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Effect of different plant density on vegetative characters, flowering and corm production in *Gladiolus* pp. cv. sancerre

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Abstract
The present investigation was carried out to study the effect of plant density on vegetative characters, flowering and corm production in *Gladiolus* sp. cv. Sancerre at the Experimental Farm of Horticulture Department, CCS HAU, Hisar during 2014-2015. Corms were planted at 30 x 30 cm, 30 x 15 cm, 20 x 20 cm, 20 x 15 cm and 15 x 15 cm spacing. Plant height, number of leaves, length of spike, duration of flowering, number and weight of corms and cormels per plant increased with increase in spacing, however days taken for initiation of spike and for opening of basal floret were significantly decreased with increase in spacing.

Keywords: *Gladiolus*, vegetative characters, corm, plant density

Introduction
Gladiolus is a flower of glamour and perfection, known as the queen of bulbous flowers due to its flower spikes with florets of massive form, brilliant colours, attractive shapes, varying size and excellent shelf life. The name *Gladiolus* is derived from the Latin word 'gladius' or 'gladiator' because of its sword-like leaves. It is popularly known as sword lily. It was introduced into cultivation at the end of the 16th century (Parthasarathy and Nagaraju, 1999) [1]. *Gladiolus* is one among the most popular cut flowers in India. The agro-ecological conditions of the country are very conducive for its survival and culture as a crop. It is mainly cultivated for cut-flowers because of its elegant appearance and prolonged vase life. *Gladiolus* spikes are most popular in flower arrangements and for preparing attractive bouquets (Mishra *et. al.,* 2006) [2]. The magnificent inflorescence with various colors has made it attractive for use in herbaceous borders, beddings, rockeries, pots and for cut-flowers. For good quality production of *Gladiolus* plant, spacing plays an important role in achieving good plant growth, quality spikes and corm and cormel production (Singh, 2000; Bijimol and Singh, 2001) [3, 5, 4]. Plants require proper space to grow and to take other available essentials like water, air and light and they have to get these from the limited space in which they grow. Therefore, they are more vulnerable to deprivation of essentials, if they are not provided enough living space. An interruption in plant spacing even for a short period has a negative effect on yield. Its optimum level provides scope for efficient utilization of solar radiation and nutrients to the plants.

Material and Methods
The present investigation was carried out during 2014-15 at the Experimental farm, Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University, Hisar. Uniform sized corms (3.5 - 4.0 cm) of cultivar Sancerre were used in this experiment. Land was prepared and brought to a fine tilth by repeated ploughing. Weeds and other debris were collected and buried deep in the soil. Ten kg of farm yard manure per square meter was added prior to planting of corms. Beds of size 1.2 x 1.2 m^2 were prepared. Nitrogen, phosphorous and potash were applied at the rate of 30, 20 and 20 g/m^2, respectively. Nitrogen was applied in three split doses as top dressing, the first before planting, second at 6 leaf stage and third at the slipping stage when inflorescence had started emerging out of the leaves. Planting was done at a depth of 5 to 7 cm in flat beds of size 1.2 x1.2 m^2. Before planting the corms were dipped in 0.2% bavistin solution for 30 minutes and air dried under shade. The corms were planted at 30 x 30 cm, 30 x 15 cm, 20 x 20 cm, 20 x 15 cm and 15 x 15 cm spacing laid out in randomized block design (RBD) with three replications. The number of treatments, replications and plots were 5, 3 and 15 respectively. Regular weeding was done to check growth of the weeds. Earthing up was done 30 days after planting to provide sufficient soil volume for the spread of cormels, better aeration and to prevent lodging. Irrigation was given at 15 days interval

throughout the growing period. Irrigation was withheld fifteen days before lifting of corms. Staking was done at the time of spike emergence to prevent breaking and bending of spikes due to their own weight or strong wind. The analysis of variance was done by using RBD at 5% level of significance (P=0.05).

