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Improvement of compactness and floral quality in azalea by means of application of plant growth regulators

Mónica Meijón[a,b], Roberto Rodríguez[a,b], Mª Jesús Cañal[a,b], Isabel Feito[c,*]

[a] *Laboratorio de Fisiología Vegetal, Dpto. B.O.S., Facultad de Biología, Universidad de Oviedo, C/Cat. Rodrigo Uria s/n, E-33071 Oviedo, Asturias, Spain*
[b] *Instituto de Biotecnología de Asturias (Associated to CSIC), Edificio Santiago Gascón, C/ Fernando Bongera s/n, E-33006, Oviedo, Asturias, Spain*
[c] *SERIDA, Servicio Regional de Investigación Desarrollo Agroalimentario, Finca "La Mata", Apdo 13, E-33820 Grado, Asturias, Spain*

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ABSTRACT

The ornamental industry's difficulties in producing compact and well branched plants have been the subject of extensive evaluation, the problems being compounded by the fact that each species, and even each cultivar, requires a specific protocol. In this work, growth regulators (daminozide, paclobutrazol and chlormequat chloride) and chemical pinching agents (fatty acids) were applied to reduce shoot extension with a view to lowering production costs whilst optimizing plant quality in the production of azalea japonica. Assessment of the effectiveness of the different treatments was achieved using image analysis as a quantitative method which we consider to be a faster and more objective technique than classic biometry. The results indicate that daminozide and paclobutrazol treatment are the best options to control vegetative development and to promote the flowering of azalea japonica in a cold and humid zone such as Asturias. However, daminozide treatment induces floral deformation in one of the tested cultivars, Blaauw's Pink.

1. Introduction

Azalea japonica is a small sector of the large genus *Rhododendron* L. (*Ericaceae*) which contains approximately 1000 described species and thousands of commercial hybrids. In the ornamental industry it is commercially important to produce plants that are compact and well branched. However, many cultivars show a very strong growth tendency and an irregular shape, as is the case with Blaauw's Pink. Consequently, many nurserymen use techniques such as manual shoot-pinching to reduce apical dominance and encourage the outgrowth of side-shoots. The major disadvantage of such manual pinching is the high labour input, particularly since pinching may have to be repeated several times due to the re-establishment of a single dominant shoot. Alternative methods of pinching, using various chemical agents, offer the opportunity of reducing labour costs although the response of different cultivars in terms of shoot growth and flowering is highly variable and not all chemicals guarantee effective control.

Furthermore, modern-day azalea japonica production requires the optimal conditions for growth and flowering in specific climatic regions to be defined. Traditional cultivars may also be adapted to new commercial demands through the application of chemical compounds, such as plant growth regulators (PGRs) (Halmann, 1990; Basra, 2000) or fatty acid methyl esters tested as chemical pinching agents (Sytsema, 1979; Shu et al., 1981).

The majority of plant growth regulators employed in ornamental plant culture are chemical growth retardants used, fundamentally, to control the size of plants, improve compactness and enhance flowering (Halmann, 1990; Basra, 2000; Marosz and Matysiak, 2005). In addition, these compounds also increase other functional aspects, such as the ability to resist the negative effects of water stress (Navarro et al., 2007) or low temperatures in winter (Fletcher et al., 2000).

A chemical plant growth regulator is a natural or synthetic chemical substance, usually organic, that in very small quantities regulates or controls some aspects of plant growth, e.g. stem length, flowering, leaf abscission or winter hardiness (Basra, 2000). A great disadvantage of using these chemicals is the development of phytotoxic symptoms, such as type chlorosis, deformed leaves or damaged flowers, which may persist for a long time (Gent, 1995, 1997, 2004). Therefore, it is important to establish specific protocols for different species under particular environmental conditions (Smit et al., 2005).

Numerous plant growth regulators, such as the triazoles, have been developed to reduce stem elongation by inhibiting the synthesis of *ent*-kaurene; an early step in the giberellin (GA)

* Corresponding author. Tel.: +34 985 754 725; fax: +34 985 754 729.
E-mail address: ifeito@serida.org (I. Feito).

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biosynthesis pathway which is catalyzed by the enzyme *ent*-kaurene synthase (Halmann, 1990; Basra, 2000). Paclobutrazol (PAC) is a compound of the triazole group used extensively in ornamental crops (Wilkinson and Richards, 1991; Gent, 1995, 1997, 2004; Marosz and Matysiak, 2005), but there are also other retardants which are useful in horticulture and agriculture. Daminozide, for example, is a very popular shoot growth inhibitor (Sytsema and Ruesink, 1996; Brown et al., 1997; Marosz and Matysiak, 2005), which also inhibits GA biosynthesis although its action mechanism is unclear. Brown et al. (1997) suggest that it acts in the same way as prohexadione which inhibits the action of 3β-hydroxylasa and, to a lesser extent, 2β-hydroxylasa. This is probably due to the structural similarity between these two inhibitors and the natural enzyme co-substrate, 2-oxoglutarate. Another useful tool in controlling the shape of ornamental plants is chlormequat chloride, a chemical growth retardant which also blocks GA biosynthesis albeit at a different step in the process to the triazoles (Krause, 1979; Halmann, 1990; Basra, 2000; Marosz and Matysiak, 2005).

