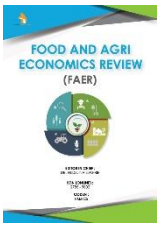
ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2785-9002 (Online)
CODEN: FAERCS

Food and Agri Economics Review (FAER)

DOI: http://doi.org/10.26480/faer.01.2022.41.47



RESEARCH ARTICLE

PHOSPHORUS INCREASES GROWTH AND FLOWER PRODUCTION OF GLADIOLUS (*Gladiolus grandiflora L.*)

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ARTICLE DETAILS

Article History:

Received 12 August 2022
Accepted 13 October 2022
Available online 21 October 2022

ABSTRACT

Phosphorus (P) is a key mineral for growth and flower production of gladiolus. An experiment was conducted at the Field Laboratory of Khulna University with four P levels (0, 150, 300, 450 kg ha^{-1}) and three gladiolus variety (Kolmilota, Red Beauty, White Queen) to investigate the effect of phosphorus and variety on growth and flower production of gladiolus. The experiment was set out in randomized complete block design following three replications. Phosphorus increased growth, flowering, corm and cormel production of gladiolus. The highest number of spike (81111 ha^{-1}) was obtained from the 150 kg P ha^{-1} and the lowest (69444 ha^{-1}) from control (no P). The highest yields of corm (5.244 t ha^{-1}) and cormel (2.578 t ha^{-1}) were recorded from 450 kg P and 300 kg P, respectively while the lowest yields of corm (5.111 t ha^{-1}) and cormel (1.861 t ha^{-1}) from control treatment. The highest corm and cormel yields were obtained from White Queen (5.258 t ha^{-1}) and Kolmilota (2.430 t ha^{-1}), respectively. Both the variety White Queen and phosphorus level 450 kg ha^{-1} resulted higher net return and benefit cost ratio suggesting cultivation of White Queen with 450 kg P ha^{-1} for better production of gladiolus.

KEYWORDS

Spike, Corm, Cormel, Phosphorus level, Net return, Benefit cost ratio

1. INTRODUCTION

Gladiolus (*Gladiolus grandiflora* L.) is one of the most important cut flowers in national and international market and ranked fourth in international cut flower trade (Bose and Yadav, 1989; Kabir et al., 2015). Gladiolus has magnificent inflorescence with varieties of color, which made it attractive for use in herbaceous border, bedding, rockeries, pot and as cut flower. There is an increasing demand for its attractive spikes having florets of huge forms, dazzling colors and varying sizes. Gladiolus spikes are most popular in flower arrangement and preparing high-class bouquets (Mukhopadhyay, 1995). Commercial cultivation of gladiolus is still at the initial stage in Bangladesh, which is becoming popular due to availability of favorable soil and climate, increasing demand, having export potential, and longer shelf life. Now a day, cultivation of gladiolus is mainly concentrated in few districts such as Jashore, Jhenaidha, Satkhira, Dhaka, Mymensingh, Cox's Bazar, Chattagram and Rangpur. Only a small number of farmers are producing gladiolus and they cannot get good production of better quality flowers and corm due to lack of technology and experiences.

Phosphorus (P) is an integral component ATP, DNA, RNA, phospholipid, and sugar phosphates (Taiz and Zeiger, 2010). It plays key roles in many plant processes such as energy metabolism, the synthesis of nucleic acids and membranes, photosynthesis, respiration, nitrogen fixation and energy regulation (Duff et al., 1994). It enhances the root development, flowering, seed development, diseases resistance and prevents wilting. P availability is controlled by primarily three factors: soil pH, amount of organic matter and proper placement of P fertilizer. P availability is highly sensitive to soil pH; at low pH, P gets fixed with Fe, Mn, Zn, Al and at high pH, it is fixed with Ca. Acid soils need to be limed to bring soil pH up to ideal levels (pH 6-7). Mineralization of organic matter provides a significant portion of P for crops. P is often recommended as a row-applied starter fertilizer for increasing early growth, even if P is not deficient. Four major P management strategies are - lime acid soils to increase soil pH between 6.0 and 6.5, apply small amounts of P fertilizer frequently, reduce P tie-up by banding/injecting P fertilizer or liquid manure, and place P fertilizers near crop row or in furrow where roots are most active.

