EFFECT OF VARIOUS CORM SIZES ON THE VEGETATIVE, FLORAL AND CORM YIELD ATTRIBUTES OF GLADIOLUS

Noor-un-Nisa Memon[1]*, Muhammad Qasim[2], Muhammad Jafar Jaskani[2], Rashid Ahmad[3] and Raheel Anwar[2]
[1]Department of Horticulture, Sindh Agriculture University, Tandojam
[2]Institute of Horticultural Sciences, University of Agriculture, Faisalabad
[3]Department of Crop Physiology, University of Agriculture, Faisalabad
*Corresponding author's e-mail: noorimemon@gmail.com

Corm and cormel production of gladiolus has major role in the growth and development of gladiolus industry. However, its commercial cultivation is mainly limited by rare production of corms and cormels and thereby does not fulfill local demand of the countries. A field experiment was conducted to investigate the effect of corm size on the vegetative and floral attributes and corm and cormel production in gladiolus. The main objective of the present study was to find out the best corm size on the basis of both corm diameter and weight in order to standardize conventional method of propagation for producing more corms and cormels. For this purpose, corms of three commercially grown varieties viz. Traderhorn, White Friendship and Peter Pears of three different sizes- small, (dia. 2.2-2.4 cm), medium (dia. 2.7-3.0 cm) and large (dia. 3.2-3.5 cm) were planted in split plot design consecutively for two years, i.e., 2006 and 2007. Large sized corms significantly increased the leaf breadth, length of flowering spike, and number of florets spike^{-1} over those produced from small and medium sized ones, whereas plant height was greatly decreased in response to large sized corms. Regarding corm production, large sized corms produced significantly higher weight of corms plant^{-1}, cormels plant^{-1} and combined total weight of corms and cormels plant^{-1} in all the three varieties of gladiolus. However, variety wise Peter Pears got the best results. The yield of new corms plant^{-1} was significantly increased in response to large sized corms both in White Friendship and Peter Pears, whereas, Traderhorn had no effect of corm size for number of corms plant^{-1}. Cormel production also depicted significant results in response to large sized corms in all the three varieties of gladiolus. All obtained corms and cormels were graded on the basis of diameter into large as well as small sized corms when categorized according to the standards of North American Gladiolus Council.
Keywords: Corm size, corm yield, gladiolus, floral yield, cormel production

INTRODUCTION

The cut flower industry is globally a fast growing industry, which has achieved significant growth during the past few decades. At present, cut flower production focus has moved from traditional growers, such as the Netherlands, Germany and France, to countries where the climates are better and production costs are low (Zhao *et al*., 2008). The best example of China, Kenya, and Ethopia that have emerged as potential producers in booming world trade of high quality cut flowers and their planning policies can be seen as a powerful demonstration of the role of floriculture industry in poverty alleviation.

Gladiolus, being a potential cut flower has great demand and is cultivated all over the world for its attractive spikes having florets of huge forms, dazzling colors, varying sizes and long vase life (Farid Uddin *et al*., 2002). The major producing countries are the United States (Florida and California) Holland, Australia, Japan, Italy, France, Poland, Iran, India, Brazil, Poland, China, Malaysia and Singapore. However mass production and quality cut flower spikes of gladiolus is still problem in many countries as its commercial cultivation is mainly restricted by rare production of corms and cormels (Singh and Doahre, 1994) and commercial cultivation is only possible through corms and cormels (Hartman *et al*., 1990; Ziv and Lilien-Kipnis, 1990). One mother corm generally produces one daughter corm of standard size and few cormels. These cormels are auxiliary buds on the corm which is a compressed thickened stem and as the resting perpuating organ (Remotti and Loffler, 1995; Sen and Sen, 1995; Ahmad *et al*., 2000; Nagaraju *et al*., 2002; Sinha and Roy, 2002). The cormels require two to three seasons to produce standard flower spike and daughter corm. However, this commercial production of corms and cormels doesn't fulfill the local demand of planting material and eventually affects corm cost.

