

Introducing Superior Cultivars of *Gladiolus* by Important Quality and Quantity Indexes

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Received: 27 May 2018

Accepted: 11 January 2019

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Suitable selection of cultivars is a major determinant of the quantity and quality of bulbous flowers in Iran's climatic conditions. In order to introduce superior cultivars of gladiolus to be grown in the temperate regions of Iran, the present experiment was carried out in a complete randomized block design (CRBD) in three replications with five cultivars of gladiolus including 'Roma', 'Wiss Sensatiow', 'Nova Lux', 'Amsterdam' and 'White Prosperity' in a greenhouse at the Ornamental Plants Research Center (OPRC) in Mahallat, Iran. Results indicated that cultivars differed significantly in all studied traits. The highest plant height and the highest number and weight of cormlets were observed in 'Amsterdam'. The highest leaf length and width, number of florets, spike length, and stem diameter were observed in 'Wiss Sensatiow'. Also, 'Roma' exhibited the longest vase life (9.66 days), the heaviest corms (40.80 g), the highest corm diameter (56 mm) and the highest floret diameter (9.25 cm). The correlation analysis between variables revealed a positive and significant correlation between the diameter and weight of the main corm ($r = +0.92$) and between spike and leaf length ($r = +0.98$). 'Roma' and 'Wiss Sensatiow' had the best flower and corm traits. So, they are recommended as alternative to some older cultivars (like 'White Prosperity') as they may have higher marketability in Iran.

Abstract

Keywords: Corm, Cormlet, Ornamental plants, Spike length.

INTRODUCTION

Gladiolus grandiflorus, which belongs to the family Iridaceae, is known as the queen of bulbous flowers (Randhawa and Mukhopadhyay, 1985). The genus *Gladiolus* has more than 150 species all over the world and is mainly native to the western, southern, and eastern areas of Africa, but about 12 species have originated from the Mediterranean areas (Cohat, 1993). *Gladiolus* is one of the important cut flowers in Iran and the world with an important role in the export of cut flowers. It has great economic value as a cut flower and for decoration. This flower is one of the main bulbous flowers in Iran. Its corms and cormlets are used for asexual propagation (Moradiashur and Azimi, 2017). This plant has two spring and summer flowering types. The summer type is more important and is extensively used to produce cut flowers (Azimi, 2017). *Gladiolus* was cultivated all over the world in the late 16th century. The leading *Gladiolus* producers are the US, the Netherlands, France, Portugal, Italy, Belgium, Brazil, Australia, and India. It has the 8th rank of cut flowers and the first rank of bulbous flowers in the world trade (Pragya *et al.*, 2010).

According to Misra and Singh (1989), more than 30,000 varieties of this flower are cultivated and new cultivars are introduced every year. The cultivars mostly grown in the Netherlands (in an area of more than 10 ha) include 'White Prosperity', 'Peter Pears', 'Jessica', and 'Green Star'. New cultivars with superior characteristics are introduced every year mainly motivated by ease of hybridization, high productivity, good pollination, and germination of the seeds of this plant (Azimi, 2017).

The knowledge of phenological steps in bulbous cut flowers can be used as a function of environmental variables in the modification and improvement of these plants management. The accelerated or delayed stages of plant development are influenced more by genetic factors and less by environmental factors in greenhouse conditions. Therefore, the knowledge of yield and growth steps of *gladiolus* cultivars can be very important. Presently, the focus of producers and consumers has been drawn to how to increase the yield of cut flowers and the production rate of bulb organs with good quality for the consumer market.

This research was conducted in Iran to introduce suitable, adaptable cultivars and replace older cultivars with newer cultivars with higher productivity and color diversity in the temperate regions of Iran.

MATERIALS AND METHODS

Five *Gladiolus grandiflorus* cultivars were used to evaluate their yield including Roma (1), 'Wiss Sensatiow' (2), 'Nova Lux' (3), 'Amsterdam' (4), and 'White Prosperity' (5). This research was conducted on the basis of a randomized complete block design with three replications and each replication in seven pots in a 110-day growth period in Ornamental Plants Research Center (OPRC) of Mahallat (Long. 30°27'50"E., Lat. 30°54'33" N., Alt. 1747).

