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Integrated weed management in gladiolus – A review

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ABSTRACT

Gladiolus (*Gladiolus hybridus* Hort.) belongs to the family Iridaceae. It is one of the most important ornamentals for cut flower trade in India and abroad. The importance of gladiolus as cut flowers is increasing day by day in domestic as well as international market. Weed is the most important biotic constraint for realizing higher productivity of gladiolus. Weeds compete for water, nutrients, space and light resulting in reduced flower yield and increased threat of serious insect and disease problems. Weed is also one of the most important yield limiting factors and significantly reduces the yield. Even with a low infestation of weeds, these should be controlled throughout the crop growing season. However, the most critical period for crop weed competition is first six weeks after planting of crop. During this critical period, weedings essentially required by chemical, non-chemical means or in integrated manner. Therefore, timely weed control at early stage is imperative for realizing desirable level of productivity. The use of herbicides offers selective and economic control of weeds right from the beginning, giving crop an advantage of good start and competitive superiority. Pre- and post emergence herbicides may also be viable option to control the weeds. Manual weed control is effective, if done frequently, but, it is very expensive. Hence, a successful integrated weed management program utilizes mulching or a combination of chemical measures, taking into consideration labour costs and availability of materials is the best way.

Keywords: Gladiolus, integrated weed management.

INTRODUCTION

India has a better scope in flowers due to diverse agro-climatic conditions and tremendous diversity in indigenous flora. Gladiolus (*Gladiolus hybridus* Hort.) is one of the most important ornamentals for cut-flower trade in India and abroad. It is also ideal for garden display, floral arrangements for table and interior decoration as well as making high quality bouquet (Lepcha *et al.* 2007). It is popular for its attractive spikes having florets of different forms and sizes, dazzling colours and long keeping quality. It is also widely used in marriage, social, official functions for decoration. Its bouquet/spikes are offered on various occasions as new year day, X-mass day, Mothers day, Valentine day, Birth day and other festivals. Gladiolus trade as cut flower is increasing day by day in domestic as well as international markets. In recent years, several new cultivars of gladiolus with wide range of colours have been developed for marketing. The commercial cultivation of gladiolus in India is a late entrant; however, there was a spectacular change in gladiolus growers in terms of area, production and market. The domestic

consumption too has increased significantly owing to changes in life style, mall culture and rapid urbanization, besides increase in per capita income and living standard of middle class people. Commercial growing of gladiolus is increasingly being considered a high remunerative economic activity by small and large farmers across the country and if the grower gets organized, there would be a massive crores business opportunities and can change the economic status of Indian farmers.

Weed is the most important biotic constraint for realizing higher productivity of gladiolus. Sixty weed species belonging to 24 angiosperm families have been found growing in the fields of gladiolus (Riaz *et al.* 2009). In Northern India, the dominant weed species both dicot and monocot such as *Convolvulus arvensis, Coronopus didymus, Parthenium hystophorus, Chenopodium murale, Trianthema portulaka, Cyperus rotundus and Cynodon dactylon,* respectively were seen. Weed control is important to reduce weed competition and maximize productivity of gladiolus through efficient utilization of resources. The early emergence and faster growth of weeds causes severe competition with crops for light, moisture, space and nutrients, resulting in yield losses up to 50-100% (Rao *et al.* 2007; Mehta *et al.* 2010; Meena *et al.* 2013). Pre-emergence herbicide can be a viable option for controlling weeds right from the emergence of crop (Shivasankar and Subramaniam, 2011). Herbicide is a cost-effective alternative to age-old practice of manual weeding. Manual weeding is costlier and has become impracticable due to non-availability of labourers during the critical period of weed competition, making gladiolus cultivation less remunerative. Worldwide different weed control strategies are employed in the crops such as preventive, cultural, mechanical, biological and chemical. However, the chemical control using herbicides is one of the recent practice that is used in modern agriculture. The effectiveness of herbicide is decided by its specificity and mode of action under a soil conditions, its organic matter content, weather conditions and soil moisture prevailing at that particular area (Zeeshan *et al.* 2015). Generally, weeds are defined as plants growing where they are not desired. Many weeds grow in areas where they are not well adapted, but may still thrive in the absence of competition. Usually, they are favoured by vigorous reproductive powers. Most of them are tolerant to adverse conditions of growth such as extreme heat or cold, drought or excessive moisture, saline or water-logged environments and marginal or disturbed soils (Ali *et al.* 2015). Weeds often possess hard seeds, underground root stocks or tubers, and show greater persistence (Athar and Shabbir, 2008). Weeds are the enemies of the crops in the sense that the needs of the both are identical in respect to light, soil, space, water, mineral salts and air for the manufacture of food substances and growth (Al-Yemeny,1999; Zhao *et al*. 2006). Besides competing for light, nutrients, moisture and space, many weeds also exhibit allelopathic effects against susceptible crops (Javaid *et al.* 2007; Khan *et al.* 2005; Belz *et al.* 2007) and depress crop growth and secrete toxic substances from their decaying and living parts (Evidente *et al.* 2007; Singh *et al.* 2005). Weeds can also act as hosts of different crop pests (Oudejan, 1994). They cause serious problems in the crops because of use of organic fertilizers like farm yard manure, urea and consistent irrigation patterns helping weeds to grow abundantly in the field crops (Rao, 1983). Herbicide use including pre emergence and post emergence applications on crops enables economic weed control and increases productivity (Taj *et al.* 1986). Weed control is

complicated in gladiolus because it is grown for two purposes both for cut flowers and corm production. A precise weed management promoting early vigour and greater growth of gladiolus plants, therefore, is highly essential. Knowing selectivity of a herbicide is a pre-requisite for its use in crops, otherwise crop injury is imminent (Richardson and Zandstra, 2006). A herbicide, even a broad-spectrum one, falls short in controlling huge weed diversity, comprising of grassy, broad-leaved and sedge weeds in the fields. The spectrum of killing weeds of most selective herbicides is narrow, which necessitates application of more than one herbicide, which can be accomplished through tank-mix or sequential application of herbicides for efficient weed control (Richardson and Zandstra, 2006). The tank-mix combination of compatible herbicides usually produces synergistic action due to which the doses of the mixing partner herbicides can be reduced by 25-50% (authors' observations) than what used under single herbicide application. Studies on weed control using tank-mix herbicides have also not been undertaken in India or elsewhere in gladiolus, a flower crop with enormous trade potential.

Effect of integrated weed management on weeds, vegetative, reproductive and yield parameters

Manuja *et al.* (2005) reported that application of pendimethalin 1.0 kg *a.i.*/ha reduced the germination of the cormels to a lesser extent. Pre-emergence application of oxyfluorfen 0.25 kg a.i./ha gave the lowest weed count and weed dry matter accumulation, comparable with weed free treatment, at 90 days after planting (DAP). The corm and cormel production was significantly higher in oxyfluorfen treatment. The results indicate that application of oxyfluorfen as pre-emergence herbicide followed by application of glyphosate at 90 DAP could be an effective treatment for weed control in gladiolus cormels. Chahal *et al*. (2013) reported that application of atrazine @ 3.0 kg/ha was observed comparatively more efficient in controlling weeds; but caused phytotoxicity to gladiolus plants. Bhat *et al.* (2013) observed that treatments, weed free and pendimethalin 1.5 kg *a.i.* ha^{-1} showed better results with vegetative, reproductive and yield parameters in gladiolus. The most effective herbicides for controlling grass weeds were alachlor, simazine, napropamide, linuron and pendimethalin. These herbicides gave excellent weed control with very slight injury at the early stage of gladiolus growth but no injury to flowers (Hong *et al.* 1996).

Deuber *et al.* (1979) studied the weed control by herbicides and their effect on gladiolus and evaluated on a field experiment on sandy-loam soil on cv. Spick and Span and White Friendship. Trifluralin and EPTC were applied pre-plant incorporated and chloroxuron, DCPA, diphenamid, pendimethalin and diuron in pre-emergence. Control by EPTC was of 83% and over 90% by all others. The broadleaves were controlled in the following decrescent order: pendimethalin, chloroxuron, diuron, trifluralin, EPTC, DCPA and diphenamid.

Bhat and Sheiakh (2015) reported that better growth and flowering characters in gladiolus were achieved with pendimenthlin @ 1.0 kg *a.i.* ha^{-1} and pendimenthalin @ 0.75 kg *a.i.* ha^{-1} which were followed by butachlor and weed free treatments. Similarly, weed density, fresh and dry weight as well as weed control efficiency was recorded lowest in pendimethalin @ 0.75 kg *a.i.* ha^{-1} treatments which were followed by atrazine and metribuzin treatments, while the unweeded treatment recorded highest values of these parameters.

A field experiment was exercised by Koutepas (1982) to see the effect of weedicides on qualitative and quantitative characters of gladiolus. Results showed that metoxuron was effective to increase plant height with flower weight and higher flowering percentage. Cuber *et al.* (1980) conducted an experiment in Brazil and got best control of dicot weeds with pendimethalin (1.0-1.5 kg/ha) in gladiolus cv. "Spic and Span" and "White Friendship". Lasker and Jana (1995) reported that high herbicide doses were found to depress plant growth and corm and cormel production and to stimulate early bud production and flower opening in gladiolus. Widaryanto *et al.* (1995) conducted a field experiment to study the effectiveness of weed control by oxyfluron, mulching and weeding. Mulching and herbicides were effective in suppressing weed growth for the first 30 DAP, especially that of broad leaved species. Mulching and weeding suppressed weed growth for the first 60 DAP. All methods of weed control affected gladiolus hybridus growth to a lesser or greater extent. An attempt was made by Stewart *et al.* (1983) to study the effect of alachlor and metolachlor in green house and open field grown gladiolus for weed control. They reported that in green house and in field experiment of gladiolus alachlor and metolachlor had potential for control of *Cyperus esculantus* at 2.2 or 4.4 kg/ha for six weeks.

Application of atrazine 1.0 kg/ha pre-emergence followed by rice residue @ 5 tonnes/ha at 2 days after atrazine application caused greatest reduction in density and dry weight of weeds in gladiolus. The tank-mix pre-emergence application of pendimethalin 0.75 kg/ha + metribuzin 0.3 kg/ha resulted in significantly greater two-year mean gladiolus plant height (116 cm), cut-flower yield (1,72,500 spikes/ha), corm yield (3.82 tonnes/ha) and net returns (Rs. 2,43,100/ha) compared to weedy check and most other treatments, and was most remunerative (Swaroop *et al.* 2014).

Yadav and Bose (1987) reported that the most effective herbicide in controlling the weeds in gladiolus field and promoting the growth and flowering of the crop was found to be oxyfluorfen (2-chloro-1-(3-ethoxy-4 nitrophenoxy) 4-(trifluoromethyl) benzene) applied at the rate of 0.5 kg per hectare. Pre-plant soil spray with this herbicide markedly reduced the weed population and gave the highest yield of 221.1 thousand spikes per hectare as compared to only 162.3 thousand spikes produced in the unweeded control plots.

Dhiman (2003) studied the effects of 0.1, 0.2, 0.3, 0.4 and 0.5% pendimethalin on the germination and growth of gladiolus cv. Mayur treatment with 0.1% pendimethalin resulted in the highest seed germination (28.7%) and number of leaves per plant (3.56). differences in the number of days before seed germination, plant height and number of cormels per plant and corm diameter were not significant. Kadam *et al*. (2014) reported that pre-emergence application of pendimethalin (1.0 and 0.75 kg/ha) had superior effect on the plant height, spike length, rachis length and number of florets in gladiolus. The number of corms/plant, fresh weight of corms and diameter of corms were maximum with application of Atrazine (@ 1.0 and 1.5 kg/ha) and number of cormels were found maximum (28.6) in pendimethalin @ 1.0 kg/ha and lowest (2.4) in Atrazine @ 1.0 kg/ha. Mynett and Jagusz (1990) studied on gladiolus and reported that application of metazachlor (1.5 kg/ha), pendimethalin (1.32 kg/ha) and pendimethalin + metamitron (1.32 + 2.1 kg/ha) caused no injury to plants originating from corms and cormels.

Arora *et al.* (2002) reported that the application of pendimethalin, linuron and trifluralin at 0.50 and 0.75 kg/ha gave an effective control of weeds. Pendimethalin and linuron significantly improved spike length, number of florets per spike, corm weight and number of cormels per corm in gladiolus.

Kumar *et al*. (2012) conducted a field experiment during *rabi* season from 2007-2010 at Chatha, Jammu to find out relative efficiency of weed management practices in gladiolus. They reported that spike yield with 2 hand weedings at 20 and 40 days after planting was (6.05 t/ha) and pendimethalin 2 kg/ha + 1 hand weeding (5.79 t/ha), both of which were superior to weedy check (3.25t/ha). The highest weed control efficiency (78.2%) was also achieved with 2 hand weedings, followed by pendimethalin + hand weeding 76.9%). Application of pendimethalin along with hand weeding proved to be economical.

Bhat and Sheikh (2014) carried out an another experiment at Regional Research Station, Wadura, SKUAST-Kashmir to evaluate different herbicides in gladiolus. Among four herbicides *i.e*. atrazine, metribuzin, butachlor and pendimethalin each with two concentrations, the better growth and flowering characters were achieved with pendimenthlin @1.0 kg *a.i.* ha^{-1} and pendimenthlin @0.75 kg *a.i.* ha^{-1} which were followed by butachlor and weed free treatments. Similarly, weed density, fresh and dry weight as well as weed control efficiency was recorded lowest in pendimethalin @ 0.75 kg *a.i.* ha^{-1} treatments which were followed by atrazine and metribuzin treatments, while the unweeded treatment recorded highest values of these parameters.

Rao *et al.* (2014 carried out an experiment for three consecutive years from 2011 to 2013 at Floricultural Research Station, Hyderabad to find out efficient and economically feasible chemicals for weed control in gladiolus. Among four pre-emergence herbicides *i.e*. atrazine, metribuzin, butachlor and pendimethalin each at two different concentrations, the highest weed control efficiency at 75 DAP (63.7%) was achieved with pendimethalin applied at 1 kg *a.i.*/ha followed by metribuzin 0.5 kg *a.i.*/ha (63.2%). Though pendimethalin @ 0.75 kg *a.i.*/ha was effective in controlling the weeds as well as promoting growth and flower quality of the crop, the highest gross monetary returns per hectare and maximum B:C ratio was achieved with butachlor@ 1.5kg *a.i.*/ha with highest corm yield of 1,66,250 corms per ha.

Zeeshan *et al.* (2015) conducted a field trial to study the effect of different herbicides on growth and yield of gladiolus plants. Pre emergence and post emergence applications of herbicides improved the growth of gladiolus plant. Pendimethalin applied at 12ml/litre as pre emergence herbicide significantly increased plant height of White Prosperity.

Khan *et al.* (2015) conducted a survey and experimented in Pakistan to identify the important weeds infesting gladiolus and to investigate the effects of various mulches (pine saw dust, pine wood chips, wheat straw, plastic mulch) and a herbicide as a check. Control (weedy check) was also included for comparison. They reported that total of 15 major weed species belonging to six different families were found in association with gladiolus. The fields were observed densely populated (7/15 weeds) with monocotyledonous belonging to family Poaceae. Among various mulching treatments, plastic mulch proved to be the most effective for inhibiting weed germination (10 weeds m^{-2}). However, it did not improve the growth and yield of gladiolus as compared to other mulching materials. Application of pine

wood chips promoted plant height of gladiolus to almost double as compared to weedy check. Numerically, higher values of corm size, corm weight, cormel size, cormel weight and cormel yield were observed in pine wood chips. The herbicide gezapex combi used as a standard, injured crop by stunting and chlorosis. Finally they concluded that weeds are a major constraint in gladiolus and mulching of pine wood chips in this crop improves yield and its other economic traits.

Dhakar *et al.* (2015) conducted an experiment and revealed that the number of monocot and dicot weeds, their fresh and dry weight was recorded maximum under control treatment while these were least with the application of atrazine 0.75 kg/ha pre-emergence + carfentrazone @ 0.030 kg/ha post-emergence at 40 days after planting. The maximum vase life of spikes (10.3 day) was recorded with the application of pendimethalin 0.75 kg/ha + metribuzin 0.3 kg/ha pre-emergence as compared to control (7.3 day). The yield of corms (81.52 q/ha), cormels (7.96 q/ha) and marketable spikes (1.43 lakh per ha), net profit (Rs. 3,48,694 per ha) and benefit cost ratio (1.99) was received maximum with the application of metribuzin 0.4 kg/ha pre-emergence + residue (dry grass 5.0 tonnes/ha) over control.

Effect of integrated weed management on nutrient uptake

Dhakar *et al.* (2015) also reported that uptake of N, P and K through gladiolus plants were recorded maximum under weed free check (four hand weeding). The uptake of N was also observed high in treatment *i.e.* (metribuzin 0.4 kg/ha pre-emergence + residue (dry grass 5 tonnes/ha)). However, the uptake of P was also observed high in treatment (pendimethalin 0.75 kg/ha pre-emergence + carfentrazone @ 0.030 kg/ha post emergence at 40 DAS). The treatment (pendimethalin 1.0 kg/ha pre-emergence + residue (dry grass 5 t/ha) also observed high uptake of K. The N, P and K uptake through weeds were recorded maximum in weedy check (control). The uptake of N was also observed high in treatment (pendimethalin 0.75 kg/ha pre-emergence + carfentrazone @ 0.030 kg/ha post emergence at 40 DAS). However, the uptake of P was also observed high in treatment (atrazine 0.75 kg/ha pre-emergence + carfentrazone @ 0.030 kg/ha post-emergence at 40 DAS). The treatment i.e application of pendimethalin 0.75 kg/ha + metribuzin 0.3 kg/ha (tank mix) pre-emergence also observed high uptake of K.

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Character association and path coefficient analysis in turfgrasses

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ABSTRACT

The present investigations on association of various morphological traits through correlation and path coefficient analysis were carried out among 12 species and varieties of turfgrasses. A significant and positive correlation at genotypic and phenotypic level was observed for germination percentage with shoot density/25 cm^2 (0.654 and 0.673), whereas it was non significant and positive for shoot and root length, fresh and dry weight of shoots and roots, dry shoot/root ratio and non significant and negative for root density/25 cm^2. Partitioning of genotypic correlation into direct and indirect effects revealed that dry weight of shoots contributed (5.037) highest and significantly positive direct effect on shoot density/25 cm^2 followed by dry shoot and root ratio and fresh weight of roots. Whereas, phenotypic path coefficient analysis revealed that the dry weight of shoots contributed (0.848) highest and significantly positive direct effect on shoot density/25 cm^2 followed by germination percentage and fresh weight of roots.

Key words: Correlation coefficient, path coefficient analysis, turfgrasses.

INTRODUCTION

Turfgrasses are considered as an integral part of landscaping worldwide which provide aesthetic value (Roberts *et al.* 1992) and are narrow-leaved grass species that form a uniform, long-lived ground cover that can tolerate traffic and low mowing heights (Rongda *et al.* 2008). These are widely used in enhancing and maintaining the function and beauty of lawns, aesthetic fields, *etc.* (Fender, 2006; King and Balogh, 2006). The main turf species of interest belongs to family Poaceae. Turfgrass is certainly one of the most popular groundcovers and useful for pathways and play surfaces. However, a very peculiar aspect of turfgrasses is to get suitable varieties for various purposes which deal with floricultural business. An effective breeding programme for developing improved varieties requires preliminary information on the nature and magnitude of variation present in the available material, transmission of traits and their inter relationship. Hence, it is important to have knowledge of association of traits among themselves. Correlation studies are useful in choosing superior cultivars from their phenotypic expression. The major objective of breeding programme is development of improved varieties with superior qualitative and quantitative traits. As far as number of turfgrass shoots and roots per unit area is concerned, it is

a complex trait known to be collectively influenced by various polygenically inherited traits. Therefore, correlation studies give an idea about the positive and negative associations of different traits with yield and also among themselves. Correlations between growth related traits have been estimated in many perennial forage grasses (De-Araujo and Coulman, 2002). However, nature and extent of contribution by these traits towards yield is not obtained. This difficulty is overcome by path coefficient studies, which facilitates partitioning of correlation coefficients into direct and indirect effects of the different traits on yield or any other traits and also helps in finding out how these effects influence a particular character to produce a given positive or negative correlation. The information helps in proper weightage to various traits during selection or other breeding programme so that the improvement of desirable trait could be achieved effectively. Most of the work on turfgrasses has been done in foreign countries viz., USA, Australia, Japan, Singapore, New Zealand, *etc*. but these grass species and varieties have proved less suitable for Indian agro-climatic conditions because a variety bred under a specific climatic zone, may not necessarily perform well under other climatic zones. No work has been carried out on the aspect of turfgrass breeding in India. In order to contribute towards improvement in turfgrasses, the present investigation was undertaken to analyse to find out the inter-relationship among the components responsible for shoot and root density per unit area and direct and indirect influences of each of the component traits towards shoot and root density per unit area.

MATERIALS AND METHODS

The material utilized for the present study consists 12 turfgrasses species and varieties. The detail of turfgrasses is given in the Table 1. The present investigation was carried out at research farm of The Division of Floriculture and Landscaping, ICAR–Indian Agricultural Research Institute, New Delhi in a randomized block design with three replications. The above farm is situated at 77°12'E longitude 28°40'N latitude and at an altitude of 228.16 m above the mean sea level. Seeds of all the species were sown in the beds to raise turfs. All the grass species were given uniform management practices for healthy growth and development.

Table 1: Details of turfgrasses used for evaluation and their sources.

Sr. No.	Turfgrasses	English/common name	Growth habit	Source
1.	*Agrostis palustris* L.	Creeping bent grass	Spreading	ICAR-IARI, New Delhi
2.	*Eragrostis curvula* (Schrad.) Nees	Love grass	Upright	ICAR-IARI, New Delhi
3.	*Dichondra repens* Forst	Dichondra	Spreading	ICAR-IARI, New Delhi
4.	*Paspalum notatum* Flugge	Bahia grass	Spreading	ICAR-IARI, New Delhi
5.	*Argentine bahia*	Argentine Bahia grass	Spreading	ICAR-IARI, New Delhi
6.	*Poa pratensis* L.	Kentucky Blue grass	Spreading	ICAR-IARI, New Delhi
7.	*Cynodon dactylon* L. var Bargusto	Bermuda grass var. Bargusto	Spreading	ICAR-IARI, New Delhi
8.	*C. dactylon* L. var. Palma	Bermuda grass var. Palma	Spreading	ICAR-IARI, New Delhi
9.	*C. Dactylon* L. var. Panam	Bermuda grass var. Panam	Spreading	ICAR-IARI, New Delhi
10.	*C. dactylon* L. var. Panama	Bermuda grass var. Panama	Spreading	ICAR-IARI, New Delhi
11.	*C. dactylon* L. var. Selection1	Bermuda grass var. Selection1	Spreading	ICAR-IARI, New Delhi
12.	*Lolium perene* L.	Lolium	Upright	ICAR-IARI, New Delhi

The species and varieties were assessed and data was recorded on various turfgrass traits *viz.*, germination percentage (%), shoot Length (cm), root length (cm), fresh weight of shoots (g), fresh weight of roots (g), dry weight of shoots (g), dry weight of roots (g), dry root/shoot ratio, relative water content (RWC)(%), shoot density/ 25 cm^2, root density/25 cm^2. The genotypic and phenotypic correlation coefficients were determined among all possible combinations of characters by considering the appropriate variance and co-variance. Path coefficient analysis was done by the following methodology suggested by Wright (1921) and using the formula given by Dewey and Lu (1959) in order to measure the direct influence of one variable upon the other and to partition the total correlation into direct and indirect effects.

