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Influence of River Waste-Based Media on Efficacy of Paclobutrazol in Inhibiting Growth of *Petunia* x *hybrida*

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Abstract: Most flowering pot plants are currently treated with plant growth regulators during development, not only for height control, but also for better branching and flower induction. Paclobutrazol is a gibberellin biosynthesis inhibitor, but obtaining consistent results without excessive stunting has been a problem. Media components affect the efficacy of growth retardant drenches. Our results showed that media total porosity changes when increased quantities of river waste were added for obtaining a light growing media. As many label recommendation for drench concentrations are determined on peat-based media, the results of this study hopefully will aid growers in modifying concentration to be more effective when components of the media are changing. A different paclobutrazol leakage pattern relate to physical properties of the media when river waste was added are discussed.

Key words: Bedding plant, growing media, *Petunia* × *hybrida*, retardant

Introduction

A fundamental objective of most commercial bedding plants growers is to produce a crop that meets the quality standards of the market in the shortest time possible. Most flowering pot plants are currently treated with plant growth regulators during development, not only for height control, but also for better branching and flower induction.

The triazol growth retardant paclobutrazol is a gibberellin biosynthesis inhibitor that suppresses internode and long-term growth. Increasing paclobutrazol concentrations reduced plant height. Paclobutrazol effectively reduce stem elongation on many herbaceous crops including *Petunia* × *hybrida* (Barrett and Nell, 1992).

When growers began to use paclobutrazol on ornamental crops, many had difficulty obtaining uniform plant size because of its greater efficacy and because of the importance of application procedures. High spray volumes, which would result in more thorough coverage of plant stems and greater solution entering the medium, increased the efficacy of paclobutrazol. Also, it has been indicated the importance of paclobutrazol spray treatments acting as a medium drench (Barrett *et al*., 1994).

Media components affect the efficacy of growth retardant drenches. Ancymidol activity in a soil-sand mix was about double that in a bark-sand mix (Tschabold *et al*., 1975). However, the effect of a drench of paclobutrazol applied to poinsettias (*Euphorbia pulcherrima* Willd. Klotzsch) grown in bark-based commercial media differed little from that observed in media not containing bark (Newman and Tant, 1995). Million *et al*. (1998) have showed that the organic components of growth media tested, this is, coir and peat had the least effect in reducing paclobutrazol activity.

Most of the ornamental crops produced in glasshouses are grown in artificial growing media. The most common substrate for such cultures is prepared with *Sphagnum* peat, due to its high physical

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and chemical stability and low degradation rate. The cost of high quality peat for horticultural use, together with the declining availability of peat in the near future due to environmental concern (Frolking *et al*., 2001; Schilstra, 2001) accelerated the search for alternative materials (Abad *et al*., 2001; Guerin *et al*., 2001; García-Gomez *et al*., 2002; Di Benedetto *et al*., 2006). For some time, river waste which is the result of the accumulation of plant residues under an anaerobic aquatic environment which is dredged from river and lakes banks was used as a locally available material for preparing soilless growing media for containerized crop production. Only during the past few years has this material become commercially popular for Argentine growers and it is now being successfully sound peat substitute for container-grown ornamental plants (Di Benedetto *et al*., 2004; Di Benedetto and Klasman, 2007). Nevertheless, research into river waste properties and the study of its potential as a plant growing medium is scarce and incomplete.

The objective of this study was to evaluate the influence of river waste-based media on the efficacy of paclobutrazol drench applications.

Materials and Methods

Petunia × *hybrida* Ultra seeds were germinated and grown in 288 plug trays. Twenty plants for each media tested and paclobutrazol level were transplanted to 1,000 cm^3 pot^{-1} when the 3rd set of true leaf pairs was developed.

