Review Article

Bulb Size and Growth Regulators on the Growth and Performance of Bulbous Ornamental Crops - A Review

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Abstract

Influence of bulb size and growth regulators on the performance of bulbous ornamental crops like Lilium, Tuberose, and Gladiolus was taken up in a study. The experiment was conducted by using different bulb size (5, 7.5, 10 cm) and these bulbs are soaked for 12 hours before planting with growth regulators like Gibberllic acid (GA_3) and Naphthalene acidic acid (NAA) before planting. The growth parameters *viz.*, Days to sprouting of 80 percent bulbs, plant height, number of leaves per plant, and leaf area were registered the highest when application of large bulb size (10 cm in diameter) along bulb treated with GA_3 @ 1000 ppm. Observation on flowering and quality parameters *viz.*, Days taken for emergence of spike, days for first floret to open, spike length, No of florets, flower bud length, flower length, flower diameter, flower weight, vase life and bulb yield characteristics *viz.*, Number of bulbs and bulblets per plant, weight of bulbs and bulblets per plant also registered the highest in the treatment combination of large bulb size (10 cm in diameter) along bulb treated with GA_3 @ 1000 ppm.

Keywords: bulb size, growth regulators, bulbous ornamental crops, Gibberllic acid, Naphthalene acidic acid

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Introduction

In the innumerable creations of nature, flowers have moved the human mind more than anything else. Floriculture is now emerging as an important venture in the agricultural world. Transformation of floriculture from a domestic into a global industry has opened up opportunities for multinational companies to have collaboration with developing countries. The area under floriculture crops have increase unbelievably from 4000 hectares in 1962 to over an area of 30,000 hectares in India Raghava and Dadlani, 2000 [1].

The area under commercial flower crops too has increased due to necessity of the peoples who are very much interested to growing in gardens, potted plants, decorating the halls, arranging the flowers in vase, making bouquet etc. In this view the cut flowers has made a big dent at the domestic level also. The country is well recognized for growing flowers because it is enriched with various eco systems. It also presents huge opportunity for commercial production and offers lucrative investment opportunity for farmer and agro entrepreneurs. Commercial cultivation of cut flowers such as Rose, Orchids, Gladiolus, Carnation, Anthurium, Gerbera, Chrysanthemum, Bird of paradise, Tulips and Lilies has also been adopted by farmers on large scale. There is high demand for these products in the domestic and international market. India has significant prowess in floriculture and it has been identified as focus area for exports. Among all cut flowers English cape lily which have a great economic value due to their showy flowers which has attracted medium scale cultivation in recent years. The global production of Lilium occurs in 10 countries. The largest production area is also in the Netherlands 4,280 ha (77%), followed by France (189 ha), China (205 ha), Japan (189 ha), and Netherland (110 ha) Emami *et al.*, 2011 [2]. The Netherlands produces 2.21 billion Lily bulbs, of which 2.21 billion are exported to the countries within the European countries (1.0 billion) and outside (0.7 billion). In India it is cultivated in the states like Himachal Pradesh, Maharashtra, Karnataka, West Bengal, Uttar Pradesh and in parts of Tamil Nadu and Andhra Pradesh. In Tamil Nadu it is cultivated for selling as a fresh flower and the most common places of cultivating Lilium *spp* are Salem, Coimbatore, Hosur, lower Palani Hills, and Shevroy Hills. Hence, attention of researches need to be focused on systematic research on commercial cultivation on English cape lily as on alternative revenue generation for the Indian farmers augmenting the supply of cut flowers to the floral industry as well as for export.

The English cape lily is a summer flowering bulb. These bulbs of English cape lily species are starchy and some are edible as root vegetables. Some bulbs are commercially grown in china as food they are eaten especially in the summer because they have the ability to reduce internal heat. They may be reconstituted and stir-fried, grated and used to thicken soup, or processed to extract starch. Flower bulbs are generally cultivated for their flower production, and there is a relationship between the reserves of the bulb scales and flower production Rees, 1992 [3]. In bulbous crops, vigor and growth of the plants are directly correlated with size of the underground organs. A certain minimum size of the bulb is essential for the plant for flower Kumar *et al.*, 2007 [4].

Plant growth regulators or plant regulators are the organic chemical compounds which modify or regulate physiological process in an appreciable measure in plants when used in small concentrations. They are readily absorbed and move rapidly through tissues when applied to different parts of the plant Dutta and Ramadas 1998 [5]. Plant growth regulators have been widely used in many ornamental crops and flower crops *viz.*, Gibberellic acid, NAA, Cycocel and Paclobutrazol have been reported to be remarkably successful in quality bloom production and gaining momentum Sanap *et al.*, 2000 [6].

