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Mefluidide-Chlorsulfuron-2,4-D Surfactant Combinations for Roadside Vegetation Management

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Abstract. Using a combination of a primary growth retardant, mefluidide, a synergistic additive, chlorsulfuron, a detergent to enhance penetration (X-77), and a herbicide, 2,4-D, to provide for control of broadleaf weeds, full-season management of bluegrass (*Poa pratensis* L.)–tall fescue (*Festuca arundinaceae* Schreb.) mixtures along roadsides has been achieved. A single spray application is made in the spring, and no additional herbicide applications or mechanical mowing are needed. The treatment is effective with greater than 90% control of fescue seed heads. Those few seed heads that do form remain short. It is economical. The costs of materials and application are equal to or less than the cost of a single mowing cycle. The treatment is environmentally safe when applied in early spring before most agricultural crops have been planted. The effectiveness and low cost of the combination derive from laboratory and greenhouse observations that various materials, herein referred to as additives, often only weakly effective as growth retardants themselves, will interact synergistically with mefluidide to provide overall treatment effectiveness at application rates that are economical. Using this principle, a combination suitable for roadside vegetation management was devised, field-tested for 2 years under actual use conditions, and found to be effective for full-season vegetation management of mixed bluegrass–tall fescue turf to permit considerable cost savings when compared to three-cycle mechanical mowing.

Mechanical mowing of roadsides as required by current safety and esthetic standards is a costly maintenance item. At current estimates of $20–25 per acre per mowing cycle, annual mowing costs would be $60–75 per acre for the three cycles of mechanical mowing normally required in the midwestern United States to maintain adequate site distances and visual appearances. In a state such as Indiana, where approximately 60,000–70,000 acres of roadside are mowed each year, the annual costs for mowing may well exceed $5 million annually.

In 1977, a research project was initiated to develop a growth retardant mixture that would reduce or prevent growth of grass and weeds so that the need for mechanical mowing along roadsides could be eliminated or reduced. Ideally, the treatment was to consist of a single spray application. The treatment was to be effective against both fescue and bluegrass and to control broadleaf weeds and brush. Maximum grass height should not exceed acceptable mowing limits anytime during the entire growing season. In addition, it was important that the treatment be environmentally safe. There should be no permanent weakening of the root system of the grass, no injury to desirable species, and no carryover that would limit repeated use on an annual basis. A healthy lawn-type appearance to the turf was most desirable, and the treatment should be competitive with three-cycle mechanical mowing. The most important criterion, however, was the requirement to prevent emergence of seed heads of fescue. If even a few seed heads form, the appearance can be unsightly. For any treatment, elimination of seed heads was an essential requirement.

The approach followed was to identify an effective primary retardant and then use various additives to interact synergistically with the primary retardant to increase both efficacy and cost effectiveness. 2,4-D amine salt was included for control of brush and broadleaf weeds. In this manner, full-season vegetation management through a single spray application was realized for about the same cost as or less than the cost to mow once.

Materials and Methods

Greenhouse Studies

Seeds of Kentucky bluegrass (*Poa prantensis* L., var. Parade) were germinated over a mixture of calcined clay and pasteurized soil contained in 524-ml polystyrene cups with perforated bottoms and covered with a thin layer of vermiculite. Watering and fertilizer feeding were done by bottom irrigation. Treatments were applied 3 weeks after seeding using a Beltsville sprayer equipped with a TX-6 TeeJet nozzle operated at 40 psi with the conveyor belt moving at 0.5 mph (555.6 l/ha). Seven days after spraying, the grass was cut 4 cm above the soil level. Two weeks later, the regrowth was again cut, and the fresh clippings was measured to the nearest 0.1 g. Each treatment was repeated five times. Data were analyzed by a one-way analysis of variance for significance and by the Colby (1967) method to test for synergism.

Field Trials

All of the field tests were under roadside conditions. Large-scale tests were applied in Miami County, Indiana, on April 4, 1983, using truck-mounted equipment provided by commercial applicators contracted by the State of Indiana

Table 1. Enhancement by surfactants of mefluidide activity on Kentucky bluegrass in the greenhouse.

