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Impact of Foliar Applied Paclobutrazol in Combination with Auxin on Rooting and Subsequent Shoot Growth in *Angelonia* Cuttings

Anna G. Baloh, W. Garrett Owen, Robert L. Geneve

Department of Horticulture, University of Kentucky, Lexington, Kentucky 40546 U.S.A.

Rgeneve@uky.edu

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Summary

Angelonia cuttings were treated with a combination of Bonzi and K-IBA as a quick dip and foliar spray. The foliar auxin spray was not as effective as a basal dip at the concentrations used in this study. A foliar spray using Bonzi increased rooting with or without auxin. Bonzi did not have a significant impact on plant height post-rooting. This study provides initial evidence that a tank-mix of auxin and a gibberellin inhibitor used as a spray application could be an efficient and effective means for application in commercial cuttings.

INTRODUCTION

Angelonia (*Angelonia angustifolia*) is native from Mexico to Columbia (Winhelmann et al., 2018). It is an annual herbaceous plant that produces snapdragon-like flowers used for bedding or mixed containers. Angelonia is typically propagated by auxin-treated cuttings (Dole and Gibson, 2006). Auxin is commonly delivered to cuttings as a basal liquid or talc application (Davies et al., 2018). Foliar auxin spray application has become an alternative application method. that is a cost-effective alternative that can increase worker safety and rooting efficiency (Blythe et al., 2004; Drahn, 2007; Martindell, 2019).

Gibberellin is generally considered inhibitory to adventitious rooting (Davies et al., 2018) and exogenous gibberellin application to cuttings reduces adventitious rooting (Mauriat et al., 2014). Gibberellin biosynthesis inhibitors such as Bonzi (Paclobutrazol) have been shown to increase adventitious root initiation possibly by reducing the negative impact of endogenous gibberellin (Upadhyaya et al., 1986; Wiesman and Riov 1994). Bonzi can also reduce plant height (Davis et al., 1986). Bonzi applied to mungbean cuttings increased rooting and drastically decreased the hypocotyl length in mungbeans compared to the control (Bora at al., 1990).

Bonzi can be applied to cuttings as a foliar spray and therefore the objective of this study was to investigate the impact of Bonzi as a foliar spray alone or in combination with auxin on rooting and subsequent shoot growth in angelonia cuttings.

METHODS AND MATERIALS

Cuttings of angelonia 'Aria Purple' were obtained from Dümmen Orange, Columbus OH. There were nine treatment combinations including:

1. Untreated
2. K-IBA at 1000 mg · L^{-1} basal quick dip
3. K-IBA at 100 mg · L^{-1} foliar spray
4. Bonzi 5 mg · L^{-1} foliar spray
5. Bonzi 20 mg · L^{-1} foliar spray
6. K-IBA at 100 mg · L^{-1} and Bonzi 5 mg · L^{-1} foliar spray
7. K-IBA at 100 mg · L^{-1} and Bonzi 20 mg · L^{-1} foliar spray
8. K-IBA at 1000 mg · L^{-1} quick dip and Bonzi 5 mg · L^{-1} foliar spray
9. K-IBA at 1000 mg · L^{-1} quick dip and Bonzi 20 mg · L^{-1} foliar spray.

Cuttings were stuck in 3 parts Promix / 1 part perlite (v/v) in six-packs. Untreated and basal quick dip cuttings were moved directly to the mist bench. Cuttings receiving a foliar spray treatment were treated prior to moving to the mist bench. Mist applied every ten minutes for 10 seconds. Foliar sprays were applied at 10 mL per six pack from a 50 mL spray bottle which covered the foliage to leaf drip.

Each six-pack was an experimental unit and there were six randomized replicates per treatment (36 cuttings per treatment). After three weeks, roots per cuttings were counted and rooting quality rated on a scale of 1 (poor root formation) to 5 (excellent root formation). The scale considered the length and secondary root formation. Once each cutting was evaluated for rooting, they were placed back into the six-pack cells in the greenhouse. After three weeks, plant height was measured from the container rim to the shoot apex.