Gibberllic acid (GA_3) plays an important role in the growth and development of plants. Gibberllins are a rather diverse group of plant substances that enhance any physiological or biochemical process in plants. The use of GA_3 for boosting the growth and vigor of various horticultural plants is very old and well documented Gul *et al*., 2006 [7].
Auxins have an essential role in coordination of many growth and behavioral process in the plant's life cycle. These are the chemicals synthesized by chemists that cause various physiological actions similar to IAA. Some of the synthetic acid (NAA) and 2, 4 – Dichloro phenoxy acetic acid (2, 4 - D). NAA is an Auxin which influences metabolic process and cell division. It induces flowering, reduces flower drop, increase fruit set and delay senescence Neha Chopped., 2012 [8].

Hence, Plant growth regulators have gained wide acceptance for optimizing the yield of plants by modifying growth, development and stress behavior Shukla & Farooqi, 1990 [9].
In order to meet the demand for many bulbous ornamental crops the effects are carried out to evolve an ideal bulb size of bulbous plant by the way to increase the performance of quality bulbous plant through growth regulators. Hence, having these ideas as back ground, the present investigation effect of bulb size and growth regulators on the performance of bulbous ornamental crops was taken up for the study.

Review of literature

English cape lily (*Crinum spp.*) is one of the leading cut flowers all over the world. Among various types of lilies and it seen to be the most promising in florist trade and they have a wide acceptability in floral industry, mainly as cut flowers and potted plants. The genus *Crinum* represents an important sector in family Amaryllidaceae with wide geographical distribution throughout the tropics, subtropics and warm temperate regions of the world.

English cape lily is propagated by "bulb" a underground stem storage organ. The bud development occurs on the upper surface of the daughter bulb from which the new plant grows in the following year. The bases of old leaves are thin and dry, which cover the bulb. These papery leaves are called husks. The husks overlap each other and meet to form a point at the top. While the new daughter bulb is forming on the top of old one, small new bulbs called bulblets are produced from the base. These bulblets are auxiliary buds on the bulb which is a compressed thickened stem and as the resting perpetuating organ Kumar *et al.*, 2007 [10].

Treatment of bulbs with growth regulator is important to have regulation of growth aimed at yield of spikes and bulbs in bulbous ornamental crops. The treatment of the growth regulators namely GA_3, NAA at different concentration with the selected sizes of bulbs will enhance the growth and development of the plants. In this chapter, an attempt is made to review the references related to the performance of the bulbs at different sizes and use of growth regulators in flower crops.

Effect of bulb size on growth and development

Flowers are in great demand both in internal and external markets is performed in by many factors especially use of optimum size of bulbs for planting goes a long way in influencing in the productivity and as well as the quality of the flowers in bulbous crop. The increasing size of plant material with sufficient stored food material which nourished the plant in the later stages of the development may be a reason for progressive increase in the growth of the plant. In bulbous crop, the plant size is proportional to the transplant size,

In Tuberose, Yadav *et al.*, 1984 [11] observed that planting of bulbs of Tuberose to a size of 1.5 cm diameter to a depth of 7 cm was found to be most effective in increasing the plant height, number of leaves, leaf area per plant, spike length, number of rachis, number of flowers per plant and flower yield as compared to other sizes of bulbs and various depth. Further Dhua *et al.*, 1987 [12] reported that planting of bulb to a size of (1.5, 2.5, 3.5 cm) among all this sizes, 2.5 cm increases the growth and flower production in tuberose.

According to Roa *et al.*, 1991 [13] reported that the bulb size of 2.5 cm with a depth of 5 cm increases the growth, flowering and bulb production of bulbs and various depth in tuberose. In Gladiolus Lascar and Jana 1994 [14] found that the planting of corm size at (5.3 cm) will increases the plant growth, flowering and corm production. Similarly, Yadav and Singh 1996 [15] revealed that planting of Gladiolus at a corm size of (6.0 cm) and spacing of 30 cm x 30 cm showed significant results on plant height, number of flowers per plant as compared to other treatment combination.

In Tuberose, Sathyanarayana Reddy *et al.*, 1998 [16] reported that bulbs of different sizes 0.5-1.0 cm, 1.1-1.5 cm, 1.6-2.0 cm, 2.1-2.5 and 2.6-3.0 cm diameter were used for planting and the maximum performance of the plants are registered from large size bulbs and it also had maximum plant height, more number of leaves, irrespective of bulb size increased with an increased order and reached maximum flower yield at 120 days after planting.

