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GENOTYPE × ENVIRONMENT INTERACTION OF CORM AND CORMEL PRODUCTION IN GLADIOLUS

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ABSTRACT
Twelve gladiolus genotypes were planted on five different dates from 10th October to 10th December, 2011 at fortnightly interval and traits for corm and cormel production were evaluated. The number of corms and cormels per plant were maximum under 10th October planting (1.75 and 24.37 respectively) and in cv. Punjab Lemon Delight (2.01) and Punjab Glance (41.52) respectively. The result of G x E interaction shows that the number of corms and cormels per plant in twelve genotypes under five different environments ranges from 1.00 to 2.66 and 1.66 to 75.00 respectively. The maximum corm weight and corm size was in cv. Rose Supreme (102.70 g and 5.66 cm respectively) and under 10th October planting (76.07g and 4.39cm respectively). The G x E interactions shows that the corm weight per plant and corm size ranges from 10.83 to 106.86g and 2.70 to 6.51cm respectively. It concluded that the best planting time with respect to corm and cormel production was 10th October while 10th December was least favourable.

INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.), a member of family Iridaceae is one of the important bulbous ornamental which occupies important position among cut flowers in domestic as well as international market. It is universally acclaimed prestigious cut flower (Ram *et al.*, 2005). Gladiolus bulbs, in botanical terminology, are referred to as corms, the main propagating material in gladiolus. A corm is a shortened and thickened section of the stem that appears at the base of the plant (Bhujbal *et al.*, 2014). The corm formation starts with the initiation of the spike and completes when the spikes attain full bloom. Bhujbal *et al.*, 2014 reported that use of growth regulators combined with cold storage temperature was effective in the breaking of corm dormancy. After flowering, when the photosynthates are directed downwards, the corm and cormels continue to increase in size (Hartmann *et al.*, 1981).

Date of planting plays an important role in improving the vegetative growth, quality and bulb production of gladiolus (Khan *et al.*, 2008) which also satisfies the consumer's demands (Zubair *et al.*, 2006). Talia and Traversa (1986) mentioned that better size gladiolus corms were obtained from February and March plantings. Suh and Kwack (1990) reported that the formation of good quality corms was promoted with early planting dates.

Phenotype in addition to the inherent make up is greatly influenced by environmental conditions as well as interaction between genotype and environment. The ability to produce corms and cormels per plant determines its rate of multiplication and these characters would be very effective in breeding programme. There is a dearth of good varieties of gladiolus which are good multiplier with respect to corm and cormel production under varying environments. The present research work was planned to investigate the best planting time and genotype of gladiolus for corms and cormel production under agro ecological conditions of Ludhiana, Punjab.

MATERIALS AND METHODS

The experimental material used for the study consisted of twelve gladiolus genotypes *viz.* Punjab Flame, Punjab Pink Elegance, Punjab Glance, Punjab Lemon Delight, Sylvia, Suchitra, CPG, Jacksonville Gold, Red Advance, Red Beauty, Fidelio and Rose Supreme planted under five different planting times *i.e.* 10th October, 25th October, 10th November, 25th November and 10th December, 2011 in the experiment farm area of Floriculture and Landscaping Department, Punjab Agricultural University, Ludhiana, during 2011-2012. The corms were planted as per Randomized Block Design (RBD) with three replications at spacing of 30x20 cm with plot size of 2.4 m^2 and recommended cultural practices were followed to raise the crop. For corm and cormel analysis, the twelve genotypes were evaluated for 4 traits *viz.* number of corms per plant, number of cormels per plants, corm size, and weight of corm per plant under five different planting dates and data was pooled. The pooled data was analyzed statistically by ANOVA test (Steel *et al.*, 1997) and critical differences were worked out at five percent level to draw statistical conclusion which indicated the significant differences existed among genotypes for all character under different environments and the genotype x environment interaction was significant for all the characters.

Number of corms/plant

Number of corms plant was counted

Number of cormels/plant

Number of cormels per plant was counted

Size of corms (cm)

Size of corms was taken with measuring scale

Corm weight (g) per plant

Total weight of all corms from one plant was weighed

RESULTS AND DISCUSSION

Number of corms per plant

It is quite evident from the data presented in Table 1 that the number of corms per plant was significantly altered by genotypes, environments and genotype x environment interactions.

