Plant Growth Retardants for Introduction of Native *Reichardia tingitana*

S. Bañón, J. Ochoa, J.A. Fernández, J.J.M. Sánchez and J.A. Franco
Dept. de Producción Agraria
Universidad Politécnica de Cartagena
30203 Cartagena, Murcia, Spain

A. González
Departamento de Horticultura
Consejería de Agua
Medio Ambiente y Agricultura CIDA
30150 La Alberca, Murcia, Spain

Keywords: Paclobutrazol, ethephon, growth control, pot production

Abstract

The adaptation of native plants to increase the diversity of marketable ornamental species and to preserve nature has been mainly focused on trees, shrubs and perennial plants, and less so on annual plants. *Reichardia tingitana* is a native plant of the southeast of the Iberian Peninsula, which produces attractive flowers from March to June. This plant produces stems, which are very tall and sinuous, with one terminal inflorescence. These two last features detract from the plant's use as a bedding plant. The ability of paclobutrazol (PBZ) and ethephon (ETH) to control the growth and development of the aerial part of this plant was investigated. PBZ (0.2, 0.3, 0.4 and 0.5 mg/pot) and ETH (25, 50, 75 and 100 mg/pot) doses were applied as a single soil drench 25 days after transplantation into 11 cm ϕ plastic pots. The most effective treatments were 0.5 mg/plant for PBZ and 100 mg/plant for ETH, which reduced plant height by 73.1 % and 50.3 %, respectively. PBZ (≥0.2 mg) and ETH (≥25 mg) significantly reduced plant width, aerial part dry weight, number of flowering stems and number of inflorescences per plant. None of the PBZ doses altered the inflorescence diameter, although all ETH doses reduced this parameter. PBZ (≥0.4 mg) and particularly ETH (≥50 mg) delayed the beginning of flowering. The results suggested that both PBZ and ETH could well be used to control the stem height of *Reichardia tingitana* and improve its ornamental value. However, we suggest future studies should look into the effect of time of application on plant height in an attempt to produce compact plants. Such studies will be able to determine the optimal relation between rates, moment of application and desirable plant height.

INTRODUCTION

There is a great international interest in the commercial utilization of native species. The Mediterranean region constitutes an important source of endemic plants with great potential for use as ornamental plants, because of its geomorphological and climatic characteristics.

Reichardia tingitana L. is a common wild plant of the Mediterranean region, found throughout SE Spain, especially in the province of Murcia. It is a glabrous annual to perennial plant, with many branched flowering stems. The basal leaves are smooth to densely white-papillose, narrowing at the base to a short, broad, winged petiole. The few to numerous capitula have yellow ligules, frequently with a purplish stripe at the base.

Plant growth regulators, such as PBZ and ETH, have mainly been used to manipulate the shape, size and flowering of new ornamental plants for pot production in order to obtain adequate standards relative to the container size. PBZ is a strong growth retardant used in many plants to control their growth and development (Ruter, 1996; Whipker and Hammer, 1997; Hamid and Williams, 1997; González et al., 1999). ETH, an ethylene-releasing compound, has also demonstrated a capacity to modify plant growth (Muse and Holcomb, 1997; Bañón et al., 1998; Cardoso et al., 1998). Both PBZ (Andersen et al., 1998; Kim et al., 1999) and ETH (Endres et al., 1999) have been shown to have an additional effect of modifying the colour of the leaves of some plants, another aspect that may increase ornamental value.

Proc. IS on Sust. Use Of Plant Biodiv.
Eds. E. Düzyaman &Y.Tüzel
Acta Hort. 598, ISHS 2003

The experiment described in this paper analyses the effectiveness of different doses of PBZ and ETH on the adaptation to pot production of the native *Reichardia tingitana* L.

MATERIALS AND METHODS

Reichardia tingitana L. cv 'Talud' (a native of Región de Murcia, SE Spain) seedlings were sown and grown in nursery conditions until they reached 4-7 cm height. The most homogeneous selection of seedlings possible was made to avoid, to the greatest extent possible, variations resulting from sexual propagation.