Different factors such as size of corm (Mckay *et al*., 1986; Farid Uddin *et al*., 2002), selection of cultivar (Sloan and Harkness, 2005) corm storage and dormancy (Tsukamoto 1974; Magie, 1975; Hosoki, 1984; Gonzalez *et al*., 1998; Zalewska and Antkowiak, 2009), clipping of leaves and flower spike (Misra, 1994; depth of planting (Farid Uddin *et al*., 2002, Bhattacharjee, 1981), planting time (Kalasareddi *et al*., 1998; Zubair *et al*., 2006) and fertilizer management (Halder *et al*., 2007; Pant, 2005) influence the production of corms and quality of gladiolus flower. The size of corms markedly influences the growth and development of gladiolus including flower and corm production (Bose *et al*., 2003). There is a direct relation between corm size, flower production and corm and cormel yield as reported by Ogale *et al*. (1995) and corm size can be better known on the basis of both diameter and weight. It is therefore essential to find out the best corm size on the basis both corm diameter and weight in order to standardize conventional propagation methods for getting more corm and cormel production. Both developed and developing countries are greatly relying on conventional propagation methods. Only few units of developed countries are totally relying on advanced technology methods like tissue culture for mass production of cormels. Literature is rather scanty on these and other works dealing with speedy mass production of corms and cormels. It is high time, therefore, to stream line technology and standardize conventional propagation methods in order to produce quality flower spikes and maximize corm and cormel production. This study was designed to evaluate the role of corm sizes on the growth, flowering and corm production in different varieties of gladiolus.

MATERIALS AND METHODS

The planting material i.e. corms of gladiolus were obtained from Sunny Seeds, Lahore, distributor of SAKATA Seed Corporation, Japan and PeterBiz International representing Stoop Flower Bulb Company Holland. The study involved nine treatments which were factorial combination of three gladiolus varieties viz. Traderhorn (red with white throat), White Friendship (white) and Peter Pears (peach with red throat) and three corm sizes- small (dia. 2.2-2.4 cm), medium (dia. 2.7-3.0 cm) and large (dia. 3.2-3.5 cm). The experiment was conducted in the Floriculture Experimental Area, University of Agriculture, Faisalabad, Pakistan consecutively for two years, i.e., 2006 and 2007. The treatments were replicated three times in split plot design using varieties as a major split. Ten corms per treatment were planted at a depth of 8-10 cm and planting distance of 20 cm from plant to plant and 60 cm from ridge to ridge. The soil characteristics were: pH- 7.8, electrical conductivity- 0.4 dSm^{-1}, organic matter- 1.04% (by Walkely-Black method), total nitrogen- 0.052% (by Kjeldahl's method), available phosphorus- 11.8 mg kg^{-1} (Olsen *et al*., 1954) and exchangeable K- 120 mg kg^{-1} (by extraction with neutral solution of 1N ammonium acetate). NPK fertilizer was applied @ 200-180-200 kg ha^{-1}. Half dose of nitrogen and full doses of phosphorus and potash were applied at the time of land preparation. Remaining half dose of nitrogen was top-dressed at fourth leaf stage. Irrigation, earthing-up, weeding and fungicide spray practices were followed according to the crop requirement.

During initial growth stages, the data were collected on the sprouting of corms, followed by the days to flowering. At later stages, additional data were collected regarding plant height, number of leaves $plant^{-1}$, leaf breadth, length of flowering spike, number of florets $spike^{-1}$, corm and cormel weight, number of corms and cormels $plant^{-1}$, and corm and cormel diameter. The corms and cormels from each treatment and variety were graded according to the North American Gladiolus Council (Wilfret, 1980) on the basis of their corm diameter to determine the actual grade of the corms. The data were subjected to statistical analysis following Fisher's analysis of variance technique and treatment means were compared according to DMR test at 5% level of probability (Steel *et al.*, 1997).