In Tuberose, Ramesh *et al.*, 2006 [17] observed the growth parameters like days to taken for the sprouting, sprouting percentage, plant height (cm), number of leaves per plant, leaf area (cm^2) were significantly increased with the small size ranges from (1.02-2.25 cm), medium size ranges from (2.6-3.5 cm), and large size ranges from (3.6-4.5cm) among all these bulb sizes small sizes increases the growth parameters as compared to the large size.

According to, Iftikhar Ahmad, *et al.*, 2009 [18] observed that large bulb size resulted in vigorous growth, maximum yield and more number of bulbils as compared to small and medium sized bulbs. It was concluded that large sized bulbs with 3-4 cm diameter are best for planting of Tuberose.

In Lily, Addai and scott 2011 [19] reported that 10, 20, 30 g sizes of small bulbs and different sizes of large bulbs of 60, 70, 80 g. Among this, the large bulbs (60-80 g) shows the more leaf width and length, chlorophyll content and also increases in inflorescence length, inflorescence height, inflorescence diameter and inflorescence quality.

In Tuberose, Ali Tehranifar and Razieh Akbari 2012 [20] concluded that effect of three bulb sizes including 1.5, 2.5 and 3.5 cm in diameter and planting depths of 4, 6 and 10 cm, on vegetative and flowering characteristics which was evaluated under green house condition for producing of desirable flowers economically, the best bulb size for about 3.5 cm in diameter and planting depth 6 cm is advised for cultivation of tuberose flowers.

Gibberellic acid

Gibberellic acid has a wide adaptability in the horticultural research for it is known to cause on cell elongation in number and size of plant parts, improves the quality of produce and also breaks the dormancy Misra *et al.*, 1993 [21].

Gibberellic acid is a simple gibberellin, promoting growth and elongation of cells. It stimulates the cells of germinating seeds to produce mRNA molecules that code for hydrolytic enzymes. Gibberellic acid is a very potent hormone whose natural occurrence in plants controls their development. Since GA regulates growth, applications of very low concentration can have a profound effect while too much will have opposite effect. It is usually used in concentrations between 0.01 – 10 mg/l. Chakradhar and Khiratkar 2003 [22]. Several investigators pointed out that the application of growth regulator, gibberellins (GA_3) at certain doses had an effective role on the growth, flowering and bulb productivity of many flowering bulbs.

Effect of Gibberellic acid on growth and yield of flower crops

In an experiment conducted by De and Dhiman 2001 [23] preplant, soaking of bulbs with higher levels of GA_3 (200 – 500 ppm) advanced spike initiation by 65 – 70 days compared to control and flower opening by 22 – 24 days compared to control by produceing maximum number of spikes per square meter.

In a study conducted by Anand 2001 [24] NPK @ 0.25 % (20:20:40) in combination with GA_3 at 250 ppm influenced the flower yield and quality of *Anthurium andreanum* var. Temptation. According to Tiwari and Singh 2002 [25] soaking of tuberose bulbs with GA_3 at 200 ppm increased the spike length, number of spike and number of leaf per clump.

Prabhat Kumar *et al.*, 2003 [26] reported that the effect of GA_3 on four cultivars of china aster, *viz.*, Kamini, Poornima, Shashak and Violet cushion with three concentration of GA_3 *i.e.* 50 ppm, 100 ppm, 200 ppm and control. In this study, it was revealed that among the cultivars, Kamini exhibited better performance in most of the characters. Among all the treatments, 200 ppm GA_3 was found the best.

Verma 2003 [27] reported that in carnation, application of GA_3 at 100 ppm registered maximum plant height (65.94 cm), buds size (1.83 cm), number of flowers per plant (7.25) and stem length (58.25 cm). Rakesh *et al.*, 2004 [28] conducted an experiment in Chrysanthemum cv. Flirt and Gauri, and revealed that yield of flowers per plant (g) in both the cultivars were maximum in plants pinched at 35 days after transplanting and sprayed with 200 ppm GA_3. GA_3 @ 200 ppm increased the number of seeds/flower in French marigold Singh, 2004 [29]. Similarly, Verma 2003 [30] reported that the plants treated with GA_3 @ 200 ppm registered maximum flower yield per plant (82.62 g) and yield per hectare (9617.18 kg) as compared to control (59.46 g and 7018.37 kg, respectively) and other treatments with Ethrel and MH at different concentrations in carnation. Likewise, GA_3 @ 200ppm increased the number of seeds/flower in French marigold Singh, 2004 [31].