Seedlings were transferred into 9.5 cm ϕ plastic pots (420 ml) filled with a mixture of peat, perlite and clay soil (1:1:2, by volume) amended with Osmocote Plus 5-11-22 (2g/l of substrate) on 25 December 2000. Air temperature and humidity percentage were monitored by an ESCORT JUNIOR data logger and were as follows: 4-12 ºC (minimum) and 18-34 ºC (maximum); 18-57 % minimum and 67-99 % maximum relative humidity. Plants were irrigated by a computer-controlled drip irrigation system, three times per week to 100 % water holding capacity (leaching 20-25 % of the applied water).

Paclobutrazol (CULTAR 25 % p/v) as a rate of 0.2, 0.3, 0.4 and 0.5 mg per plant, or Ethephon (FRUITEL 48 % p/v) at 25, 50, 75 and 100 mg per plant, were applied to the substrate surface as a single 45 ml liquid drench on the morning of 18 January 2001, two hours after the last watering. Untreated plants acted as a control.

The following parameters were recorded at the end of the experimental growing period: 1) plant height, 2) plant width, 3) number of flowering stems per plant, 4) flowering stem diameter, 5) flowering stem internode length, 6) number of flower buds per plant (completely open), 7) leaf blade area, 8) dry weight of the aerial part, 9) culture cycle from transplantation to flowering initiation (plants with 1-2 flowering buds opened), 10) culture cycle from flowering initiation to end of flowering, 11) the relative amount of chlorophyll in leaves (RCC). Leaf area was measured with a DELTA T leaf area meter (Device Ltd., Cambridge, UK) in mature leaves. The relative amount of chlorophyll was measured in the midpoint of mature leaves with a MINOLTA SPAD 502 chlorophyll meter.

The significance of the effects of both plant growth regulators (PBZ and ETH) were analysed by ANOVA using STATGRAPHICS PLUS for Windows. Treatment means were separated with Duncan's Multiple Range Test ($P \leq 0.01$).

RESULTS AND DISCUSSION

Paclobutrazol

Plant height was significantly reduced by all doses compared with the control plants, the 0.5 mg dose having the greatest effect (73.1 % reduction). Such an effect has been widely described in numerous ornamental plants (Barrett et al., 1995; Gad et al., 1997; Whipker and Hammer, 1997; González et al., 1999; Bañón et al., 2001a, b). All doses significantly reduced plant width compared with the control, but no statistically significant differences were observed between doses. Dasoju et al. (1998) observed the same effect in ornamental sunflower as did Bañón et al. (2001a) in *Asteriscus maritimus* plants. PBZ reduced the leaf blade area by 61.55 % (0.2 mg) to 86.1 % (0.5 mg), an effect already seen in oleander (Bañón et al., 2001b) and not necessarily a major objective in *Reichardia tingitana* since the leaves form a natural rosette. The height of treated *Reichardia tingitana* plants was reduced to a highly significant degree (84.3 % reduction compared with control), this being the most strongly affected parameter by PBZ (0.5 mg). The reduction in aerial part dry weight by PBZ agreed with the results obtained by Ruter (1996) in lantana**,** Nasr (1995) in *Pelargonium zonale* and by Bañón et al. (2001a, b) in *Asteriscus maritimus* and oleander. Doses ≥ 0.3 mg significantly increased the relative chlorophyll content compared with the control, as was seen in pot carnation and oleander, an effect probably related with the increased chlorophyll level of leaves (Pan and Luo, 1994; Nasr, 1995). The darkening of the leaves was an effect seen in evergreen *Lolium*

