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EFFECT OF POTASSIUM ON PREFLOWERING GROWTH OF GLADIOLUS CULTIVARS

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ABSTRACT

The experiment was conducted at Agricultural Research Farm, Department of Horticulture, NWFP Agricultural University, Peshawar during 2003-05. Eight cultivars of gladiolus namely Deciso, Hong Kong, Jessica, Jester Ruffled, Madonna, Peters Pears, Rose Supreme and White Friendship were used to study the influence of potassium levels (0, 100 and 200kg K ha^{-1}). All growth parameters except plants corm^{-1} studied during the experiment were significantly affected by the two experimental years. Plants emergence (Sprouting), spike emergence, first floret and full spike opening were earlier in first year (2003-04). Number of plants corm^{-1} was more in first year whereas plant height was higher in second year (2004-05). Potassium levels significantly affected days to spike emergence and first florets opening. Spike emergence was earlier at 100kg ha^{-1} and first floret opening was delayed with an increase in potassium levels. Cultivars irrespective of years and potassium levels were significantly different in preflowering growth characteristics. Similarly years X cultivars interaction resulted in significant differences in preflowering growth characteristics. Cultivars X potassium interaction significantly influenced spike emergence and days to first florets opening. Days to spike emergence were significantly affected by an interaction among years, phosphorus levels and cultivars. Rose Supreme and Jessica and potassium @100kg ha^{-1} are recommended for commercial cultivation of gladiolus in Peshawar, Pakistan.

Keywords: gladiolus, spike, floret, potassium, preflowering.

INTRODUCTION

Gladiolus (*Gladiolus grandiflorus*) belongs to family irridaceae. It is grown primarily for cut flowers and to a limited extent for landscaping and exhibition purposes. Production of quality flowers as well as plants depends on vigorous preflowering (vegetative) growth. Preflowering growth depends on the amount and availability of macro- and micronutrients in the soil. Potassium is one of the most important macronutrients that affect growth of gladiolus. After nitrogen and phosphorus, soils are usually most deficient in potassium (Salisbury and Ross, 1992). Potassium (or Potash) plays roles in regulating the opening and closing of stomata and water retention. It promotes the growth of meristematic tissue, activates some enzymatic reactions, aids in nitrogen metabolism, and the synthesis of proteins, catalyzes activities of some mineral elements, and aids in carbohydrate metabolism and translocation (Bhandal and Malik, 1988). Potassium also reduces the corm rot incidence (Singh *et al*., 1997). Potassium is more mobile in the soil than phosphorus but less than nitrates, which can be readily leached from light sandy soils. Some soils can fix potassium (render it unavailable to plants), but unless the soils are very low in potassium, the fixing is not too important since the reaction is reversible; the element is not fixed permanently (Hartmann *et al*. 1981).

A lack of potassium causes reduced bud count, shortening of the flower stem, and delay in flowering of gladiolus, general yellowing of older leaves, and interveinal yellowing of younger leaves (Wilfret, 1980).

Potassium deficiency also causes weak stalks and roots become more easily infected with root-rotting organisms. These two factors cause the plants to be rather easily bent to the ground (lodged) by wind and rain (Salisbury and Ross, 1992). Keeping in view the aforementioned importance of potassium in the plant growth and development, the present experiment has been planned to investigate an optimum level of potassium for gladiolus cultivation in Peshawar, Pakistan.

MATERIALS AND METHODS

This experiment was conducted at the Agricultural Research Farm, Department of Horticulture, NWFP Agricultural University, Peshawar during the year 2003-05.

Cultivars Deciso, Hong Kong, Jessica, Jester Ruffled, Madonna, Peters Pears, Rose Supreme, and White Friendship were used in the experiment. The corms of these cultivars were fertilized with potassium (K) at the rate of 0 (control), 100, and 200kg ha^{-1}. Potassium Sulphate (K_2SO_4 Sulphate of Potash) was used as a source for potassium. Potassium was applied before corms plantation.

Farm yard manure was mixed in the field at the rate of four loaded tractor trolleys ha^{-1}. A basic dose of nitrogen and phosphorus was added to the field at the rate of 100kg each ha^{-1}. Phosphorus was applied before corms plantation whereas nitrogen was applied in split doses. First dose of nitrogen was applied at three-leaf stage while the second dose was applied at the time of spike emergence.

All cultural practices (irrigation, weeding and spraying insecticides) were performed uniformly. The soil was analyzed for physico-chemical properties and the following information were noted: Sand (17.12%), silt (54%), clay (28.88 %), pH (8.32), EC (0.33dSm^{-1}), N (100% deficient), P (27% deficient and 73% marginal), K (50% marginal and 50% adequate).

The corms were imported from Netherlands through a reliable commercial nursery 'SUNNY SEEDS' located in Lahore, Pakistan. The corms were planted in a well-prepared field at a depth of 10cm (Hartmann *et al*. 1981) in the month of November. The corms were planted in a row at a distance of 20cm while the rows were made at a distance of 60cm.

The experiment was laid out as Randomized Complete Block Design (RCBD) with split plot arrangement. The potassium levels were put in main plot whereas the cultivars were placed in subplots. The data were analyzed with the general linear model procedures in SAS (SAS Institute, ver. 6.12, Cary, N. C.), and the least significant difference (LSD) test was used for the means separation.

