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Assessment and ranking of new gladiolus hybrids in Iran

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ABSTRACT

Purpose: The aims of this research were to collect reliable information about economic traits, introducing superior genotypes for production, exportation and breeding programs in new hybrids of gladiolus. **Research Method**: 48 promising genotypes with 4 parents of gladiolus evaluated on the basis of a randomized complete block design in three replications. The Research was conducted in Ornamental Plants Research Center in Mahallat from 2017-2018. **Main findings**: The results showed that the highest number of florets was observed in OPRC16 (19.0 florets) and the lowest in OPRC412, OPRC413, and OPRC99 (8.00 florets). The highest floret width of 12.00 cm was related to OPRC16 and the lowest of 7.00 cm to OPRC712. The longest spike was 71.00 cm observed in OPRC16 and the shortest was 33.00 cm observed in OPRC411. OPRC311 and OPRC61 exhibited the highest and lowest plant height of 210 and 132 cm, respectively. It was found that the flowers of the new hybrids were almost whitish in color. It was also indicated that the diversity in the traits was mostly related to the genetic factors and the environment was less influential on them. According to the North American Gladiolus Council, the length of the cut branch (spike and branch length) of all hybrids (48 hybrids) and the parents P1, P2, and P3 were categorized in the fantasy group. The hybrids that were placed in the fantasy group in terms of the spike length were more marketable. **Research limitations**: No limitations were founded. **Originality/Value**: The results revealed high diversity among the hybrids and parents in traits. Therefore, hybrids that are superior (fantasy group) in these commercial traits can be introduced as new cultivars.

INTRODUCTION

Gladiolus (*Gladiolus grandiflorus*) is a cross-pollinating and diploid (2n = 2x = 30) plant species from the family *Iridaceae*, the subfamily Ixioideae, the tribe Ixieae, and the sub-tribe Gladiolines (Ranjan et al., 2010). Its other names are sword silly and corn flag (Poon et al., 2012), which is also known as the queen of bulbous flowers (Randhawa & Mukhopadhyay, 1985). The name sword silly has its roots in the sword-shaped leaves of gladiolus. The genus of Gladiolus contains over 276 species throughout the world, but they are mostly native to the western, southern, and eastern parts of Africa although 12 species have been originated from the Mediterranean regions (Cohat, 1993; Rina & Hiroshi, 2016). The acreage of gladiolus cultivation in Iran was reportedly 350 ha in 2017-2018 (Ministry of Agriculture Jihad, 2017). Gladiolus is ranked the eighth among cut flowers and the first among bulbous flowers in the global trade (Pragya et al., 2010). The leading gladiolus producing countries are the US, the Netherlands, France, Portugal, Italy, Belgium, Brazil, Australia, and India (Pragya et al., 2010). According to Misra and Singh (1989), over 30,000 cultivars of gladiolus are cultivated and every year new cultivars are produced (Singh, 2006). The demand for high-quality and commercially valuable cultivars is also on the rise. Several studies have been conducted on gladiolus: phenology (Schwab et al., 2015); estimation of genetic variability (Rashmi & Kumar, 2014); heritability and genetic advance (Patra & Mohanty, 2014); genotypic and phenotypic variability (Pattanaik et al., 2015, Bhujbal et al., 2013); hybridization (Ohri & Khoshoo, 1983a; 1983b; Suresh, 2015; Azimi, 2018; Hossain et al., 2012). Intervarietal hybridization is another common way for transferring desirable attributes between different cultivars and producing progenies with new characteristics (Azimi et al., 2018; Yang et al., 2015; Zamani et al., 2010).

Most cultivars of gladiolus, which are used as cut flowers, have come into existence by inter-species crosses. Due to the complexity of breeding and multiple inter-species hybridizations, it is not possible to classify the cultivars based on their origins, so they are classified by color, color intensity, and flower size (Wilfret, 1980). Several years of hybridization and selection of superior populations of gladiolus have yielded in the production of new types and the replacement of old wild species with diverse new cultivars. These cultivars have drawn attention owing to their diversity in color, flowering time, and disease resistance (Willery, 2010). Azimi (2018) performed genetic, phenotypic, and heredity assessments on new gladiolus hybrids and classified them in different categories.

Many associations of bulbous flowers have been established to expand ornamental bulbs. These associations publish many periodicals, annals, CDs, and books about bulbous plants. They also have other functions including the identification and classification of native ornamental bulbs, breeding, and production of new cultivars (Fairchild, 1979; Howie, 1984; Koeing & Crowly, 1972; Benschop et al., 2010). They also present new cultivars (www.bulbosociety.org). The North American Gladiolus Council works on gladiolus (http://www.gladworld.org). When it comes to the production, storage, and cultivation of ornamental plants, the consumer demand fuels the continuous development of new genotypes (Teixeira da Silva & Kulus, 2014).