(Wang et al., 1994) *Dicentra spectabilis* (Kim et al., 1999) and in oleander (Bañón et al., 2001b). The number of flower stems per plant was highly and significantly reduced by all the doses of PBZ, especially by the highest dose (0.5mg), which reduced this parameter from 9.4 to 4.8. These findings are in contrast with those of Nasr and Shalabi (1996), Hammid and Williams (1997), Karaguzel et al. (1999) and Bañón et al. (2001a) in *Zantedeschia, Swainsonia formosa, Bougainvillea spectabilis,* and *Asteriscus maritimus*, respectively, who noted an increase in this parameter after PBZ application. Flower stem diameter was reduced by all the doses assayed, reaching 52.1 % with the highest dose. Yewale et al. (1998) found similar results in chrysanthemum. Among other reasons, this would be due to the reducing effect PBZ has on xylem development (Proietti et al., 1998). Internodal distance was reduced by PBZ doses ≥ 0.3 mg, the greatest reduction being obtained with 0.5 mg (33.4 % reduction). This is a well known effect but one which was well below the reduction in the height (73.1 %), which suggest that PBZ reduces the number of nodes per shoot**.** This aspect does not contribute to improving the plant's compactness or to its ornamental quality. There was a clear reduction in the number of flower buds with all the PBZ doses assayed (16.8-21.6 buds per plant). Several authors have pointed to such an effect in other species including fuchsia (Gad et al., 1999) and in *Asteriscus* (Bañón et al., 2001a), although the opposite effect has also been noted by Song and Lee (1995) in camellia and Karaguzel et al. (1999) in bougainvillea**.** Flower size was not affected to any significant degree, a finding that coincides with that of Yewale et al. (1998) in chrysanthemum. This is very important since it shows that PBZ reduces the overall size of the plant without affecting one of the most important organs from an ornamental point of view. Doses ≥ 0.4 mg increased the time taken to flower but no dose significantly altered the duration of flowering. The delay in the culture cycle caused by PBZ has also seen by other authors, including Healy et al. (1993) in bougainvillea, Kim et al. (1999) in *Dicentra spectabilis* and Dasoju et al. (1998) in ornamental sunflower.

Ethephon

All the doses used reduced plant height and width to a statistically significant degree compared with the control, the maximum doses of 100 mg having the greatest effect (50.32 and 64.9 % reduction, respectively). The reduction of plant height by this plant regulator has already been noted in a number of species (Sim et al., 1997; Cardoso et al., 1998; Bañón et al., 1998; Han and Kim, 1999; Bañón et al., 2001b). There was also a highly significant reduction in leaf blade area (up to 88.6 % reduction compared with control), which, together with the finer texture, gave the impression of a dwarf plant alongside the control. The maximum dose also strongly reduced aerial part growth (87.1 % reduction). A similar reduction in the aerial dry weight was observed by Kasele et al. (1995) in maize and by Bañón et al., (2001a, b) in *Asteriscus* and oleander, probably as a result of the effect of ethylene on cell division and differentiation (Han and Nobel, 1995). The results obtained demonstrate the efficacy of ETH in reducing the growth and development parameters evaluated. Doses ≥ 50 mg significantly reduced the relative chlorophyll content by between 27.9 and 36.4 % with respect to the control, an effect that was related with the leaf chlorophyll content. An accelerated degradation of chlorophyll by ETH has been noted in several species (Centurion et al., 1998; Endres et al., 1999). In addition the leaves became a much lighter shade of green, again probably related to the relative chlorophyll content. ETH substantially reduced the number of flower stems per plant at all the studied doses. This finding contrasts with available data in the literature concerning its inhibitory role in apical dominance (Yeang and Hillman, 1984; Abeles et al., 1992) and its favouring of lateral shooting (Bañón et al., 1998) and agrees with the results obtained in *Asteriscus maritimus*. Stronger presences of secondary shoots improve plant compactness, although this is in accordance with the size of the plant in question. In our study, flower size, internodal distance and the number of flowering buds were substantially reduced in relation with the overall decrease in plant in doses ≥ 25 mg, although internodal distance was most affected by doses ≥ 75 mg. Similar effects were seen by Bañón et al. (2001a) in *Asteriscus maritimus* with ETH. All the above points to the need for an effective control of growth and development in *Reichardia tingitana* that does not affect its ornamental value as a potted plant. Doses ≥ 50 mg lengthened the time necessary to begin to flower although no dose significantly affected the time the flowers lasted, an aspect noted after treatment with ETH (Bañón et al., 2001a), that should not be considered a negative factor in the commercial pot production of *Reichardia tingitana*.