The following growth parameters were studied:

- Days to plants emergence (sprouting) (DE)
- Days to spike emergence (DSE)
- Days to first floret opening (DFFO)
- Days to full spike opening (DFSO)
- Average number of plants corm^{-1}
- Average plant height (cm)

RESULTS AND DISCUSSION

Concise analysis of variance (ANOVA) and means tables instead of giving individual ANOVAs and means tables are presented for the interpretation of results. Graphs are also presented for the interpretation of certain growth parameters. Before interpreting and discussing the individual growth parameters, it is important to discuss briefly the environmental conditions prevailed during the two experimental years. High and low ambient air temperature in Celsius, soil temperature at a depth of 10cm at 8.0 AM and 5.0 PM, and precipitation in millimeters during first year (Nov. 1, 2003 to June 30, 2004) are presented in Figures 1 to 3 whereas of second year (Nov. 1, 2004 to Aug. 31, 2005) in Figures 4 to 6. It was observed that maximum temperature in first year and second year was decreasing from November and reached lower than 15^{0}C in the month of January of first year and lower than 10^{0}C in second year, respectively. The maximum temperature again was on rise from the first week of February in first year while from the last week of February in second year. On the other hand, minimum temperature reached -1^{0}C in second year. This shows that the weather was colder in second year as compared to first year (Figure-1 and Figure-4). The soil temperature in first year was lower than the soil temperature in second year (Figure-2 and Figure-5). During the second year of the experiment, the amount and number of precipitation events were more as compared to the first year of experiment (Figures 3 and 6).

Days to plants emergence (sprouting):

Years and their interaction with cultivars had a significant effect on days to plant emergence of gladiolus cultivars (Table-1). First year plantation of the two experimental years resulted in earlier sprouting than the sprouting in second year (Table-2). This might be due to the lower soil temperature in first year that caused the production of growth promoters and consequently enhanced the sprouting of corms. These results are in conformity with those of Lu *et al*. (1996) who reported that different climatic conditions significantly affected growth and yield of gladiolus. Cultivars White Friendship, Rose Supreme and Madonna sprouted earlier with average number of 17.1, 19.5 and 27.3 days, respectively while cultivars Hong Kong, Jester Ruffled and Deciso sprouted lately and took more than two months to sprout (Table-2). This could be due to the different genetic capabilities of several genotypes. These results are in agreement with those of Arora and Sandhu (1987) who reported that several cultivars sprouted earlier as compared to others. These results supported the findings of Leena *et al.* (1993) who reported similar results while studying the performance of selected cultivars. All cultivars except White Friendship sprouted earlier when grown in first year. Nevertheless, cultivars Rose Supreme and White Friendship grown in first year and second year sprouted earlier in 14.8 and 15.5 days, respectively while cultivar Hong Kong sprouted in 120.4 days when planted in second year as compared to first year planting that caused Hong Kong to sprout in 19.4 days (Table-3). These results are in agreement with those of Al-Humaid (2004) who reported that not only the genetic make-up but also the environmental conditions are important factors determining the success of gladioli cultivars to grow under the existing field conditions. These results opposed the findings of Vinceljak (1990) who reported that period between planting and emergence was the same for different cultivars under test.

Days to spike emergence:

Days to spike emergence of gladiolus cultivars was significantly affected by years, potassium levels, and various interactions (years X cultivars, potassium levels X cultivars, and years X potassium levels X cultivars) (Table-1). The spike emergence was earlier in first year as compared to second year with average values of 110.7 and 157.2 days, respectively (Table-2). This could be due to higher air temperature in first year as compared to second year that caused earlier spike emergence. Spike emergence was the earliest with 100kg K ha^{-1} as compared to 0 and 200kg K ha^{-1} (Figure-7). This confirms the fact that higher amount of potassium delays flowering (Wilfret, 1980). As far as no potassium (control) is concerned, it is clear that nutrients like nitrogen might have played its role and delayed spike emergence. Cultivar White Friendship took minimum number of 99.5 days to spike emergence while cultivars Hong Kong and Jester Ruffled took maximum number of 154.3 and 153.2 days, respectively to spike emergence. However, rests of the cultivars were remained

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in between these extremes (Table-2). This might be due to variation in the genetic structure and capabilities of the cultivars. In years X cultivars interaction, cultivars when planted in first year emerged their spikes earlier than the spikes emerged in second year by the same cultivars (Table-3). It might be due to the response of different cultivars to different environmental conditions existed during the two experimental years. Potassium affected days to spike emergence of various cultivars differently. An increase in potassium levels caused earliness in spike emergence of cultivars Jessica and White Friendship when planted in first year. However, potassium at the rate of 100 kg ha^{-1} caused earliness in cultivars Hong Kong, Madonna, Peters Pears and Rose Supreme but delayed spike emergence in cultivar Jester Ruffled. Cultivar Deciso was different in its response to potassium levels where an increase in potassium levels delayed spike emergence (Figure-8). This could be due to different environmental conditions that affected the effect of potassium on the growth of gladiolus. These results are in accordance with the findings of Wilfret, (1980) who reported that fertilizer requirements of gladiolus vary with climatic conditions. In year X potassium levels X cultivars interaction, fluctuations were observed in the response of cultivars to potassium levels in both years. An increase in potassium levels increased earliness of spike emergence in cultivars Jessica and White Friendship grown in first year and the same trend was observed in cultivar Jester Ruffled planted in second year. However, with an increase in potassium levels the spike emergence was delayed in Peters Pears when planted in first year whereas the same trend was recorded in cultivars Jessica and Hong Kong planted in second year (Figure-9). These variations in the response of cultivars to various levels of potassium applied in different years might be due to variations in the genetic structures of cultivars and different environmental conditions existed during the two experimental years.