RESULTS

Untreated angelonia cuttings had the lowest roots per cutting and the poorest root rating (Table 1). Cuttings treated with 1000 mg · L^{-1} K-IBA quick dip plus 20 mg · L^{-1} Bonzi foliar spray resulted in the highest roots per cutting and root rating quality. All quick dip treatment combinations resulted in higher roots per cutting and root ratings than the foliar spray application combinations (**Table 1**). Bonzi foliar spray alone at 5 or 20 mg · L^{-1} increased the number of roots per cutting compared to untreated cuttings by about two roots per cutting, but only Bonzi at 20 mg · L^{-1} increased rooting percentages (79.7 to 95.8%).

There was no statistical difference in plant height in any cuttings (**Table 2**). Untreated angelonia cuttings had lower but not significantly reduce height compared to treated cuttings (**Table 2**).

Table 1. Root formation in *Angelonia* cuttings treated with K-IBA and Bonzi as a dip or foliar spray.

Application method	K-IBA (mg · L^{-1})	Bonzi (mg · L^{-1})	Rooting percentage	Roots per cutting	Root rating
Untreated	0	0	79.7c	3.9d[x]	1.7b
Quick dip	1000	0	98.1b	13.1b	3.6a
	1000	5	100a	14.2b	3.6a
	1000	20	100a	18.7a	4.1a
Foliar spray	0	5	88.9bc	6.3c	2.9a
	0	20	95.8b	6.1c	3.1a
	100	0	100a	5.9c	3.2a
	100	5	100a	5.6c	2.6ab
	100	20	100a	7.1c	2.8a

[x]means in a column followed by the same letter were not different by Tukey at the 5% level.

Table 2. Plant height in *Angelonia* cuttings treated with K-IBA and Bonzi as a dip or foliar spray.

Application method	K-IBA (mg · L^{-1})	Bonzi (mg · L^{-1})	Height (cm)
Untreated	0	0	6.2
Quick dip	1000	0	7.5
	1000	5	7.3
	1000	20	7.7
Foliar spray	0	5	8.0
	0	20	7.3
	100	0	7.6
	100	5	7.5
	100	20	7.7

DISCUSSION

It is common for gibberellin inhibitors in combination with auxin application to increase rooting in cuttings (Davies et al., 2018). Many of the early studies used bean (*Phaseolus* and *Vigna*) model systems where auxin and a gibberellin inhibitor were applied to cuttings in a basal solution (Bora et al., 1991; Porlingis and Koukourikou-Petridou 1996; Upadhyaya et al., 1986; Wiesman and Riov, 1994). Later studies with woody perennials like *Ligustrum* (Šebánek et al., 1991), *Rhamnus* (Bañón et al., 2003) and *Delonix* (Abdi et al., 2009) reinforced the promotive effect on rooting as a basal treatment combination of auxin and a gibberellin inhibitor. The current study using an herbaceous perennial showed a similar promotive effect of a gibberellin inhibitor used as a foliar spray (Table 1). This provides initial evidence that a tank-mix of auxin and a gibberellin inhibitor used as a spray application could be an efficient and effective means for application in commercial cuttings.

There is also evidence that a gibberellin inhibitor application alone can increase rooting in cuttings (Davies et al., 2018). In the current study, Bonzi at the highest concentration did improve both rooting percentage and root number compared to untreated cuttings. The mode of action could be a reduction of endogenous gibberellin, which could be antagonistic to rooting (Davies et al., 2018). It is becoming more evident that endogenous gibberellin impacts adventitious root formation by altering polar auxin transport reducing the endogenous auxin concentration in the basal rooting portion of the stem (Mauriat et al., 2014). Reducing the endogenous gibberellin titer with a gibberellin biosynthesis inhibitor could be responsible for the increased rooting in cuttings treated with a gibberellin inhibitor like Bonzi (Nagy, et al., 1991; Šebánek, et al., 1991).

Bonzi applied as a foliar spray to cuttings did not play a significant role in controlling the height of the angelonia cuttings after rooting (Table 2). Bonzi typically acts as a growth regulator to reduce plant height in greenhouse crops (Goulston and Shearing, 1985). Additional research is needed to see if Bonzi has similar effects on other herbaceous perennials.

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