Mature 'Starkrimson Delicious' Apple Tree Response to Paclobutrazol Application Method

Laura J. Lehman¹, C.R. Unrath, and Eric Young

Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Additional index words. growth regulator, *Malus domestica*, PP333

Abstract. Mature spur-type 'Delicious'/seedling apple trees (*Malus domestica* Borkh.) were examined for 2 years after paclobutrazol (PB) foliar sprays with or without a soil cover to direct spray runoff away from the root zone, soil sprays, or a trunk drench. Foliar sprays with runoff reduced shoot number and fruit pedicel length in the year of treatment, but had no effect on shoot length. Trees that received foliar sprays with no runoff had fewer and shorter shoots and shorter pedicels the year after treatment. Soil sprays or a trunk drench reduced shoot number and pedicel length for 2 years after application, while only soil sprays reduced fruit weight, diameter, and length. Chemical name used: β -[(4-chlorophenyl)methyl]- α -(1,1-dimethylethyl)-1 H-1,2,4-triazol-1-ethanol (paclobutrazol).

Many fruit tree growth regulators are applied with airblast sprayers "to drip" or "to runoff", implying that the spray material is freely dripping or flowing from the tree canopy. Thorough spray contact with above-ground tree parts is thought to be necessary for regulator uptake, while runoff onto the soil is generally presumed to be incidental to regulator effectiveness.

Several researchers have examined fruit tree response to paclobutrazol (PB), a synthetic growth retardant. Field experiments have usually been conducted for just 1 year, but PB effects often persist for two or more seasons after application (Blanco, 1988; Jones et al., 1988). Because PB rate and timing often vary from study to study, valid comparisons between application methods are difficult. With these considerations in mind, a 3-year experiment was established to determine if PB mode of application influenced its effect on mature apple tree vegetative growth and fruit quality. A secondary objective was to evaluate the impact of PB foliar uptake with or without subsequent soil uptake from runoff.

Ten-year-old 'Starkrimson Delicious' (spur type) on seedling apple trees in a Lawndale, N. C., commercial orchard were selected for study. Trees were spaced 4.6 × 7.6 m in a Hapludult Thermic micaceous clay loam soil and averaged 12 to 15 scaffold limbs per tree with uniform canopy volume. Mowed sod

was present in alleys and bare ground in the tree row.

Because mature apple trees have absorbing roots that extend beyond the canopy perimeter, lateral roots on all sides of trees that were to receive a soil cover were severed with a motorized ditcher to a depth of 1.5 m at 2.3 m from the trunk. A white 0.13-mm (5-mil) polypropylene soil cover on a sloping wooden frame sealed at the tree trunk was used to direct spray runoff away from the root zone. Covers were in place from May 1986 to Jan. 1987 because of possible PB residue transfer from fallen leaves. Irrigation lines under the covers delivered water at a rate equal to rainfall measured in the previous week. Covers did not significantly alter soil temperature.

The treatments were applied to single-tree plots in a randomized complete-block design with four replications. Treated trees were separated by border trees to maintain treatment independence. Nine treatments, including PB applications in 1986 and/or 1987, were as follows: control, soil cover in 1986

only, PB foliar sprays in 1986 only, PB foliar sprays in 1987 only, soil cover plus PB foliar sprays in 1986 only, PB soil sprays in 1986 only, PB soil sprays in 1986 and 1987, PB soil sprays in 1986 plus PB foliar sprays in 1987, and PB soil sprays in 1986 and 1987.

In 1986, seven foliar sprays of 200 mg PB (Cultar 2SC; ICI Americas, Greensboro, N. C.) in 11.7 liters of water per tree (2.38 g/tree per application) plus 0.1% (v/v) Tween 20 surfactant were applied biweekly beginning 2 weeks after petal fall. Applications were made to drip, and runoff was estimated at < 10% of spray volume per application. Soil sprays in 1986 were made at the same rates and on the same days as the foliar sprays. Some trees received five additional soil or foliar applications of 200 mg PB in 11.7 liters of water per tree plus 0.1% (v/v) Tween 20 in 1987. All spray applications were made using a handgun attached to an airblast sprayer. The 1986 trunk drench treatment was 8.16 g PB/tree applied to the trunk-soil interface 2 weeks after petal fall. Dormant season pruning, consisting of small cuts and watersprout removal, was performed after shoot growth measurements in 1986 and 1987.

One 20-fruit sample per tree was collected in 1987 and 1988 at fruit maturity. After 1 month in storage (0°C and 90% RH), fruit length, diameter, weight, pedicel length, and flesh firmness were measured. Firmness was measured on two opposite sides of the fruit equator using a Magness-Taylor tester with an 11-mm plunger.

