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Early transplanting will most often benefit fast growing deciduous trees and have a negligible effect on slower growing coniferous trees.

Because there was not a significant container size-transplant date interaction, it appears that early transplanting cannot overcome the restricted growth incurred by tree seedlings propagated in small containers.

Based on the results of these and previous studies, rapid growing tree seedlings can be expected to increase in size as container volume increases up to a volume of approximately 680.0 cm^3 (41 in^3). A bottomless container that permits air root pruning is recommended, and propagation container design similar to that of the unused half pint milk carton (41 in^3) should be further investigated.

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Evaluation of Herbicides for Use in Closed Structures[1]

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Abstract

The herbicides Hyvar X (bromacil) WP, Pramitol (prometon) 5 PS and WP, Princep (simazine) WP and Karmex (diuron) WP were each applied at 3 rates to soil in closed structures with test plants held above the soil. Karmex (diuron) at the 11.25, 22.5 and 45 kg ai/ha (10, 20 and 40 lbs aia) rate did not damage 3 test species. Hyvar X (bromacil) at the 17 kg ai/ha rate (15 lbs aia) may also be safe. Pramitol (prometone) 5 PS or WP and Princep (simazine) damaged most test plants.

Index words: greenhouse, volatile, Pennsylvania bittercress *(Cardamine pensylvanica* Muhl.), yellow wood sorrel *(Oxalis stricta* L.)

Introduction

The control of weeds on the floors of greenhouses and overwintering structures that are either soil or gravel is a serious problem. Weeds like Pennsylvania bittercress *(Cardamine pensylvanica* Muhl.) and yellow wood sorrel *(Oxalis stricta* L.), have mechanisms for propelling the seed at maturity. Weeds may harbor disease organisms, insects, spiders, mites, and also give the nursery or greenhouse an unsightly appearance. Many herbicides cannot be used inside structures because of volatility or residual which may cause injury to crops, especially at high temperatures. There has been little research to show what herbicides may be used for weed control under greenhouse benches and in overwintering structures. Karmex (diuron) and Princep (simazine) have been mentioned in some greenhouse-related publications but with no supporting evidence. Burt (1) and Kearney *et al.* (4) have shown that triazine herbicides will volatilize under laboratory conditions, however, whether they volatilize from a soil surface has not been established. The objective of this study was to determine if certain herbicides could be safely used on the floor of a closed chamber as evaluated with sensitive species.

Methods and Materials

Unvented chambers 92 cm^3 (3 ft^3) were constructed and covered with 4 mil polyethylene plastic and placed on the floor of a greenhouse equipped with fan-pad cooling (Fig. 1). Three 30.5 x 56 x 5.7 cm (12 x 22 x 2.2

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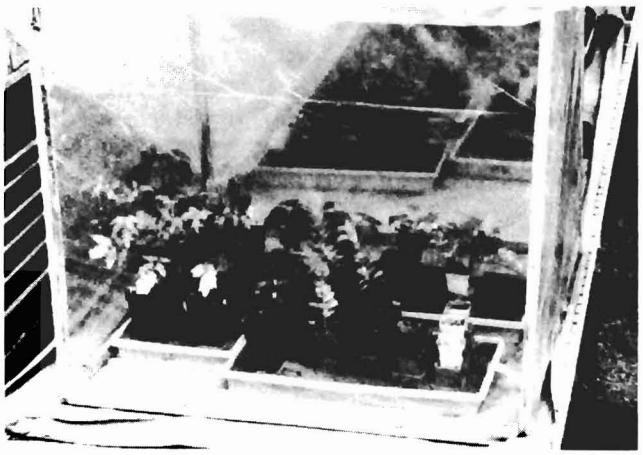

Fig. 1. Experimental greenhouse simulation chamber.

Fig. 2. Position of plants in relation to treated soil: (top) test plant pot; (center) inverted pot to provide bench-like condition; and (bottom) herbicide treated soil.

in) plastic flats filled with unsterilized sandy loam soil were placed inside each chamber. The soil in the flats was kept moist throughout the study.

The following herbicides and rates were applied to the soil in flats: Hyvar X (bromacil) WP and Princep (simazine) WP at 0, 17, 34 and 68 kg ai/ha (15, 30 and 60 lbs aia) and Pramitol (prometone) 5 PS pellets and WP, and Karmex (diuron WP at 0, 11.25, 22.5 and 45 kg ai/ha (10, 20 and 40 lbs aia). A pot containing a test plant was placed on top of an inverted empty pot on top of the treated soil, to simulate a bench-like arrangement with test plants about 8 cm (3 in) above the treated soil, but not in direct contact (Fig. 2). The 4 treatments were replicated 3 times with 3 subsamples per replication for each test species. The 3 subsamples in each replication were averaged to give 1 rating for each species in each chamber. Three plants 10 to 15 cm (4 to 6 in) tall of each of the following species in 7.5 cm^2 (3 in^2) containers were placed in each chamber: *Pilea cadierei* (aluminum plant); *Alternanthera amoena* (Jacob's coat); *Hedera helix* (Envligh ivy) and *Lycopersicon esculentum* 'Rutgers' (tomato). In addition, *Kalanchoe spp.* (kalanchoe) and *Cissus rhombifolia* (grape ivy) were used with Hyvar X and Pramitol.

