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Ragini BK
Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, Chikmagalur, Karnataka, India

Chandrashekar SY
Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, Chikmagalur, Karnataka, India

Hemla Naik B
Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, Chikmagalur, Karnataka, India

Shivaprasad M
Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, Chikmagalur, Karnataka, India

Ganapathi M
Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, Chikmagalur, Karnataka, India

Corresponding Author:
Ragini BK
Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, Chikmagalur, Karnataka, India

Effect of cytokinins (benzyl adenine and kinetin) on bulbous flower crops: A review

Ragini BK, Chandrashekar SY, Hemla Naik B, Shivaprasad M and Ganapathi M

Abstract
The flowers have been considered as the symbol of grace and elegance and a feast for our eyes. With changing lifestyles and increased urban affluence, floriculture has assumed a definite commercial status in recent times. Appreciation of the potential of commercial floriculture has resulted in the blossoming of this field into a viable agri-business option. Availability of natural resources like diverse agro-climatic conditions permits the production of a wide range of temperate and tropical flowers, almost all through the year in some part of the country or other. Among the different management practices in flower crops, plant growth regulators have a great bearing in influencing the growth and flowering attributes. Now a days these growth regulators can be easily available in the market. They play an important role in dormancy breaking, production of quality cut flowers and corms or bulbs. In bulbous flower crops benzyl adenine and kinetin helps in stimulating cell division, they regulate shoot meristem size, leaf primordia number, and leaf and shoot growth, setting blossoms, increases post-harvest life of flowers, affects tuberization by enhancing the activation of starch-synthesizing enzymes. Benzyl adenine and kinetin quite effective in improving the growth of plants and yield of flowers. It increases the number and size of the corms/bulbs and produces quality planting material and it is also effective in improving the vase life of cut flowers.

Keywords: Benzyl adenine, kinetin, growth, flower, vase life, bulbs and corms

Introduction
Commercial floriculture is one of the most profitable agro industries in the world (Ezhilmathi *et al.*, 2008) [12]. 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. The 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 bulbous flower crops like liliums, gladiolus, tuberose and tulip which have a great economic value due to their showy flowers which has attracted medium scale cultivation in recent years. Netherland is the leading bulb producing country in the world. In 2018, approximately 14,200 ha of farmland was dedicated to the production of tulip bulbs, 6,400 ha for lily bulbs and 1,000 ha for gladiolus (Anon., 2018) [2]

In horticulture, the word bulb includes underground modified stems which are used for propagation e.g. bulb, corm, tuber and rhizome. Plants with tuberous roots are also grouped as bulbous plants. A large number of these plants producing attractive flowers are grown in the hills and are commercially important plants in floriculture. Many types, flower well both in plains and hills but the season of growth and flowering may vary.

The cytokinins are essential plant hormones. By stimulating cell division, they regulate shoot meristem size, leaf primordia number, and leaf and shoot growth. Kinetin is a natural cytokinin and 6-Benzylaminopurine, benzyl adenine or BAP (Benzylaminopurine) is a first generation synthetic cytokinin that elicits the plant growth and development responses, setting

blossoms and stimulating fruit richness by stimulating cell division. It is an inhibitor of respiratory kinase in plants and increases post-harvest life of green vegetables and flowers (Siddiqui *et al*., 2011) [40]

The benzyl adenine has the added advantage that it is easily available and is relatively inexpensive. It indirectly affects tuberization by enhancing the activation of starch-synthesizing enzymes to support continuing starch deposition (Obata-Sasamoto and Suzuki, 1979) [31]. By activating cell division, cytokinins may be locally involved in the initial creation of the strong tuber sink. Starch accumulation is an important component of tuberization, and cytokinins promote the mobilization of carbohydrates (Mothes, 1964) [26]. Regarding postharvest physiology, cytokinins applied on the foliage, or sometimes in a holding solution, were shown to delay petal senescence and thus to prolong average vase life.

Gowda (1983) [14] reported that in gladiolus corms treated with BA found effective in promoting sprouting than untreated ones.

Roychoudhuri *et al*. (1985) [37] studied on the effect of chemicals on germination, growth, flowering and corm yield of gladiolus. The corms treated with BA @ 25 ppm recorded maximum plant height, leaf number and corm weight.

