Use of Paclobutrazol to Regulate Shoot Growth and Flower Development of 'Roseum Elegans' Rhododendron[1]

Thomas G. Ranney, Richard E. Bir, Joseph L. Conner and Everett P. Whitman II
North Carolina State University, Mountain Horticultural Crops Research and Extension Center
Department of Horticultural Science, 2016 Fanning Bridge Road, Fletcher, NC 28732-3562

Abstract

'Roseum Elegans' rhododendron (*Rhododendron* sp. L.) were grown in 2.5 l (#1) containers and treated with foliar sprays of 50, 100, and 200 ppm or root-zone drenches of 2.5 (0.89), 5.0 (1.78), 10.0 (3.55), and 20.0 (7.10) ppm (mg ai/plant) of paclobutrazol immediately following completion of the first flush of annual shoot growth. Shoot lengths of the subsequent growth flush following treatment were decreased with increasing rates of paclobutrazol when applied as either a drench or foliar spray. Drenches were more effective in suppressing shoot length with less active ingredient than were foliar sprays. The number of flower buds per plant increased with increasing rates of paclobutrazol when applied as a drench but not as a foliar spray. The highest drench rate resulted in 8.0 flower buds/plant, a 240% increase over non-treated plants. No phytotoxicity was observed from any of the treatments; however, inflorescence diameter, measured the year following treatment, was slightly (< 1.1 cm, < 7.5%) reduced with increasing rates of paclobutrazol when applied as a drench. Flowering duration, the period from bud break to abscision of the last flower, increased with increasing rates of paclobutrazol for both application methods with a maximum increase of 5.6 days for the highest drench treatment. Length of shoot growth the year following treatment was reduced by as much as 33% with increasing paclobutrazol rates when applied as a drench but not as a foliar spray.

Index words: flowering, plant growth regulator, phenology, production.

Chemicals used in this study: Bonzi™ (paclobutrazol), (±)-(R*,R*)-ß-[(4-chlorophenyl)methyl]-α-(1,1,-dimethylethyl)-1*H*-1,2,4,-triazole-1-ethanol.

Species used: 'Roseum Elegans' Rhododendron (*Rhododendron* sp. L.).

Significance to the Nursery Industry

Some vigorous growing rhododendron cultivars, e.g. 'Roseum Elegans', tend to have excessive shoot growth and delayed or limited flower initiation under favorable growth conditions. Results indicated that paclobutrazol applied as either a root-zone drench or foliar spray was effective in reducing shoot growth and in some cases increasing flower bud number in container grown 'Roseum Elegans' rhododendron with minimal undesirable side effects. Foliar sprays were much less effective than drench treatments in reducing shoot growth and had no effect on flower bud number, suggesting that foliar rates may need to be greater than 200 ppm to be effective under our growing conditions. Root-zone drenches in the range of 10–20 ppm (3.55–7.10 mg ai/plant) proved to be most effective, resulting in more compact plants with greater numbers of flower buds. Due to the potential for changing efficacy based on environment, growing conditions, and cultivar sensitivity, rates may need to be adjusted for variations in these factors.

Introduction

When growing rhododendrons in commercial production, it is typically desirable to produce a compact, evenly branched plant with an abundance of flower buds. Achieving these goals can require skillful manipulation of fertilizer, irrigation, light level, and pruning with all being adjusted for the specific growth characteristics of a given species or cultivar. Some rhododendron hybrids, including 'Roseum Elegans' rhododendron (*Rhododendron* sp.), can be difficult to manage as they can have undesirable, vigorous growth characteristics resulting in long internodes, floppy growth habits, and few flower buds.

Considerable research has been conducted on the use of growth regulators for controlling shoot elongation and flower initiation in rhododendrons. Stuart (16) first reported that the growth regulators chlorphonium (phosphon) and chlormequat chloride could effectively retard shoot growth while stimulating initiation of flower buds in azaleas (*Rhododendron* spp. *L.*).

