Trifluralin (Preen) Dissipation from the Surface Layer of a Soilless Plant Growth Substrate[1]

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Abstract

Southeastern U.S. container nursery crop production relies upon frequent applications of preemergence herbicides for broad-spectrum weed control. An experiment was conducted to determine the length of residual control and the sensitivity of two grass species to Preen (trifluralin) applied to the surface of a pine bark:sand (7:1 by vol) potting substrate. The experiment was conducted twice at each of two locations during 2001. Samples of the potting substrate were taken 0, 1, 3, 7, 14, 28, 42 and 56 days after treatment (DAT) for laboratory analysis. Trifluralin was extracted from the potting substrate and quantified using gas chromatographic techniques. Large crabgrass and perennial ryegrass were seeded 0, 7, 14, 28, 42 and 56 DAT to bioassay for herbicide residues. Shoot and root length were measured two weeks after each seeding date. Preen residues in the surface of the potting substrate decreased rapidly after application and leveled off approximately 21 DAT. Based on the bioassay, March applications of Preen controlled large crabgrass and perennial ryegrass for 37 days or greater while May and June applications of Preen controlled the two species for only 3 to 21 days. These results suggest that trifluralin reapplication should be more frequent than the common interval of 56 to 70 days in the southeastern United States.

Index words: herbicide dissipation, container nursery production, dinitroaniline, preemergence herbicides.

Species used in this study: large crabgrass [*Digitaria sanguinalis* (L.) Scop.]; perennial ryegrass (*Lolium perenne* L.).

Herbicides used in this study: Preen (trifluralin) 2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl)benzenamine.

Significance to the Nursery Industry

During May and June in the southeastern United States, trifluralin dissipates quickly in soilless pine bark-based substrates. In addition to being applied alone, it is also the grass control component of Snapshot TG (trifluralin + isoxaben), a standard preemergence nursery herbicide. Based on applications made in March through June, the half-life of trifluralin is less than 7 days in soilless substrates. Large crabgrass and perennial ryegrass, two sensitive species, are controlled for less than 21 days from May and June applications, yet they are controlled longer from March applications. These results, and previous reports, suggest that residual weed control with trifluralin will last longer in cooler weather than in the heat of summer. Therefore, in the southeastern United States, reapplication intervals of preemergence herbicides may need to be longer during the cool weather of fall and winter and shortened during the summer months. However, these results need to be confirmed with other herbicides that have different chemical and physical properties.

Introduction

Weeds can significantly reduce the growth of container nursery crops. Fretz (7) reported that one redroot pigweed (*Amaranthus retroflexus*) or large crabgrass (*Digitaria sanguinalis*) plant in a 2.4 liter container reduced the dry weight of Japanese holly (*Ilex crenata* 'Convexa' Mak.) by 47% and 60%, respectively. Berchielli-Robertson et al. (2) reported that one plant each of prostrate spurge (*Euphorbia humistrata*) and eclipta (*Eclipta prostrata*) were as competitive as greater number of weeds. Creager (4) also reported that a combination of broadleaf and grass weeds reduced the size of container-grown cotoneaster (*Cotoneaster dammeri* 'Bearberry,' *Cotoneaster dammeri* 'Lowfast'), euonymus (*Euonymus fortunei* 'Longwood'), Japanese holly (*Ilex crenata* 'Convexa' Mak.), juniper (*Juniperus horizontalis* 'Plumosa'), privet (*Ligustrum lucidum*), pyracantha (*Pyracantha coccinea* 'Lalandei'), and azalea (*Rhododendron obtusum* 'Hino Crimson'). Due to the lack of selective postemergence herbicides available for broad-spectrum weed control in container crop production, frequent applications, every 56 to 70 days, of preemergence herbicides are relied upon for broad-spectrum weed control (13). Most preemergence herbicide programs include dinitroaniline herbicides such as trifluralin, pendimethalin, oryzalin or prodiamine. This family of herbicides offers a broad range of crop tolerance (13) and controls a wide spectrum of annual grass and some small-seeded broadleaf weeds (17, 21). Often, dinitroaniline herbicides are pre-packaged or tank-mixed with more effective broadleaf herbicides to achieve broad-spectrum weed control (5, 8, 12, 16, 17, 23).

