Performance Evaluation of Gladiolus Varieties under Diverse Climatic Conditions

Zeshan Ali 1, Muhammad Shabbir 1, Abdul Qadeer 1, Hafiz Muhammad Ahmad 2, Muhammad Qasim 1, Omar Aziz 1

1 Institute of Horticultural Science, University of Agriculture Faisalabad, Pakistan
2 Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan
3 Institute of Soil and Environmental Science, University of Agriculture Faisalabad, Pakistan

Abstract Crop production is inherently sensitive to climatic variations. Flowers have been admired and used by human to beautify their environment, and also as objects of romance, ritual, religion, medicine and as a source of food. Gladiolus (Gladiolus grandiflorus Andrews; family Iridaceae) is an important bulbous cut flower grown all over the world. The present study was carried out to check the growth and development of three cultivars of Gladiolus under different ecological conditions. As far as vegetative results are concerned early germination was observed at Faisalabad plantation, maximum plant height was observed at Rawalakot. Floral characteristics such as number of florets, diameter of florets, fresh and dry weight of spike were the best at Rawalakot plantation. Parameters such as corm weight, corm diameter, number of cormels and their weight were also favoured by Rawalkot climatic conditions. The temperature remained a critical factor for growth and production, early germination was observed at 26.5˚C at Faisalabad whereas ideal average temperature for vegetative, flowering and corm growth was 23.18˚C at Rawalakot plantation.

Keywords Gladiolus; Comparison study; Climatic factors; Climatic variability

Introduction Floriculture is emerging as a profitable venture due to divergence of farmers towards high value floral crops and utilization of flowers in social and industrial level (Ali et al., 2015). International trade in cut flowers is growing at a rate of 25 per cent annual growth rate. It has been reported that Pakistan is earning 35 million rupees from cut flower export (Bashir, 2010). Comprehensive survey indicates gladiolus is next to roses in preference by the consumers in various cities of the Pakistan (Riaz et al., 2007). Gladiolus is one of the most beautiful bulbous cut flowers in the floriculture industry and occupies the fifth position in the international floriculture trade (Sharma and Sharma, 1988; Butt et al., 2015) It is native to South Africa and presently has been cultivated throughout the world due to its attractive characteristics, dazzling colors, varying sizes and long vase life (Farid et al., 2002). These ornamental plants exhibit great diversity in their morphology, physiological responses to environmental factors, growth and developmental biology. Pakistan has a possibility to produce gladiolus all the year around. The sowing time of gladiolus in plains of Pakistan is from late July to early October liable upon the climatic circumstances of the area and flowering starts from December to March. Where as in hilly areas April-May is the sowing time and flowering starts in July-November. Thus gladiolus is considered as winter crop in plain areas and summer crop in hilly areas (Aftab et al., 2007). Agro-ecological conditions such as: Light, temperature, rainfall, humidity and soil condition are important in flowering of this crop. In gladiolus temperature affects all aspects of plant growth including shoot emergence, leaf area and flower development (Smith and Langhans, 1962). The suitable agro-climatic conditions of the country clearly indicate that wide range of ornamental crops can be grown, which can improve the economic conditions of the growers. The present experiment was conducted to study the effect of two different agro-ecological conditions on for growth, yield and quality of three Gladiolus varieties of Gladiolus.
1 Result and Discussion

Ornamental plants show considerable diversity in their growth habits, colors, blooming structure, flower shape and size (Pasha et al., 2015) Hence the performance of a cultivar in respect of growth and yield is known to be greatly influenced by the environmental conditions particularly integrated temperature and light (White and Warrington, 1988; Hodges, 1991). Growth and development of bulbous plants are mainly affected by seasonal thermo periodicity, constituting the basis of the techniques used to control flowering during forcing (Rees, 1992). In some bulbous species daily thermoperiodic changes are required to induce flowering (Halevy, 1990). Analyses of variance showed highly significant results for all the studied traits of gladiolus plants. Corm diameter was the only trait which showed non-significant results. Variety×climate interaction was also found significant (Table 1). The results regarding effect of different climatic conditions on all the studied traits of three gladiolus cultivars are given as treatment means (Figure 1 and Figure 2).