Days to first floret opening:

Analysis of variance indicated that years, potassium levels and various interactions (years X cultivars, potassium levels X cultivars) had a significant effect on days to first florets opening of gladiolus cultivars (Table-1). Years across cultivars and potassium levels indicated earliness in opening of first florets in first year as compared to second year (Table-2). It might be due to higher ambient air temperature existed in first year that caused earlier first florets opening. An increase in potassium levels delayed first florets opening and it was noticed that the delay was gradual from zero to 100kg K ha^{-1} but afterward a sharp enhancement in delay was observed (Figure-10). These results are similar to those of Wilfret (1980) who reported that higher amount of potassium delays flowering in gladiolus. Cultivar White Friendship was earlier in opening its first florets with an average days of 127.3 while cultivars Jester Ruffled, Hong Kong and Deciso opened their first florets in 169.6, 167.3 and 165.4 days, respectively (Table-2). Variations in first florets opening among cultivars are due to the differences in the genotypes. Cultivars performed significantly different in both years and it was observed that first florets' opening in all cultivars was earlier in first year as compared to first florets' opening in second year (Table-2). It could be due to the different capabilities of different genotypes growing in different environmental conditions. An increase in potassium levels caused a delay in first florets opening of cultivars Deciso, Hong Kong, Jessica and Rose Supreme whereas an increase in potassium levels resulted in earliness of first florets opening in cultivars Madonna and white Friendship. Besides, a delay and earliness in first floret opening were observed in cultivars Jester Ruffled and Peters Pears respectively when fertilized at the rate of 100kg K ha^{-1} (Figure-11). This might be due to the different interactive effects of potassium and cultivars. It may be because several cultivars are efficient consumers of nutrients as compared to others.

Days to full spike opening:

Number of days to full spike opening of gladiolus cultivars was significantly affected by years and their interaction with cultivars (Table-1). Full spikes opened in lesser number of days during first year than the number of days taken in second year for opening full spikes (Table-2). This might be due to lower ambient air temperature in second year that caused a delay in flowering. Cultivars Jester Ruffled and Hong Kong took maximum number of 183.2 and 179.7 days, respectively to open their full spikes whereas cultivar White Friendship took minimum number of 142.3 days to open their full spikes (Table-2). Interaction between years and cultivars revealed that cultivars grown in first year took less number of days to full spike opening than the same cultivars grown in second year (Table-2). This might be due to the performance of different genotypes in different environmental conditions existed during the two experimental years. These findings are in conformity with those of Desh and Misra (1998) who reported significant mean squares due to genotype X environment for certain characteristics of gladiolus studied.

Average number of plants per mother corm:

Years and their interaction with cultivars had a significant effect on average number of plants per corm of gladiolus cultivars (Table-1). Corms planted in first year produced more plants $corm^{-1}$ than the plants $corm^{-1}$ produced by corms planted in second year (Table-2). Cultivars Jessica proved to be superior in producing the greatest number of plants (1.7) $corm^{-1}$ while cultivar Hong Kong produced the least number (0.7) of plants $corm^{-1}$ (Table-2). It might be due to the different capabilities of cultivars of producing different number of plants $corm^{-1}$. Year X cultivars interaction indicated that all cultivars except Rose Supreme and Jester Ruffled yielded maximum number of plants $corm^{-1}$ when planted in first year as compared to plants $corm^{-1}$ produced in second year. The overall comparison of all cultivars grown in first and second year revealed that Jessica, Madonna and White

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Friendship produced 2.0, 1.8 and 1.7 plants corm^{-1}, respectively when grown in first year. It was further noted that Jester Ruffled and Rose Supreme resulted in the highest number of 1.9 and 1.6 plants corm^{-1} in second year (Table-2). Variation in production of plants corm^{-1} was observed and it might be due to the different genotypes and their interaction with different environmental conditions.

Average plant height (cm):

Average plant height of gladiolus cultivars was significantly affected by years and their interaction with cultivars (Table-1). Taller plants of gladiolus were recorded in second year with an average value of 117.8cm whereas plants produced in first year were of 101.12cm height (Table-2). This could be due to delayed flowering in second year that provided maximum time for vegetative growth and consequently increased plant height. The tallest plants of 138.0cm height were recorded in cultivar Rose Supreme whereas cultivar White Friendship produced the shortest plants of 81.8cm height. Rest of the cultivars was found intermediate (Table-2). This could be due to the maximum adaptability of Rose Supreme to the environmental conditions existed in the region of Peshawar. All cultivars produced taller plants when grown in second year except White Friendship and Madonna that produced taller plants in first year (Table-3). This could be due to the lower ambient air temperature and more precipitation events in second year that delayed spike emergence, first floret opening and hence prolonged the period of vegetative growth which resulted in taller plants.

CONCLUSION AND RECOMMENDATIONS

It is concluded from the experimental results that cultivar Rose Supreme surpassed all other cultivars under trial in most characteristics. Jessica proved to be superior in producing more number of plants. White Friendship was earlier in sprouting, spike emergence, first florets opening and full spike opening. Cultivars like Jester Ruffled, Deciso and Peter Pears yielded some convincing results and were put second in ranking after Rose Supreme. Besides, other cultivars like Madonna and Hong Kong also performed well and yielded some good results. Hence cultivars Rose Supreme and Jessica are recommended for commercial cultivation of gladiolus in Peshawar, Pakistan. Other tested cultivars can not be ignored and they are also suggested for cultivation as the people look for a variety of colors. Potassium did not affect significantly most of growth characteristics under the prevailing soil and environmental conditions of Peshawar, any how its role in the plant physiology is of utmost importance and it is advised that the growers use potassium while growing gladiolus.