Therefore, the main goal of the production and cultivation of ornamental plants is introducing new cultivars with novel characteristics, such as resistance to diseases, new colors, and changes in the structure and morphology of flowers (Tanaka, 2006). Breeding ornamental plants to achieve diversity in production is imperative. Since a major aim of the present study is introducing new genotypes of gladiolus, the results can contribute to producing gladiolus cut flowers.

MATERIALS AND METHODS

The present study assessed the main flower-related traits of 48 promising genotypes (Fig. 1) with the OPRC codes (All promising genotypes were named based on the name of the institute, i.e. 'OPRCn' where 'n' refers to the numerical identifier for the genotype); as well as four commercial parents of gladiolus including 'Amsterdam' (P1), 'White Prosperity' (P2), 'Advance Red' (P3), and 'Rose Supreme' (P4) in the Ornamental Plants Research Center in 2017-2018 on the basis of a randomized complete block design in three replications (10 samples were recorded in each replication). In a single 110-day growth cycle, all agronomic and horticultural operations required for the optimal growth were performed on the genotypes. The 52 genotypes were planted in the research greenhouse of Ornamental Plants Research Center (Latitude: 33° 53' N., Longitude: 50° 29' E., altitude 1732 m, average temperature 23.4 °C, relative humidity 57.1%).

The corm size (a perimeter of 6-8 cm) and plant depth (5.00 cm) were picked according to what was common in the region. The corms were planted by the plot method at a density of 40 plants m^{-2}. The recorded traits including cut branch length (from crown from the soil surface to the tip of the branch in cm), number of florets per branch, spike length (from the first flower to the tip of the flowering branch in cm), and floret size (the size of the first flower of the spike in cm). The traits of floret size, floret number, spike length, and cut branch length were ranked as per the instruction of the North American Gladiolus Council (http://www.gladworld.org). According to this council, the number of florets, the cut branch length, and the spike length are classified into fantasy, specific, standard, and multipurpose and the size of floret is classified into miniature, small, medium, large, and very large.

Statistical analyses including the calculation of descriptive statistics, analysis of variance (ANOVA), and means comparison by the LSD test at the 5% level ($P<0.05$) were all performed in the SAS 9.1 software package.

RESULTS AND DISCUSSION

Cut flower height

According to the results of means comparison (Table 1), among the parents, the highest cut flower height was observed in P1 (146 cm) and the lowest was observed in P4 (82.2 cm). Among the promising genotypes, the highest was for OPRC311 (210 cm), which was the result of P1 × P4 crossing. The lowest was observed in OPRC61 (P2 × P3) whose cut flower height was 132 cm. Most promising genotypes outperformed their parents in this trait. Since all genotypes and parents were in the same conditions. Cut flower height is an important trait. Promising genotypes, which have higher cut flower height than their parents, can be highly successful as commercial cultivars in flower markets. In this respect, Moradi (2009) who studied gladiolus reported that cv. 'Oscar' had the highest height and cv. 'Sefidmasti' had the lowest among all studied cultivars, showing significant differences with other cultivars. The increase in corm size in gladiolus increases the height and length of flowering spikes. Similar results have been reported by Bijimol and Singh (2001), and Moradi-Ashour (2013) for tuberose. Roy and Sharma (2000) reported a high diversity in height among gladiolus cultivars so that 'Vedio' showed a height of 114 cm and 'White Prosperity' showed a height of 152 cm. According to Rai et al. (2000), the height was 128.5, 123.5, 123.3, 121.4, and 135.8 cm for 'White Prosperity', 'White Goddess', 'Red Beauty', 'White Friendship', and

'First Lady', respectively. Sidhu and Arora (2000) revealed that among different cultivars of gladiolus, 'White Prosperity' had the highest height of 135.8 cm in summer.