Later work has further evaluated the effectiveness and limitations of a variety of plant growth regulators on *Rhododendron* spp. The growth regulator daminozide has been shown to increase flower initiation of *Rhododendron* spp., but has given inconsistent control of shoot growth, generally required multiple applications of foliar sprays, and in some cases, high rates reduced flower size, diminished flower color, and delayed flower development (5, 8, 11, 12, 18). Similarly, chlormequat chloride has been shown to increase flower bud number in *Rhododendron* spp., but the affects on shoot elongation are sometimes inconsistent and transitory, multiple foliar sprays are generally required, and high rates may result in abnormal flowers, advanced or delayed bloom time, leaf curl, and leaf margin necrosis (5, 8, 11, 12, 17, 18). Limited testing of ancymidol has indicated that this chemical can inhibit shoot growth and promote flower initiation in rhododendron, but was less effective than daminozide or chlormequat chloride (20) and plants were affected over a narrow concentration range (4). Chlorphonium has given some of the most promising results and has been shown to provide effective control of shoot growth and increase flower initiation, but on some cultivars (e.g. *R.* 'Roseum Elegans') resulted in smaller, paler flowers, and limber stems with

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side effects lasting several years (5, 11, 12, 16). Furthermore, chlorphonium is no longer available as a commercial plant growth regulator.

Most recently, triazole growth regulators, including paclobutrazol, have been found to effectively regulate shoot length and often increase flower initiation in a wide range of woody plants (1, 6, 7, 9, 10, 15, 21). Use of paclobutrazol on *Rhododendron* spp. has also been promising. Joustra (8) reported that paclobutrazol was a more effective growth regulator than daminozide or chlormequat for selected rhododendron and azalea cultivars. In a comparison among 8 plant growth regulators, Whealy et al. (20) found that paclobutrazol was one of the most efficient and effective chemicals for reducing shoot length, without affecting flower size or time to flower in 'Gloria' azalea (*R. obtusum*). In addition to regulating shoot growth, research has indicated that paclobutrazol can increase flower initiation, is effective as a foliar or drench application, and that foliar sprays are often effective with only one application on a number of *Rhododendron* spp. (8, 10, 20, 22). Although many of the results with paclobutrazol are promising, some undesirable side effects, including malformed leaves, prolonged growth suppression, reduction in flower diameter, and delayed flowering, have been reported for *Rhododendron* spp. treated with high rates of paclobutrazol (8, 10, 21). It has also been reported that different cultivars of rhododendron can vary considerably in sensitivity to paclobutrazol (8).

The objectives of this project were to evaluate the effect of paclobutrazol rate and application method (foliar spray and root-zone drench) on shoot growth, flower initiation, flowering phenology and duration, and phytotoxicity on 'Roseum Elegans' rhododendron.

Materials and Methods

Container-grown 'Roseum Elegans' rhododendron liners were transplanted into 2.5 l (#1) black plastic containers in April 1992. The container media consisted of milled pine bark:sphagnum peat (5:1 by vol) amended with dolomitic limestone at 4.2 kg/m^3 (7.0 lbs/yd^3). Plants were then grown outdoors on a gravel bed located at the Mountain Horticultural Crops Research Station in Fletcher, NC. Irrigation was applied as needed via spray emitters placed in each container and located below the leaf canopy of the plants. Thirteen grams (0.46 oz) of 22N-1P-8K (22-3-10 ProKote Plus, O.M. Scott, Marysville, OH) was surface-applied to each container on June 15, 1992.

