Tolerance of Rootstocks and Established *Malus, Pyrus,* and *Prunus* Trees to Terbacil[1]

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Abstract. Several annual and perennial weed species were effectively controlled with 3-tert-butyl-5-chloro-6-methyluracil (terbacil) in orchards. One-year-old seedling rootstocks of peach, *Prunus persica,* (L.) Patsch, were most tolerant to terbacil; pear, *Pyrus communis,* L., and apple, *Malus sylvestris,* L., seedlings were intermediate; the East Malling (EM) VII clone, Mazzard, *Prunus avium,* L., and Mahaleb cherry, *Prunus mahaleb,* L., seedlings were most susceptible. Both surface and soil incorporated applications were toxic, indicating that terbacil was readily leached into the root zone. Applications were made in 2 and 6-year-old experimental blocks and in commercial orchards (age 2–15 years) from 1965 to 1968. No major damage was observed on apple, peach, tart cherry or sweet cherry trees that were established 3 years or longer. Toxicity symptoms manifested as veinal chlorosis were occasionally observed on sandy loam soils at rates 2–3 fold greater than required for satisfactory weed control.

Introduction

Chemical weed control has become a common cultural practice in the production of tree fruit. Herbicides which control a wide and changing weed spectrum and which provide no toxicity or unfavorable side effects on trees are needed. The uracil herbicides provide a group of compounds with activity on a wide range of annual and perennial weeds (5).

Price and Fisher (3) reported on the relative tolerance of newly planted apple and peach trees to several uracil herbicides. The substituted uracils 3-tert-butyl-5-chloro-6-methyluracil (terbacil) and 3-tert-butyl-5-promo-6-methyluracil (Herbicide 733) produced less toxicity than 5-bromo-3-isopropyl-6-methyluracil (isocil) or 5-bromo-3-sec-6-methyluracil (bromacil). Newly planted peach trees exhibited more tolerance to the uracil herbicides than apple trees (1, 3). The superior tolerance of peach seedlings was also evident in nutrient culture studies with bromacil (2).

The uptake of terbacil occurs primarily through the roots of plants and the herbicidal activity appears to occur, at least in part, from the inhibition of photosynthesis.[5] The herbicide is relatively soluble in water (710 mg/L at 25°C). Movement in the soil is related to organic matter, clay content and precipitation level, the compound being readily leached in sandy soil under high rainfall (4).

The objectives of this research were to determine the nature and magnitude of tolerance by common tree fruit rootstocks to terbacil, and to determine the effect of repeated terbacil applications on the growth of established fruit trees grown under commercial conditions.

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[5]Weed, M. B. 1965. 'Sinbar' weed killer. Technical Data Sheet. E. I. Dupont Co.

[6]E. I. DuPont Co., Wilmington, Delaware.

Materials and Methods

Rootstocks. The experimental plots were located on a Hillsdale sandy loam soil with organic matter content of 1.9%. A split plot design was employed with method of application being the primary division. The herbicides were applied as broadcast sprays (36 gpa) on half of the plots and incorporated to a depth of 3 to 4 inches with a disk prior to planting the trees. Furrows 6 inches deep were plowed through the center of each plot after which seedling rootstocks of peach, *Prunus persica* (L.) Patsch, pear, *Pyrus communis,* L., apple, *Malus sylvestris,* L., and clonal rootstocks of EM VII apple, Mazzard cherry, *Prunus avium* L., and Mahaleb cherry, *Prunus mahaleb,* L., were planted. Four trees of each species were included in 3 replicates of 4 × 25 ft plots. All trees were headed at 12–14 inches, after which the remaining half received broadcast sprays on the soil surface. Terbacil (Sinbar 80% wp[6]) was utilized at 0, 0.5, 1.0, 2.0, and 4.0 lb./A and 2-chloro-4,6-bis (ethyl-amino)-*s*-triazine (simazine) at 4.0 lb./A was included as a reference herbicide. Sprinkler irrigation was employed to apply approximately 0.5 inches of water after herbicide application.

Weed control and tree damage were estimated utilizing a rating system of 1–9 in which 1 indicates no toxicity and 9 indicates complete kill of trees or weeds. Ratings were obtained 30, 90, and 380 days following herbicide application. All data were statistically evaluated utilizing analysis of variance, and Tukey's HSD test.