Phosphorus is a very crucial mineral for gladiolus and only judicious application can ensure higher quantity produce such as flower (spike), corm and cormel with premium quality. A few reports are available that evaluated the effects of major mineral elements such as N, P, and K or combination of inorganic (N, P, K) or with organic fertilizers on growth, yield and economical aspects of gladiolus (Gangadharan and Gopinath, 2000) or other crops (Saha et al., 2019; Islam et al., 2020). However, reports on the sole effect of P for gladiolus growth and flower production are limited. Therefore, the present investigation was undertaken to identify the effect of P on growth and flower production of gladiolus and to find out a suitable dose of P for higher economic return.

2. MATERIALS AND METHODS

2.1 Experimental Site, Treatments and Design of Experiment

The experiment was conducted at the Field Laboratory of Agrotechnology Discipline of Khulna University, Khulna from November 2012 to April 2013 with four levels of P (0, 150, 300, 400 kg ha^{-1}) and three varieties of gladiolus (Kolmilota, Red Beauty, and White Queen) following three replications. Thus, the experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications and the unit plot size was 2 m^2 (2m ×1m). The distance between two adjacent blocks and plots were 1 m and 0.5 m, respectively (Appendix 1).

Quick Response Code	Access this article online	
	Website: www.faer.com.my	DOI: 10.26480/faer.01.2022.41.47

Cite The Article: Ram Chandra Biswas, Md. Abdul Mannan, Md. Yamin Kabir (2022). Phosphorus Increases Growth and Flower Production of Gladiolus (Gladiolus Grandiflora L.). *Food and Agri Economics Review, 2(1): 41-47.*

2.2 Land Preparation and Application of Fertilizers

The selected land was first opened with a power tiller on 10 October 2012 and it was kept open to the sun for 2 weeks prior to next ploughing. The large clods were breaking up for making a good tilt. All the stables and weeds were removed from the land. The basal dose of manure was applied to the land during the land preparation and incorporated with soil. Irrigation channels were made around the experimental land. Ten kg well rotten cow dung, half of N and total K were applied during final land preparation. Phosphorus also applied during final land preparation following treatments (0, 150, 300, 450 kg ha^{-1}). The rest of N was applied at 5th leaf-stage of gladiolus.

2.3 Planting and Intercultural Operations

The corms of gladiolus were collected from Godhkali of Jashore; before planting, corms were soaked in 0.1% bavistin solution for five minutes and air-dried to avoid rotting of corm in the field. Corms were planted at 7 cm depth in furrows on 29 November 2012 maintaining 25 cm distance from corm to corm and 30 cm distance from row to row. Gap filling, weeding, mulching, irrigation, earthing up, stalking, disease-pest managements were conducted as and when necessary.

2.4 Harvesting of Flowers, Corms and Cormels

The spikes of gladiolus were harvested when the basal florets showed colors. Corm and cormels were harvested after two months of spike harvest, when the leaves turn into yellow color. The harvested corms and cormels were cured for 7 days under shade and then data were recorded.

2.5 Data Collection and Analyses

Data were collected on days required to 80% emergence, plant height, number of leaves per plant, number of tiller per hill, days required to first spike initiation, days required to first bud break; spike length, rachis length and leaf length at harvest; number of spike, number of florets per spike; number, diameter, and weight of corm and cormel. The recorded data were statistically analyzed using MSTAT computer package programme. The analysis of variance for each of the character under study was performed by F test. The significance of differences among the treatment means were evaluated by least significance difference (LSD) test.

2.6 Economic Analyses

The cost of production was analyzed in order to find out the most profitable treatment of phosphorus. All the non-material and material input costs and interests on fixed and running capital were considered for computing the cost of production. The interests were calculated for six months. The value of land per ha was considered to be TK. 5,55,000.00 (according to land price of the experimental field during the period of experiment). The price of corms and cormels were TK. 100.00/kg and 50.00/kg, respectively. The benefit cost ratio (BCR) was calculated according to following formula.

$$\text{Benefit Cost Ratio (BCR)} = \frac{\textit{Gross return per ha}}{\textit{Total cost of production per ha}}$$