The growth system was hydroponic initiated from the beginning of the spring in April. The nutrient solutions were composed of 64 mg/l N (10 mg/l NH₄-N, 54 mg/l NO₃-N), 45 mg/l P, 239 mg/l K, 31 mg/l Mg, 59 mg/l S, 1.680 mg/l Fe, 0.400 mg/l Mn, 0.500 mg/l B, 0.030 mg/l Cu, and 0.050 mg/l Mo (Wahome *et al.*, 2010). The circumference of the corms was 10-12 cm. The corms were planted in 1.20-L pots containing 30% perlite and 70% cocopeat and were kept in a greenhouse at 23 ± 4°C and 65 ± 5% RH in April-May. Stem height (from the crown on the surface of the soil to the tip of the stem), leaf width and length, the number of florets in branch, spike length, floret diameter, stem diameter, vase life (days after harvesting to 50% of floret wilting), weight, and the number and diameter of corms and cormlets were recorded on each plant. A nutrient solution with an electrical conductivity of 1.86 dS/m and pH=5.5 ± 0.2 was used during the growth period.

Statistical analyses including descriptive statistics, simple correlation coefficients, variance

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analysis, and means comparison were performed by Duncan’s test. The analysis of variance was carried out in the SAS version 9.0 statistical package (SAS Institute, Cary, NC, US).

RESULTS AND DISCUSSION

Variance analysis showed that cultivars differed significantly ($P < 0.01$) in terms of all studied characteristics. In addition, there was a significant ($P < 0.01$) difference among blocks. In other words, blocking was done in the correct direction (Table 1). Coefficient of variation (CV) of the traits was in the range of 25.74-37.01% with the maximum and minimum being for cormlet weight (25.74%) and floret weight (3.01%), respectively (Table 1).

The results showed that the maximum plant height was for ‘Amsterdam’ (104 cm) and the minimum for ‘Nova Lux’ (88 cm), showing significant differences from the other cultivars (Table 2). These results show that the variation in height is mainly caused by genetic factors, and environmental influences are less important for these traits. Flowering stem height is another important characteristic. One of the important characteristics of cut flowers is market-friendliness. The height difference of plants can be associated with their competitiveness for light, space, RH, nutrition, and ventilation (Karavadia and Dhaduk, 2002). Bush height in cut flowers is one of the very important characteristics with flower size in flower rating. Therefore, the results showed that plants had bigger reproductive parts, leaf number, and dimensions.

Table 1. Analysis of variance in the evaluated cultivars.

S.o.V	df	Plant length	Leaf width	Leaf length	Floret no.	Spike length	Floret diameter	Stem diameter	Vase life	Corn weight	Corn diameter	Cornlet no.	Cornlet weight
Block	2	5.51 ^{ns}	0.09 ^{**}	7.44 ^{**}	0.20 ^{ns}	9.16 ^{**}	0.01 ^{ns}	0.02 ^{**}	0.46 ^{**}	51.10 ^{**}	45.80 ^{**}	2.60 [*]	0.26 ^{**}
Cultivar	4	138.48 ^{**}	0.17 ^{**}	31.63 ^{**}	5.33 ^{**}	33.23 ^{**}	0.30 ^{**}	0.01 ^{**}	5.43 ^{**}	306.12 ^{**}	140.26 ^{**}	47.10 ^{**}	0.16 ^{**}
Error	8	44.78	0.02	5.89	1.28	6.70	0.07	0.002	0.38	28.18	9.96	3.85	0.10
CV (%)	-	6.88	4.38	5.53	10.29	5.86	3.01	3.56	8.21	21.57	6.98	16.62	25.74

^{*}, ^{**} and ^{ns}: Significant at $P < 0.05$, $P < 0.01$ and insignificant, respectively.

Table 2. Mean comparison of traits in cultivars (1 to 5) of gladiolus (Roma (1), ‘Wiss Sensatiow’ (2), ‘Nova Lux’ (3), ‘Amsterdam’ (4), and ‘White Prosperity’ (5)).

