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Effects of Plant Growth Retardants and Pot Sizes on the Height of Potting Ornamental Plants: A Short Review

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Abstract

Due to its aesthetic values and economic benefits, the Production of potting ornamental plants for home use and marketing purposes are rising from time to time and moving a billion of dollars of worth around the globe. Thus, the production of these potting ornamental plants needs careful management practices starting from its early stage of development to throughout of its lifetime in order to give a beautification and marketable value. Among the crucially important practices of the potting ornamental plant, production is controlling of the plant to the desired height. This practice can be done either by planting the ornamental plants in to the appropriate pot sizes, which have the ability to limit the plant root development and consequently reduces the nutrient uptake by limiting the root system of the plant and/or by using of plant growth retardant chemicals, which have the ability to control the height of plants by suppressing plant growth regulator activities to the desired plant height. Different research outputs have confirmed that the larger pot size allowed the plant to grow taller whereas the smaller pot size restricted the height of the plants. Also, applying a high concentration of plant growth retardant chemicals reduced the internodal stem elongation of ornamental plants by inhibiting the action of growth hormone activities, which has the ability to enhance the plant, stem elongations by exhibiting the cell divisions and consequently increases the plant height. Considering all these points, this review aimed to discuss the effects of pot sizes and plant growth retardant chemicals on the potting ornamental plants for commercial use.

Keywords: Cell division; Chemical plant growth retardants; Container size; Gibberellins; Nutrient restriction; Stem elongation

Introduction

Ornamentals are plants being cultivated and commercialized for their decorative purpose, usually associated with gardening or landscaping activities. It is one myriad of residential commodities associated with urbanization and especially with suburban living environments [1].

The history of using ornamental plants had been traced back to the ancient Roman and Greek civilization for their gardening and decorating of the Emperor palaces to induce the mental satisfaction. However, recently the ornamental plants are widely grown for use by the green industry and for public purposes of landscaping for sport, conservation and recreational as well as for its lucrative economic benefits around the globe. These plants including of perennial deciduous and evergreen shade trees, conifers, and shrubs are grown in horticultural production by the commercial nursery industries. Hence, plants like herbaceous and woody indoor and outdoor landscape broadleaf plants, grasses, and palms produced by traditional floricultural and nursery techniques within greenhouses, shade structures, and other environments significantly modified to favor healthy, rapid and profitable plant growth [2]. They are contributing significantly to the quality of life by acting as barriers to wind, providing cooling, shade, reducing or eliminating erosion, cleaning the air and water of pollutants like dust and chemicals, reducing noise pollution, and providing food and habitat for wildlife while making both suburban and urban areas [2].

Experimental

Ornamental plants can be grown either in the ground or in pots for home users and garden beautification. The main advantages of producing these plants into the pots are due to its compactness, flexibility, and portability for areas of requirements [3]. Today, the world population living in metropolitan is increasing at the fastest rate, which is limited in time and space whereas container gardening is a more appropriate method of production of the ornamental plants in this area. Production of these pot-growing ornamental plants needs a careful and specific cultivation and treatment systems. According to the plant type and purposes of intended end uses, the growers and users [3] practice managing of the ornamental plant height to the desired level. These can be done either by using of a mechanical height control method like of growing of the plants into different pot sizes and/or by applying different concentrations of plant growth retardant chemicals (Ancymidol [Abide or A-Rest], Daminozide [B-Nine or Dazide], Chlormequat chloride [Citadel or Cycocel], Flurprimidol [Topflor], Paclobutrazol [Bonzi, Downsize, Paczol, Piccolo, or Piccolo 10 XC], and Uniconazole [Concise or Sumagic]) to get the desired plant structures. The pot size can affect the plant growth by restricting the nutrient availabilities and plant root length of ornamental plants [4]. This nutrient restriction to the plant roots can have a direct influence on plant growth and developments, which have an influence on the photosynthetic product partitioning into different plant parts that are crucially important for plant stem internode length and overall plant growth and developments [5].