Established orchards. Trees of apple, 'Northern Spy'/Malling Merton (MM) 106, peach, 'Redskin'/seedling, plum, 'Stanley'/Myrobalan, and tart cherry, 'Montmorency'/Mahaleb, were planted in April, 1966 on a Miami loam soil. The orchard was maintained in cultivation during the 1966 season. The herbicides were applied May 15, 1967, on areas 8 × 8 ft around the base of each tree. Each herbicide treatment was replicated 5 times in randomized blocks within each species. Terbacil was applied at 1.5 and 3.0 lb./A and compared to other methods of weed control. The predominant weed species in this orchard were red sorrel, *Rumex acetosella,* L., yellow rocket, *Barbarea vulgaris,* R. Br., and field pepperweed, *Lepidium campestre* (L.) R. Br. Weed control and tree damage ratings were obtained 90 days after spraying. Terminal growth measurements (10 per tree) were obtained in December of 1967 and 1968.

Table 1. Phytotoxicity to rootstocks from surface applied or soil incorporated herbicides.

Rootstocks	Injury rating[x]			
	Surface applied		Incorporated	
	Terbacil 2.0 lb/A	Simazine 4.0 lb/A	Terbacil 2.0 lb/A	Simazine 4.0 lb/A
Peach Seedling	2.0a	1.0a	1.0a	2.7b
Pear Seedling	3.7b	1.0a	3.3b	1.0a
Apple Seedling	4.0b	1.0a	4.3b	5.3c
EM VII Apple	5.7c	1.0a	6.3c	7.0d
Mazzard Cherry	7.7d	1.3a	7.0c	7.0d
Mahaleb Cherry	8.3d	1.3a	9.0d	8.7e
Mean[y]	5.2	1.1	5.2	5.3

[x]1 = no damage, 9 = complete kill of crop. Means with the same letters within a column are not significantly different at P = .05.
[y]F value for interaction of herbicide × method of application is significant at P = .01.

Table 2. Weed control and growth of 4 fruit tree species after successive applications of terbacil.[x]

Chemical	Rate (lb/A)	Terminal growth (cm)[y]				Weed control rating[z]
		Apple	Cherry	Peach	Plum	
			1967			
None	—	31a	40a	69a	33a	1.0a
None (cultivated)	—	42b	54b	85b	70c	7.3bc
Terbacil	1.5	48b	47ab	87b	53b	6.4b
Terbacil	3.0	45b	47b	90b	62b	8.2c
			1968			
None	—	63a	50a	77a	59a	1.0a
None (cultivated)	—	65a	62b	84ab	79b	5.6b
Terbacil	1.5	70a	60b	88b	82b	7.5c
Terbacil	3.0	59a	61b	89b	81b	8.9d

[x]Trees were 2 years old the first year of application.
[y]Means with the same letters within a column each year are not significantly different at P = .05.
[z]1 = no damage, 9 = weed eradication.

A test was initiated in 1965 on 6-year-old trees of apple, 'Northern Spy'/EM VII, 'Jonathan'/EM VII, 'Golden Delicious'/EM VII, tart cherry, 'Montmorency'/Mahaleb, peach 'Ambergem'/seedling. Areas of 8 × 8 ft were sprayed under the trees in May of 1965, 1966, and 1967 utilizing terbacil at 0, 1.0, 2.0, 4.0, and 8.0 lb./A and simazine plus amitrole-T (4.0 + 2.0 lb./A) on apples or simazine (4.0 lb./A) on tart cherries and peaches. Weed control and injury ratings were obtained annually and terminal growth of all trees was measured in December, 1967.

Similar studies were conducted in commercial plantings of apple, pear, peach, tart cherry, and sweet cherry located on sandy loam soils from 1965–1968 (Table 5). All applications were made in late April or early May. Weed control and tree injury data were obtained in July and September of each year.

Fig. 1. Typical toxicity symptoms manifested on leaves of 'Bartlett' pear (above) and 'Montmorency' cherry (below) from excessive applications of terbacil.

Results and Discussion

Rootstocks. Toxicity symptoms on all species of rootstocks except peach were evident 30 days after herbicide application. The symptoms first appeared as veinal chlorosis (Fig. 1), followed by complete chlorosis, necrosis, and in severe cases, leaf abscission and death of the trees. Ratings obtained 90 days after herbicide application indicated various degrees of susceptibility by rootstocks (Fig. 2). The EM VII rootstocks and the Mahaleb and Mazzard cherry were killed with applications of 4.0 lb./A terbacil. Peach, apple, and pear seedlings were tolerant to higher rates than the clonal rootstocks. Clonal rootstocks may be more susceptible because of limited size and vigor in initial growth.

