid and deoxyribonucleic acid.

These results supported various researchers conducted work on gladiolus. Same results have been that found maximum number of corms plant^{-1} with phosphorus applications at 100 kg ha^{-1} (Pant, 2005). According to him different responses were observed at number of corms for different levels of phosphorus but it was clear that number of corms respond well at higher levels of phosphorus.

Table 3
Corm and cormels characteristics.

Phosphors levels	corms/plant	cormels/plant	Wet. of corms	Wet. of cormels	siz. of corms	siz. of cormels
P0	1.22^{f}	15.67^{f}	46.67^{f}	0.98^{f}	4.35^{e}	1.35^{e}
P1	2.11^{e}	45.00^{e}	52.00^{e}	1.22^{e}	4.91^{d}	1.57^{d}
P2	2.83^{d}	71.07^{d}	56.33^{d}	1.50^{d}	5.07^{d}	1.72^{c}
P3	3.21^{c}	85.33^{c}	59.33^{c}	2.03^{c}	5.36c	1.76^{c}
P4	4.11^{a}	93.67^{b}	62.00^{b}	3.10^{b}	6.55^{b}	1.87^{b}
P5	4.18^{a}	102.70^{a}	67.33^{a}	3.43^{a}	7.43^{a}	2.06^{a}

3.11. Weight of corms (gm)

The effect of different fertilizer treatments on average weight of corms was significant. P_5 and P_4 more weight of corms as compare to other cultivars i.e. 67.33gm and 66.00gm respectively. While P_0 was dominated by all the other treatments and gave the minimum results i.e. (46.67gm) weight of corm. These results clearly predict that phosphorus at the rate of 160 kg ha^{-1} and 130 kg ha^{-1} is best as compared to control as for as average weight of corms concerned. This is because phosphorus chiefly enhances the reproductive growth. More energy is stored in the corms and they look healthier and stronger. 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 will be applied (Paint, 2005).

3.12. Size of corms (cm)

Data regarding size of the corms, the and P_4 gave the maximum size of corms i.e. (7.43) and (7.29) respectively. These two treatments showed no significant difference among each other and dominated all other treatments. Minimum size of corms was measured for T_0 i.e. (4.35). The increase in size of corm with increasing levels of phosphorus might be due to the fact that phosphorus really enhances the growth and development of reproductive phase of plant. These results are also in line with the results of many other scientists who performed work on gladiolus which reflects that maximum size of corms with phosphorus applications (Sehrawat *et al.*, 2001).

3.13. Cormels plant^{-1}

Maximum number of cormels were produced by P_5 (102.70) followed by P_4 (93.67) as compared to other treatments whereas the least number of cormels were produced by P_0 i.e. 1.22. With increasing levels of phosphorus there will be more number of cormels because phosphorus plays very important role in reproductive growth of plant on being an integral part of plant reproductive system as a component of genetic memory system: ribonucleic acid and deoxyribonucleic acid. Higher doses of phosphorus produced the more corms weight and cormels yield (Paint, 2005).

3.14. Weight of cormels (gm)

Results obtained on weight of cormels-1 plant showed significant differences among each other.

P_5 (3.43) produced more weight of cormels as compare to other levels of phosphorus followed by P_4 (3.10) and least weight of cormels was produced by P_0 (0.98). These results showed that on increasing levels of phosphorus weight of the cormels was increased because Phosphorus is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant. Paint (2005) also found that increasing levels of phosphorus produced the more corms weight and cormel yield.

3.15. Size of cormels (cm)

Data regarding size of cormels showed significant differences among each other. P_5 (2.06) produced the maximum cormel size followed by P_4 (1.87) as compared to other treatments while least size of 1.35 was produced by $P_{0.}$ The increase in size of corm with increasing levels of phosphorus might be due to the fact that phosphorus really enhances the growth and development of reproductive phase of plant.

4. Conclusion

Above studies revealed that P_4 (130 kg ha^{-1}) showed best results for number of days to sprouting, while maximum number of plants per corms, florets, spikes and corms per plant were recorded in P_5 and P_4 where asP_5 (160 kg ha^{-1}) depicted best results for all other parameters. From the above results it was concluded that the Phosphorus levels i.e; P4 (130 kg ha-1) and P5 (160 kg ha-1) were best for gladiolus production.

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