Tjia (1986) [45] conducted a study on growth and flowering of container – grown calla lily as affected by growth regulating chemicals. He reported that an earlier flowering of the *Zantedeschia elliottiana* was achieved after the soaking of its rhizomes in a benzyl adenine solution at 50–100 mg·dm^{-3} for 30 minutes.

Mahesh and Misra (1993) [23] reported that BA at 50 ppm applied on gladiolus showed maximum size of corms compared to other levels of BA and BA exhibited early sprouting of gladiolus corms.

Muthoo and Maurya (1993) [27] observed that soaking of gladiolus corms with 400 µg benzyl adenine per L promoted early sprouting in both seasons (summer and autumn) with more pronounced effect on autumn corms.

Singh (1999) [41] in tuberose observed that number of bulbs per plant and bulb weight per plant were maximum in plants sprayed with 100 ppm kinetin.

The effect of BA, ethephon and GA_3 on freshly harvested cormels of three cultivars of gladiolus were studied for 3 years and reported that BA @ 25 mg per L showed maximum value for sprouting per cent (50.30 %) with increased corm diameter (4.20 cm), corm weight (38.40 g), number of cormels per plant (17.40) and weight of cormels per plant (6.50 g) as reported by Ram *et al*. (2001) [34].

Singh and Bijimol (2001) [42] conducted an experiment on tuberose cv. Double and found that the maximum diameter of florets, number of bulbs and weight of bulbs per plant with kinetin @ 100 ppm.

Nagaraju *et al*. (2002) [28] investigated the effect of certain chemicals on the vase life of the tuberose (*Polianthes tuberosa*) and recorded that the maximum vase life of 8.66 days in 1000 ppm of BA as compared control (6.33 days).

Singh *et al*. (2003) [43] conducted an experiment on tuberose (*Polianthes tuberosa* L.) cv. Double with application of growth regulators and they revealed that large bulbs treated with 100-200 ppm of BA produced maximum number of bulbs and bulb weight

Barma and Rajini (2004) [4] investigated on effect of chemicals on dormancy breaking, growth, flowering and multiplication of corms in gladiolus was studied and opined that corms multiplication was maximum in treatment BA @ 75 mg per L.

Luria *et al*. (2005) [22] conducted a study on the effect of planting depth and density, leaf removal, cytokinin and gibberellic acid treatments on flowering and rhizome production in *Zantedeschia aethiopica*. The dipping rhizomes in BA @ 350 ppm increased flower yield five-fold over the control.

Nelofar *et al*. (2005) [29] reported that BA @ 200 ppm recorded the maximum vase life (6.82 days) with tulip cut stems pulsed for 4.00 hours duration.

Baskaran and Misra (2007) [5] studied the effect of plant growth regulators on growth and flowering of gladiolus and found that the maximum number of shoots per corm was observed with BA @ 100 ppm and minimum number of shoots and leaves per plant was recorded in BA @ 25 ppm in gladiolus.

Pogroszewska *et al*. (2007) [32] studied on the effect of gibberellic acid and benzyl adenine on the yield of (A*llium karataviense* Regel.) 'Ivory Queen'. It was discovered that BA application increases the total yield of bulb number per m^2 (35.30) and total yield of bulb weight per m^2 (2049.00 g).

Tawar *et al*. (2007) [44] studied the effect of growth regulators on corm and cormels production of gladiolus cv. Jester. They opined that BA @ 50 ppm recorded the highest number of corms and cormels per plant and also maximum weight of corms and cormels per plant.

An experiment was conducted to study the effect of growth regulators and chemicals on corm and cormels production of gladiolus by Havale *et al*. (2008) [15]. The results revealed that BA @ 50 ppm recorded maximum number of corms per plant (1.13), number of corms per plot (26.13), number of corms per ha (1, 30, 666), weight of corms and cormels per plant, while the minimum number of corms per plant (1.00), number of cormels per plot (20.33) and corm yield per hectare (1, 01,666) was observed under the control.

Baskaran *et al*. (2009) [6] studied the performance of gladiolus by spraying and dipping the corms with different growth hormones at different concentration and they reported that propagation co-efficient was maximum in BA @ 100 ppm as spray method of treatment.