Cultivars	Plant length (cm)	Leaf width (cm)	Leaf length (cm)	Floret no.	Spike length (cm)	Floret diameter (cm)	Stem diameter (cm)	Vase life (day)	Corn weight (g)	Corn diameter (mm)	Cornlet no.	Cornlet weight (g)
1	91.10ab	3.63b	44.00a	10.33b	45.46a	9.25a	1.46a	9.66a	40.80a	56.00a	11.66b	1.37a
2	101.16ab	4.03a	47.30a	13.00a	47.30a	8.89a	1.40ab	7.00bc	25.96b	47.66b	10.00b	1.16a
3	88.00b	3.53b	38.50b	9.66b	38.50b	8.72ab	1.33bc	6.33c	13.56c	39.00c	9.00b	1.12a
4	104.00a	3.46b	44.66a	11.66ab	44.66a	8.82ab	1.30c	6.66c	21.94bc	41.00c	9.66b	1.00a
5	100.66ab	3.43b	44.83a	10.33b	44.83a	8.38b	1.26c	8.00b	20.75bc	42.33bc	18.66a	1.59a

*In each column, means with the similar letter(s) are not significantly different ($P < 0.05$) using LSD test.

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Taller cultivars produce flowers with higher quality. The stem height of ornamental flowers is considered a valuable characteristic of the apparent structure. In spite of this, the suitable effect on physiological characteristics increases the resistance of flowers when they are transferred from garden to market (Azimi *et al.*, 2012). In this research, the used corms had similar sizes. So, the observed difference in height of *Gladiolus* cultivars could be attributed to the difference in genetic structure as well as environmental factors, which are similar to the results from Hossein *et al.* (2012). Moradiashur (2008) showed that 'Oscar' had the maximum mean height and 'White Prosperity' had the minimum height versus the other cultivars and showed a significant difference from the others. Increasing corm size in gladiolus would increase height and length of the flower spike. Similar results have been reported by Bijimol and Singh (2001) and Moradiashur (2013) for *Polianthes tuberosa*. In this regard, Roy and Sharma (2000) reported that there were height variations based on height among gladiolus cultivars as 'Vedio' was 114 cm and 'White Prosperity' was 152 cm tall. Rai *et al.* (2000) reported that 'White Prosperity' had a plant height of 128.5 cm, 'White goddess' had a plant height of 123.5 cm, 'Red beauty' had a plant height of 123.3 cm, 'White friendship' had a plant height of 121.4, and 'First Lady' had a plant height of 135.8 cm. Sidhu and Arora (2000) showed that 'White Prosperity' had the highest plant height (135.8 cm) in the summer among all gladiolus cultivars.

According to the results, the maximum leaf width was related to 'Wiss Sensatiow' (4.03 cm) and the minimum to 'White Prosperity' (3.43 cm). Also, the maximum leaf length was obtained from 'Wiss Sensatiow' (47.3 cm) and the minimum from 'Nova Luc' (38.05 cm) (Table 2). Hegde (1994) focused on different *gladiolus* cultivars and showed that leaf number was 4.20 and 7.6 per plant in 'Green Wood Pecker' and 'American Beauty', respectively. The maximum number of leaves was reported to be 9.7 observed in 'White Prosperity' and 'Wind Song' and the minimum was 4.6 observed in 'American Beauty' (Kalasaraddi, 1996). Higher leaf area increased photosynthesis and carbohydrate accumulation resulting in the prolongation of vase life. Longer vase life makes it possible to transfer and move them to farther places in flower export (Jozghasemi *et al.*, 2015). Therefore, cultivars with higher leaf area have better quality and quantity indexes. In this regard, Moradiashur (2008) showed that gladiolus cultivars 'Rose Supreme' and 'Orange' had the maximum and minimum mean leaf width, respectively, significantly differing from other cultivars. Moreover, 'Oscar' and 'Yellow' exhibited the maximum and minimum mean leaf length, respectively.