Despite frequent herbicide applications during the growing season, herbicides often lose their effectiveness before re-application. As a result, weeds that germinate between herbicide applications must be removed by hand, an expensive and laborious task. Gilliam et al. (10) reported that depending on nursery size, annual hand weeding costs can range from $608 to $1401 per hectare ($246 to $567 per acre), based on hourly wages from $3.53 to $3.97, and Darden and Neal reported more recently that, when no herbicides are used, it costs up to $1,367 to hand weed 1000 pots over a 4-month period, based on hourly wages of $14.75, an average of labor costs provided by local nurseries (3). If these more current labor costs are applied to figures provided by Gilliam et al.

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(10), the cost for supplemental hand weeding could range from $2,389 to $5,506 per hectare ($967 to $2,228 per acre).

Snapshot TG (Dow AgroSciences, 9330 Zionsville Rd., Indianapolis, IN) is commonly used in container nursery production for broad-spectrum preemergence weed control. It is a granular combination of the dinitroaniline trifluralin for grass control, plus isoxaben for expanded broadleaf weed control. Trifluralin, registered in 1963, was the first dinitroaniline herbicide (20). It has a very low water solubility of 0.3 mg/mL (19), but is readily soluble in organic solvents (18). It is susceptible to decomposition by ultraviolet irradiation (18) and has a high vapor pressure that causes volatilization (20, 21). In agronomic crop production, Treflan (trifluralin) is often soil incorporated to reduce volatilization (20). This practice is not feasible in container nursery production. Therefore, granular formulations are often used such as Preen, Trifluralin 5G or Snapshot TG. Trifluralin is strongly sorbed to soil especially organic, lipophilic, and/or proteinaceous substances (20). Weber (20) reported trifluralin half-life values ranging from 19 to 132 days in various field soils. While trifluralin persistence has been reported for many field soils, container substrates are generally soil-free and consist of organic materials such as pine bark (22). No data are available on the half-life of trifluralin in irrigated soilless nursery substrates. Based on the need for frequent re-application to maintain acceptable weed control, it is likely that the half-life in the surface of soilless substrates is less than those observed in field soils. An experiment was conducted to determine trifluralin dissipation over time in a soilless substrate and to assay the inhibition of sensitive grass species over the same time period.

Materials and Methods

General methods. Plastic containers 9.5 liter (2.5 gal), 25.4 cm (10 in) in diameter, were filled with a pine bark:sand (7:1 by vol) substrate amended with 2.1 kg per m^3 (6 lbs per yd^3) pulverized dolomitic limestone and a controlled release fertilizer (Wibro 15–4–9 with micros; Harrells, Inc., Lakeland, FL) providing 0.525 kg per m^3 (1.5 lbs per yd^3) nitrogen, 0.06 kg per m^3 (0.17 lbs per yd^3) phosphorus, and 0.26 kg per m^3 (0.75 lbs per yd^3) potassium. Preen (Greenview, a division of Lebanon Seaboard Corp., Lebanon, PA) 1.47G [trifluralin, 1.47% active ingredient (ai) granule] was applied at 4.48 kg ai/ha (4.0 lbs ai/A) to the containers using a handheld shaker jar. The experiment was conducted twice at each of two locations, for a total of four experimental repetitions. At the Horticultural Field Laboratory, Raleigh, NC, the first experimental repetition was initiated March 28, 2001, and the second experimental repetition was initiated June 12, 2001. At the Horticultural Crops Research Station, Castle Hayne, NC (near Wilmington, NC), the first experimental repetition was initiated May 17, 2001, and the second experimental repetition was initiated June 18, 2001. The experimental design for each test was a randomized complete block with four replications. In each experimental repetition, all containers were irrigated with 2.5 cm (1 in) water via overhead irrigation within 6 hours after application. Thereafter, containers received approximately 2.5 cm (1 in) water daily via overhead irrigation at each location.

Herbicide dissipation. Container substrate samples were removed from a single container within each plot 0 (after irrigation), 1, 3, 7, 14, 28, 42 and 56 days after treatment (DAT), for a total of 8 containers per plot. Samples were taken from the top 2 cm (0.8 in) of the substrate and pot edge effects were removed by placing a cardboard frame inside the perimeter of the pot to allow the sample to be scooped with a plastic cup from the total interior 21.6 cm (8.5 in) diameter of substrate. Each sample was sealed in a plastic bag and stored at –12C (10F) until laboratory analysis. The top 2 cm (0.8 in) of substrate was chosen as the sampling region because the majority of small-seeded grasses germinate in this region (1). Losses from volatilization and/or leaching were not quantified because we assumed trifluralin does not contribute to weed control after it has moved from the surface layer of the substrate.