Treatments were applied on June 5, 1992 following cessation of the first growth flush. Paclobutrazol (Bonzi, 0.128% L, Uniroyal Chemical Company, Middlebury, CT) was applied either as a foliar spray or as a root-zone drench (Table 1). Foliar spray treatments of 50, 100, and 200 ppm paclobutrazol were applied with approximately 2.2 oz (65 ml)/plant to the point immediately prior to run-off with a hand-held sprayer. Root-zone drenches consisted of 355 ml (12 oz) of solution applied per plant at 2.5, 5.0, 10, and 20 ppm paclobutrazol. Weather was partly cloudy/overcast with no rain that day. Air temperature at time of treatment was 22°C (72°F). The experimental design was a randomized complete block with twelve single-plant replications.

Flower bud number and shoot growth were measured in October 1992. Shoot growth was measured as the length from the last terminal bud scar to the terminal point for each of the three longest shoots of each plant. This measurement reflected shoot growth of the one growth flush following treatment application.

Table 1. Rates and application methods for paclobutrazol (Bonzi .128% L) applied to 'Roseum Elegans' rhododendron.

Treatment	Application rates		
	ppm	mg ai/plant	grains ai/plant
Control	0.0	0.00	0.000
Foliar spray^z	50.0	3.25	0.050
	100.0	6.50	0.101
	200.0	13.00	0.201
Root-zone drench^y	2.5	0.89	0.014
	5.0	1.78	0.027
	10.0	3.55	0.055
	20.0	7.10	0.110

^{z}Applied to the point of run-off with an average volume of 65 ml (2.2 oz) per plant.

^{y}Applied with a volume of 355 ml (12 oz) per plant.

Plants were stored in an unheated polyethylene greenhouse during winter and then moved into a heated greenhouse on February 1, 1993. Flowering characteristics, including inflorescence diameter, date of flower bud break, date of full bloom, and date of last flower drop were recorded for each individual inflorescence on each plant. Shoot growth was measured, as previously described, following the first growth flush in 1993.

Results and Discussion

1992 measurements. Shoot length of the first growth flush following treatment decreased with increasing rates of paclobutrazol when treatments were applied either as a container drench (quadratic response, Fig. 1A) or foliar spray (linear response, Fig. 1B). However, container drenches were considerably more effective in reducing shoot length, with less active ingredient, than were foliar applications. A container drench of 20 ppm (7.1 mg ai/plant) resulted in a 66% reduction in shoot length vs. control plants, while a 200 ppm foliar spray (13.0 mg ai/plant) resulted in only a 24% reduction in shoot length.

The number of flower buds increased with increasing rates of paclobutrazol when applied as a container drench (linear response, Fig. 1C), but not when applied as a foliar spray (Fig. 1D). Plants treated with a 20 ppm drench had a mean of 8 flower buds per plant, representing a 242% increase over the controls.

1993 measurements. Inflorescence diameter was reduced slightly with increasing concentrations of paclobutrazol when applied as a container drench (linear response, Fig. 2A), but not when applied as a foliar spray (Fig. 2B). However, the reduction in inflorescence diameter, even for plants treated at 20 ppm as a container drench was small, < 1.1 cm or a 7.5% reduction, compared to the control plants, and would probably not be an important factor for the average consumer.

Flowering duration, defined as the period from flower bud break to abscission of the last flower, increased in a linear response with increasing rates of paclobutrazol when applied both as a root-zone drench (Fig. 2C) and foliar spray (Fig. 2D). Flowering duration increased by as much as 5.5 days for plants treated with 20 ppm root-zone drench and 4.6 days for plants treated with 200 ppm foliar spray. There was no effect of paclobutrazol, regardless of application method, on mean date of flower bud break or mean date of full bloom (data not shown). Thus, the increase in flowering duration in response to paclobutrazol appeared to result from a delay in flower senescence and/or flower abscision. Although an increase in flower duration may be considered desirable, the quality of these inflorescences with many abscised flowers and the remainder often with flaccid petals suggests that this additional period of bloom should not be considered a time of peak plant attractiveness or salability.