The results revealed that the maximum cormlet number and spike length were 13 and 47.3 cm observed in 'Wiss Sensatiow', respectively, and the minimum ones were 9.66 and 38.5 cm observed in 'Nova Lux', respectively (Table 2). Rai *et al.* (2000)'s study of various gladiolus cultivars showed that the maximum number of cormlet in 'White Prosperity' was 17 and 'Green Wood Pecker' had the minimum one of 12 florets. According to the results about cultivars cultured in similar conditions (greenhouse), environmental variance is a source of genetics and accounts for all non-genetic variations. It impairs the efficiency of the selection procedure by the interaction between genotypes and phenotypes (Lynch and Walsh, 1998). Singh *et al.* (2001) compared different cultivars and showed that the maximum number of floret was obtained from 'White Prosperity'. This happens because of nutrition storage in big corm and its preparation by corm which at first helps the plant growth and finally increases the number of florets in inflorescence and corms. In addition, it has been established (Uddin *et al.*, 2002; Bhat *et al.*, 2009; Memon *et al.*, 2009; Kareem *et al.*, 2013) that lower corm size significantly decreases the number of florets in spikes. Spikes with more florets are produced because of less competition of plants over water, minerals, nutrition, and light (Mojiri and Arzani, 2003). Similar results have been reported by Padaganur *et al.* (2005), Khalaj and Edrisi (2013), and Moradiashur (2013) on *Polianthes tuberosa*. In this regard, Sharma and Gupta (2003) showed that increasing plant spacing increases the

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number of florets in the flower spike. In another research, cultivation type and intervals of gladiolus corm did not have significant effects on the new main corm diameters and also weight, number, cormlet diameter, the ratio of florets to flower height, leaf number, length and width, and stem diameter (Daneshvar and Heydari, 2009). Gladiolus nutrition in 'Oscar' increases flower branch height, leaf number in the plant, stem diameter, chlorophyll index, plant wet and dry weights, and the number of corms and cormlets than the control sample with 1500 g m⁻² Fe (II) sulfate (Banijamali and Shafiei, 2005). In a study on various ratios of nitrate to ammonium, Banijamali *et al.* (2018) reported that the increase in ammonium concentration from 0 to 20 percent increased the number of flower branches, peduncle length, and fresh weight of stem flower on *Rosa* than control not subjected to ammonium.

The maximum floret size (0.25 cm) among all *gladiolus* cultivars was observed in 'Roma' and the minimum (8.38 cm) in 'White Prosperity' (Table 2). Commercial cultivars with bigger floret had better conditions for sale in flower and plant markets. Similarly, Moradiashur (2008) showed that 'Rose Supreme' had the maximum mean floret diameter and 'White Prosperity' had the minimum mean values for these traits.

In this respect, Sindhu and Verma (1995) showed that the biggest floret (11.7 cm) was obtained from Sancera and the minimum (6 cm) from 'Arc'. Moreover, Sidhu and Arora (2000)'s study on gladiolus cultivars indicated that the biggest floret was 8.92 cm observed in 'Rose Supreme' and the smallest one was in 'Slamone Queen' among 12 gladiolus cultivars based on Mishra *et al.* (1987)'s report.

The results revealed that the highest stem diameter among 5 gladiolus cultivars (Table 2) was 1.4 cm observed in 'Roma' and the minimum was 1.26 cm observed in 'White Prosperity' and they had statistically significant differences with others. In this regard, Moradiashur (2008) showed that gladiolus cv. 'Oscar' and 'Yellow Spot' had the maximum and minimum stem diameter, respectively. Moradiashur and Azimi (2017) showed no significant difference in this trait among gladiolus cultivars by evaluating various cultivars performance such as 'Rose Supreme' and 'White Prosperity'. Moreover, Daneshvar and Heydari (2009) showed that cultivation type and corm cultivation interval of gladiolus did not have a significant effect on stem diameter. Flowering stem diameter is one of the valuable characteristics of the cut flowers and increases flower resistance to the transfer from the garden to the sale market (Azimi *et al.*, 2012).

The maximum and minimum vase life was observed in 'Roma' (9.66 days) and 'Nova Lux' (6.33 days), respectively (Table 2). Cultivars with longer vase life are significantly important according to the commercial and economic importance of the cut flower. The vase life of cut flowers is influenced by pre-harvest and post-harvest factors. Quality and vase life of the cut flowers depend on cultivation conditions and the conditions under which they are transferred.

The maximum corm weight (40.80 g) and corm diameter (56.03 mm) were observed in 'Roma', and the minimum (13.56 g, 39.00 mm) in 'Nova Lux'. However, no significant difference was observed among various cultivars (Table 2). In a study on various non-native gladiolus cultivars, Roy and Sharma (2000) reported that the maximum corm diameter of 6.6 cm was related to 'Ice Gold' and 'Rose Supreme' and the minimum one of 5 cm to 'Priseilla' and 'Viedo'. Furthermore, the maximum and minimum corm weight was reported in 'Ice Gold' (92.6 g) and 'Viedo' (38.6 g), respectively.