Bharathi and kumar (2009) [8] noticed that foliar spray of kinetin @ 200 ppm increased the flower diameter in tuberose cv. Suvasini.

Janowska *et al*. (2009) [16] reported that the use of benzyl adenine accelerated the flowering of the poppy anemone 'Sylphide' by 3–7 days. The soaking of its tubers in benzyl adenine caused the formation of flowers with shorter pedicels. The use of benzyl adenine reduced the number of leaves formed by the tubers to one-third and development of leaves with shorter stalks and blades.

An experiment was conducted on effect of plant growth regulators on dormancy, corm and cormel production in gladiolus (*Gladiolus* × *grandiflorus* L.) by Kumar *et al*., 2009 [21]. The results of the experiment revealed that BA at 100 ppm recorded maximum number of replacement corms (1.28), number of cormels produced per corm (5.29), maximum cormel weight per corm (8.02 g) and highest propagation coefficient (193.68).

Eid *et al*. (2010) [10] studied the effect of zinc sulphate and benzyl adenine as foliar application on the flower yield and some chemical constituents of *Polianthes tuberosa* L. All parameters like flowering characteristics, number of bulblets per plant and fresh weight of bulblets were significantly increased by foliar spraying of BA. The increase in BA rate from the lower to the middle rate significantly increased the floral characters and further increments of BA rate had no

significant effect in some of the investigated flowering traits and bulblets yield.

Kumar *et al*. (2010) [20] studied the effect of bio-regulators on growth, flowering and corm production in gladiolus cv. Candyman. The results revealed that BAP @ 25 ppm increased the cormels weight per plant and BA @ 50 ppm increased the number of shoots per plant (1.98).

The response of tuberose (*Polianthes tuberosa* L.) to gibberellic acid and benzyl adenine on tuberose cv. Goldorosht Mahallat was studied by Asil *et al.* (2011) and they reported that BA @ 100 ppm and BA @ 200 ppm were recorded reduced spike length, rachis length and length of leaves, resulted in maximum diameter of floret and vase life of cut flower.

The effect of gibberellic acid and benzyl adenine on growth and flowering of lily (*Lilium longiflorum)* was studied by Emami *et al*. (2011) [11] and they reported that maximum number of buds per plant (4.63) and total chlorophyll content (3.20 mg per g) was obtained by using gibberellic acid @ 75 ppm with benzyl adenine of 75 ppm, benzyl adenine @ 150 ppm and benzyl adenine @ 75 ppm showed the maximum anthocyanin content (3.31 and 2.92, respectively) in case of *Lilium longiflorum*.

Khan *et al*. (2011) [19] conducted an experiment to determine the optimum concentration of BA and GA_3 on dormancy breaking of gladiolus cormels and their effects on cormels growth and subsequent production of gladiolus corm and cormels. The maximum number of leaves per plant (10.41), number of hills per corm (1.16) was produced by the treatment BA @ 75 mg per L. BA @ 50 mg per L and BA @ 125 mg per L were produced statistically similar corms yield (1,06,000.00 and 1,08,000.00 per ha, respectively) and cormels yield (1.18 and 1.13 t per ha, respectively).

Khan *et al*. (2013) [18] emphasized that among different levels of BA, dormancy breaking was comparatively earlier by 29.60 days when corms were treated with 50 ppm of BA. Whereas 90 days stored corms treated with 125 ppm of BA produced the maximum number of suckers per corm (2.41) and corms (2.50) per hill.

Mohammadi *et al*. (2013) [25] conducted an experiment to know the influence of benzyl adenine (BA), gibberellic acid (GA) and salicylic acid (SA) on tulip cut flowers and they found the reduced rate of anthocyanin contents during experimental days and best results were found in BA or GA treated plants in tulip.

Reddy *et al*. (2013) [35] investigated on the effect of plant growth regulators on corm and cormel production in gladiolus (*gladiolus grandiflorus L.)* cv. White Prosperity. They revealed that BA at 100 ppm recorded maximum number of cormels (29.75) and cormel weight per corm (14.00 g) with highest propagation coefficient (194.20 %).

