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Response of Shade Trees to Root Collar Drenches of Inhibitors Flurprimidol and Paclobutrazol

J. P. Sterrett and T. J. Tworkoski

U. S. Department of Agriculture, Agriculture Research Service, Bldg. 1301, Fort Detrick, Frederick, Maryland 21701, USA

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Abstract. Root collars of white ash (*Fraxinus americana* L.) and black walnut (*Juglans nigra* L.) were drenched in April with wettable powder formulations containing 2, 4, or 12 g of flurprimidol {α-(1-methylethyl)-[4-(trifluoromethoxy)phenyl]-5-pyrimidinemethanol} or paclobutrazol [(2RS, 3RS)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-pentan-3-ol)] to determine shoot growth inhibition and the soil location of residual activity. By the end of the first growing season, black walnut shoots were inhibited by all doses of flurprimidol or paclobutrazol. Growth inhibition of black walnut was dramatic (<50% the growth of control) during the second season with a linear positive response to increasing flurprimidol doses. White ash growth was inhibited by flurprimidol but not paclobutrazol. Flurprimidol activity was concentrated within 10 cm of the treated root collar 1½ years after treatment, which is evidence that the root collar and adjacent roots were the major avenues to the vascular system.

Utility company foresters are investigating the use of chemical growth inhibitors to reduce the need for mechanical tree trimming. Gibberellin biosynthesis inhibitors, flurprimidol and paclobutrazol, are potentially popular tree growth inhibitors of shoot internode elongation, because they are not phytotoxic to woody plants even at high concentrations and may be applied to roots, buds, or vascular systems (Hield et al. 1981, Sterrett 1985, Sterrett and Tworkoski 1986). The only visible signs of their presence are shortened internodes and smaller, dark green foliage. Tree injection of these growth regulators is the most common method of application, but response of plant parts some distance from the injection site has been erratic, especially in large trees (R. M. Couture, ICI Americas, Inc., Goldsboro, NC, personal communication; S. D.

Cockreham, Lilly Research Laboratories, Greenfield, IN, personal communication). Uniform growth inhibition has been accomplished by penetrating young, thin-barked trees with trunk sprays of growth inhibitors (bark banding), but older, thick-barked trees have been less pervious to trunk sprays, possibly owing to a thicker suberin layer (Bowen 1963, Hield et al. 1977, 1981). Soil treatments under trees have been successful with flurprimidol and paclobutrazol (Hield et al. 1981, Williams 1984), but there is little evidence to indicate that effective uptake of these growth regulators will occur through the root collar and adjacent roots. Most researchers have not distinguished between uptake by the root collar zone and nonwoody (fibrous) roots located beneath the outer edge of the foliage canopy. Since the root bark is usually more permeable to water than the trunk bark owing to a thinner cork layer (Zimmerman and Brown 1974), the objective of this study was to determine the growth response of woody saplings to root collar treatments of flurprimidol and paclobutrazol and to determine if all growth inhibitor activity in the soil remained close to the root collar.

Materials and Methods

Growth Response

Ten-year-old white ash and black walnut saplings were grown in Duffield silt loam in Frederick, MD. In mid-April 1984, the root collar zones of these trees were treated with flurprimidol or paclobutrazol by removing soil at ground line to expose the root collar bark for a depth of 5 cm and wetting the exposed bark with 250 ml of 50% wettable powder water formulations containing 2, 4, or 12 g per tree. Before treatment, each tree was pruned to three branches of 2-year-old wood. Shoot growth was measured from the three branches during the 1984 and 1985 growing seasons. Treatments were replicated five times in a randomized complete block design. Linear regression analysis was used to determine dose-response relationships within growth inhibitors.