In the production of flowering plants, it is also crucial to define the optimal conditions to enhance flowering. Plant growth regulators influence flower production and can advance or delay flowering depending on the species and timing of application (Basra, 2000; Yuceer et al., 2003). Triazole growth regulators such as paclobutrazol promote flower bud initiation and induce precocious flowering in diverse species (Wilkinson and Richards, 1991; Yuceer et al., 2003). Inhibition of GA biosynthesis reduces vegetative growth and increases the availability of assimilates to the apex, thereby leading to flower initiation (Katz et al., 2003).

Another strategy, used extensively to reduce growth and improve compactness in ornamental plants, is the application of fatty acid methyl esters from C_6 to C_{18}. When used as chemical pinching agents, lower alkyl esters of C_8–C_{12} fatty acids and C_8–C_{10} fatty alcohols were found to selectively kill the terminal meristem of a wide variety of plants without damaging the axillary meristems, foliage or stem tissue (Shu et al., 1981).

The correct architecture for an ornamental plant involves many factors, many of which are difficult to evaluate using classic biometry. This study is designed with the aim of finding a fast and objective method for the evaluation of plant shape, and comparing the effectiveness of various treatments. Lootens et al. (2000) showed that it is possible to evaluate bloom quality in azalea by determining the colour match value via image analysis. We consider that it may also be possible to evaluate the architecture of plants by means of such an image analysis system.

The main objective of this work is to find alternatives that will improve the commercial production of azalea whilst minimizing costs. The effectiveness of the application of different plant growth regulators and chemical pinching agents on the control of plant shape was evaluated; in relation to both vegetative growth and flowering. However, to this end it was first necessary to establish an objective evaluation methodology for the assessment of plant quality through image analysis.

2. Material and methods

2.1. Plant material and growth conditions

Rooted cuttings of Johanna and Blaauw's Pink (*Rhododendron* sp), selected as a contrast, were received from the Eo nurseries (Fomento Vegetal, S.A.) in May and transplanted into 2.5 l pots containing pinus bank (1812 refora) as substrate, supplemented with slow release fertilizers (basacote plus 6 M, compo 3.5 g/l). The plants were grown outside on the experimental fields of SERIDA (Servicio Regional de Investigación y Desarrollo Agroalimentario de Asturias; Spain) in Villaviciosa (5°25′ O, 43°28′ N) with a planting density of 3 plants per m^2. The plants were fertirrigated three times a week with the following nutritional balances: 1–0.5–0.5 from May to July, 1–5–0 two weeks, 1–2–2 in August and 1–1.5–3 in September and October.

2.2. Experimental design and application of chemical compounds

A sample of 100 plants of each cultivar, was randomly divided into 20 blocks of 5 azaleas. A nest design was devised with two factors (chemical treatment and cultivars) and four repetitions in which the main factor was the chemical treatment and the secondary factor the cultivars. Each block was randomly allocated to a treatment regime.

In this study Plant Growth Regulators (gibberellin biosynthesis inhibitors) and fatty acids were used, both of which reduce plant growth and improve floral quality in numerous species. The selected treatments were:

- Two applications of daminozide spray (B-nine 85%, Uniroyal Chemical) at a concentration of 6375 ppm, following the recommendations of Sytsema and Ruesink (1996) and Brown et al. (1997), administered on 18 July and 28 August 2003.
- One application of paclobutrazol spray (99% Sigma–Aldrich) was administered on 18 July 2003 at a concentration of 190 ppm following the instructions of Gent (1995, 1997).
- Two applications of chlormequat chloride in drench (Cycocel 36%, American Cyanamid Company) were administered: the first application on 18 July 2003 at a dose of 1.96 g/l of substrate and second application on 27 August 2003 at a dose of 1.51 g/l of substrate, following the recommendations of Krause (1979) and Basra (2000).
- Fatty Acid spray (Sinbrot, Masso Division Agro) was used on the following dates: 18 July, 28 August and 6 October 2003 at a concentration of 32 ppm, as recommended by Shu et al. (1981).

2.3. Morphological parameters and quality determination

These parameters were determined in the first year of culture. In addition to classic biometry, a system of image analysis was used to evaluate the quality of the plants.

2.3.1. Biometry

Every month the maximum diameter and height of all the plants was registered. In addition, during the flowering period (April and May), we counted the number of flowers and flowering buds of each plant every week.

When the rooted cuttings of azalea were received, three branches of each plant were randomly targeted and marked with adhesive tape. Twice a week, from August of 2003 until July of 2004, their length was measured.

2.3.2. Image analysis

At the beginning of the rest period (October) eight representative azaleas of each cultivar from each treatment were photographed. Later the images were processed with Leica QWIN software at the Image Analysis Service, University of Oviedo. Roundness, roughness and leaf coverage parameters were selected to evaluate plant quality:

- Roundness is a ratio between the real plant surface and the approximation to circularity of the plant surface. This ratio presents values between 0 and 1, 1 being a perfect circle ratio.

$$\text{Roundness} = \frac{\text{Acircle}}{\text{Aobject} \times 1.064} = \frac{\eta(P^2/4\eta^2)}{A \times 1.064} = \frac{P^2}{4\eta \times A \times 1.064}$$