In Tulip (*Tulipa gesneriana* var. Cassini), according to the results of Ertan Sait Kurtar and Ali Kemal Ayan 2005 [32] application of GA_3 (250 ppm) gave highest number of earlier flower (9.10 flower m^{-2}), but lowest number of earlier flower obtained from the application of IAA @ 500 ppm.

Anu *et al.*, 2005 [33] studied the effect of different concentration of GA_3 (100, 150 and 200 ppm) for 8, 16 and 24 hours before planting and GA_3 @ 150 ppm for 24 hours recorded the best for plant height, plant spread, leaf area, number of scapes/bulb and flowering and maximum longevity of the whole spike, however GA_3 @ 1000 ppm concentration envisaged the maximum plant height.

Prashanth 2006 [34] reported that the Floribunda Roses sprayed with GA_3 @ 200 ppm showed elongated shoots (20.66 cm), internodes length (4.42 cm) with reduced shoot diameter and number of laterals.

In Chrysanthemum, the duration of flowering increased significantly with all levels of GA_3 (50, 100, 150, 200 and 250 ppm) and @ 150 ppm, the maximum flower yield (815 g per plant) was obtained. The flowers harvested from plant sprayed with GA_3 @ 150 ppm concentration recorded maximum vase life (10.33 days) Moond and Rakesh Geholt 2006 [35].

Tyagi and Vijay Kumar 2006 [36] reported that in African marigold, GA_3 @ 200 ppm envisaged the maximum plant height (22.25 cm), plant spread (25.88 cm), stem diameter (1.03 cm) number of primary branches per plant (15.49), number of flowers per plant (14.00), flower diameter (5.62 cm) and stalk length (2.47 cm).

A study conducted by Gautam *et al.*, 2006 [37] with different growth regulators *viz.*, GA_3 (50, 100, 150 and 200 ppm), NAA (50, 100, 150 and 200 ppm), Ethrel (750, 1000, 1250 and 1500 ppm) and B-nine (1000, 1500, 2000 and 2500 ppm) on growth, flowering and yield of chrysanthemum cv. Nilima. Among all the levels, GA_3 @ 200 ppm have significantly influenced the vegetative growth and flowering parameters.

Devadanam *et al.*, 2007 [38] recorded that application of GA_3 @ 150 ppm recorded minimum days required for spike emergence (43.48), maximum spike length (87.20 cm), length of florets (6.56 cm), diameter of floret (3.88 cm) and maximum vase life (11.35 days) of spikes in Tuberose. Baskaran and Misra 2007 [39] reported that corm dipping of Gladiolus with GA_3 @ 500 and 1000 ppm caused early sprouting of 4.67 and 5.16 days respectively.

According to, Singh *et al.*, 2008 [40] Tuberose bulb dipping in 200 ppm GA_3 for 12 hours resulted in earliness in days to spike emergence 83.83 days, spike length (95.25 cm), number of florets per spike (36.83), number of spikes per clump (3.07) and spike weight (90.33) in cv. Single. Soaking of Gladiolus corms with GA_3 @ 200 ppm produced significantly higher plant height (55.50 cm), spike length (66.99 cm), number of florets per spike (13.33) and yield 1,54,009 spikes per ha then control Havale *et al.*, 2008 [41].

In *Lilium longiflorum*, Emami *et al.*, 2011 [42] found that the bulbs soaked for 24 hours by Gibberellic acid and 6-Benzyladinine with different concentration and planted in a green house condition. Application of GA_3 @ 75 ppm and 6-Benzyladinine @ 75 ppm increases the anthocyanin, chlorophyll content, and vase life respectively.

In Iris, Ragaa and Taha 2012 [43] reported that application of GA_3 @ 250, 500 and 750 ppm and CCC @ 250, 500 and 1000 ppm and Alar @ 125, 250 and 500 ppm. The results showed that GA_3 @ 750 ppm significantly increased vegetative growth characters and it also influenced the days to flowering, maximize the flower stalk characters, bulbils parameters, total chlorophyll and carbohydrate content.

Naphthalene acetic acid (NAA)

Auxins-NAA

Auxins are a class of plant growth substances and morphogens (often called phytohormone or plant hormone). Alpha – Naphthalene acetic acid belongs to the Auxin group of growth regulators. It is a synthetic Auxin and activity of the naphthalene acid was first observed by Zimmerman *et al*., 1936 [44].

They are characterized principally by their capacity to stimulate stem elongation in excised stem and coleoptiles section, but also influenced a host of other development responses, including root initiation, vascular differentiation, tropic responses and the development of auxiliary buds, flowers and fruits Salibury and Ross, 1969 [45].

