Use of Herbicides and Plant Growth Regulators to Suppress Italian Ryegrass Growth

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ADDITIONAL INDEX WORDS. living mulch, *Lolium multiflorum*, plant growth suppression, mefluidide, sethoxydim, triclopyr

SUMMARY. Several concentrations of mefluidide (Embark), a plant growth regulator; sethoxydim (Poast), a grass herbicide; and triclopyr (Rely) a nonselective herbicide, were evaluated to determine if italian ryegrass (*Lolium multiflorum* Lam.) growth could be suppressed. Ryegrass grows prolifically during the winter in states adjacent to the Gulf of Mexico and may serve as a living mulch for strawberry (*Fragaria* ×*ananassa* Duch.) and other winter crops if its growth can be controlled. Different chemicals and concentrations were screened over 5 years for their efficacy to produce living mulch. Mefluidide produced good ryegrass control but was not evaluated after Study 1 because it is designed for industrial use and does not have an U.S. Environmental Protection Agency fruit crop label. Triclopyr, which has a label for several fruit crops, was studied only in the final year and it provided desired ryegrass control at the 0.016 and 0.030 $mL \cdot L^{-1}$ (parts per thousand) rate. Prime oil (paraffin base petroleum oil + polyol fatty acid esters) concentration affected results when sprayed with various sethoxydim rates. We concluded that 0.156 $mL \cdot L^{-1}$ sethoxydim plus 0.25 $mL \cdot L^{-1}$ prime oil will control ryegrass growth at the desired level (reduce growth by 40% to 50%) for living mulch. These rates are too low to cause much ryegrass browning. Chemical names used: N-[2,4dimethyl-5-[[(trifluoromethyl)-sulfony]amino]phenyl]acetamide, 2-[1-(ethoxylmino)buty1]-5-[2-(ethylthio)propy1]-3-hydroxy-2-cyclohexen-1-one), and ammonium-Dl-homoalanin-4-yl-(methyl) phosphinate.

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In the coastal plain soils of states adjacent to the Gulf of Mexico, living mulch may be useful in a strawberry or winter vegetable plasticulture system to reduce soil erosion, control winter weeds, and provide a clean picking area. Methodology for producing living mulch is needed for evaluation on strawberry and possibly other winter crops. Living mulch can reduce soil erosion, aid in maintaining soil structure, and reduce bed degradation (Roe et al., 1994).

Living mulch has been evaluated for sweet corn (*Zea mays* L.) and cabbage (*Brassica oleracea* L. var. Capitata) (Nicholson and Wien, 1983), bell pepper (*Capsicum annuum* L.) and squash (*Cucurbita pepo* L.) (Roe et al., 1994), broccoli (*Brassica oleracea* L. var. italica) (Castello, 1994), and field corn (*Zea mays* L.) (Elkins et al., 1979) production systems. Nicholson and Wien (1983) and Roe et al. (1994) screened grasses and legumes for use as living mulch that did not stress sweet corn, cabbage, bell pepper, and squash. Attempts at intercropping with living mulches have been successful with (Elkins et al., 1979) and without (Infante and Morse, 1996) chemical suppression of the living mulch to prevent excessive competition with the crop. Grubinger and Minotti (1990) controlled white clover (*Trifolium repens* L.) mulch with partial rototilling. Because winter fruit and vegetable crops may be protected from competition with living mulch by polypropylene mulch on a bed, chemical suppression is usually needed only to contain ryegrass growth within furrows.

Italian ryegrass has the potential to serve as living mulch if its growth can be controlled. Sublethal concentrations of chemicals are needed to suppress ryegrass growth. Several concentrations of mefluidide, a plant growth regulator; sethoxydim, a grass herbicide; and triclopyr, a nonselective herbicide, were evaluated 1993–96. The objective of this study was to determine a suitable sublethal concentration of each chemical to reduce ryegrass growth by an estimated 40% to 50%.