Surfactants[a]	Clipping fresh weights of regrowth[b] 1st cut 7 days after spraying (g/pot)
None	8.9 ab
XM-12, 0.5%	1.1 e
X-77, 0.5%	2.7 d
Checks	9.8 a

[a] All treatments except the checks contained mefluidide at 0.224 kg/ha.
[b] Two weeks of regrowth after first cut. Means followed by the same letter are not significantly different at the 95% confidence interval.

Table 2. Fescue seed head suppression from mefluidide and mefluidide plus surfactant X-77 with and without 2,4-D amine.

Treatment (rate per acre)	Seed heads (per ft^2)[a]	Suppression (%)
None (check)	18 a	0
Mefluidide (0.56 kg/ha)	9 b	50
Mefluidide (0.56 kg/ha) + surfactant X-77 (1%)	4 c	75
Mefluidide (0.56 kg/ha) + 2,4-D amine (2.24 kg/ha)	13 a	28
Mefluidide (0.56 kg/ha) + surfactant X-77 (1%) + 2,4-D amine (2.24 kg/ha)	2 c	89

[a] 9.29 Square decimeters. Means followed by the same letter are not significantly different at the 95% confidence interval.

and coordinated by Mr. John Burkhardt, Indiana Department of Highways. A segment of highway I-70 between Indianapolis and the Illinois state line was also treated using truck-mounted equipment in the spring of 1984. Applications were at 234 l/ha (25 gpa) in the 1984 tests using a commerical (Swinglok) applicator system.

All other tests were located in Tippecanoe County, Indiana. Applications were with a hand-held compressed air sprayer, spraying systems 8004 nozzles, 40 psi, and 374 l/ha (40 gpa). Plots were located either adjacent to the pavement or adjacent to the fence in mixed stands of fescue (*Festuca arundinaceae* Schreb.) and bluegrass (*Poa prantensis* L.), unless indicated otherwise. Except where indicated, all grass was unmowed at the time of application. Plots were 0.9 × 1.8 m or 1.8 × 4.5 m and in triplicate. Seed heads were counted in three 1-ft squares (9.29 square decimeters) in three different regions in each plot. Seed head height was an average of "maximum" seed head height in three different areas of each plot. Blade height is the maximum extended blade height (soil to tip) of the lower blades originating at the base of the grass clump from three different areas of each plot.

Amounts of all herbicides and retardants are reported as active ingredients: Embark as mefluidide (N-[2,4-dimethyl-5-[(trifluoromethyl) sulfonyl] amino]-

phenyl acetamide); Telar or Glean as chlorsulfuron (2-chloro-N-[(4-methoxy-6-methyl-1,3,5-triazin-2yl)aminocarbonyl] benzenesulfonamide); 2,4-D amine as acid equivalent of the dimethylamine salt or 2,4-dichlorophenoxyacetic acid. Surfactants were given as percent of the total spray mixture. Surfactant XM-12 was a product of Witco Chemical Corporation, Houston (also known as Sponto-H3A). Surfactant X-77 was from Ortho. Surfactant WK was from DuPont.

Results

Effect of Surfactant

Surfactants enhanced the effectiveness of mefluidide both in the greenhouse (Table 1) and in the field (Table 2). With mowed bluegrass in the field and the surfactant XM-12, the optimum concentration was between 0.25% and 0.5% for enhancement of the action of 0.56 kg/ha mefluidide in suppression of blade elongation (Fig. 1). Some surfactants were more effective than others, but in the field these differences tended to be minimized with the time from date of treatment so that in the end for those surfactants evaluated the choice was not critical. Relative to mefluidide alone at various rates, the overall effect of surfactant was to enhance the effectiveness of the primary retardant material in the control of fescue seed heads (Fig. 2), so that 90% control of fescue seed heads could be achieved at a rate of mefluidide between 0.56 and 1.08 kg/ha with added surfactant as compared to about 2 kg/ha in the absence of surfactant. Surfactant alone did not significantly influence seed head number.

Effect of Additives

As shown in Table 3, mefluidide is synergistic with certain herbicides, especially DuPont material, chlorsulfuron. Mefluidide is synergistic with other plant growth regulators and herbicides such as PP-333 (paclobutrazol), EL-500 (flurprimodol), bentazon, acifluorefen, sethoxydim, naptalam, and the thiocarbamates (Rao and Harger 1981, McWhorter and Barrentine 1979; Tautvydas 1983). For various reasons including cost, commerical availability, and control of some 2,4-D–resistant weed species such as wild carrot (*Daucus carota* L.), chlorsulfuron was selected for further evaluation.