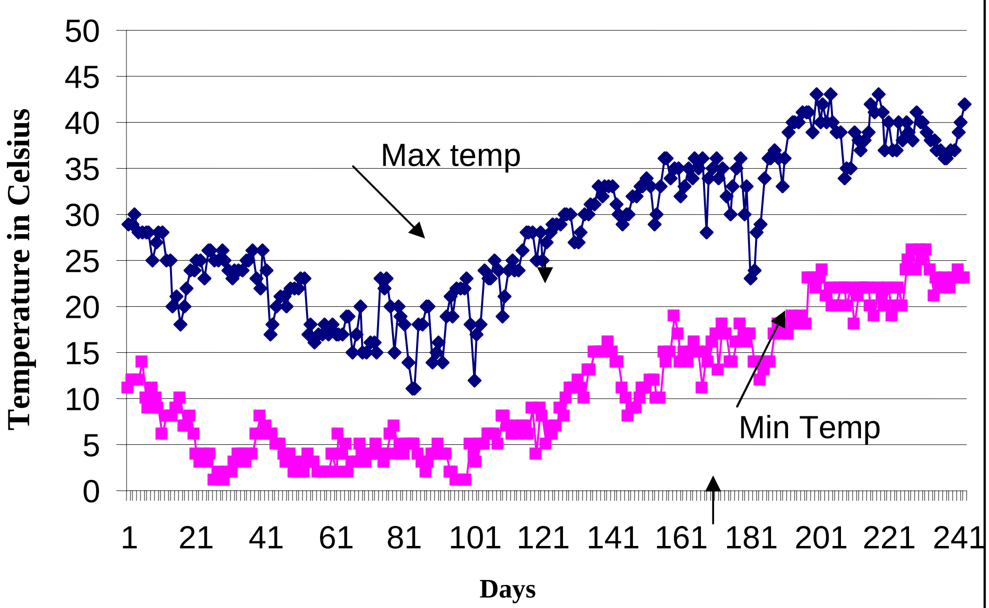

Figure-1. Daily ambient air temperature during 2003-04.

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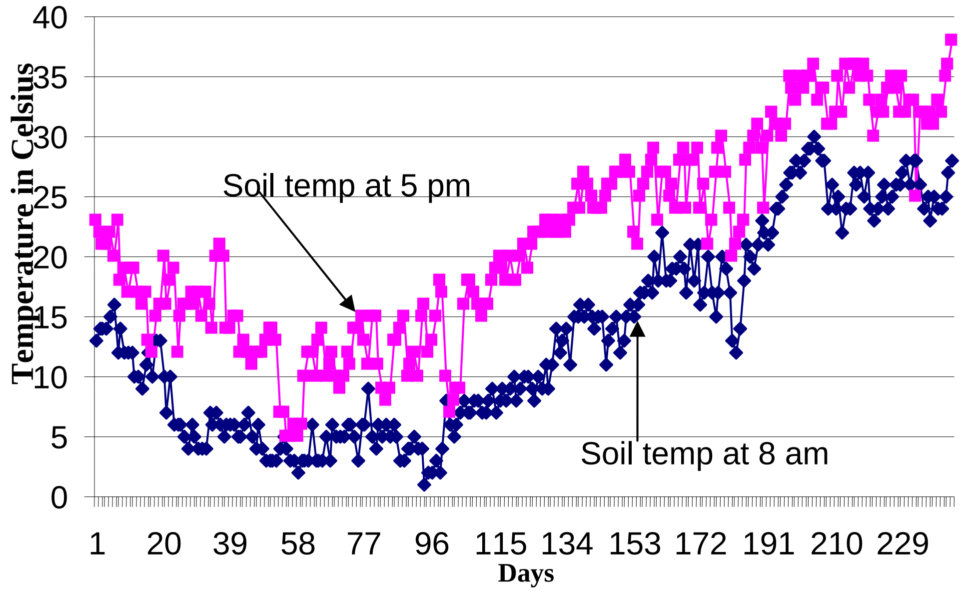

Figure-2. Daily soil temperature at a depth of 10cm during 2003-04.