Floret number

The results of means comparison (Table 1) revealed that the highest and lowest number of florets among the parents were related to P1 (16.5 florets) and P4 (9.0 florets). Among the promising genotypes, OPRC16 had the highest number of florets (19.0 florets) and OPRC412, OPRC413, and OPRC99 had the lowest one (8.0 florets). In their study on different cultivars of gladiolus, Rai et al. (2000) found that the highest and lowest number of florets were related to 'White Prosperity' and 'Green Wood Pecker' (17 and 12 florets), respectively. Sanjai and Singh (2000), also, reported that 'White Prosperity' had the highest number of florets. This may be associated with the nutrient reserves of big corms and their availability that help early growth and development of the plant and finally influence the number of florets on inflorescences. There are similar reports about the reduction of florets on inflorescences with the decrease in corm size (Uddin Farid et al., 2002; Bhat et al., 2009; Memon et al., 2009; Kareem et al., 2013). The production of spikes that have more florets is related to lower competition of plants over water, minerals, nutrients, and radiation (Mojiri & Arzani, 2003). Padaganur et al. (2005), Khalaj and Edrisi (2013), and Moradi-Ashour (2013) reported similar results for tuberose.

Floret size

According to the results of means comparison (Table 1), floret size in the parents was in the range of 8.39-10.52 cm, the highest being for P4 and the lowest for P2. Among the promising genotypes, OPRC16 had the highest floret size of 12.00 cm and OPRC712 had the lowest one of 7.00 cm. In a similar work, Moradi (2009) showed that 'Rose Supreme' had the highest mean floret diameter and 'White Prosperity' had the lowest one. Also, Sindhu and Verma (1995) found that the largest floret was 11.7 cm in 'Sancera' and the smallest was 6 cm in 'Arc'. Likewise, Sidhu and Arora (2000) observed the biggest florets of 8.92 cm in 'Rose Supreme' and Mishra et al. (1987) reported that among 12 gladiolus cultivars, 'Slamone Queen' had the biggest florets. Floret size is a major economic trait. Promising genotypes whose floretsare larger than their parents' florets can be viably commercialized in flower markets. Obviously, introducing commercial cultivars can enhance diversity in flower markets and help its prosperity. In some flowers like cyclamen, the focus is on flower characteristics so that cyclamens have been developed in different flower shapes and sizes (Anderson, 2007), but no such work has been done on gladiolus.

Spike length

The highest and lowest spike length among the parents was observed in P1 (52.25 cm) and P2 (42.47 cm). Among the promising genotypes, OPRC16 had the longest spikes with a length of 71.00 cm and OPRC411 had the lowest ones with a length of 33.00 cm (Table 1). Spike length is an important trait. Promising genotypes that grow spikes longer than their parents are very likely to succeed in flower markets. In this respect, Sharma and Goupta (2003) found that the increase in planting distance increased the number of florets on the flowering spike. In a study on the planting type and corm spacing of gladiolus, no significant impact was reported on the diameter of new corms, the weight, number and diameter of cormlets, the ratio of floret number to flowering stalk length, leaf number, length and width, and stalk diameter (Daneshvar & Heidari, 2009).

Table 1. Mean (±SD) and status of the crossing of 48 promising genotypes and parents of gladiolus in terms of flower-related traits