RESULTS AND DISCUSSION

The correlation parameters in general indicates that the genotypic correlation coefficient was higher than the corresponding phenotypic correlation coefficient for most of the characters studied (Table 2 and 3), thereby establishing inherent relationship between different traits under study but phenotypic value is lessened by significant influence of environment, thereby suggesting the usefulness of genotypic estimates.

The statistically significant and positive correlation both at genotypic and phenotypic level was observed for germination percentage with shoot density/25 cm^2 (0.654 and 0.673), whereas it was non significant and positive for shoot and root length, fresh and dry weight of shoots and roots, dry shoot/root ratio and non significant and negative for root density/25 cm^2. Since turfgrasses are grown for its landscape characteristics, therefore apart from shoot and root density, other traits like shoot and root length, fresh and dry weight of shoots and roots, dry shoot/root ratio, *etc*. are of paramount importance due to contribution towards their ornamental value. Therefore, correlation analysis was done to find out association of growth traits among themselves. Shoot length showed significant and positive correlation both at genotypic and phenotypic level with root length (0.908 and 0.850), fresh weight of root (0.821 and 0.772) and dry weight of root (0.768 and 0.642), root length with fresh weight of root (0.832 and 0.788) and dry weight of root (0.796 and 0.725) at 1% significant level. The fresh weight of shoots exhibited significant and positive correlation both at genotypic and phenotypic level with dry weight of shoots (0.915 and 0.881) and relative water content (0.688 and 0.648) at 1% significant level. Whereas, fresh weight of roots exhibited significant and positive correlation both at genotypic and phenotypic level with dry weight of roots (1.002 and 0.855). Shoot density/25 cm^2 exhibited significant but negative genotypic and phenotypic correlation with root density/25 cm^2 (-0.466 and -0.453) (Table 2 and 3). The correlation among growth related traits was also analyzed in seashore paspalum by Jiang *et al.* (2003), crested wheatgrass by Robins *et al.* (2007), perennial ryegrass for various growth related traits by Studer *et al.* (2008) and Jiang *et al.* (2009), in tall fescue by Majidi *et al.* (2009) and in cool season turfgrasses by Koch *et al.* (2011).

Significant genotypic correlation between shoot density/25 cm^2 and other growth related traits suggested that the genes which influence these traits will tend to influence that trait understudy (Dabohlkar, 1992). The difference between genotypic and phenotypic correlation for each pair of trait studied showed that there is environment influence which mask the actual genotypic correlation. The higher genotypic correlation in magnitude than phenotypic correlation coefficient indicating that there is

Table 2: Genotypic correlations among growth related traits of turfgrasses.

Sl. No.	Traits	Germination percentage	Shoot length (cm)	Root length (cm)	Fresh weight of shoot (gm)	Fresh weight of root (gm)	Dry weight of shoot (gm)	Dry weight of root (gm)	Dry shoot/ root ratio	Relative water content	Shoot density/ 25 cm^2	Root density/ 25 cm^2
1.	Germination percentage	1.000	0.122	0.020	0.281	0.27	0.207	0.229	0.238	-0.044	0.654**	-0.171
2.	Shoot length (cm)		1.000	0.908**	0.074	0.821**	0.357	0.768**	0.251	0.267	-0.26	0.014
3.	Root length (cm)			1.000	0.098	0.832**	0.327	0.796**	0.337	0.314	-0.453**	0.116
4.	Fresh weight of shoot (gm)				1.000	0.105	0.915**	0.189	-0.61	0.688**	0.3	0.098
5.	Fresh weight of root (gm)					1.000	0.375*	1.002**	0.431**	0.384	-0.296	0.433**
6.	Dry weight of shoot (gm)						1.000	0.441**	-0.58	0.634**	0.2	0.215
7.	Dry weight of root (gm)							1.000	0.489**	0.422**	-0.375*	0.589**
8.	Dry shoot/root ratio								1.000	-0.154	-0.372*	0.21
9.	Relative water content									1.000	-0.045	0.276
10.	Shoot density/25 cm^2										1.000	-0.466**
11	Root density/25 cm^2											1.000

* significant at 5%;** significant at 1% level

Table 3: Phenotypic correlations among growth related traits of turfgrasses.

Sl. No.	Traits	Germination percentage	Shoot length (cm)	Root length (cm)	Fresh weight of shoot (gm)	Fresh weight of root (gm)	Dry weight of shoot (gm)	Dry weight of root (gm)	Dry shoot/ root ratio	Relative water content	Shoot density/ 25 cm^2	Root density/ 25 cm^2
1.	Germination percentage	1.000	0.102	0.008	0.273	0.210	0.210	0.202	0.168	-0.020	0.637**	-0.144
2.	Shoot length (cm)		1.000	0.850**	0.077	0.772**	0.357	0.642**	0.158	0.267	-0.247	0.007
3.	Root length (cm)			1.000	0.089	0.788**	0.298	0.725**	0.337	0.289	-0.329	0.108
4.	Fresh weight of shoot (gm)				1.000	0.109	0.881**	0.179	-0.475**	0.648**	0.287	0.078
5.	Fresh weight of root (gm)					1.000	0.339	0.855**	0.372*	0.328	-0.188	0.385*
6.	Dry weight of shoot (gm)						1.000	0.374*	-0.514**	0.601**	0.197	0.203
7.	Dry weight of root (gm)							1.000	0.387*	0.436**	-0.322	0.883**
8.	Dry shoot/root ratio								1.000	-0.093	-0.334	0.156
9.	Relative water content									1.000	-0.033	0.555**
10.	Shoot density/25 cm^2										1.000	-0.453**
11.	Root density/25 cm^2											1.000

* significant at 5%;** significant at 1% level

strong association between various growth related traits studied. This association is mainly because of genetic and environmental sources of variation which affected the trait through different physiological mechanisms (Falconer, 1989), pleiotropy, linkage and environmental effects being more common in experimental and breeding populations of cross pollinated ones (Aastveit and Aastveit, 1993)

Information on correlation alone is often misleading as the correlation observed may not be always true. Correlation studies give an idea about the positive and negative associations of different characters with shoot and root density and also among themselves. However, nature and extent of contribution by these characters towards shoot and root density is not obtained. This difficulty is overcome by path coefficient studies. Path analysis is the most reliable method which provides direct and indirect association among the characters. The information helps in proper weightage to various characters during selection or other breeding programme so that the improvement of desirable trait could be achieved effectively. Path coefficient analysis (genotypic and phenotypic) was carried out by taking shoot density/25 cm^2 (Table 4 and 5) and root density/25 cm^2 (Table 6 and 7) as dependent character, separately. Partitioning of genotypic correlation into direct and indirect effects revealed that dry weight of shoots contributed (5.037) highest and significantly positive direct effect on shoot density/25 cm^2 followed by dry shoot and root ratio and fresh weight of roots. However negative direct effect on shoot density/ 25 cm^2 were attributed by germination percentage (-0.179), shoot length (-1.142), root length (-1.212), fresh weight of shoots (-2.675), dry weight of roots (-1.075) and root density/25 cm^2 (-1.402) (Table 4). Partitioning of phenotypic correlation into direct and indirect effects revealed that the dry weight of shoots

Table 4: Genotypic path coefficient analysis of different quantitative traits on shoot density/25 cm^2.

Sl. No.	Traits	Germination percentage	Shoot length (cm)	Root length (cm)	Fresh weight of shoot (gm)	Fresh weight of root (gm)	Dry weight of shoot (gm)	Dry weight of root (gm)	Dry shoot/ root ratio	Relative water content	Root density/ 25 cm^2	Shoot density/ 25 cm^2 (r value)
1.	Germination percentage	-0.179	-0.139	-0.024	-0.751	0.237	1.044	-0.246	0.476	-0.004	0.24	0.654
2.	Shoot length (cm)	-0.022	-1.142	-1.1	-0.198	0.719	1.799	-0.825	0.502	0.025	-0.018	-0.260
3.	Root length (cm)	-0.004	-1.037	-1.212	-0.263	0.729	1.647	-0.856	0.675	0.03	-0.162	-0.453
4.	Fresh weight of shoot (gm)	-0.05	-0.084	-0.119	-2.675	0.092	4.607	-0.203	-1.222	0.065	-0.111	0.300
5.	Fresh weight of root (gm)	-0.048	-0.937	-1.008	-0.282	0.876	1.887	-1.077	0.863	0.036	-0.606	-0.296
6.	Dry weight of shoot (gm)	-0.037	-0.408	-0.396	-2.447	0.328	5.037	-0.474	-1.162	0.06	-0.301	0.200
7.	Dry weight of root (gm)	-0.041	-0.877	-0.965	-0.506	0.878	2.223	-1.075	0.775	0.04	-0.827	-0.375
8.	Dry shoot/root ratio	-0.043	-0.286	-0.409	1.633	0.378	-2.923	-0.416	2.002	-0.015	-0.293	-0.372
9.	Relative water content	0.008	-0.305	-0.38	-1.841	0.337	3.192	-0.454	-0.309	0.094	-0.387	-0.045
10.	Root density/25 cm^2	0.031	-0.015	-0.14	-0.211	0.379	1.082	-0.634	0.419	0.026	-1.402	-0.465

Residual effect = 0.025

Table 5: Phenotypic path coefficient analysis of different quantitative traits on shoot density/25 cm^2.

Sl. No.	Traits	Germination percentage	Shoot length (cm)	Root length (cm)	Fresh weight of shoot (gm)	Fresh weight of root (gm)	Dry weight of shoot (gm)	Dry weight of root (gm)	Dry shoot/root ratio	Relative water content	Root density/25 cm^2	Shoot density/25 cm^2 (r value)
1.	Germination percentage	0.574	-0.04	-0.003	-0.167	0.068	0.178	-0.046	0.004	-0.004	0.073	0.637
2.	Shoot length (cm)	0.059	-0.389	-0.347	-0.047	0.25	0.303	-0.125	0.003	0.049	-0.003	-0.247
3.	Root length (cm)	0.004	-0.33	-0.408	-0.054	0.255	0.253	-0.164	0.007	0.053	0.055	-0.329
4.	Fresh weight of shoot (gm)	0.156	-0.03	-0.036	-0.612	0.035	0.747	-0.041	0.01	0.018	0.04	0.287
5.	Fresh weight of root (gm)	0.12	-0.3	-0.322	-0.067	0.324	0.287	-0.493	0.008	0.06	0.195	-0.188
6.	Dry weight of shoot (gm)	0.121	-0.139	-0.222	-0.539	0.11	0.848	-0.185	0.011	0.089	0.103	0.197
7.	Dry weight of root (gm)	0.116	-0.349	-0.296	-0.412	0.277	0.318	-0.326	0.01	0.079	0.261	-0.322
8.	Dry shoot/root ratio	0.197	-0.061	-0.138	-0.291	0.224	-0.436	-0.111	0.121	-0.017	0.178	-0.334
9.	Relative water content	-0.012	-0.104	-0.148	-0.396	0.106	0.509	-0.099	-0.202	0.182	0.131	-0.033
10.	Root density/25 cm^2	-0.083	-0.002	-0.044	-0.048	0.125	0.173	-0.117	0.003	0.047	-0.507	-0.453

Residual effect = 0.168

Table 6: Genotypic path coefficient analysis of different quantitative traits on root density/25 cm^2.

Sl. No.	Traits	Germination percentage	Shoot length (cm)	Root length (cm)	Fresh weight of shoot (gm)	Fresh weight of root (gm)	Dry weight of shoot (gm)	Dry weight of root (gm)	Dry shoot/root ratio	Relative water content	Shoot density/25 cm^2	Root density/25 cm^2 (r value)
1.	Germination percentage	-0.067	-0.108	-0.016	-0.584	0.193	0.774	-0.209	0.335	-0.005	-0.484	-0.171
2.	Shoot length (cm)	-0.008	-0.887	-0.733	-0.154	0.586	1.335	-0.703	0.353	0.033	0.192	0.014
3.	Root length (cm)	-0.001	-0.806	-0.807	-0.204	0.594	1.222	-0.729	0.475	0.039	0.333	0.116
4.	Fresh weight of shoot (gm)	-0.219	-0.366	-0.479	-2.08	0.075	3.417	-0.573	0.76	0.085	-0.522	0.098
5.	Fresh weight of root (gm)	-0.018	-0.728	-0.671	-0.219	0.714	1.4	-0.918	0.607	0.048	0.218	0.433
6.	Dry weight of shoot (gm)	-0.014	-0.317	-0.264	-1.903	0.268	3.736	-0.404	-0.818	0.079	-0.148	0.215
7.	Dry weight of root (gm)	-0.015	-0.681	-0.643	-0.394	0.715	1.649	-0.916	0.545	0.052	0.277	0.589
8.	Dry shoot/root ratio	-0.016	-0.222	-0.272	1.27	0.308	-2.168	-0.355	1.409	-0.019	0.275	0.21
9.	Relative water content	0.003	-0.237	-0.253	-1.431	0.274	2.367	-0.387	-0.217	0.124	0.033	0.276
10.	Shoot density/25 cm^2	-0.044	0.23	0.364	-0.624	-0.21	0.746	0.343	-0.525	-0.006	-0.74	-0.466

Residual effect =0.013

Table 7: Phenotypic path coefficient analysis of different quantitative traits on root density/25 cm^2.

Sl. No.	Traits	Germi-nation per-centage	Shoot length (cm)	Root length (cm)	Fresh weight of shoot (gm)	Fresh weight of root (gm)	Dry weight of shoot (gm)	Dry weight of root (gm)	Dry shoot/ root ratio	Relative water content	Shoot density/ 25 cm^2	Root density/ 25 cm^2 (r value)
1.	Germination percentage	0.201	-0.071	-0.004	-0.178	0.114	0.178	0.073	-0.01	-0.003	-0.444	-0.144
2.	Shoot length (cm)	0.021	-0.693	-0.437	-0.051	0.421	0.302	0.232	-0.009	0.034	0.187	0.007
3.	Root length (cm)	0.002	-0.589	-0.514	-0.058	0.43	0.252	0.262	-0.02	0.037	0.306	0.108
4.	Fresh weight of shoot (gm)	0.055	-0.054	-0.046	-0.654	0.059	0.744	0.065	0.028	0.082	-0.201	0.078
5.	Fresh weight of root (gm)	0.042	-0.535	-0.405	-0.071	0.546	0.286	0.309	-0.022	0.041	0.194	0.385
6.	Dry weight of shoot (gm)	0.042	-0.248	-0.153	-0.576	0.185	0.844	0.135	0.03	0.076	-0.132	0.203
7.	Dry weight of root (gm)	0.41	-0.445	-0.373	-0.117	0.466	0.316	0.361	-0.029	0.055	0.239	0.883
8.	Dry shoot/root ratio	0.034	-0.109	-0.173	0.311	0.203	-0.434	0.177	-0.059	-0.012	0.218	0.156
9.	Relative water content	-0.004	-0.185	0.149	-0.424	0.179	0.507	0.157	0.005	0.126	0.045	0.555
10.	Shoot density/25 cm^2	0.128	0.185	0.226	-0.189	-0.152	0.16	-0.124	0.018	-0.008	-0.697	-0.453

Residual effect =0.232

contributed (0.848) highest and significantly positive direct effect on shoot density/25 cm^2 followed by germination percentage and fresh weight of roots. Whereas, negative direct effect on shoot density/25 cm^2 were attributed by shoot length (-0.389), root length (-0.408), fresh weight of shoots (-0.612), dry weight of roots (-0.326) and root density/25 cm^2 (-0.507) (Table 5).

Partitioning of genotypic correlation into direct and indirect effects revealed that dry weight of shoots contributed (3.736) highest and significantly positive direct effect on root density/25 cm^2 followed by dry shoot and root ratio and dry weight of shoots. However, negative direct effect on root density/25 cm^2 were attributed by germination percentage (-0.067), shoot length (-0.887), root length (-0.807), fresh weight of shoots (-2.080), dry weight of roots (-0.916) and shoot density/ 25cm^2 (-0.740) (Table 6). Partitioning of phenotypic correlation into direct and indirect effects revealed that the dry weight of shoots contributed (0.844) highest and significantly positive direct effect on root density/25 cm^2 followed by fresh weight of roots and dry weight of roots, germination percentage and relative water content. Whereas, negative direct effect on root density/25 cm^2 were attributed by shoot length (-0.693), root length (-0.514), fresh weight of shoots (-0.654), dry shoot/root ratio (-0.059) and shoot density/25 cm^2 (-0.697) (Table 7). In confirmation to our studies, the path coefficient analysis was also done for various growth related traits in *Festuca pratensis* by Fang *et al.* (2004) and perennial ryegrass (Studer *et al.* 2008).

The overall analysis of component contribution in the present study revealed that fresh and dry weight of shoots and roots were the main contributing traits towards shoot and root density, suggesting that during selection

programme aimed at developing cultivars having more shoot and root density, preference should be given for these traits.

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Effects of pulsing and holding solutions on postharvest keeping quality of cut daffodil (*Narcissus pseudonarcissus* L.)

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ABSTRACT

Effects of different pulsing treatments and holding solutions were assessed on the vase life and flower quality of cut daffodils cvs. Trumpet, Texas Semi-double and Golden Harvest. The maximum vase life (14.9 days) was recorded with 16 h pulsing with 4% Sucrose followed by 4% Sucrose + Al_2SO_4 (300 pm). The amount of water absorbed per cut stem was maximum (31.56 ml) with 4% Sucrose. However, the cut daffodils pulsed with 2 mM Silver Thiosulfate (STS) absorbed minimum water (17.22 ml) per cut stem. Among the three tested cultivars, the maximum vase life was recorded in Texas Semi-double (16.0 days) followed by Trumpet (15.67 days) with 16 h pulsing with 4 percent sucrose. Pulsing the cut daffodils with 2 mM STS (either alone or in combination with 4 percent sucrose), adversely affected the bud opening and vase life in all the cultivars. Stem breaking was observed in all the STS pulsed cut flowers. Among different holding solutions, 2% Sucrose + Citric Acid (300 ppm) was found to be most effective for enhancing the vase life (15.26 days) of cut daffodils and improving the water relations of the cut stems. Among the three cultivars, the maximum vase life was recorded in Golden Harvest (17.00 days) with 2% Sucrose + Citric Acid (300 ppm) followed by Texas Semi-double (15.67 days) with Citric Acid (300 ppm). As with pulsing treatment, addition of STS (50 ppm) in the holding solution had negative impact on bud opening, vase life and water relations of cut daffodils.

Keywords: Narcissus, pulsing, holding solution, vase life, citric acid.

INTRODUCTION

Narcissus is a genus of hardy, spring-blooming, bulbous plants in the family Amaryllidaceae. The number of species in this genus has been reported to be between 50 and 100 including species variants and wild hybrids (Brent and Becky, 2001).The daffodil, (*Narcissus pseudonarcissus* L.) is native to Western Europe, and is found in the area bounded by Portugal in the west, Germany in the east, and England and Wales to the north (Gul and Tahir, 2013). Daffodils are symbols of spring and known for their bright yellow, orange, red, pink, and white colours and are garden favourites world-wide. It grows at altitudes from sea level to at least 1,500 m and is found growing wild in woods and grassland, and its many cultivars and hybrids are also widely cultivated in parks and gardens in most temperate regions. The flower consists of a dark yellow trumpet (corona) surrounded by a ring of 3 sepals and 3 petals (perianth), which are a lighter yellow. The flowers are up to 60 mm long and the trumpet and ring of petals are roughly the same length. There are few reports on cultivation and post

harvest handling of daffodils in India. Unfortunately, these flowers have relatively short vase lives that cannot as yet be increased substantially with standard postharvest treatments. Van Doorn (1997) demonstrated that when freshly cut daffodils are placed in the same tap water with freshly cut roses, the roses wilted very rapidly due to the slime that is exuded from the cut stem ends of the daffodil. However, if a germicide was added to the water such as bleach, this negative effect on roses can be eliminated. It is therefore important to hydrate daffodils in a solution that contains a germicide.

Vase life of cut flowers is affected by several factors such as: cell programmed death (Eason *et al.* 2002), ethylene induced senescence (Liao *et al.* 2000), dehydration (Van Doorn and De Witte, 1997; Knee, 2000; Lu *et al.* 2010), or loss of assimilates and substrates (Ichimura *et al.* 2005). Among the above mentioned, water relation and balance play a major role in postharvest quality and longevity of cut flowers (Lu *et al.* 2010) and water stress during this period is often the reason of short vase life for cut flowers (Van Doorn and De Witte, 1997). One of the greatest problems in postharvest flower physiology is the blockage of the vascular system due to air or bacterial growth. This results in reduced water uptake, and combined with the blockages in the xylem vessels, results in water stress (Van Meeteren *et al.* 2001). This has been observed as early wilting of flowers, which resulted from the loss of cell turgor caused by an imbalance between transpiration and water uptake over a long period (Van Doorn and De Witte, 1997). The use of preservative solution is considered a common practice for prolonging the postharvest life of cut flowers. These treatments allow to control ethylene synthesis, pathogen development, maintenance of hydric and respiration balance, to contribute to colour conservation, floral buttons induction and latter to complete their development (Halevy and Mayak 1981). For these reasons, many floral preservative contain germicides, ethylene synthesis inhibitors, growth regulators, some mineral compounds, and carbohydrates that are essential to extend the vase life of cut flowers (Halevy and Mayak 1981). Several treatments have been tested for their ability to improve cut flowers opening and vase life. Sucrose is the most commonly used sugar for prolonging the vase life of cut flowers. The exogenous supply of sucrose provides the cut flowers with much needed substrates for respiration. In addition, it enables cut flowers harvested at the bud stage to open. Controlling and reducing microbial proliferation is a prerequisite for extending quality and longevity of cut flowers. In order to prevent vase solution microbial count and proliferation, most preservatives incorporate acidifying agents. One of the most widely and commercially used acidifying agent has been citric acid (Jowkar *et al.* 2012). Acids or acid salts such as Citric Acid and Al_2SO_4 are added to adjust the pH of the water to 3.5 to 5.0. At this pH, fewer microbes can grow and water is taken up by the flowers more easily. Van Doorn (1997) has shown that low pH prevents vascular blockage in cut rose stems by reducing the bacterial population in the vase solution. STS is the most common bactericides and competes with ethylene for the same site of action (Reid *et al.* 1998). STS acts as an ethylene antagonist, reducing ethylene production and respiration and extending floral longevity. Sexton *et al.* (1995) reported that a pulse treatment of sucrose and/or STS effectively prolonged the vase life of cut sweet pea flowers.