Materials and methods

STUDY 1 (1992–93). To obtain a thick, uniform stand, italian ryegrass was broadcast on 20 Oct. 1992 at 57 $kg \cdot ha^{-1}$ (50 lb / acre) on a 0.11-ha (0.27-acre) plot. Before seeding, 800 $kg \cdot ha^{-1}$ (700 lb / acre) fertilizer (13N–6P–11K) was broadcast and tilled into a Ruston fine sandy loam soil (fine-loamy, siliceous, Thermic Typic paleudult). Irrigation was applied only after seeding to promote uniform germination. Ryegrass for all future studies was established by the same procedure. All studies were conducted at the Small Fruit Research Station, Poplarville, Miss.

On 22 Jan. 1993, five sethoxydim (Poast; BASF Corp., Research Triangle Park, N.C.) treatments (8, 6, 4, 2, and 1 $mL \cdot L^{-1}$) plus 8 $mL \cdot L^{-1}$ prime oil (PO) (Riverside / Terra Corp. Sioux City, Iowa) as a spreader-sticker in each treatment, five mefluidide (Embark; pbi / Gordon Corp., Kansas City, Kans.) treatments (0.0030, 0.0022, 0.0015, 0.0011, and 0.0004 $mL \cdot L^{-1}$), and an untreated control were included in each of three replications. When the ryegrass was about 15 cm (6 inches) tall, the plots were misted but not wet to runoff using a high pressure backpack sprayer with a no. 3 flat fan nozzle at 2.1 $g \cdot cm^{-2}$ (30 lb / inch²). Plots 1 × 6 m (3.3 × 19.7 ft) with 1.2 m (4 ft) borders between plots to protect from drift were arranged in a randomized complete block design. Ryegrass from the mefluidide treated plots was harvested by replication with a 61 cm (2 ft) wide sickle mower between 6 and 14 May 1993. Fresh weight ($kg \cdot m^{-2}$) of ryegrass from each plot was determined. The regression of weight on treatment level was computed by an asymptotic regression model, Y = a–b exp (–cX) where b = Y intercept, α = asymptote, and c = the rate at which y changes from its initial value to its final value (Ratkowsky, 1983). An F test comparing lack of fit sums of squares was not statistically different from the pure error sums of squares at $\alpha = 0.05$. Bates and Watts, 1988). Hence, the asymptotic regression model provides a good fit to the data.

STUDY 2 (1995). On 24 Jan. 1995

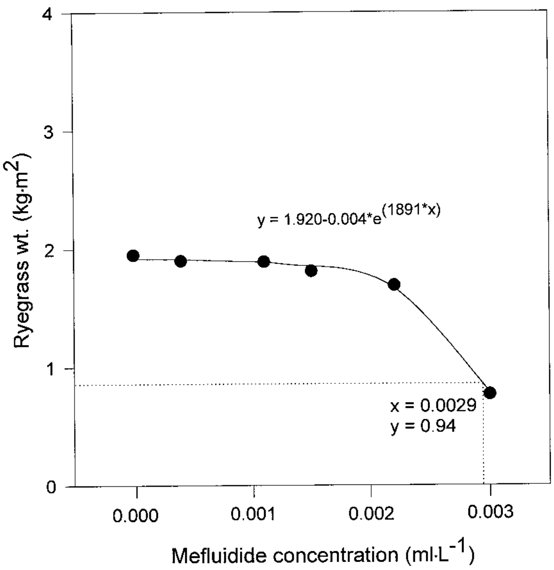

Fig. 1. Asymptotic regression of ryegrass fresh weight on mefluidide (mL·L^{-1} = parts per thousand) concentration in 1993. Fit of the equation to the actual data is not statistically different at α = 0.05.

sethoxydim was applied to ryegrass planted between strawberry seedling rows when they were established during Oct 1994. Plots 30.5 m (100 ft) long were delineated in a randomized complete block design with two replications. Sethoxydim at four concentrations (0.50, 0.25, 0.06, and 0 mL·L^{-1}) in all possible combinations with PO at three levels (0.06, 0.13, and 0.25 mL·L^{-1}) were applied. Plots were rated 2 Mar. 1995 using the following scale: 1) normal ryegrass growth; 2) slight growth suppression and some ryegrass browning; 3) medium growth suppression and medium amount of ryegrass browning; 4) medium growth suppression and large amount of ryegrass browning; 5) most of the ryegrass brown; and 6) all ryegrass dead. The data were analyzed by general linear models procedure (SAS Institute, Inc.; Cary NC). Means were separated by Duncan's multiple range test ($P \leq 0.05$).