Setting the Rate of Chlorsulfuron

Rates of chlorsulfuron of 35 g/ha per acre or greater were not considered because of phytotoxicity. There is a tendency for chlorsulfuron alone to give 25–50% suppression of seed heads with rates in the range of 8.8–70 g/ha but with a variable dose dependency (Fig. 3). In both 1983 and 1984, 8.8, 17.5, and 35 g/ha of chlorsulfuron were equivalent in combination with 0.56 or 0.28 kg/ha of mefluidide. Since 4.4 g/ha of chlorsulfuron was ineffective for control of wild carrot but wild carrot control was achieved at higher rates (Table 4),

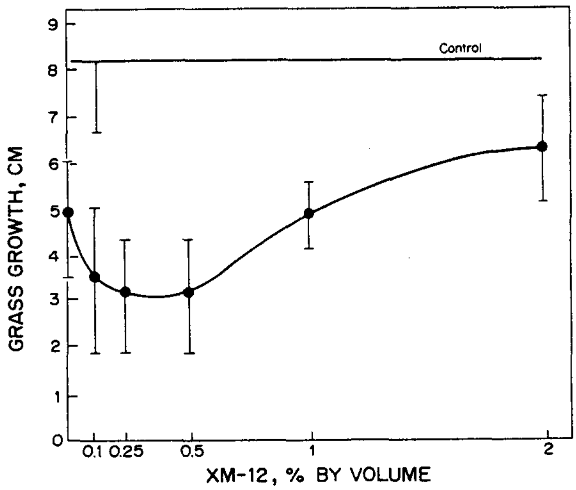

Fig. 1. Effect of rate of application of surfactant XM-12 on growth of mowed bluegrass in the field in the presence of 0.56 kg/ha mefluidide plus 2.24 kg/ha of 2,4-D amine (acid equivalent). Applications were on August 8, September 9, September 11, and September 16, 1982. Each treatment was repeated three times. Growth measurements were 1 month after treatment. Values are the averages of the four experiments (12 replicates total) ± SD.

chlorsulfuron rates of 8.8 and 17.5 g/ha were tested in greatest detail in 1984—i.e., the dose range giving both effective control of broadleaf weeds and no persistent phytotoxicity.

Emphasis was on fescue seed head formation in formulating rates of additives. Mefluidide-chlorsulfuron combinations that control seed head formation in fescue may fail to control seed heads of bluegrass, especially at late dates of application. However, the bluegrass seed heads that do form under these conditions are generally not taller than the vegetative parts of the fescue, are uniform in appearance, and are not unsightly.

Addition of 2,4-D to the Basic Mefluidide + Chlorsulfuron Combination

While giving excellent control of wild carrot and some other species, chlorsulfuron is totally ineffective in the control of plantains (*Plantago lanceolata* L. *Plantago major* L.)—dominant weed species in turf, for example. It was therefore necessary to include a broadleaf herbicide such as 2,4-D amine. However, we have noted frequently, but not always, an antagonism between mefluidide (alone or in combination with chlorsulfuron) and 2,4-D amine in suppression of fescue seed heads (Table 5). Combination of 2,4-D amine with surfactant, increased weed control and lessened the 2,4-D-mefluidide antagonism (Table 5). Maximum weed control with 2,4-D was achieved in the range of 1.68–2.24 kg/ha as the acid equivalent. The mefluidide-2,4-D amine antagonism was also less at the higher 2,4-D rates (Table 5). Similar results were obtained in 1982, 1983, and 1984 regarding this latter point such that the rate of 2,4-D amine in the mixture was set at 2.24 kg/ha. A rate of 1.12 of 2,4-D amine was insufficient to enhance weed control significantly, considering the wide range of species encountered in a roadside situation. Ester formulations of