In Dec. 1987 and Oct. 1988, the length of six randomly selected terminal shoots in the upper canopy (> 3 m from the ground) per tree was measured. In 1987 and 1988, shoot measurements were also made on four vigorous scaffold limb sections 1.5 m long, < 3 m from the ground per tree, and including wood up to 3 years old. For each limb section (average number of buds = 50), the number of buds shorter than 2.5 cm was counted and the lengths of all current season shoots longer than 2.5 cm, termed "escape shoots", were noted. Percent escape shoots was calculated as their number divided by

Table 1. Mean apple tree shoot length in the upper (above 3 m) and lower (below 3 m) canopy and percent escape shoots (> 2.5 cm long) in the lower canopy on various sampling dates (month/year) as affected by paclobutrazol foliar sprays (Fs) with or without soil covers, soil sprays (Ss), or a trunk drench (Td).^a

Treatment		Terminal shoot length (cm)				Escape shoots (%)	
		Lower canopy		Upper canopy		Dec. 1987	Oct. 1988
1986	1987	Dec. 1987	Oct. 1988	Dec. 1987	Oct. 1988		
None	None	15.2 a	13.0 a	51.3 a	23.1 ab	21.5 a	21.7 a
Cover	None	16.7 a	12.3 ab	33.3 bc	20.1 ab	19.8 a	14.4 bc
Fs	None	11.4 ab	13.9 a	52.1 a	26.5 a	4.3 c	22.4 a
Fs, cover	None	5.3 bc	9.3 bc	16.5 d	15.8 ab	2.8 c	17.9 ab
Ss	None	4.1 c	7.9 cd	22.7 cd	17.6 ab	0.9 c	11.0 bcd
Td	None	4.5 bc	5.1 de	26.9 c	14.0 b	4.9 c	10.1 cd
Ss	Ss	15.8 a	6.1 cde	40.5 b	15.5 b	4.0 c	10.5 cd
Ss	Fs	5.7 bc	6.1 cde	33.6 bc	19.5 ab	3.7 c	6.5 d
None	Fs	13.3 a	4.0 c	28.1 c	17.4 ab	11.9 b	4.3 d

^aCover = polypropylene soil cover under tree canopy. Fs or Ss = seven biweekly 200 mg paclobutrazol/liter of water applications in 1986 and/or five applications in 1987. Td = 8.16 g paclobutrazol/tree. Mean separation (four pooled observations per treatment) within each column by Duncan's multiple range test ($P = 0.05$). Each value is the mean of four observations.

Received for publication 1 May 1989. Paper no. 12179 of the Journal Series of North Carolina Agricultural Research Service (NCARS), Raleigh, NC 27695-7643. The use of trade names in this publication does not imply endorsement by the NCARS of the products named, nor criticism of similar ones not mentioned. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

¹Graduate Research Assistant.

Table 2. Mean apple fruit weight, diameter, length, and pedicel length in 1987 and pedicel length in 1988 as affected by paclobutrazol foliar sprays (Fs) with or without soil covers, soil sprays (Ss), or a trunk drench (Td).^z

		1987			1988	
Treatment		Wt (g)	Diam (cm)	Length (cm)	Pedicel length (mm)	Pedicel length (mm)
1986	1987					
None	None	112 a	6.35 a	5.56 a	24.1 a	20.8 a
Cover	None	89 bc	5.89 c	5.13 b	17.9 bc	20.6 a
Fs	None	106 ab	6.30 ab	5.33 ab	14.0 d	17.9 bc
Fs, cover	None	91 bc	5.99 bc	5.08 b	10.4 e	18.8 ab
Ss	None	88 c	5.92 c	5.03 b	15.0 cd	15.6 cde
Td	None	103 abc	6.25 abc	5.31 ab	14.9 cd	15.3 cde
Ss	Ss	99 abc	6.12 bc	5.26 ab	15.8 cd	16.2 bcd
Ss	Fs	101 abc	6.13 abc	5.36 ab	15.4 cd	13.1 c
None	Fs	102 abc	6.17 abc	5.36 ab	21.3 ab	14.8 de

^zCover = polypropylene soil cover under tree canopy. Fs or Ss = seven biweekly 200 mg paclobutrazol/liter of water applications in 1986 and/or five applications in 1987. Td = 8.16 g paclobutrazol/tree. Mean separation (four pooled observations per treatment) within each column by Duncan's multiple range test ($P = 0.05$). Each value is the mean of four observations.

the number of buds per limb section. Short shoots were counted because it was difficult to distinguish between young spurs and waterspouts with severely retarded extension growth.