A reduction in shoot length of the first growth flush in 1993, for plants treated in 1992, was evident with increasing concentrations of paclobutrazol when applied as a container drench (Fig. 3A) but not for plants treated with a foliar spray (Fig. 3B). Shoot length of plants that were treated with a 20 ppm container drench was reduced by 6.4 cm or 33% as compared to controls. The amount of growth reduction, even for the 20 ppm root-zone drench, was not excessive the following year and in many cases would be considered desirable.

No signs of foliar phytotoxicity or deformation were evident for any of the treatments. Nor were there any signs of root deformation as has been reported for other plants treated with root-zone applications of paclobutrazol (2, 14).

Under the growing conditions imposed in this experiment, application rates of 10–20 ppm (3.5–7.1 mg, 0.05–0.11 grains ai/plant) applied as a root-zone drench gave effective control of shoot length for two growth flushes following treatment and significantly increased flower bud number with no signs of phytotoxicity. Keever et al. (10) found that increasing rates of root-zone applied paclobutrazol up to 100 mg (1.5 grains) ai/plant decreased shoot growth for 2 azalea cultivars grown in #1 containers with a pine bark medium, but that the greatest reduction in shoot growth typically occurred between 0–6 mg (0–0.1 grains) ai/plant. Wilkinson and Richards (22) reported that root-zone drenches of paclobutrazol at rates from 100–400 mg (1.5–6.2 grains) ai/plant to *Rhododendron* 'Sir Robert Peel' in 4.3 l (1.1 gal) containers with a pine bark:sandy loam:sand (3:1:1 by vol) medium proved excessive and resulted in prolonged shoot growth reduction and malformed flowers.

Foliar sprays up to a concentration of 200 ppm provided minimal control of shoot growth and had no effect on flower bud number in our research. Brand (3) recently reported that foliar sprays of paclobutrazol at rates as low as 10 ppm provided effective shoot control on 'Roseum Elegans' rhododendron, particularly if applied in April before the first flush of annual growth. Wilkinson and Richards (22) found that