Flurprimidol Soil Activity

The level of flurprimidol activity in the soil was determined via a bean bioassay test. A standard curve was established with Duffield silt loam soil that was dried and sprayed with six doses of flurprimidol (2.5–80 μg/cc of soil). Three bean seeds (*Phaseolus vulgaris* L. "Black Valentine") were then planted in 400 cc of soil in individual styrofoam pots (3 replications/dose) 1½ cm deep and watered lightly for 21 days in a growth chamber at 25 ± 1°C, 60% relative humidity, and 158 $\mu mol\ s^{-1}\ m^{-2}$ PAR (400–700 nm) (16-h photoperiod). Bean stem height was regressed against soil flurprimidol concentration to provide the standard curve (bean height = 2.7 log x + 5.6 μg/cc flurprimidol).

To determine the location and level of flurprimidol activity in the soil, 400-cc soil samples were taken 1½ years after treatment at two depths (0–10 cm and 11–20 cm) and two distances from white ash root collar bark (0–10 cm and

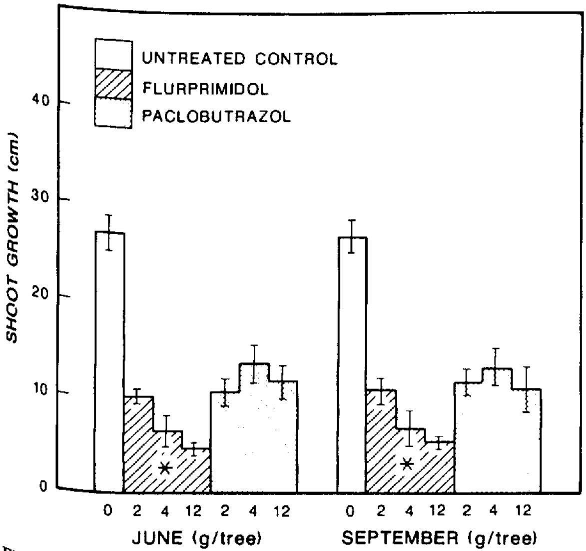

Fig. 1. Response of black walnut to root collar drenches of flurprimidol and paclobutrazol (performed in April 1984) 14 months (June 1985) and 17 months (September 1985) after treatment. Vertical lines represent standard error of the means. Asterisks indicate significant linear regression coefficients for 2, 4, and 12 g per tree flurprimidol (growth = a + b log dose), 5% level (n = 15).

50–60 cm) (on the north and east sides of the tree). Bean seeds were planted in the white ash soil samples, and stem height growth after 21 days was compared with the bean bioassay standard curve to determine relative flurprimidol activity. Soil samples in the field were taken from five trees (replications) per treatment.

Results and Discussion

Growth Response

Black walnut shoot growth inhibition was not evident until the end of the first growing season (1984), at which time all doses of flurprimidol or paclobutrazol were effective. In contrast, white ash growth was not inhibited with either chemical in 1984.

In June 1985, black walnut growth was inhibited by all doses (2, 4, or 12 g) of flurprimidol or paclobutrazol and remained inhibited until the end of the growing season (Fig. 1). The degree of shoot inhibition was linearly related with the dose of flurprimidol but not paclobutrazol. White ash shoot growth measured in June and September 1985 was inhibited by all doses of flurprimidol (2, 4, or 12 g) but not by any dose of paclobutrazol, and the degree of shoot growth inhibition in September 1985 was linearly related with the dose of flurprimidol (Fig. 2).

