

Growth Retarding Effects of Paclobutrazol and RSW 0411 on Granny Smith and Fuji Apple Trees

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Abstract. The growth retardants paclobutrazol (β -[(4-chlorophenyl)methyl]- α -(1,1-dimethylethyl)-1H-1,2,4-triazole-1-ethanol) and RSW 0411 (β -(cyclohexyl methylene)- α -(1,1-dimethylethyl)-1H-1,2,4-triazole-1-ethanol) were tested on two-year-old trees of Granny Smith and Fuji apple. RSW 0411 at 100 mg/L did not cause any growth reduction in Granny Smith, while 500 and 1000 mg/L significantly reduced growth below that of the control between 27 and 40 days after application. Paclobutrazol at 100 mg/L had a small effect on growth of Granny Smith shoots; however 500 mg/L significantly reduced shoot growth between 27 and 55 days after application, and 1000 mg/L reduced shoot growth between 27 and 82 days after application. By 100 days after application, there were no longer differences between treatments. Shoot growth on Fuji trees was reduced below that of the control as follows: between 14 and 27 days following a single application of 500 mg/L RSW 0411; between 27 and 55 days following two applications; between 14 and 72 days following three applications; and between 14 and 82 days following four applications. Treatments were applied 14 days apart. Paclobutrazol was a more active growth retardant than RSW 0411 at the same rate, and the growth-retarding effects of RSW 0411 were short-lived.

In recent years, trees in many New Zealand apple orchards have been planted intensively; 3–5 m between rows and 1–3 m within rows. In Europe, most trees at these spacings are planted on the dwarfing M 9 or M 26 rootstocks; however, in New Zealand, trees continue to be planted on the semi-dwarfing MM 106 rootstock.

Growers and advisors thought that height and spread of trees on MM 106, at close spacings, would be adequately controlled through early cropping. How-

ever, it is already apparent that vigor-related problems are occurring, especially where tree management is not sufficiently precise. Excess growth in the upper canopy has increased shading in the lower canopy, reduced fruit color, and caused much of the crop to be carried further from the ground each year. Some form of growth retardation is necessary; and although deficit irrigation is an option on lighter soils (Chalmers et al. 1984, Irving and Drost 1987), most workers look toward chemical methods of vigor control.

Several triazole bioregulators [e.g., paclobutrazol, LAB 150 978 (1-(4-trifluoromethyl)-2-(1,2,4-triazolyl-(1))-3-(5-methyl-1,3-dioxan-5-yl)-propen-3-ol), XE 1019 ((E)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-pentan-3-ol), triadimefon (1-(4-chlorophenoxy)-3,3-dimethyl-1-(1H-1,2,4-triazol-1-yl)-2-butanone), RSW 0411] have been found, which inhibit gibberellin synthesis (Dalziel and Lawrence 1984). Of this group, paclobutrazol has been the most intensively tested for its effects as a growth retardant on pip and stonefruit (Quinlan and Richardson 1984, Williams 1984). Results have been promising, and registration has been obtained in the UK for pip and stonefruit. Registration has been obtained in New Zealand for stonefruit, and is sought for pip-fruit.

Recently, studies have commenced on other triazole bioregulators (Curry et al. 1987, Steffens 1988, Sterrett 1988). Curry et al. (1987) reported that the experimental regulator RSW 0411, when applied as a foliar spray to apple trees, was as effective as paclobutrazol, but that growth control was short-lived. In another study, Wulster et al. (1987) found RSW 0411 to limit height in lilies.

We compared the growth-retarding effects of foliar sprays of paclobutrazol and RSW 0411 on the vigorous apple variety Granny Smith. We also tested the magnitude and longevity of growth control of RSW 0411 on Fuji.

Materials and Methods

The study was conducted in the orchard at the Levin Horticultural Research Centre. The Granny Smith and Fuji trees used were in their second year of growth since being planted as one-year-old rods on MM 106 rootstock. Trees were trained to a center leader at spacings of 5×2.75 m (Granny Smith) and 5×2.5 m (Fuji). Trees were selected for uniformity of height and butt circumference 30 cm above ground. Chemical treatments were initiated when current growth of terminal shoots was about 100-mm long.