Multiple observations were reduced to plot means before analysis. Results were subjected to analysis of variance and mean separation was performed using Duncan's multiple range test.

Trees that received foliar sprays with runoff experienced no change in terminal shoot length for the next 2 years, but did have fewer escape shoots the year after application (Table 1). Foliar sprays with soil covers resulted in shorter terminal shoots and fewer escape shoots in 1987, but the runoff-control treatment reduced terminal shoot length in the upper canopy in 1987 and the escape shoot percentage in the following year.

The runoff-control treatment was included to determine the effect of root pruning and the soil covers. Schupp and Ferree (1987) reported that dormant season root pruning of young 'Melrose'/M.7A apple trees decreased terminal shoot growth and resulted in considerable root regeneration in the year of root pruning. To remove possible confounding of root pruning and soil cover modification of the environment with the foliar spray response, response to the foliar spray treatment with cover can be compared to that of the runoff-check treatment. Using this

comparison, PB foliar sprays without runoff reduced terminal shoot length in the upper and lower canopy and also reduced escape shoot number in 1987, but had no effect on shoot growth in 1988 (Table 1). Our results agree, in principle, with those of Richardson and Quinlan (1986), who showed that labelled PB migrated directly to young leaves and that runoff was not necessary for growth retardation. Miller and Swietlik (1986) noted that a PB collar drench was highly effective in retarding apple shoot growth compared to ground or foliar sprays and that inhibition became more uniform by the 3rd year after treatment. Foliar uptake and storage of PB in the perennial framework of a tree may be responsible for long-term growth suppression, but root absorption of runoff appears to be less important than uptake by above-ground tree parts.

Soil sprays or a trunk drench reduced the number and length of shoots in the lower canopy for 2 years after application, and PB treatment in two successive years did not enhance vegetative growth retardation (Table 1). Elfving and Proctor (1986) reported that 'Spartan'/M.26 apple trees that received a 2000 mg PB/liter foliar spray to runoff grew fewer terminal shoots than trees that received the same spray rate, with runoff prevented from entering the soil.

Regardless of mode of application, PB did not have a significant effect on fruit length

: diameter ratio or flesh firmness (data not shown), although both diameter and length were affected by some treatments (Table 2). Foliar sprays with runoff reduced pedicel length for 2 years after application, while the runoff-control trees had smaller fruit with shorter pedicels in 1987. Foliar sprays without runoff reduced fruit pedicel length in 1987 beyond the effect of the soil cover alone, but had no effect by 1988. Soil sprays reduced fruit weight, diameter, and length in the year after treatment, and pedicel length for 2 years. Applications of PB in two successive years or a single trunk drench reduced pedicel length in both 1987 and 1988. Others have also observed shorter pedicels after PB treatment (Curry and Williams, 1983; Elfving and Proctor, 1986). Although pedicel length is not directly related to fruit quality, it may influence ease of harvesting or yield.

Our results indicate that mode of application can influence mature apple tree response to PB. Shoot growth retardation after foliar sprays in these studies appears to be due primarily to absorption by the tree canopy and not to runoff and subsequent absorption of PB by roots.

Literature Cited

- Blanco, A. 1988. Control of shoot growth of peach and nectarine trees with paclobutrazol. *J. Hort. Sci.* 63:201-207.
- Curry, E.A. and M.W. Williams. 1983. Promalin or GA₃ increase pedicel and fruit length and leaf size of 'Delicious' apples treated with paclobutrazol. *HortScience* 18:214-215.
- Elfving, D.C. and J.T.A. Proctor. 1986. Long-term effects of paclobutrazol (Cultar) on apple-tree shoot growth, cropping and fruit-leaf relations. *Acta Hort.* 179:473-480.
- Jones, K.M., P. Jotic, T.B. Koen, S.B. Longley, and G. Adams. 1988. Restructuring and cropping large 'Red Delicious' apple trees with paclobutrazol and daminozide. *J. Hort. Sci.* 63:19-25.
- Miller, S.S. and D. Swietlik. 1986. Growth and fruiting response of deciduous fruit trees treated with paclobutrazol. *Acta Hort.* 179:563-566.
- Richardson, P.J. and J.D. Quinlan. 1986. Uptake and translocation of paclobutrazol by shoots of M.26 apple rootstock. *Plant Growth Regulat.* 4:347-356.
- Schupp, J.R. and D.C. Ferree. 1987. Effect of root pruning at different growth stages on growth and fruiting of apple trees. *HortScience* 22:387-390.