CONCLUSION

The results obtained demonstrate the great effectiveness of PBZ and ETH for use as growth retardants in *Reichardia tingitana*, both strongly reducing plant size. However these preliminary results have not optimised all the ornamental parameters of interest. For example, the reduced number of shoots per plant is to be considered a negative aspect in this plant for pot growth. The greatest number of shoots possible or the ramification of the main shoots to obtain a strong development of inflorescences should accompany any reduction in plant height. Furthermore, the reduction in leaf area was excessive, which suggests that some sort of treatment to minimise this effect should be sought. From the results, we conclude that the most useful doses are 0.3 mg of PBZ and 75 mg of ETH, since these produced a miniaturized plant but had the least negative effects. Further experimentation will combine these doses with different application times in an attempt to minimise the undesirable aspects and to produce a more compact plant.

ACKNOWLEDGEMENTS

This work has been supported by Projects CICYT-FEDER 1FD97 0420 CO2 01 "Evaluación y adaptación de especies vegetales comerciales y autóctonas para su utilización como planta en maceta, jardinería y paisajismo".

Literature Cited

Abeles, F.B., Morgan, P.W. and Saltveit, M.E. 1992. Ethylene in plant biology. 2nd ed. Academic Press, INC, San Diego, California. P. 414.

Andersen, A.S., U. Beckman, U., Moller, L.S., Considine (ed.) J.A. and Gibbs, J. 1998. *Pseudoeranthemum repandum*, potential as a new flowering potted plant. Acta Horticulturae 454: 229-239.

Bañón, S., González, A., Fernández, J.A. and Franco, J.A. 1998. The effect of ethephon on the growth and devolopment of *Liatris spicata*. *Journal of Horticultural Science & Biotechnology*, 73(5): 777-784.

Bañón, S., Ochoa, J., Fernández, J.A. and Franco, J.A. 2001a. Adecuación de *Asteriscus maritimus* al cultivo en maceta mediante reguladores del crecimiento. Actas de Horticultura de la SECH, 31: 51-61.

Bañón, S., Ochoa, J. and González, A. 2001b. Manipulation of oleander growth, development and foliage colour by paclobutrazol and ethephon. *Gartenbauwissenschaft*, 66(3): 123-132.

Barrett, J.E. and Bartuska, C.A., 1982. PP333 effects on stem elongation depend on site of application. HortScience 17: 737-738.

Cardoso, A.I., Silva, N., Della Vecchia, P.T. and Da Silva, N. 1998. Effect of ethephon on a summer squash line. Horticultura Brasileira 16 (2), 140-143

Centurion, A.R., Gonzalez, S.A., Tamayo, J.A., Argumedo J.J. and Sauri, E. 1998. The effect of ethephon on the colour, composition and quality of mango (Mangifera indica, cv. Kent). Food Science and Technology International Ciencia and Tecnologia de Alimentos Internacional 4(3): 199-205.

Dasoju, S., Evans, M.R. and Whipker, B. E. 1998. Paclobutrazol drenches Control growth of Potted Sunflowers. Department of Horticulture, Iowa State University, Ames, IA 50011-1100, USA. Horttechnology, 8(2): 235-237.

Endres, L, Finger, F.L. and Mosquim, P.R. 1999. Phytohormones and postharvest senescence of broccoli. Horticultura Brasileira 17 (1): 29-33.

Gad, M., Schmidt, G. and Gerzon, L. 1997. Comparison of application methods of growth retardants on the growth and flowering of Fuchsia magellanica Lam. Horticultural