RESULTS

Vegetative and floral parameters

The data in Table 1 revealed that plant height, leaf breadth, length of flowering spike, and number of florets $spike^{-1}$ were significantly influenced by corm

Table 1. Effect of corm size on the vegetative and floral characteristics in different varieties of gladiolus

Variety	Corm size†	Plant height (cm)	Leaf breadth (cm)	Length of flowering spike (cm)	No. florets $spike^{-1}$
Traderhorn	SC	72.57±2.12 a	2.49±0.05 f	59.99±2.25 de	12.93±0.18 e
	MC	64.59±0.26 bc	2.72±0.03 de	66.87±2.97 bc	15.87±0.24 b
	LC	66.68±1.14 b	3.23±0.09 a	68.90±1.33 b	16.47±0.13 a
White Friendship	SC	65.48±0.69 b	2.48±0.04 f	58.48±1.00 e	13.07±0.18 e
	MC	64.32±0.68 bc	2.77±0.01 cd	62.08±0.73 d	15.20±0.23 c
	LC	61.95±0.11 cd	2.88±0.04 bc	69.46±0.45 b	15.73±0.07 b
Peter Pears	SC	67.52±1.05 b	2.58±0.02 ef	58.99±0.40 e	13.80±0.20 d
	MC	65.52±0.40 b	2.66±0.07 de	65.96±0.97 c	15.80±0.12 b
	LC	59.83±0.90 d	3.01±0.07 b	72.07±0.47 a	16.80±0.12 a

† SC: Small corms (dia. 2.2-2.4 cm); MC: Medium corms (dia. 2.7-3.0 cm); LC: Large corms (dia-3.2-3.5 cm)

* For each parameter, the values sharing the same letter(s) are not significantly different at 5% level by DMRT.

size in all the three varieties of gladiolus, whereas the parameters not affected by corm size were: sprouting of the corms, number of leaves plant^{-1} and number of days to flowering (data not reported).

The plants grew significantly taller in each variety when planted with small sized corms as compared to large sized corms. Highest plant height was observed in variety Traderhorn (72.57±2.12 cm) as compared to White Friendship and Peter Pears which exhibited statistically similar plant height from small as well as medium sized corms. A reverse trend was, however, observed in all the three varieties for the other parameters viz. leaf breadth, length of flowering spike and number of florets spike^{-1}. In each case, significantly highest values were noted when planted through large sized corms, and lowest values were obtained for each parameter when planting material consisted of small sized corms (Table 1). Comparison among the varieties revealed that variety Peter Pears yielded maximum number of florets (16.8±0.12) and length of flowering spike (72.07±0.47cm), whereas, Traderhorn yielded maximum leaf breadth (3.23± 0.09 cm) followed by Peter Pears (3.01± 0.07 cm).

Corm and cormel production

With the exception of single corm weight, the corm and cormel production was highly dependent upon the corm size used for planting and the variety planted (Table 2). The data for single corm weight showed that the differences between variety means were non-significant at 5% level and that it was unaffected by the corm size also. However, the interaction between variety and corm was highly significant. Highest mean weight of single corm was noted in variety Traderhorn (63.96 g) which also produced overall highest single corm weight (72.87±0.60 g) when planted through large corms. In case of the two other varieties, highest weight of single corm was obtained either from medium sized corms (65.53±4.50 g, White Friendship) or from small sized corms (64.62±0.92 g, Peter pears).

The data in Table 2 further showed that the effect of varieties as well corm size was highly significant regarding total corm weight plant^{-1}, cormel weight plant^{-1}, and collective total weight of corms and cormels plant^{-1}. Besides, the interactions between varieties and corm size were also significant at 5% level. Large sized corms produced best results in each variety for all the three parameters. The varieties Peter Pears and White Friendship gave highest and statistically similar weight of total corms plant^{-1} (92.87±1.86 g, 92.74±0.91 g), weight of cormels plant^{-1} (22.37±1.12, 22.80±0.58) and collective total weight of corms and cormels plant^{-1} (115.23±1.47, 115.5±1.47 g) in response to large sized corms. Significant reduction was observed in all the three varieties of gladiolus in response to small and medium sized corms (Table 2).

