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Review

Use of gibberellin in floriculture

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This review aimed to show the use of gibberellin in floriculture. In this context, it should be noted that the benefit of the activity of the gibberellins has brought major advances in the field of physiology. Its use is one of the most important tools for the development of agriculture. Thus, the study concluded that the use of gibberellins has been increasingly used by producers and is also a vast important subject that may help in increasing the production of flowers if the farms are dedicated to this purpose.

Keywords: Regulators plants, flowers, phenotypic characteristics, postharvest.

INTRODUCTION

Floriculture, in its broadest sense, covers the cultivation of ornamental flowers and plants with many purposes, which include cultures of cut flowers and seedlings production. This sector is found in the economy of many countries, but mostly in European countries such as Netherland, Italy and Belgian and a few Latin-American countries such as Colômbia and Costa Rica (Castro, 1998). The tendency to cultivate certain species in areas with boundary conditions for adaptation has generated certain difficulties which has led to the search for solutions. Studies then emerged with vegetables regulators about growth plants and the benefits promoted by these substances such as gibberellin. This study aim at improving the quality and quantity of cultivations productivity. Both the quality and other characteristics of flowers can be modified by the application of vegetables regulators, which are organic substances with an important role in growth regulation, acting as a stimulator and an inhibitor, depending on its concentration and others intrinsic plant characteristics (Teixeira and Marbach, 2000). Inside the main group, with the possibility of exogenous utilization, gibberellin was found (Taiz and Zeiger, 2004). Thus, this review aims to detail the use of gibberellin at floriculture.

GIBBERELLINS

In the 1950's, gibberellin was characterized as phytohormones. Phytohormones are organic compounds, non-nutrients, produced by plants and in low concentrations (10-4 M), they promote, inhibit or modify physiological and morphological processes of vegetables (Davies, 2004). The most important gibberellin is GA1 and most of the others are precursors of GA1, except GA3, GA5 and GA6. It has a complex structure, being chemically isoprenoid. It is synthesized by a branch in the route of terpenoids, which are synthesized by the route of mevalonic acid and by the route of metileritritolfosfato (MEP). The differences between many gibberellin are the number and the localization of the double connections and the hydroxyls group (Taiz and Zeiger, 2004).

The gibberellin group covers a large number of compounds, where 1/3 are gibberellin with 20 carbons and the others are gibberellin with 19 carbons, being more active with the GA1, GA3, GA4, GA7, GA9 and GA20

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Abbreviations: MEP, Metileritritolfosfato; **GA,** gibberellic acid.

(Hopkins, 1999; Taiz and Zeiger, 2004). Gibberellin determines important physiological changes in plants, such as cell division and expansion, promote the growth of shorts, induce seeds germination that needs cold or light, stimulation of enzyme production such as α-amylase in the germination of cereal seeds, induce flowering, partenocarpia, sexual expression, fruit development, senescence and abscission, break of the yolks dormancy, maintenance of apical dominance and promotion of stem elongation (Metivier, 1979; Davies, 2004; Coll et al., 2001). Gibberellins are present throughout the plant and can be detected in leafs, stems, roots, seed, embryos and pollen. In general, the reproductive tissues has high concentration of gibberellin, on the other hand, the roots has lower concentration (Metivier, 1979; Coll et al., 2001). High levels of endogenous gibberellin are also found in petals, stamens and in the inflorescence of most species as a function of the growth stage. However, the distribution of hormones fluctuates between the organs according to the reproductive development, showing its important role in stamens development (Kinet et al., 1985).

The translocations of gibberellins are performed at the same speed as the constituents of the phloem, such as amino-acids and carbohydrates, moving in all directions in the symplast of the plant. The movement of gibberellin, exogenous or endogenous, appears to be non-polarized and can occur at both the phloem and xylem (Metivier, 1979; Rodrigues and Leite, 2004). The biosynthesis of gibberellins can be affected by environmental conditions and in general, the greater production of gibberellins occurs in long days more than in short days (Rodrigues and Leite, 2004). Moreover, the levels of gibberellin can be affected by changes in photoperiod and temperature modifying the activity of specific enzymes in the pathways of their biosynthesis (Hazebroek et al., 1993). In general, long day plants and plants which require a cold period are more responsive to exogenous gibberellin, while short and neutral day plants are not responsive at all (Zeevaart, 1971). That way, the induction of flowering can be obtained through artificially reducing the duration of one or more seasons (Hertogh and Le nard, 1993). Commercially, gibberellins is used in Pro-Gibb® - a product which contains 10% of active principle of gibberellic acid (GA) in its formulation. When the GA became commercially available, it was applied to many plants and extraordinary results were obtained. It was thought that gibberellins could cause very large increase in plant productivity (Rodrigues and Leite, 2004).

APPLICATION OF GIBBERELLIC ACID (GA)

In the floriculture area, some producers use GA in order to improve the phenotypic characteristics of plants. The GA3 has been used in species of *Hyacinthus*, *Liatris*, *Muscari*, *Iris*, *Lilium* and *Tulipa* as a substitute for treatments with low temperatures. Although it promotes flowering, its efficiency is considered low compared to treatments with low temperatures, especially for species of the genus *Tulipa*. Treatments with gibberellin application has also been used in *Zantedeschia* to increase the number of flowers (Hertogh and Lenard, 1993). Under non inductive conditions, GA32 and 2,2-dimethil GA4 applications in *Lolium temulentum* promoted flowering, which is already at *Sinapsis alba,* while some gibberellins (GA1, GA3, GA4, GA7, GA9) limited the flowering process, which was also observed in fruit, such as cherry, peach, apricot, almond and citrus (Zeevaart, 1971; Bernier et al., 1993). In plants of *Azalea* treated with 1000 mg L^{-1} GA3, at a minimum temperature of 16°C, significant results were obtained in the uniformity of flowering, without the need for treatment with low temperature for the Hexe and Sweatheart-Supreme cultivars. When the combination of 100 to 500 mg L^{-1} (GA3) and 100 mg L^{-1} of kinetin (adenine-derived molecule that stimulates cell division) was performed and applied in 'red wing cultivar', at intervals of four days, it promoted the anticipation of flowering (Iersel, 1998).