Both surface and soil incorporated terbacil sprays produced similar degrees of toxicity (Table 1). With 2.0 lb./A the tolerance of peach seedling > pear seedling = apple seedling > EM VII > Mazzard cherry > Mahaleb cherry. Under the conditions of this experiment, position of the terbacil was not responsible for the rootstock tolerance. In contrast, surface applied simazine at 4.0 lb./A produced only slight chlorosis on EM VII and Mahaleb cherry while all species except pear seedling were damaged when the herbicide was incorporated into the root zone. This observation indicated that terbacil was more readily leached than simazine. Soil bioassays utilizing oat, *Avena sativa,* L., confirmed the presence of terbacil at the 4–8 inch soil depth 90 days after a surface application of 4.0 lb./A. Simazine was detectable only at the 0–2 inch depth.

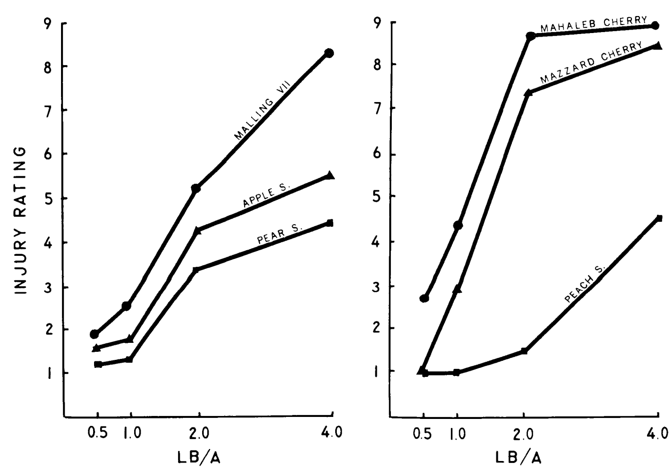

Fig. 2. Phytotoxicity of several rates of terbacil application on clonal or seedling rootstocks of *Malus* and *Pyrus* Spp. (left) and *Prunus* Spp. (right) after 90 days. 1 = no damage, 9 = complete kill of crop.

Table 3. Weed control and growth of 3 apple varieties[x] after 2 successive annual applications of herbicides.

Chemical	Rate (lb./A)	Terminal growth (cm)[z] Jonathan	Golden Delicious	Northern Spy	Weed control rating[y,z]
None	—	22.8a	22.4a	54.6a	1.0a
Terbacil	1.0	31.4b	30.2b	52.6a	7.5b
Terbacil	2.0	30.0b	28.4ab	45.7a	8.5c
Terbacil	4.0	30.8b	39.2c	52.7a	9.0c
Terbacil	8.0	26.7ab	35.8bc	63.5b	9.0c
Simazine + Amitrole-T	4.0 + 2.0	—	27.0ab	50.0a	8.3bc

[x]Trees were 6 years old the first year of application.
[y]1 = no damage, 9 = weed eradication.
[z]Means with the same letters within a column are not significantly different at P = .05.

Table 4. Weed control and growth of Montmorency cherries[x] after 2 successive annual applications of herbicides.

Chemical	Rate (lb./A)	Terminal growth (cm)[z]	Weed control rating[y,z]
None	—	18.9a	1.0a
Terbacil	1.0	21.6a	6.0b
Terbacil	2.0	25.2ab	8.3c
Terbacil	4.0	27.1b	9.0c
Terbacil	8.0	19.1a	9.0c
Simazine	4.0	21.5a	8.0c

[x]Trees were 6 years old the first year of application.
[y]1 = no damage, 9 = weed eradication.
[z]Means with the same letters within a column are not significantly different at P = .05.

Complete control of redroot pigweed, *Amaranthus retroflexus,* L., common purslane, *Portulaca oleracea* L., and large crabgrass, *Digitaria sanguinalis* (L.) Scop., was maintained for 90 days with 0.5 lb./A terbacil. Higher rates provided acceptable weed control until the following spring. An adequate safety margin may exist for applications of low rates (0.5 lb./A) of herbicide for weed control in seedling rootstocks or established clonal rootstocks on soils relatively high in organic matter.