The data regarding number and size of corms and cormels (Table 3) exhibited highly significant effect of corm size, varieties and their interaction. In case of corms plant^{-1}, significantly highest number (1.83 corms plant^{-1}) was obtained in White Friendship and Peter Pears in response to large sized corms, while there was no effect of corm size in variety Traderhorn. As for the number of cormels plant^{-1}, large sized corms produced significantly more number of cormels palnt^{-1} in each variety as compared to medium or small sized corms. Peter Pears produced the highest number of cormels plant^{-1} (66.90±2.11) followed by medium sized corms (56.33±0.58) in the same variety with significant difference. The treatment response was distinctly different in case of corm diameter wherein variety Traderhorn outperformed the two other varieties in two ways: (a) this was the only variety to produce jumbo sized corms (5.95±0.09 and 5.24±0.07 cm) in response to large and medium sized corms, respectively and (b) the response to each corm size

Table 2. Influence of corm size on weight of corm and cormels in differnet varieties of gladiolus

Variety	Corm size†	Weight of single corm (g)	Total corm weight (g plant^{-1})	Cormel weight (g plant^{-1})	Corm + cormel weight (g plant^{-1})
Traderhorn	SC	57.23±2.33 bc	57.23±2.33 d	5.91±1.23 e	63.14±3.20 e
	MC	61.78±5.44 bc	65.36±1.52 c	11.13±1.38 d	76.50±2.25 d
	LC	72.87±0.60 a	75.11±1.30 b	15.61±0.56 c	90.71±1.33 bc
White Friendship	SC	59.86±2.12 bc	64.74±1.67 c	9.57±0.73 d	74.31±1.77 d
	MC	65.53±4.50 ab	73.47±1.05 b	14.41±1.60 c	87.88±2.59 c
	LC	58.37±1.94 bc	92.74±0.91 a	22.80±0.58 a	115.40±1.47 a
Peter Pears	SC	64.62±0.92 abc	64.62±0.92 c	8.55±0.54 de	73.17±1.28 d
	MC	56.70±3.36 bc	76.52±1.80 b	19.09±1.14 b	95.61±2.51 b
	LC	55.19±1.53 c	92.87±1.86 a	22.37±1.12 a	115.23±1.47 a

† SC: Small corms (dia. 2.2-2.4 cm); MC: Medium corms (dia. 2.7-3.0 cm); LC: Large corms (dia-3.2-3.5 cm)

* For each parameter, the values sharing the same letter(s) are not significantly different at 5% level by DMRT.

produced significant differences in corm diameter (Table 3). Contrary to this, there was no effect of corm size in variety Peter Pears and that all the treatments in White Friendship and Peter Pears produced large size corms of number one grade, ranging from dia. corms of No. 6 were obtained from medium and large sized corms in Peter Pears and White Friendship (Table 4). Peter Pears produced highest number of small sized corms (66.90) of grade No. 6.

Table 3. Diameter and number of corms and cormels as affected by corm size in different varieties of gladiolus