In experiment 1, seven treatments were applied to five replicate Granny Smith trees (single tree plots) in a completely randomized design. RSW 0411 (β -(cyclohexyl methylene)- α -(1,1-dimethylethyl)-1H-1,2,4-triazole-1-ethanol), supplied by Bayer New Zealand Ltd., and paclobutrazol (β -[(4-chlorophenyl)methyl]- α -(1,1-dimethylethyl)-1H-1,2,4-triazole-1-ethanol), sold as Cultar (ICI New Zealand Ltd.) each at 100, 500, or 1000 mg/L a.i., were sprayed to runoff on November 12, 1987. The chemicals were applied using a knapsack spray unit. A nonionic wetting agent [0.1% (v/v) Regulaid (principal functioning agents: polyoxyethylenepolypropoxypropanol, dihydroxypropane,

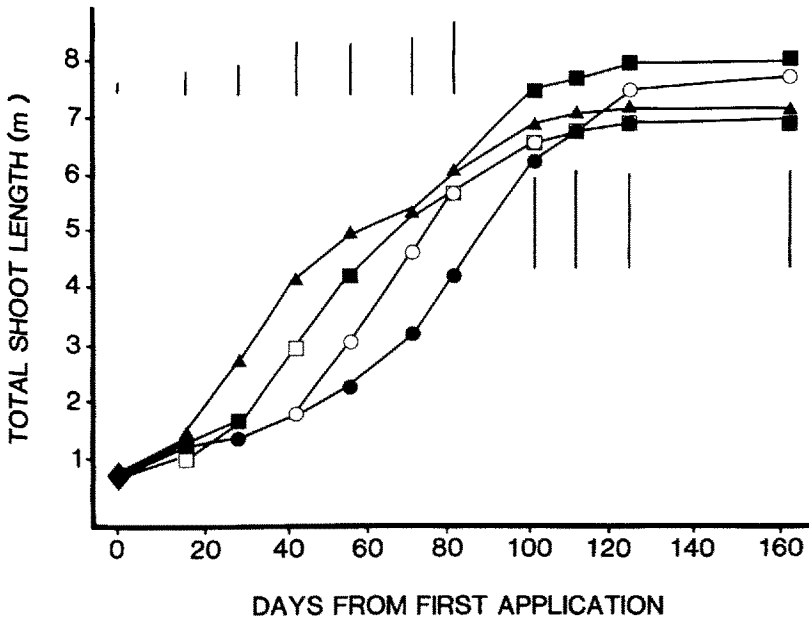


Fig. 1. Shoot growth on two branches of Granny Smith apple trees with time, following no treatment or single applications of RSW 0411 or paclobutrazol: ▲, control; □, RSW 500 mg/L; ■, RSW 1000 mg/L; ○, paclobutrazol 500 mg/L; ●, paclobutrazol 1000 mg/L. The bar represents LSD (5%). Day 0 = November 12, 1987. Data for both 100 mg/L RSW 0411 and paclobutrazol treatments have been included in analyses of variance but have been omitted from the graph for clarity.

and alkyl 2-ethoxyethanol), Kalo Inc., Overland Park, KS 66211, USA)] was included. Control trees received Regulaid only.

In experiment 2, five treatments were applied to five replicate Fuji trees (single tree plots) in a completely randomized design. Trees received 0.1% (v/v) Regulaid only (controls) or, 1, 2, 3, or 4 applications of RSW 0411 (500 mg/L a.i. in 0.1% Regulaid) at approximately two-week intervals. Sprays were applied to runoff on November 12 and 26, and December 11 and 24, 1987 using a knapsack sprayer. Trees not due for an RSW 0411 spray received Regulaid only.

At approximately two weekly intervals, the number and total length of new shoots (>2 cm) on two previously tagged branches per tree were determined.

The apple crop on the Fuji trees was small (2–4 kg/tree) while there was no crop on the Granny Smith due to poor fruit set and complete fruit drop.

Results

Figure 1 shows the pattern of shoot growth by Granny Smith trees following a single treatment with growth retardants. The 100 mg/L RSW 0411 treatment did not cause any growth reduction (data not shown), while 500 and 1000 mg/L