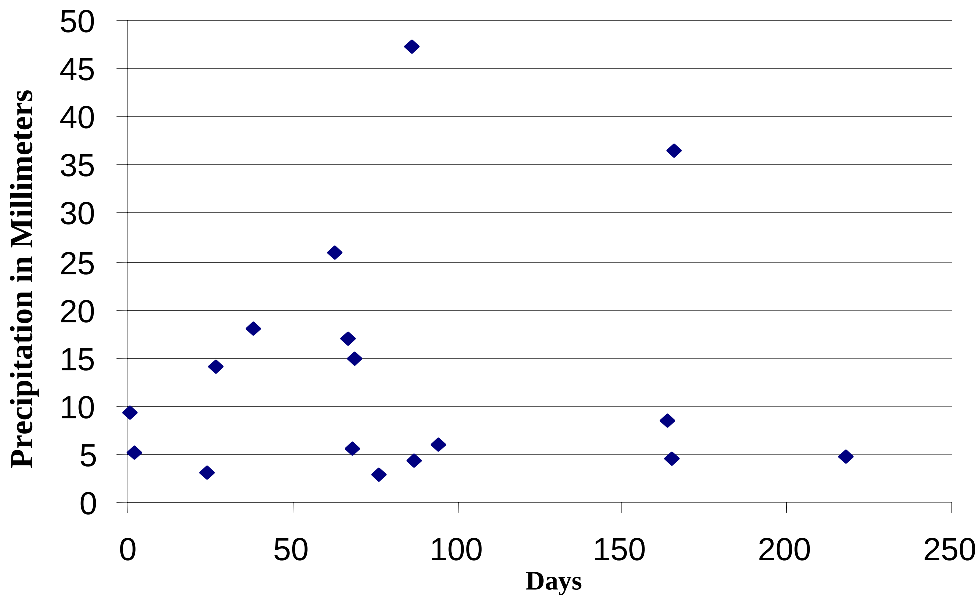

Figure-3. Daily precipitation during 2003-04.

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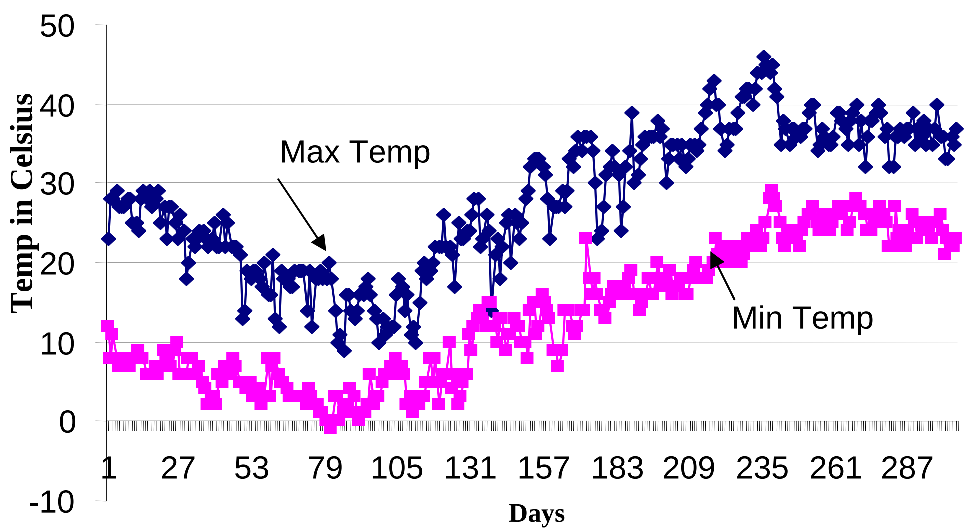

Figure-4. Daily ambient air temperature during 2004-05.

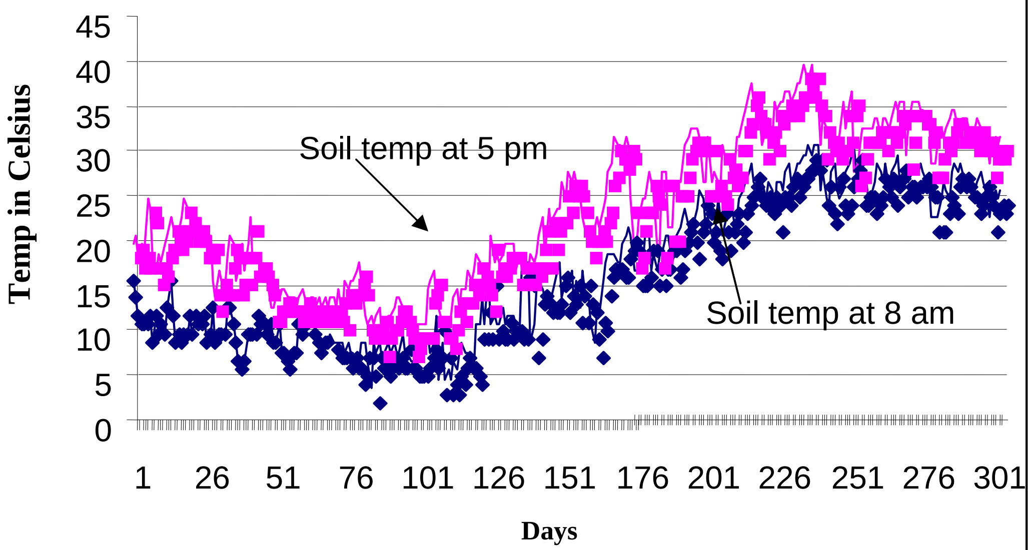

Figure-5. Daily soil temperature at a depth of 10cm during 2004-05.