3. Results

3.1 Soil and Climate of Experimental Site

The soil analysis report from the experimental plot showed that the soil is a silty loam having pH 6.5. The total N and K contents are 0.07% and 0.01 ppm, respectively whereas the critical values of N and K are 0.12% and 0.2 ppm. The experimental field has only 5 ppm available P whereas the critical value for the element is 10 ppm (Table 1). The weather report during the experimental period (November 2012 to April 2013) showed that the minimum average temperature was in December (16.87 °C) and maximum in April (24.83 °C). The lowest relative humidity was recorded in November (82.05%) and highest in April (87.23%). There was no rainfall at all in December, January, and February and highest rainfall was recorded in April (86.97 mm). The maximum hours of sunshine was recorded at March (234.54 h) and the minimum at January (111.56 h) (Table 2).

3.2 Days Required to 80% Emergence

Days required for 80% emergence of new gladiolus plant from corm varied significantly with the doses of P. The minimum days (11.667) required for 300 kg P ha^{-1} and maximum (13.556 days) for control treatment (Table 3). However, days required for 80% emergence did not vary due to gladiolus variety (Table 4). The interaction effect of P and gladiolus varieties differed significantly. The variety White Queen with 300 kg P resulted minimum days (11.333) required for 80% emergence (data not shown).

3.3 Effect of P And Variety on Growth Attributes of Gladiolus

Plant height increased gradually and reached at peak at 65 days after planting (DAP). However, plant height differed significantly due to P application only at 35 DAP (Table 3). The highest plant height (28.17 cm) was obtained from 300 kg P ha^{-1} and the lowest (22.80) from control at 35 DAP. Plant height did not differ due to gladiolus variety (Table 4).

Though number of leaves plant^{-1} did not vary with the level of P (Table 3), it varied based on variety at 35 DAP (Table 4). The variety White Queen produced the maximum number of leaves (3.99) while Kolmilota had the minimum (2.89). Leaf breadth differed significantly for P levels at only 35 DAP (Table 5) and for varieties at all DAP (Table 6). The highest breadth (3.626 cm) of leaves was recorded at 150 kg P ha^{-1} and the lowest (2.371 cm) from 0 kg P ha^{-1} at 65 DAP (Table 5). The highest (3.643 cm) and the lowest (2.303 cm) leaf breadth were measured from White Queen and Red Beauty, respectively at 65 DAP (Table 6). Number of tiller plant^{-1} did not differ significantly either by P levels (Table 5) or due to varieties (Table 6). The interaction effect of P levels and gladiolus varieties did not vary for plant height, leaf number, leaf breadth and tiller number of gladiolus (data not shown).

3.4 Effect of P And Variety On Flower and Corm Production of Gladiolus

Level of P had a significant effect on number of florets spike^{-1} and cormel diameter. The highest number (9.61) of florets spike^{-1} was obtained from 150 kg P and the lowest (8.95) from control (no P). The highest cormel diameter (0.96 cm) was measured from 450 kg P and the lowest from 150 kg (Table 7). However, P did not affect number of spike plot^{-1}, spike length, corm diameter, corm yield plot^{-1} and cormel yield plot^{-1} (Table 7).

The gladiolus varieties differed significantly for days required to first spike initiation (DRFSI), days required to first bud break (DRFBB), and spike length (Table 8). The variety White Queen required the lowest number of days for first spike initiation (63.67) and for first bud break (71.08) whereas Kolmilota required the highest number of days for first spike initiation (78.5) and for first bud break (87.08). The highest spike length was measured from White Queen (97.07 cm) and the lowest from Kolmilota (75.88 cm) (Table 8). There was no varietal effect on number of spike plot^{-1}, number of florets spike^{-1}, corm yield plot^{-1}, corm diameter, cormel yield plot^{-1}, and cormel diameter of gladiolus (Table 8).

No significant interaction effect of P and variety was observed for number of spike and corm yield of gladiolus. However, numerically highest number (1000 ha^{-1}) of spike (85.67) was obtained from the variety White Queen while treated with 450 kg P and lowest from Kolmilota (65) with no P (Figure 1). Similarly, numerically highest corm yield (5.367 t ha^{-1}) was obtained from the combination of White Queen and 450 kg P and lowest (4.9 t ha^{-1}) from Red Beauty and 150 kg P (Figure 2).