In addition, the plant growth retardant chemicals have applied to the potting ornamental plants to restrict the stem internode lengths into the desired level of plant height due to their direct control effects on the cell division of ornamental plants. The growth retardant chemicals are available in different forms and brands based on the ornamental plant types, their developmental stages and the suitable growing areas of the

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plants. By considering all these points, the paper aimed to review the effects of container sizes and plant growth retardant chemicals on the height of ornamental potting plants for commercial uses.

Results and Discussion

Status of ornamental plant production around the world

In the 21st century, the production of ornamental horticulture has made an important impact on the horticultural industry around the world [6]. The ornamental plants are mainly cultivated with the aim of being marketed and used for decorative and displayed purpose rather than functional. Most of the consumers mainly in the developed nations buy the plants because of their traditions, cultures, and lifestyles around the world. In addition, it is suggested as being of around plant helps to improve concentration, boosting of creativity, and accelerates the healing process and generally help to improve the well-being of human beings [7]. Currently, due to the fact of its economic importance, its production is becoming an increase in different countries. The industry moves a huge economic sector in which the cut flower represents the largest segment followed by flowering potting ornamental plants, trees and nursery crops, flower bulbs, and other propagation materials [8]. Nowadays, the industry exceeding to the fourth huge global marketed commodity next to petroleum, Coffee, and Banana respectively [9,10]. The total turnover from all these aspects has estimated to be more than 300 billion USD [11]. Also, Lütken et al. [12] reported that the global production value of ornamental potting plants and cut flowers are accounting about 50 billion dollars, corresponding to an estimated global consumption of between 100 and 150 billion dollars.

The developed nations are the main producers and consumers of ornamental potting plants. In addition, recently some Asian, Latin American and African countries are involved. Hence, Netherlands is the dominating import and export country of commercial ornamental potting plants like Begonia, Ficus, Cyclamen, Philodendron, Saintpaulia, Spathiphyllum and Rhododendron [13].

In Ethiopia, the production and commercial uses of ornamental potting plants are at an infant stage. However, the produced ornamental plants have mainly exported to the country like the Netherland, Germany, and Russia. The contribution of the sector to the Ethiopian GDP is negligible but it is at an increasing rate.

Production status of potting ornamental plants

Ornamental plants can propagate from the seed or vegetatively in nurseries to be transplanted for berry production or for sale as potting ornamental plants [3]. The ornamental potting plants (pot flower and pot greens) are produced mainly for their aesthetic values, like propagation and improvement quality attributes; such as leaf types, flower color, longevity and form, plant shape and architecture [14]. Therefore, a plant that may seem common and lack special appeal in a landscape, can take on an entirely new character when displayed in a container where its unique shape and interest has spotlighted. As a result, the Production of ornamental potting plant needs great careful management practices based on the consumer preferences because of the potting ornamental plant is a living entity and they are on the progress of growth and development for a long period and hence its different management activities should continue throughout of its entire life. As a result, for herbaceous and tree potting plants, a height control is the main important management activity of the growers which can be done by different techniques like growing the plants on different containers sizes or/and by using of plant growth retardant chemicals.

Effect of pot size on the production of potting ornamental plant height

The container production of the plant is a form of gardening in which a variety of plants, flowers, and even vegetables have grown in pots rather than in the ground. In commercial potting ornamental plants, the height control is very important activity and essential to reduce the plant height as well as the quality at a desirable level. Plants with longer flowering period and shorter height are more valuable for the producers to keep the product until it reaches to the end consumers as well as for the traders to keep in for longer periods and available space utilization. Therefore, the control of vegetative growth with the ultimate plant height reduction is a very important ornamental pot production factors in the industry [4].