![Figure 1 Means of Gladiolus varieties for studied traits under the agro-climatic conditions of Faisalabad (C1)](image)

Note: Where: D Gr = Days to germination, Gr P= Germination percentage, PH= Plant height, No.L Number of leaves per plant, D Sp= Days taken to spiking, Sp.L= Spike length, Sp.D= Spike diameter, FD= Floret Diameter, No.F/S= Number of Florets Spike⁻¹, FWSp= Fresh Weight of Spike, DW Sp= Dry Weight of Spike, Cr D= Corm Diameter, Cr W= Cormel Weight, Cr/C= Cormels Clump⁻¹

1.1 Effect of different Agro-ecological conditions on vegetative growth of Gladiolus

Plants have to face various environmental stresses simultaneously, which affect their growth and development severely (Ahmad et al., 2015). The response of three gladiolus varieties with respect to their vegetative growth under the environmental conditions of Faisalabad and Rawalakot are given (Table 2). From the data it is concluded that temperature is an important factor for the vegetative growth of this flowering plant. Therefore Days to germination (11.13) and germination percentage (93.31%) was best under Faisalabad climatic conditions while at Rawalakot due to low temperature more number of days (13.43) was taken for to sprouting (Table 2). Early germination at high temperature is also reported by (Hartmann et al., 1981). Due to low temperature during germination, under Rawalakot climatic conditions germination percentage also remained low (85.8%). High sprouting percentage at Faisalabad might be due the fact that the environmental conditions were favorable for the sprouting at that time when the temperature was higher (Figure 3). As the varieties are concerned at Faisalabad
conditions maximum germination percentage was observed in White prosperity while at Rawalakot maximum germination percentage was observed in rose supreme. Carpenter et al. (1995) also reported that temperature between 20˚C to 25˚C promoted germination to 97% in gladiolus. The traits Plant height and Number of leaves plant were best under Rawalakot climatic conditions. At the Faisalabad plant height was recorded 90.2 cm whereas under Rawalakot climatic conditions it was 107 cm. Maximum plant height was recorded in the variety Rosesuoreme at Rawalakot, whereas minimum plant height was recorded in the variety Amsterdam at Faisalabad.

![Means of Gladiolus varieties for studied traits under the agro-climatic conditions of Rawalakot (C2)](image)

**Note:** Where: D Gr = Days to germination, Gr P= Germination percentage, PH= Plant height, No.L= Number of leaves per plant, D Sp= Days taken to spiking, Sp.L= Spike length, Sp.D= Spike diameter, FD= Floret Diameter, No.F/S= Number of Florets Spike¹,

FWSp= Fresh Weight of Spike, DW Sp= Dry Weight of Spike, Cr D= Corm Diameter, Cr W= Cormel Weight, Cr/C= Cormels Per clump¹

**Table 1** Analyses of variance for studied traits in Gladiolus varieties

| Source of variation | DF | Days to germination | Germination percentage | Days to spiking | Spike length | Spike diameter | Floret diameter | Number of florets per spike¹ | Fresh weight of spike | Dry weight of spike | Corm diameter | Cormel weight | Cormel Per clump |
|---------------------|----|---------------------|------------------------|-----------------|-------------|---------------|-----------------|---------------------------|------------------|-----------------|--------------|---------------|-----------------|
| Replication         | 2  | 0.039               | 1.72                   | 0.39            | 0.0289           | 0.555          | 0.418           | 0.00629                    | 0.016            | 0.591           | 0.0055       | 0.220         | 0.144           |
| Climate             | 1  | 23.78**             | 242.00**               | 1266.72         | 12.50*          | 183.68*        | 130.89*         | 4.877*                    | 624.81           | 73.0035         | 520.56       | 77.37*        | 2.553          |
| Variety             | 2  | 18.70**             | 186.72**               | 572.72*         | 2.4339          | 43.28*         | 76.035*         | 1.4852*                   | 43.28*           | 2.756*          | 76.035       | 15.98*        | 0.7642         |
| Interaction         | 2  | 0.51*               | 63.16*                 | 44.06*          | 2.7617          | 5.216*         | 15.98*          | 0.7648*                   | 90.16*           | 2.22*           | 24.26*       | 5.70*         | 0.5774         |
| Error               | 10 | 0.0073              | 0.322                  | 0.32            | 0.0502          | 0.231          | 0.110           | 0.0045                    | 0.014            | 0.0123         | 0.289        | 0.0699       | 0.224          |
| Total               | 17 |                     |                        |                 |               |               |                 |                           |                  |                 |             |               |                 |