3.5 Economic Analysis

All the input costs as well as returns were recorded for a single plot, which is expressed per hectare (Tables 9-10) to calculate BCR (Alam et al., 1989). The total cost of production (BDT ha^{-1}) ranged from Tk. 603590 to Tk. 614660. The highest cost of production (Tk. 614660) was involved with the 450 kg P and lowest with no P (Table 9). However, the cost of production for all the varieties were similar (Tk. 608510) (Table 10) due to similar input cost for the varieties. The gross return includes income through sale of spikes, corm and cormel. For P levels, the highest gross return (Tk. 1299888) was obtained from the treatment 450 kg P and the lowest (Tk. 1175552) from control (Table 9). Among the varieties, the highest gross return (Tk. 1253336) was obtained from White Queen and the lowest (Tk. 1235700) from Red Beauty (Table 10). The highest (2.12) benefit cost ratio (BCR) was calculated for 450 kg P and lowest (1.95) for control (Table 9). Likewise, the highest BCR (2.05) was calculated for White Queen and the lowest (2.026) for Red Beauty (Table 10).

4. Discussion

4.1 Days Required to 80% Emergence

Days required to emergence of new plants from the corm varied depending on P level. This study reported minimum number of day requirement for emergence of gladiolus plants from optimal level of P, which is in agreement with another study (Deswal et al., 1983). However, similar number of days requirement for gladiolus variety might be due to similar genetic makeup of studied gladiolus varieties.

4.2 Effect of P and Variety on Growth Attributes of Gladiolus

Plant height is an important growth contributing characteristics of

gladiolus. Phosphorus being a required component of photosynthesis and energy metabolism, it increased plant height and leaf breadth. Has a reported that gladiolus plant height increased with the increase of P. Variation in gladiolus leaf number among the variety might be due to varietal differences of the selected variety (Bawaja, 2003).

4.3 Effect of P And Variety on Flower and Corm Production of Gladiolus

Phosphorus increased the number of florets in a spike and cormel diameter in the present study. Other studies reported that P increased number of florets spike^{-1}, number of cormel and weight of corm and cormel (Sujatha et al., 1990; Kumar and Chattopadhyay, 2001; Pimpini and Zanin, 2002; Bijimal and Singh, 2001; Gowda et al., 1987; Shah et al., 1984; Kumar et al., 2006; Waly et al., 2006). Though spike length did not vary with the level of P in the present study, reports are available that spike length increased with the increased level of phosphorus which might be due to varietal differences of gladiolus (Bhattacharjee, 1981; Bawaja, 2003). The increased level of phosphorus increased the number of spike ha^{-1} and corm yield of gladiolus (Godse et al., 2006; Das, 1998; Kathiresan and Venkatesha, 2002; Gangadharan and Gopinath, 2000).Variation in days required to first spike initiation, days required to first bud break, and spike length among the studied gladiolus variety indicated varietal differences.

4.4 Economic Analysis

Cost benefit analysis of gladiolus cultivation reported low net return from the cultivation of this flower. Among the P levels, the highest BCR was 2.12 for 450 kg P; among the varieties, it was 2.05 for the variety White Queen. Almost similar BCR (1.56) was reported in another gladiolus study and performance of white gladiolus varieties is better compared to red, violet, orange and yellow (Hossain et al., 2011; Gangadharan and Gopinath, 2000).

Table 1: Soil Analysis Report of Experimental Field Along with Critical Value. Soil Samples from the Experimental Field Were Collected Before Starting of Experiment and Analyzed at the Soil Science Laboratory of Khulna University, Bangladesh.

Soil Properties	Determined Value	Critical Values
Soil pH	6.5	6.5
Total N	0.07%	0.12%
Available P	5 ppm	10 ppm
K	0.01 ppm	0.2 ppm

Table 2: Monthly Temperatures (Mean, Max, Min), Average Relative Humidity (RH), Total Rainfall and Sunshine (H) During Study Period in the Experimental Site (Data Collected from a Weather Station Within 50 m of the Experimental Field).

Year	Month	Air Temperature (°C)			RH (%)	Rainfall (mm)	Sunshine (h)
		Average	Max.	Min.			
2012	November	22.45	25.33	14.45	82.05	0.20	151.8
	December	16.87	24.87	11.67	82.98	0.00	129.44
2013	January	17.47	23.41	10.87	80.90	0.00	111.56
	February	19.51	25.65	15.76	84.87	0.00	149.56
	March	20.82	25.98	17.93	86.65	76.87	234.54
	April	24.84	29.98	22.70	87.23	86.97	200.34

Table 3: Effect of P on Days Required to 80% Emergence (DRE), Number of Leaves and Plant Height of Gladiolus.