To date, there have been few studies on the effects of various pulsing treatments and holding solutions on improving the vase life of cut daffodils in India. Therefore, the main objective

of the present study was to investigate the roles of various possible preservative solutions on cut flower longevity and quality of daffodil cut flowers and to standardise the pulsing and holding solutions for enhancing the vase life of cut daffodils.

MATERIALS AND METHODS

The present study was conducted at ICAR-Indian Agricultural Research Institute (IARI), Regional Station, Katrain, Kullu-Valley, Himachal Pradesh, India. The bulbs of daffodil cultivars Golden Harvest, Trumpet and Texas Semi-double were planted in the month of October at the research farm of the station under natural growing conditions. All standardized package of practices were followed to raise the successful crop. The scapes were harvested at gooseneck stage in the morning hours. After harvesting the scapes were immediately put into cold water to remove field heat. The scapes were brought to the laboratory and cut to a uniform scape length of 25 cm. The effects of eight different pulsing treatments: (i) Sucrose (4%); (ii) STS (2mM); (iii) Al_2SO_4 (300 pm); (iv) Citric Acid (1000 pm); (v) Sucrose (4%) + STS (2mM); (vi) Sucrose (4%) + Al_2SO_4 (300 pm); (vii) Sucrose (4%) + Citric Acid (1000 pm); (viii) Control (distilled water) on keeping quality of three daffodil cultivars was assessed. After 16h of pulsing, the scapes were removed from the pulsing solutions and placed in the distilled water. Similarly, the effects of eighth different holding solutions (i) Sucrose (2%); (ii) STS (50 ppm); (iii) Al_2SO_4 (100 pm); (iv) Citric Acid (300 pm); (v) Sucrose (2%) + STS (50 ppm); (vi) Sucrose (2%) + Al_2SO_4 (100 pm); (vii) Sucrose (2%) + Citric Acid (300 pm); (viii) Control (distilled water) on post harvest longevity and water relations of cut daffodils was also assessed.

The experiments were laid in completely randomised block design. 5 scapes were used per treatment and each treatment was replicated thrice. The observations were recorded on days to bud opening (d), flower size (cm), per cent increase in scape length, vase life (d) and total water absorbed per cut stem. The data was analyzed employing completely randomized design. COSTAT programme was used for statistical analysis. Data were subjected to analysis of variance (ANOVA) test. The means were compared using Duncan's New Multiple Range test (DMRT).

RESULTS AND DISCUSSION

Effects of pulsing treatments on flower quality and post harvest longevity of cut daffodils

Pulsing of cut daffodils with various preservatives had significant effect on flower quality, post harvest longevity and water relations of cut daffodil (Table 1 and 2). The earliest (1.78 d) bud opening was observed with 16h pulsing with Citric Acid (1000 pm), whereas, the scapes pulsed with distilled water (control) took the maximum (3.00 d) days to bud opening. Among three daffodil cultivars, the earliest bud opening was recorded in Golden harvest with Citric Acid (1000 ppm), whereas, the same cultivar pulsed with STS (2 mM) took the maximum (3.33 d) days to bud open. Among all the cultivars, pulsing treatment significantly affected the flower size of cut daffodils upon subsequent opening. The maximum (7.43 cm) and minimum (5.45 cm) flower sizes were recorded with 16h pulsing with 4% Sucrose and STS (2 mM), respectively. In all the cultivars, 16h pulsing with STS (2 mM) adversely affected the subsequent bud opening and most buds failed to open completely. Similar results on pulsing with STS have been reported by Gul

Table 1: The effect of pulsing treatments on days to bud opening, flower size and percent increase in scape length in different cultivars of daffodil.

Treatments/cultivars	Days to bud opening (d)				Flower size (cm)				Per cent increase in scape length			
	Trumpet	Texas Semidouble	Golden Harvest	Mean	Trumpet	Texas Semidouble	Golden Harvest	Mean	Trumpet	Texas Semidouble	Golden Harvest	Mean
Sucrose (4%)	1.67	2.67	2.67	2.33 bc	8.38	5.97	7.93	7.43 a	1.03	0.48	2.92	1.48 ab
STS (2mM)	2.67	2.67	3.33	2.89 ab	7.23	4.23	4.90	5.45 c	1.10	0.12	0.74	0.65 b
Al_2SO_4 (300 pm)	1.67	2.67	2.00	2.11 c	8.69	5.73	7.80	7.41 a	1.89	1.01	2.28	1.73 a
Citric Acid (1000 pm)	2.00	2.00	1.33	1.78 c	8.42	5.70	7.33	7.15 b	1.05	0.88	3.78	1.90 a
4% Sucrose + STS (2mM)	1.67	3.33	3.33	2.78 ab	7.88	4.30	4.63	5.60 d	1.59	0.12	0.18	0.63 b
4% Sucrose + Al_2SO_4 (300ppm)	1.67	2.33	1.67	1.89 c	7.37	5.80	8.07	7.08b	0.65	0.57	2.08	1.10 b
4% Sucrose + Citric Acid (1000ppm)	1.67	2.33	1.67	1.89 c	8.52	5.73	7.80	7.35 ab	0.78	0.68	4.08	1.85 a
Control (distilled water)	2.67	3.67	2.67	3.00 a	8.81	5.53	7.33	7.22 ab	1.26	0.11	2.65	1.34 ab
LSD (P=0.05)												
Treatments	0.54 (S)				0.34 (S)				0.45 (NS)			
Variety	0.33 (S)				0.21 (S)				0.67 (S)			
Teratment x variety	NS				S				NS			

* Means followed by different letters within columns are significantly different at P ≤0.05, Duncan test

Table 2: The effect of pulsing treatments on vase life and total solution consumed in different cultivars of daffodil.

Treatments/ Cultivars	Vase life (d)				Total solution consumed per scape (ml)			
	Trumpet	Texas Semidouble	Golden Harvest	Mean	Trumpet	Texas Semidouble	Golden Harvest	Mean
4% Sucrose	15.67	16.00	13.00	14.89 a	42.67	33.67	18.33	31.56 a
STS (2mM)	4.67	8.33	6.67	6.56 e	24.00	23.33	4.33	17.22 e
Al_2SO_4 (300 pm)	11.00	12.67	13.33	12.33 b	36.00	29.33	15.67	27.00 cd
Citric Acid (1000 ppm)	14.00	12.33	12.33	12.89 b	40.33	29.33	14.67	28.11 c
4% Sucrose + STS (2mM)	5.67	9.00	8.33	7.67 d	24.67	23.33	7.33	18.44 e
4% Sucrose + Al_2SO_4 (300ppm)	15.33	13.67	15.00	14.67 a	40.67	26.67	19.00	28.78 bc
4% Sucrose + Citric Acid (1000ppm)	15.00	12.33	15.67	14.33 a	38.33	32.00	20.33	30.22 ab
Control	11.00	9.00	11.33	10.44 c	37.33	25.17	13.67	25.39 d
LSD (P=0.05)								
Treatments	0.91 (S)				Treatment		1.78 (S)	
Variety	0.55 (NS)				Variety		1.09 (S)	
Teratment x variety	S				Treatment x Variety		S	

* Means followed by different letters within columns are significantly different at P ≤0.05, Duncan test

and Tahir (2013). The per cent increase in the scape length was maximum with Citric Acid (1000 ppm). However, the pulsing treatments did not have any significant effects on per cent increase in scape length in daffodil.

The maximum vase life (14.9 d) was recorded with 16 h pulsing with 4% Sucrose (Table. 2). This treatment was found statistically at par with 4% Sucrose + Al_2SO_4 (300 ppm) and 4% Sucrose + Al_2SO_4 (300 ppm) for the vase life of cut daffodil. The minimum vase life was recorded with STS (2 mM) pulsing. Among the three tested cultivars, the maximum vase life was recorded in Texas Semi-double (16.0 d) followed by Trumpet (15.67 d) with 16h pulsing with 4% Sucrose. The amount of water absorbed per cut stem was maximum (31.56 ml) with 4% Sucrose. While, the cut daffodils pulsed with 2 mM Silver Thiosulfate (STS) absorbed minimum water (17.22 ml) per cut stem. Sucrose supplementation to cut flowers maintained their ATP levels and the movement ability for a longer time than in those kept in water (Azad *et al*. 2008). Preservative for consumers include sugars and antimicrobial compounds that inhibit vascular occlusion (Ichimura *et al.* 2005; Van Doorn, 2008). At least part of sugar effect could be explained by abundance of EIL3 mRNA, which is a transcription factor that translates ethylene signals (Hoeberichts *et al.* 2007) and by lower levels of EIL3 protein. The presence of high sugar level was observed to promote proteasomal degradation of EIN3. Sucrose addition to the vase solution exerts an effect on flower opening and senescence in cut lily flowers by altering the hormonal balance of several floral tissues among other factors. Pulsing the cut daffodils with 2 mM STS (either alone or in combination with 4 percent sucrose), adversely affected the bud opening and vase life in all the cultivars. Stem breaking was observed in all the STS pulsed cut flowers. The involvement of ethylene in senescence of daffodil flowers (*Narcissus* spp) appears to depend on the species under study. Some such as N. poeticus appear to be ethylene-insensitive as pretreatment of them with STS does not make them last longer in the vase (Sultan and Farooq, 2000). Others such as *N. tazetta* do last longer when pretreated with STS and so endogenously produced ethylene may have a role in their senescence (Ichimura and Goto, 2002; Hunter *et al*. 2004). Senescence of these flowers is accelerated by exposure to ethylene, although their natural senescence does not involve ethylene. Pretreatment with 1-MCP or STS has been reported to extend flower life where flowers are handled in ethylene-polluted environments such as mass market outlets.

Effects of holding solutions on flower quality and post harvest longevity of cut daffodils

The holding solutions had significant effect on flower quality, post harvest longevity and water relations of cut daffodil (Table 3 and 4). Among different holding solutions, the earliest (2.04 d) bud opening was with 2% Sucrose + Al_2SO_4 (100 ppm) and 2% Sucrose + Citric Acid (300 ppm), while, the scapes held in distilled water (control) took the maximum (3.30 d) days to bud opening. Holding solutions significantly affected the flower size of cut daffodils with maximum (7.33 cm) and minimum (6.29 cm) flower sizes recorded with 2% Sucrose + Citric Acid (300 ppm) and STS (50 ppm), respectively. The per cent increase in the scape length was maximum with 2% Sucrose + Citric Acid (300 ppm). However, the holding solutions did not have any significant effects on per cent increase in scape length in daffodil.

The cut daffodils held in 2% Sucrose + Citric

Table 3: The effects of holding solutions on days to bud opening flower size and percent increase in scape length in different cultivars of daffodil.

Treatments/cultivars	Days to bud opening (d)				Flower size (cm)				Per cent increase in scape length			
	Trumpet	Texas Semidouble	Golden Harvest	Mean	Trumpet	Texas Semidouble	Golden Harvest	Mean	Trumpet	Texas Semidouble	Golden Harvest	Mean
2% Sucrose	2.00	2.67	2.00	2.22 d	8.29	5.67	7.70	7.22 a	1.13	1.67	7.04	3.28 ab
STS (50 ppm)	2.56	3.33	3.33	3.07 ab	7.70	4.43	6.73	6.29 b	0.87	2.58	0.73	1.40 b
Al_2SO_4 (100 ppm)	2.67	3.00	1.33	2.33 cd	7.81	5.87	8.03	7.24 a	1.78	1.22	4.80	2.60 ab
Citric Acid (300 ppm)	2.56	3.67	1.33	2.52 cd	7.99	6.03	7.93	7.32 a	2.00	2.59	3.66	2.75 ab
2% Sucrose + STS (50ppm)	2.22	3.33	2.67	2.74 bc	7.80	4.27	6.80	6.29 b	2.39	1.40	1.38	1.72 b
2% Sucrose + Al_2SO_4 (100 ppm)	2.11	2.67	1.33	2.04 d	7.90	6.00	7.63	7.18 a	0.65	0.51	5.72	2.29 ab
2% Sucrose + Citric Acid (300 ppm)	2.44	2.33	1.33	2.04 d	8.27	5.93	7.80	7.33 a	2.02	2.64	7.57	4.07 a
Control (Distilled water)	2.89	3.67	3.33	3.30 a	7.79	5.73	7.53	7.02 a	1.92	1.67	3.10	2.23 ab
LSD (p=0.05)												
Treatments	0.43 (S)				Treatments		0.33 (S)		Treatment		1.96 (NS)	
Variety	0.26 (S)				Variety		0.20 (S)		Variety		1.20 (S)	
Teratment x variety	S				Teratment x variety		S		Teratment x variety		(NS)	

* Means followed by different letters within columns are significantly different at P ≤0.05, Duncan test

Table 4: The effects of holding solutions on vase life and total solution consumed per scape in different cultivars of daffodil.

Treatments/ Cultivars	Vase life (d)				Total solution consumed per scape (ml)			
	Trumpet	Texas Semidouble	Golden Harvest	Mean	Trumpet	Texas Semidouble	Golden Harvest	Mean
2% Sucrose	13.00	13.00	13.33	13.11 c	46.00	41.33	37.67	41.67 b
STS (50 ppm)	10.44	10.33	9.33	10.04 d	31.00	39.00	27.33	32.44 e
Al_2SO_4 (100 ppm)	11.67	12.67	14.67	13.00 c	40.33	42.00	26.67	36.33 d
Citric Acid (300 ppm)	13.22	15.67	14.67	14.52 b	42.00	44.50	31.67	39.39 bc
2% Sucrose + STS (50 ppm)	9.67	11.67	9.67	10.33 d	29.33	40.50	23.33	31.06 e
2% Sucrose + Al_2SO_4 (100 ppm)	12.11	12.33	15.00	13.15 c	32.33	43.00	30.67	35.33 d
2% Sucrose + Citric Acid (300 ppm)	14.44	14.33	17.00	15.26 a	45.67	48.50	41.67	45.28 a
Control (Distilled water)	10.22	9.33	12.00	10.52 d	43.33	36.33	34.00	37.89 cd
LSD (p=0.05)								
Treatments	0.68 (S)			Treatments		2.62 (S)		
Variety	0.41 (S)			Variety		1.61 (S)		
Treatment x variety	S			Teratment x variety		S		

* Means followed by different letters within columns are significantly different at P ≤0.05, Duncan test

Acid (300 ppm) exhibited the maximum vase life (15.26 d), while the minimum vase life (10.04 d) was recorded with STS (50 ppm). Among the three cultivars, the maximum vase life was recorded in Golden Harvest (17.00 d) with 2% Sucrose + Citric Acid (300 ppm) followed by Texas Semi-double (15.67 d) with Citric Acid (300 ppm). As with pulsing treatment, addition of STS (50 ppm) in the holding solution had negative impact on bud opening, vase life and water relations of cut daffodils. The major cause of vase life reduction in cut flowers is water relation interruption which is mostly due to vase solution microbial proliferation and consequently vascular occlusion resulting in solution uptake reduction. Water relation interruption is mostly due to microorganism proliferation in vase solution and occlusion in the basal end of the cut flower stem by microbes (Van Doorn *et al.* 1997); Bleeksma and Van Doorn, 2003; Liu *et al.* 2009). Besides vessel blockage, bacteria secrete pectinases and toxic compounds and produce ethylene (Williamson *et al.* 2002), thereby, accelerate senescence. Most vase preserving solutions contain a pH reducing compound (Nowak and Rudnicki, 1990). Van Doorn (1998) has showed that low pH prevents vascular blockage in cut rose stems by reducing the bacterial population in the vase solution. One key ingredient in a preservative solution that is critical for the handling of field-grown cut flowers is citric acid, which is used to lower the pH. It has been shown that low pH water (pH=3.5) travels faster in the water-conducting system (xylem), thereby preventing or reducing wilting that frequently occurs in field-grown flowers. Commercial rehydration solutions (such as Hydraflor) often contain sufficient citric acid to lower the pH of the solution to 3.5. Beside microbial proliferation control, biocides could affect cut flower's quality and physiology in various aspects. Effects of citric acid application as vase solution biocide and its impact on vase life, water relation, vase solution microbial kind and population beside different physiological parameters such as chlorophyll degradation, chlorophyll fluorescence and membrane permeability were investigated by (Jowkar *et al.* 2012). They have indicated that citric acid increased vase life of rose, and resulted in better fresh appearance during last days of vase life. Further, Ion leakage trend showed a steady increase during vase life and was significantly increased by citric acid application during the last days of vase life as membrane permeability and vase life decrease. Citric acid significantly increased leaf chlorophyll content of treated flowers while it resulted in chlorophyll fluorescence reduction during vase life.

The pulsing treatments and holding solutions had significant effects on vase life and flower quality of cut daffodil. The keeping quality of cut daffodils can be significantly improved with 16 h pulsing with 4% Sucrose. Among different holding solutions, 2% Sucrose + Citric Acid (300 ppm) was found to be most effective for enhancing the vase life of cut daffodils and improving the water relations of the cut stems. So, commercial preservatives containing citric acid can be utilised for improving the keeping quality of cut daffodils.

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Effect of bulb size and growth regulators on flower and bulb production in chincherinchee (*Ornithogalum thyrsoides*)

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ABSTRACT

A field experiment was carried out to study the effect of bulb size and growth regulators application on cut flower and bulb production of ornithogalum. The experiment was laid down in factorial Randomized Block Design with 21 treatments replicated thrice. Three different bulb sizes were treated with three concentrations each of GA_3 and BA. Findings revealed that application of GA_3 @ 200 ppm on large bulb size (3-4 cm diameter) has higher potential in enhancing sprouting of bulb and initiation of flowering earlier (17.60 and 181.36 days, respectively) and the same treatment also increased the number of floret per spike, bulb weight and bulb diameter as compared to other treatments. However, maximum vase life (16.66 days), maximum number of daughter bulbs per plant (5.10) and highest B:C ratio (3.06:1) were recorded with the application of 100 ppm BA applied on large bulbs.

Key words: Chincherinchee, bulb size, growth regulator, BA, GA_3.

INTRODUCTION

Chincherinchee *(Ornithogalum thyrsoides)* is an important ornamental bulbous plant of high commercial value. It belongs to family Hyacinthaceae and is a native of South Africa. The white *Ornithogalum thyrsoides* is a tall stemmed species and has been used for cut flower production since the early 1900's (Littlejohn *et al.* 2000). It is also suitable for herbaceous borders, naturalized wild gardens and rockeries besides using in bouquets and flower arrangements. Spikes even if cut after complete drying on the plant, remained presentable for much longer duration and can be used for dry decorations profitably. It is pertinent to note that cut flower of ornithogalum last relatively for much longer duration than the vase life of most of the cut flowers. In most of the bulbous crop including ornithogalum, the size of bulb plays an important role for obtaining good vegetative growth, quality flowers and bulb production. There is a direct relation among bulb size, flower production as well as bulb yield (Misra *et al.* 1985). Plant growth regulators on the other hand are known to modify and regulate various physiological processes applicable in an appreciable measure in plants. The application of plant growth regulators is reported to have positive effects on growth, yield and flowering attributes of various ornamentals (Eraki *et al.* 1993; Vijai *et al.* 2007; Singh *et al.* 2009; Kumar *et al.* 2009; Nuvale *et al.* 2010; Wagh *et al*. 2012; Zahoor *et al*. 2013; Padmalatha *et al.* 2013; Rani and Singh. 2013; Sarkar *et al.* 2014). Considering the importance

of the crop in commercial floriculture and lack of information regarding general cultivation and behaviour of ornithogalum crop under Jammu conditions, the present study was undertaken to ascertain the appropriate concentration of GA_3 and BA and most suitable bulb size for improving growth, flowering and bulb production in Chincherinchee.

MATERIALS AND METHODS

The experiment was carried out at the experimental farm of the Division of Vegetable Science and Floriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, India during the year 2014-15.

The experiment comprises of 21 different treatment combinations laid out in Factorial Randomized Block Design with three replications. Three levels of GA_3 @ 100 (G_1), 150 (G_2) and 200 ppm (G_3) and three levels of BA @ 50 (G_4), 75 (G_5), 100 ppm (G_6) and control (G_0) were tested on three bulb sizes *viz.* 1-2, 2-3, 3-4 cm as represented by S_1, S_2 and S_3, respectively. The plots were prepared in the form of raised beds and as per the specifications. Well decomposed FYM @ 5kg/m^2 was incorporated into the soil at the time of bed preparation. NPK through Urea, DAP and MOP was applied uniformly to all the experimental plots @ 20:10:10 g/m^2. According to the treatment combinations, different grades of bulbs were soaked overnight prior to planting in different concentrations of GA_3 and BA while the control was soaked in distilled water. The treated bulbs were planted in October, 2014 at a depth of 3 cm, maintaining a spacing of 20 cm × 20 cm thus accommodating 25 bulbs per plot of 1m × 1m dimensions. Routine intercultural operations were followed. Five plants were randomly selected from each unit plot for collecting data and the mean values of all the parameters were analysed by analysis of variance at 5% level of probability.

RESULTS AND DISCUSSION

Vegetative growth and flowering

Larger size bulb (3-4 cm) treated with 200 ppm GA_3 took minimum number of days to sprouting, spike emergence and opening of first floret (17.60, 128.63 and 181.36 days). With the increase in bulb size, the numbers of days for sprouting of bulb were significantly decreased. Minimum days for sprouting of bulb, spike emergence and opening of first floret (18.69, 130.61 and 182.96 days, respectively) and maximum plant height (46.22 cm) were recorded with 3-4 cm bulb size which might be attributed to larger amount of reserved food material present in the large sized bulbs which are available for initial growth of the plant after the bulb has been placed in the soil. The results get support from the findings of Bhat *et al.* 2009 and Kareem *et al.* 2013.

Among the growth regulator treatments, 200 ppm GA_3 recorded minimum number of days to sprouting, spike emergence and opening of first floret (20.12 days, 130.51 days and 183.35 days, respectively) and maximum plant height (46.65 cm). Free GA_3 from exogeneous application was active in breaking down reserved food material by hydrolytic enzymes and hence, caused earlier sprouting (Laishram and Hatibarua, 2013). GA_3 also induce active cell division in apical meristem and is also helpful in elongation of individual cells which results in improved growth of the plant. Similar results were also obtained by Ogale *et al.* (2000), Singh *et al.* (2009), Khan *et al.* (2013), Amin *et al.* (2013) and Neetu *et al.* (2013).