Established orchards. Terbacil at 3.0 lb./A effectively controlled annual weeds on a Miami Loam soil for the entire growing season (Table 2). Acceptable weed control was lost after 90 days with 1.5 lb./A. No toxicity symptoms occurred on 2-year-old peach, tart cherry, or apple; however, veinal chlorosis was evident with 3.0 lb./A terbacil on plum 90 days after application. Where weeds were controlled regardless of method, terminal growth of cherry, peach, plum, and apple was increased. Toxicity to plum trees at the 3.0 lb./A rate did not result in decreased terminal growth. This experiment indicated that an adequate safety margin exists for terbacil on 2-year-old apple, peach and tart cherry trees grown on orchard soils relatively high in organic matter and clay content. Six-year-old apple trees of 3 cultivars tolerated 3 successive annual applications of 4 times the rate of terbacil required for weed control (Table 3). No chlorosis or abnormal symptoms were observed in any of the 3 years. Terminal growth measurements obtained after each year of application revealed no decreases in growth. An apparent stimulation of growth was obtained with 2 cultivars at higher rates of application. The trees appeared more vigorous as has been reported by Ries et al. (6) with simazine in certain seasons. In this experiment, acceptable control of quackgrass, *Agropyron repens* (L.) Beauv., and several annual weed species was obtained with 2.0 lb./A.

In an adjacent orchard, 'Montmorency' cherry trees of similar age manifested no chlorosis at 1.0, 2.0, and 4.0 lb./A after 3 successive annual applications. Veinal chlorosis occurred with applications of 8.0 lb./A after 2 years, however, there was no decrease in terminal growth when compared to the control (Table 4). 'Red Haven' peach responded similarly to annual applications of terbacil on this soil type.

Weed control and toxicity data from these experiments indicate that an adequate safety margin exists for established trees grown on a sandy loam soil. When used at rates required for acceptable weed control, the herbicide did not build up to toxic levels in the soil after 3 successive annual applications. Bioassays of soils treated one year earlier indicated slight carry-over of the herbicide when applied at the 2.0 lb./A rate.

Experiments in commercial orchards confirmed that the tolerance of apple, peach, tart cherry and sweet cherry was adequate when using rates required to control annual weeds and quackgrass. There was no evidence of an accumulation of chemical in the soil to toxic levels after 3 annual applications. Toxicity symptoms were observed at 4 of the 11 experimental locations (Table 5). Three of the sites involved apple, peach and pear trees only 2 years-old. The fourth occurred on 'Montmorency' cherry on a sandy loam soil, low in organic matter. Where phytotoxicity occurred, the rates of application were 2–4 times the rates required for acceptable weed control at the same site.

Weeds which were effectively controlled in these orchards with rates of 2.0 lb./A or less were quackgrass, large crabgrass, prickly lettuce, *Lactuca scariola,* L., rough cinquefoil, *Potentilla norvegica,* L., horseweed, *Erigeron canadensis,* L., yellow foxtail, *Setaria glauca* (L.) Beauv., yellow toadflax, *Linaria vulgaris,* Hill, redroot pigweed, red sorrel, white cockle, *Lychnis alba,* Mill., chickweed, *Stellaria media* (L.) Cyrillo, mouse-ear chickweed, *Cerastium vulgatum,* L., curly dock, *Rumex crispus,* L., cheat, *Bromus secalinus,* L., dandelion, *Taraxacum officinale,* Weber, common mallow, *Malva neglecta,* Wall, common purslane and henbit, *Lamium amplexicaule,* L. On soils with higher clay or organic matter content, 3.0 lb./A was required to adequately control quackgrass. Other perennial weeds which were somewhat suppressed were common milkweed, *Asclepias syriaca,* L., and bouncing bet, *Saponaria officinalis,* L. Control of Canada thistle, *Cirsium arvense* (L.) Scop., and field bindweed, *Convolvulus arvensis,* L., was not obtained with rates as high as 6.0 lb./A.