Growing media tested were formulated with an inverse proportion of river waste (RW) and field soil (v/v) to generate a significant total porosity range as following:

RW_0 : Field Soil (100%)
RW_{20} : River Waste (20%) + Field Soil (80%)
RW_{40} : River Waste (40%) + Field Soil (60%)
RW_{60} : River Waste (60%) + Field Soil (40%)
RW_{80} : River Waste (80%) + Field Soil (20%)
RW_{100} : River Waste (100%)

River waste was collected from the coasts of the Paraná river (Argentine) (Organic Matter: 62.3%; pH: 5.0; Electric Conductivity: 0.4 dS m^{-1}; Cation Exchange Capacity: 7.15 me/100 cm^3) while a Soil from the field organic horizon of Pilar City (Argentine) (Organic Matter: 4.7%; pH: 7.4; Electric Conductivity: 0.15 dS m^{-1}; Cation Exchange Capacity: 25.3 me/100 g) was used.

Plants were irrigated as needed, using intermittent overhead mist and a weekly soil fertilization (150 ppm N; 15N:7P:14K) was included.

The triazol growth retardant paclobutrazol (β-[(4-chlorophenyl)methyl]-α-(1,1-dimethylethyl)-1H-1,2,4-triazole-1-ethanol) was added to the media as a drench treatment (50 cm^3 pot^{-1} from a solution of 20 and 40 ppm) twenty days after transplant.

Plants were harvested at the commercial sale stage (twelve weeks from transplant); they were dried at 80°C for 48 h and weighed. At the same time, plant height (measured from the top rim of the pot to the top of the canopy) and last internode height was recorded.

Samples of each growing medium were collected at the beginning of the study and physical properties (total porosity and air-filled porosity) were determined according the methodology and equations suggested by Fonteno (1996). The procedure required to fill a container of known volume with the medium. The standard pot used had holes in the bottom that were taped closed and covered on the inside by nylon screen. The volume of medium used was recorded and water was added slowly until the medium was saturated to the surface and the volume of water added was registered. The tape from the bottom of the container was removed and the drained water was collected for 60 min. The wet sample was weighed, then dried and reweighed.

The values from the above procedures were used to calculate total porosity and air-filled porosity using the following equations:

$$\text{Total porosity (\% v/v)} = \frac{(\text{wet weight} - \text{dry weight}) + \text{drained volume}}{\text{media volume}} \times 100$$

$$\text{Air-filled porosity (\% v/v)} = \frac{\text{drained volume}}{\text{media volume}} \times 100$$

The experiment design was a split plot, with growing media as main plots and paclobutrazol concentration as subplots. Data were subjected to analysis of variance and means were statistically checked by Tukey tests ($p<0.05$).

Changes in air-filled porosity, plant height, last internode length and total dry weight related to total porosity were estimated through a straight-line regression. The significance of differences was determined through the Test for zero slopes and Test for zero intercept from Kleinbaum and Kupper (1978).

Results

At the beginning of the experiments, the highest total porosity with high percentages of river waste in the media was found (Table 1). At the same time, a high coefficient correlation between air-filled porosity and total porosity was found too. Twelve weeks later, total porosity decrease was associated with a lower air-filled porosity (Fig. 1).

Plant height, as measured from the top rim of the pot to the top of the canopy increased as total porosity increased. A significant decrease in plant height was shown when a paclobutrazol solution of 40 ppm was added as a drench treatment (Fig. 2). A decrease in the last internode length according to an increase in paclobutrazol dosage was found (Fig. 3).

There were not significant changes in total dry weight related to total porosity when the paclobutrazol solution was added to the substrate (Fig. 4).

Discussion

Data from Fig. 4 suggest that it is possible to obtain high quality *Petunia x hybrida* plants grown in a soilless media containing high percentages of river waste. Changes in media physical properties, such as a decrease in total porosity, gave a lower dry weight accumulation. Although it has been indicated that triazols may indirectly influence photosynthetic activity in several ways, our results are not in agreement because there was no significant differences in dry weight in response to paclobutrazol retardant applications.

A growth medium should ideally incorporate both the physical and biological requirements for good plant growth together with those requirements of practical plant production. It is therefore important to identify those properties and conditions that directly affect the growth and quality of the plants finally produced. Our results showed that it is possible to obtain high values for total porosity and air-filled porosity (Table 1 and Fig. 1) using a river waste-base media which would be affect the water and aeration conditions of the medium. Although the fitted curves from air-filled porosity vs. total porosity changed between the beginning and the end of the experiments, it is possible to sure a range upon 20% air-filled porosity with high river waste percentages in the media.

