Journal of Applied Horticulture, 16(1): 76-79, 2014

Planting density and corm size effects on flower yield and quality of cut-freesia (*Freesia* hybrid) in Ethiopia

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Abstract

Greenhouse experiment was conducted at Freesia Ethiopia Plc., located at Sululta, Ethiopia, to determine the effects of planting density and corm size on flower yield and quality of cut-freesia. Planting densities 90, 100 and 110 corms per m^2 and corm sizes of 3, 3.5 and 4 cm in circumference were evaluated on two varieties 'Volante' and 'Casino' using Randomized Complete Block Design in factorial arrangement (3 x 3 x 2) with three replications. Emergence date, flowering date, cut flower yield and quality parameters were recorded and analyzed. Consequently, increment of planting density resulted highest number of cut-flowers. Corm size difference positively influenced the stem length, spike length and cut-flowers yield. Significant interaction effects were also found between corm sizes and varieties on yield and quality traits. In general, using the biggest corm and highest planting density exhibited superior result for the greenhouse production of the stated varieties. However, to come up with complete recommendations, further investigations should be conducted in line with other agronomic packages and varieties of economic viability.

Key words: Cut-flower, freesia corm, freesia hybrid, Ethiopia

Introduction

Floriculture is relatively new sub-sector in Ethiopia as for long the production of flowers had been limited to few genera/species of field flowers (like *Allium spp*.). Even if the country is known for its potential for fertile soil, abundant water, proximity to main markets, growing cut-flowers for export purpose is new, dating back only to 1992 (EHPEA, 2006). The country earned 114 million dollars from the floriculture industry in 2008 (Biruk *et al.*, 2013). The rapidly growing flower sector in Ethiopia has now become the fourth foreign-currency generator of the country next to the top three: coffee, oilseeds and cereals (Gebre, 2011). In this regard, many local and international investors are getting involved to take advantage of the manifold potentialities.

Freesia, a genus of about 14 species, belongs to the *Iridaceae* family and is native to mountainous areas of South Africa. It is usually grown as cut-flower. Their appealing shapes make them suitable for flower arrangement, and their wide range of colour increases their versatility. The flowers are popularly used for wedding in which it is the seventh wedding anniversary flower and in the language of flowers, freesias are the symbol of innocence and friendship (Teleflora, 2009). It is also used in making fragrant additions to bouquets and body flavours since most of the cultivars are highly fragrant. Moreover, Freesias are also used as a forced pot crop, becoming popular when cultured in cool houses or in hobby greenhouses (Wang, 2006). Owing to the existence of the favourable investment environment and abundant resources, freesia is known to be grown near the capital city, Addis Ababa, Sululta (25 km from Addis Ababa) since 2007.

Due to the fact that the plant is new to Ethiopia's agro-ecological condition, a number of production constraints such as lack of recommended agronomic practices in plant protection, fertigation, planting spacing in relation to corm size, varietal screening etc. are being observed on the already established farm. Among these, problems associated with the plant spacing and planting materials selection in terms of corm size are of major considerations.

Proper plant spacing is important for providing good open position for sunlight, availability of moisture and nutrients vital for successful crop production and quality (Sanjib *et al.,* 2002). Besides, it affects yield of quality spikes and corms (Singh *et al.,* 2000). Plant spacing of freesia corms or cormels is dependent on time of the year, cultivars and size of corms (Cuppen, 2006; Singh *et al.*, 2011). For cut flower production, growers usually use corms sizes from 5 to 7 cm in circumference, planting depth and density of 5 cm and, 96 to 120 corms per m^2, respectively (De Hertogh, 2008). Therefore, the study was conducted with objectives of evaluating the effects of different planting densities, corm sizes and their interaction on flower yield and quality of freesia.