STUDY 3 (1995–96). A 0.05-ha (0.124-acre) ryegrass plot was seeded 12 Oct. 1995. Plots 1 × 3 m (3.3 × 9.8 ft) in size were delineated so that seven treatments were arranged in a randomized complete block with four replications. Plots were separated by a 1-m (3.3-ft) border on all sides. We suspected that the usual PO level was causing browning when used with reduced sethoxydim rates. Sethoxydim and PO were applied 13 Nov. 1995 in the following combinations: 0 sethoxydim plus 0 and 0.25 mL·L^{-1} PO, 0.06 mL·L^{-1} sethoxydim plus 0.13 mL·L^{-1} PO, 0.25 mL·L^{-1} sethoxydim plus 0.13 and 0.25 mL·L^{-1} PO, and 0.50 mL·L^{-1} sethoxydim plus 0.06 and 0.13 mL·L^{-1} PO. Plots were rated 5 Feb. 1996 using the above scale and the data were analyzed as in the January 1995 sethoxydim treatments.

STUDY 4 (1996). Ryegrass was again seeded in the 0.05 ha plot 1 Oct. 1996. Experimental units consisted of 1-m^2 test plots with 1-m-wide borders on all sides. Seven levels of triclopyr (Rely; Hoechst-Roussel, Wilmington, Del.), six sethoxydim-PO combinations, and an untreated control were applied in a randomized complete block design with four replications. Treatments consisted of 0.500, 0.250, 0.125, 0.062, 0.030, 0.016, and 0.008 mL·L^{-1} triclopyr; 0 sethoxydim plus 0.5 mL·L^{-1} PO; 0.06 mL·L^{-1} sethoxydim plus 0.25 mL·L^{-1} PO; 0.25 mL·L^{-1} sethoxydim plus 0.25 and 0.50 mL·L^{-1} PO, 0.50 mL·L^{-1} sethoxydim plus 0.08 and 0.25 mL·L^{-1} PO; and an untreated control. The treatments were applied 13 Nov. 1996 and the plots were rated 16 Dec. 1996 and analyzed as in the previous two experiments. The asymptotic regression of rating on sethoxydim concentration at 0.25 mL·L^{-1} PO and on

Table 1. Effects of four sethoxydim and three prime oil (paraffin-base petroleum oil + polyol fatty acid esters) concentrations on ryegrass suppression in strawberry seedling furrows when treated 24 Jan. 1995 and rated 2 Mar. 1995.

Treatment		
Sethoxydim (mL·L^{-1})[z]	Prime oil (mL·L^{-1})	Rating[y]
0.50	0.25	6.0 a[x]
0.50	0.13	5.0 b
0.50	0.06	4.0 b
0.25	0.25	4.0 b
0.25	0.13	4.0 b
0.25	0.06	2.5 c
0.06	0.25	2.5 c
0.06	0.13	2.5 c
0.06	0.06	1.5 cd
0	0.25	1.5 cd
0	0.13	1.0 d
0	0.06	1.0 d

[z]Parts per thousand.
[y]Rating from 1 to 6 where 1 = normal ryegrass growth and 6 = ryegrass dead (a 3 rating is desired).
[x]Means followed by the same letter do not differ significantly by Duncan's multiple range test at $P \leq 0.05$.

Table 2. Effects of four sethoxydim and variable prime oil (paraffin-base petroleum oil + polyol fatty acid esters)concentrations on ryegrass growth suppression when treated 13 Nov. 1995 and rated 5 Feb. 1996.

Treatment		
Sethoxydim (mL·L^{-1})[z]	Prime oil (mL·L^{-1})	Rating[y]
0.25	0.13	6.0 a[x]
0.25	0.25	5.2 a
0.50	0.06	5.2 a
0.50	0.13	3.7 b
0.06	0.13	2.5 c
0	0.25	1.0 d
0	0	1.0 d

[z]Parts per thousand.
[y]Rating from 1 to 6 where 1 = normal ryegrass growth and 6 = grass dead (a 3 rating is desired).
[x]Means followed by the same letter do not differ significantly by Duncan's multiple range test at $P \leq 0.05$.