Level of P (kg ha^{-1})	DRE (days)	Plant Height (cm)			Number of Leaves Plant^{-1}		
		35 DAP	50 DAP	65 DAP	35 DAP	50 DAP	65 DAP
00	13.56	22.80	37.37	48.82	3.24	5.06	7.43
150	13.33	23.97	39.62	50.86	3.36	5.29	8.10
300	11.67	28.17	42.12	52.88	3.53	5.69	7.88
450	12.78	23.55	38.11	48.34	3.37	5.52	8.10
LSD (0.05)	--	--	--	--	--	--	--
LSD (0.01)	1.757	11.18	--	--	--	--	--
LS	**	**	NS	NS	NS	NS	NS

DAP = Days after planting; LSD (0.05) = Least significant difference at 5% level; LSD (0.01) = Least significant difference at 1% level; LS = Level of significance; **=significant at 1% level; NS = Non significant

Table 4: Effect of Varieties on Days Required to 80% Emergence (DRE), Number of Leaves and Plant Height of Gladiolus.

Variety	DRE (days)	Plant Height (cm)			Number of Leaves Plant^{-1}		
		35 DAP	50 DAP	65 DAP	35 DAP	50 DAP	65 DAP
Kolmilota	13.25	22.08	38.52	49.28	2.89	5.12	7.85
Red Beauty	12.67	22.32	38.17	49.02	3.26	5.52	8.38
White Queen	12.58	29.46	41.22	52.37	3.99	5.52	7.40
LSD (0.05)	--	--	--	--	--	--	--
LSD (0.01)	--	--	--	--	1.070	--	--
LS	NS	NS	NS	NS	**	NS	NS

DAP = Days after planting; LSD (0.05) = Least significant difference at 5% level; LSD (0.01) = Least significant difference at 1% level; LS = Level of significance; **=significant at 1% level; NS = Non significant

Table 5: Effect of P on Gladiolus Leaf Breadth (cm) and Number of Tiller.

Level of P (kg ha^{-1})	Leaf Breadth (cm)			No. Tiller Plant^{-1}		
	35 DAP	50 DAP	65 DAP	35 DAP	50 DAP	65 DAP
00	1.34	2.98	2.37	1.22	1.35	1.35
150	1.73	2.08	3.63	1.12	1.22	1.22
300	2.73	2.19	2.45	1.20	1.36	1.36
450	1.50	2.99	2.42	1.30	1.46	1.46
LSD (0.05)	0.6714	--	--	--	--	--
LSD (0.01)	--	--	--	--	--	--
LS	*	NS	NS	NS	NS	NS

DAP = Days after planting; LSD (0.05) = Least significant difference at 5% level; LSD (0.01) = Least significant difference at 1% level; LS = Level of significance; *=significant at 5% level; NS = Non significant

Table 6: Effect of Varieties on Gladiolus Leaf Breadth (cm) and Number of Tiller.

Variety	Leaf Breadth (cm)			No. Tiller Plant^{-1}		
	35 DAP	50 DAP	65 DAP	35 DAP	50 DAP	65 DAP
Kolmilota	1.47	2.00	2.46	1.18	1.40	1.40
Red Beauty	1.41	2.91	2.30	1.18	1.24	1.24
White Queen	2.85	2.27	3.64	1.27	1.39	1.39
LSD (0.05)	--	0.4317	0.4937	--	--	--
LSD (0.01)	0.6710	--	--	--	--	--
LS	**	*	*	NS	NS	NS

DAP = Days after planting; LSD (0.05) = Least significant difference at 5% level; LSD (0.01) = Least significant difference at 1% level; LS = Level of significance; *=significant at 5% level; NS = Non significant

Table 7: Effect of P on Flower, Corm, and Cormel Attributes of Gladiolus.