Baskaran *et al*. (2014) [7] conducted a study on the effect of plant growth regulators on yield and quality in gladiolus cv. Chandini under Bay Island conditions. The results of the study revealed that maximum number of shoots per corm (3.30) was recorded by BA @ 75 ppm, the maximum number of corms (3.10), cormels per plant (16.60), weight of cormels per plant (6.00 g) was recorded in BA @ 100 ppm.

Faraji and Basaki (2014) [13] revealed that plants sprayed with BA @ 200 mg per L showed maximum vase life of 12 day and there is significantly maximum protein content in the petals (7.5 mg per L) in the same treatment. BA @ 100 mg per L was most effective in retarding chlorophyll degradation.

The investigation was done to study the effect of gibberellic acid and benzyl adenine on morphological, phenological and yield attributes of gladiolus cv. Red Candyman under Assam conditions by Aier *et al.* (2015) [1] and they reported that BA @ 250 ppm exhibited maximum economic yield in terms of number of spikes per corm (2.66) and number of corms per plant (4.26).

A field study on growth, yield and quality of gladiolus as influenced by growth regulators and methods of application was carried out by Chopde *et al*. (2015) [9]. The results revealed that application of BA @ 100 ppm produced significantly maximum number of corms and cormels per plant.

Naji *et al*. (2015) [30] conducted an experiment on the effect of plant growth regulators on vegetative characters of lily. The results showed that BA @ 50 ppm recorded maximum plant height, number of leaves, leaf area, fresh weight of leaf and stem and dry weight of stem.

The effect of growth regulators on growth, flowering, vase life and corms production of *Gladiolus grandiflorus* L. under calcareous soil was done by Sajid *et al*. (2015) [39] and they concluded that BA @100 ppm showed maximum plant height (57.03 cm), number of leaves per plant (6.33), fresh weight of the spike (84.80 g), number of florets per spike (17.66), vase life (15.26 days) and took maximum days to spike emergence (108.27).

Sajjad *et al.* (2015) [38] studied on the pre-plant soaking of corms in growth regulators influences the multiple sprouting, floral and corm associated traits in *Gladiolus grandiflorus* L. The results revealed that BA @ 150 ppm showed the maximum number of sprouting per corm (2.14) and reduced the plant height (87.00 cm).

The investigation was carried out on effect of plant growth regulators (GA_3, BA, CCC and control) on growth, flowering and bulb production of tuberose by Zhumara (2015) [46] and he opined that BA @ 100 ppm had increased the growth, flowering (4.80 lakh spikes per ha) and bulb production (12.50 t per ha) over other treatment.

Kalsi (2016) [17] studied on the effect of growth regulators on plant growth and cormel production of gladiolus. The results revealed that the maximum number of cormels per plant was recorded with BA @ 125 ppm (3.34)

Manasa *et al*. (2017) [24] conducted the experiment on the influence of growth regulators on vegetative parameters of gladiolus cv. Summer Sunshine. The results revealed that BA at 100 ppm was recorded the maximum number of suckers per plant (4.03) and the maximum number of leaves per plant (12.43).

An experiment was conducted on the effect of pre-plant soaking of corms in growth regulators on sprouting, vegetative growth and corm formation in gladiolus (*Gladiolus grandiflorus* L.). The results revealed that various growth, flowering and corm characters were significantly affected by the application of different growth regulators at different concentrations. The maximum number of shoots per corm (5.20) was recorded by benzyl adenine (BA) at 300 ppm with variety Jessica. BA was responsible for multiple sprouting which was responsible for the formation of multiple corms as reported by Roy *et al.* (2017) [36].

Priyanka *et al.* (2018) [33] conducted an experiment on effect of benzyl adenine and gibberellic acid on flowering and flower quality attributes of gladiolus. The results revealed that BA @ 300 ppm exhibited the maximum number of days for spike initiation (85.83), first floret opening (91.40 days), 50 per cent flowering (96.17 days) and maximum spike yield per plant (3.30).

Conclusion

Benzyl adenine and kinetin is effective in improving the growth of plants and yield of flowers. It increases the number and size of the corms/bulbs and produces quality planting material and also effective in improving the vase life of cut flowers.

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