**=Highly significant (p<0.05), *=significant, n.s= non-significant
Figure 3 Mean temperature of both climatic conditions during various growth stages of Gladiolus plants
Note: Where: D Gr= Temperature during germination, D Vg= Temperature during vegetative growth, DFl= Temperature during flowering, and D Cr= Temperature during Corm and cormles growth

The increase in plant height of gladiolus at high temperature is also reported by Gursan (1993). At Rawalakot 8.45 number of leaves plant$^{-1}$ were obtained whereas under Faisalabad climatic conditions 6.78 number of leaves was counted. Highest number of leaves per plant at Rawalakot was formed during high temperature 23.18˚C and minimum number of leaves per plant was observed at Faisalabad where temperature was 14.3˚C during vegetative growth. Rose supreme produced maximum number of leaves at Rawalakot and at Faisalabad Amsterdam produced minimum number of leaves. The results are in line with the findings of (Kishan et al., 2005) and (Bose et al., 1981) who reported maximum number of leaves in plants grown under warmer temperature and long day lengths.

Table 2 Effect of climatic conditions on vegetative growth among three varieties of Gladiolus

| Location | Vegetative growth parameters | Days to germination | Germination % age | Plant height (cm) | No. of leaves plant$^{-1}$ |
|----------|------------------------------|---------------------|-------------------|------------------|--------------------------|
| C1       |                              | 11.13*              | 93.31*            | 90.22            | 6.78                     |
| C2       |                              | 13.43               | 85.8              | 107.0*           | 8.45*                    |

Note: * shows superiority of climatic effect on growth, C1=Faisalabad, C2= Rawalakot

1.2 Effect of different climatic conditions on flowering of Gladiolus

Earlier researchers have reported that temperature is an important determinant for the rate of plant development under climatic changes (Craufurd and Wheeler, 2009). The response of three Gladiolus varieties viz. Amsterdam, White Prosperity and Rosesupreme with respect to their flower indices under both environmental conditions (Table 3). During flowering stage average temperature was recorded high (23.18˚C) at Rawalakot where as it was observed (14.3˚C) at Faisalabad (Figure 3).

The results regarding effect of different climatic conditions on days to spike emergence of three cultivars of gladiolus (Table 3) which shows that different climatic conditions of the Faisalabad and Rawalakot have a significant effect on days to spike emergence of Gladiolus varieties. At Rawalakot 75.4 days were taken to spike emergence whereas at Faisalabad it took 81.8 days. Minimum number of days to spike initiation at Rawalakot
climatic conditions might be due the fact that the environmental conditions were favorable for floral growth at that time when temperature at Rawalakot was higher than Faisalabad. At Faisalabad the temperature was lower due to which maximum number of days to spike initiation was obtained. The variety White prosperity took the minimum number of days to spike initiation at Rawalakot and at Faisalabad Amsterdam got maximum number of days to spike initiation. The early spiking of gladiolus was observed during high temperatures, which promoted quicker transition from the vegetative state to the reproductive state. Early spiking at high temperature is also reported by Halevy (1985) who stated that gladiolus flowered more rapidly under warm temperatures regardless of photoperiod. The results are in accordance with the finding of Piringer and Borthwick (1961) who reported increase in the number of days to inflorescence formation in gladiolus under lower temperatures.