The maximum and minimum number of cormlets were observed in 'White Prosperity' (18.66) and 'Nova Lux' (9.00), respectively. The maximum and minimum corm weight were observed in 'White Prosperity' (1.56 g) and 'Amsterdam' (1.00 g), respectively. There was no significant statistical difference in cultivars (Table 2). In this regard, Moradiashur (2008) showed that the maximum and minimum cormlet number were for 'Oscar' and 'Yellow Spot', respectively. Singh *et al.* (2000) reported that cormlet number varies in the range of 18.7-55.5 in gladiolus cul-

tivars and that the maximum was 50.2 observed in ‘White Prosperity’.

Correlation among quantitative traits

Correlation coefficients of the quantitative traits among various cultivars (Table 3) show that the maximum positive and significant correlation was related to spike length with leaf length ($r= +0.98$), corm diameter and weight ($r= +0.92$), and corm weight and vase life ($r= +0.71$). In addition, the minimum negative and significant correlation was related to floret length with corm numbers ($r= -0.38$) and stem diameter with number of corms ($r= -0.33$). In other words, spike length is one of the flower structures that enlarge by the increase in leaf length which is considered an important factor in gladiolus and can be evaluated in breeding programs. Increasing leaf surface raises photosynthesis and results in the accumulation of more carbohydrates, which increases spike length and this intensifies market-friendliness. Vase life and corm diameter were increased by corm weight and influenced physiological traits such as fresh and dry weight which are effective in the quantity and quality of the flower performance. Moreover, number of days to budding and to flowering have a positive and significant phenotype and genetic correlation with stem diameter. This is important for increasing the postharvest quality of flowers. In other studies, it has been shown that leaf length has a positive correlation with spike length, and floret length with weight and spike length (Suresh, 2015). Leaf length, leaf number, and plant height have the maximum phenotype and genetic coefficients with floret numbers in the plant (Moradiashur, 2008).

Table 3. Correlation of quantitative traits among cultivars.

Traits	1	2	3	4	5	6	7	8	9	10	11	12
1	1											
2	0.15	1										
3	0.59**	0.36*	1									
4	0.76**	0.48**	0.58**	1								
5	0.50**	0.35*	0.98**	0.52**	1							
6	-0.13	0.44**	0.39*	0.17	0.15	1						
7	-0.04	0.24*	0.18	0.33*	0.28*	0.59**	1					
8	-0.15	-0.06	0.07	-0.27*	0.18	0.27*	0.25	1				
9	-0.04	0.07	0.44**	0.06	0.55**	0.49**	0.58**	0.71**	1			
10	-0.09	-0.07	0.36*	0.13	0.47**	0.47**	0.65**	0.70**	0.92**	1		
11	0.14	-0.29*	0.12	-0.21*	0.11	-0.38*	-0.33*	0.37*	0.06	0.07	1	
12	0.15	0.02	0.08	-0.10	0.10	-0.20*	-0.26*	0.38*	0.21*	0.23*	0.66**	1

*, ** and ns: Significant at $P>0.05$, $P>0.01$ and insignificant, respectively. 1. Plant length; 2. Leaf width; 3. Leaf length; 4. Floret No; 5. Spike length; 6. Floret diameter; 7. Stem diameter; 8. Vase life; 9. Weight Corm; 10. Corm diameter; 11. Cormlet No.; 12. Cormlet weight.

CONCLUSION

‘Amsterdam’ and ‘Wiss Sensatiow’ were superior in most traits than others with regard to the results, so they can be recommended to the farmers and producers for more profitability and economic efficiency. It is to be noticed that ‘White Prosperity’ is grown in most parts of Iran.

ACKNOWLEDGEMENTS

The financial support of the Ornamental Plants Research Center is gratefully acknowledged. Also, the authors gratefully thank Mr. Shahmohamadi for his constructive suggestions.

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How to cite this article:

Azimi, M. H. and Banijamali, S.M. 2019. Introducing superior cultivars of *Gladiolus* by important quality and quantity indexes. *Journal of Ornamental Plants*, 9(1), 33-40.

URL: http://jornamental.iaurasht.ac.ir/article_664257_ad6775bbb8ede1b438cf779acb444200.pdf