It should be clearly noted that the size of the containers has the ability to regulate different physiological and morphological traits in plants through the influences of planting bed volume that creates the imbalance between roots and shoots, which ultimately causes a short-term or long-term effects on plant growth and developments [5]. Additionally, the container size reduces the volume of aerial plant parts by reducing root volume of the plant. The root and shoot growth, biomass accumulation, photosynthesis and chlorophyll content, plant water relations, uptake of elements, respiration, flowering, and yield are some features of plants affected by the pot size and root restriction [5]. According to Taherpazir and Hashemabadi, [15] finding, the leaf area of zinnia grown on larger pot size showed a larger leaf area and conversely, the smaller pot size showed the smaller leaf area as compared to the normal plant leaf. The dry weight, fresh weight, volume of the root, flower diameter and flower round directly affected by pot sizes, which have a direct influence on the plant height. Therefore, the smaller pot size has reduced the plant height because the small volume of the pot creates an unfavorable environmental condition for enough nutrient and water uptake which directly affects the photoassimilate rate of the plant and plant vegetative growths [15]. Also, Al-Menaie et al. [16] reported on the effects of pot size on the growth and multiplication of water lilies (*Nymphaea* spp) and they found that the larger container size was produced larger plant size of water lilies than the smaller container ones. Bouzo and Favaro [17] also investigated similar findings on the effects of container size on the ornamental plant production and precocity in tomato (*Solanum lycopersicum L.)* and they were reported that using of a larger container sizes has encouraged the plants to grow taller due to absence of the physical restriction of the root by the containers. Generally, the bigger the pot size produces the longer ornamental potted plant and the smaller pot size produces the shorter plant height of ornamental potting plants [18].

Effect of plant growth retardants on the potting ornamental plant height

The height of potting plant can also regulate by a chemical treatment 'plant hormone that is responsible for the cell'. These typical PGR includes Ancymidol (Abide or A-Rest), Daminozide (B-Nine or Dazide), Chlormequat chloride (Citadel or Cycocel), Flurprimidol (Topflor), Paclobutrazol (Bonzi, Downsize, Paczol, Piccolo, or Piccolo 10 XC), and Uniconazole (Concise or Sumagic) [19]. The chemicals mostly used in the greenhouse and/or nursery production have used to regulate a shoot growth of container crops. It has the ability to prevent cell divisions and growth in the area below the apex of the plant but they have no direct effect on the meristematic tissues [19]. This could be by inhibiting the production of Gibberellins, the primary growth promoter of plant hormone

that is responsible for the cell elongation [20]. According to author the explanation, the plant growth promoter, Gibberellins, can cause the stem elongation, an undesirable feature for ornamentals, and it interacts with other hormones to facilitate the plant growth and developments [21].

However, the effects of plant growth-retardant have primarily seen in stem, petiole, and flower stalk tissues by inhibiting the Gebrilin action. Thus, the activity of Plant Growth Retardants does not involve in the reduction of plant sizes but they limit the plant's growth rate, improve the plant appearance by maintaining the size and shape in proportion to the pot sizes, and have increased shipping capacity with the smaller plants [22]. This PGR also increases the tolerance ability of plants to the stresses of shipping and handling, as well as retail marketing, thereby improving the shelf life and extending plant marketability [19].

Therefore, the main advantages of using plant growth retardants in ornamental potting plants production are mainly for the improvement of the appearance of the plant by maintaining the shape and size of the plant in accordance with the size of the pot [23]. The effects of different plant growth retardants on different ornamental plants have reported from different corners of the world. According to Yassin et al. [24] investigation on the effects of growth retardant chemicals on stock plant growth and subsequent rooting of Verbena (*Verbena X hybrids*) cuttings, the chemicals, Alar and Cycocel, have influenced the growth of Verbena without affecting the root performance of the crop. Bosch et al. [25] also investigated the effects of plant growth retardants on the physalis, a fruit-bearing ornamental plant, by using Paclobutrazol growth regulator focusing on the plant height. According to the finding, the highest concentration of PBZ applications reduced to the plant height to the desired level (Figure 1).

In addition, the application of PGR, paclobutrazol and chlormequat chloride to the orchids on the vegetative development of containerized *A. graminifolia* has reduced the height of the plants [26]. Furtherly, according to Taherpazir and Hashemabadi et al. [15] finding a report on the interaction effects of pot sizes and plant growth retardants (Cycocel), the longer plant height and maximum amount flowering of zinnia on the larger pot size with higher Cycocel concentration has obtained. On this investigation, the highest concentration of Cycocel did not influence the plant growth and amount of flower may be due to the larger pot size created conducive environment to facilitate the growth and all over performances of the plants.