Perusal of data clearly shows differences in

Table 1: Effect of bulb size and growth regulators on growth and flowering in chincherinchee.

Treatments	Days to sprouting of bulb	Plant height (cm)	Days to spike emergence	Days to opening of first florets	Number of spikes per bulb	Flowering duration (days)
Bulb sizes (S)						
S_1 (Small bulb)	23.56	42.28	133.06	185.49	3.81	28.92
S_2 (Medium bulb)	21.55	45.43	131.59	183.96	4.80	30.74
S_3 (Large bulb)	18.69	46.22	130.61	182.96	6.03	31.85
C.D 0.05	0.35	0.70	1.15	0.56	0.23	0.71
Growth regulators (G)						
G_0 (Control)	22.85	42.51	133.42	185.42	4.41	29.64
G_1 (100 ppm GA_3)	20.86	45.95	131.38	183.78	4.47	30.01
G_2 (150 ppm GA_3)	20.43	46.14	130.73	183.40	4.76	30.12
G_3 (200 ppm GA_3)	20.12	46.65	130.51	183.35	4.80	30.53
G_4 (50 ppm BA)	21.94	43.08	132.47	184.54	5.13	30.56
G_5 (75 ppm BA)	21.36	43.53	132.14	184.26	5.17	31.23
G_6 (100 ppm BA)	21.30	44.64	131.64	184.18	5.42	31.45
C.D 0.05	0.53	1.08	1.765	0.85	0.35	1.08
Interactions S x G						
$S_1 \times G_0$	25.40	39.00	134.53	186.90	3.43	27.60
$S_1 \times G_1$	23.00	44.53	132.96	185.26	3.53	28.06
$S_1 \times G_2$	22.76	44.20	131.93	184.00	3.83	28.96
$S_1 \times G_3$	22.30	42.93	132.63	185.60	3.56	29.43
$S_1 \times G_4$	24.14	40.43	133.63	185.66	4.06	28.86
$S_1 \times G_5$	23.60	41.30	133.23	185.93	4.06	29.66
$S_1 \times G_6$	23.70	43.56	132.53	185.06	4.20	29.90
$S_2 \times G_0$	22.73	44.23	133.60	185.26	4.40	29.86
$S_2 \times G_1$	21.26	46.20	130.83	183.93	4.30	30.70
$S_2 \times G_2$	20.60	46.06	131.00	183.03	4.53	30.13
$S_2 \times G_3$	20.46	48.23	130.26	183.10	4.86	30.33
$S_2 \times G_4$	22.46	44.02	132.10	184.36	5.10	30.90
$S_2 \times G_5$	21.40	44.63	131.46	184.26	5.00	31.46
$S_2 \times G_6$	21.96	44.65	131.90	183.76	5.43	31.83
$S_3 \times G_0$	20.43	44.30	132.13	184.10	5.40	31.46
$S_3 \times G_1$	18.33	47.13	130.36	182.16	5.60	31.26
$S_3 \times G_2$	17.93	48.16	129.26	183.16	5.93	31.26
$S_3 \times G_3$	17.60	48.80	128.63	181.36	5.96	31.83
$S_3 \times G_4$	19.23	44.80	131.70	183.60	6.23	31.93
$S_3 \times G_5$	18.33	44.68	131.73	182.60	6.46	31.56
$S_3 \times G_6$	18.20	45.70	130.50	183.73	6.63	31.63
C.D 0.05	N.S	1.87	N.S	N.S	N.S	N.S

number of spikes per bulb and flowering duration. Large bulbs recorded maximum number of spikes/bulb planted (6.03) and maximum flowering duration (31.85 days). Among the different treatments of growth regulators 100 ppm BA recorded maximum number of spike per plant (5.42) and maximum flowering duration (31.45 days). Extended duration in flowering with higher concentration of BA might be due to fact that BA delay

senescence by protecting cells and proteins. The results are in conformity with the findings of Reddy *et al.* (2013), Singh and Sharma (2004), Kumar *et al.* (2010), Panwar *et al.* (2006), Devadanam *et al.* (2007) and Lahiji (2013).

Flower quality

Significant variation in flower quality was also recorded due to planting of different sizes of bulb and application of growth regulators (Table

Table 2: Effect of bulb size and growth regulators on flower quality in chincherinchee.

Treatments	Spike length (cm)	Rachis length (cm)	Floret diameter (cm)	Number of florets per spike	Fresh weight of spike at harvest (g)	Vase life (days)
Bulb sizes (S)						
S_1 (Small bulb)	37.08	17.13	2.32	54.09	24.86	14.69
S_2 (Medium bulb)	39.80	18.30	2.65	56.64	27.62	14.77
S_3 (Large bulb)	40.57	18.85	2.98	58.62	30.37	15.54
C.D 0.05	0.59	0.42	0.09	1.36	1.05	0.54
Growth regulators (G)						
G_0 (Control)	37.76	17.25	2.51	54.55	26.46	14.24
G_1 (100 ppm GA_3)	39.34	18.45	2.68	55.36	27.36	14.75
G_2 (150 ppm GA_3)	40.15	18.62	2.70	56.47	28.24	14.75
G_3 (200 ppm GA_3)	41.03	18.63	2.75	59.63	29.04	15.17
G_4 (50 ppm BA)	38.03	17.60	2.62	55.44	26.92	15.43
G_5 (75 ppm BA)	38.47	18.03	2.61	56.02	27.36	15.43
G_6 (100 ppm BA)	39.27	18.08	2.69	57.70	28.14	15.86
C.D 0.05	0.90	0.65	N.S.	2.08	1.61	0.83
Interactions S x G						
S_1 x G_0	34.03	15.96	2.11	52.06	23.60	14.93
S_1 x G_1	37.76	17.46	2.40	53.40	24.76	15.06
S_1 x G_2	39.23	17.66	2.33	53.70	25.60	14.03
S_1 x G_3	39.53	17.76	2.35	58.93	26.23	15.26
S_1 x G_4	35.23	16.70	2.26	52.86	23.90	14.70
S_1 x G_5	36.53	17.16	2.40	52.93	24.76	14.96
S_1 x G_6	37.26	17.20	2.38	54.76	25.23	15.80
S_2 x G_0	39.36	17.26	2.62	55.30	26.80	13.66
S_2 x G_1	39.56	18.70	2.74	55.96	26.80	14.90
S_2 x G_2	40.06	18.93	2.67	57.13	27.56	13.93
S_2 x G_3	41.40	19.00	2.82	58.50	29.90	14.76
S_2 x G_4	39.00	17.66	2.55	55.06	26.26	15.93
S_2 x G_5	39.36	18.40	2.51	55.96	26.80	15.10
S_2 x G_6	39.90	18.16	2.66	58.60	28.86	15.13
S_3 x G_0	39.90	18.53	2.79	56.30	29.00	14.13
S_3 x G_1	40.70	19.20	2.91	56.73	30.53	14.30
S_3 x G_2	41.16	19.26	3.10	58.60	31.56	16.30
S_3 x G_3	42.16	19.13	3.08	61.46	31.00	15.50
S_3 x G_4	39.86	18.43	3.06	58.40	30.60	15.66
S_3 x G_5	39.53	18.53	2.93	59.16	30.53	16.23
S3 x G_6	40.66	18.90	3.03	59.73	30.33	16.66
C.D 0.05	1.56	N.S	N.S	N.S	N.S	N.S

2). Planting of large size bulbs produced longest spike (40.57), maximum rachis length (18.85 cm), maximum number of florets per spike (58.62) and maximum floret diameter (2.98 cm). Maximum fresh weight of spike at harvest (30.37 g) and vase life (15.54 days) were also recorded in 3-4 cm bulb size. A gradual decrease in spike length was observed with decreasing size of bulb. The same pattern was also recorded in case of other quality parameters. This increase in flower quality might be due to more food reserve in larger sized bulbs, due to which large size bulbs sprouted earlier, put on more vegetative growth and in turn results in more photosynthetic area of the plant and hence, more photosynthates are translocated to the developing spikes. The results are in agreement with the findings of Singh (2000).

Plant growth regulator treatments also improve flower quality. Bulbs dipped in 200 ppm GA_3 recorded maximum spike length and rachis length (41.03 cm and 18.63 cm), respectively maximum number of florets per spike (59.63) and floret diameter (2.75 cm). The increase in spike and rachis length might be due to rapid intermodal elongation as a result of increase in cell division and cell elongation in the intercalary meristems. GA_3 promote vegetative growth and increase photosynthetic and metabolic activities causing more transport and utilization of photosynthates which in turn results in increase in number of florets per spike and floret diameter. The findings are in accordance with those reported by Singh (1999), Chang *et al.* (1999), Sanap *et al.* (2000), Barman and Rajni (2004), Al- Khassawreh *et al.* (2006), Sharma *et al.* (2006), Prakash *et al.* (2006), Bhalla and Kumar (2008), Mayoli *et al.* (2009), Dogra *et al.* (2012), and Sarkar *et al.* (2014). However, maximum vase life (15.86 days) was recorded from 100 ppm BA treatments which might be due to fact that BA delay senescence and also increase sugar availability in the cell by increasing amylase and invertase enzyme activity. Our results are in accordance with the findings of Han (1995), Faraji *et al.* (2011) and Yadav and Tyagi (2007).

Quality of bulb

Data in Table 3 reveal that among different bulb size, large bulbs recorded maximum number of daughter bulb per plant (4.55), maximum bulb size (3.36 cm diameter) and bulb weight (10.95 g). It might be due to availability of more food material stored in bigger size mother bulb that help in better plant growth, bulb and bulblets production. Our results are in conformity with the findings of Mukhopadhyay and Yadav (1984), Rao *et al.* (1999), Patil *et al.* (1995), Islam *et al.* (2000), Arya *et al.* (2006), Bhat *et al.* (2009), Hossian *et al.* (2011), Amin *et al.* (2013) , Reddy *et al.* (2013) and Sarkar (2014). Among different treatments of growth regulators, 100 ppm BA recorded maximum number of daughter bulbs per plant (4.50) which might be due to general effect on vegetative growth rather than direct effect on tuberization. Benzyl adenine hastens the growth of the new emerging shoots. Sufficient foliage production in the early stages of growth enables fairly long duration of growth period for maximum increase in number of daughter bulbs as has been observed in the study. The results are in accordance with the study of Levy *et al.* (1993), Devi *et al.* (2007) and Kumar *et al.* (2008). However, maximum bulb size (3.27 cm) and bulb weight (11.26 g) were recorded with 200 ppm GA_3. The increase in size and weight of bulb was due to the rapid vegetative growth which resulted in increased dry matter production and partitioning to the developing bulb. The results are in accordance with the findings of Ravidas *et al.* (1992), Maurya and Nagda (2002), Sharma *et al.* (2006), Umrao *et*

Table 3: Effect of bulb size and growth regulators on quality of bulb produced in chincherinchee.

Treatments	Number of daughter bulbs harvested per plant	Size of daughter bulb (cm)	Bulb weight (g)
Bulb sizes (S)			
S_1 (Small bulb)	3.37	2.39	8.42
S_2 (Medium bulb)	4.09	3.00	9.79
S_3 (Large bulb)	4.55	3.36	10.95
C.D 0.05	0.13	0.09	0.43
Growth regulators (G)			
G_0 (Control)	3.53	2.59	8.51
G_1 (100 ppm GA_3)	3.76	3.03	9.95
G_2 (150 ppm GA_3)	3.91	3.05	10.14
G_3 (200 ppm GA_3)	4.08	3.27	11.26
G_4 (50 ppm BA)	4.04	2.76	9.21
G_5 (75 ppm BA)	4.21	2.83	9.40
G_6 (100 ppm BA)	4.50	2.90	9.58
C.D 0.05	0.20	0.14	0.65
Interactions S x G			
$S_1 \times G_0$	2.80	2.10	7.00
$S_1 \times G_1$	3.20	2.50	8.73
$S_1 \times G_2$	3.33	2.63	8.63
$S_1 \times G_3$	3.60	2.80	10.03
$S_1 \times G_4$	3.40	2.16	8.03
$S_1 \times G_5$	3.50	2.23	8.33
$S_1 \times G_6$	3.80	2.35	8.21
$S_2 \times G_0$	3.56	2.56	8.70
$S_2 \times G_1$	3.73	3.10	9.80
$S_2 \times G_2$	3.93	3.11	10.10
$S_2 \times G_3$	4.13	3.33	11.70
$S_2 \times G_4$	4.20	2.93	9.33
$S_2 \times G_5$	4.46	2.96	9.40
$S_2 \times G_6$	4.60	3.03	9.50
$S_3 \times G_0$	4.23	3.13	9.83
$S_3 \times G_1$	4.36	3.50	11.33
$S_3 \times G_2$	4.46	3.41	11.70
$S_3 \times G_3$	4.53	3.70	12.05
$S_3 \times G_4$	4.53	3.20	10.26
$S_3 \times G_5$	4.66	3.20	10.47
$S_3 \times G_6$	5.10	3.33	11.03
C.D 0.05	N.S	N.S	N.S

al. (2007), Bhalla and Kumar (2008), Laishram and Hatibarua (2009), Sudhakar and Kumar (2012), Dogra *et al.* (2012), Reddy *et al.* (2013) and Lahiji (2013).

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Assessment of betel leaf extract and 8-HQC on keeping quality and vase life of flowers of rose cvs. Konfetti and Bordeaux

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ABSTRACT

In cut roses, increasing of quality and duration of storage and minimizing postharvest losses is very vital. Using preservatives in the vase solution is one of the common methods to increase the life span of rose flowers. In order to replace chemicals with natural compounds as antimicrobial preservatives used in solutions for cut flowers, the effectiveness of betel leaf extract as well as 8-HQC were assessed. In this study, cut rose cvs. Konfetti and Bordeaux were pulsed with 2% betel leaf extract as well as 200 ppm 8-HQC in combination with 3, 6 and 9% sucrose with tap water as control for 24 hours. 6% sucrose+2% betel leaf extract was highly proficient in increment of vase life (14.17 days) water uptake (45.34 g/stem) and flower diameter (9.97 cm). The qualitative aspects like freshness of leaves and petals, low blueing of petals and bent neck free flowers were also noticed in the same treatment. This study convincingly demonstrates that betel leaf extract is a safe and environment friendly biocide that enhances the quality and longevity of cut roses by preventing microbial vascular plugging.

Key words: Rose, betel leaf extract, vase life, quality, 8-HQC.

INTRODUCTION

Cut flowers of rose *(Rosa × hybrida)* have a very short life in the vase which can be attributed to due to the premature failure of the water connections. This could also result in several deformities in the flower like partial wilting of leaves, failure of bud opening, bending of neck and rapid fall of leaves and petals. Various factors like water stress, rapid carbohydrate depletion, growth of micro-organisms and adverse ethylene effects are responsible to induce senescence in cut flowers. Among these, growth of microorganisms is one of the most pivotal factors affecting the vase life of cut flowers. These microorganisms are found in huge numbers in the vase solutions used by flower growers, consumers and whole-salers to keep the cut flowers fresh. Moreover, microorganisms present in the vase solution including bacteria, yeasts and moulds are harm-ful to cut flowers through their uncontrolled growth and subsequent blockage of the xylem at cut ends, preventing the water absorption (Solgi, 2008).

Application of suitable germicides might control the microbial activity in the vase water (Nowak and Rundnicki, 1990). All holding solutions should essentially contain sugar and germicides. The sugars are utilized as a respiratory substrate, however, application of

germicides control harmful bacteria and prevent plugging of the xylem vessels. Therefore, any effort made in the direction of prolonging the vase-life of cut flowers will be very beneficial to the floriculture industry in general and consumers in particular.

Antimicrobial compounds that have been used to extend the vase life of cut flowers are, hydroxyquinoline (HQ) compounds, such as 8-hydroxyquinoline citrate (HQC) (Knee, 2000) and 8-hydroxyquinoline sulphate (HQS) (Hussein, 1994) as well as silver compounds like silver nitrate ($AgNO_3$) (Fujino *et al.* 1983). 8-HQ which is broadly used in cut-flower industry is very expensive and has serious consequences like intense irritation to skin, eyes and respiratory tract in human beings. Moreover, use of other silver compounds like silver nitrate and silver thiosulfate may lead to blackening of the flower stem and severe damage to the human and environment health (Damunupola and Joyce, 2008). Therefore, researchers have now focused on the identification and use of new safe and less hazardous compounds for preservation and enhancing the vase life of cut flowers (Shimamura *et al.* 1997). These safe alternatives may include natural compounds like herbal extracts and essential oils extracted from many aromatic and medicinal plants.

One such plant is piper betle, which is rich in a wide variety of secondary metabolites such as phenolic compounds (chavicol, hydroxyl chavicol), volatile oils (safrole, eugenol, isoeugenol, eugenol methyl ester), fatty acids (stearic and palmitic) and hydroxyl fatty acids (stearic, palmitic, myristic) which in vitro illustrate the antibacterial properties and might be used as an choice, useful, cheap and safe antibacterial for the treatment of microbial infections (Bangash *et al.* 2012).

Plant extracts have been well documented to inhibit microbial growth (Barkai-Golan, 2001). So we hypothesized that the inclusion of betel leaf extract in rose vase water would extend flower longevity and quality by reducing the accumulation of stem-plugging microorganisms in solutions.

MATERIALS AND METHODS

Preparation of the betel leaf extract

Ten grams of air dried powder of leaves of betel leaf was placed in 100 ml of organic solvent (95% ethanol) in a conical flask and plugged with cotton. Then, these conical flasks were kept on a rotary shaker at 190-220 rpm for 24 h. After 24 h, they were filtered through 8 layers of muslin cloth and subsequently centrifuged at 5000 rpm for 15 min. The supernatant was collected and was dried to evaporate the organic solvent at room temperature.

Experimental details

The experiment was conducted on cut rose cvs Konfetti and Bordeaux at Model Floriculture Centre, Pantnagar. The cut stems of the roses were harvested at a stage when calyx was fully reflexed and outer most petals were unfurled. After harvest-ing, the cut stems were pre cooled at 4°C for an hour and then cut to uniform length of 60 cm. The cut stems were then kept in pulsing solutions -2% betel leaf extract (P_1), 200 ppm 8-HQC (P_2), 1% sucrose+200 ppm 8-HQC (P_3), 2% sucrose+200 ppm 8-HQC (P_4), 2% sucrose+200 ppm 8-HQC (P_5), 1% sucrose+2% betel leaf extract (P_6), 2% sucrose+2% betel leaf extract (P_7), 3% sucrose+2% betel leaf extract (P_8) along with control (tap water, P_9) for 24 hours replicated in thrice under Factorial CRD. Then they were kept in tap water to study the vase life. The vase life was determined as the number of days taken from placing the cut stem in holding solution till the wilting of the outer five petals occurred or bent neck was observed

(Bleeksma and van Doorn, 2003).The equatorial diameter of open flower at two places after full opening of bloom was recorded and average of two values was calculated for recording final flower diameter (cm). The difference between the consecutive measurements of the cylinder plus solution (without the flower) represents the water uptake (g/stem). Freshness of leaves and petal was evaluated using a scale of 1-5 where 5=very fresh, 4=moderately fresh, 3=slightly fresh, 2=apparent wilt, and 1=completely wilt. Blueing of petals was evaluated using a scale of 0-3 where 0=no blueing, 1=slight blueing, 2=moderate blueing, and 3=extreme blueing. Cut flower in vases were observed for degree of bent neck and categorized into bent and unbent categories. The data recorded was subjected to statistical analysis by following Gomez and Gomez (1983). The treatments effects were tested at 1% level of significance.

Table 1: Vase life (days) of cut rose cvs. Konfetti and Bordeaux in the pulsing solution.

Treatment	Vase life (days)		
	konfetti	Bordeaux	Mean
P_1	9.00	10.67	9.83
P_2	9.33	10.00	9.67
P_3	10.33	11.67	11.00
P_4	11.00	12.00	11.50
P_5	13.00	13.67	13.33
P_6	10.67	12.00	11.33
P_7	13.67	14.67	14.17
P_8	11.67	13.33	12.50
P_9	5.33	5.67	5.50
Mean	10.44	11.52	
	S.Em.±	C.D. at 1%	
P	0.163	0.629	
C	0.346	1.334	
P x C	0.490	1.887	

P-Holding solution, P_1-2% Betel leaf extract, P_2-200ppm 8-HQC, P_3-3% sucrose + 200 ppm 8-HQC, P_4-6% sucrose + 200 ppm 8-HQC, P_5-9% sucrose + 200 ppm 8-HQC, P_6-3% sucrose + 2% betel leaf extract, P_7-6% sucrose + 2% betel leaf extract, P_8-9% sucrose + 2% betel leaf extract, P_9-Control (tap water).

RESULTS AND DISCUSSION

Longevity of cut roses was significantly influenced by pulse treatments (Table 1). Cut roses held in P_7 (6% sucrose + 2% betel leaf extract : 14.17 days) extended the vase life significantly over P_9 control (5.50 days).The interactions were also significant with the highest value for the interaction between Bordeaux and 6% sucrose + 2% betel leaf extract (14.67 days). The previous results show that adding sucrose extended the vase-life and improved the quality of cut roses. Adding a carbohydrate source such as sucrose to the holding solution resulted in an extension of vase-life if the growth of microorganisms was controlled by a suitable biocide. In the present study the increased flower longevity was observed in the treatment 6% sucrose + 2% betel leaf extract since the betel leaf extract acted as a biocide and prevented the vascular blockage and increased the water absorption (Marousky, 1971). This is in agreement with the previous study conducted in carnation by Rahman *et al.* (2012) where longevity of the Carola and Pallas Orange carnation flowers doubled when treated with leaf extracts of *Psidium guajava* and *Piper betle* compared to the flowers placed in the control solution.

The highest water uptake (Table 2) was noticed in the treatment P_7 (6% sucrose+2% betel leaf extract : 45.34 g/stem) while the lowest was noticed in the P_9 *i.e.* control treatment (P_9) (9.45g/stem). The highest interaction effects were noticed between Bordeaux and 6% sucrose + 2% betel leaf extract (47.18, g/stem) and lowest in the control treatment of Konfetti (9.02 g/stem). Germicides control the microbial growth and partially decrease the resistance to water uptake (Jones and Hill, 1993). The control solution was full of bacteria cells since no germicide was used to control the microbial growth. This might have caused the vascular

plugging and subsequent lower water uptake. Rahman *et al.* (2012) in their trial to prolong the vase life of cut carnation flowers affirmed that flowers treated with leaf extracts of *Psidium guajava* and *Piper betle* had the highest water uptake, followed by 8-HQC and copper coin by day 11. Flowers in tap water had the lowest water uptake.