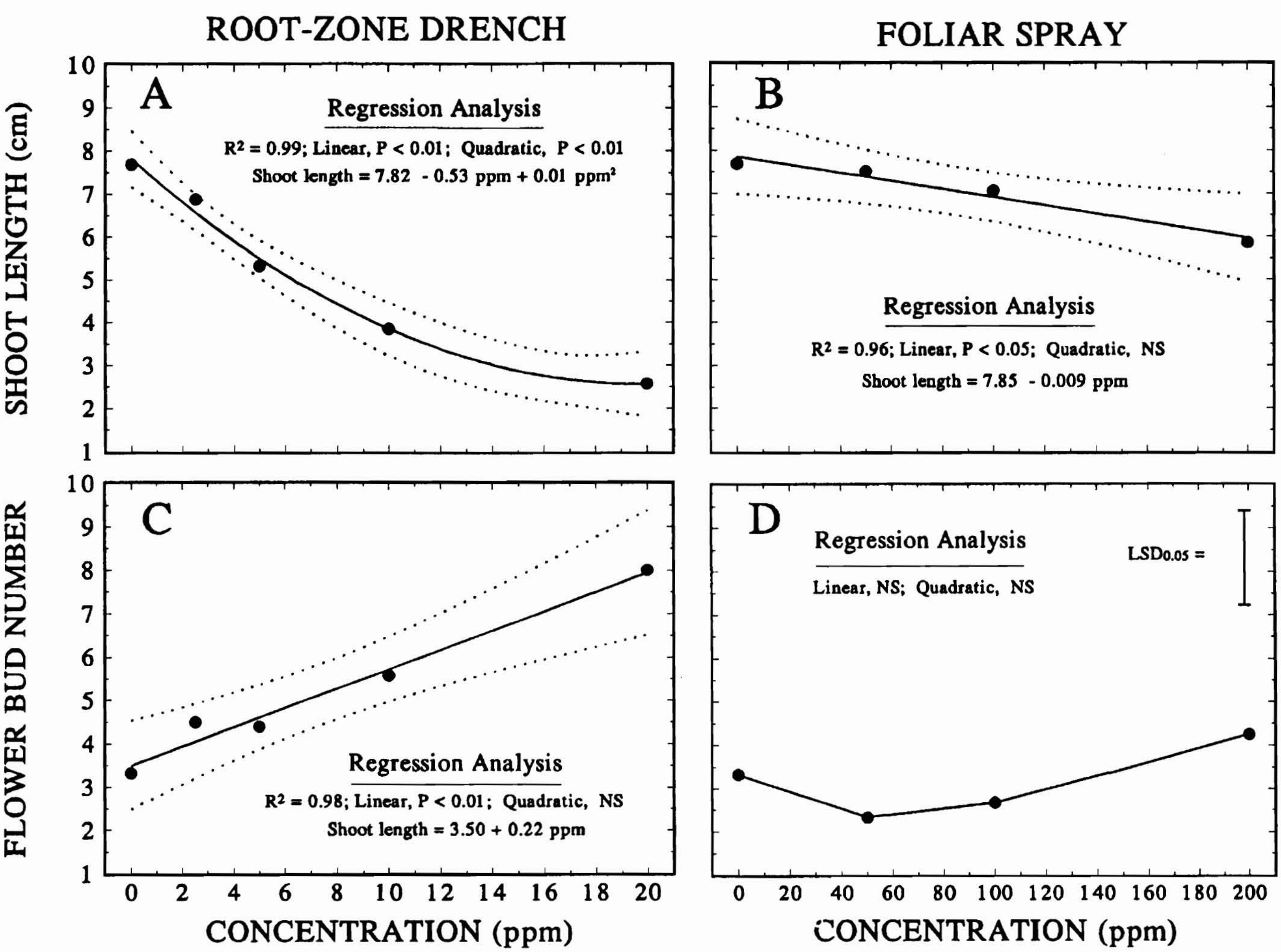

Fig. 1. Response of shoot length and flower bud number to paclobutrazol rate for root-zone and foliar treated plants at the completion of the 1992 growing season. Solid lines represent the predicted regression response in cases where regression terms were significant. Dotted lines represent a 95% confidence interval for the mean response. Data points represent means, n = 12.

foliar application during the last growth flush in autumn on 'Sir Robert Peel' rhododendron required paclobutrazol concentrations of 500 ppm to provide effective shoot control and increase flower initiation. Noting that paclobutrazol concentrations above approximately 125–250 ppm can cause leaf deformation on some rhododendron cultivars, Joustra (8) recommends foliar spray concentrations of 50–125 ppm as an experimental rate for evergreen rhododendrons. Research on azaleas typically has found paclobutrazol rates between 250 and 500 ppm to provide desirable control of shoot growth (10, 20).

Variations in reports of dose responses of paclobutrazol for both foliar sprays and root-zone drenches emphasize the potential for variation in efficacy as a function of growing conditions, timing, and the taxa being treated. Translocation studies have demonstrated that paclobutrazol typically moves acropetally, through the xylem, within a plant (13, 19). Uptake through the roots, young stems, and unrolled leaves have been shown to be effective uptake sites, but applications to mature leaves have generally been found to be ineffective in controlling shoot growth. This knowledge helps explain why root-zone drenches are typically more effective and why foliar applications may be more effective when applied to immature stems.

High temperatures have also been found to be an important factor in affecting shoot elongation and efficacy of triazole growth retardants. At high temperatures [e.g. 30/22°C (86/72°F) day/night] uniconazole was found to have less effect on height growth of poinsettias than at lower temperatures (Larson, per. comm.). Variation in temperatures may also affect efficacy of paclobutrazol in rhododendrons.

Results from our research demonstrate that paclobutrazol can be used effectively to control shoot growth and to promote flower bud initiation in 'Roseum Elegans' rhododendron with minimal undesirable side-effects. In our evaluations root-zone drenches in the range of 10–20 ppm (3.55–7.10 mg ai/plant) provided effective responses. Under our growing conditions, foliar sprays may need to be increased in excess of 200 ppm to elicit greater effects.