The results indicates that the maximum number of corms per plant under first planting was produced by cv. CPG (2.60) which is at par with cv. Punjab Glance (2.33).Under second and third plantings the maximum corms per plant were recorded in cv. Punjab Lemon Delight (2.26 and 2.66 respectively). Cultivar Rose Supreme produced maximum corms per plant under fourth and fifth planting (2.06 and 1.90 respectively). Under first planting minimum number of corms per plant was observed in cultivars Punjab Flame and Red Advance (1.20).

The number of corms per plant ranges from 1.08 to 2.01 in twelve genotypes under study. The highest was recorded in cv. Punjab Lemon Delight (2.01) which is at par with cv. Rose Supreme (1.99). Cultivar Red Advance produces lowest number of corms (1.08).

The number of corms produced in five different environment ranges from 1.44 to 1.74. The maximum number of corms per plant was produced under first planting (1.75) followed by third and fourth planting (1.54). Under fifth planting the minimum corms were produced (1.44).

The number of corms per plant ranges from 1.00 to 2.66 in twelve genotypes in five different environments. The highest number of corms was reported in cv. Punjab Lemon Delight (2.66) under third planting followed by cv. CPG (2.60) under first planting. Cultivar Red Advance produces lowest number of corms (1.00) under third and fifth planting.

In the present study, the number of corms per plant was found to be significant; maximum number of corms were produced by cv. Punjab Lemon Delight followed by Rose Supreme. While analyzing the effect of planting time on corm production it was observed that corm production was not affected due to varied temperature till mid-November, but drastic reduction was noticed in December planting. Therefore this might be due to the poor establishment resulting in poor plant growth, smaller spikes which results in minimum corm number in all varieties. This result is synergistic with the findings Saini *et al.*, 1988 as they also reported highest yield of corm under early planting of 10th November and minimum under late planting of 10th December.

Number of cormels per plant

The number of cormels produced per plant by various genotypes under different environments is presented in Table 2. There was significant variation due to genotypes, environment and genotype x environment interactions.

The results indicates that the maximum number of cormels produced per plant under 0ctober to November planting was recorded in cv. Punjab Glance ranging from 29.13 to 75.00 which is considered as best for cormel production. Cultivar Rose Supreme produces highest number of cormels under fifth planting (10.33) which is at par with cv. Punjab Glance (9.70). The minimum number of cormels per plant was produced in cv. Suchitra under first, second and third planting. Cultivars Punjab Pink Elegance (3.50) and Punjab Flame (1.66) produced lowest number of cormels under fourth and fifth planting.

The number of cormels per plant showed a large variation with its values ranging from 5.19 to 41.52 in twelve genotypes. The highest number produced in cv. Punjab Glance (41.52) which differs significantly from cv. Punjab Lemon Delight (20.15). Cultivar Suchitra produces the lowest number of cormels (5.19) which differs significantly from cv. Jackson Ville Gold (8.81).

The number of cormels per plant ranges from 6.28 to 24.37 in

Table 1: Effect of genotypes and environment on number of corms per plant

Genotypes	Environment					
	10 Oct	25 Oct	10 Nov	25 Nov	10 Dec	Mean
CPG	2.60	1.93	1.60	1.66	1.80	1.92
Fidelio	1.66	1.73	1.33	1.50	1.83	1.61
Punjab Lemon Delight	1.96	2.26	2.66	1.66	1.83	2.01
Punjab Flame	1.20	1.33	1.73	1.66	1.19	1.42
Red Beauty	1.40	1.20	1.13	1.19	1.41	1.26
Punjab Pink Elegance	1.80	1.26	1.33	1.33	1.00	1.34
Sylvia	1.60	1.26	1.26	1.26	1.13	1.30
Punjab Glance	2.33	1.33	1.60	1.86	1.19	1.66
Red Advance	1.20	1.06	1.00	1.13	1.00	1.08
Jacksonville Gold	1.40	1.26	1.33	1.33	1.40	1.34
Rose Supreme	1.94	1.80	2.26	2.06	1.90	1.99
Suchitra	1.98	1.62	1.33	1.93	1.66	1.70
Mean	1.75	1.50	1.54	1.54	1.44	-