Only one herbicide was studied at a time due to space requirements of the chambers. The time sequence is as follows: Hyvar X, applied on October 28 and terminated December 7, Pramitol 5 PS, applied December 10 and terminated January 8, Pramitol WP, applied January 11 and terminated January 25. Karmex WP, applied January 27 and terminated March 10. A second study with Karmex WP was begun April 29 and terminated June 10. Princep was applied on March 14 and terminated April 25. During each study the test plants were evaluated with a 0 to 10 rating scale where 0 = no injury; 1 to 3 = slight injury; 4 to 7 = moderate injury from which plants sometimes recovered; 8 and 9 = severe injury; and 10 = dead plants. Plants rated 5 or above were considered unsalable.

Results and Discussion

Hyvar X (bromacil). After 26 days in the chambers with Hyvar X at the 68 kg ai/ha (60 lbs aia) rate, 2 of the 9 English ivy plants developed marginal chlorosis.

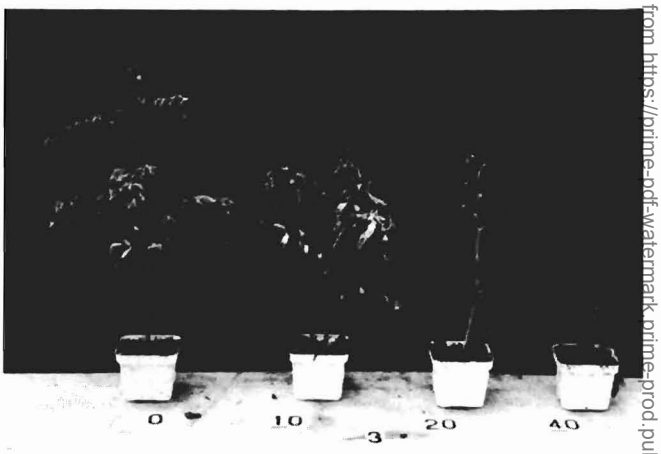

Fig. 3. Effects of Pramitol (prometone) 5 PS at 0, 11.25, 22.5 and 45 kg ai/ha (0, 10, 20 and 40 lbs aia) on tomato plants after 21 days.

Chlorosis became severe after 36 days. At the 17 and 34 kg ai/ha rate (15 and 30 lbs aia) slight injury was observed only on 1 of the 18 plants. Injury occurred only on the older leaves. No other test species showed any injury from Hyvar X throughout the 6 week study. Tomato plants never showed injury at any rate. Six tomato plants from each rate were transplanted into the field at the termination of the experiment and grew normally. No weed growth was present in any of the 27 flats treated with Hyvar X suggesting that rates above 17 kg ai/ha (15 lbs aia) are unnecessary to achieve satisfactory weed control. Maximum soil temperature was 25 °C (78 °F).

Pramitol (prometon) 5 PS. Damage was evident on the leaf margins of tomatoes at the 45 kg ai/ha rate (40 lb aia) after 7 days. This injury was different from "typical triazine" herbicide injury (i.e. interveinal chlorosis). Tomato plants became limp as though frozen or cooked and later tissue turned brown, but chlorosis was not detected at any time. After 10 days similar damage was visible at the 22.5 kg ai/ha rate (20 lb aia), and after 15 days, damage to tomatoes could be detected at

the 11.25 kg ai/ha (10 lb aia) rate. All tomatoes were dead at the 22.5 and 45 kg ai/ha rates (20 and 40 lbs aia) (Fig. 3).

Some damage could be detected on grape ivy, English ivy and Jacob's coat at the 22.5 and 45 kg ai/ha rate (20 and 40 lba aia) after 20 days. Damage continued to develop at the 22.5 and 45 kg ai/ha rates (20 and 40 lbs aia) on grape ivy after 25 days. English ivy and Jacob's coat (particularly at 45 kg ai/ha rate (40 lbs aia) looked like they had been cooked or frozen on the leaf margins. Aluminum plants showed no leaf discoloration after 25 days, but at all rates the plants appeared wilted. The stems drooped although the color of all stems and leaves both old and new still appeared normal. The plants appeared to be suffering from lack of soil moisture although the soil was adequate. Roots of these plants continued to appear normal until the tops died. Tips of kalanchoe plants at the 45 kg ai/ha rate (40 lbs aia) began to show a scorched effect on the leaf margins after 25 days. A slight yellowing could be detected at the 22.5 kg ai/ha rate (20 lbs aia) and a few leaves began to drop. Leaf and stem injury to the kalanchoe at both 22.5 and 45 kg ai/ha (20 and 40 lbs aia) was much more dramatic after 28 days.