Results and Discussion

Vegetative characters

Data presented in Table 1 shows that plant height and number of leaves per plant increased significantly with the increase in plant spacing. Maximum plant height (22.46 cm, 35.24 cm and 46.36 cm respectively) after 30, 60 and 90 days of planting was observed at wider spacing (30 x 30 cm), while minimum was observed at closer spacing (15 x 15 cm). Maximum number of leaves per plant (7.88) was observed when corms were planted at 30 x 30 cm spacing which was at par with 30 x 15 cm (7.46) and 20 x 20 cm (7.35) and minimum (6.56) at 15 x 15 cm spacing. Plant height depends upon availability of moisture and nutrient from soil and utilization of sunlight which are more at wider spacing giving way for higher synthesis of carbohydrates in the plant resulting into more plant height. The results of present investigation are in confirmation with the findings of Kumar and Yadav (2006) [6], Bhat and Khan (2007) [7, 16], Rohids *et. al* (2010) [8], Sheetal Dogra *et. al* (2012) [9] and Bhande *et. al* (2015) [10]. Their work revealed that wider spacing increased the plant height and number of leaves while closer spacing reduced it.

Floral Parameters

The data presented in Table 2 depicts that the days taken for initiation of spike were significantly reduced by wider spacing. Minimum number of days (90.46 days) for spike initiation was observed in 30 x 30 cm spacing while maximum (95.12 days) in 15 x 15 cm. The early emergence of spike in wider spacing has been reported earlier by Bhat *et. al* (2010) [11] in *Gladiolus*. They reported that, days taken for spike initiation decreases with increase in plant spacing. Similar results were also observed by Sudhakar and Kumar (2012) [12], Kamal Narayan (2013) [13] and Virendra Pal *et. al* (2015) [14]. Early opening of basal floret from the date of planting was reported in wider spacing and it was late in the plants with closer spacing. Minimum days taken for opening of basal floret (127.11 days) was recorded when corms were planted at 30 x 30 cm plant spacing followed by 30 x 15 cm (130.11 days) and 20 x 20 cm (130.88 days) and maximum (133.93 days) at 15 x 15 cm spacing.

The number of spikes per plant and number of florets per spike increased significantly with the increase in plant spacing as compared to closer spacing. Maximum number of spikes (1.51) and florets per spike (13.65) were recorded in 30 x 30 cm spacing followed by 30 x 15 cm (1.32, 13.08 respectively) while minimum (1.00, 11.72 respectively) in 15 x 15 cm spacing. The length of spike also increased significantly with decrease in plant density. At 30 x 30 cm spacing maximum length of spike (54.10 cm) was observed. This might be due to the fact that at wider spacing, plant population per unit area is less and all the plants received the proper amount of sunlight, aeration and nutrition and face less competition for water and minerals as a result the vegetative growth was better which resulted in production of longer spikes with more number of florets. Similar results were obtained by Singh *et. al* (2011) [15] and Sudhakar and Kumar (2012) [12]. They reported that maximum number of florets per spike and length of spike was observed at 30 x 30 cm spacing.

The effect of spacing on diameter of basal floret and duration of flowering was found to be significant. Increase in spacing resulted in increase in the diameter of basal floret and also duration of flowering. Maximum diameter of basal floret (8.29 cm) and duration of flowering (13.03 days) was recorded in 30 x 30 cm spacing whereas minimum (6.95 cm, 11.36 days respectively) in 15 x 15 cm. Simillar effects on diameter of basal floret and duration of flowering were observed by Bhat and Khan (2007) [7, 16], Singh et. al (2011) [15], Sudhakar and Kumar (2012) [12]. This might be due to the fact that the close spacing hampered intercultural operations and as such more competition arises among the plants for nutrients, air and light. As a result plants become weaker, thinner and consequently produced florets of less diameter with reduced duration of flowering.