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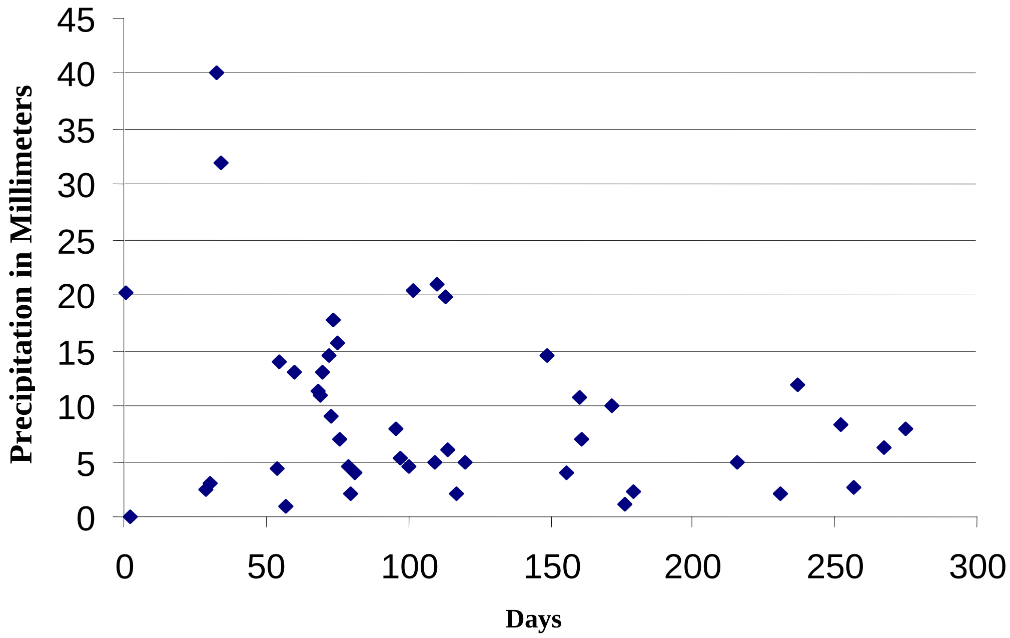

Figure-6. Daily precipitation during 2004-05.

Source: NWFP Agricultural University, Peshawar, Pakistan

Table-1. Results of ANOVA on days to plants emergence (DE), days to spike emergence (DSE), days to first florets opening (DFFO), days to full spike opening (DFSO), average number of plants per corm (plants corm^{-1}) and average plant height (cm) of gladiolus cultivars fertilized with potassium at the rate of 0, 100 and 200kg per ha during 2003-04 and 2004-05.

Source	DF	DE	DSE	DFFO	DFSO	Plants/ corm	Plant Height
Model	59						
Error	84						
Corrected Total	143						
Year (Y)	1	**	**	**	**	NS	**
Rep (Year)	4						
Potassium(K)	2	NS	**	*	NS	NS	NS
Year X K	2	NS	NS	NS	NS	NS	NS
Rep (Year X K)	8						
Cultivar (C)	7	**	**	**	**	**	**
Y X C	7	**	**	**	**	**	**
K X C	14	NS	**	**	NS	NS	NS
Y X K X C	14	NS	*	NS	NS	NS	NS

NS,*, ** Nonsignificant or Significant at $P < 0.05$ or 0.01, respectively.

Table-2. Effect of years (2003-04 and 2004-05) on DE, DSE, DFFO, DFSO, Plants corm^{-1} and average plant height (cm) of gladiolus cultivars.

Source	DE	DSE	DFFO	DFSO	Plants Corm^{-1}	Plant Height(cm)
Years					**NS**	
First Year	19.5b	110.7b	129.6b	143.0b	1.4	101.1b
Second Year	70.7a	157.2a	174.9a	186.4a	1.2	117.8a
Cultivars						
Deciso	67.4a	147.1ab	165.4a	167.9b	1.3bc	121.7b
Hong Kong	69.9a	154.3a	167.3a	179.7a	0.7d	96.1d
Jessica	45.6b	124.8c	147.9bc	161.4b	1.7a	103.7cd

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Jester Ruffled	68.5a	153.2a	169.6a	183.2a	1.4b	118.3b
Madonna	27.3c	129.2c	145.8c	158.6b	1.2c	108.3c
Peters Pears	45.4b	140.2b	153.2b	166.4b	1.2c	107.7c
Rose Supreme	19.5cd	123.3c	141.1c	157.8b	1.3bc	138.0a
White Friendship	17.1d	99.5d	127.3d	142.3c	1.4b	81.8e
LSD	**9.86**	**8.1**	**6.86**	**10.53**	**0.19**	**7.89**

Table-3. Effect of interaction (years X cultivars) on DE, DSE, DFFO, DFSO, Plants corm^{-1} and average plant height (cm) of gladiolus cultivars planted during 2003-04 and 2004-05.

Source	**DE**	**DSE**	**DFFO**	**DFSO**	**Plants Corm^{-1}**	**Plant Height** (cm)
Year X cultivars						
First year X Deciso	21.2d	115.0ef	135.4fg	148.0f	1.3d	107.4de
Hong Kong	19.4d	118.9e	128.2fgh	142.9f	1.0ef	92.2fg
Jessica	22.7cd	93.9g	123.3h	137.0f	2.0a	93.4fg
Jester Ruffled	20.0d	124.3de	137.8f	151.2f	0.9fg	100.1ef
Madonna	18.9d	113.1ef	129.3fgh	142.2f	1.8abc	110.5cde
Peters Pears	20.0d	114.7ef	126.6gh	139.7f	1.3d	100.0ef
Rose Supreme	14.8d	113.1ef	132.0fgh	145.7f	1.1def	119.9c
White Friendship	18.7d	92.8g	123.8h	137.2f	1.7bc	85.4gh
Second YearXDeciso	113.6a	179.2a	195.3b	207.9ab	1.2de	135.9b
Hong Kong	120.4a	189.8a	206.4a	216.6a	0.4h	100.1ef
Jessica	68.5b	155.8bc	172.6c	185.9cd	1.3d	114.1cd
Jester Ruffled	116.7a	182.2a	201.4ab	215.2a	1.9ab	136.5b
Madonna	35.7c	145.4c	162.3d	175.1de	0.7g	106.0de
Peters Pears	70.8b	165.7b	179.9c	193.1bc	1.2de	115.3cd
Rose Supreme	24.3cd	133.5d	150.3e	169.9e	1.6c	156.2a
White Friendship	15.5d	106.3f	130.9fgh	147.4f	1.2de	78.1h
LSD	**13.95**	**11.45**	**9.7**	**14.89**	**0.26**	**11.15**