Materials and methods

Description of the study site: The study was conducted in a plastic greenhouse at Freesia Ethiopia PLC located at Sululta District of North Shewa Administrative Zones of Oromia Region, Ethiopia which is 20 km away from Addis Ababa, geographically, situated at 9° 11' latitude and 38° 39' longitude at an altitude of 2785 m. The inside temperature and relative humidity (RH) were controlled within the range of 15-20°C and 65-75%, respectively using a computerized system (Hogendoren systems). The soil type of the area is Luvisoils.

Experimental materials, design and treatments : Two freesia hybrid varieties, Volante and Casino, having three different corm sizes 3, 3.5 and 4 cm in circumference were imported from The Netherlands and tested with planting density of 90, 100 and 110 corm per m^2 at 5 cm planting depth. The experiment was laid in 3x3x2 (planting densities, corm sizes and varieties) factorial arrangements using a Randomized Complete Block Design (RCBD) and replicated three times. Each experimental plot was 0.6 m x 1.2 m=0.72 m^2 with 8 rows and spacing of 0.125 m, 0.45 m and 0.5 m between rows, plots and blocks, respectively. Fertilizer was applied as per the recommendation of soil analysis result throughout the growing season and other management practices like supporting, weeding and pest management were performed whenever necessary. Fertigation was conducted using a computerized system.

Emergence date, days to flowering, stem length, number of florets, total cut-flower yield and vase life were recorded and analyzed from 10 to 16 randomly selected plants depending on the plant population size per plot, except for cut-flower yield in which the data were recorded on whole plot basis.

Statistical analysis: The replication-wise mean values of different entries were subjected to three way factorial experiment in Randomized Complete Block Design (RCBD) analysis of variance according to Montgomery (2005) using SAS version 9.1 (SAS Institute, 2001) statistical package after the data were checked for meeting the various ANOVA assumptions.

Results and discussion

Emergence date: The interaction effects of varieties with corm sizes were found highly significant (Table 2) while other two way and three way interaction were non-significant with respect to emergence date. Volante with bigger corm size emerged earlier (12 days) than others. While Casino of corm size 3 cm in circumference emerged late. On the other hand, all corm sizes of variety Casino took the longest period for emergence. This might be due to the inherent genetic differences between the two varieties as far as dormancy period is concerned. On top of this, within both vaieties, as the corm size increased emergence date was early. The considerable effect of corm size on days of emergence may be attributed to the length of dormancy period, which normally is short in larger corms. These findings are in agreement with the previously reported investigation in gladiolus (Uddin *et al.*, 2002).

Days to flowering: The number of days required for flowering is the major concern in cut-flower production due to the fact that, it enables the grower to develop production scheme as well as marketing plan. Highly significant difference between varieties, corm sizes and planting densities were obtained in relation to flowering date. In addition, the combined effect between varieties and corm sizes was also statistically significant. However, three-way interaction effects among planting densities, corm sizes and varieties; and two-way interaction effects between planting densities and varieties; and planting densities with corm sizes were non-significant. With the increment of corm size within varieties, the days to flowering showed reduction (Table 2). This is in line with the finding of Uddin *et al.* (2002) in gladiolus and Kapczynska (2008) in *Sparaxis tricolor*. This might be due to the fact that flower initiation is dependent on the availability of food reserves in the corm (Rees, 1992). Moreover, comparing the two varieties, Volante with corm size 4 cm in circumference was the earliest in flowering (115 days). On the other hand, Casino with corm size 3 cm in circumference took the longest time for flowering (136 days). In any of the corm sizes and varieties combinations, Casino flowered later than Volante. Variation in days required for spike emergence was due to difference in genetic composition of the cultivars that responded differently to the environment (Ahmed *et al.*, 2010). Variation in planting density was also found to be one of the factors that affected flowering time (Table 1). Subsequently, as the planting density increased from 90 to 110 corms per m^2, the days to flowering was reduced from 127 to 123 days. The reason could be the competition for available nutrients and light, which forced the plants to shorten their life cycle.