The flowers treated with combination 6% sucrose + 2% betel leaf extract *i.e.* P_7 (Table 2) recorded the largest final flower diameter (9.97 cm) followed by P_5 : 9% sucrose + 200 ppm 8-HQC (9.02 cm) and P_8 : 9% sucrose + 2% betel leaf extract (9.01 cm) and lowest for the control (4.49 cm). It seems that high water uptake, supply of sucrose and lack of contamination in the treatment 6% sucrose + 2% betel leaf allow the maximum flower opening. Similar results were obtained Hajizadeh *et al.* (2012) in rose hybrid cv. Black magic using ethanol and aluminium sulphate. This is in agreement with the previous study conducted by Rahman *et al.* (2012) in cut carnation flowers. The flowers treated with leaf extract of P. betle had significantly larger flower diameter compared to flowers treated with 8-HQC by day 9.

Amid the treatments the highest score of 5.00 for freshness of leaves and petals (Table 3) were noticed in 6% sucrose + 2% betel leaf extract, 9% sucrose + 2% betel leaf extract and 9% sucrose + 200ppm 8-HQC. The increase in water uptake and subsequently cut flower fresh weight are apparently due to the acidifying and stress alleviating properties of the biocide. According to our results, we can generally discuss that the major part of the absorbed water is gathered in the petals and leaves which in fact helps to have a better visual quality in betel leaf treated cut flower samples.

The data on bluing of petals are presented in the Table 3. Among the cultivars bluing was noticed only in Bordeaux which was red coloured. Among the treatments the highest

Table 2: Total water uptake (g/stem) and final flower diameter (cm) of cut roses cvs. Konfetti and Bordeaux in the pulsing solution.

Treatment	Total water uptake (g/stem)			Final flower diameter(cm)		
	Konfetti	Bordeaux	Mean	Konfetti	Bordeaux	Mean
P_1	28.65	31.13	29.89	7.45	7.00	7.23
P_2	26.45	28.01	27.23	6.63	6.06	6.35
P_3	35.27	38.79	37.03	8.78	7.88	8.33
P_4	37.09	42.82	39.95	8.35	8.11	8.23
P_5	41.50	43.87	42.68	9.13	8.90	9.02
P_6	41.77	39.80	40.78	8.88	8.68	8.78
P_7	43.50	47.18	45.34	9.72	10.21	9.97
P_8	42.41	43.54	42.98	9.32	8.69	9.01
P_9	9.02	9.87	9.45	4.09	4.89	4.49
Mean	33.96	36.11		8.04	7.83	
	S.Em.±	C.D. at 1%		S.Em.±	C.D. at 1%	
P	0.235	0.906		0.089	0.343	
C	0.499	1.922		0.189	0.728	
P x C	0.706	2.719		0.267	1.030	

P-Holding solution , P_1-2% Betel leaf extract, P_2-200 ppm 8-HQC, P_3-3% sucrose + 200 ppm 8-HQC, P_4-6% sucrose + 200 ppm 8-HQC, P_5-9% sucrose + 200 ppm 8-HQC, P_6-3% sucrose + 2% betel leaf extract, P_7-6% sucrose + 2% betel leaf extract, P_8-9% sucrose + 2% betel leaf extract, P_9-Control (tap water).

Table 3: Freshness of leaves and petals and blueing of petals of cut roses cvs. Konfetti and Bordeaux in the pulsing solution.

Treatment	Freshness of leaves and petals			Blueing of petals		
	Konfetti	Bordeaux	Mean	Konfetti	Bordeaux	Mean
P_1	3.33	4.00	3.67	0.00	1.00	0.50
P_2	3.33	3.67	3.50	0.00	1.00	0.50
P_3	4.33	4.67	4.50	0.00	1.00	0.50
P_4	5.00	5.00	5.00	0.00	0.67	0.33
P_5	4.67	5.00	4.83	0.00	0.67	0.33
P_6	4.67	4.67	4.67	0.00	1.00	0.50
P_7	5.00	5.00	5.00	0.00	0.67	0.33
P_8	5.00	5.00	5.00	0.00	1.00	0.50
P_9	1.00	1.00	1.00	0.00	1.33	0.67
Mean	4.04	4.22				
	S.Em.±	C.D. at 1%	S.Em.±	C.D. at 1%		
P	0.074	0.284	0.052	0.201		
C	0.157	0.604	0.111	0.427		
P x C	0.222	0.854	0.157	0.604		

P-Holding solution, P_1-2% Betel leaf extract, P_2-200 ppm 8-HQC, P_3-3% sucrose + 200 ppm 8-HQC, P_4-6% sucrose + 200 ppm 8-HQC, P_5-9% sucrose + 200 ppm 8-HQC, P_6-3% sucrose + 2% betel leaf extract, P_7-6% sucrose + 2% betel leaf extract, P_8-9% sucrose + 2% betel leaf extract, P_9-Control (tap water).

bluing was noticed in the control treatment (0.67). In the interaction effects Bordeaux + control treatment recorded the highest score (1.33). Weinstein (1957) suggested that petal bluing was due to pH increase resulting from increased free cellular ammonia accompanying proteolysis. The well-known bluing phenomenon in senescing red roses is tightly linked to a shift into the blue range of some anthocyanins when pH is increased. It is evident from Table 4 that all the treatments and both the cultivars resulted in bent-neck free flowers except the flowers which were kept in control (tap water). The vase life of cut rose flowers often terminates by bending the floral axis just below the flower head, which is called bent-neck. In the present study, bent neck was observed only in the control treatment. The development of such symptoms is considered to be caused by vascular occlusion, which inhibits water supply to the flowers (Mayak *et al.* 1974; De Stigter, 1980; Van Doorn, 1997). Bent neck occurs not only by the reduction of water uptake due to the blockage, but also by water stress caused by elevated transpiration rate and competition for water between leaves and petals. Lack of bent neck in the treatments containing Betel leaf extract or 8-HQC might be due to their antimicrobial properties.

Table 4: Bent neck of cut roses cvs. Konfetti and Bordeaux in the pulsing solution.

Treatment	Bent neck	
	Konfetti	Bordeaux
P_1	Unbent	Unbent
P_2	Unbent	Unbent
P_3	Unbent	Unbent
P_4	Unbent	Unbent
P_5	Unbent	Unbent
P_6	Unbent	Unbent
P_7	Unbent	Unbent
P_8	Unbent	Unbent
P_9	Bent	Bent

P-Holding solution, P_1-2% Betel leaf extract, P_2-200 ppm 8-HQC, P_3-3% sucrose + 200 ppm 8-HQC, P_4-6% sucrose + 200 ppm 8-HQC, P_5-9% sucrose + 200 ppm 8-HQC, P_6-3% sucrose + 2% betel leaf extract, P_7-6% sucrose + 2% betel leaf extract, P_8-9% sucrose + 2% betel leaf extract, P_9-Control (tap water).

On the basis of the results summarized above, it can be concluded that the pulsing treatments were effective in increasing the vase life and presentability of the cut flowers of rose as Konfetti and Bordeaux. 6% sucrose + 2% betel leaf extract was the best treatment among the pulsing solutions followed by 9% sucrose + 200 ppm 8-HQC. Considering the findings of this study, one can argue that the use of natural compounds such as betel leaf extract can help decrease the microorganisms existing in preservative solutions and increase the postharvest quality and longevity of cut roses. Betel leaf extract is a better, safe and environment friendly alternative to 8-HQC in improving the postharvest life of cut roses.

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Studies on genetic variability, heritability, genetic advance and correlation in *Alstroemeria* spp.

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ABSTRACT

The study was carried out to evaluate nine diverse genotypes of Alstroemeria collected from different sources. Genotypes planted in randomized block design with three replications were assessed to know the nature and magnitude of variability and genetic advance for different floricultural traits. The genotype Aladdin showed maximum mean performance for plant height (105.13 cm) , spike length (94.17 cm), number of leaves per plant (38.03), flower diameter (6.12 cm) and number of shoots per plant (32.33) in one growing cycle, while minimum was observed in genotype Capri and Pink Panther for the traits, respectively. The coefficient of variation found highest for number of shoots per plant (GCV=46.86, PCV=50.51) and minimum for days taken to flowering (GCV=9.02, PCV=9.40). Heritability estimates were high for all the characters studied. Highest heritability was noticed for spike length (h^2=96.93). High heritability coupled with high genetic advance was noted for plant height (h^2=95.88, GA=40.46) and spike length (h^2=96.93, GA=38.84). High heritability estimates coupled with high genetic advance observed for spike length and plant height, indicated the existence of wide range of variations and offers better scope for improvement through selection. High genetic advance as per cent mean was exhibited for spike length (72.12) while the minimum of 17.81 was noticed for number of days taken to flowering. In the present study, estimates of high heritability coupled with high genetic advance were observed in all the traits studied except Leaf length, leaf width, flower diameter and flower bud length, in which high heritability was combined with moderate genetic advance. Plant height gave the highest positive significant genotypic and phenotypic association with the spike length. On the contrary, days to flowering had strong negative correlation with spike length, plant height and number of shoots per plant. The character leaf width was found to have a direct significant effect on the number of shoots per plant, while a negative and direct relationship was found between leaf length and number of shoots per plant.

Key words: Alstroemeria, variability, heritability, genetic advance, correlation.

INTRODUCTION

Alstroemeria is still a relatively new cut flower of continuously growing interest due to its ease in cultivation. It is commonly known as Peruvian Lily or Brazilian Lily or Incas lily, which possesses beautiful flowers and has a very long vase life. It belongs to family Alstromeriaceae and originated in South America, with Chile and Brazil as the main diversity centre. Alstroemeria cultivation is popular in Europe, Japan and North America because there are many cultivars, which flowers all the year

around, even at temperature below 20°C (Tombolato *et al*. 1991). The taxonomic identification in the Alstroemeria genus is based on rhizome, stem, leaf, flower and fruit morphological characteristic (Aagesen and Sanso, 2013). All species are herbaceous perennial and rhizomatous plants with big flowers, living in a wide range of habitat from rainy forests to desert area and from Andes Mountains to the coast (Munoz and Moreira, 2003).

Due to their showy flowers and excellent keeping quality, these plants have been successfully introduced into cultivation and are used as vase flowers. Since their introduction into Europe as early as 16th century, several works of improvement have been carried out. It has been developed by hybridization primarily and a great deal of variation is possible among the wild species. Thus far, numerous cultivars, which are used as cut flowers and potted plants worldwide, have been produced by interspecific hybridization and mutational breeding. Recently, biotechnological approaches are being applied in order to improve alstroemeria strains. Due to the increasing demands for this crop, it is necessary to increase the variation and enhance the quality of the commercial cultivars. For this purpose the idea of mean performance, magnitude of genetic variability, heritability and genetic advance is necessary because of their frequent application in plant breeding. Thus, the information gathered the current study could be incorporated into a breeding program to develop a better cultivar that can be grown as pot plants or garden perennials.

Furthermore, if any improvement program is to be carried out, evaluation of germplasm is imperative in order to understand the genetic background and the breeding value of the available germplasm (Agong *et al.* 2000). The genetic variation of any qualitative trait is composed of additive variance (heritable) and non-additive variance and include dominance and epistasis (non-allelic interaction).Therefore, it becomes necessary to partition the observed phenotypic variability into its heritable and non-heritable components with suitable parameters, such as phenotypic and genotypic coefficients of variation, heritability and genetic advance. So, proper evaluation of genetic resources is essential to understand and estimate the genetic variability and heritability. Hence, the present study was conducted to study the genetic variability, heritability and genetic advance for different growth parameters in nine cultivars of alstroemeria.

MATERIALS AND METHODS

The study was carried out at ICAR-Indian Agricultural Research Institute, Regional Station, Katrain, Himachal Pradesh during 2014-15. The study was carried out on diverse genotypes of alstroemeria collected from different sources exhibiting significant differences in the characters considered for the study. Nine alstromeria genotypes namely Aladdin, Pluto, Rosita, Serena, Amor, Cinderella, Capri, Pink Panther and Tiara were evaluated. Genotypes were planted in Randomized Block Design out of which, ten plants were selected for observation and data was recorded on 11 growth and yield related parameters. On the basis of the data obtained, the coefficients of variation were calculated by using methods proposed by Burton (1952). Furthermore, genotypic as well as phenotypic coefficient of variation was calculated. Heritability (h^2) as expressed in percentage was computed following the method described by Lush (1940), which was further categorized as suggested by Robinson *et al.* (1949). The expected genetic advance was computed following Johnson *et al.* (1955).

RESULTS AND DISCUSSION

Analysis of variance revealed highly significant difference among the genotype for all the characters studied (Table 1). This suggested the presence of wide range of variability for different characters studied. The data presented in Table 2 revealed a high range in Days to flowering (137.15-176.67), Plant height (35.33-105.13cm), Spike length (26.67-94.17cm), Number of leaves (18.43-38.02), rachis length (7.27-19.30 cm), leaf length (7.77-14.20 cm), number of flowers per spike (4.33-14.83), inflorescence longevity (12.00-30.92 days) and number of shoots per plant (6.75-32.33).

From Table 3, a narrow difference between estimates of genotypic coefficient of variation and corresponding phenotypic coefficient of variation is seen. Thus, it is evident that major variations were mainly due to the genetic makeup and there is a little environmental influence on the expression of these traits. Similar results were reported by Anitha *et al.* (2013) in lisianthus. The high estimates of PCV and GCV were recorded for the traits *viz.* Plant Height (GCV-30.73; PCV-31.38), spike length (GCV-35.56; PCV-36.12), number of leaves (GCV-21.34; PCV-25.48), rachis length (GCV-30.49; PCV-36.37), number of flowers per spike (GCV-26.21; PCV-30.43), inflorescence longevity (GCV-24.68; PCV-27.95) and number of shoots per plant (GCV-46.86; PCV-50.51) showed that these characters have ample scope of improvement. Almost, all the character exhibited high heritability along with high values of genetic advance which indicated that there was additive gene action in the expression of these traits and thereby further improvement could be made by selection. Similar results were noticed for number of flowers per stem in China aster as reported by Ravi Kumar and Patil (2003) and Namita *et al.* (2008) in French

Table 1: Analysis of variance for growth and yield related traits in alstroemeria.

Source of variance	d.f.	MSS										
		Days to flowering (days)	Plant height (cm)	Spike length (cm)	Number of leaves	Rachis length (cm)	Leaf length (cm)	Leaf width (cm)	Number of flowers per spike	Flower bud length (cm)	Flower diameter (cm)	Inflore-scence longevity (days)	Number of shoots per plant
Replication	2	32.76	82.48	31.99	4.78	2.48	0.28	0.03	0.92	0.34	0.02	1.27	7.44
Treatment	8	649.58**	1,224.16**	1,111.74**	104.25**	45.47**	16.76**	0.68**	27.67**	0.71**	1.23**	83.39**	270.39**
Error	16	18.49	17.29	11.62	12.94	5.63	0.86	0.07	2.87	0.12	0.09	4.83	13.81

Table 2: Mean performance of alstroemeria genotypes for growth and flowering traits.

Genotypes	Days to flowering (days)	Plant height (cm)	Spike length (cm)	Number of leaves	Rachis length (cm)	Leaf length (cm)	Leaf width (cm)	Number of flowers per spike	Flower bud length (cm)	Flower diameter (cm)	Inflore-scence longevity (days)	Number of shoots per plant
Aladdin	137.15	105.13	94.17	38.03	10.30	13.27	2.76	12.20	4.37	6.12	18.30	32.33
Pluto	137.42	80.17	68.58	28.40	11.17	11.33	2.59	13.15	4.97	4.39	18.38	29.48
Rosita	162.00	63.40	54.17	28.40	8.00	10.23	2.94	12.23	3.43	6.00	21.30	29.50
Serena	164.33	61.97	51.57	23.03	12.07	11.28	2.70	12.40	3.67	5.83	22.33	22.00
Amor	156.17	66.40	50.03	25.67	19.30	13.30	2.70	14.83	3.83	6.07	22.20	17.10
Cindrella	172.67	58.33	48.00	22.50	12.25	9.30	2.11	10.33	3.81	5.66	30.92	6.75
Capri	171.07	35.33	26.67	19.83	7.27	7.77	2.20	4.33	3.87	4.74	12.00	11.33
Pink Panther	176.67	44.27	35.80	18.43	10.40	7.85	1.58	8.93	3.83	5.73	15.67	8.77
Tiara	170.43	72.50	55.67	28.33	16.83	14.20	3.12	10.33	4.53	6.20	18.27	20.33
Mean	160.88	65.28	53.85	25.85	11.95	10.95	2.52	10.97	4.03	5.64	19.93	19.73
SEd	3.51	3.39	2.78	2.94	1.94	0.76	0.21	1.38	0.28	0.26	1.79	3.03
CD at 5%	7.51	7.26	5.951	6.28	4.14	1.62	0.46	2.96	0.59	0.55	3.84	6.49

Table 3: Estimates of genetic parameters for growth and flowering traits.

Characters	Genotypic coefficient of variation (GCV)	Phenotypic coefficient of variation (PCV)	Heritability (Hb) (%)	Genetic advance	Genetic Advance value % means
Days to flowering (days)	9.02	9.40	91.92	28.64	17.81
Plant height (cm)	30.73	31.38	95.88	40.46	61.98
Spike length (cm)	35.56	36.12	96.93	38.84	72.12
Number of leaves	21.34	25.48	70.18	9.52	36.83
Rachis length (cm)	30.49	36.37	70.24	6.29	52.63
Leaf length (cm)	21.03	22.67	86.06	4.40	40.19
Leaf width (cm)	17.89	20.70	74.73	0.80	31.87
Number of flowers per spike	26.21	30.43	74.20	5.10	46.51
Flower Bud length (cm)	11.06	13.91	63.26	0.73	18.13
Flower diameter (cm)	10.91	12.24	79.38	1.13	20.02
Inflorescence longevity (days)	25.68	27.95	84.42	9.69	48.60
Number of shoots per plant	46.86	50.51	86.10	17.68	89.58

marigold. Moderate PCV and GCV estimates were noticed for the characters such as days to flowering, number of leaves length, leaf width, and flower bud length and flower diameter. The above results are in line with Anitha *et al.* (2013) in lisianthus.

The magnitude of heritable variability is most important aspect of genetic constitution of the genetic material which is one of the basic criteria for the selection of variety/genotype. High heritability coupled with high genetic advance was observed for number of parameters indicating they are governed by additive genes and could be effectively improved through selection. The high heritability indicated that the characters were less influenced by the environmental factors. Moderate heritability was recorded for flower bud length. Table 3 also revealed that plant height, number of shoots per plant and spike length showed high heritability coupled with high genetic advance (as percent of mean). High heritability coupled with high genetic advance (as per cent of mean) would respond to selection, better than those with high heritability and low genetic advance confirmed with Johnson *et al.* (1955). If heritability was mainly due to additive gene action it would be associated with high genetic gain and if it is due to non additive gene action genetic gain would be low.

The estimates of heritability and genetic advance as percentage mean considered together will no doubt help in drawing conclusion about the nature of the gene action governing a particular character. Moreover, parameters such as flower bud length and flower diameter exhibited low GCV, genetic advance and heritability indicating non additive gene effect and for improving these characters, heterosis breeding of recurrent selection should be followed. Furthermore, genotypes which exhibited both, high variability and high genetic advance for certain characteristics may be evaluated in multi location trails and isolated as donors for these characters or used as parents for hybrid development programs. Therefore, the significant genetic variability for these characters in the genotypes recorded in the test materials can be further exploited through improvement and selection program.

The phenotypic and genotypic correlation for various traits is present in Table 4. Plant height which is one of the most important morphological trait, gave the highest positive significant genotypic and phenotypic association with the spike length implying that improving this character could lead to an improved and desirable spike length of flower. On the contrary, days to flowering had strong negative correlation with spike length, plant height and number of shoots per plant. An understanding of inter character correlation is essential to successful selection of useful genotype from whole population but intensive selection for any characteristic might result in losses in other (Lebsock and Amaya, 1969). The magnitude of genotypic and phenotypic correlations and their utilization in selection had been stated by a number of researchers (Ali *et al.* 2008). Genotypic correlation coefficient offers a measure of the genetic association between characteristic and may provide an important criteria for selection procedure (Can and Yoshida, 1999). Genotypic correlation coefficient values were greater for most of the characters than their corresponding phenotypic correlation values, indicating the inherent association of those characters.

Table 5 represents the direct and indirect effect of several characters on number of shoots per plant at genotypic level in alstroemeria. The character leaf width was found to have a direct

Table 4: Estimates of genotypic and phenotypic correlation among different traits of alstroemeria.

Characters		Days to flowering (days)	Plant height (cm)	Spike length (cm)	Number of leaves	Rachis length (cm)	Leaf length (cm)	Leaf width (cm)	Number of flowers per spike	Flower bud length (cm)	Flower diameter (cm)	Inflorescence longevity (days)	Number of shoots per plant
Days to	P	1.00											
flowering (days)	G	1.00											
Plant height	P	-0.796**	1.00										
(cm)	G	-0.842**	1.00										
Spike length	P	-0.812**	0.984**	1.00									
(cm)	G	-0.856**	0.991**	1.00									
Number of	P	-0.681**	0.834**	0.844**	1.00								
leaves	G	-0.862**	1.025**	1.012**	1.00								
Rachis length	P	-0.024NS	0.225NS	0.084NS	-0.026NS	1.00							
(cm)	G	0.004NS	0.232NS	0.097NS	0.176NS	1.00							
Leaf length	P	-0.483**	0.730**	0.640**	0.644**	0.611**	1.00						
(cm)	G	-0.540**	0.801**	0.700**	0.792**	0.750**	1.00						
Leaf width	P	-0.390*	0.514**	0.458*	0.562**	0.312NS	0.799**	1.00					
(cm)	G	-0.465	0.648**	0.575**	0.771**	0.352NS	0.820**	1.00					
Number of flowers	P	-0.490**	0.616**	0.577**	0.367NS	0.487**	0.545**	0.333NS	1.00				
per spike	G	-0.628	0.675**	0.626**	0.628**	0.571**	0.756**	0.625**	1.00				
Flower bud length	P	-0.529**	0.501**	0.461*	0.314NS	0.148NS	0.390*	0.202NS	0.059NS	1.00			
(cm)	G	-0.631**	0.600**	0.568**	0.567**	0.234NS	0.488**	0.254NS	0.210NS	1.00			
Flower diameter	P	0.152NS	0.242NS	0.200NS	0.314NS	0.379*	0.446*	0.302NS	0.283NS	-0.431*	1.00		
(cm)	G	0.228NS	0.294NS	0.245NS	0.285NS	0.479**	0.498**	0.351NS	0.416*	-0.370*	1.00		
Inflorescence	P	0.038NS	0.152NS	0.145NS	0.054NS	0.304NS	0.134NS	0.075NS	0.482**	-0.278NS	0.357NS	1.00	
longevity (days)	G	0.079NS	0.176NS	0.155NS	0.037NS	0.350NS	0.171NS	0.108NS	0.510**	-0.238NS	0.329NS	1.00	
Number of shoots	P	-0.773**	0.741**	0.752**	0.657**	-0.021NS	0.543**	0.644**	0.523**	0.327NS	0.059NS	-0.083NS	1.00
per plant	G	-0.827**	0.800**	0.820	0.953**	-0.157NS	0.605**	0.789**	0.576**	0.418*	0.070NS	-0.161NS	1.00

* & ** significant at 5% and 1% level of significance, respectively. G = genotypic correlation; P = phenotypic correlation.