Table 1: Total porosity (%) at the beginning of the experiment for the six growing media tested. Data are the mean of five replicates

Growing media	Total porosity (%)
RW_0	25.0d
RW_{20}	52.7c
RW_{40}	56.4c
RW_{60}	68.5b
RW_{80}	75.0b
RW_{100}	85.0a

Lower case letter(s) indicate statistically significant differences ($p \leq 0.05$) between growing media tested

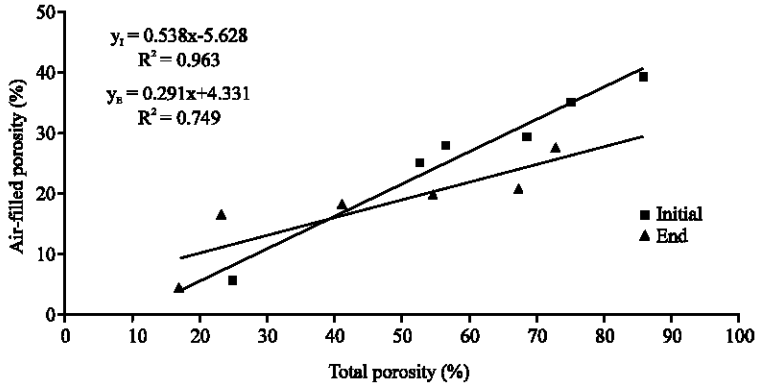

Fig. 1: Changes in Air-filled porosity (%) related to Total porosity (%) for substrates formulated with river waste-based media at both the beginning and the end of the experiments. Each point is mean of twenty replicates

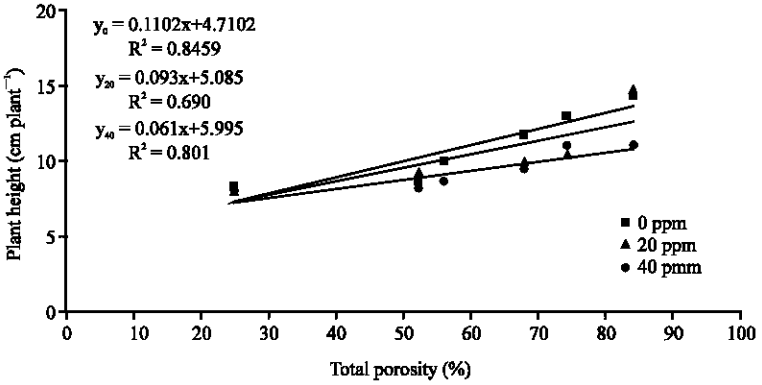

Fig. 2: The effect of media total porosity and paclobutrazol treatment on *Petunia x hybrida* plant height at the end of the experiment for substrates formulated with river waste-based media. Each point is mean of twenty replicates

It is a common practice in horticultural potted plant production to use chemical growth regulators for controlling shoot elongation and habit during production and to improve plant appearance and quality during marketing. Increasing the triazol growth retardant paclobutrazol concentrations reduced *Petunia x hybrida* plant height (Barrett and Nell, 1992). Results from Fig. 2 are in agreement with previous reports; the effect was amplified when last internode length was recorded (Fig. 3).

Dosage and application recommendations are associated to the effect of volume related to how much chemical penetrates the canopy of the plants and lands on the soil surface (Latimer *et al*., 1995).

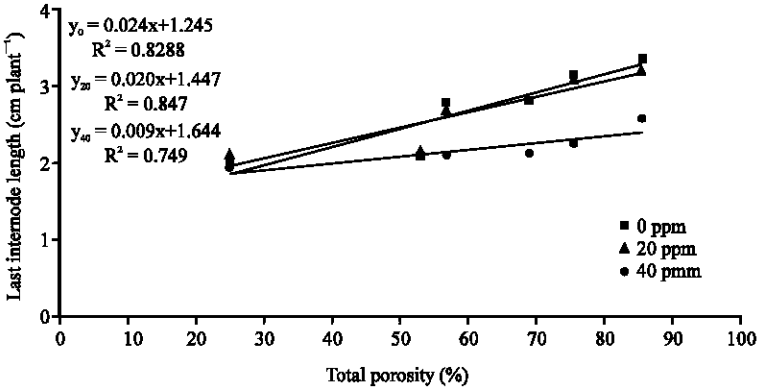

Fig. 3: The effect of media total porosity and paclobutrazol treatment on *Petunia x hybrida* last internode length at the end of the experiment for substrates formulated with river waste-based media. Each point is mean of twenty replicates