Trifluralin extraction procedures for the first experimental repetition at each location (Raleigh-March, Castle Hayne-May) were as follows. Samples were extracted according to methods described by Tepe and Scroggs (18) and Garcia-Valcarcel et al. (9). Ten grams of potting substrate were tared into a Soxhlet thimble and extracted for 4 hours with 225 mL of hexane:acetone (1:1 by vol) at 6 turnovers per hour. Extracts were concentrated to 2 to 3 mL by rotary evaporation at 40C (104F) and brought to 10 mL with hexane. Samples were transferred to a glass column [30.5 by 1.25 cm internal diameter (i.d.), (12 by 0.5 in)] containing 10 g of 6% deactivated Florisil, a magnesium silicate with basic properties that serves as a selective adsorbent (US Silica Co., Berkeley Springs, WV), topped with 2.5 cm $Na_2SO_{4(anhyd.)}$ pre-rinsed with 25 mL of hexane. Trifluralin was eluted with 100 mL of hexane:acetone (97:3 by vol) and concentrated to 2 to 3 mL by rotary evaporation at 40C (104F). Samples were diluted with hexane and transferred to gas chromatography vials.

Due to unexplainable circumstances that caused a dramatic decrease in recovery efficiency, a different extraction procedure was used for the remaining experimental repetitions (Raleigh-June, Castle Hayne-June). The new method was validated by reextracting residues from the first two experimental repetitions and comparing trifluralin concentrations. Since the new method reflected the same residue levels, it was deemed satisfactory and it was deemed fair to compare data between all four experimental repetitions. Ten grams of potting substrate were tared into a 100-mL beaker and 80 mL of acetonitrile were added. The sample suspension was sonicated for 3 minutes (40% full strength) on a Model 450 Branson Sonifier (Branson Ultrasonics Corp., Danbury, CT). The solvent was filtered from the potting substrate using vacuum filtration through #5 Whatman filters (Whatman, Inc., Clifton, NJ) in a Buchner funnel. Extracts were concentrated to 2 to 3 mL by rotary evaporation at 40C (104F) and brought to 10 mL with acetonitrile. Samples were diluted with acetonitrile and transferred to gas chromatography vials.

For all four experimental repetitions, residue levels were quantified on a dry weight basis using a Varian (Varian, Inc., Walnut Creek, CA) Model 3400 Gas Chromatograph equipped with a Thermionic Specific Detector (TSD), Model 8200CX Autosampler and Varian Star data system. The column was a 30 m (98 ft) by 0.53 mm (0.02 in) (i.d.) fused silica DB-35 (J&W Scientific, Inc., Folsom, CA). Helium was the carrier gas at a flow rate of 6.1 mL/min. Gases to the detector were H_2, air and He (make up gas) at flow rates of 4.03, 169.15 and 22.35 mL/min, respectively. Temperatures were 175C (347F) for the inlet and 300C (572F) for the detector. A temperature program was run as follows: 150C (302F), hold 2 minutes; to 215C (419F) at 10C (50F) per minute, hold 2 minutes; to 290C (554F) at 15C (58F) per minute, hold 2 minutes. Injections were made in the splitless mode. The retention time of trifluralin was 5.8 minutes for the first two experimental repetitions (Raleigh-March, Castle Hayne-May) and 3.7 minutes for the second two experimental repetitions (Raleigh-June, Castle Hayne-June). Average percent recovery was greater than 95%, therefore data were not corrected for percent recovery.

Concentrations are reported as µg trifluralin per g dry weight of potting substrate. Data were subjected to analysis of variance. A significant repetition by treatment interaction was present. Therefore, data are presented individually for each experimental repetition. Data were fitted using non-linear least squares to a Weibull model described by Rawlings et al. (15) shown in Equation 1.