At Faisalabad 40.9 cm of spike length was achieved whereas at Rawalakot 46.3 cm was obtained. Among the varieties under high temperature at Rawalakot the Rose supreme got the maximum spike length (48.3 cm) as compare to white prosperity and Amsterdam whereas at Faisalabad under low temperature Amsterdam showed minimum spike length (35.7 cm) as compare to White prosperity and Rosesupreme. Shortening of gladiolus spike at low temperature is also reported by (McCalla et al., 2011). At Rawalakot 8.03 mm spike diameter were recorded and 6.98 mm spike diameter were recorded at Faisalabad. Rose supreme produced maximum spike diameter at Rawalakot while at Faisalabad Amsterdam produced minimum spike diameter. The results are in line with the findings of Pasian and Lieth (1994) who reported low temperature causes reduction in spike diameter and length. At Rawalakot 13.11 number of florets was recorded while at Faisalabad 10.75 number of floret were obtained. Highest number of florets (14.20) was recorded in the variety Rosesupreme at Rawalakot, whereas the lowest number of florets (12.40) was recorded in the variety Amsterdam at Faisalabad. The results are in conformity with the results of Larson (1992) who reported the decreased number of florets per spike at low temperature. At Rawalakot 74.04 mm diameter of florets was observed while at Faisalabad 62.26 mm diameter of floret was observed. Among the varieties at Rawalakot Rosesupreme showed maximum diameter of floret while at Faisalabad Amsterdam showed minimum diameter of floret (Table 2, Table 3 and Table 4). Increase in floret diameter at high temperature is also reported by Gill et al. (2003) who reported increased diameter of the first floret during high temperature in early planting dates as compared to inflorescences obtained at low temperature during later dates of planting.

In Rawalakot climatic conditions 50.12 g fresh weight of the spike was found whereas at Faisalabad 39.36 g fresh weight of spike (g) was recorded. Rose supreme showed the best results regarding the fresh weight of spike at Rawalakot while minimum fresh weight of spike at Faisalabad was shown by Amsterdam (Table 2, Table 3). The results are in accordance with Kamble (2001). The results are in line with the findings of (Ko et al., 2005) who reported increased fresh weight of chrysanthemum flower at 17°C as compared to 21°C in a winter greenhouse experiment. At Rawalakot climatic conditions 14.28 g dry weight of spike was found whereas at Faisalabad 10.13 g dry weight of spike (g) was observed. Best results regarding the dry weight of spike at Rawalakot the variety Rosesupreme proved to have maximum dry weight while in Faisalabad Amsterdam has minimum spike dry weight. The results are in line with the findings of Bose and Tripathi (1996) who reported increased dry matter production at high temperature may be attributed to greater accumulation of photosynthates by vegetative parts in gladiolus.

| Location | Days to Spike mergence | Spike length (cm) | Spike diameter (mm) | Number of Florets | Fresh weight of Spike (g) | Dry Weight of Spike (g) |
|----------|------------------------|-------------------|---------------------|-------------------|--------------------------|------------------------|
| C1       | 81.8                   | 40.9              | 6.98                | 12.75             | 62.26                    | 39.36                  |
| C2       | 75.4*                  | 46.3*             | 8.030*              | 13.11*            | 74.04*                   | 50.12*                 |

Note: * Shows superiority of climatic effect on growth, C1=Faisalabad, C2=Rawalakot

1.3 Effect of climatic conditions on corms and cormels growth among three varieties of Gladiolus

Corm size is a major factor to determine the capacity of bulbous plants to flower (Le Nard and De Hertog, 1993). Difference in corm size is responsible for the wide differences reported in the time of flower initiation and
flowering in different places (Koul and Farooq, 1984; Negbi, 1999). Flower formation is directly related to the corm size (Negbi et al., 1989; De Mastro and Ruta, 1993) and a quantitative relationship between these two parameters was found by (Negbi et al., 1989). It is observed that under Rawalakot climatic conditions corm and cormels growth was better as compare to growth under Faisalabad climatic conditions (Table 4).

During corm and cormels growth temperature was higher (24.95˚C) at Rawalakot as compare to Faisalabad where it was (10.02˚C). At Rawalakot 5.94 cm corm diameter was recorded whereas at Faisalabad 5.03 cm corm diameter was recorded. Rosesuprem obtained maximum corm diameter at Rawalakot while at Faisalabad revealed minimum diameter. The results are in line with the findings of Parker and Borthwick (1951) who reported an increase in corm diameter at high temperature in part to the production of more photosynthates. At Rawalakot climatic conditions 55.62 g corm weight was recorded whereas at Faisalabad 50.72 g corm weight was recorded. The minimum corm weight (g) at Faisalabad was observed during low temperatures (10.02˚C), while maximum corm weight at Rawalakot was observed during high temperature (24.95˚C). At Rawalakot maximum corm weight was found in Rose supreme while at the Faisalabad minimum weight of corm was observed in Rosesupreme. The results are in line with the findings of Shilo and Halevey (1981) who reported increase in corm weight at high temperature and long day lengths.