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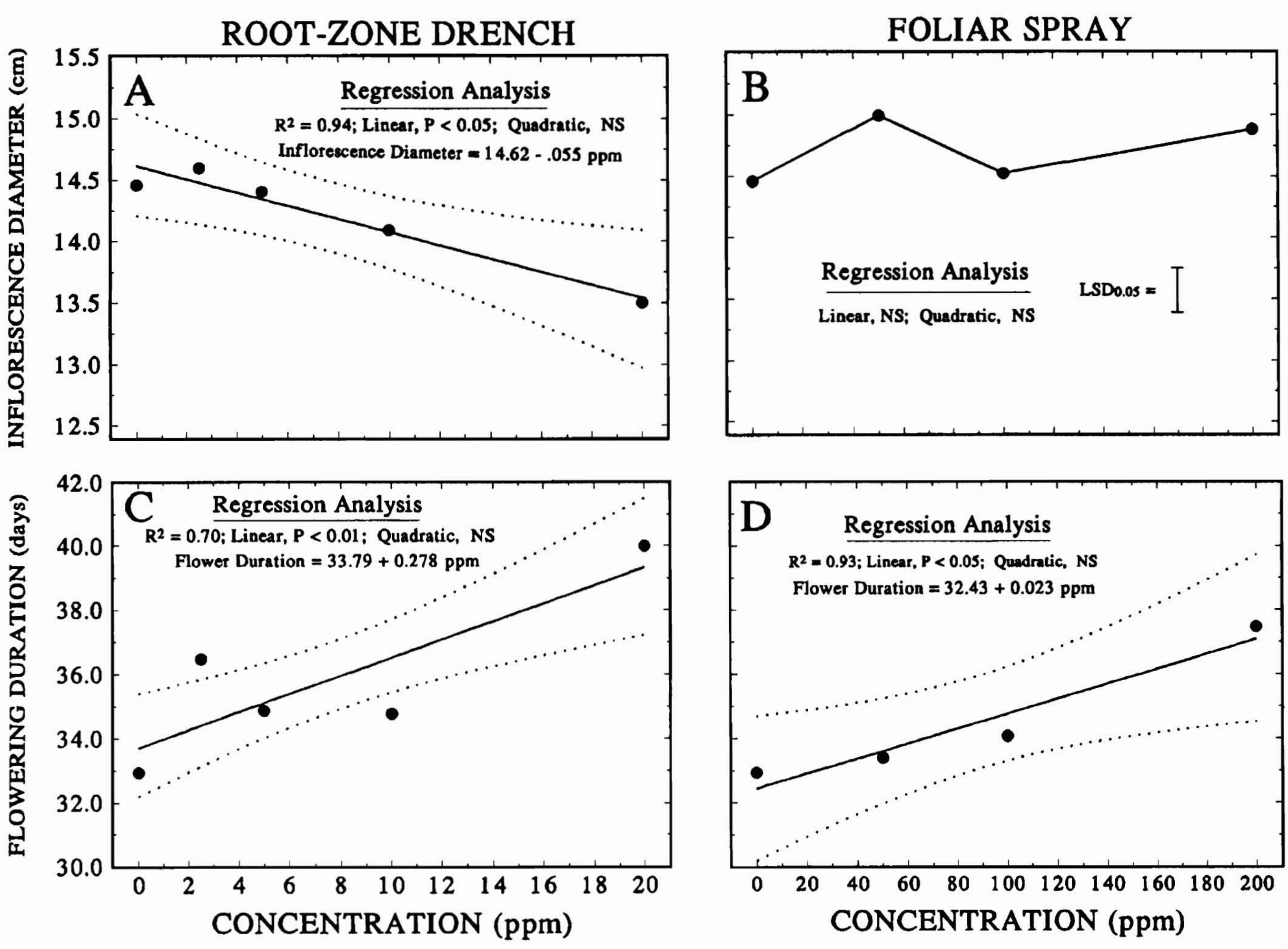

Fig. 2. Response of inflorescence diameter and flowering duration to paclobutrazol rate for root-zone and foliar treated plants measured in 1993 after being treated in 1992. Solid lines represent the predicted regression response in cases where regression terms were significant. Dotted lines represent a 95% confidence interval for the mean response. Data points represent means, n = 12.