Variety	Corm size†	Corms plant^{-1}	Cormels plant^{-1}	Corm diameter (cm)	Cormel diameter (cm)
Traderhorn	SC	1.00±0.00 c	17.63±1.13 f	4.69±0.23 cd	0.42±0.05 c
	MC	1.07±0.03 c	24.83±0.90 e	5.24±0.07 b	0.54±0.02 c
	LC	1.10±0.06 c	31.57±1.69 d	5.95±0.09 a	0.77±0.04 b
White Friendship	SC	1.17±0.03 c	32.40±3.15 d	3.91±0.16 e	0.72±0.08 b
	MC	1.23±0.15 c	43.70±1.84 c	4.92±0.33 bcd	1.06±0.05 a
	LC	1.83±0.09 a	49.00±1.85 c	4.40±0.10 d	1.05±0.08 a
Peter Pears	SC	1.00±0.00 c	35.20±2.90 d	4.89±0.06 bcd	0.84±0.04 b
	MC	1.53±0.07 b	56.33±0.58 b	4.95±0.18 bc	1.02±0.01 a
	LC	1.83±0.03 a	66.90±2.11 a	4.90±0.08 bcd	1.09±0.10 a

† SC: Small corms (dia. 2.2-2.4 cm); MC: Medium corms (dia. 2.7-3.0 cm); LC: Large corms (dia-3.2-3.5 cm)
* For each parameter, the values sharing the same letter(s) are not significantly different at 5% level by DMRT.

Table 4. Grading of obtained corms and cormels plant^{-1} on the basis of diameter according to the North American Gladiolus Council (Wilfret, 1980)

Variety	Traderhorn			White Friendship			Peter Pears		
Corm size†	SC	MC	LC	SC	MC	LC	SC	MC	LC
Large sized corms Jumbo (> 5.1cm)	-	1.07	1.1	-	-	-	-	-	-
No.1(> 3.8 to ≤ 5.1cm)	1.0	-	-	1.17	1.23	1.83	1.0	1.53	1.83
Medium sized corms No.2(>3.2 to ≤ 3.8 cm)	-	-	-	-	-	-	-	-	-
No.3(> 2.5 to ≤ 3.2 cm)	-	-	-	-	-	-	-	-	-
Small sized corm No.4 (> 1.9 to ≤ 2.5 cm)	-	-	-	-	-	-	-	-	-
No.5 (> 1.3 to ≤ 1.9 cm)	-	-	-	-	-	-	-	-	-
No.6(> 1.0 to ≤ 1.3 cm)	-	-	-	-	43.7	49	-	56.33	66.90
Total No. corms plant^{-1}	1.0	1.07	1.1	1.17	44.93	50.83	1.0	57.86	68.73

† SC: Small corms (dia. 2.2-2.4 cm); MC: Medium corms (dia. 2.7-3.0 cm); LC: Large corms (dia-3.2-3.5 cm)

3.91 to 4.95 cm. Significant differences were observed for cormel diameter which ranged from 0.42 to 1.09 cm. Medium and large sized corms obtained cormel diameter of more than 1 cm only in White Friendship and Peter Pears. Significant reduction occurred in response to small sized corms in each variety (Table 3).

To determine the actual number of corms plant^{-1}, all obtained corms and cormels were graded on the basis of corm and cormel diameter according to the North American Gladiolus Council (Wilfret, 1980). On the basis of this categorization, most of the small sized

DISCUSSION

Corm size can have a wide ranging influence on vegetative and floral parameters as well as on the corm and cormel production (Bhattacharjee, 1981; Dod *et al*., 1989; Mohanty *et al*., 1994; Singh, 2000; Farid Uddin *et al.*, 2002). Differential plant response to corm size is primarily related to the size of storage tissue which subsequently influences corm sprouting, plant vigour and plant growth (Mckay *et al*., 1981; Singh et al., 2002). In this study, sprouting of the corms was not influenced by corm size and similar results were reported by Mohanty *et al*. (1994). Besides, the plants produced from large sized corms were significantly shorter than small and medium sized corms with more leaf breadth. Singh (2000) also observed greater plant height from corm size >5.10 to <6.00 cm as compared to those from the largest size grade (>6.0 to <6.50 cm dia.). These findings are contrary to the results of Mohanty *et al*. (1994) who reported taller plants from large sized corms (dia. 2.45–2.55 cm) with more number of leaves and longer leaf blade as compared to medium (dia. 1.25-1.30 cm) and small (dia. 0.50-0.53 cm) Similar results were also observed by Farid Uddin *et al.* (2002).