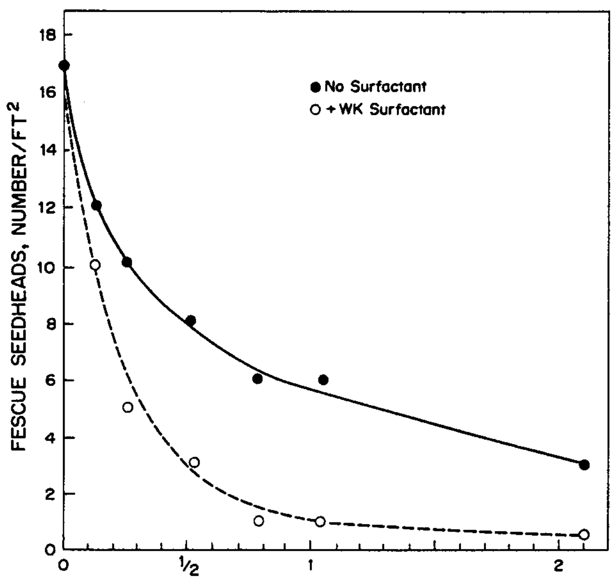

Fig. 2. Influence of application amount of mefluidide on seed head formation in fescue. Applications were on May 3, 1983, under roadside conditions. WK surfactant was present as 0.5% of the total spray mixture. Fescue blade height was 30 ± 2 cm at the time of spraying. Evaluations were on June 22, 1983. One square foot = 9.29 square decimeters.

Table 3. Retardation of Kentucky bluegrass.

		Clipping weight of regrowth mefluidide[a]				
	g/ha	0	35	70	140	280
Grams per pot						
Chlorsulfuron	0	12.7 a	11.4 a	8.6 c	4.0 d	2.0 e
	3.3	10.9 b	4.7 d	2.8 de	1.2 ef	0.5 f
	11.2	10.2 b	2.3 e	1.0 ef	0.1 f	0.1 f
	33.6	11.4 a	1.0 ef	0.6 f	0.1 f	0.0 f
Percent growth retardation						
Chlorsulfuron	0	0.0 a	10.2 a	32.3 c	68.5 d	84.3 e
	3.3	14.2 b	63.0 d	78.0 de	90.6 ef	96.0 f
			(23.0)[b]	(42.0)	(78.0)	(86.5)
	11.2	19.7 b	81.9 e	92.1 ef	99.2 f	99.2 f
			(27.2)	(45.6)	(74.9)	(87.4)
	33.6	10.2 a	92.1 ef	99.3 f	99.2 f	100.0 f
			(19.0)	(39.2)	(71.7)	(85.9)

[a] Means followed by the same letter are not significantly different at the 95% confidence interval.
[b] Means in parentheses are the expected additive responses for the combinations as calculated by the Colby (1967) method.

2,4-D were not considered owing to problems with volatility and toxicity to fish when directly oversprayed to streams. Only the environmentally safer amine formulations of 2,4-D have been recommended for general roadside applications.

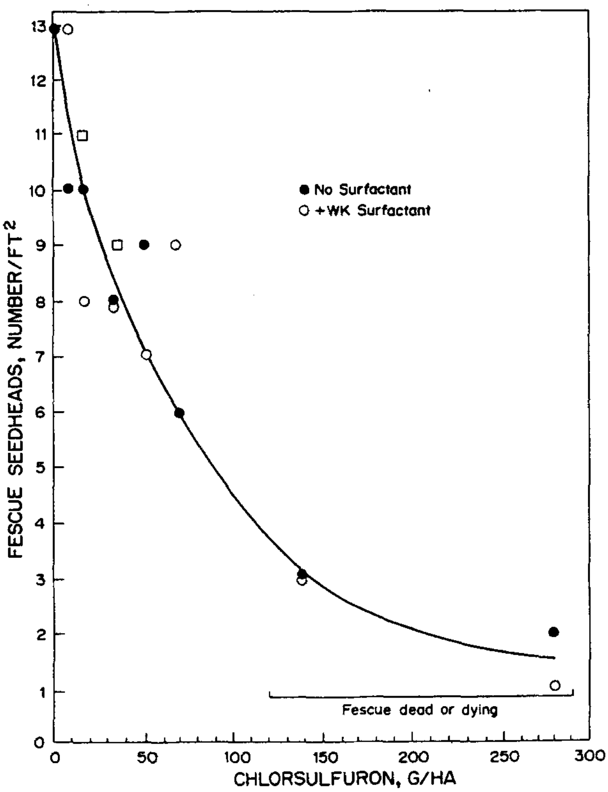

Fig. 3. Influence of application amount of chlorsulfuron on seed head formation in fescue. Applications were on May 4, 1983, under roadside conditions with evaluations on June 23, 1983. WK surfactant was present as 0.5% of the total spray mixture. Open square symbols indicate X-77 surfactant. Fescue blade height was 30 ± 2 cm at the time of spraying. One square foot = 9.29 square decimeters.