Equation 1.

$$Y = A * \left[p + (1-p) e^{-(X/\sigma)^C} \right]$$

Where:
Y = Trifluralin concentration (µg trifluralin/g dry weight of substrate)
X = Sampling date (expressed as days after treatment)
A = The amount of herbicide after the first irrigation
C = Estimated parameters describing the shape of the curve
σ = The time (days) until 37% of the amount of herbicide (A) remains, 63% has dissipated
p = Defined as 0.05 for the Raleigh-March and both Castle Hayne repetitions and 0.0 for the Raleigh-June repetition (equivalent to the amount remaining long after the end of the experiment)

Residual bioassay. Concurrent with sampling of the potting substrate, large crabgrass (collected locally) and perennial ryegrass (*Lolium perenne*) were seeded to the surface of the substrate. While large crabgrass is a target species in container management, perennial ryegrass was also included as another sensitive bioassay species. It is readily available and germinates quickly and uniformly. One-half of a single container within each plot was seeded with ½ teaspoon of each grass species 0, 7, 14, 28, 42 and 56 DAT, for a total of 6 containers per plot. Shoot and root length of ten randomly selected plants of each species were measured two weeks after each seeding date and data are expressed as percent of the non-treated. Shoot and root length were measured because trifluralin does not prevent germination, rather it inhibits root growth and subsequent shoot growth. Therefore, these were the best parameters to measure growth inhibition. Each experimental repetition is presented separately. Data were subjected to analysis of variance and fitted using non-linear least squares to a Weibull model (Figures 2 and 3) shown in Equation 2. Additionally, the number of days after treatment when seeding resulted in 20% (GR_{20}) and 50% (GR_{50}) growth was estimated by solving Equation 2.

Equation 2.

$$Y = 100 * e^{-(X/\sigma)^C}$$

Where:
Y = Shoot or root percent inhibition
X = Date that plants were seeded (expressed as days after treatment)
σ = The time (days) until 37% of the amount of herbicide (A) remains, 63% has dissipated
C = Estimated parameter describing the shape of the curve

Table 1. Approximate half-life values of trifluralin [Preen 1.47G at 4.48 kg ai/ha (4.0 lb ai/A)] in a pine bark:sand (7:1 by vol) substrate.

Experiment repetition	Initial trifluralin concentration[z]	Approx. half-life[y]
	µg/g	days
Raleigh – March 28	174	1
Raleigh – June 12	48	6.5
Castle Hayne – May 17	35	5
Castle Hayne – June 18	75	3.5

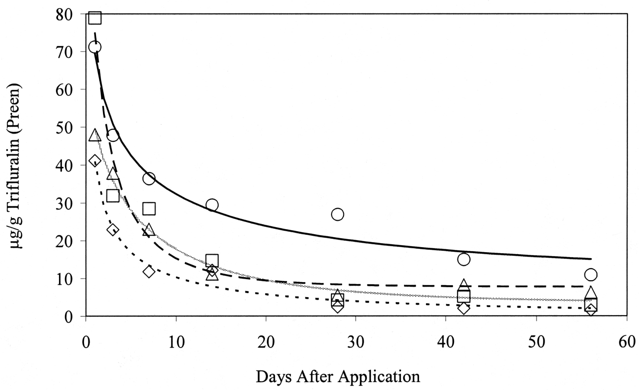
[z]Concentration quantified by gas chromatographic techniques from samples taken on day 0 (initiation date) after irrigation.

[y]Based on regression equations (Figure 1).

Results and Discussion

Herbicide dissipation. Dissipation of herbicides in soil is dependent upon the physiochemical properties of the herbicides and environmental conditions. Initial concentrations varied significantly. Initial concentration was measured after irrigation and differences may be due to the amount of time between herbicide application and first irrigation, though they all were irrigated within 6 hours of application. Additionally, the climatic conditions at application and until irrigation may also account for differences during this initial time frame. Despite the initial differences, half-life values calculated from the initial concentration and regression equations were less than 7 days for all four repetitions (Table 1). Weber (20) reported the half-life values of trifluralin ranged from 19 to 132 days in various field soils (20). According to Vencill et al. (19), the average half-life of trifluralin in the field is 45 days with less than 10% remaining one year after application. These data confirm that trifluralin dissipates more rapidly in containerized soilless substrates than in field soil. Laabs et al. (11) reported the half-life of trifluralin to be less than one day in a Brazilian tropical region and attributed the fast initial disappearance to chemical and microbial degradation, volatilization, and physical losses. In a more temperate region, Ying and Williams (25) reported the half-life of trifluralin between 27 to 30 days while examining herbicide dissipation in a Haploxeralf soil in South Australian vineyards.