At Rawalakot, it took 28.76 number of cormels clump\(^1\) while 26.17 number of cormels clump\(^1\) were obtained at Faisalabad. Highest number of cormels was recorded in the variety White prosperity at Rawalakot, whereas lowest number of cormels was recorded in the variety Amsterdam at Faisalabad. The results are in line with the findings of Laskar and Jana (1994) who reported an increase in gladiolus cormels production at slightly high temperature. At Rawalakot 8.58 g cormels weight was recorded while at Faisalabad 6.84 g weight of cormels was recorded. Among the varieties at Rawalakot in White prosperity obtained the maximum weight of cormels while at Faisalabad Amsterdam obtained minimum number of cormels. The results are in line with the findings of Laskar and Jana (1994) who reported an increase in gladiolus cormels production at slightly high temperature.

Table 4 Effect of climatic conditions on corms and cormels growth parameters among three varieties of Gladiolus

| Location | Corm weight (g) | Corm Diameter (cm) | Cormel Weight (g) | Number of cormels Clump\(^1\) |
|----------|----------------|--------------------|------------------|-----------------------------|
| C1       | 50.72          | 5.03               | 6.84             | 26.17                       |
| C2       | 55.62\(^*\)    | 5.94\(^*\)         | 8.58\(^*\)       | 28.76\(^*\)                 |

Note: * shows superiority of climatic effect on growth, C1=Faisalabad, C2= Rawalakot

2 Conclusion

Plantation under Faisalabad climatic conditions took minimum days to sprouting (11.13 days) and had maximum sprouting percentage (91.30%). The ideal temperature for sprouting was 26.5˚C. Among the varieties Amsterdam performed the best in days to germination (9.63) while in germination % age White prosperity (97.66) performed the best. The results regarding days to spiking (75.4 days), spike length (46.3 cm), spike diameter (8.030 mm), number of florets per spike (13.11 florets), diameter of florets (74.04 mm), fresh weight of spike (50.12 g) and dry weight of spike (14.28 g) was the best under Rawalakot climatic condition. As for as varieties were concerned, white prosperity produced flowering in (77.7) days, maximum numbers of florets (14.20), maximum spike length (48.3 cm), fresh weight of spike (55.10 g), dry weight of spike (16.32 g), maximum spike diameter (8.21 mm) and floret diameter (77.65 mm) was observed to be the best in Rosesupreme cultivar under Rawalakot. The parameters like maximum corm diameter (5.94 cm) and corm weight (55.62 g), number of cormels (28.76) and cormel weight (8.58 g) were the best under Rawalakot. The variety Rosesupreme gained maximum corm diameter (6.34 cm) and corm weight (58.33 g), White prosperity produced the maximum number of cormels (31.66) and cormels weight (9.34 g) at Rawalakot. From all above information, it can concluded gladiolus can be grown in Faisalabad during winter and in Rawlakot during summer with marketable quality, so gladiolus production throughout the year is possible however Rawalakot climatic conditions are more favorable for quality cuts.
3 Materials and Methods

The present study was conducted under the Agro-climatic conditions of Faisalabad and Rawalakot. Three Gladiolus cultivars namely, Rose supreme, Amsterdam and White prosperity were used for the present research. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Uniform agronomic practices were applied to all three cultivars. Ten plants from each of the entry were selected randomly and data was recorded for morphological traits i.e. Days to Germination, Germination Percentage, Plant Height (cm), Number of Leaves, Days to Spiking, Length of Spike (cm), Diameter of Spike (cm), Diameter of Florets (mm), Number of Floret Spike, Fresh Weight of Spike (g), Dry Weight of Spike (g), and corm indices i.e. Diameter of Corms (mm), Weight of Corms (g), Number of Cormels, Weight of Cormels (g). Complete data was analyzed statistically by using analysis of variance technique and treatment means were compared through LSD test at the 5% level of significance according to (Steel et al., 1997). Before starting experiment, soil samples from various blocks of experimental field in Faisalabad and Rawalakot were collected randomly to assess physio-chemical properties (pH, EC, texture, organic matter contents and N, P, K and Zn contents) of the soil. Soil analysis was performed to examine physical and chemical properties of soil. The results regarding physio-chemical analyses of soil from both ecological conditions are given below (Table 5).