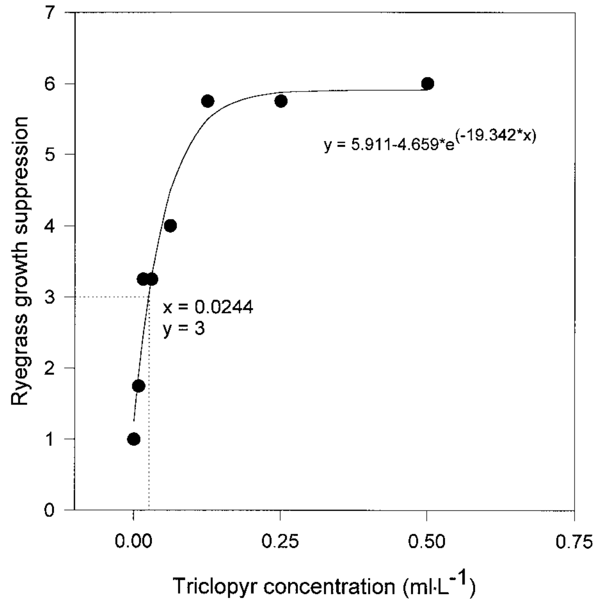

Fig. 2. Asymptotic regression of ryegrass growth suppression on triclopyr (mL·L^{-1} = parts per thousand) concentration in 1996. Fit of the equation to the actual data is not statistically different at α = 0.05.

triclopyr were computed as for the 1993 mefluidide data. In each instance the regression model provided a good fit to the data by the F test described in Study 1.

Results and discussion

STUDY 1 (1992–93). Sethoxydim at all rates was lethal to the ryegrass in 1993 (data not shown). A significant quadratic response of reduced plant growth to increased mefluidide concentration occurred (Fig. 1). Mefluidide regulated ryegrass growth sufficiently for living mulch purposes at 0.0030 mL·L^{-1}, which is close to the concentrations predicted by the regression curve (Fig. 1). This treatment produced about 40% of the fresh weight of untreated ryegrass. Mefluidide was not evaluated further because it is unlikely to be labeled for use on fruit crops. It is a growth regulator used to reduce the frequency of mowing and trimming in public, commercial, and industrial areas.

STUDY 2 (1995). PO at a fraction of the usual spray concentration used with sethoxydim to kill grass (8 mL·L^{-1}) resulted in ryegrass browning in strawberry seedling rows in 1995 (Table 1). Higher PO concentrations generally produced more ryegrass browning at the same sethoxydim level. All 0.50 and the 0.25 mL·L^{-1} sethoxydim with 0.13 and 0.25 mL·L^{-1} PO resulted in unacceptable ryegrass browning. Optimum ryegrass control (close to 3 rating) was produced by the 0.25 mL·L^{-1} sethoxydim with 0.06 mL·L^{-1} PO and 0.06 mL·L^{-1} sethoxydim with 0.13 or 0.25 mL·L^{-1} PO. No browning was produced by PO alone.

STUDY 3 (1995–96). The sethoxydim plus PO treatment combinations were inconsistent in their effect on ryegrass growth in 1995–96 (Table 2). The 0.50 mL·L^{-1} sethoxydim treatment rated significantly better than the 0.25 mL·L^{-1} treatment at 0.13 mL·L^{-1} PO. This discrepancy could have been caused by an error in application. The 0.25 mL·L^{-1} PO treatment alone produced no effect on ryegrass growth. Desirable growth suppression was accomplished by 0.06 mL·L^{-1} sethoxydim plus 0.13 mL·L^{-1} PO treatment.

STUDY 4 (1996). In 1996, triclopyr produced a significant quadratic effect on ryegrass growth suppression with increased rates between 0 and 0.50 mL·L^{-1} (Fig. 2). The mean rating for untreated ryegrass was 1.0 and that for the 0.50 mL·L^{-1} triclopyr concentration was 6.0 (Table 3). Triclopyr at the 0.016 and 0.030 mL·L^{-1} concentrations provided desired ryegrass growth control (3 rating). The prediction curve was in close agreement with actual growth suppression (Fig. 3). The predicted optimum concentration was 0.024 mL·L^{-1}.