The regression curves (Figure 1) show trifluralin dissipation over time starting with day one. In all repetitions, dissipation curves followed the same pattern, with an initial rapid decline in the first seven days and a leveling off approximately 21 DAT. Similarly, Ying and Williams (25) reported a fast initial loss of trifluralin followed by slower degradation. Concentrations of trifluralin did vary among experimental repetitions. In the Raleigh-March repetition, trifluralin concentrations were higher at the onset and remained higher



—○— Raleigh — March to May:

$$Y = 165.69 * \left[0.05 + (1 - 0.05) e^{-(X/1.22)^{0.30}} \right], \quad R^2 = 0.97$$

- -◇- - Castle Hayne — May to July:

$$Y = 68.04 * \left[0.05 + (1 - 0.05) e^{-(X/5.30)^{0.64}} \right], \quad R^2 = 0.98$$

······□······Raleigh — June to August:

$$Y = 292.78 * \left[e^{-(X/0.05)^{0.23}} \right], \quad R^2 = 0.98$$

– –Δ– –Castle Hayne — June to August:

$$Y = 154.57 * \left[0.05 + (1 - 0.05) e^{-(X/1.54)^{0.58}} \right], \quad R^2 = 0.95$$

Fig. 1. Trifluralin (Preen) dissipation curves over 56 days in a soilless substrate [pine bark:sand (7:1 by vol)].

throughout the 56 days than the May and June repetitions, which were all similar (Fig. 1). The day 1 concentration was much higher for the Castle Hayne-June repetition, but by 3 DAT, concentrations quickly dissipated to levels similar to the other May and June repetitions (Fig. 1).

The differences in overall trifluralin concentrations between the Raleigh-March and the May and June repetitions (Fig. 1) are most likely temperature and water dependent. Irrigation was similar across all experimental repetitions, but rainfall varied. Overall, the three experimental repetitions initiated in May and June received approximately twice as much rainfall as the repetition initiated in March. Additionally, temperature differences were noted among the experiments. The Raleigh-March repetition was conducted earlier in the growing season (March to May) than the other three repetitions, which ran from May to July and June to August. The mean temperature for the day of initiation for the Raleigh-March repetition was 3C (37F), while it was 16C (61F) for Castle Hayne-May, 25C (78F) for Raleigh-June and 23C (74F) for Castle Hayne-June. Additionally, mean daily temperatures for Raleigh-March were lower than 20C (68F) for the majority of the trial while in the other three repetitions (May and June) temperatures were rarely lower than 20C (68F). Trifluralin vapor losses are greater with increased temperature and moisture (11, 20). Vencill (19) also reported that the half-life of trifluralin is longer in cool, dry areas. Furthermore, leaching losses were probably minimal due to its low water solubility (14). In an Oxisol soil, after 28 days, only 0.07% of trifluralin was detected below 15 cm (6 in) soil depth (11). In container production with a soilless substrate, less than 1% of applied trifluralin was detected in runoff water within 5 days after treatment and decreased to below the detection limit by 14 DAT (24). In the second year of the same run-off experiment, no trifluralin residues were detected in pond water (24). Therefore, rapid initial losses of trifluralin and greater losses from May and June applications of trifluralin (Preen) are presumed to be primarily due to volatilization or biological and chemical decomposition.

Residual bioassay. Days after seeding that resulted in 20% growth ($GR_{20,}$ equivalent to 80% inhibition) and 50% growth ($GR_{50,}$ equivalent to 50% inhibition), compared to the nontreated, were determined from regression curves (Figures 2 and 3) based on the bioassay (Tables 2 and 3). Once plant growth has reached its GR_{20} (80% inhibition), it is no longer considered effectively controlled. In the Raleigh-March repetition, GR_{20} values for large crabgrass shoot growth were reached 37 days after treatment, while root growth did not reach 20% growth during the entire study (Table 2). In the other three experimental repetitions conducted in May and June, GR_{20} values for large crabgrass root and shoot were

Table 2. Days after treatment that seeding resulted in 20% (GR_{20}) and 50% (GR_{50}) root and shoot growth of large crabgrass (*Digitaria sanguinalis*) and the corresponding trifluralin concentration in the top 0.8 in (2 cm) of a pine bark:sand (7:1 by vol) potting substrate (as determined by gas chromatographic techniques).