There was direct relationship between corm size and the floral parameters. Thus the number of florets and length of flowering spike were greatly reduced by small sized corms as compared to large and medium sized corms. This might be based on the size storage tissue of the corm. Both these floral parameters were also directly related with leaf area which was greatly reduced by small sized corms due to production of narrow leaves. These results are in accordance with those obtained by Farid Uddin *et al*. (2002). They reported highest number of florets spike^{-1} (11.94) and maximum length of flowering spike (66.0 cm) from large corms as compared to medium and small corms. Similar results were also reported by Bhattacharjee (1981) and Dod *et al.* (1989). Mckay *et al*. (1981) also reported that planting of whole large corms produced larger and better quality blooms as compared to small ones.

The response to size was also evident from the total corm weight plant^{-1} and combined weight of corms and cormels which were significantly increased by large sized corms in each variety. Similar results have been reported by Misra *et al*. (1985). They used 9 different corm sizes from jumbo to 0.6 cm in diameter and reported that number and weight of corms and cormels increased with the increase in corm size. The varieties used in this study, however, differed in the weight of single corms produced, being the lowest from large sized corms in two varieties of White Friendship and Peter Pears. This was possibly due to internal compensation resulting due to production of more daughter corms plant^{-1} in these two varieties as compared to the variety Traderhorn.

The growers use medium sized corms for commercial cultivation of gladiolus as large sized corms add to the cost of cultivation. However, cost of cultivation can be reduced by using large sized corms which produce standard size daughter corms and quality flower spike (Misra *et al.*, 1985). Spikes and corms that meet quality standards get economically more rates as compared to low quality material. In this study, increased number of small sized corms plant^{-1} were also produced from large sized corms in variety Peter Pears and White Friendship, when categorized on the basis of their diameter according to the North American Gladiolus Council (Wilfret, 1980). These results are in accordance with the results of Mukhopadhyay and Yadav (1984). They reported more corm and cormel from large size corms (4.6-5.0 cm in diameter) than other corm sizes.

The North American Gladiolus Council has suggested three categories of corms on the basis of their diameter viz., large, medium and small. Jumbo (> 5.1 cm) and No. 1 (> 3.8 to ≤ 5.1 cm) category comes under large sized corms, where as No. 2 (>3.2 to ≤ 3.8 cm) and No. 3 (> 2.5 to ≤ 3.2 cm) lie under medium category. Small sized corms include No. 4 (> 1.9 to ≤ 2.5 cm), No.5 (> 1.3 to ≤ 1.9 cm) and No. 6 (> 1.0 to ≤ 1.3 cm) (Wilfret, 1980). In this sense, jumbo sized corms were only produced by Traderhorn in response to large and medium sized corms, whereas, all treatments in rest of the varieties produced large sized corms of grade No. 1. This reduction in corm diameter of the two varieties (White friendship and Peter pears) was just because of production of more than one corms plant^{-1}. However it is not necessary that corms of same diameter produce same weight form all corms. Both diameter and weight of any corm size count for the sound vegetative growth, healthy florets and standard corm and cormel production in gladiolus. According to the North American Gladiolus Council, cormels of more than 1 cm lie under small sized corm category. In the present field experiment, medium and large sized corms produced more small sized corms of grade No. 6 in White Friendship and Peter Pears and in this way we got more number of corms plant^{-1} in both the varieties of gladiolus. Medium sized corms greatly reduced the number of small sized corms of Grade No. 6 as compared to large sized corms.

CONCLUSION

This study was successful for corm and cormel production from large sized corms to rapidly propagate new planting material. Commercial producers may be able to use large sized corms for producing both marketable flower spikes as well as corm and cormel production. Whereas, for home use medium sized corms produce satisfactory bloom. Small sized corms, though most will bloom, produce smaller spikes and less number of corms and cormels plant^{-1}.