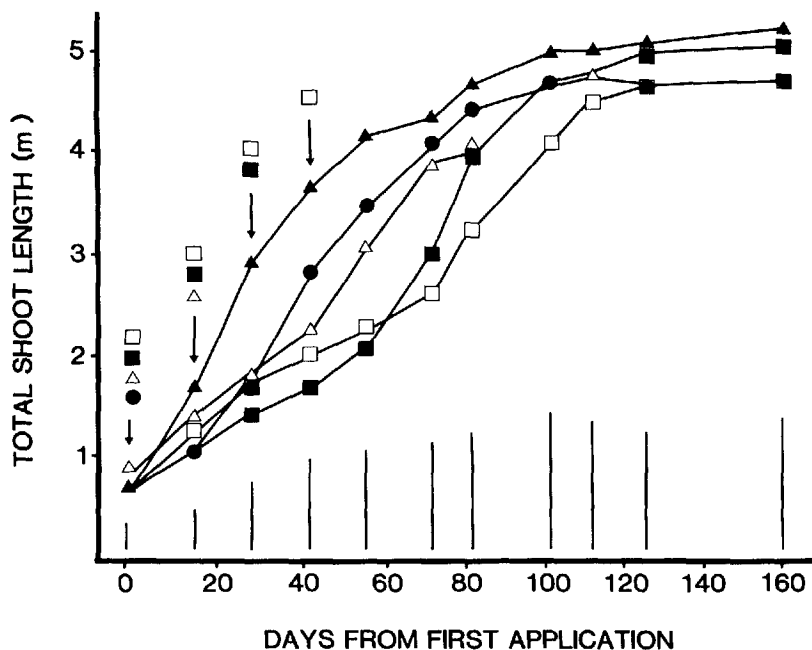


Fig. 2. Shoot growth on two branches of Fuji apple trees with time, following no treatment or 1, 2, 3, or 4 applications of 500 mg/L RSW 0411: ▲, control; ●, 1 application; △, 2 applications; ■, 3 applications; □, 4 applications. The bar represents LSD (5%). Day 0 = November 12, 1987. Arrows indicate times of chemical application.

significantly reduced growth below that of the control between days 27 and 40 from application. Following application of paclobutrazol at 100 mg/L, shoot length was significantly different from the controls ($p < 0.05$) only on day 40. Paclobutrazol at 500 mg/L significantly reduced shoot growth between days 27 and 55, while 1000 mg/L slowed shoot growth between days 27 and 82. By 100 days after application, there were no longer any differences between treatments.

Figure 2 shows the pattern of shoot growth by Fuji trees following multiple applications of 500 mg/L RSW 0411. Shoot growth was reduced below that of the controls between days 14 and 27 by a single application, between days 27 and 55 by two applications, between days 14 and 72 by three applications, and between days 14 and 82 by four applications.

The number of secondary shoots on labeled branches at the end of the growing season in both Granny Smith and Fuji was not influenced by the growth retardants (data not shown).

Discussion

Early tree growth is widely acknowledged to play a major role in later orchard performance. We have conducted experiments with the two growth retardants

paclobutrazol and RSW 0411, in an attempt to obtain some control over early growth. Our purpose was to slow tree growth chemically until competition from the crop load could take over this role.

In our experience, termination in shoot growth normally occurs around day 70 (January 22 in this study). However, since there were few fruits on trees, shoot growth was not inhibited, and, in order to get some estimate of the magnitude of growth reduction on January 22, shoot length data were examined on this date. Growth of Granny Smith shoots was 1, 2, and 3% below that of the controls for the 100, 500, and 1000 mg/L RSW 0411 treatments, and 0, 14, and 41% below that of the controls for the 100, 500, and 1000 mg/L paclobutrazol treatments. The reduction in shoot growth in Fuji was 7, 11, 31, and 40% for 1, 2, 3, and 4 applications of RSW 0411, respectively.

The period of effectiveness of the RSW 0411 treatments for Fuji can be determined from changes in slope in Fig. 2. The first application of chemical was effective for about 14 days, while the second, third, and fourth applications were effective for about 28 days. Sequential sprays seem necessary for satisfactory growth retardation. RSW 0411 at 1000 mg/L did not reduce shoot growth more than at 500 mg/L.

Growth retardation by paclobutrazol, especially the highest concentration used (1000 mg/L), was prolonged. The work of Quinlan and Richardson (1984) and Williams (1984) would suggest that higher concentrations may give even better control over shoot growth.

The absence of appreciable fruit crop on the Granny Smith and Fuji trees meant that both varieties were unable to retard shoot growth after the effects of the retardants had worn off. As a result, by the end of the season there was no net reduction in shoot length (Figs. 1 and 2). Curry et al. (1987) reported increased return bloom following RSW 0411 treatment. A heavier crop next season should help reduce shoot growth. However, growth retardant treatment will still be required to curb shoot growth during the early part of the next growing season as the MM 106 rootstock is too vigorous for Granny Smith and Fuji at the close spacings on the heavier soils.

Paclobutrazol and RSW 0411 appear to offer the opportunity of chemically regulating plant growth where size-controlling rootstocks are not available, are inappropriate, or where vigor control is still inadequate. The short-term effectiveness of RSW 0411 could be of advantage where soil residue from paclobutrazol might undesirably reduce growth in subsequent seasons. In addition, RSW 0411 would be of definite advantage if growth retardants are to be administered through irrigation systems.

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