Setting the Rate of Mefluidide

Assuming that synergisms between mefluidide and chlorsulfuron and the interactions between mefluidide and surfactant and between mefluidide, surfactant, and 2,4-D amine will be retained in the final mixture, the amount of mefluidide required to control fescue seed heads could be reduced from 0.56 kg/ha to possibly 0.14 kg/ha (mefluidide effectiveness is about doubled by mixing with chlorsulfuron and is doubled again by application with surfactant). In both 1983 and 1984, the combinations of 0.28 kg/ha mefluidide + 17.5 g/ha chlorsulfuron + 0.25% or 0.5% surfactant + 2.24 kg/ha 2,4-D amine (schedule B) as well as 0.14 kg/ha mefluidide + 8.8 g/ha chlorsulfuron + 0.25% or 0.5% surfactant + 2.24 kg/ha 2,4-D (schedule C) were equivalent or superior to 0.56 kg/ha mefluidide + 0.25% or 0.5% surfactant + 2.24 kg/ha 2,4-D amine (schedule A) for seed head suppression in fescue. The response to these treatments resulted in the same general trend at all dates of application between the last week of March and the first week of May (Table 6).

Table 4. Effect of varying concentrations of chlorsulfuron on the control of wild carrot (*Daucus carota*) under roadside conditions. Applications on May 19, 1983, with evaluations on June 28, 1983.

Chlorsulfuron (g/ha)	Wild carrot (plants/50 ft^2)[a]
—	37 ± 24
4.4	24
8.8	2
13.1	4
17.5	8
35.0	2
52.6	4
70.0	1

[a] 465 Square decimeters.

Table 5. Comparisons of different rates of 2,4-D amine on mefluidide-2,4-D antagonism under roadside conditions. Applications were on May 6 (B) and 9 (A), 1982, with evaluations on May 26 (B) and June 7 (A).

Treatment and amount			Seed heads per ft^2[b]		Seed head height (cm)	
Mefluidide	XM-12[a]	2,4-D Amine	Fescue	Bluegrass	Fescue	Bluegrass
A: Applied May 9						
0	0	0	16.7 a	3.4 a	94.7 a	52.6 a
0.56 kg/ha	0	0	5.6 b	3.6 a	62.0 b	44.2 a
0.56 kg/ha	0.5%	0	4.6 b	1.3 a	46.5 c	34.3 b
0.56 kg/ha	0	2.24 kg/ha	9.0 b	3.3 a	64.5 b	42.9 a
0.56 kg/ha	0.5%	2.24 kg/ha	5.3 b	2.3 a	52.0 b	36.3 b
B: Applied May 6						
0	0	0	15.4 a	1.4 a	89.9 a	39.1 b
0.56 kg/ha	0.5%	0.56 kg/ha	8.9 b	1.7 a	35.0 b	24.6 c
0.56 kg/ha	0.5%	1.12 kg/ha	6.2 b	0.7 b	30.2 b	22.9 c
0.56 kg/ha	0.5%	2.24 kg/ha	6.7 b	1.1 a	34.0 b	30.5 c

[a] As percent of the total spray mixture.
[b] 9.29 Square decimeters.
Means followed by the same letter are not significantly different at the 95% confidence interval.

Effect on Turf Quality

Turf remained healthy and vigorous in a series of test plots receiving mefluidide applications (0.56 kg/ha) annually for 7 years since the spring of 1977. Neither mefluidide alone nor the combination of mefluidide and chlorsulfuron resulted in any permanent inhibition of root growth (Table 7) with fescue or bluegrass. Repeat applications of high rates of mefluidide (e.g., 1.12–2.24 kg/ha) reduce or eliminate some strains of native bluegrass, but fescue continues to grow vigorously even in these plots.