Effect of NAA on growth and yield of flower crops

In *Jasminum grandiflorum*, Nagaraja *et al.*, 1991 [46] reported that treatment of cuttings with IBA or NAA @ 4000 ppm resulted in maximum rooting percentage, number of roots per cutting, length and thickness of longest shoot. Roy and Chowdhury 1998 [47] observed that GA_3 and NAA increased plant height, number and size of leaves, thickness and width of shoots in Gladiolus *cv*. Eurovision. In French marigold (*Tagetes patula* Linn.) application of GA_3 @ 200 ppm and NAA @ 100 ppm showed the maximum seed yield/plant (63.41) as reported by Anil 2004 [48]. Vahid Reza Safari *et al.*, 2004 [49] reported that application of NAA @ 200 ppm increased the number of flowers in plants rather than other treatments and also control in *Rosa damascene* Mill.

Sharma *et al*., 2004 [50] revealed that application of NAA @ 100 ppm recorded maximum number of cormels per plant (39.4), maximum weight (33.6 g) and size (4.78 cm) in Gladiolus. Vahid Reza Saffari *et al.*, 2004 [51] noticed that treatment of NAA, Alar and Cycocel increased the number of flowers in plants rather than other treatments and also control in *Rosa damascene* Mill.

In Tulip (*Tulipa gesneriana* var. Cassini), according to the results of Ertan Sait Kurtar and Ali Kemal Ayan 2005 [52]. Application of GA_3 @ (250 ppm) gave highest number of earlier flower (9.10 flower m^{-2}), but lowest number of earlier flower obtained from NAA @ 500 ppm (671.7 g m^{-2} and 6.25 g) and GA_3 caused reduction on bulb yield and bulb weight (494.2 g m-2 and 4.99 g).

According to Sunitha *et al*., 2007 [53] in African marigold, (*Tagetes erecta* Linn.) application of NAA increased the 1000 seed weight (3.3 g), germination percentage (88 %) and shoot length (5.4 cm).

Naveen Kumar *et al*., 2008 [54] reported that treatment of NAA @ 100 ppm resulted in maximum corm size (4.86 cm), maximum corm weight (25.88 g) and maximum corm volume (27.31 ml) in Gladiolus. Suresh Kumar *et al*., 2008 [55] studied that significantly higher number of leaves, leaf length and leaf area were observed due to application of NAA @ 500 ppm when compared to other growth regulators in Gladiolus.

In Gladiolus (*Gladiolus grandiflorus* L.) application of NAA @ 150 ppm recorded maximum corm size (4.66 cm) and corm weight (23.15 g) in cv. White prosperity. Suresh kumar *et al.*, 2009 [56]. In Calcutta single (Tuberose), the application of NAA @ 100 ppm was found to be the most effective in increasing the spike length, number of rachis and flower yield Jayoti sarkar *et al.*, 2009 [57]. Parmar *et al.*, 2009 [58] observed that application of GA_3 @ 200 ppm and NAA @ 100 ppm was found most effective in increasing growth and yield of Spider Lily.

The application of NAA @ 200 ppm for rooting in branch cutting of (*Hibiscus rosa-sinensis* L.) showed an increased effect of sprouting, root length, number of roots and leaves per cutting, higher leaf area and percentage of survival in the field as compared to control Nanda and Meerambika Mishra. 2010 [59].

In Gaillardia, Ghadage *et al*., 2010 [60] reported that application of NAA @ 100 ppm increased size of flowers but application of NAA in higher concentration, the flower size were decreased. Grisha *et al*., 2012 [61] reported that in Daisy, application of NAA @ 150 ppm significantly increased the plant height (28.28 cm), plant spread (22.50 cm). Number of leaves per plant (30.83), dry matter production (9.77 g/plant) and chlorophyll content of leaves (0.89 mg/g) as compared to control.

Foliar application of NAA @ 300 ppm recorded the maximum corms per plant (5.84), maximum diameter of corms per plant (5.84 cm) and weight of corms per plant (102.64 g). The yield and quality of Gladiolus corms improved due to foliar application of NAA might been due to increased allocation of energy towards the development of corms Neha Chopped., 2012 [62].

Conclusion

From the present study, it can be concluded that the treatment combination of large bulb size (10 cm in diameter) along bulb treated with GA_3 @ 1000 ppm is best suited to grow Lilium, Tuberose, Gladiolus in open field condition and protected condition to achieve good growth, profuse flowering and bulb yield.

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