C.D. (P = 0.05); Genotype = 0.11; Environment = 0.17; G x E Interaction = 0.39

Table 2: Effect of genotypes and environment on number of cormels per plant

Genotypes	Environment					
	10 Oct	25 Oct	10 Nov	25 Nov	10 Dec	Mean
CPG	12.93	17.00	17.33	13.46	9.06	13.96
Fidelio	25.60	9.13	26.80	4.66	5.33	14.30
Punjab Lemon Delight	56.46	13.93	19.86	6.66	3.83	20.15
Punjab Flame	20.40	9.59	16.73	4.33	1.66	10.54
Red Beauty	12.13	21.40	25.20	9.47	7.69	15.17
Punjab Pink Elegance	26.60	10.66	15.26	3.50	4.33	12.07
Sylvia	13.30	12.40	9.53	9.86	8.00	10.62
Punjab Glance	75.00	37.03	56.73	29.13	9.70	41.52
Red Advance	25.93	13.23	18.86	7.40	4.93	14.07
Jacksonville Gold	7.06	15.93	7.53	8.21	5.33	8.81
Rose Supreme	12.83	10.86	15.43	13.46	10.33	12.58
Suchitra	4.27	4.03	6.83	5.63	5.20	5.19
Mean	24.37	14.59	19.67	9.64	6.28	_

C.D. (P = 0.05); Genotype = 0.95; Environment = 0.61; G x E Interaction = 2.12

Table 3: Effect of genotypes and environment on corm weight (g) per plant

Genotypes	Environment					
	10 Oct	25 Oct	10 Nov	25 Nov	10 Dec	Mean
CPG	80.06	49.40	28.33	25.13	20.13	40.61
Fidelio	103.73	67.73	38.40	32.50	28.66	54.20
Punjab Lemon Delight	68.13	41.33	31.46	22.33	18.66	36.38
Punjab Flame	36.40	23.60	26.66	13.33	10.83	22.16
Red Beauty	66.26	55.13	39.00	35.30	27.53	44.64
Punjab Pink Elegance	73.86	31.40	30.00	17.33	13.66	33.25
Sylvia	59.40	37.40	29.60	22.06	15.80	32.85
Punjab Glance	100.00	53.93	36.60	47.10	23.63	52.25
Red Advance	52.00	39.93	32.86	27.66	20.86	34.66
Jacksonville Gold	60.86	46.46	29.26	31.13	30.20	39.58
Rose Supreme	106.86	101.00	105.66	102.00	98.00	102.70
Suchitra	105.33	89.00	72.00	68.30	62.30	79.38
Mean	76.07	53.02	41.65	37.01	30.85	_

C.D. (P = 0.05); Genotype = 4.70; Environment = 3.03; G x E Interaction = 10.51

five different environments. The maximum was observed under first planting (24.37) which is significantly more than third planting (19.67). The minimum numbers of cormels were produced under fifth planting (6.28). The number of cormels produced per plant in twelve genotypes under five environments ranges from 1.66 to 75.00. The maximum number was recorded in cv. Punjab Glance under first planting followed by third planting (75.00 and 56.73 respectively). Cultivar Punjab Flame (1.66) under fifth planting produces the minimum number of cormels.

Adil *et al.*, 2013 reported positive correlation between temperature at time of planting and number of cormels recorded. The temperature was higher during October planting (32.1ºC) than December planting (21.6C) which favored cormel production in October. This could be supported with finding of Ahmad *et al.*, 2011 as they reported maximum number of cormels production under 4th April planting and minimum under 20th March planting because gladiolus requires slightly high temperature for cormels production and Sharma and Talukdar., 2003 reported minimum number of cormels per corm under late planting of December. This result is synergistic with that of Laskar and Jana (1994) who reported that the corms productions were best with planting on 19th March as compare to 7th and 27th February.

Size of corms

The statistical data presented in Table 4 indicates that size of corms is significantly affected by genotypes, environment and genotype environment interaction.

The results show that the maximum size of corm was recorded in cv. Rose Supreme and it was 6.51 cm in second planting. The minimum size of corm was observed in cv. Punjab Flame ranging from 2.70 to 3.59 cm. Cultivar Punjab Lemon Delight produces minimum corm size under third planting (3.00 cm). The minimum size was in cv. Punjab Pink Elegance (2.85 cm) under fourth planting.

The size of corms in twelve genotypes ranges from 3.16 to 5.66 cm. The significant differences were recorded among the genotypes for the corm size in terms of diameter. Cultivar Rose Supreme produces the maximum corms size (5.66 cm) which differs significantly from Red Beauty (4.58 cm). The least size was observed in cv. Punjab Flame (3.16 cm) which was at par with cv. CPG (3.34 cm). Roy and Sharma., 2000 also reported maximum corm diameter in cv. Rose Supreme.