		20% Growth		50% Growth	
Experimental rep.	**Plant part**	**GR_{20}**	**Trifluralin concentration**	**GR_{50}**	**Trifluralin concentration**
		days	**µg/g**	**days**	**µg/g**
Raleigh (March)	Root	90[z]	12.5	167[z]	10.3
	Shoot	37	18.1	74[z]	13.4
Raleigh (June)	Root	21	9.1	50	4.3
	Shoot	17	11.2	46	4.6
Castle Hayne (May)	Root	6	15.0	29	4.1
	Shoot	7	13.4	31	3.8
Castle Hayne (June)	Root	8	18.6	39	7.9
	Shoot	9	16.7	53	7.8

[z]Extrapolated value.

Table 3. Days after treatment that seedling resulted in 20% (GR_{20}) and 50% (GR_{50}) root and shoot growth of perennial ryegrass (*Lolium perenne*) and the corresponding trifluralin concentration in the top 0.8 in (2 cm) of a pine bark:sand (7:1 by vol) potting substrate (as determined by gas chromatographic techniques).

Experimental rep.	Plant part	20% Growth		50% Growth	
		GR_{20}	Trifluralin concentration	GR_{50}	Trifluralin concentration
		days	µg/g	days	µg/g
Raleigh (March)	Root	39	17.7	59[z]	14.7
	Shoot	40	17.5	41	17.3
Raleigh (June)	Root	5	28.1	16	11.8
	Shoot	4	31.5	11	16.4
Castle Hayne (May)	Root	6	15.0	35	3.4
	Shoot	3	23.2	16	7.0
Castle Hayne (June)	Root	7	20.9	17	10.3
	Shoot	4	33.4	11	14.1

[z]Extrapolated value.

much lower, ranging from 6 to 21 days (Table 2). GR_{20} values for perennial ryegrass root and shoot growth were reached approximately 40 days after treatment in the Raleigh-March repetition; whereas GR_{20} values for perennial ryegrass root and shoot were reached in less than 7 days in the other three repetitions (Table 3). Similarly, large crabgrass root and shoot GR_{50} values had to be extrapolated for the Raleigh-March repetition, as growth never was greater than 50% during the 56 day trial. However, for the other three repetitions, GR_{50} values for large crabgrass root and shoot ranged from 29 to 50 days (Table 2). Likewise, perennial ryegrass root and shoot GR_{50} values for the Raleigh-March repetition were 59 and 41,