At the same level of sethoxydim, PO concentration did not make a significant difference in ryegrass growth (Table 3), but PO alone at the 0.50 mL·L^{-1} level increased browning and significantly reduced plant growth. The prediction curve indicates that the most desirable growth suppression is produced by 0.156 mL·L^{-1} sethoxydim plus 0.25 mL·L^{-1} PO (Fig. 3). This is a much lower rate than that used by Bush et al. (1998) to suppress seedhead formation and height in carpetgrass (*Axonopus affinis* Chase). At the time ryegrass is treated to produce living mulch it is much more succulent than carpetgrass at seedhead formation and it probably requires a lower rate of sethoxydim than the latter.

Several concentrations of sethoxydim was found in the course of the studies to suppress ryegrass growth sufficiently to produce living mulch. None differed much from the prediction of 0.156 mL·L^{-1} sethoxydim plus 0.25 mL·L^{-1} PO in Study 4. Triclopyr produced suitable living mulch at two concentrations. It is labeled for use on some fruit crops but not on strawberry. Mefluidide also produced suit-

Table 3. Effects of spraying ryegrass planted 1 Oct. 1996 with various triclopyr herbicide rates and various combinations of sethoxydim and prime oil (paraffin-base petroleum oil + polyol fatty acid esters) levels applied on 13 Nov. 1996 and rated on 16 Dec. 1996.

	Treatment		
Herbicide	Herbicide (mL·L^{-1})[z]	Prime oil (mL·L^{-1})	Rating[y]
Triclopyr	0.500	0	6.0 a[x]
Triclopyr	0.250	0	5.7 ab
Triclopyr	0.125	0	5.7 ab
Sethoxydim	0.500	0.08	4.5 bc
Sethoxydim	0.500	0.25	4.2 cd
Triclopyr	0. 062	0	4.0 cd
Sethoxydim	0.250	0.50	4.0 cd
Sethoxydim	0.250	0.25	3.5 cd
Triclopyr	0.030	0	3.2 cde
Triclopyr	0.016	0	3.2 cde
Sethoxydim	0	0.50	3.2 cde
Sethoxydim	0.060	0.25	2.7 de
Triclopyr	0.008	0	1.7 ef
Sethoxydim	0	0	1.0 f

[z]Parts per thousand.
[y]Rating from 1 to 6 where 1 = normal ryegrass growth and 6 = ryegrass dead (a 3 rating is desired).
[x]Means followed by the same letter do not differ significantly by Duncan's multiple range test at $P \leq 0.05$.

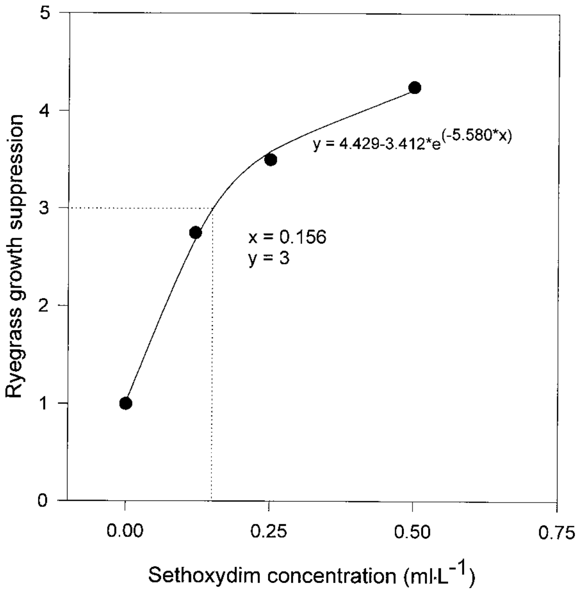

Fig. 3. Asymptotic regression of ryegrass growth suppression on sethoxydim concentration at the 0.25 mL·L^{-1} (parts per thousand) prime oil (paraffin base petroleum oil + polyol fatty acid esters) concentration in 1996. Fit of the equation to the actual data is not statistically different at α = 0.05.

able growth control but obtaining a label for use on strawberry and winter vegetable crops may be difficult. We concluded that the best rate of sethoxydim (0.156 mL·L^{-1}) plus PO (0.25 mL·L^{-1}) predicted by the curve in Fig. 3 would provide the most suitable living mulch at the present time.

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