Crossing	Code	Cut flower height (cm)	Floret number	Floret size (cm)	Spike length (cm)
P1×P2	OPRC11	161.0±8.1	13.0±0.650	8.00±0.40	56.00±2.80
P1×P2	OPRC15	154.5±5.5	15.2±0.541	8.59±0.31	45.45±1.62
P1×P2	OPRC16	193.0±9.7	19.0±0.950	12.00±0.60	71.00±3.55
P1×P3	OPRC21	159.0±8.0	11.0±1.803	9.00±0.99	44.00±10.56
P1×P3	OPRC24	174.0±8.7	11.7±0.833	8.67±0.51	53.33±8.59
P1×P4	OPRC31	172.0±8.6	13.7±0.907	8.00±0.40	54.67±2.94
P1×P4	OPRC35	139.4±5.0	11.1±3.401	8.92±0.48	41.39±3.41
P1×P4	OPRC39	175.0±8.8	10.0±1.790	9.17±0.75	47.67±8.36
P1×P4	OPRC310	172.0±8.6	10.0±0.500	8.45±0.42	45.00±2.25
P1×P4	OPRC311	210.0±10.5	14.00±0.70	9.50±0.48	56.00±2.80
P1×P4	OPRC312	156.0±7.8	11.00±0.55	8.50±0.43	47.00±2.35
P1-self	OPRC45	150.5±5.4	13.10±1.68	8.92±0.48	44.10±1.70
P1-self	OPRC46	157.0±7.9	13.00±5.22	10.33±1.52	51.67±16.87
P1-self	OPRC48	145.0±7.3	12.00±1.82	8.67±0.51	48.00±12.30
P1-self	OPRC49	176.0±8.8	12.00±0.60	8.17±0.49	47.67±8.36
P1-self	OPRC411	149.0±7.5	11.00±0.55	7.50±0.38	33.00±1.65
P1-self	OPRC412	152.0±7.6	8.00±0.40	8.00±0.40	39.00±1.95
P1-self	OPRC413	130.0±6.5	8.00±0.40	9.00±0.45	35.00±1.75
P1-self	OPRC414	174.0±8.7	11.00±0.55	8.50±0.43	40.00±2.00
P1-self	OPRC415	169.0±8.5	12.00±0.60	8.00±0.40	38.00±1.90
P2×P1	OPRC55	133.3±4.8	12.40±2.25	8.52±0.29	38.01±6.17
P2×P1	OPRC56	158.0±7.9	13.70±4.65	9.33±2.34	49.00±19.15
P2×P1	OPRC57	135.0±6.8	12.70±2.94	8.33±1.49	43.67±13.40
P2×P3	OPRC61	132.0±6.6	12.30±0.83	7.33±0.68	46.00±8.90
P2×P3	OPRC64	140.0±7.0	13.00±1.87	8.00±0.94	38.00±5.48
P3×P1	OPRC72	162.0±8.1	10.70±1.26	9.33±1.50	48.33±3.29
P3×P1	OPRC73	165.0±8.3	13.00±0.65	9.33±0.73	55.67±3.95
P3×P1	OPRC75	153.5±5.5	13.80±1.14	10.28±1.59	50.86±5.41
P3×P1	OPRC76	148.0±7.4	15.00±3.53	10.00±1.79	57.00±12.38
P3×P1	OPRC78	173.0±8.7	14.00±0.70	9.00±0.45	54.67±6.84
P3×P1	OPRC711	156.0±7.8	11.00±0.55	8.00±0.40	41.00±2.05
P3×P1	OPRC712	152.0±7.6	9.00±0.45	7.00±0.35	37.00±1.85
P3×P1	OPRC714	193.0±9.7	14.00±0.70	9.00±0.45	58.00±2.90
P3×P2	OPRC81	194.0±9.7	15.70±2.46	8.00±0.40	69.33±12.16
P3×P2	OPRC83	165.0±8.3	13.00±0.65	8.00±1.77	55.00±4.36
P3×P2	OPRC84	163.0±8.2	11.70±0.83	9.00±0.45	46.67±3.33
P3×P2	OPRC87	162.0±8.1	13.30±2.39	9.33±0.73	43.67±13.40
P3×P2	OPRC89	158.0±7.9	11.30±0.80	8.50±0.43	47.00±8.91
P3-self	OPRC93	154.0±7.7	13.00±0.65	9.00±0.96	51.00±7.32
P3-self	OPRC98	162.0±8.1	13.30±0.87	9.00±0.45	54.00±7.37
P3-self	OPRC99	151.0±7.6	8.00±3.48	8.17±0.49	35.00±19.09
P3-self	OPRC911	143.0±7.2	11.00±0.55	7.50±0.38	36.00±1.80
P3-self	OPRC912	151.0±7.6	9.00±0.45	8.00±0.40	42.00±2.10
P3-self	OPRC913	178.0±8.9	11.00±0.55	8.00±0.40	48.00±2.40
P3-self	OPRC914	188.0±9.4	12.00±0.60	7.50±0.38	51.00±2.55
P3×P4	OPRC101	132.0±6.6	12.30±0.83	8.00±0.40	42.00±12.25
P3×P4	OPRC107	146.0±7.3	12.70±2.94	8.67±1.22	44.33±12.84
P3×P4	OPRC108	142.0±7.1	12.70±1.30	8.00±0.94	49.33±11.18
Parent	P1	143.2±4.4	16.50±0.50	9.43±0.12	52.25±2.38
Parent	P2	128.0±2.9	12.10±0.51	8.39±0.10	42.47±3.71
Parent	P3	130.2±1.0	13.10±0.42	8.44±0.21	51.47±0.24
Parent	P4	82.2±7.0	9.00±1.00	10.52±1.10	46.51±3.09
$LSD_{0.05}$	-	4.61	2.40	1.15	10.71

Ranking of promising genotypes and parents based on the North American gladiolus council

Floret size

Two groups of large-flower and small-flower plants are used for commercial purposes (Halevy, 1998). The small-flower group, known as Orchidola gladiolus, is specifically used to produce cut flowers because of their shorter production time and adaptability with winter conditions (Gonzalez et al., 1998). According to the most reliable association of gladiolus in North America, floret size is classified into miniature, small, medium, large, and very large (Table 2). The results showed that promising genotypes and parents were not in the miniature and large groups. Only OPRC16 was placed in the large group, and other promising genotypes and parents were classified in the small and medium-sized groups (Table 2). Presently, commercial cultivars of gladiolus with diverse floret sizes are in a better position in flower markets.