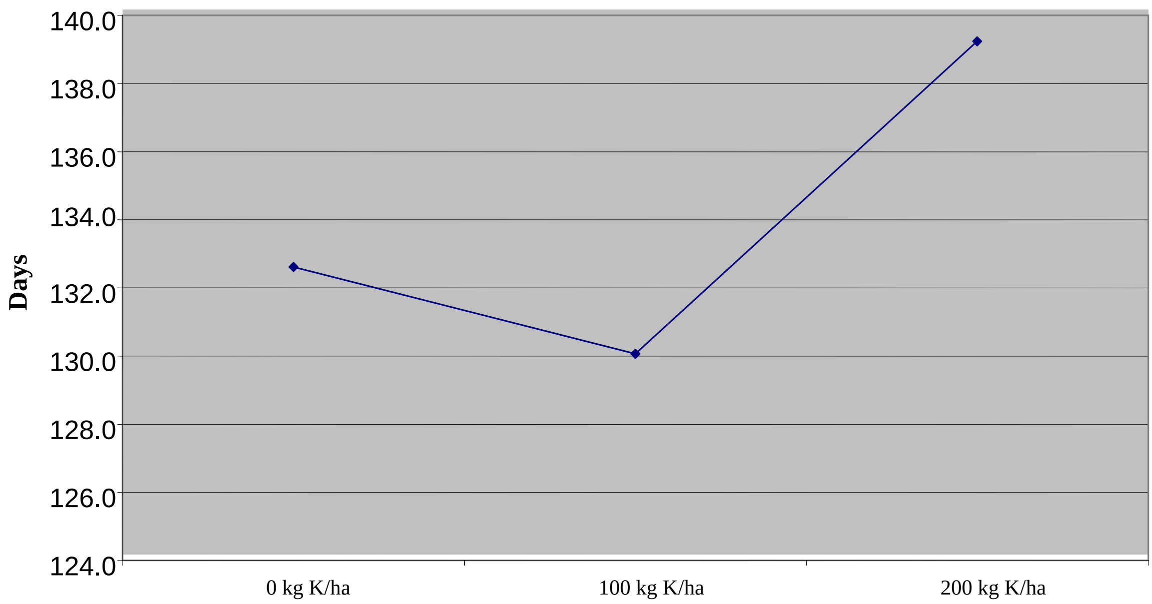

Figure-7. Days to spike emergence as affected by potassium levels.

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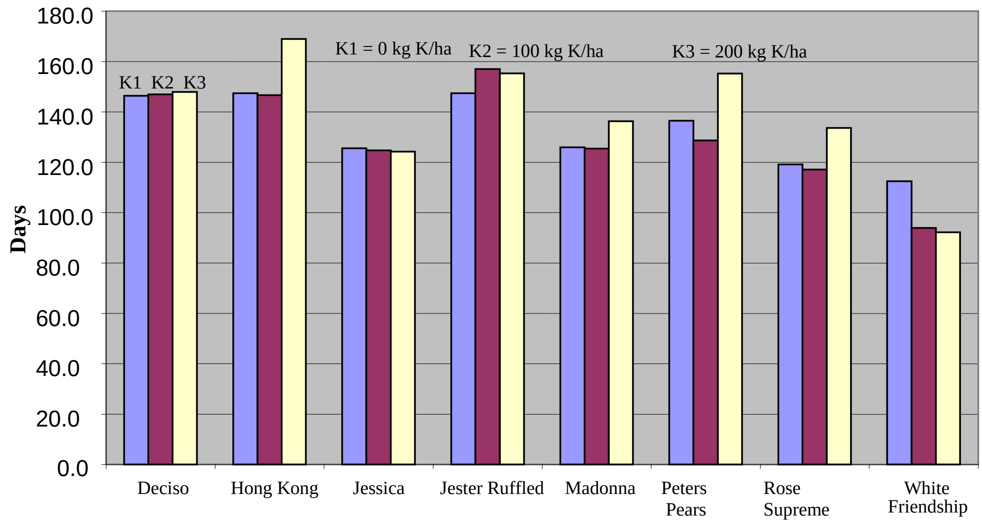

Column 1, 2 and 3 represent K1, K2 and K3, respectively for each cultivar.

Figure-8. Interaction between potassium and cultivars affected days to spike emergence.