Furthermore, Bañón, et al. [27] reported on the effects of plant growth retardants on plant height of *Reichardia*. The chemical has influenced the all over performances of the plant parts (height of plant, width of the plant, leaf blade area, aerial part dry matter, and relative chlorophyll content) which reduced finally the height of the plants *Reichardia tingitana* (Figures 2 and 3). The PGR (paclobutrazol and Ethephon) has reduced the internodal stem height. So that, the chemicals have used to control the potting ornamental plants.

In addition, the effects of plant growth retardants (Uniconazole) and plant growth promoter (gebrilic acid) were investigated and reported that the application of uniconazole to the growing plants showed the internodal stem height and number of nodium reduction (Figures 4 and 5). This is because; the application of plant growth retardants to the growing plants can have the ability to suppress the activity of gebrilic acid by inhibiting the internodal stem lengths, which consequently reduces the plant height [20].

Generally, most of the findings on the effects of plant growth retardants have the tendency to reduce the height of ornamental plants

Figure 1: Effects of different concentrations of 0, 30, 60, 90, 120 and 150 mg a.i L-1 of Paclobutrazol (PBZ) applied via foliar spray, one single time, to Physalis plants (*Physalis angulata* L.). Source: Bosch et al. [25].

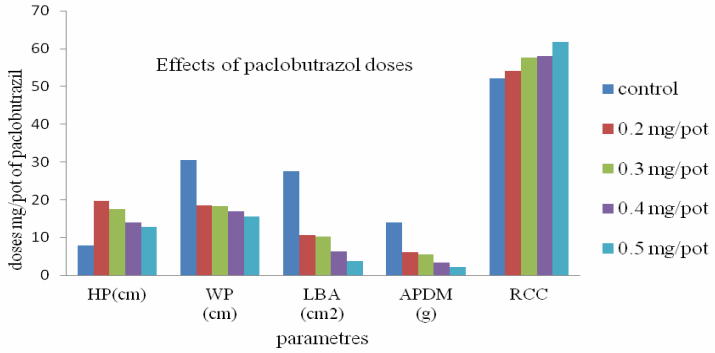

Figure 2: Influence of paclobutrazol doses on the height of plant (HP), width of the plant (WP), leaf blade area (LBA), aerial part dry matter (APDM) and relative chlorophyll content (RCC) of *Reichardia tingitana*.

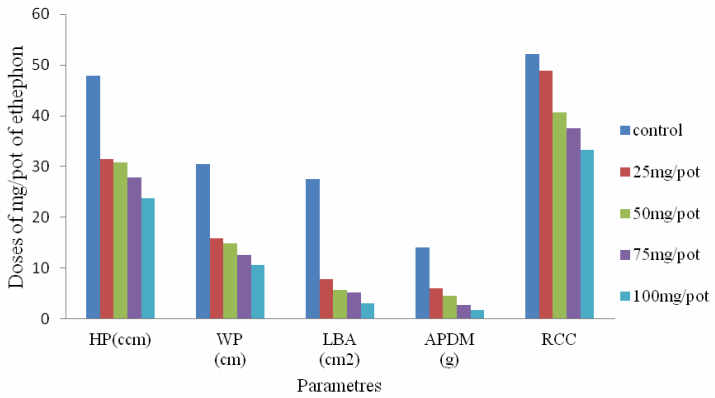

Figure 3: Influence of ethephon doses on the height of plant (HP), width of the plant (WP), leaf blade area (LBA), aerial part dry matter (APDM) and relative chlorophyll content (RCC) of *Reichardia tingitana*.
Source: Bañón et al. [27].