Table 5 Physio chemical analysis of soil in Faisalabad and Rawalakot

| Soil properties                  | Faisalabad (soil depth 6-12 inch ppm) | Rawalakot (soil depth 6-12 inch ppm) | Adequate ranges (mg kg⁻¹) |
|---------------------------------|---------------------------------------|--------------------------------------|--------------------------|
| Organic matter %               | 0.49                                  | 0.35                                 | >1.29%                   |
| Ph                              | 8.2                                   | 8.1                                  | 7                        |
| EC (dS m⁻¹)                     | 1.69                                  | 1.25                                 | 3                        |
| Nitrogen (%)                    | 0.024                                 | 0.017                                | >20                      |
| Available Phosphorus (ppm)     | 9.2                                   | 10.3                                 | >15                      |
| Exchangeable Potassium (ppm)   | 60                                    | 70                                   | >150                     |

References

Aftab M., Shabbir G., and Mahmood A., 2007, Production of high quality bulbous flowers in Pothwar. Proc. Int. Symp. Prosp. Hort. Ind. Pak. 315-321
Ahmad H.M., Rahman M.U., Qurban A., and Shahid I.A., 2015, Plant cuticular waxes: a review on functions, composition, biosyntheses mechanism and transportation, Life Sci J., 12(4s): 60-67.
Ali Z., Qadeer A., Ahmad H.M., Aziz O., Qasam M., Ali Q., 2015, Assessment of effect of different herbicides on morphological traits of Gladiolus grandiflorus, Life Sci J., 12(4s): 87-93
Bashir F., 2010, Steps taken to enhance cut flowers output, www.phdeb.org.pk
Bose T.K., Jana B.K., and Mukhpadhyay T.P., 1981, Note on the effect of day length on growth and flowering in Hippeastrum, Ind. J. Hort., 38: 110-112
Bose U.S. and Tripathi S.K., 1996, Effect of micronutrients on growth, yield and quality of tomato cv. Pusa Ruby in M.P. Cro. Res. 12: 61-64.
Buti S.J., Varis S. Nasir I.A., Sheraz S., Shahid A., and Ali Q., 2015, Micro Propagation in Advanced Vegetable Production: A Review. Adv. Life Sci., 2(2): 48-57
Damann M.P., and Lyons R.E., 1995, Juvenility and photoperiodic flowering requirements of Chrysanthemum grown under short- and long-day conditions, J. Amer. Hort. Sci., 120(2): 241-245
Craufurd P.Q., and Wheeler T. R., 2009, Climate change and the flowering time of annual crops, Journal of Experimental Botany, 60(9): 2529-2539
Mastro G.D., and Ruta C., 1993, Relation between corm size and saffron (Crocus sativus L.) flowering, Acta Horticul, 344: 512-517
Uddin F.M., Rahman M.M., Rabban M.G., and Mannan M.A., 2002, Effect of Corm size and Depth of Planting on the Growth and Flowering of Gladiolus. Pak. J. Biol. Sci., 5(5): 553-555
Gill A.P.S., Aulakh M., and Paswan L., 2003, Studies on the corms production of gladiolus in the subtropical region of Punjab, India, Acta. Hort., 177: 369-374

Gursan K., 1993, Growing Gladiolus, Atatürk Hort. Res. Inst., Yalova (Tr)

Haley A.H., 1990, Recent advances in control of flowering and growth habit of genotypes, Acta Hort., 266:35-42

http://dx.doi.org/10.17660/ActaHortic.1990.266.3

Haley A.H., 1985, Gladiolus in the Handbook of Flowering Vol. III, CRC Press, Boca Raton, FL

Hartmann H.T., Flocker W.J., and Kofranek A.M., 1981, Plant science: Growth, development and utilization of cultivated plants, Prentice-Hall, Inc. Englewood Cliffs, pp. xii+676

Hodges T., 1991, Predicting crop phenology, Crc Press., pp.248

Kamble B.S., 2001, Evaluation of gladiolus (Gladiolus hybrids Hort.) varieties, M.Sc.(Hrt.) Thesis, University of Agriculture Sciences, Dharwad

Kamble B.S., Reddy B.S., Gangadharappa P.M., and Kulkarni B.S., 2004, Evaluation of gladiolus varieties for quality parameters, flower and corm yields, Haryana J. Hort. Sci., 36(1): 430-434.