Table 6. Summary of comparisons of schedules A, B, and C on seed head formation in fescue and bluegrass comparing all 1984 dates of application under roadside conditions.

	Control of seed heads (%)					
	Fescue			Bluegrass		
Date of application	Sched A (560 Mef)	Sched B (280 Mef + 17.5 Chl)	Sched C (140 Mef + 8.8 Chl)	Sched A (560 Mef)	Sched B (280 Mef + 17.5 Chl)	Sched C (140 Mef + 8.8 Chl)
April 7	98	99	92	95	50	75
April 10	74	68	68	74	53	53
April 18	90	85	85	84	20	52
April 25	89	93	95	98	79	64
April 26	93	90	—	88	29	—
May 2	52	74	91	(0)	(0)	(0)
May 7	75	85	—	90	51	—
May 8	—	92	100	—	0	38
May 9	71	100	—	75	63	—
May 10	—	100	—	—	38	—
May 14	—	97	—	—	28	—
May 15	—	100	—	—	25	—
May 16	—	79	—	—	0	—
May 17	67	97	100	(0)	(0)	(0)
Average	79 ± 15	88 ± 11	90 ± 11	86 ± 9	44 ± 20	56 ± 14

Mef = mefluidide; Chl = chlorsulfuron; Rates are g/ha. All treatments contained 2.24 kg/ha 2,4-D amine (acid equivalent) and 0.5% X-77 surfactant as % of the total spray mixture applied at 374 l/ha (40 gpa) and 40 psi.

Any of the treatments may display some initial phytotoxicity (yellowing) of the grass in the second week posttreatment. The discoloration is temporary and is usually gone when the vegetative growth of the grass resumes, about 3 weeks after application (Fig. 4).

No problems have been encountered from injury to nontarget species (fish, wildlife, other plants) resulting from drift or inadvertent direct overspraying under normal roadside use conditions (see, also, technical data bulletins of respective compounds).

Implementation Tests, 1982–1984

In 1982 and 1983, 0.56 kg/ha mefluidide + 0.5% surfactant + 2.24 kg/ha 2,4-D amine was tested successfully using commercial applicators and application equipment with seed head suppression in fescue averaging about 80% (Table 8). In 1984, a spring application of 0.28 kg/ha mefluidide + 17.5 g/ha chlorsulfuron + 2.24 kg/ha 2,4-D amine and 0.25% surfactant was tested and gave 90% control of seed heads of fescue, bluegrass, and broadleaf weeds (Table 9). The area would not have required mowing at any time during the growing season. Its appearance was equivalent to that of adjacent road segments that had received a full three cycles of mechanical mowing.

Table 7. Comparison of schedules A, B, and C on root lengths of fescue and bluegrass. Applications were on April 7, 1984, under roadside conditions. Fescue was 12 cm tall. Bluegrass was 6 cm tall. The mixture was applied at 374 l/ha (40 gpa) and 40 psi. Evaluations were on June 11, 1984.

	Treatment and amount[a]				Root length (cm)	
Schedule	Mefluidide	X-77	Chlorsulfuron	2,4-D amine	Fescue	Bluegrass
	—	—	—	—	5.8 ± 0.4	5.6 ± 0.6
A	0.56 kg/ha	0.5%	—	2.24 kg/ha	5.9 ± 0.4	6.3 ± 1.4
B	0.28 kg/ha	0.5%	17.5 g/ha	2.24 kg/ha	6.5 ± 0.8	5.9 ± 0.7
C	0.14 kg/ha	0.5%	8.8 g/ha	2.24 kg/ha	5.0 ± 0.9	5.7 ± 0.4

[a] Amounts of materials are of active materials except for X-77, which is percent of the total spray mixture. Differences in root length were not significant statistically for any of the treatments.

Similar trials on secondary roads in 1983 were less successful. The treatments were effective in controlling seed heads in fescue and bluegrass, as on the dual-lane roads. However, the treatments were much less effective on smooth brome (*Bromus inermis* Lyss.), orchard grass (*Dactylis gomerata* L.), and timothy (*Phleum pratense* L.) that frequently are present along secondary roads in small clumps. Mowing was reduced from three cycles to one on these roads. The need for mowing was due primarily to growth of late-germinating weeds (such as *Abutilon theophrasti* Madic.) and annual grasses (e.g., *Setaria faberii* Herrm.) that tended to dominate these narrow rights-of-way adjacent to cropped fields late in the growing season. While adding to the expense of the mixture, these problems have been overcome by addition of a preemergence material (e.g., benefin) to the spray mixture.