Table 5: Direct (diagonal) and indirect effect of different characters on number of shoots per plant at genotypic level in alstroemeria.

Characters	Days to flowering (days)	Plant height (cm)	Spike length (cm)	Number of leaves	Rachis length (cm)	Leaf length (cm)	Leaf width (cm)	Number of flowers per spike	Flower bud length (cm)	Flower diameter (cm)	Inflore-scence longevity (days)	Correlation coefficient for no of shoots/plant
Days to flowering (days)	-0.206	-0.539	0.319	-0.073	-0.001	0.673	-0.439	-0.358	-0.269	0.093	-0.028	-0.827**
Plant height (cm)	0.173	0.640	-0.370	0.087	-0.041	-0.999	0.612	0.385	0.255	0.120	-0.062	0.800**
Spike length (cm)	0.176	0.634	-0.373	0.085	-0.017	-0.873	0.543	0.357	0.242	0.100	-0.055	0.820**
Number of leaves	0.178	0.656	-0.377	0.084	-0.031	-0.987	0.728	0.358	0.242	0.116	-0.013	0.953**
Rachis length (cm)	-0.001	0.148	-0.036	0.015	-0.178	-0.935	0.332	0.326	0.100	0.195	-0.123	-0.157
Leaf length (cm)	0.111	0.513	-0.261	0.067	-0.134	-1.247	0.775	0.432	0.208	0.203	-0.060	0.605**
Leaf width (cm	0.096	0.415	-0.215	0.065	-0.063	-1.023	0.944	0.357	0.108	0.143	-0.038	0.789**
Number of flowers per spike	0.129	0.432	-0.234	0.053	-0.102	-0.943	0.590	0.571	0.089	0.169	-0.180	0.576**
Flower bud length (cm)	0.130	0.384	-0.212	0.048	-0.042	-0.609	0.240	0.120	0.426	-0.151	0.084	0.418*
Flower diameter (cm)	-0.047	0.188	-0.091	0.024	-0.086	-0.621	0.331	0.238	-0.157	0.407	-0.116	0.070
Inflorescence longevity (days)	-0.016	0.113	-0.058	0.003	-0.062	-0.214	0.102	0.291	-0.101	0.134	-0.353	-0.161

Note: Residual effect: Genotypic (G) = **-0.06801** (Bold diagonal values are direct effects).
* & ** significant at 5% and 1% level of significance, respective

significant effect on the number of shoots per plant, while a negative and direct relationship was found between leaf length and number of shoots per plant. Findings of this study suggest that there is enough scope of improvement of these characters through selection.

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Influence of calcium nitrate ($CaNO_3$) sprays and cormel grades on vegetative growth and corm production in gladiolus (*Gladiolus hybridus* Hort.) cv. Priscilla

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ABSTRACT

The experiment was carried out to evaluate the influence of calcium nitrate sprays on improvement of corm size in gladiolus (*Gladiolus hybridus* Hort.) cv. Priscilla .Twelve treatment combinations comprising three levels of calcium nitrate sprays (1%) were applied at 45 and 60; 45, 60 and 75; 45, 60, 75 and 90 DAP, besides control (no spray) and the cormel grades were employed ranging from 1.5-2.0 cm, 2.0-2.5 cm and 2.5-3.0 cm. Four sprays of calcium nitrate and cormel grade 2.5-3.0 cm were best in recording most of the vegetative and corm growth characteristics in comparison to control.

Key words: Gladiolus, calcium nitrate, nitrogen, cormel grade, DAP, days after planting.

INTRODUCTION

Gladiolus (*Gladiolus hybridus* Hort.) is a very popular bulbous ornamental plant in the national as well as the international market. Its magnificent inflorescence with florets of dazzling colours, varying forms and sizes and long keeping quality makes it an attractive cut flower. In India, area under the cultivation of gladiolus flower is about 1270 hectares out of which 50 hectare area is occupied by the flower in the state of Jammu and Kashmir (Arora *et al.* 2002). Nitrogen is one of the most important nutrients that encourage the vegetative growth and consequently the good quality corm production. Calcium nitrate supplies readily available nitrate form of nitrogen to plant resulting in better growth and corm characteristics. The size of corm also has a marked influence on the growth, development and production of corms. Presently, very less information has been documented on the influence of calcium nitrate sprays on improving the corm size in gladiolus, thus the present investigation was initiated with the objective to determine the effect of foliar spray of calcium nitrate and cormel grades on the vegetative growth and corm production at different stages of crop growth.

MATERIALS AND METHODS

The experiment was conducted at the experimental field of the Division of Floriculture and Landscape Architecture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Shalimar Campus during the year

2014-15, consisting of twelve treatments with two factors (Calcium nitrate sprays and cormel grades). The plants from cormels of three different grades (*viz.*, 1.5-2.0 cm, 2.0-2.5 cm and 2.5-3.0 cm) were sprayed with 1% calcium nitrate sprays at regular intervals (*viz.*, 45 and 60 DAP; 45, 60 and 75 DAP; and 45, 60, 75 and 90 days after planting besides control, where the plants were not sprayed with calcium nitrate. The experiment was replicated thrice in a randomized complete block design. The observations were recorded in various vegetative growth, corm and cormel production characteristics.

RESULTS AND DISCUSSION

The vegetative growth characteristics (Table 1 and 2) and corm and cormel characteristics (Table 3 and 4) are presented and discussed under the following sub-headings:

Effect of calcium nitrate sprays on vegetative growth and corm and cormel characteristics of gladiolus

Number of leaves plant^{-1} recorded at 90 DAP (Table 1) was significantly improved by foliar sprays of calcium nitrate as well as due to the

Table 1: Effect of calcium nitrate sprays and cormel grades on number of leaves plant^{-1} and leaf area plant^{-1} (cm^2) of gladiolus cv. Priscilla.

Treatment	Number of leaves plant^{-1}	Leaf area plant^{-1}			
		60 DAP	75 DAP	90 DAP	105 DAP
Calcium nitrate sprays					
S_0	6.07	23.70	28.56	35.50	30.99
S_1	7.04	27.53	34.86	44.37	41.33
S_2	7.42	30.86	40.77	52.76	47.45
S_3	8.16	34.07	45.36	55.72	50.76
CD ($p \leq 0.05$)	0.49	2.82	2.20	2.70	2.84
Cormel Grades					
G_1	6.37	24.21	32.37	40.77	37.75
G_2	7.20	29.04	37.24	48.34	42.79
G_3	7.88	33.87	42.53	52.15	47.36
CD ($p \leq 0.05$)	0.43	2.44	1.90	2.34	2.46

Table 2: Effect of calcium nitrate sprays and cormel grades on shoot dry weight plant^{-1} (g) and relative growth rate (RGR) of shoot (g day^{-1}) of gladiolus cv. Priscilla.

Treatment	Shoot dry weight plant^{-1}				Shoot RGR		
	75 DAP	90 DAP	105 DAP	120 DAP	75-90 DAP	91-105 DAP	106-120 DAP
Calcium nitrate sprays							
S_0	6.94	8.40	10.47	7.51	0.012	0.014	-0.023
S_1	8.59	11.88	16.60	11.77	0.019	0.021	-0.024
S_2	8.77	14.05	22.94	16.12	0.030	0.031	-0.025
S_3	8.94	14.81	24.47	17.52	0.031	0.033	-0.025
CD ($p \leq 0.05$)	**1.10**	**2.84**	**4.74**	**4.12**	**NS**	**0.003**	**0.008**
Cormel Grades							
G_1	6.71	9.01	12.62	8.98	0.018	0.020	-0.023
G_2	8.59	12.57	18.73	13.27	0.023	0.024	-0.024
G_3	9.63	15.29	24.51	17.43	0.028	0.029	-0.025
CD ($p \leq 0.05$)	**0.95**	**2.46**	**4.10**	**3.56**	**NS**	**0.003**	**0.007**

Table 3: Effect of calcium nitrate sprays and cormel grades on corm dry weight plant^{-1} (g) and relative growth rate (RGR) of corm plant^{-1} (g g^{-1} day^{-1}) of gladiolus cv. Priscilla.

Treatment	Corm dry weight plant-1				Corm RGR plant-1		
	75 DAP	90 DAP	105 DAP	120 DAP	75- 90 DAP	91- 105 DAP	106- 120 DAP
Calcium nitrate sprays							
S_0	3.34	3.87	4.86	6.70	0.008	0.010	0.013
S_1	5.03	5.89	7.27	9.85	0.010	0.012	0.016
S_2	5.38	6.44	8.08	11.19	0.011	0.013	0.018
S_3	5.82	7.06	9.36	14.40	0.012	0.018	0.025
CD ($p \leq 0.05$)	1.27	1.55	1.27	3.95	NS	0.005	0.005
Cormel Grades							
G_1	3.28	3.62	4.30	5.37	0.006	0.009	0.012
G_2	5.16	6.02	7.38	10.37	0.010	0.013	0.020
G_3	6.23	7.80	10.51	15.87	0.014	0.018	0.022
CD ($p \leq 0.05$)	1.10	1.34	1.10	3.42	0.005	0.004	0.005

Table 4: Effect of calcium nitrate sprays and cormel grades on weight of main corm plant^{-1} (g), diameter of main corm plant^{-1} (cm), number of corms plant^{-1}, number of cormels plant^{-1} and propagation coefficient of gladiolus cv. Priscilla.

Treatment	Weight of main corm plant^{-1}	Diameter of main corm plant^{-1}	Number of corms plant^{-1}	Number of cormels plant^{-1}	Propagation coefficient
Calcium nitrate sprays					
S_0	13.75	4.88	1.02	17.44	4.51
S_1	20.39	5.68	1.47	24.78	9.06
S_2	38.93	5.95	1.85	31.24	11.90
S_3	41.78	6.16	2.37	39.94	13.10
CD ($p \leq 0.05$)	4.01	0.66	0.34	6.64	1.95
Cormel Grades					
G_1	19.37	4.95	1.23	22.71	6.21
G_2	25.22	5.62	1.67	28.06	8.47
G_3	31.02	6.44	2.13	34.28	10.32
CD ($p \leq 0.05$)	3.47	0.57	0.29	5.75	1.69

cormel grades in comparison to control. Significantly maximum number of leaves (8.16) was recorded with four sprays of calcium nitrate (S_3) followed by three sprays of $CaNO_3$ (S_2) statistically at par with two sprays of $CaNO_3$ (S_1). Number of leaves plant^{-1} (6.07) was significantly recorded minimum with control (S_0). Foliar application of calcium nitrate at regular intervals ensured adequate supply of nitrogen to the plants and the proper utilization of this available nitrogen may have resulted in the increased number of leaves in gladiolus. The present findings of the experiment are in accordance with the report of Memon *et al.* (2013), who revealed that increasing KNO_3 concentration up to 3 per cent for pre-soaking treatment and foliar spray, resulted significant increase in number of leaves plant^{-1} in gladiolus cv. White Friendship. Baral *et al.* (2012), also reported that increasing the level of nitrogen up to 200 kg ha^{-1}, resulted in more number of leaves in gladiolus cv. Candyman.

Among $CaNO_3$ sprays, maximum leaf area plant^{-1} 34.07, 45.36, 55.72 was recorded by treatment S_3 at 60, 75 and 90 DAP intervals respectively. Whereas, minimum leaf area plant^{-1} was observed by the control (S_0) under the same intervals respectively. However, at 120 DAP $CaNO_3$ spray dose S_3 maintained in recording significantly largest leaf area, whereas, the control plants (S_0) recorded significantly lowest leaf area plant^{-1}. In monocots, there has been a scope for increasing the leaf cover by way of improved leaf expansion even after vegetative bud initiation, if the plant continues to receive nutrition through critical stages of growth. Thus, the most appropriate cause of increase in leaf area can be the availability of nitrate provided by calcium nitrate sprays at critical stages of growth. The results are in conformity with the findings of Reddy *et al.* (2014), who reported that at three leaves stage and spike emergence stage calcium nitrate (300 ppm) proved superior in promoting leaf area in gladiolus cv. Summer Sunshine. Similar were the results of Sewedan *et al.* (2012), who concluded that treating gladiolus plants cv. "Sancerre" with ammonium nitrate (6g plant^{-1}) improved the leaf area.

In case of calcium nitrate sprays, maximum and minimum shoot dry weight was recorded under treatment S_3 and S_0, respectively at 75 DAP, 90 DAP and 105 DAP intervals. The present results may be attributed to the improved vegetative characteristics under the influence of $CaNO_3$ sprays as a source of nitrogen, which may have resulted in increased shoot dry weight. In conformity to the results of the present investigation, Sewedan *et al.* (2012), reported increase in dry weight of leaves by application of nitrogen (6 g plant^{-1}) in gladiolus cv. Sancerre.

Regarding calcium nitrate sprays, maximum shoot RGR was recorded by treatment S_3 under the growth intervals 75 to 90 and 91 to 195 DAP. Whereas, lowest shoot RGR was registered by control (S_0) for intervals of 75-90 and 91-105 DAP. However, for the last growth interval 106-120 DAP, there was no significant effect of $CaNO_3$ sprays on shoot RGR in gladiolus cv. Priscilla. Nitrogen increases the photosynthetic efficiency in plants increasing the biosynthesis of proteins and carbohydrates which in turn increases the leaf number, leaf size and leaf area that results in the accumulation of dry matter in the leaves. Results are in conformity with those of Su *et al.* (2012), who reported higher NO_3-increased the accumulation of dry matter in shoots of lilium.

Influence of cormel grades on vegetative growth and corm and cormel characteristics

Regarding the cormel grades, number of leaves plant^{-1} was significantly recorded maximum (7.88) for cormel grade G_3 (2.5-3.0 cm) which was followed by G_2 (2.0-2.5 cm) and G_1 (1.5-2.0 cm). Since large sized corms are embedded with more food reserves, sufficient for the optimal vegetative growth of the plant. This may be the probable cause for the production of maximum number of leaves plant^{-1} by the large sized corm as compared to the smaller ones. The results are supported by Verma *et al.* (2015), who reported that maximum number of leaves was recorded with largest corm size (4-5 cm) in gladiolus cv. Nova Lux. Noor ul Amin *et al.* (2013) also reported that the large size cormels resulted in highest values for number of leaves plant^{-1} in comparison to other grades.

Under the influence of cormel grade, maximum leaf area plant^{-1} at 60, 75 and 90 DAP was registered by the cormel grade G_3 (33.87, 42.53, 52.15, respectively). Whereas, minimum leaf area plant^{-1} was recorded by the smallest cormel

grade G_1 under 60, 75 and 90 DAP intervals. However, at 105 DAP interval, significantly maximum leaf area was recorded by the largest grade G_3, followed by G_2 and significantly lowest leaf area plant-1 by the smallest cormel grade G_1. Maximum leaf area produced by large size cormels may be attributed to more assimilates resulting in plants acquiring optimum growth and development. The present results are in accordance to the findings of Noor ul Amin *et al.* (2013), while working on three different corm grades (1.5-2.0, 1.0-1.5 and 0.5-1.0 cm) of gladiolus cv. White Friendship reported that largest sized cormels produced plants with increased leaf area.

Regarding cormel grades, significantly maximum shoot dry weight plant^{-1} was registered by cormel grade G_3 (9.63, 15.29, 24.51) at the intervals of 75, 90 and 105 DAP, respectively. Whereas, minimum shoot dry weight was recorded for G_1 grade at the same intervals. At 120 DAP interval, maximum shoot dry weight plant^{-1} was recorded by cormel grade G_3, followed by G_2 and minimum by G_1. Larger bulbs have normally more stored food reserves than smaller ones and are thus capable to producing more side shoots and in turn more vegetative growth (Mukhopadhyay, 1963), that eventually increases the shoot dry weight of the plants. In the present investigation, the increased number of leaves plant^{-1} as well as increase in leaf area plant^{-1} by the large cormel grade provided maximum photosynthetic activity of the plant. This factor enhanced the accumulation of dry matter in shoots, hence increased the shoot dry weight of the plants.

In case of cormel grades, highest shoot RGR was observed by cormel grade G_3 (0.028, 0.029) for growth intervals of 75-90 and 91-105 DAP, whereas, lowest shoot RGR plant^{-1} was registered by the smallest cormel grade G_1. The probable cause of increased shoot RGR may be the increased shoot dry weight under the influence of bigger cormel grade. The favourable effect of large size corm on shoot RGR might be due the fact that such corms contain sufficient food material necessary for vegetative growth of the plant that ends up increasing the production of assimilates, their translocation and accumulation of more dry matter in shoots.

In case of calcium nitrate sprays, maximum corm dry weight plant^{-1} was recorded (Table 3) by treatment S_3 (5.82, 7.06, 9.36, 14.40) at 75, 90, 105 and 120 DAP. Whereas, minimum corm dry weight plant^{-1} was recorded under control (S_0) for the same growth interval. The results regarding increase in corm dry weight under the influence of $CaNO_3$ spray doses as compared to control may be due to the positive effect of nitrogen on stimulation of vegetative growth that increased the translocation and accumulation of the organic matter in the corms, eventually resulting in increased dry weight of corms. The present findings are in accordance with the results of Sewedan *et al.* (2012), who reported that use of nitrogen at 6 g plant^{-1} resulted in maximum increase of corm dry weight in gladiolus cv. Sancerre.

Perusal of data (Table 3) revealed that there was no significant effect due to $CaNO_3$ sprays on corm RGR during the growth interval of 75-90 DAP. For 91-105 and 106-120 DAP growth intervals, significantly highest corm RGR was registered by treatment S_3. Whereas, lowest corm RGR was recorded for growth intervals 91-195 DAP and 106-120 DAP by control (S_0). Increase in corm RGR under the influence of $CaNO_3$ sprays may be attributed to the fact that nitrogen increases the total leaf area of the plant causing high dry matter accumulation in the plants (Potti and Arora, 1986) and its greater mobilization in corms. Nazki and Arora (2000)

reported improved RGR under four splits application of nitrogen in corm development from cormels of gladiolus.

Observations recorded after harvesting of corms revealed that with each increment in $CaNO_3$ spray doses, there was corresponding increase in weight gain of main corm plant^{-1}. Maximum weight of main corm plant^{-1} (Table 4) was measured under treatment S_3 (41.78), recorded at par with S_2 (38.93). These treatments were followed by S_1 being significantly different from S_3 and S_2 treatments. Significantly minimum corm weight plant^{-1} was observed by the plants under control (S_0). Increase in main corm weight due to $CaNO_3$ sprays as compared to control may be attributed to increased leaf area due to nitrogen, leading to more photosynthetic activities which resulted in production of more photosynthates, their translocation and accumulation in corms and hence increased weight of the corms. The present findings are in accordance with the studies of Memon *et al.* (2013), who observed that maximum corm weight was achieved by the pre- soaking of corms and foliar application of KNO_3 (3 per cent) in gladiolus cv. White Friendship. Similar were the findings of Khan *et al.* (2012) in gladiolus, who reported production of heaviest corm was achieved by fertilization of plants with nitrogen at 150 kg ha^{-1}.

Regarding $CaNO_3$ sprays, there was simultaneous increase in the size of main corm plant^{-1} with each increment in the spray doses (Table 4). Maximum diameter of main corm plant^{-1} was measured under treatment S_3 (6.16), followed by S_2 (5.95) and S_1 (5.68). All these treatments were at par among themselves. Whereas, control (S_0) measured significantly minimum corm size plant^{-1}. Nitrogen increases the photosynthetic and respiratory rates which enhances nutrient uptake and transport, consequently producing plants with larger diameter. The present results are in concurrence with the observations of Sewedan *et al.* (2012), who reported that application of nitrogen at 6 g plant^{-1} increased the corm diameter of gladiolus cv. Sancerre. Similar were the results obtained by Khan *et al.* (2012), Gupta *et al.* (2010) and Bijimol and Singh (2001) while working on different cultivars of gladiolus.

Number of corms plant^{-1} was recorded significantly maximum under treatment S_3 (2.37), followed by S_2 (1.85) and S_1 (1.47). Significantly minimum number of corms plant^{-1} was recorded under S_0 *i.e.,* control (Table 4). The results are supported by the findings of Memon *et al.* (2013), who noted increased number of corms under the influence of KNO_3 treatment in gladiolus cv. White Friendship. Similarly, numerous workers (Khan *et al.* 2012; Lehri *et al.* 2011; Rajhansa *et al.* 2011; Butt, 2005; Pant, 2005; Bijimol and Singh, 2001) reported similar results while working on different cultivars of gladiolus.

Perusal of data (Table 4) revealed that number of cormels plant^{-1} increased simultaneously with each increment in $CaNO_3$ spray doses. Significantly maximum number of cormels plant^{-1} was recorded under treatment S_3 (39.94), followed by S_2 (31.24) and S_1 (24.78). Minimum number of cormels plant 1 was significantly recorded under control (S_0). The present results regarding number of cormels plant^{-1} were in conformity with findings of Khan *et al.* (2012), who achieved highest cormel yield under nitrogen (250 kg ha^{-1}) treatment in gladiolus. Similarly, Baral *et al.* (2012) observed highest number of cormels plant^{-1} at 200 kg ha^{-1} nitrogen while working on three different cultivars (*viz.*, American Beauty, Interpret and Candyman) of gladiolus.

From the perusal of data (Table 4) pertaining

calcium nitrate sprays, significantly highest propagation coefficient was calculated by S_3 (13.10), followed by S_2 (11.90), S_1 (9.06) and S_0 (4.51). Since the propagation coefficient is calculated on the basis of number of corms and cormels produced plant^{-1}, which were recorded more in $CaNO_3$ sprays as compared to control. Hence, the propagation coefficient was observed best in plants sprayed with $CaNO_3$ as against the control.