Total cut-flower yield: The combination effects of variety with corm size revealed significant difference with regard to cut flowers harvested per unit area. In addition, significant differences resulted with varying plant densities. However the three way interactions among variety, planting density and corm size; and two way interactions between variety and planting density as well as planting density with corm size were non-significant. The highest cut-flowers (124 cut-flowers/m^2) were harvested from the biggest corm size (4 cm) of Volante while the least (29 cut-flowers/m^2) was from smallest corm size of Casino (Table 2). This result is in agreement with studies conducted on Saffron (Omidbeigi *et al.*, 2003). As the planting density increased from 90 to 110 corms per m^2, the cut-flowers yield also increased from 61.4 to 76.8 per m^2 (Table 1). This result illustrated the existence of a positive relationship between planting densities and marketable yield. Obviously, as the number of plants per unit area increased, more marketable stems per unit area could be obtained provided that each plant has the capability to produce more under high competition. These results are in agreement with those of Mili and Sable (2003).

Stem length: Highly significant variation among corm size was noticed for stem length. However, both the two way and three-way interactions among planting densities, corm sizes and varieties exhibited no significant difference. In addition, main effects of planting density and variety showed non-significant effect on stem length. The biggest corm size (4 cm in circumference) produced higher average stem length (30.5 cm) while least average stem length (25 cm) was obtained from smallest corm size (3 cm in circumference) (Table 1). This could be due to more stored food materials in large sized corms, which helped in early and rapid vegetative growth (Uddin *et al.*, 2002). On the other hand, though non-significant differences were found regarding planting density differences, there was slight increment in the average stem length with the increasing planting density (Table 1). It is in agreement with the study on gladiolus grown under polythene tunnel (Roychowdhury, 1989).

Spike length: Highly significant variability was exhibited in the average spike length with the main effects of varieties and corm sizes differences. However, there was non-significant variation for this trait with respect to two ways as well as three way interactions. In addition, planting densities influence on spike length was also statistically non-significant. Casino produced longer average spike length (12.7 cm) than Volante (8.9 cm). The biggest corm size (4 cm in circumference) produced longer spike length (11.8 cm) than medium (3.5 cm in circumference) and smallest (3 cm in circumference) corms (Table 1). The observed result could be due to the presence of more reserve

Table 1. Effect of planting density, corm size and variety on flowering and quality of cut-freezia at Sululta, Ethiopia

Effects and levels	Days to flowering	Total cut-flowers per m^2	Stem length (cm)	Spike length (cm)
Planting density				
90 corms m^{-2}	127.1[a]	61.4[b]	27.2	10.7
100 corms m^{-2}	126.6[ab]	69.1[ab]	27.9	10.8
110 corms m^{-2}	123.6[c]	76.8[a]	28.9	10.9
LSD (P=0.05)	1.33	11.31	ns	ns
Corm size (circumference)				
3.0 cm	128.7[a]	43.8[c]	25.0[c]	10.1[b]
3.5 cm	126.6[b]	72.7[b]	28.5[b]	10.5[b]
4.0 cm	121.9[c]	90.9[a]	30.5[a]	11.8[a]
LSD (P=0.05)	1.32	11.31	2.0	1.4
Variety				
Volante	118.5[b]	94.1[a]	27.5	8.9[b]
Casino	133.0[a]	44.2[b]	28.5	12.7[a]
LSD (P=0.05)	1.1	9.2	ns	1.2

Means followed by different letters within a column are significantly different at 0.01 level of probability; ns= non-significant difference

Table 2. Interaction effect of variety with corm size on emergence date, days to flowering, number of florets per spike and vase life of cut-freesia