ACKNOWLEDGEMENTS

We are thankful to Higher Education Commission of Pakistan for financial support for the project.

REFERENCES

Ahmad, T., M.S. Ahmad, I.A. Nasir and S. Riazuddin. 2000. *In vitro* production of cormels in gladiolus. Pak. J. Biol. Sci. 3(5): 819-821.

Bhattacharjee, S.K. 1981. Flowering and corm production of gladiolus as influenced by corm size, planting depth and spacing. Singapore J. Prim. Ind. 9: 18-22.

Bose, T.K., L.P. Yadav, P. Pal, P. Das and V.A. Parthasarathy. 2003. Commercial flowers. Vol. II (2nd Rev. ed.). NAYA UDYOG, Bidhan Sarani, Kolkata.

Dod, V.N., K.T. Sadawartr, L.V. Kulwal and S.W. Vaidya. 1989. Effects of different dates of planting and size of corm on growth and flower yield of gladiolus. P.K.V. Res. J. 13: 164-165.

Farid Uddin, M., M.M. Rahman, M.G. Rabbani and M.A. Mannan. 2002. Effect of corm size and depth of planting on the growth and flowering of gladiolus. Pak. J. Biol. Sci. 5(5): 553–555.

Gonzalez, A., S. Banon, J.A. Fernandez, J.A. Franco, J.L. Casas and J. Ochoa. 1998. Flowering responses of G*ladiolus tristis* (L.) after exposing corms to cold treatment. Scientia Horti. 74(4): 279-284.

Halder, N.K., R. Ahmed, S.M. Sharifuzzaman, K.A. Bagam and M.A. Siddiky. 2007. Effect of boron and zinc fertilization on corm and cormel production of gladiolus in grey terrace soils of Bangladesh. Int. J. Sustain Crop Prod. 2(5): 85-89.

Hartman, H.T., D.E. Kester and F.T. Davis. 1990. Plant propagation: Principles and practices. 5th ed. Prentice-Hall, International Inc. Englewood Cliffs, New Jersey. pp.443-445.

Hosoki, T. 1984. Effect of dormancy-breaking treatments on respiration of gladiolus corms. Bull Fac. Agric. Shimane Univ. 18: 16-20.

Kalasareddi, P., B. Reddy, S. Patil, Y.Y. Ryagi and P. Gangadharappa. 1998. Effect of corm size on growth and spike yield of gladiolus cv. Snow white. Karnataka. J. Agric. Sci. 4(11): 1133-1135.

Magie, R.O. 1975. Gladiolus corm curing and storage environments in relation to flower production. Acta Hort. (ISHS) 47: 267-276.

McKay, M.E., D.E. Byth and J. Tommerup. 1981. The effect of corm size and division of the mother corm in gladioli. Australian J. Exp. Agric. Anim. Husb. 21(110): 343-348.

Misra, R.L. 1994. Effect of leaf and spike clippings on corm and cormel yield of gladiolus. *In*: J. Prakash, K.R. Bhandary (Eds.). Floriculture-Technology, trades and trends. Oxford & IBH Pub. Co. Pvt. Ltd. India, pp.55-58.

Misra, R.L., T.S. Verma, R. Kumar, A. Singh and B. Singh. 1985. Effect of different grade sizes of planting materials on flowering and multiplication of gladiolus var. White Oak. Indian J. Hort. 42**:** 290–295.

Mohanty, C.R., R.C. Das and T. Maharana. 1994. Effect of corm size and growth regulators on growth, flowering and corm production in gladiolus (*Gladiolus grandiflorus* L.). In: J. Prakash and K.R. Bhandary (Eds.). Floriculture-Technology, trades and trends. Oxford & IBH Pub. Co. Pvt. Ltd., India. 209–211.