Among cormel grades, the highest and lowest corm dry weight at 75, 90, 105 and 120 DAP was registered by cormel grade G_3 and G_1. The probable cause of increased corm dry weight plant^{-1} could be attributed to the source and sink relationship. Big sized underground structures produce healthy plants having increased vegetative growth characteristics leading to the production of more assimilates translocated to the corms up to the end of the growth period. This leads to the production of bigger size corms which in turn recorded maximum corm dry weight plant^{-1} in the present study.

Among cormel grades, highest (0.014, 0.018, 0.022) corm RGR was observed by cormel grade G_3 for the growth interval 75-90, 91-105 ad 106-120 DAP. Lowest corm RGR was measured by G_1 grade for the same growth intervals of 75-90, 91-105 and 106-120 DAP. The increase in corm RGR under the influence of cormel grades may be due to the sufficient number of leaves, more plant height and leaf area which lead to more photosynthesis and subsequently good growth resulting in increased corm dry weight plant^{-1} and ultimately the corm RGR.

With the increase in cormel grade (from G_1 to G_3) there was a significant gain in weight of main corm plant^{-1} recorded after harvest. Significantly highest weight of main corm plant^{-1} was registered with G_3 (31.02 g), followed by G_2 (25.22 g) and minimum by G_1 (19.37 g). Increase in main corm weight in response to cormel grades may be attributed to availability of more food reserves stored in the large sized corms sufficient for enhancing the vegetative growth thereby promoting the corm weight. The results of the present investigation are in line with the findings of Verma *et al.* (2015), who authenticated that large corm size (4-5 cm) resulted in maximum corm weight in gladiolus cv. Nova Lux. Similar results were reported by Narayan *et al.* (2013), that large corm size produced highest weight of corms in gladiolus.

Diameter of main corm plant^{-1} increased significantly with the increase in cormel grades from G_1 to G_3. Significantly largest corm plant^{-1} was measured by grade G_3 (6.44 cm), followed by G_2 (5.62 cm) and G_1 (4.95 cm) grades. The most probable reason for increase in diameter of main corm under the effect of cormel grade is the availability of stored food material in large sized corms that improves both vegetative as well as corm growth characteristics. The results of the present study are in conformity with the findings of Verma *et al.* (2015), who employed two different corm grades (3-4 and 4-5 cm) of gladiolus cv. Nova Lux for the studies and reported that large sized corm (4-5 cm) produced maximum corm size as compared to smaller ones.

The data recorded on number of corms plant^{-1} influenced by cormel grades, revealed that with the increase in cormel grade (from G_1 to G_3) there was significant increase in the number of corms plant^{-1}. Significantly maximum number of corms plant^{-1} was recorded for G_3 (2.13), followed by G_2 (1.67) and G_1 (1.23). The latter two treatments were also statistically different from each other. Corm/cormel yield is directly related to the corm size (Ogale *et al.* 1995).

Since large size corm provides a good supply of reserved food used initially for vegetative growth by the plant and then corm growth and development. This phenomenon may be attributed to the cause for increased number of corms influenced by the size of the cormel grades. The results for number of corms plant^{-1} in terms of cormel grades are in harmony with the findings of Verma *et al.* (2015), who reported increased corm number was produced by the large sized corm in gladiolus cv. Nova Lux.

Number of cormels plant^{-1} after harvest less significantly increased with increase in cormel grades from G_1 to G_3. Significantly maximum cormel number was obtained from cormel grade G_3 (34.28), followed by at par treatments G_2 (28.06) and G_1 (22.71). The results of present investigation are in agreement with the findings of Verma *et al.* (2015), who reported that cormel number varied significantly under the influence of cormel grades recording maximum number of cormels with the large sized corm (4-5 cm) in gladiolus cv. Nova Lux. Similar were the findings of Narayan *et al.* (2013), who reported that large size corms (25 g) produced more number of cormels in gladiolus cv. White Prosperity.

Among cormel grades, significantly highest propagation coefficient was calculated under cormel grade G_3, followed by G_2, whereas, smallest grade G_1 calculated significantly lowest propagation coefficient in gladiolus cv. Priscilla. As the propagation coefficient has been calculated on account of number of corms and cormels plant^{-1}, which were recorded highest under largest cormel grade than smaller grades. Hence, the best propagation coefficient under G_3 can be directly attributed to the production of more number of corms/cormels plant^{-1} by the bigger sized cormel grade as compared to the smaller ones.

The present investigation revealed that among the calcium nitrate spray treatments, four sprays of calcium nitrate at 45, 60, 75 and 90 days after planting (S_3) was the best in recording the vegetative growth and corm production in gladiolus cv. Priscilla. In case of cormel grades, grade 2.5-3.0 cm was superior in registering improved vegetative as well as corm growth characteristics.

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Effect of integrated weed management on nutrient uptake by weeds and yield of gladiolus (*Gladiolus hybridus* Hort.)

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ABSTRACT

An experiment was conducted to study nutrient uptake and yield of gladiolus as affected by integrated weed management cv. Pusa Srijna. A set of eleven integrated treatments laid out in simple randomized block design with three replications. The results revealed that maximum uptake of nitrogen, phosphorus and potassium by weeds was 24.0, 8.9 and 25.6 kg/ha, respectively, in weedy check (T_{11}) and minimum uptake of nitrogen, phosphorus and potassium by weeds was 4.1, 1.2 and 6.6 kg/ha, respectively, in T_5, *i.e.* application of metribuzin 0.4 kg/ha pre-emergence + residue (dry grass 5 t/ha). The maximum uptake of nitrogen, phosphorus and potassium by gladiolus was 19.6, 6.7 and 25.4 kg/ha, respectively, in weed free check (T_{10}) and minimum uptake of nitrogen, phosphorus and potassium by gladiolus was 7.1, 2.6 and 15.4 kg/ha, respectively, in weedy check (T_{11}). The yield of corms, cormels and number of marketable spikes/ha, net profit and benefit cost ratio was received maximum with the application of metribuzin 0.4 kg/ha pre-emergence + residue (dry grass 5.0 tonnes/ha).

Key words: Gladiolus, weedicides, pre-emergence, post-emergence.

INTRODUCTION

Gladiolus is an important cut flower crop commercially grown in many tropical, sub-tropical and temperate parts of the world. It is popular for its attractive spikes having florets of huge form, dazzling colours varying sizes and long keeping quality. The importance of gladiolus as cut flowers is increasing day by day in domestic as well as international market. In recent years, several new cultivars of gladiolus with wide range of colours have been developed for different markets. In the modern agriculture, the weed control is becoming essential for higher yield of gladiolus. Employing labour increases cost of cultivation and affects successful commercial flower production. Integrated weed management is effective, economic and eco-friendly approach in improving and sustaining the agricultural productivity (Foy 1993). Weeds that grow with crop deplete considerable amount of nutrients and soil moisture thereby resulting poor crop growth. Control of weeds is very important not only to check the losses, caused by them, but also to increase the fertilizer use efficiency (Kaur *et al.* 2013). Therefore, the present

experiment was undertaken to evaluate the comparative performance of herbicides alone and weed combination on nutrient uptake and yield of gladiolus cv. Pusa Srijana.

MATERIALS AND METHODS

A field experiment was carried out at the experimental farm of the Division of Floriculture and Landscaping, ICAR–Indian Agricultural Research Institute, New Delhi, during *Rabi* season of 2014-2015. The experiment was planted in October, 2014 which laid out in randomized complete block design with eleven treatments and replicated thrice. Row to row distance 40 cm and plant to plant 15 cm was maintained in a plot size of 2.5 m to 2.0 m. The weed control treatments imposed are: T_1 (Atrazine 1.0 kg/ha pre-emergence), T_2 (Atrazine 0.75 kg/ha pre-emergence + metsulfuron-methyl @ 0.005 kg/ha post-emergence at 40 DAS), T_3 (Atrazine 0.75 kg/ha pre-emergence + carfentrazone @ 0.030 kg/ha post-emergence at 40 DAP), T_4 (Atrazine 0.75 kg/ha pre-emergence + residue (dry grass 5 tonnes/ha)), T_5 (Metribuzin 0.4 kg/ha pre-emergence + residue (dry grass 5 tonnes/ha)), T_6 (Metribuzin 0.4 kg/ha pre-emergence + metsulfuron-methyl @ 0.005 kg/ha post-emergence at 40 DAS), T_7 (Pendimethalin 1.0 kg/ha pre-emergence + residue (dry grass 5 tonnes/ha)), T_8 (Pendimethalin 0.75 kg/ha pre-emergence + carfentrazone @ 0.030 kg/ha post emergence at 40 DAS), T_9 (Pendimethalin 0.75 kg/ha + metribuzin 0.3 kg/ha (tank-mix) pre-emergence), T_{10} (Weed free check (4 hand weeding)), T_{11} (Weedy check). Hand weeding and weedy check treatments were kept for comparison with weedicides treatments. A uniform dose of 120 kg N, 80 kg P_2O_5, 80 kg K_2O/ha was applied to the crop as basal dose. Pre-emergence herbicides, residue and post-emergence herbicides were applied treatment-wise after planting and thereafter 40 days after planting of corms with the help of a hand operated knapsack sprayer fitted with flat-fan nozzle. Uniform size of gladiolus corms (4.0-5.0 cm), cv. Pusa Srijna were planted on 31.10.14. The N-content were measured by Kjeldahl method, and the P-content with spectrophotometer and the potassium content by flame photometer in weeds and gladiolus plants.

RESULTS AND DISCUSSION

The results revealed that maximum uptake of nitrogen, phosphorus and potassium by weeds was 24.0, 8.9 and 25.6 kg/ha, respectively, in weedy check (T_{11}) due to heavy weed infestation and minimum uptake of nitrogen, phosphorus and potassium by weeds was 4.1, 1.2 and 6.6 kg/ha, respectively, in T_5, *i.e.* application of metribuzin 0.4 kg/ha pre-emergence + residue (dry grass 5 t/ha) due to reduced germination and emergence of weeds by inhibiting photosystem II of photosynthesis by disrupting electron transfer. This results in death due to starvation in the target plant. Bankar and Mukhopadhyay (1990) concluded in tuberose experiment that leaf N content was positively correlated but leaf P and K contents were negatively correlated with number of flower spikes. The maximum uptake of nitrogen, phosphorus and potassium by gladiolus was 19.6, 6.7 and 25.4 kg/ha, respectively, in weed free check (T_{10}) due to less weed infestation which makes available the required nutrients, air and free space to crop plants and minimum uptake of nitrogen, phosphorus and potassium by gladiolus was 7.1, 2.6 and 15.4 kg/ha, respectively, in weedy check (T_{11}) due to heavy weed infestation. Singh and Bal (2013) found in their findings that the maximum leaf P and K content in jujube plants were recorded with paddy straw

Table 1: Effect of integrated weed management on NPK uptake kg/ha by weeds.

Treatment	N	P	K
T_1: Atrazine 1.0 kg/ha pre-emergence	8.8	2.8	9.0
T_2: Atrazine 0.75 kg/ha pre-emergence + metsulfuron-methyl @ 0.005 kg/ha post-emergence at 40 DAS	7.7	2.6	10.3
T_3: Atrazine 0.75 kg/ha pre-emergence + carfentrazone @ 0.030 kg/ha post-emergence at 40 DAS	7.2	2.9	11.5
T_4: Atrazine 0.75 kg/ha pre-emergence + residue (dry grass 5 tonnes/ha)	4.7	1.4	7.3
T_5: Metribuzin 0.4 kg/ha pre-emergence + residue (dry grass 5 tonnes/ha)	4.1	1.2	6.6
T_6: Metribuzin 0.4 kg/ha pre-emergence + metsulfuron-methyl @ 0.005 kg/ha post-emergence at 40 DAS	7.0	2.5	11.3
T_7: Pendimethalin 1.0 kg/ha pre-emergence + residue (dry grass 5 tonnes/ha)	4.9	1.3	7.0
T_8: Pendimethalin 0.75 kg/ha pre-emergence + carfentrazone @ 0.030 kg/ha post emergence at 40 DAS	9.1	2.6	10.3
T_9: Pendimethalin 0.75 kg/ha + metribuzin 0.3 kg/ha (tank-mix) pre-emergence	8.3	2.5	12.3
T_{10}: Weed free check (4 hand weeding)	0	0	0
T_{11}: Weedy check	24.0	8.9	25.6
SE±	0.2	0.01	0.5
CD(P=0.05)	0.7	0.2	1.2

Table 2: Effect of integrated weed management on NPK uptake (kg/ha) by gladiolus.

Treatment	N	P	K
T_1: Atrazine 1.0 kg/ha pre-emergence	11.1	4.3	21.3
T_2: Atrazine 0.75 kg/ha pre-emergence + metsulfuron-methyl @ 0.005 kg/ha post-emergence at 40 DAS	10.4	3.9	20.3
T_3: Atrazine 0.75 kg/ha pre-emergence + carfentrazone @ 0.030 kg/ha post-emergence at 40 DAS	10.1	2.8	18.6
T_4: Atrazine 0.75 kg/ha pre-emergence + residue (dry grass 5 tonnes/ha)	15.3	5.4	21.6
T_5: Metribuzin 0.4 kg/ha pre-emergence + residue (dry grass 5 tonnes/ha)	18.5	4.3	18.0
T_6: Metribuzin 0.4 kg/ha pre-emergence + metsulfuron-methyl @ 0.005 kg/ha post emergence at 40 DAS	11.9	4.3	18.6
T_7: Pendimethalin 1.0 kg/ha pre-emergence + residue (dry grass 5 tonnes/ha)	15.9	4.7	22.4
T_8: Pendimethalin 0.75 kg/ha pre-emergence + carfentrazone @ 0.030 kg/ha post emergence at 40 DAS	17.6	5.7	18.4
T_9: Pendimethalin 0.75 kg/ha + metribuzin 0.3 kg/ha (tank-mix) pre-emergence	14.7	4.6	18.8
T_{10}: Weed free check (4 hand weeding)	19.6	6.7	25.4
T_{11}: Weedy check	7.1	2.6	15.4
SE±	0.3	0.1	0.4
CD(P=0.05)	0.8	0.3	1.1

mulch. Johri *et al*. (1992) reported that the uptake of NPK was greatest in grass weeds and least in the sedge; broadleaved weeds removed NPK at a moderate rate in wheat. Application of 1 kg/ha of isoproturon was superior to 0.5 kg *a.i.* in reducing NPK removal by weeds and increasing NPK uptake by the crop.

The application of metribuzin 0.4 kg/ha pre-emergence + residue (dry grass 5.0 t/ha)

Table 3: Economics of different treatment combinations of gladiolus cultivar Pusa Srijna (2014-15).

Treatment	Corm and cormel yield (q/ha)	Spike (lakh/ha)	Returns from corms (lakh Rs/q) (A)	Returns from spike (lakh Rs/ha) (B)f	Total gross returns (lakh Rs/ha) (A+ B)	Common cost of cultivation (lakh Rs/ha)	Treatment cost (Rs/ha)	Total cost of production (lakh Rs/ha)	Net returns (lakh Rs/ha)	Benefit: cost
T_1	43.59	1.27	1.30	3.81	5.12	3.44	600	3.45	1.66	1.48
T_2	32.88	1.25	0.98	3.77	4.75	3.44	613	3.45	1.30	1.37
T_3	40.70	1.22	1.22	3.67	4.88	3.44	885	3.45	1.42	1.41
T_4	77.34	1.41	2.32	4.22	6.54	3.44	5450	3.50	3.04	1.86
T_5	89.48	1.43	2.68	4.31	6.99	3.44	6000	3.50	3.48	1.99
T_6	51.82	1.17	1.55	3.52	5.07	3.44	1163	3.46	1.61	1.46
T_7	72.46	1.31	2.17	3.93	6.11	3.44	5500	3.50	2.60	1.74
T_8	74.47	1.34	2.23	4.02	6.25	3.44	885	3.45	2.79	1.80
T_9	70.63	1.34	2.11	4.02	6.13	3.44	1200	3.46	2.67	1.77
T_{10}	74.56	1.31	2.23	3.93	6.17	3.44	20,475	3.65	2.51	1.68
T_{11}	21.20	0.18	0.63	0.63	1.17	3.44	Nil	3.44	-2.27	-0.34

1. Rate of corms @ 3000/q, 2. Rate of spikes @ 3.00 per spike

produced the maximum marketable spikes (1.43 lakh) per ha as compared to control (0.18 lakh). Higher spike yield might be attributed to the availability of nutrients, moisture and less competition from weeds for sunlight and space. The lowest marketable spike (0.18 lakh) was obtained in weedy check. This was due to severe weed competition which ultimately resulted in lower yield. Similar results were also obtained by Swaroop *et al.* (2014) in gladiolus. T_5, *i.e.* application of metribuzin 0.4 kg/ha pre-emergence + residue (dry grass 5.0 tonnes/ha) produced the maximum corms yield and cormels yield. This could be due to reduced weed competition and promoting crop growth, which provided a favourable environment for growth. The results of present investigation are in line with that of results reported by Bhat *et al.* (2013), Kadam *et al.* (2014), Swaroop *et al.* (2014), Kumar *et al.* (2012) and Manuja *et al.* (2005) in gladiolus.The maximum net profit (Rs. 3.48 lakh/ha) and benefit cost ratio (1.99) was obtained at T_5, *i.e.* application of metri-buzin 0.4 kg/ha pre-emergence + residue (dry grass 5 tonnes/ha). This could be due to reduced weed competition and promoting crop growth, which provided a favourable environment for growth; whereas, T_{11}, *i.e.* control treatment (weedy check) gave the lowest benefit cost ratio (-0.34) due to heavy weed infestation.

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Effect of substrate type on growth and development in lily

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ABSTRACT

This study was conducted to evaluate the growth and development response of different substrate types on the commercial varieties of LA-hybrid lilies *viz.* Courier and Cilesta. Different substrates types (T_1) sand + soil + FYM (1:1:1 v/v), (T_2) sand + soil + FYM (2:1:1 v/v), (T_3) cocopeat + FYM (1:1 v/v), (T_4) cocopeat + soil + FYM (1:1:1 v/v), (T_5) (sand + soil + FYM) + cocopeat (1:1 v/v), (T_6) (sand + soil + FYM) + vermicompost (2:1 v/v), (T_7) (sand + soil + FYM) + vermicompost + cocopeat (2:1:1 v/v) were used to check the best suitable substrate for lilium cultivation under protected conditions. Plant parameters of growth and development such as spike length, plant height, days to flowering, number of flowers per plant and bud length showed best results with cocopeat + FYM in both the cultivars. Maximum bulb size found in Cilesta than Courier with cocopeat + FYM. Interaction effects between substrate and cultivars resulted significant effect on all the measured bulbous. In conclusion, media amended with cocopeat, could be used successfully in lily forcing with an appropriate fertilization program.

Key words: *Lilium*, substrate, flower quality, bulb traits.

INTRODUCTION

The genus *Lilium* belong to family Liliaceae includes 110-115 species that are distributed throughout cold and temperate regions of the northern hemisphere, especially East Asia and North America (McRac, 1998; Liang and Tamura, 2000). Due to its size, beauty and longevity, lilium is one of the ten most important cut flowers in the world (Thakur *et al.* 2005) and ranked fourth for value on the Dutch auction. Lilium hybrids have a wide range of colours and shape which are produced from interspecies hybridization. The popularity of these hybrids, especially Longiflorum Asiatic, Oriental and Oriental Trumpet types, is increasing both as cut flower, pot plants and grown in the garden (Lian *et al.* 2003).

Lilium can be planted in a wide variety of soils, but ideally a sandy soil with a high organic content and good drainage is optimal (Miller, 1993). Due to the requirement for a lightweight medium without excessive water holding capacity, soilless culture of lilium may be advantageous. Grassotti *et al.* (2003) investigated the effects of time and media on Narbonne and Cordelia lilies. They recommended cocopeat over the other investigated media (perlite and coco peat, either used singly, mixed together or mixed with clay pellets or peat) in terms of improved flower size, stem length and stem weight. Tribulato *et al.* (2003) investigated the effects of density and

media on Star Gazer Oriental lily and Elite Asiatic lily. The media were expanded clay, perlite and basalt as single media or mixed with peat. They concluded that the effect of media was more important than plant density on the quality of lilium flowers.

For proper growth and development, a medium must serve four functions: (1) provide water, (2) supply nutrients, (3) permit gas exchange to and from the roots and (4) provide support for the plants. The physical and chemical properties of media like structure, texture, pH as well as nitrogen, phosphorus and potassium are the dominant factors for the growth and development of plant. These properties determine the availability of nutrients to plants, mobility of water into or through soil and penetration of roots in the soil. The purpose of this study was to investigate the influence of different growing media with different combinations on the growth and development of lilium.

MATERIALS AND METHODS

The experiment was conducted at the ICAR-Indian Agricultural Research Institute, Regional Station, Katrain, Kullu-Valley, Himachal Pradesh during 2014-15 with the objective to test the efficacy of seven substrates on growth and development of hybrid lily. The site is located at an altitude of 1650 amsl at latitude of 31058'00"N and longitude of 77006'4" E. The climate of the area is typical temperate type. The experiment was laid out in two factor factorial randomized block design consisting of two LA-hybrid lily cultivars *viz.* Courier and Cilesta using seven growing medium (T_1) sand + soil + FYM (1:1:1 v/v), (T_2) sand + soil + FYM (2:1:1 v/v), (T_3) cocopeat + FYM (1:1 v/v), (T_4) cocopeat + soil + FYM (1:1:1 v/v), (T_5) (sand + soil + FYM) + cocopeat (1:1 v/v), (T_6) (sand + soil + FYM) + vermicompost (2:1 v/v), (T_7) (sand +soil + FYM) + vermicompost + cocopeat (2:1:1 v/v) under protected conditions with three replications. Non-vernalized bulbs were planted at a density of fifty bulbs/m^2 in the month of November. Before planting, the bulbs were treated with mancozeb (0.2%) + carbendazim (0.1%) for ½ an hour. Drenching with Mancozeb (0.2%) + Carbendazim (0.1%) was done at weekly intervals. The data recorded on various vegetative and bulb parameters were subjected to analysis of variance (ANOVA) using factorial RRD (Gomez and Gomez, 1984) and treatments were compared by using tabulated 'F' value at 5% level of significance.

RESULTS AND DISCUSSION

There were non-significant differences between the two cultivars Courier and Cilesta in terms of days taken to 50% at 5% level (Table 1). Further, it is clear from the table that earliest sprouting (70.8 days) was observed when non-vernalized bulbs were planted in cocopeat + FYM. Like cumulative effect of substrate and cultivars, they showed similar effects on reducing the number of days taken to 50% sprouting in both the cultivars. Earliest sprouting in cultivar Cilesta (63.0 days) was recorded with cocopeat + FYM. Data on plant height presented in Table 1 reveals that plant height was more in cultivar Cilesta (113.1 cm) as compared to Courier (73.0 cm). Similar variation among lilium varieties with respect to plant height was also reported by Dalai *et al.* (2015). It is clear from the table that maximum plant height (104.7 cm) was observed with cocopeat + soil + FYM. Interaction cultivars and substrate showed that maximum plant height (129.3 cm) in cultivar Cilesta was recorded with cocopeat + FYM. These observations are in line with the findings

Table 1: Effect of substrates on days to 50% sprouting (days) and plant height (cm) in lilium cultivars.