The size of corms in five environment ranges from 3.59 to 4.39. The biggest corms were produced under first planting (4.39 cm) which is at par with second planting (4.35 cm). The

Table 4: Effect of genotypes and environment on size of corms (cm)

Genotypes	Environment					
	10 Oct	25 Oct	10 Nov	25 Nov	10 Dec	Mean
CPG	3.61	3.83	3.30	3.11	2.87	3.34
Fidelio	4.64	4.59	4.30	3.87	3.38	4.16
Punjab Lemon Delight	4.15	3.40	3.00	3.50	3.25	3.46
Punjab Flame	3.50	3.29	3.19	3.12	2.70	3.16
Red Beauty	4.55	5.26	4.79	4.36	4.00	4.59
Punjab Pink Elegance	4.18	3.73	3.65	2.85	3.33	3.55
Sylvia	4.12	3.95	3.81	3.42	3.07	3.67
Punjab Glance	4.45	4.66	3.93	4.16	4.05	4.25
Red Advance	4.58	4.44	4.32	4.00	3.78	4.22
Jacksonville Gold	4.38	4.42	4.03	3.57	3.87	4.05
Rose Supreme	6.16	6.51	5.90	4.80	4.93	5.66
Suchitra	4.40	4.13	4.07	3.77	3.90	4.05
Mean	4.39	4.35	4.02	3.71	3.59	_

C.D. (P = 0.05); Genotype = 0.21; Environment = 0.13; G x E Interaction = 0.47

minimum corm size was recorded under fifth planting (3.59 cm).

The size of corm ranges from 2.70 to 6.51 cm in twelve genotypes under different environments. The maximum corm size was recorded in cv. Rose Supreme in second planting followed by first and third planting (6.51, 6.16 and 5.90 cm respectively). Cultivar Punjab Flame under December planting produces the smallest corms (2.70 cm) followed by cv. Punjab Pink Elegance (2.85 cm) under fourth planting. The corm size was reported maximum under 10th October planting followed by 25th October planting.

The delay in planting time from October to December resulted in decreased size of corm due to reduced performance and availability of photosynthates. These results justify the reports of Ahmad *et al.*, 2011 who reported the maximum diameter of corms under 18th February planting (3.19 cm) because at that time the plants had best performance due to which they produced more photosynthates which caused big sized corms. Zubair *et al.*, 2006 and also suggested that a delay in planting time resulted in the decreased diameter of both daughter corms and cormels. Sharma and Talukdar., 2003 also reported minimum corm size under December planting.

Weight of corms per plant

Corm weight is an important yield associated trait in gladiolus. The statistical analysis of data presented in Table 3, reveals that the genotypes exhibited ample diversity for corm weight. The effect of genotype, environment and genotype environment interaction was significant for weight of corms per plant.

The result indicates that the maximum weight of corms per plant was observed in cv. Rose Supreme in all planting dates ranging from 98.00 to106.86 g. Cultivar Punjab Flame produces the minimum corm weight per plant under all plantings ranging from 10.83 to 36.40g.

The weight of corm per plant ranges from 22.16 to 102.70 g of twelve genotypes under study. The maximum was in cv. Rose Supreme (102.70g) which differs significantly from cv. Suchitra (79.38g). Cultivar Punjab Flame produces the minimum corm weight per plant (22.16g).

The weight of corms per plant in five different environment ranges from 30.85 to 76.07 g and was reduced as planting time was delayed. The maximum was in first planting (76.07 g) which is significantly higher than second planting (53.02 g). The minimum weight was under fifth planting (30.85 g). Sharma and Talukdar., 2003 also reported maximum weight of corm under early planting of October- November and under late planting of December.

The weight of corms per plant ranges from 10.83 to 106.86 g in twelve genotypes under five different environment. The maximum weight was recorded in cv. Rose Supreme under first planting (106.86 g) followed by third planting (105.66 g). Cultivar Punjab Flame under fifth planting (10.83 g) followed by fourth planting (13.33 g) produces the minimum corm weight per plant.

Adil *et al.*, 2013 reported that the positive correlation occurs between temperature at the time of planting and corm weight. These result supports our finding as maximum corm weight was recorded during October planting when maximum temperature of 32.1ºC prevailed; while minimum corm weight was during December planting when temperature was 21.6º C prevailed.

The corm size and corm weight are interrelated parameters and are significantly affected by the growing environment in terms of temperature. Significant reduction in corm size and weight is attributed to reduced accumulation of photosynthates. These results also justify the findings of Sharma and Talukdar (2003) who justified the availability of more food material stored in big size mother corms presenting better plant growth and corm size. Arora and Sandhu., 1987 reported higher number of corms and cormels per plant and more corm weight produced under early planting (September) than in late planting (November).

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