Level of P (kg ha^{-1})	No. Spike Plot^{-1}	Spike Length (cm)	No. of Florets spike^{-1}	Corm Yield (kg) plot^{-1}	Corm Diameter (cm)	Cormel Yield (kg) Plot^{-1}	Cormel Diameter (cm)
00	13.78	85.23	8.95	1.04	3.72	0.27	0.74
150	16.22	83.30	9.61	1.02	3.74	0.28	0.70
300	15.00	83.71	9.33	1.04	3.75	0.82	0.77
450	16.00	83.77	9.49	1.04	3.68	0.33	0.96
LSD (0.05)	--	--	2.649	--	--	--	0.3257
LSD (0.01)	--	--	--	--	--	--	--
LS	NS	NS	*	NS	NS	NS	*

LSD (0.05) = Least significant difference at 5% level; LSD (0.01) = Least significant difference at 1% level; LS = Level of significance; * = Significant at 5% level; NS = Non significant

Table 8: Effect of Variety on Flower, Corm, and Cormel Attributes of Gladiolus.

Variety	DRFSI	DRFBB	No. Spike Plot^{-1}	Spike Length (cm)	No. of Florets Spike^{-1}	Corm Yield (kg) Plot^{-1}	Corm Diameter (cm)	Cormel Yield (kg) Plot^{-1}	Cormel Diameter (cm)
Kolmilota	78.50	87.08	14.92	75.88	8.64	1.03	3.75	0.84	0.74
Red Beauty	70.92	80.25	15.25	79.07	8.87	1.03	3.42	0.38	0.90
White Queen	63.67	71.08	15.58	97.07	10.53	1.05	4.01	0.25	0.74
LSD (0.05)	--	--	--	--	--	--	--	--	--
LSD (0.01)	12.59	13.53	--	18.82	--	--	--	--	--
LS	**	**	NS	**	NS	NS	NS	NS	NS

DRFSI = Days required to first spike initiation, DRFBB = Days required to first bud break, LSD (0.05) = Least significant difference at 5% level, LSD (0.01) = Least significant difference at 1% level; LS = Level of significance; ** = Significant at 1% level; NS = Non significant

Table 9: Economic Analysis of Gladiolus Cultivation Based on P Levels.

Level of P (kg ha^{-1})	Spike No. ('000 ha^{-1})	Corm Yield (t ha^{-1})	Cormel Yield (t ha^{-1})	Spike Price (Tk. ha^{-1})	Corm Price (Tk. ha^{-1})	Cormel Price (Tk. ha^{-1})	Gross Return (Tk. ha^{-1})	Total Cost of Production (Tk.)	Net Return (Tk.)	BCR
00	69.44	5.17	2.04	555552	517800	102200	1175552	603590	571962	1.94
150	81.11	5.11	1.86	648888	511100	93050	1253038	607280	645758	2.07
300	75.0	5.17	2.57	600000	517800	128900	1246700	608510	638190	2.05
450	80.0	5.24	2.53	640000	524400	126600	1291000	614660	685228	2.12
LSD(0.05)	--	--	--	--	--	--	--	--	--	--
LSD(0.01)	--	--	--	--	--	--	--	--	--	--
LS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

LSD (0.05) = Least significant difference at 5% level; LSD (0.01) = Least significant difference at 1% level; LS = Level of significance; NS = Non significant. Spike price: Tk. 8 spike^{-1}, Corm price: Tk. 100 kg^{-1}, Cormel price: Tk. 50 kg^{-1}

Table 10: Economic Analysis of Gladiolus Cultivation Based on Varieties.

Varieties	No. Spike ('000 ha^{-1})	Corm Yield (Tk. ha^{-1})	Cormel Yield (Tk. ha^{-1})	Spike Price (Tk. ha^{-1})	Corm Price (Tk. ha^{-1})	cormel Price (Tk. ha^{-1})	Gross Return (Tk. ha^{-1})	Total Cost of Production	Net Return	BCR
Kolmilota	75.0	5.15	2.43	600000	515200	121500	1236700	608510	628190	2.03
Red Beauty	76.25	5.13	2.24	610000	513300	112400	1235700	608510	627190	2.03
White Queen	77.91	5.25	2.08	623336	525800	104200	1253336	608510	644826	2.05
LSD (0.05)	--	--	--	--	--	--	--	--	--	--
LSD (0.01)	--	--	--	--	--	--	--	--	--	--
LS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