Treatment	Days to 50% sprouting			Plant height (cm)		
	Courier	Cilesta	Mean	Courier	Cilesta	Mean
T_1 = Sand + Soil + FYM (1:1:1; v/v)	107.7	107.0	107.3	56.1	106.0	81.1
T_2 = Sand + Soil + FYM (2:1:1; v/v)	89.7	93.0	91.3	75.2	102.7	88.9
T_3 = Cocopeat + FYM (1:1; v/v)	78.7	63.0	70.8	75.3	129.3	102.8
T_4 = Cocopeat + Soil + FYM (1:1:1; v/v)	85.0	90.3	87.7	83.0	126.3	104.7
T_5 = (Sand + Soil + FYM) + cocopeat (1:1; v/v)	92.0	89.7	90.8	83.9	105.9	94.9
T_6 = (Sand + Soil + FYM) + vermicompost (2:1; v/v)	92.3	91.0	91.7	68.9	124.5	96.7
T_7 = (Sand + Soil + FYM) + vermicompost + cocopeat (2:1:1; v/v)	94.3	104.3	99.3	67.6	97.3	84.4
Mean	91.2	91.2		73.0	113.1	
	CD (P=5%)			CD (P=5%)		
	Cultivars = NS			Cultivars = 2.402		
	Growing Media = 2.356			Growing media= 4.494		
	Cultivars x Growing Media = 3.332			Cultivars x Growing Media = 6.356		

of Fred *et al.* (1997) where they found that ornamental plants like chrysanthemum showed maximum plant height when grown in compost mixes.

Length of flowering stem is an important trait of cut flowers and longer stems are always preferred which fetch better price. Maximum spike length (98.7 cm) was found in cultivar Cilesta as compared to Courier (52.9 cm). It is clear from the table that maximum spike length (91.7 cm) was recorded with cocopeat + FYM + soil growing media. Interaction between cultivars and substrate revealed that cocopeat + FYM resulted maximum spike length (116.6 cm) in cultivar Cilesta. The highest stem length of lilium was reported in cocopeat by Grassotti *et al.* (2003). Tribulato and Noto (2001) also reported that using a mixture of peat and basalt increases flower stem length in lilium cultivars.

Data pertaining to number of days taken to lower

Table 2: Effect of substrates on spike length (cm) and number of days taken for the lower most bud to show colour (days) on lilium cultivars.

Treatment	Spike length (cm)			Number of days taken for the lower most bud to show colour (days)		
	Courier	Cilesta	Mean	Courier	Cilesta	Mean
T_1 = Sand + Soil + FYM (1:1:1; v/v)	33.7	90.6	62.2	175.7	159.0	178.3
T_2 = Sand + Soil + FYM (2:1:1; v/v)	49.7	86.7	68.2	169.0	166.7	174.4
T_3 = Cocopeat + FYM (1:1; v/v)	47.4	116.6	82.0	162.0	147.0	167.2
T_4 = Cocopeat + Soil + FYM (1:1:1; v/v)	70.5	112.9	91.7	168.4	172.0	171.3
T_5 = (Sand + Soil + FYM) + cocopeat (1:1; v/v)	67.4	88.5	77.9	169.3	167.5	171.0
T_6 = (Sand + Soil + FYM) + vermicompost (2:1; v/v)	54.9	113.5	84.2	169.2	172.5	171.3
T_7 = (Sand + Soil + FYM) + vermicompost + cocopeat (2:1:1; v/v)	46.4	82.0	64.2	171.5	172.0	173.1
Mean	52.9	98.7		169.3	165.3	
	CD (P=5%)			CD (P=5%)		
	Cultivars = 1.551			Cultivars = 1.260		
	Growing Media = 2.901			Growing media= 2.357		
	Cultivars x Growing Media = 4.103			Cultivars x Growing Media = 3.33		

most bud to show colour presented in Table 2 revealed that cultivar Cilesta (165.3 days) took less number of days to show bud colour. Further, this shows that earliest bud colour showing (167.2 days) was observed with cocopeat + FYM. These results are in line with the findings of Grassotti *et al*. (2003) who observed the reduce time to flowering in media containing coconut fiber together are mixed with clay pellets or peat. The interaction effect of cultivar and substrate showed that minimum number of days taken to show the bud colour was observed in cultivar Cilesta (147.0 days) when bulb were planted in cocopeat + FYM.

In general, cultivar Cilesta (167.3 days) took less number of days to flowering as compared to Courier (172.4 days) (Table 3). Further, data also shows that earliest flowering (158.6 days) was recorded when bulbs were grown in cocopeat + FYM. Trader (2008) also reported that lilium grown in cocopeat flower earlier than the control. Data pertaining to interaction between cultivars and substrate revealed that cocopeat + FYM resulted in earliest flowering in both the cultivars. The effect of growing media was more pronounced in cultivar Cilesta as compared to Courier. Table 3 clearly indicated that cultivar Cilesta produced more flowers per plant (5.3) than Courier (3.5). Among different substrates, maximum flowers (4.9) were recorded with cocopeat + FYM. Interactions show that in cultivar Cilesta (5.9) maximum numbers of flowers were recorded with cocopeat + FYM. Beneficial effects of cocopeat amended substrate in terms of good water holding capacity, high porosity and nutritive value on plant growth and development might have resulted in better performance with respect to various floral characters as observed in the present study.

Flower bud length differed in both the cultivars significantly. In general, flower bud of cultivar Cilesta (11.3 cm) were longer than Courier (9.3 cm) (Table 4). Similar bud length in lilium cultivars was also reported by Dalai *et al*. (2015). Planting of bulbs in cocopeat + soil + FYM gave maximum flower bud length (10.9 cm). The interaction effect reveals that in cultivar Cilesta maximum flower bud length was recorded in cocopeat + soil + FYM, which was found to be at par with (sand + soil + FYM) + vermicompost. Vermicompost is bulky organic

Table 3: Effect of substrates on days to flowering (days) and number of flowers per spike on lilium cultivars.

Treatment	Days to flowering (days)			Number of flowers per spike		
	Courier	Cilesta	Mean	Courier	Cilesta	Mean
T_1 = Sand + Soil + FYM (1:1:1; v/v)	178.3	161.3	169.8	3.0	4.7	3.8
T_2 = Sand + Soil + FYM (2:1:1; v/v)	174..4	168.7	171.5	4.3	5.0	4.6
T_3 = Cocopeat + FYM (1:1; v/v)	167.2	150.0	158.6	4.1	5.9	4.9
T_4 = Cocopeat + Soil + FYM (1:1:1; v/v)	171.3	173.3	172.3	3.6	5.4	4.5
T_5 = (Sand + Soil + FYM) + cocopeat (1:1; v/v)	171.0	169.5	170.3	3.5	4.1	3.8
T_6 = (Sand + Soil + FYM) + vermicompost (2:1; v/v)	171.3	174.8	173.0	3.2	5.5	4.4
T_7 = (Sand + Soil + FYM) + vermicompost + cocopeat (2:1:1; v/v)	173.1	173.5	173.3	2.8	6.4	4.6
Mean	172.4	167.3		3.5	5.3	
	CD (P=5%) Cultivars = 1.043 Growing Media = 1.951 Cultivars x Growing Media = 2.759			CD (P=5%) Cultivars = 0.412 Growing media= 0.772 Cultivars x Growing Media = 1.091		

Table 4: Effect of substrates on bud length (cm) in lilium cultivars.

Treatment	Bud length (cm)		
	Courier	Cilesta	Mean
T_1 = Sand + Soil + FYM (1:1:1; v/v)	9.3	11.7	10.5
T_2 = Sand + Soil + FYM (2:1:1; v/v)	8.9	10.3	9.6
T_3 = Cocopeat + FYM (1:1; v/v)	9.3	11.6	10.5
T_4 = Cocopeat + Soil + FYM (1:1:1; v/v)	9.4	12.3	10.9
T_5 = (Sand + Soil + FYM) + cocopeat (1:1; v/v)	9.4	11.7	10.6
T_6 = (Sand + Soil + FYM) + vermicompost (2:1; v/v)	9.2	12.1	10.7
T_7 = (Sand + Soil + FYM) + vermicompost + cocopeat (2:1:1; v/v)	9.2	9.2	9.2
Mean	9.3	11.3	
	CD (P=5%) Cultivars = 0.199 Growing Media = 0.372 Cultivars x Growing Media = 0.526		

manure rich in enzymes and plant nutrients, beneficial bacteria and mycorrhizae. It increases total microbial population of nitrogen fixing bacteria actinomycetes and symbiotic association of mycorrhiza on plant root system. Hence, its beneficial effects as one of the ingredients in medium on plant growth and floral characters observed in the present investigation.

Data in Table 5 revealed that cultivar Cilesta produced more number of bulbs (1.65) as compared to Courier (1.26). It is clear from the table that bulblet formation was significantly higher in Cilesta (7.49) than Courier (5.83). Further, among different substrate types, maximum bulblets formation (10.33) was recorded when bulbs were grown in cocopeat + FYM (1: 1; v/v). The interaction cultivar and substrate revealed that maximum bulblet formation in cultivar Cilesta (12.22) was also noticed in cocopeat + FYM (1: 1; v/v). Data also reveals that maximum fresh weight of bulb (57.23g) was observed in cv. Cilesta than Courier. Similar variation in bulb weight in lilium cultivars was also reported by Dalai *et al*. (2015). Among different substrates,

Table 5: Effect of substrates on bulbous traits in lilium cultivars.

Treatment	Number of bulbs			No. of bulblets			Weight of bulb (g)		
	Courier	Cilesta	Mean	Courier	Cilesta	Mean	Courier	Cilesta	Mean
T_1	1.1	1.8	1.45	1.18	4.90	3.04	33.38	39.08	36.23
T_2	1.1	1.6	1.35	5.20	5.77	5.48	48.97	46.90	47.93
T_3	1.5	1.8	1.60	8.44	12.22	10.33	43.56	68.12	55.84
T_4	1.4	1.2	1.30	3.11	8.11	5.61	43.55	79.03	61.29
T_5	1.4	1.6	1.50	10.83	8.27	9.55	32.67	46.03	39.35
T_6	1.1	1.8	1.46	6.11	6.87	6.49	55.83	76.43	66.13
T_7	1.2	1.8	1.50	5.95	6.27	6.11	32.96	45.05	39.01
Mean	1.26	1.65		5.83	7.49		41.56	57.23	
CD (P=5%)	Growing Media: NS Varieties:0.193 Growing media x varieties:NS			Growing Media: 1.885 Varieties:1.007 Growing media x varieties:2.666			Growing Media: 10.931 Varieties:5.843 Growing media x varieties:15.459		

Table 6: Effect of substrates on bulbous traits in lilium cultivars.

Treatment	Size of bulb (cm)			Size of bulblet (cm)			Average weight of bulblets (g)		
	Courier	Cilesta	Mean	Courier	Cilesta	Mean	Courier	Cilesta	Mean
T_1	9.75	12.41	11.08	2.28	4.11	3.19	0.88	9.04	4.96
T_2	10.76	12.25	11.50	3.90	3.90	3.90	10.27	9.08	9.67
T_3	12.49	14.86	13.68	4.44	4.17	4.30	12.63	16.97	14.80
T_4	10.61	13.61	12.11	3.16	3.89	3.52	4.54	11.17	7.85
T_5	11.34	11.89	11.61	4.52	3.78	4.15	22.33	11.81	17.07
T_6	11.25	14.17	12.71	3.53	3.55	3.54	7.88	12.49	10.18
T_7	9.47	12.31	10.89	3.58	3.44	3.51	8.937	6.86	7.89
Mean	10.81	13.07		3.63	3.83		9.64	11.06	
CD (P=5%)	Growing Media: 1.452			Growing Media: 0.507			Growing Media: 2.404		
	Varieties:0.776			Varieties: NS			Varieties:1.285		
	Growing media x varieties:NS			Growing media x varieties:0.717			Growing media x varieties:3.399		

T_1 = Sand + soil + FYM (1:1:1 v/v), T_2 = Sand + soil + FYM (2:1:1 v/v), T_3 = Cocopeat + FYM (1:1 v/v),
T_4 = Cocopeat + soil + FYM (1:1:1 v/v), T_5 = (Sand + soil + FYM) + Cocopeat (1:1 v/v),
T_6 = (Sand + soil + FYM) + Vermicompost (2:1 v/v), T_7 = (Sand + soil +) + Vermicompost + Cocopeat (2:1:1 v/v)

maximum (66.13 g) fresh weight of bulb was recorded in (sand + soil + FYM) + vermicompost (2:1 v/v). Interaction effect showed that in cultivar Cilesta maximum fresh weight of bulb (79.03 g) was recorded with cocopeat + soil + FYM (1:1:1 v/v).

Maximum bulb size (13.07 cm) was found in cv. Cilesta than Courier (10.81 cm) (Table 6). Maximum bulb size (13.68 cm) was observed when bulbs were grown in cocopeat + FYM (1:1; v/v). These results are in close conformity with the findings of Dalai *et al.* (2015). Size of bulblets were observed maximum (4.30 cm) in cocopeat + FYM (1:1; v/v). This can be attributed to the fact that cocopeat have optimum K content. More K leads to more bulblet size. This is in conformity with the findings of Varshney *et al.* (2001) in which it was observed that an increase in the dose of potassium improved bulblet size. An interaction reveals that maximum bulblet size (4.52 cm) was recorded in cv. Courier in (sand + soil + FYM) + cocopeat (1:1; v/v). The larger bulblet sizes observed in the substrate amended with cocopeat may be due to the fact that cocopeat showed high water holding capacity, better aeration, more food reserves and porosity of the media which might have helped in better development of root system. It is also clear from the data presented in Table 6 that fresh weight of bulblets were higher in Cilesta (11.06 g) than Courier (9.64 g). Among different substrate types, maximum fresh weight of bulblets (17.07 g) was recorded in (sand + soil + FYM) + cocopeat (1:1; v/v). Interaction between substrate and cultivars shows that fresh weights of bulblets were higher (22.33 g) in cv. Courier when bulbs were grown in (sand + soil + FYM) + cocopeat (1:1; v/v).

In conclusion, media amended with cocopeat, due to suitable physical, chemical and biological properties could be used successfully in lily forcing with an appropriate fertilization program.

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Book Review

Ornamental plants and garden design in tropics and subtropics

(Hard bound, Two volume set in a jacket, published 2015), Price Rs. 9,995 + postage.

Edited by

T.K. Bose, L.J. Singh, M.K. Sadhu, T.K. Maity, R.S. Dhua, S. Chakraborty and K.B. Jagtap

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India has progressed well in the field of floriculture and recently many standard books have been published, one of which is the **Ornamental Plants and Garden Design in Tropics and Subtropics** published in 2015 in two volumes with a total of 952 technical pages + *xxxvii* miscellaneous pages including 12 pages on **Preface** which is really special and very informative, and the book contains some 7,000 nice colour photographs along with drawings.

Volume I comprises of 10 chapters. Chapter 1 is on **Importance, Uses and Scope of Ornamental Horticulture** elaborating the floral wealth of various kinds in terms of plant diversity, their uses in various forms and occasions, vis-à-vis health and social benefits, scenario of floriculture industry in the country at government level as well as with the private entrepreneurs, status of global floral trade and India's share, the dry flower business, and human resource development at higher level through higher education, training and research. Chapter 2 is on **Improvement of Ornamental Plants** which elaborates the objectives of breeding, introduction and selection of plants through field trials, breeding standards for vegetatively propagated ornamentals, the scope of advance breeding techniques where apart from various methods of improvement described, embryo rescue, haploid culture, *in vitro* mutation breeding and introduction of foreign genes for improving a particular character are briefly described. The scenario of researches on ornamentals being carried out on various aspects in the country by various organizations are listed and briefly described along with activities of the All India Coordinated Research Project on Floriculture (AICRP on Floriculture) with centres in various states of the country which looks after the promotion of research programmes in floriculture with a view to develop technologies so that growers may improve their economy by growing quality products and to earn handsome foreign exchange. Chapter 3 is on a very general aspect, *i.e.* on **Garden Tools, Implements, Machineries and Accessories**. Though it is a general aspect but without these no garden activities can run. These have been described in a very elaborative manner. Chapter 4 relates to the starting point of the gardening, *i.e.* **Propagation, Establishment and Management of Nursery of Ornamental Plants**. This is the most important aspect and here the editors have given various structures necessary for gardening, *i.e.* raising of nursery,

various polythene chambers for misting, fogging, propagating and crop raising. The editors have rightly elaborated various plant structures such as seeds, bulbs, corms, rhizomes, tubers, runners, stolons, offsets and offshoots, divisions, cuttings, layering, budding and grafting together with pot types, potting, repotting and necessary media for propagation and crop cultivation, vis-à-vis maintenance of the nurseries, along with a list of various nurseries across the country dealing with ornamental plants. Now-a-days, among the people there is proper awareness about the flowers and flower products and established businessman deals only with quality produce from reliable persons or sources. Through greenhouse technology, one can produce the plants and flowers of best international quality by providing optimum required conditions under controlled atmosphere. Here in the Chapter 5 on **Greenhouse Technology and Cultivation of Ornamental Plants** the editors have enlisted the ornamentals worth growing in greenhouses, the greenhouse types and orientation, the bed types for plant raising and suitable media or soilless culture including NFT, controlled atmosphere, fertigation and various other necessary activities.

Chapters 6, 7 and 10 deal with **Trees, Shrubs and Climbers,** respectively. They have given the role of such plants, their role in combating soil erosion, air ~ water ~ and noise pollution, emitting oxygen, in controlling temperature, as windbreak, enhancing aesthetic values of the area, supplying fuel wood, timbers, fruits, flowers, litters, and animal feeds, providing shade against the scorching sun and shelter against rains and storms, working as shelter house for birds and various other animals, create a scenery of their own and against the background of an obsolete places, and so on. Under all the three categories an exhaustive account of plant species with full account of their cultivation is provided individually supported with individual photographs. Chapter 8 is on **Bulbous Plants** which include gladiolus, dahlia, tuberose, amaryllis, achimines, acorus, agapanthus, alstroemeria, amaryllis and hippeastrum, belamcanda, canna, crinum, cyclamen, eucharis, gloriosa, haemanthus, hedychium, habranthus, hemerocallis, hymenocallis, lilium, nelumbo, nymphaea, ornithogalum, pancratium, strelitzia, victoria and zantedeschia, and these are described briefly with their distribution and cultivation supported with many coloured photographs with each individual so this chapter has also been quite charming. However, calathea, sansevieria, paeony and bird of paradise though have perennial rhizome-like rootstocks but in fact these are not rhizomes so this would have been better to deal them in their respective categories, *viz.* calathea and sansevieria under house plants, and paeonia & bird of paradise under perennials or as individual cut flower plants. In such a nice book, it would have superimposed the worth of the book further if freesia, begonia, caladium, kniphofia, sparaxis, alocasia and anigozanthos would also have been added as these all are quite beautiful tropical bulbs. Chapter 9 deals with **House Plants** and this is also quite comprehensive chapter dealing with the description, the use and cultivation of almost all the common house plants whether foliage or flowering and these all are supported with many nice photographs. Orchids, palms. ferns, conifers, bromeliads, and many of the individually important house plants are described. However, the last photograph on page 421 is of *Aeonium* and not of the *Zingiber* so this should be corrected before the next edition. I understand that arranging such a vast number of photogtraphs is not an easy task,

indeliberately a few mistakes are crept while compiling the manuscript and a few creep on at the level of publisher, and such mistakes usually occur. In the end, a comprehensive **Glossary**, a few supported with photographs is presented, followed by subject **Index**.

Volume 2 comprises of 13 chapters. Chapters 11, 12, 13, 15, 16, 17, 18, 19 and 20 deal with **Annuals, Orchids, Rose, Carnation, Cacti and other succulents, Chrysanthemum, Gerbera, Anthurium and Palms,** respectively. All these crops have exhaustive lists of the respective plant species along with a comprehensive hint on their cultivation practices including management of their respective diseases and insect-pests. It would have been certainly better if the chapter on Annuals would have been titled as Annuals, Biennials and Perennials as here not only annuals but biennials and perennials are also described. Chapter on Orchids is highly elaborative touching every aspect of their life as well as the description and cultivation of individual genera and species. Rose, its comprehensive classification, propagation, the protected and otherwise cultivation are properly described which can be adopted even by a private grower to follow for technology for commercial growing. Modern commercial and otherwise cultivation of Carnation, Chrysanthemum, Gerbera and Anthurium are correctly described supported with photographs on various aspects and crops. The Chapter on Cacti and other succulents elaborates the difference between cacti and other succulents, their ecology, the propagation methods and cultivation practices so that a grower can perfect their cultivation in the tropics and subtropics and almost all the individual genera are described. The chapter on the Palms is complete in itself as what to say of ornamental palms, even oil-yielding palms are also described with their morphology, propagation, cultivation, disease and pest management and description of the individual species. Through chapter 14 on **Landscape Architecture and Garden Design,** the authors have described the evolution of the designs, the influence of religion on the design development, the principles or elements of the landscape design and various types of gardens existing in the country supported everywhere with appropriate colour photographs and drawings. Chapter 21 is on **Lawn**, the soul of a balanced garden. Various other plants compatible with lawn which may superimpose the beauty of a lawn, the choice of lawn grass species, establishment and management, everything is properly described. Chapter 22 on **Bonsai** describes the world scenario in a nutshell, about its making technique appropriate to various types, the implements and tools necessary for its making and more so about their upkeep and selection of plant species for the purpose. Chapter 23: **Flower Arrangement and Floral Decoration** is the last chapter about various use of detached flowers in ancient Indian and various other cultures, the principles of floral arrangement and design elements, the arrangement of cut flowers in various designs, dry flower arrangement including the potpourri and so on. In the end there is a column on **Bibliography** and then crop wise **Index**. However, it would have been better to give the glossary in the second volume instead of the first.

Overall the book is very comprehensive ~ a complete textbook for the postgraduate students, a comprehensive treatise for researchers and professional teachers especially up to postgraduate levels, and a perfect growing manual for the commercial flower growers and amateurs. This book certainly deserves a special place in the stack room of every library. This is

the best book on complete floriculture I have ever seen. The arrangement of 7,000 photographs is not an easy task but here everything has been executed so superbly. I congratulate the authors and publisher for this enterprise.

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