Ko J.Y., Kim S.K., Um N.Y., Han J.S., and Lee K.K., 1994, Planting times and corm grades of gladiolus gandavensis for retarding culture in high land, J. Agric. Sci. Hort., 36(1): 430-434.

Koul K.K., and Farooq S., 1984, Growth and differentiation in the shoot apical meristem of the saffron plant (Crocus sativus L.), J. Indian Bot. Soc., 63: 153–160

Larson R.A., 1992, Introduction to Floriculture. 2nd ed, Acad. Press, San Diego, California

Laskar M.A., and Jana B.K., 1994, Effect of planting time and size of corms on plant growth, flowering and corm production of Gladiolus, Ind. Agric., 38: 89-97

Le Nard M., and De Hertog A., 1993, Bulb growth and development and flowering, In: De Hertog, A., Le Nard, M. (Eds.), The Physiology of Flower Bulbs, Elsevier, Amsterdam, (Chapter 4), pp. 29–43

McCalla A.G., Weir J.R., and Neatby K.W., 2011, Effects of temperature and sunlight on the rate of elongation of stems of maize and gladiolus, Can. J. Res., 17(11): 388-409

Negbi M., 1999, Saffron cultivation: past, present and future prospects, In: Negbi, M. (Ed.), Saffron: Crocus sativus L., Harwood Academic Publishers, Australia, pp.1–18

Negbi M., Dagan B., Dror A., and Basker D., 1989, Growth, flowering, vegetative reproduction, and dormancy in the saffron crocus (Crocus sativus L.), Isr. J. Bot., 38(2-3): 95–113

Pasian C.C., and Lieth J.H., 1994, Prediction of flowering rose shoot development based on air temperature and thermal units, Scientia Hort., 59(2): 131-145

http://dx.doi.org/10.1016/0304-4238(94)90080-9

Parker M.W., and Borthwick H.A., 1951, Day-length proved vital factor in gladiolus flowering, Florists Exchange, 117(26): 38-40

Pasha M.F.K., Ahmad H.M., Qasim M., and Javed I., 2015, Performance evaluation of zinnia cultivars for morphological traits under the Agro-climatic conditions of Faisalabad, Eurp. J. Biotech. Biosci., 3(1): 35-38

Piringer A.A., and Borthwick H.A., 1961, Effects of photoperiod and kind of supplemental light on growth, flowering, and stem fascination of celosia, Am. J. Bot., 48(7): 588-592

http://dx.doi.org/10.2073/2439371

Riaz T., Khan S.N., and Javid A., 2007, Scenario of gladiolus production in Punjab, Pakistan, Pak. J. Bot. 39(7): 2389-2393

Sharma S.C., and Sharma A.N., 1988, Commercial cultivation of gladiolus in: J. Parkash and R. Bhandary (Eds), Floriculture technology trades and trends, Oxford publishing Co. Pvt. Ltd., New delhi, India, pp.199-202

Shilo R., and Haley A.H., 2005, The effect of various environmental factors on flowering of gladiolus, Sci. Hort., 4:147-155

http://dx.doi.org/10.1016/S0304-4238(76)80006-4

Smith D.R., and Langhans R.W., 1962, The influence of day and night temperatures on the growth and flowering of the Easter lily (Lilium longiflorum Thunb. var. Croft), Proc. Am. Soc. Hort. Sci., 80: 593-598

Steel R.G.D., Torri J.H., and Dickey D.A., 1997, Principles and procedures of statistics: A biometrical approach, McGraw Hill Book Company, New York, USA

White I.W., and Warrington L.J., 1988, Temperature and light integral effects on growth and flowering of hybrid Geraniums, J. Amer. Soc. Hort. Sci., 113(3): 354-359