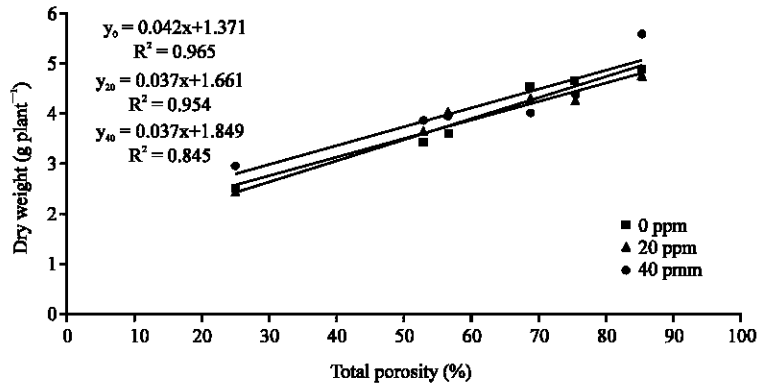

Fig. 4: Total dry weight related to total porosity for substrates formulated with river waste-based media under two paclobutrazol growth retardant treatments. Each point is mean of twenty replicates

The paclobutrazol landing on the medium surface may have been bound to medium particles near the surface and, therefore, no leached into the root zone during watering. Our results (Fig. 2 and 3) are not in agreement because the effect of a standard paclobutrazol dose on plant height and last internode length are related to total porosity determined by the quantity of river waste amendment to a peat-base media.

Evidence suggests that the optimum triazol concentration for controlling geranium height depends on cultural methods such as time of application or size of container. Paclobutrazol drenches resulted in significantly greater growth suppression than sprays (Cox and Keever, 1988). Present results showed that physical properties such as total porosity during plant growth affect paclobutrazol activity too (Fig. 2 and 3).

The lignin content of sphagnum peatmoss is 20 to 30%. The oxidation of lignin during microbial decomposition increases their reactivity and the modified lignin-like compounds are largely responsible for the adsorption of chemicals in soils. Reduced activity of nonionic organic chemicals added to soil is often attributed to adsorption reactions with the soil humus. The half life of the compounds in soil

varies considerably between sites, but is generally between 3 and 12 months. It has been indicating that mobility in soils is slow and the compound does not pose a leaching hazard (Grimstad, 1993). Present results are not in agreement and suggest a higher paclobutrazol leaching for a river waste-based soilless (Fig. 2 and 3).

There are several important factors that determine whether use of any given compound will be commercially feasible on floricultural crops. One of them is that a growth retardant provided consistent results across a reasonable range of environmental and cultural conditions that might be encountered during production. The effect of medium composition for optimum paclobutrazol application rates has not been fully documented for bedding plants (Million *et al*., 1998). However the results of this work suggest that the use of amendments such as river waste which increased total porosity (Table 1 and Fig. 1) and a potentially leaching of solutes would require a recalculation of the paclobutrazol dose (Corr, 1997) for optimum growth retardant activity.

It has indicated that new growing media are often introduced in horticulture without knowledge about the specific characteristics of the material and demands in horticulture use (Verhagen, 1997; Di Benedetto *et al*., 2006). As many label recommendation for drench concentrations are determined on peat-based media, the results of this study hopefully will aid growers in modifying concentrations to be more effective when components of the media are changing. Uniform recommendations for drench rates of paclobutrazol for commercial production will be difficult due to the wide range of components used in mixes and differences among sources of these components. Adding different amounts of river waste would have a significant effect on the amount of paclobutrazol required to achieve desired growth reduction. But, by other hand, the fact that the paclobutrazol efficiency would be more related to the physical properties imposed by the added of different amendments (this work) that the alternatives amendments itself, would let us calibrate the standard paclobutrazol dosage starting from, by example, the total porosity of the growing media.

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