Variety	Corm size (cm)	Emergence date	Days to flowering	Number of florets	Vase life (days)	Total flower per m^2
Volante	3.0	14.4[c]	121.3[d]	6.5[e]	12.9[e]	59.0[c]
	3.5	13.9[d]	118.7[e]	6.9[ae]	13.1[e]	99.0[b]
	4.0	12.2[e]	115.4[f]	7.3[ab]	13.8[bcd]	124.0[a]
Casino	3.0	17.9[ab]	136.1[a]	7.1[ad]	13.9[ac]	29.0[d]
	3.5	18.0[a]	134.6[b]	7.3[ac]	14.2[a]	46.0[c]
	4.0	18.0[a]	128.3[c]	7.4[a]	14.0[ab]	58.0[c]
LSD (P=0.05)		0.2	1.0	0.1	0.1	9.2

Means followed by different letters within a column are significantly different at P=0.01; ns= non-significant difference

food in large sized corms, which may result in early growth and development, thereby the plant could produce longer stem as well as spike. Singh (2000) and Uddin *et al.* (2002) also reported the same result in gladiolus. Conversely, non-significant difference was observed on the mean value of spike length measurement from medium (3.5 cm in circumference) and smallest (3 cm in circumference) corm.

Number of florets: Significant combined effects between varieties with corm sizes were obtained for the average number of florets count. However, statistical differences were not detected between planting densities; two way interactions between planting densities with varieties; planting densities with corm sizes; and three-way interactions. The interaction effects of varieties with corm sizes on number of florets (Table 2) showed increasing trend in the mean number of florets of both varieties with the rise of corm size. It may be due to high food reserve in large sized corms (Uddin *et al.*, 2002). This is in accord with Uddin *et al.* (2002) and Singh (2000) results who reported higher number of spikelet (florets) from large sized gladiolus corm. However, there were non-significant differences among all combinations, except between Volante of corm size 3 cm in circumference (Table 2). Furthermore, the biggest corm size of both varieties produced more florets as compared to the medium and smallest corm sizes. In contrast, Volante of corm size 3 cm in circumference produced the least number of florets.

Vase life: Varieties and corm sizes showed highly significant interaction effects on average vase life of cut freesias. Volante of corm size 3 cm in circumference exhibited least vase life (12.9 days) (Table 2). However, there was non-significant difference among corm sizes of Casino. Nevertheless, the mean value of Casino with corm size 3.5 cm in circumference was found to be superior (14.2 days). Additionally, Casino with all corm sizes showed longer vase life as compared to Volante. The observed result suggested the presence of the genetic variations between the two varieties. Besides, as the corm size increased, increasing trend was observed in vase life. This could be due to the presence of more reserved food in the large sized corms that ensured vigorous growth and development of the plant, and also helps in prolonging the vase life of the cut-flowers.

Planting density of 110 corms per m^2 exhibited significant improvement in total cut-flower yield. As the corm size increased, the early flowering date was recorded. Flower stalk length, number of florets, spike length, vase life, and cut-flowers production increased with bigger corm. Therefore, the results suggest that the use of biggest corm (4 cm in circumference) has imperative advantages. There was also varietal difference on yield and quality parameters evaluated. Volante was superior in terms of total flower yield, earlier in emergence and flowering. Conversely, Casino was superior with regard to quality attributes such as spike length, number of florets and vase life. Therefore, the pronounced variability of the two varieties may suggest that they are distinct in their genetic makeup. The combined effect of cultivars and corm sizes were significant on emergence date, days to flowering, average number of floret and total cut-flowers.

In general, it can be concluded that planting density, variety and corm size difference have valid effects on flower yield and quality of cut-freesia and using the biggest corm (4 cm in circumference) and highest planting density (110 corms per m^2) is advisable for cut flower production of the tested varieties. However, to come up with complete package of practices, informaiton on planting depth, environmental influences (temperature, relative humidity, light etc.), fertigation and varieties of economic viability will be useful.

Acknowledgement

We thank Freezia Ethiopia Plc and its management team for sponsoring the overall research project and Jimma University College of Agriculture and Veterinary Medicine for kind support during write-up of the report.

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Received: October, 2013; Revised: January, 2014; Accepted: February, 2014