LSD (0.05) = Least significant difference at 5% level; LSD (0.01) = Least significant difference at 1% level; LS = Level of significance; NS = Non significant
Spike price: Tk. 8 spike^{-1}, Corm price: Tk. 100 kg^{-1}, Cormel price: Tk. 50 kg

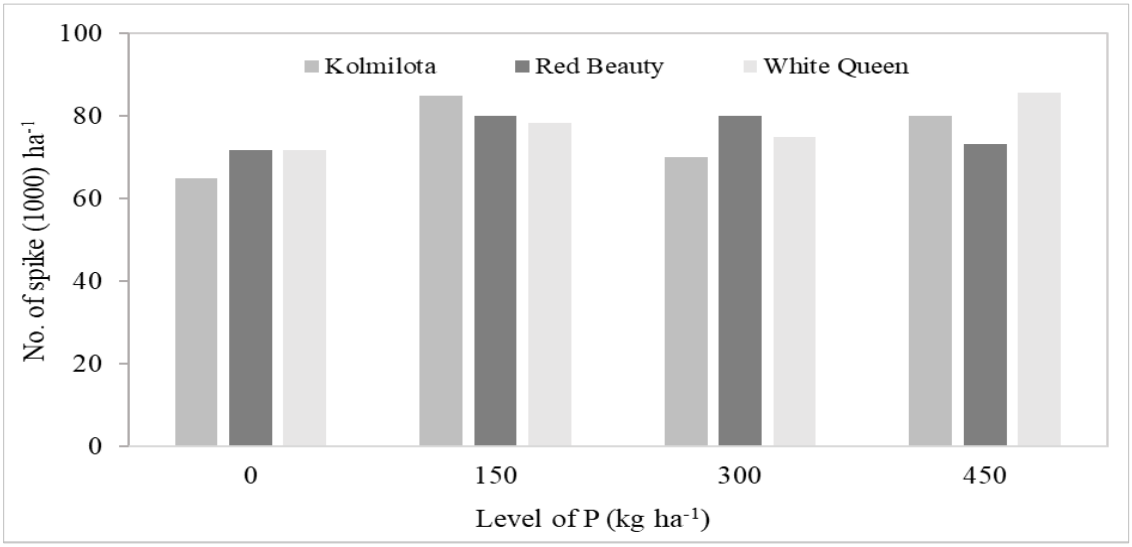


Figure 1: Number of spike (1000 ha^{-1}) of gladiolus as influenced by level of P and variety. The interaction effects of P level and gladiolus variety did not differ significantly according to least significance difference (LSD) test at $P<0.05$.

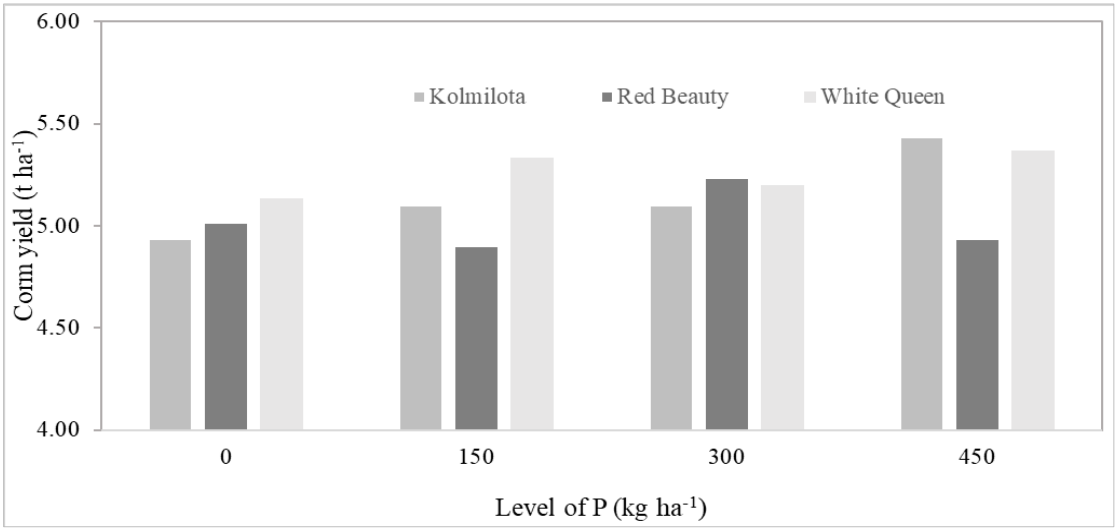


Figure 2: Corm yield (t ha^{-1}) of gladiolus as influenced by level of P and variety. The interaction effects of P level and gladiolus variety did not differ significantly according to least significance difference (LSD) test at $P<0.05$.