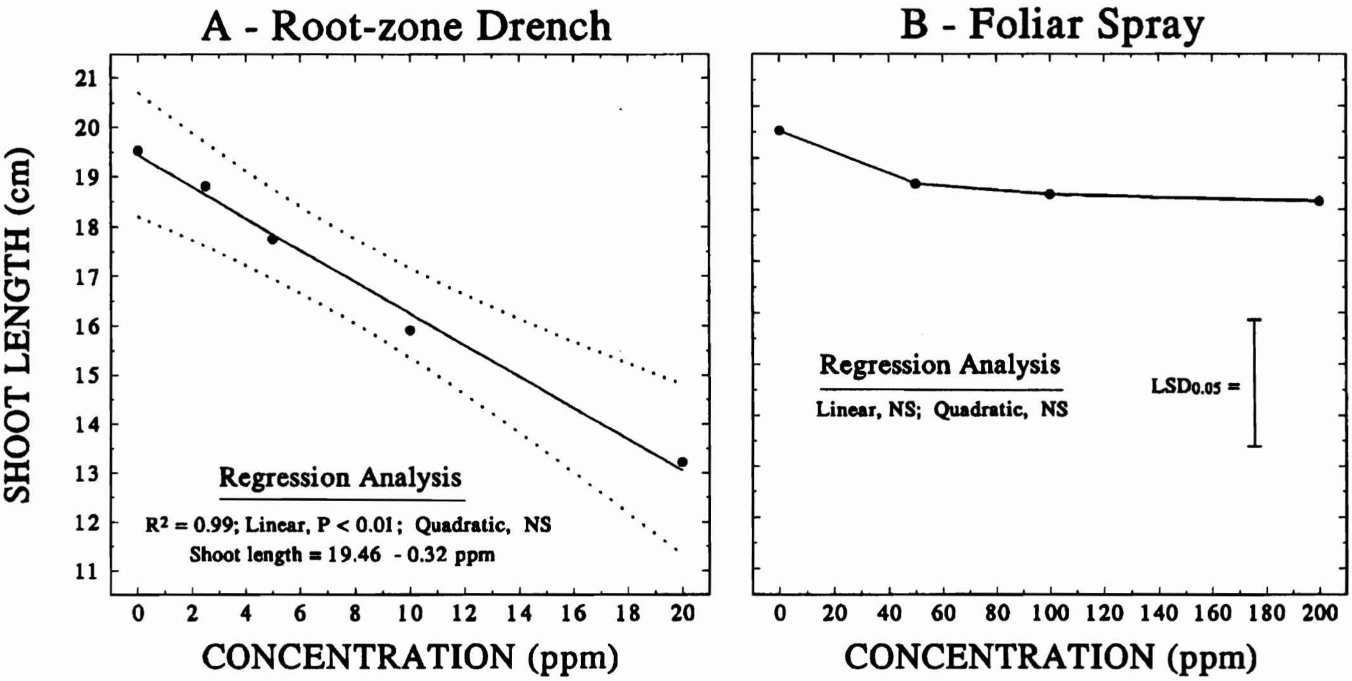

Fig. 3. Response of shoot length to paclobutrazol rate for root-zone and foliar treated plants measured in 1993 after being treated in 1992. Solid line in (A) represents the predicted regression response with dotted lines representing a 95% confidence interval for the mean response. Data points represent means, n = 12.

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