Table 5. Performance of terbacil in commercial orchards located on sandy loam soils.[y]

Species and Cultivar	Age[z]	% Organic matter	Years applied	Acceptable weed control rate (lb./A)	Rate at which veinal chlorosis occurred (lb./A)
Apple					
McIntosh, Delicious	2	1.22	1965–67	2.0	4.0
Delicious, Jonathan	4	3.44	1965–67	2.0	None
Golden Delicious	5	2.76	1965–66	1.0	None
Peach					
Red Haven	2	1.19	1965–68	1.0	4.0
Red Haven, Elberta	3	1.77	1965–66	1.0	None
Pear					
Bartlett	2	2.28	1967–68	1.0	4.0
Tart Cherry					
Montmorency	2	3.22	1965–68	1.0	None
Montmorency	4	1.64	1967–68	2.0	None
Montmorency	5	1.14	1967–68	1.0	4.0
Sweet Cherry					
Windsor, Napoleon	2	3.22	1965–68	1.0	None
Schmidt	15	1.39	1967	2.0	None

[y]Terbacil was applied at 0, 1.0, 2.0, and 4.0 lb/A in all orchards except apples which also received 6.0 lb/A.
[z]Age of trees the first year of application.

Because of its activity on many weed species, terbacil is a useful orchard herbicide. However, the safety margin is reduced for young plantings on soils low in organic matter. The choice of selective rates of application will depend on tree species, age, and soil type as well as the precipitation levels and irrigation practices in the area.

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Evaluation of Dichlobenil, Abscisic Acid and Temperature on Shoot Growth During and After Storage of Woody Ornamentals[1]

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Abstract. Dormant plants of *Forsythia intermedia, Rosa hybrida, Rosa multiflora* and *Cornus alba siberica* were treated with 2,6 dichlorobenzonitrile (dichlobenil) (0 – 500 ppm) and abscisic acid (ABA) (0 – 250 ppm) to prolong dormancy in storage and increase growth after storage. These treatments were carried out in a common nursery storage and controlled temperature rooms. A factorial treatment arrangement with temperatures 1°, 10°, 21° C and each chemical was completed. Dichlobenil inhibited growth during and after storage. ABA did not affect shoot growth during or after storage. The lower temperatures inhibited growth during storage and resulted in better shoot growth after storage. There was no significant interaction of temperatures and the dormancy prolonging material on growth after storage.

Introduction

Deciduous woody ornamentals pose a handling problem when stored and sold bareroot. Buds of these plants break dormancy after a period in storage and grow. These shoots grow rapidly when moved into a warm sales room or in unrefrigerated storage houses in late spring when the low temperature can no longer be maintained. Chemicals or handling procedures that would prolong dormancy and suppress shoot growth would give the consumer a better product because these shoots are easily broken and subject to infection. In addition prolonging dormancy would extend the bareroot planting season and eliminate root pruning for a potting operation.

Several workers (5, 6, 9) used a variety of growth regulating chemicals attempting to control shoot growth during storage. However, these regulators were difficult to apply, had inconsistent effects on shoot growth in storage, and persisted to retard the growth of shoots when the plants were removed from storage and planted. Mahlstede (7) suggested that 2,6 dichlorobenzonitrile (dichlobenil) would maintain the dormancy of roses for short periods. This material is highly volatile and it should disperse after storage thus preventing any deleterious residual carry over effects.

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[3]Dichlobenil was supplied by Thompson Hayward Chemical Company.
[4]Abscisic acid was supplied by R. J. Reynolds Tobacco Company.
[5]Storage facilities and woody ornamentals were supplied by Bork Nursery, Onarga, Illinois and Home Nursery, Edwardsville, Illinois.

Recently a naturally occurring growth chemical, abscisic acid (ABA), has been discovered (2). This compound has been implicated in the regulation of bud dormancy of woody plants (3, 4) and it might be a convenient material for suppressing shoot growth in storage. Since this compound is a normal plant constituent it could foreseeably be metabolized when the plants are removed from storage thus eliminating any deleterious carry over effects that the compound might have.

The following experiments were performed to study the effects of dichlobenil, ABA and temperature on shoot growth of several woody ornamental plants during and after storage.

Methods and Materials

A special emulsifiable formulation (E-1R) (8) containing 1% dichlobenil[3] was diluted with water containing 0.1% Tween 20. These dilutions were applied as fine sprays to completely wet the plant treated. The ABA[4] was obtained as dried powder, converted to a K salt by adding KH_2CO_3, dissolved in water containing 0.1% Tween 20, and applied as above.

Experiments were carried out during the spring 1966 with dichlobenil in a nursery storage situation[5]. These storages consisted of large slightly underground unrefrigerated rooms in which the temperature fluctuated between 5°–20° C depending on the outside temperatures. Five dormant plants of *Forsythia intermedia,* Zabel 'Spring Glory' and *Cornus alba siberica,* L. were treated