When the study was terminated after 4 weeks, the tomato plants were dead in the chambers receiving the 22.5 and 45 kg ai/ha rate (20 and 40 lbs aia) of Pramitol 5 PS, and severely damaged at the 11.25 kg ai/ha rate (10 lbs aia) (Table 1). Tomatoes in chambers with untreated soil, although spindly from the high temperature [frequently exceeding 38 °C (100 °F)] remained healthy. Grape ivy was the most resistant plant to Pramitol. Only 6 grape ivy plants out of the 36 in the treated chambers were moderately to severely injured. All English ivy plants were dead at the 45 kg ai/ha rate (40 lbs aia). They appeared to be severely injured at the 22.5 kg ai/ha rate (20 lbs aia), but only slightly injured at the 11.25 kg ai/ha rate (10 lbs aia). Jacob's coat plants were dead at the 45 and 22.5 kg ai/ha rates (4o and 20 lbs aia) and severely injured at the 11.25 kg ai/ha rate (10 lbs aia) with no likelihood of recovery. Kalanchoe plants were dead or nearly dead at the 45 kg ai/ha rate (40 lbs aia) and severely injured at the 22.5 kg ai/ha rate (20 lbs aia). However, injury was only slight at the 11.25 kg ai/ha rate (10 lbs aia). Maximum soil temperature was 27 °C (80 °F).

Pramitol (prometon) WP. Within two weeks after plants were placed in the chambers with Pramitol WP all plants were dead or severely damaged. This suggests that the WP formulation began volatilizing more rapidly than the pellets. Extent and appearance of damage was similar to the pelletized formulation.

Karmex (diuron) WP. The first study with Karmex was begun January 27 and was terminated after 6 weeks. Maximum soil temperature was 24 °C (73 °F) and air temperatures in the chambers never exceeded 32 °C (90 °F). A second study was begun April 29 and was terminated after 6 weeks. Air temperatures in the chamber reached 46 °C (115 °F) and soil temperatures reached 34 °C (94 °F). No injury could be detected on any plant during or at termination of the experiments. All rates of Karmex (diuron) controlled all weeds in the treated soil suggesting that 11.25 kg ai/ha (10 lbs aia) is sufficient to give weed control. Only the sensitive species, aluminum plant, Jacob's coat, English ivy and tomato were used in this study.

Table 1. Effects of prometone 5 PS treated soil in enclosed chambers on 6 herbaceous species, evaluated after 4 weeks exposure.

Species	Pramitol kg/ha (lbs/aia)			
	0	11.25 (10)	22.5 (20)	45 (40)
	Injury Rating[z]			
Tomato	0	7.0	9.8	10.0
Aluminum plant	0	6.3	5.8	8.3
Grape Ivy	0	3.3	3.8	4.0
English Ivy	0	1.8	5.8	10.0
Jacob's coat	0	6.8	9.6	10.0
Kalanchoe	0	2.0	5.0	9.0

[z]Scale 0-10, with 0 being no injury and 10 being dead. Values represent the average rating of 9 plants.

Princep (simazine) WP. All plants showed some marginal necrosis in chambers treated with the 34 and 68 kg ai/ha rate (30 and 60 lbs aia) after 6 weeks. However, no further damage occurred during the study. Maximum soil temperature recorded was 30 °C (86 °F). Based on the initial injury observed, although not severe, Princep (simazine) should not be used in any enclosed structure.

Of the 5 herbicides studied, Karmex (diuron) WP at the 11.25, 22.5 or 45 kg ai/ha rate (10, 20 or 40 lbs aia) did not damage any test plant. Neither did Hyvar X (bromacil) at the 17 kg ai/ha rate (15 lbs aia), but higher rates caused injury. Pramitol (prometone) 5 PS or WP or Princep (simazine) should not be used in any enclosed structure. None of the herbicides used in these studies are labeled for use in closed structures.

If injury from herbicides applied to the floor of a closed structure is suspected, mixing activated charcoal into the soil at rates up to 1.5 kg/10 m² (3 lbs per 100 ft²), may inactivate the herbicide (2, 3). Activated charcoal is available under the trade name of Gro-Safe, manufactured by ICI United States Inc. Specialty Chemicals Division, Wilmington, Delaware and Darco charcoal. Other sources may also be available.

Significance to the Nursery Industry

Karmex (diuron) appears to be safe for use in enclosed structures such as greenhouses or overwintering houses for nursery stock at rates up to 45 kg ai/ha (40 lba aia). Under conditions of higher than normal temperatures and no ventilation, no injury from volatilization of the herbicide could be detected. Hyvar X (bromacil) at 17 kg ai/ha (15 lbs aia) also appeared safe. Pramitol (prometon) killed many of the test plants even at 11.25 kg ai/ha (10 lbs aia) while Princep (simazine) at 68 kg ai/ha (60 lbs aia) caused slight injury. However, none of these herbicides are registered for use in closed structures.

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