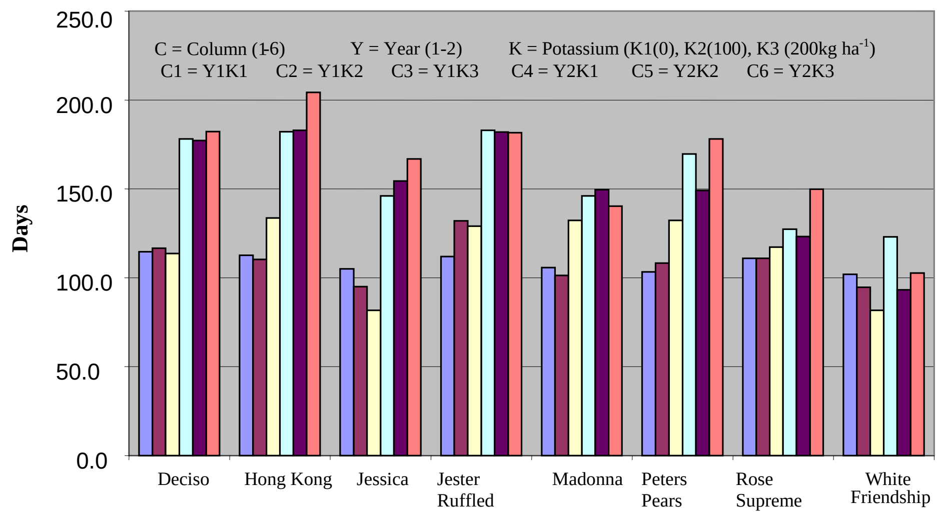

Figure-9. Interaction among year, potassium and cultivars affected days to spike emergence.

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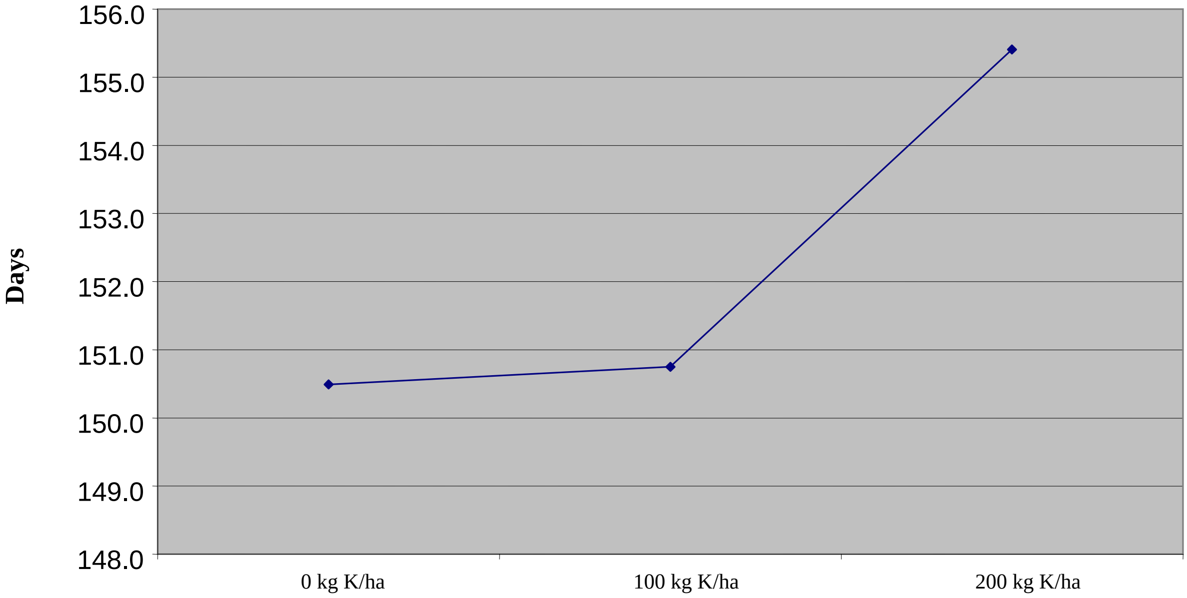
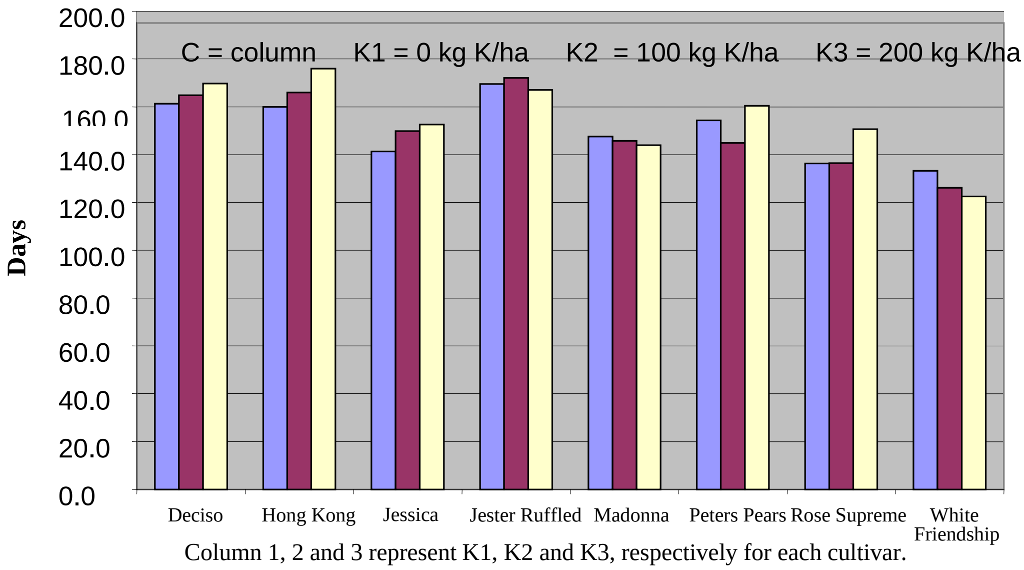


Figure-10. Potassium affected days to first florets opening of gladiolus cultivars.



Column 1, 2 and 3 represent K1, K2 and K3, respectively for each cultivar.

Figure-11. Interaction between potassium and cultivars affected days to first florets opening.

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