5. Conclusions

Higher level of P increases plant height, leaf breadth, and number of floret spike^{-1} and decreases days required to 80% emergence of gladiolus. The variety White Queen has maximum number of leaf with wider leaf blade and larger spike. White queen also requires minimum days for spike initiation and first bud break. Numerically highest net return and BCR are calculated from 450 kg P ha^{-1} and White Queen. Therefore, cultivation of 'White Queen' gladiolus with 450 kg P ha^{-1} is suggested. However, multi-locational trials on gladiolus varieties and phosphorus levels are recommended.

ACKNOWLEDGMENTS

The authors express their sincere appreciation and gratefulness to the farm authority of Agrotechnology Discipline of Khulna University, Khulna, Bangladesh.

Funding Details

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

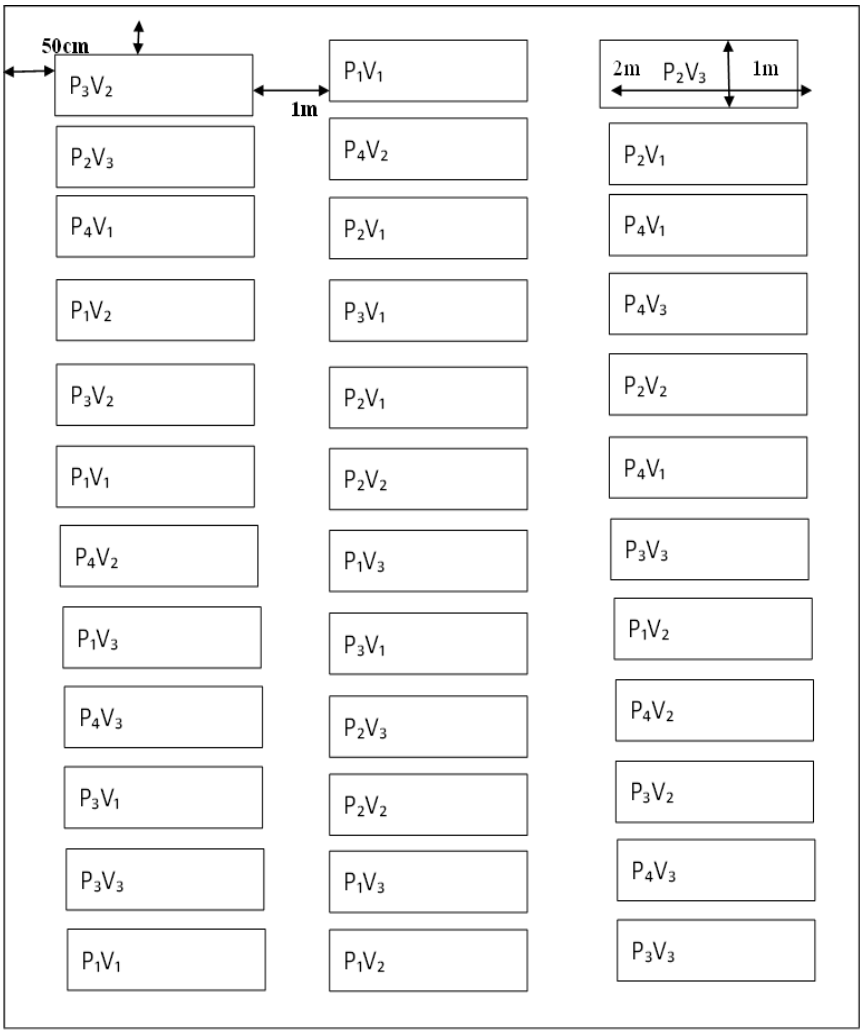
Disclosure Statement

The authors report there are no competing interests to declare.

Data Availability Statement

Most of the data are included in the manuscript.

APPENDIX I



Appendix I. Field layout of the experimental plot

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