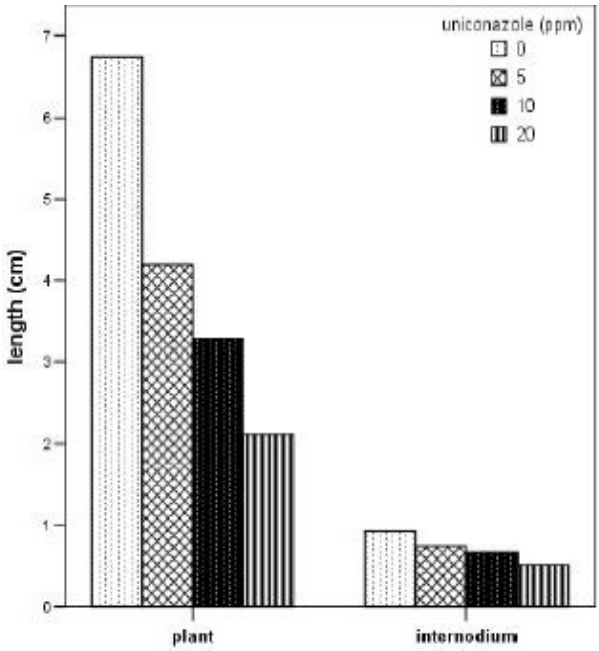

Figure 4: Effects of different doses of Uniconazole on plant height an internodium length.

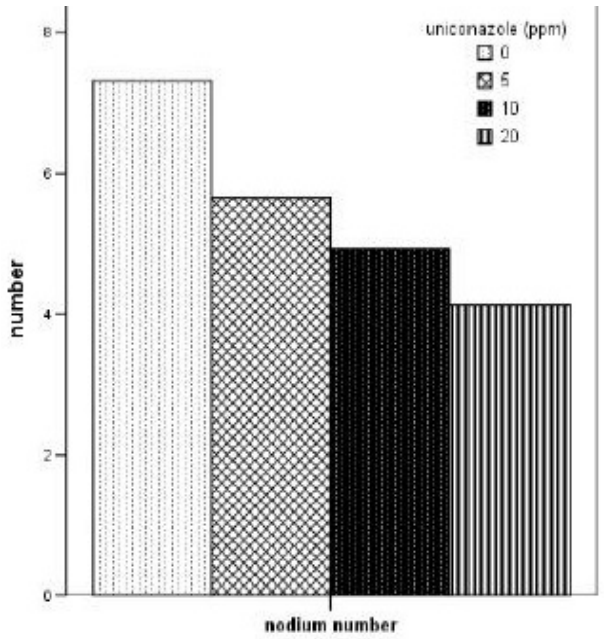

Figure 5: Effects of different doses of Uniconazole on a number of nodium.
Source: Atlar [20].

based on their optimum chemical concentration levels. Different ornamental plants have their own unique responses based on the chemical types. The time, amounts and type of plant also have an influence on the efficiency of the chemical on the potting ornamental plant growths and developments.

Conclusion

The importance of ornamental plants is nowadays getting increases around the globe in order to satisfy the consumer's needs due to it has needed in human lifestyle. Due to this, currently, the economic importance of ornamental plants are increasing in many countries and the international demand has been rapidly expanding. Among the kinds of ornamental plants used widely around the world, ornamental potted plants are the main type for home use and/or for commercial purposes. While transporting from the production area to the consumers, handling convenience is very important and should manage to the desired height. This can be done either by using different container sizes or/and using different plant growth retardants. The pot size has a direct effect on the height of potting ornamental plants. So that, the larger pot size encourages the plants to grow taller, whereas the smaller size reduces the plant height due to it restricts the plant all over requirements to grow freely. In addition, the PGR chemical reduces the plant height based the chemical types and its concentration levels by inhibiting the growth promoters action. As a result, it is possible to manage the ornamental potted plants to the desired plant height either for home use or for transportation convenience to a long-distance trade. Generally, using Plant Growth Retardant chemicals with their specific recommendations and using of appropriate pot size depends on the plant specious reduces the ornamental plant to the required height. The application of the chemical should base on the plant growth stages, optimum environmental condition, appropriate time of application and the required end purposes of the plants.

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