Cut branch length

According to the North American Gladiolus Council, the cut branch length (spike and stalk length) is classified into fantasy, specific, standard, and multipurpose (Table 3). The results showed that all promising genotypes and the parents P1, P2, and P3 were placed in the fantasy group. The parent P4 was placed in the standard group (Table 3). Flowering stalk height is an important trait underpinning the marketability of cut flowers. It is also a crucial trait from the breeding perspective because it has applications when grading is made by floret size. Flowering branch length and diameter are invaluable characteristics of gladiolus appearance that, in addition to influencing physiological properties, improve flower resistance to farm-to-market transport. As well, the difference in plant height relates to their competition for radiation, moisture, space, nutrient, and aeration (Karavadia & Dhaduk, 2002).

Table 2. Ranking of promising genotypes and parents based on the floret size

Sr. No.	Ranking	Floret size (cm)	Genotypes
1	Miniature	<6.3	-
2	Small	6.3-8.9	11, 15, 24, 310, 312, 48, 49, 411, 412, 414, 415, 55, 57, 61, 64, 711, 712, 81, 83, 89, 99, 911, 912, 913, 914, 101, 107, 108, P3, P2
3	Medium	8.9-11.4	21, 31, 35, 39, 311, 54, 46, 413, 56, 72, 73, 75, 76, 78, 714, 84, 87, 93, 98, P4, P1
4	Large	11.4-14	16
5	Very large	>14	-

Table 3. Ranking of promising genotypes and parents based on the cut branch length

Sr. No.	Ranking	Floret size (cm)	Genotypes
1	Fantasy	>107	All promising genotypes and the parents P1, P2, and P3
2	Specific	107-97	-
3	Standard	96-81	P4
4	Multipurpose	<80	-

Spike length

The North American Gladiolus Council divides gladiolus in terms of spike length into fantasy, specific, standard, and multipurpose (Table 4). The results revealed that most promising genotypes, as well as P1, P2, and P3, were placed in the group with the spike length of >45 cm. The parent P4 and some promising genotypes were placed in the specific group (Table 4). According to the results, the promising genotypes that are in the fantasy group are in a better place for marketability.

Floret number

Floret number is divided by the North American Gladiolus Council into fantasy, specific, standard, and multipurpose (Table 5). The results indicated that most promising genotypes and parents were in the specific group. The fantasy group contained OPRC16 and P1. The genotypes 412, 413, 712, 99, 912, and P4 were categorized in the multipurpose group. The promising genotypes 21, 24, 35, 39, 310, 312, 411, 414, 72, 711, 84, 89, 911, 913, and 914 were categorized in the standard group (Table 5). Presently, the commercial cultivars of gladiolus with more florets are more preferred in flower markets (Fig. 1).

Table 4. Ranking of promising genotypes and parents based on the spike length

Sr. No.	Ranking	Spike length (cm)	Genotypes
1	Fantasy	>45	11, 15, 16, 24, 31, 39, 310, 311, 312, 46, 48, 49, 56, 61, 72, 73, 75, 76, 78, 714, 81, 83, 84, 89, 93, 98, 913, 914, 108, P4, P3, P1
2	Specific	32-45	21, 35, 45, 411, 412, 413, 414, 415, 55, 57, 64, 711, 712, 87, 99, 911, 912, 101, 107, p2
3	Standard	20-32	-
4	Multipurpose	<20	-

Oprc712 Oprc55 Oprc46 Oprc11 Oprc311

Fig.1. Promising genotypes of gladiolus.

Table 5. Ranking of promising genotypes and parents based on the floret number

Sr. No.	Ranking	Spike length (cm)	Genotypes
1	Fantasy	>16	16, P1
2	Specific	15	11, 15, 31, 311, 45, 46, 48, 49, 415, 55, 56, 57, 61, 64, 73, 75, 76, 78, 714, 81, 83, 87, 93, 94, 101, 107, 108, P3, P2
3	Standard	12	21, 24, 35, 39, 310, 312, 411, 414, 72, 711, 84, 89, 911, 913, 914
4	Multipurpose	10	412, 413, 712, 99, 912, P4

CONCLUSION

The traits of floret number and size, spike length, and cut stalk length are of crucial importance in cut flowers. Collecting reliable information about flowers is very important for the use of genotypes in production, exportation, and breeding programs. The results revealed that the promising genotype OPRC16 outperformed the other genotypes and their own parents in most flower-related traits.

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Conflict of interest

The authors declare that they have no conflict of interest.

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