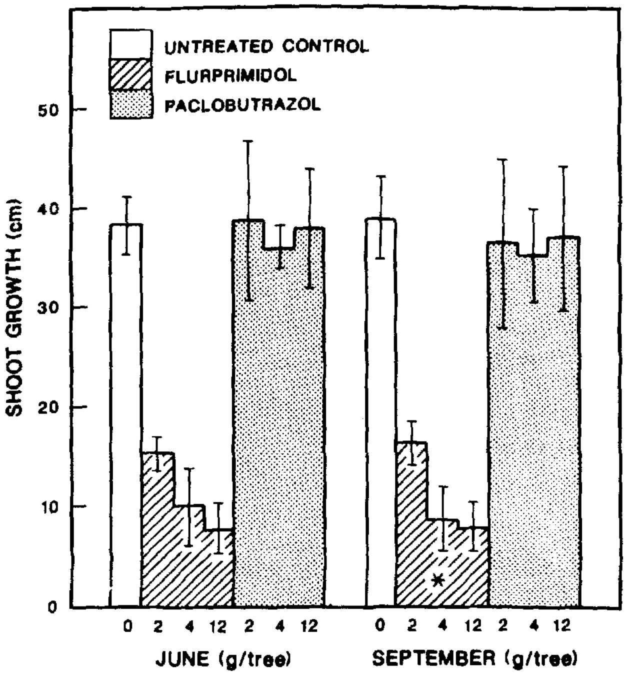

Fig. 2. Response of white ash to root collar drenches of flurprimidol and paclobutrazol (performed in April 1984) 14 months (June 1985) and 17 months (September 1985) after treatment. Vertical lines represent standard error of the means. Asterisk indicates significant linear regression coefficient for 2, 4, and 12 g per tree flurprimidol (growth = a + b log dose), 5% level (n = 15).

Flurprimidol Soil Activity

Flurprimidol was selected for determining the location of growth inhibitor activity in the soil since it inhibited both black walnut and white ash. One and one-half years after treatment, growth inhibitor activity (from 0.9–24 μg/cc soil) was found laterally within 10 cm of the white ash root collar bark and down to a depth of 20 cm (Table 1). No growth inhibitor activity could be detected 50 cm from the root collar. These results indicate that flurprimidol entered the tree through the root collar bark and probably via larger (2–8 cm diam.) lateral roots which radiated out from the root collar. Excavation revealed that most of the nonwoody (fibrous) roots of white ash and black walnut were located laterally about 150 cm from the root collar within 20 cm of the soil surface. There were few nonwoody roots growing from the root collar and larger woody roots within the 10-cm growth inhibitor zone.

The inability of white ash to respond to root collar drenches of paclobutrazol is not readily explained. It was clear that the 12-g treatment of paclobutrazol was still active in the soil adjacent to white ash 1½ years after treatment, because bean seeds planted in the adjacent soil (3 replications) did not grow. Since white ash growth can be inhibited from direct injections of paclobutrazol into the xylem (Sterrett 1985), it is possible that the root bark of white ash may

Table 1. Flurprimidol in soil (μg/cc of soil) based on bean growth bioassay 1½ years after white ash root collar drench in April 1984.

Root collar drench, April 1984 (g/tree)	Soil sample distance from root cellar (cm): 0–10, Sample depth (cm) 0–10	0–10, Sample depth (cm) 11–20	50–60, Sample depth (cm) 0–10	50–60, Sample depth (cm) 11–20
	(October 1985, μg/cc)			
2	0.9 ± 0.6[a]	1.6 ± 0.1[a]	0	0
4	4.8 ± 1.1	3.2 ± 0.8	0	0
12	10.0 ± 6.0	24.0 ± 10.0	0	0

[a] Mean ± SE of 10 soil samples.

be less pervious to paclobutrazol than flurprimidol. Flurprimidol is about four times more soluble in water than paclobutrazol, which would facilitate absorption through the white ash root bark.

Root collar drench is a rapid and convenient method for applying the gibberellin biosynthesis inhibitors. Root collars of city street trees are usually accessible while the fibrous roots located below the outer foliage canopy may be covered with concrete or macadam. Also, confining the plant growth inhibitor to the root collar zone reduces the possibility of contacting nontarget plants. Growth of white ash and black walnut saplings can be uniformly inhibited. However, before the root collar drench technique is widely used, responses of various species and sizes of trees must be investigated. Also, more information is needed regarding effective treatment periods and longevity and movement of residues in the soil.

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