It can also be found, in plants of the same habit of growth - such as annual plants at different responses to the application of GA3. It was evidenced by an experiment with *Petunias* and *Impatiens*, where only the latter responded to an application to a GA3 based-product interfering with the stimulation of its flowering (Iersel, 1998). Similar results were observed by Al-khassawneh et al. (2006) on growth and flowering of *Iris nigricans* Dinsm., using plant growth regulators, especially GA3 at tested concentrations (125, 250, 375 e 500 mg L^{-1}). However, in low concentrations of GA3, changes were not observed in growth and flowering of chrysanthemum 'Faroe' (Vieira, 2008). Several studies have confirmed the earliness of flowering by GA3 application. Chang and Sung (2000) observed in rhododendron (*Rhododendron pulchrum*) that the application of GA3 was effective on the growth of buds and flowers per plant, showing the colors of the buttons 10 days before and anticipating the flowering in nine days against the control. For Aglaonema (*Aglaonema* sp), the appearance of first flower was enhanced by GA3 application in concentrations of 100 and 200 mg L^{-1}, but in a concentration of 400 mg L^{-1}, this event happened five days later. However, the earliness of flowering was with GA3 when compared with controls (Henny, 1983).

Other phenotypic characteristics were observed by other authors. In Better Times rose cultivar, application of GA3 at concentrations of 10 to 100, increased the stem length and fresh weight of cut flowers (Castro, 1998). In bulbous plants, such as cyclamen (Treder et al., 1999), tulip (Rudnicki et al., 1976) and dahlia (Khan and Tewari, 2003), there was an increase in the height of the plants after GA3 application. In anthurium (*Anthurium andreanum*) these applications were not enough to increase the height or to stimulate flowering (Wang, 1999). Taiz and Zeiger (2004) assume that the increase in height of the plant can also be attributed to auxin, since it can cause the synthesis of gibberellins and thereby induce cell elongations. In the literature, it was generally observed that, GA3 caused an increase in the number of flower buds or in the number of flowers or inflorescences. In *Syngonium podophylum* Schott cv. White Butterfly treated with GA3 (0, 10, 20, 40 e 80 mg L^{-1}) showed that the best average number of flowers produced by the plant (2,4) occurred in treatment with 80 mg L^{-1}, when compared to the control (Henny et al., 1999). Lower value was found in *Hemerocallis hybrida* cv. Graziela Barroso in the third application of GA3, wich showed 2.93 buds per plant (Ottman, 2006). The pre-treatment with GA3 at a concentration of 83 mg L^{-1} was effective for the production of seedlings serum by rhizomes, due to the formation of trees with greater height (Tavares and Almeida, 2005).

In post-harvest, the application of exogenous plant growth regulators interferes with the senescence of leaves. This can be observed in lily, where application of GA3 in the preservative solutions significantly delayed yellowing and respiration rate (Franco and Han, 1997), but did not influence the longevity of flowers (Mello, 2001). The addition of 50 ppm of GA to the solution of "pulsing" delayed leaf senescence in lily and aster (Dias-Tagliacozzo et al., 2003b; Dias-Tagliacozzo and Castro, 2001a). The foliar application of 100 mg L^{-1} GA3, besides increasing the diameter of the stems, inflorescences and floral disc, also increased the vase life of 12 varieties of chrysanthemum grown in greenhouses (pot) (Dehale et al., 1993). This effect was also observed in chrysanthemum 'Gompier-cha', in which application of 100 mg L^{-1} in plants grown in greenhouses (pot), prolonged the vase life of 16 days compared to untreated controls (Freitas, 2001). The induced absorption of a solution by exposing the stems at an elevated temperature with low concentrations of GA3 (10 e 20 mg L^{-1}), has also shown increased durability in species such as chrysanthemum (Laschi, 1999). However, little is known about the effects of plant growth regulators on the flowers and as such, these effects are contradictory. This result is similar to that of Brackmann et al. (2005) who evaluated the effect of GA3 on three varieties of chrysanthemums and noted the promotion of senescence of both leaves and flowers. The application of GA3 in the field did not reduce or retard the senescence process in chrysanthemum ‘Faroe’ (Vieira et al., 2010). This author also studied the biochemical changes in post-harvest chrysanthemum 'Faroe' submitted to different concentrations of GA3 applied field and observed increase in the level of polyamines.

Some authors assert that the action of regulators may vary according to species and cultivar (King, 1997; Paulin, 1997; Laschi, 1999), which could explain the increased of longevity in post-harvest treated with GA3 (Freitas, 2001). In this review some studies have shown that the efficiency of gibberellin application in flower is related to application technology (product concentration, shape and timing) as well as various factors such as plant age, types of gibberellins, growth and share treated plant, plant species and climatic conditions. In this study we conclude that there are several studies showing the effect on exogenous application of gibberellin in flower, but many other studies show contrary situations. Certainly, relations between some of the components of this system are unclear and difficult to be traced.

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