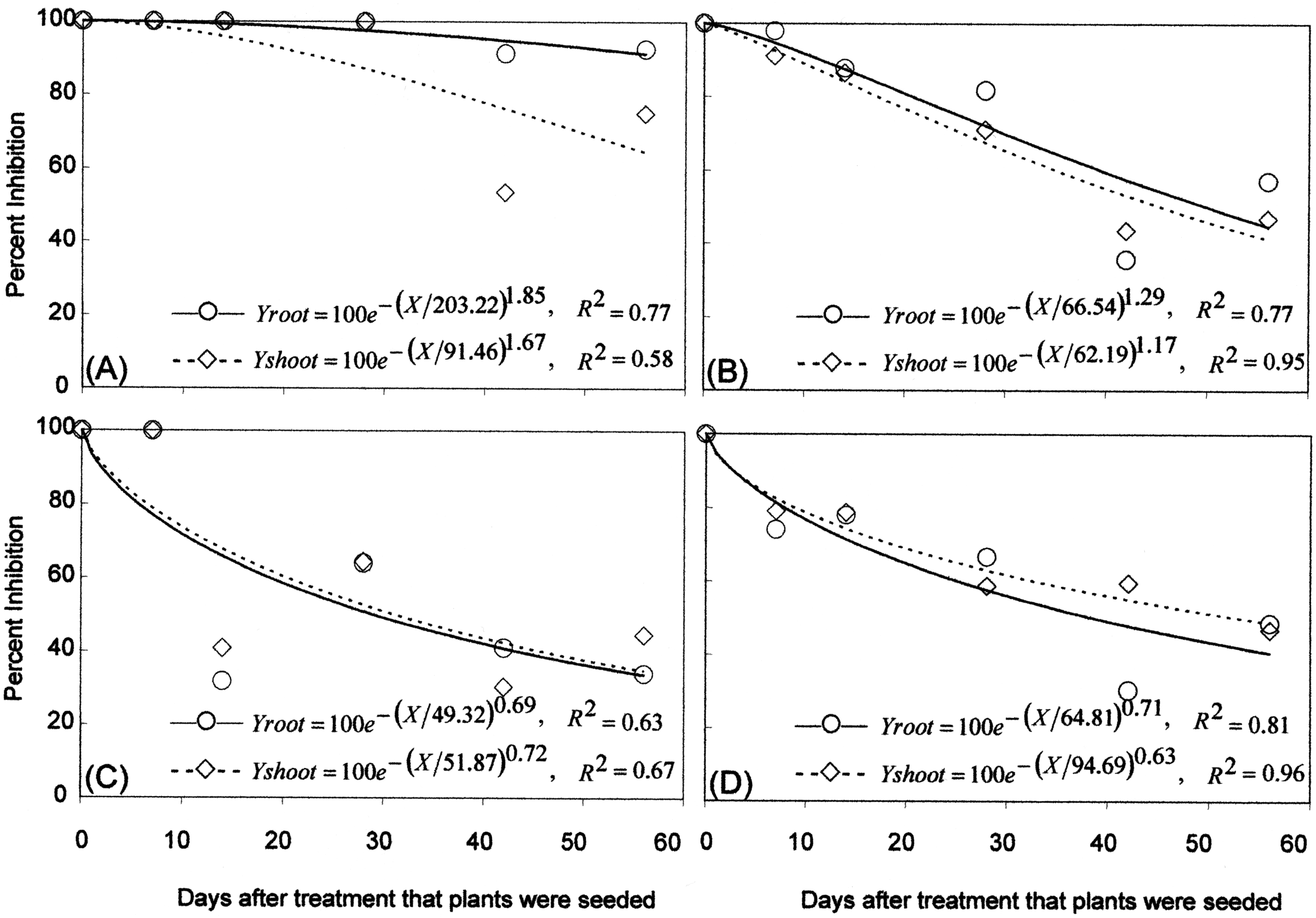


Fig. 2. Inhibition (expressed as a percent of the non-treated) of large crabgrass (*Digitaria sanguinalis*) root and shoot length over time by preemergence applications of Preen 1.47G (trifluralin) at (A) Raleigh — March to May, (B) Raleigh — June to August, (C) Castle Hayne — May to July, and (D) Castle Hayne — June to August.