Science, 29: 70-73.
González, A., Lozano, M., Casas, J.L., Bañón, S., Fernández, J.A. and Franco, J.A. 1999. Influence of growth retardants on the growth and development of *Zantedeschia aethiopica*. Acta Hort, 486: 333-337.
Hamid, M.N. and Williams, R.R. 1997. Effect of different types and concentrations of plant growth retardants on Sturt's desert pea (*Swainsonia formosa*). Scientia Horticulturae, 71(1-2): 79-85.
Han, S. and Nobel, J. 1995. Ethylene-induced abscission of Easter cactus phylloclades for vegetative propagation. Hortscience 30(5): 1070-1073.
Han, I.S. and Kim, J.G. 1999. Effects of growth retardants on growth, flowering and germination of harvested seed in *Clinopodium chinense* var. Parviflorum. Journal of the Korean Society for Horticultural Science 40 (6): 765-768.
Healy, W., Klick, S., Roh, M.S. (ed.) and Lawson, R.H., 1993. Controlling shoot elongation of potted alstroemeria. Second international symposium on the development of new floricultural crops, Baltimore, Maryland, USA, 15-21 Sep., 1991. Acta Hort 337: 25-29.
Kamoutsis, A.P., Chronopoulou, A.G. and Paspatis, E.A. 1999. Paclobutrazol affects growth and flowering. Hortscience 34(3): 674-675.
Karaguzel, O. 1999. Effects of paclobutrazol on growth and flowering of *Bougainvillea spectabilis* Wild. Turkish Journal of Agriculture and Forestry, 23: 527-532
Kasele, I.N., Shanahan, J.F. and Nielsen, D.C. 1995. Impact of growth retardants on corn leaf morphology and gas exchange traits. Crop Science, 35(1): 190-194.
Kim, S.H., De Hertogh, A.A. and Nelson, P.V. 1999. Effects of plant growth regulators applied as sprays or media drenches on forcing Dutch-grown bleeding heart as a flowering potted plant. Horttechnology, 9 (4): 629-33.
Muse, G. and Holcomb E.J. 1997. Florel as a growth regulator for use on *Vinca major* and *Pelargonium peltatum*. Bulletin Pennsylvania Flower Growers 439: 1-3
Nasr, M.N. 1995. Effect of methods of application and concentration of paclobutrazol on *Pelargonium zonal* (L.). Alexandria Journal of Agricultural Research, 40: 261-279.
Nasr, M.N. and Shalabi, H.G. 1996. Production of *Zantedeschia* as flowering pot plant by using growth regulators. Alexandria Journal of Agricultural Research, 41: 247-262.
Pan, R.C and Y.X. Luo 1994: Effect of PP333 on growth, development leaf structure of *Cymbidium sinense*. Acta Horticulturae Sinica 21: 269-272.
Proietti P., P. Pallioti, E. Amtognozzi, F. Ferrante and J.D. Quinla 1998: Patterns of anatomy differentiation, growth and physiology activity following paclobutrazol application in chestnut. Acta Hort 463: 177-184.
Ruter, J.M. 1996. Paclobutrazol application method influences growth and flowering of New Gold Lantana. Horttechnology, 6 (1): 19-20.
Sim, Y.G., Han, Y.Y., Woo, J.H., Seong, Y.C., Choi, K.B. and Choi, B.S. 1997. Effect of shading and growth regulator on growth and flowering of potted *Campanula takesimana* Nakai. RDA Journal of Horticulture Science 39 (1): 89-94
Song, C.Y. and Lee, J.S. (1995). Effect of growth regulators on growth and flowering of potted camellia. Journal of the Korean Society for Horticultural Science, 36 (1): 98-106.
Wang, S.M., Zhang, M.R. and Zhov, Z.Y. 1994. Effect of pp333 on growth and contents of several substances in *Lolium perenne*. Plant physiology communications, 30 (1): 15-18.
Yeang, H. Y Hillman, J.R. 1984. Ethylene and apical dominance. Physiol. Plant 60: 275-280.
Yewale, A.K.; Belorkar, P.V.; Jayeeta, B.; Chanekar, M.A. and Chimurkar, B.S. 1998. Effect of paclobutrazol on thickness of stem, flower diameter, fresh weight and dry weight of aerial portion of chrysanthemum. Journal of Soils and Crops, 8 (1): 73-75.
Whipker, B.E. and Hammer, P.A. 1997. Efficacy of ancymidol, paclobutrazol and uniconazole on growth of tuberous rooted dahlias. Horttechnology 7: 269-273.