Corm and cormel parameters

Studies on corms and cormels were carried out for five different characters i.e. number of corms per plant, weight of corm per plant, diameter of corm, number of cormels per plant and weight of cormels per plant in each treatment. All five characters were found to be significantly influenced by the spacing. Data presented in table 3 shows that maximum number of corms per plant (1.68) was recorded in 30 x 30 cm spacing which was at par with 30 x 15 cm spacing (1.40), whereas minimum (1.06) in 15 x 15 cm. Weight and diameter of corm was also significantly increased in wider spacing. Maximum weight of corms per plant (24.66 g) andmaximum diameter of corm (4.69 cm) was recorded in 30 x 30 cm spacing while it was minimum (19.12 g and 3.02 cm respectively) in 15 x 15 cm spacing. Number of cormels per plant (12.72) and weight of cormels per plant (3.02g) were also found to be maximum at 30 x 30 cm spacing and minimum (10.91 and 1.15g respectively) at 15 x 15 cm spacing. This might be due to availability of more light at wider spacing which ultimately increased the net photosynthesis rate and translocation of assimilates towards the storage organs. Wider spacing also provides more area for better root growth and nutrient absorption. This is inconformity with the work of Kumar and Yadav (2006) [6], Bhat and Khan (2007) [7, 16] and Sudhakar and Kumar (2012) [12].

It can be concluded from the above summarized results, that days taken for initiation of spike and for opening of basal floret were significantly decreased with increase in spacing. Plant height, number of leaves, length of spike, duration of flowering, number and weight of corm or cormels per plant increased with increase in spacing.

Table 1: Effect of plant density on vegetative characters of *Gladiolus*

Treatments	Plant height at 30 DAP (cm)	Plant height at 60 DAP (cm)	Plant height at 90 DAP (cm)	No. of leaves per plant
T1- (30 x 30 cm)	22.46	35.24	46.36	7.88
T2- (30 x 15 cm)	21.48	33.33	44.37	7.46
T3- (20 x 20 cm)	21.04	31.43	42.19	7.35
T4- (20 x 15 cm)	19.21	30.45	41.01	7.05

T5- (15 x 15 cm)	17.54	28.40	39.58	6.56
S.E (m)±	0.88	0.61	0.43	0.18
C.D (5%)	2.91	2.05	1.45	0.60

Table 2: Effect of plant density on different floral parameters of *Gladiolus*

Treatment	Days taken for initiation of spike	Days taken for opening of basal floret	No. of spikes per plant	Length of Spike(cm)	Diameter of basal floret (cm)	Duration of flowering (days)	No. of florets per spike
T1- (30 x 30 cm)	90.46	127.11	1.51	54.10	8.29	13.03	13.65
T2- (30 x 15 cm)	93.06	130.11	1.32	53.96	7.89	12.82	13.08
T3- (20 x 20 cm)	93.65	130.88	1.15	51.56	7.52	12.12	12.62
T4- (20 x 15 cm)	94.41	132.23	1.06	51.03	7.19	11.94	12.16
T5- (15 x 15 cm)	95.12	133.93	1.00	50.59	6.95	11.36	11.72
S.E (m)±	0.43	0.84	0.09	0.68	0.11	0.23	0.33
C.D (5%)	1.44	2.79	0.32	2.27	0.38	0.78	1.11

Table 3: Effect of plant density on corm and cormel parameters of *Gladiolus*

Treatment	No of corms per plant	Weight of corm (g)	No. of cormels per plant	Weight of cormels per plant(g)	Diameter of corm (cm)
T1- (30 x 30 cm)	1.68	24.66	12.72	3.02	4.69
T2- (30 x 15 cm)	1.40	23.71	12.00	2.59	4.13
T3- (20 x 20 cm)	1.26	21.77	11.74	2.05	3.93
T4- (20 x 15 cm)	1.10	20.80	11.26	1.56	3.15
T5- (15 x 15 cm)	1.06	19.12	10.91	1.15	3.02
S.E (m)±	0.08	0.47	0.21	0.22	0.17
C.D (5%)	0.29	1.56	0.70	0.74	0.58

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