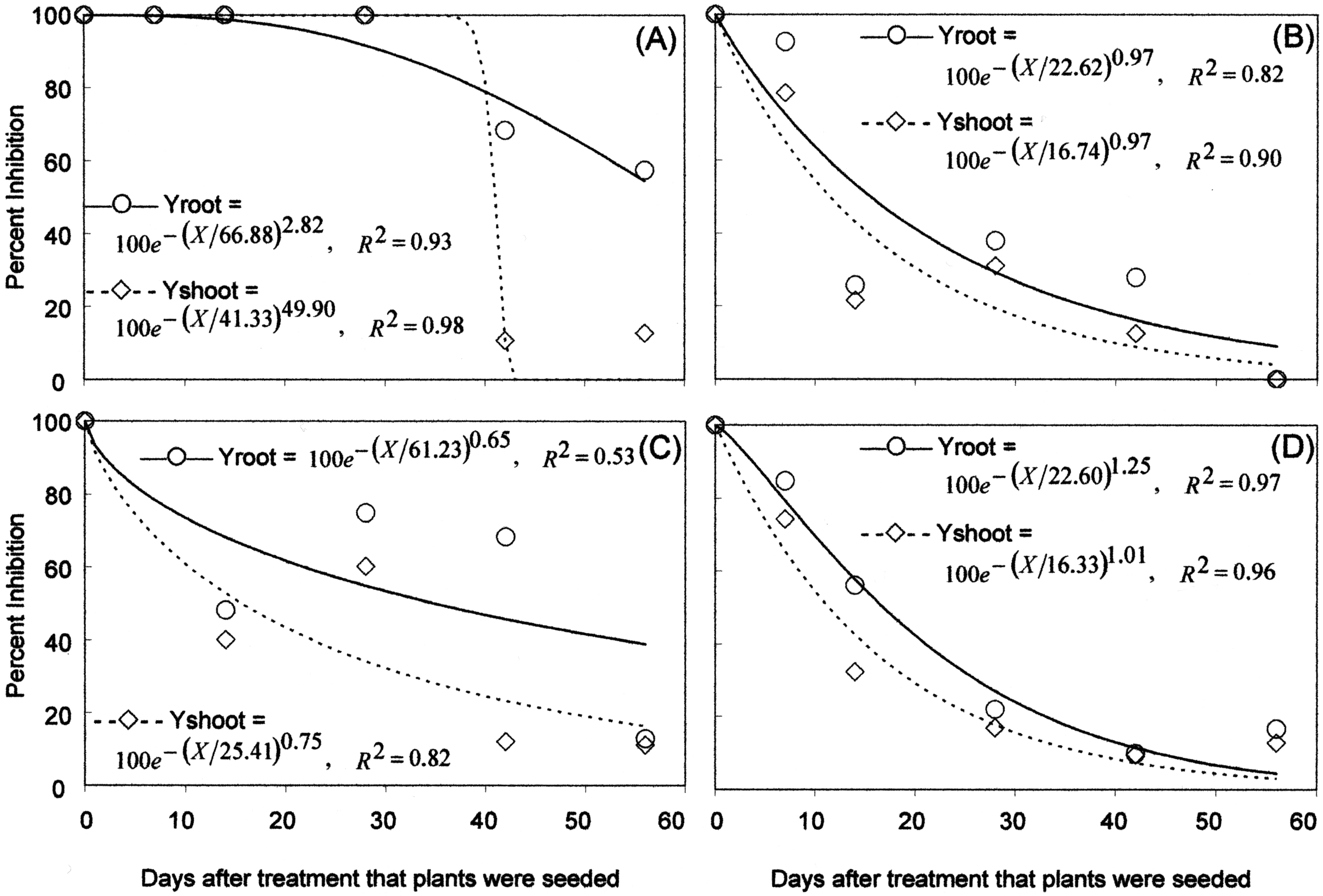


Fig. 3. Inhibition (expressed as a percent of the non-treated) of perennial ryegrass (*Lolium perenne*) root and shoot length over time by preemergence applications of Preen 1.47G (trifluralin) at (A) Raleigh — March to May, (B) Raleigh — June to August, (C) Castle Hayne — May to July, and (D) Castle Hayne — June to August.

respectively, and ranged from 11 to 35 days for the other three repetitions (Table 3). In summary, early season trifluralin applications provided longer residual control of large crabgrass and perennial ryegrass than May and June applications. During May and June, trifluralin provided 80% control (GR_{20}) of large crabgrass and perennial ryegrass for 21 days or less and 50% control (GR_{50}) for 53 days or less, the longest control observed from May and June applications (Tables 2 and 3).

Despite the differences in days after treatment when seeding resulted in varying levels of growth, inhibitory concentrations were quite similar. For example, 20% large crabgrass root growth occurred when trifluralin concentrations were 12.5 and 9.1 µg/g for the Raleigh repetitions and 15.0 and 18.6 µg/g for the Castle Hayne repetition (Table 2). Similarly, for 20% perennial ryegrass root growth trifluralin concentrations were 17.7 and 28.1 µg/g for the Raleigh repetitions and 15.0 and 20.9 µg/g for the Castle Hayne repetitions (Table 3).

In the southeastern United States, during the warmer months of the growing season, trifluralin dissipates quickly in soilless substrates. Data from this study demonstrate a trifluralin half-life of less than 7 days from applications made in March through June. Additionally, trifluralin applications made in May through June, the growth of sensitive grass species are inhibited (GR_{20}) for less than 21 days, the longest amount of time where large crabgrass or perennial ryegrass was effectively controlled. Based on these data, the current herbicide reapplication interval of 56 to 70 days may need to be shortened to improve the performance of trifluralin and reduce the need for hand weeding. Another option to improve herbicide performance might be to apply lower rates of trifluralin more frequently. In a preliminary test we have found one-half labeled rates of Surflan (oryzalin) and Gallery (isoxaben) applied every four weeks to be equally or more effective than full rates applied every eight weeks (unpublished data, 2001). Another way to utilize this information may be in the development of slow-release nursery herbicides, such as that reported for oryzalin by Fain et al. (6). For such strategies or formulations, herbicide applicators or formulation release rates will need to target the maintenance of trifluralin concentrations greater than 33 µg/g, the average concentration below which weeds were not controlled. Furthermore, these data show that trifluralin persists longer in container substrates during cooler weather, suggesting reapplication intervals in the southeastern United States may be longer during the cool weather of fall and winter, and shortened during the summer months. Additionally, these recommendations are only for trifluralin. Thus, dissipation and longevity of other common herbicides also need to be quantified.

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