Tables

Table 1. Influence of paclobutrazol doses on the height of plant (HP), width of plant (WP), leaf blade area (LBA), aerial part dry matter (APDM) and relative chlorophyll content (RCC) of *Reichardia tingitana.*

Doses (mg/pot)	HP (cm)	WP (cm)	LBA (cm^2)	APDM (g)	RCC
Control	47.87 a	30.5 a	27.52 a	14.04 a	52.2 a
0.2	19.66 b	18.5 b	10.60 b	6.14 b	54.1 ab
0.3	17.50 bc	18.3 b	10.23 b	5.54 b	57.6 bc
0.4	14.00 bc	16.9 b	6.37 bc	3.40 bc	58.1 cd
0.5	12.89 c	15.5 b	3.83 c	2.20 c	61.7 d
Signification	***	***	***	***	***

*** (significant *P*=0.001 using analysis of variance)

Table 2. Influence of paclobutrazol doses on the number of flowering stems (NF), flowering stems diameter (FSD), flowering stems iternode length (FSIL), number of flower buds (NFB), flower diameter (FD), time from transplantation to flowering period initiation (T-FI) and flowering duration (FD)of *Reichardia tingitana.*

Doses (mg/pot)	NF	FSD (mm)	FSIL (mm)	NFB	FD (cm)	T-IF (days)	FD (days)
Control	9.4 a	54.5 a	46.92 a	32.0 a	4.64	77.7 a	95.3
0.2	6.4 b	45.8 b	42.40 ab	15.2 b	4.45	78.6 a	96.3
0.3	5.9 b	43.2 b	38.37 bc	13.0 b	4.35	78.0 a	96.6
0.4	6.1 b	32.0 c	36.26 cd	12.3 b	4.39	89.7 b	94.6
0.5	4.8 c	26.1 d	31.07 d	10.4 b	4.25	90.0 b	91.3
Signification	***	***	***	***	*ns*	**	*ns*

ns, **, *** (non-significant, significant *P*=0.01 or 0.001, respectively, using analysis of variance)

Table 3. Influence of ethephon doses on the height of plant (HP), width of plant (WP), leaf blade area (LBA), aerial part dry matter (APDM) and relative chlorophyll content (RCC) of *Reichardia tingitana.*

Doses (mg/pot)	HP (cm)	WP (cm)	LBA (cm^2)	APDM (g)	RCC
Control	47.87 a	30.5 a	27.52 a	14.04 a	52.2 a
25	31.45 b	15.8 b	7.97 b	6.36 b	48.87 a
50	30.89 b	14.9 b	5.64 b	4.49 bc	40.6 b
75	27.9 b	12.6 bc	5.27 b	2.72 bc	37.6 bc
100	23.78 c	10.7 c	3.14 b	1.81 c	33.2 c
Signification	***	***	***	***	***

*** (significant *P*=0.001 using analysis of variance)

Table 4. Influence of ethephon doses on the number of flowering stems (NF), flowering stems diameter (FSD), flowering stems iternode length (FSIL), number of flower buds (NFB), flower diameter (FD), time from transplantation to flowering period initiation (T-FI) and flowering duration (FD)of *Reichardia tingitana.*

Doses (mg/pot)	NF	FSD (mm)	FSIL (mm)	NFB	FD (cm)	T-IF (days)	FD (days)
Control	9.4 a	54.5 a	46.92 a	32.0 a	4.64 a	77.7 a	95.3
25	1.2 b	40.9 b	40.32 b	17.0 b	3.34 b	90.3 a	92.4
50	2.3 b	34.6 b	35.19 b	16.4 b	3.10 b	90.3 b	90.6
75	2.6 b	26.0 c	27.90 c	13.5 b	2.96 b	103.3 b	90.3
100	3.3 b	21.6 c	24.44 c	11.3 b	2.78 b	106.0 c	83.7
Signification	***	***	***	***	***	***	*ns*

ns, *** (non-significant, significant *P*=0.001, respectively, using analysis of variance)