Mukhopadhyay, T.K. and L.P. Yadav. 1984. Effect of corm size and spacing on growth, flowering and production of gladiolus. Haryana J. Horti. Sci. 13:95–99.

Nagaraju, V., G. Bhowmik and V.A. Parthasarathy. 2002. Effect of paclobutrazol and sucrose on *in vitro* cormel formation in gladiolus. Acta Bot. Croat. 61(1): 27-33.

Ogale, V.K., V.A. Rode and S.D. Mishra. 1995. Role of corm sizes in gladiolus flowering and final (corm) yield. Ind. J. Pl. Physiol. 38: 241-243.

Olsen S., C. Cole, F. Watanabe and L. Dean. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular No. 939, US Gov. Print. Office, Washington, D.C.

Pant, S.S. 2005. Effect of different doses of nitrogen and phosphorus on the corm and cormel development of gladiolus (Gladiolus sp.) cv. American beauty. J. Inst. Agric. Anim. Sci. 26: 153-157.

Remotti, P.C. and H.J.M. Loffler. 1995. Callus induction and plant regeneration from gladiolus. Plant Cell, Tissue and Org. Cult. 42(2): 171-178.

Sen, J. and S. Sen. 1995. Two step bud culture technique for a high regeneration of gladiolus corm. Scientia Hort. 64: 133-138.

Singh, A.P. and S.R. Dohare. 1994. Maximization of corm and cormel production in gladiolus. In: J. Prakash and K.R. Bhandary (Eds.). Floriculture-Technology, trades and trends. Oxford & IBH Pub. Co. Pvt. Ltd., India, 205–208.

Singh, K.P. 2000. Growth, flowering and multiplication in gladiolus cultivar “Aarti” as affected by grades of mother corm and cormel. J. Appl. Horti. 2(2): 127-129.

Singh, M.K., A.S. Parmar and S.V.S. Rathore. 2002. Corm production in gladiolus as affected by size of cormels and GA_3 application. Proc. National Symp. India Floriculture in the New Millennium, Bangalore.

Sinha, P. and S.K. Roy. 2002. Plant regeneration through *In vitro* cormel formation from callus culture of *Gladiolus primulinus* Baker. Plant Tissue Cult. 12(2): 139-145.

Sloan, R.C. and S.S. Harkness. 2005. Gladiolus cultivar evaluation. Ann. Rep. North Mississippi Res. Ext. Cent., Mississippi Agric. Fores. Exp. St. Inf. Bul. 419: 306-308.

Steel, R.G.D., J.H. Torri and D.A. Dicky 1997. Principles and procedures of statistics. A biometric approach. 3rd ed. McGraw Hill Book Co. Inc., New York, USA.

Tsukamoto, Y. 1974. Breaking dormancy of gladiolus corms and inhibitors inducing dormancy. Acta Hort. (ISHS) 43: 393-404.

Wilfret, G.J. 1980. Gladiolus. In: R.A. Larson (Ed.). Introduction to Floriculture. Academic Press Inc., New York, USA, pp.166-181.

Zhao, J., Y. Zhao and Y. Wen. 2008. Development and countermeasures of flower industry in Yunnan, China. Ecol. Econ. 4: 151-160.

Zalewska, M. and M. Antkowiak. 2009. Effect of corm storage temperature on the growth and flowering of gladiolus L. in the glasshouse. Elec. J. Polish Agric. Univ. 12(1): 03.

Ziv, M. and H. Lilien-Kipnis. 1990. Gladiolus. In: P.A. Ammirato, D.A. Evans, W.R. Shark and Y.P.S. Bajaj (Eds). Handbook of Plant Cell Culture, Vol. 5, McGraw Hill Publishing Co., New York, pp. 461-478.

Zubair, M., F.K. Wazir, S. Akhtar and G. Ayub. 2006. Planting dates affect floral characteristics of gladiolus under the soil and climatic conditions of Peshawar. Pak. J. Biol. Sci. 9(9): 1669-1676.