Discussion

This study demonstrates the practical use of combinations of chemicals to reduce or prevent growth of grass and weeds along roadsides so that the need for mechanical mowing is eliminated or reduced. Mefluidide, a proven effective retardant of grass growth (Glenn et al. 1981, Jagshitz 1982, Watschke et al. 1977, Wilkinson 1982), is the primary retardant in the mixture. Its advantages are effectiveness, safety, and no appreciable inhibition of root growth. By mixing the mefluidide with various additives, seed heads in fescue are reduced or eliminated at rates that are economically competitive with mechanical mowing.

Additives are employed as a means to decrease the rate of mefluidide required for suppression of seed heads in fescue through a synergistic interaction. One of the most effective additives is chlorsulfuron. The standard treatment of 0.56 kg/ha mefluidide + surfactant + 2.24 kg/ha 2,4-D amine (schedule A, Table 4) can be duplicated or exceeded by 0.28 kg/ha mefluidide + surfactant + 17.5 g/ha chlorsulfuron + 2.24 kg/ha 2,4-D amine. Since neither mefluidide nor chlorsulfuron gives satisfactory control of broadleaf weeds, 2,4-D amine is added. 2,4-D amine formulations sometimes show an antagonism with low

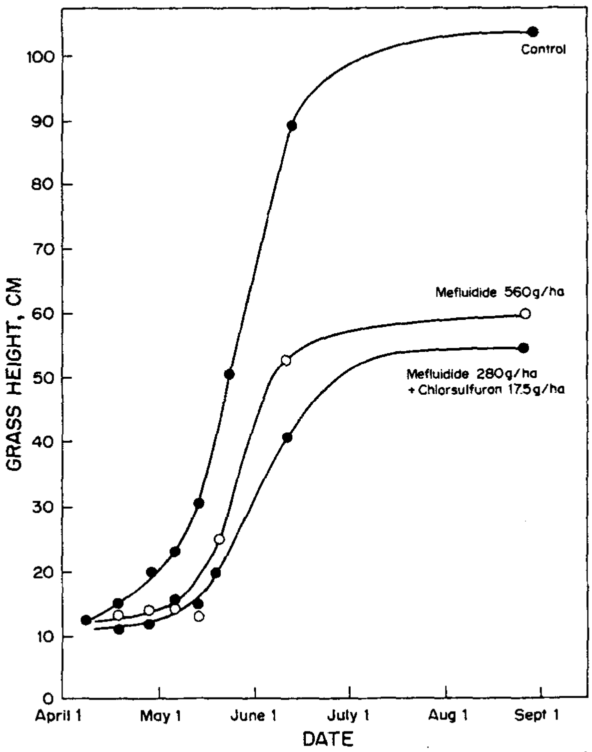

Fig. 4. Growth suppression of fescue by the combination of 0.28 kg/ha mefluidide + 17.5 g/ha chlorsulfuron + 2.24 kg/ha 2,4-D amine with X-77 surfactant as 0.5% of the total spray mixture (●) compared to the same conditions of 2,4-D and surfactant but with 0.56 kg/ha of mefluidide instead (○). Applications were on April 7, 1983, under roadside conditions with evaluations on the dates indicated. Values are total grass height.

Table 8. Tests under roadside use conditions of mefluidide (0.56 kg/ha) + surfactant (0.5%) + 2,4-D amine (2.24 kg/ha).

		Fescue seed head suppression (%)	
Year	Location	Range	Average
1982	Tippecanoe Co.	68–93	83
1983	Miami Co.	64–94	81

application rates of mefluidide. However, the antagonism is overcome largely by the surfactant in the mixture. Similar antagonisms have been observed with other broadleaf herbicides including Picloram, Banvel, and Silvex.

The effect of the surfactant in increasing effectiveness of both the mefluidide and the 2,4-D amine is presumably due to enhanced foliar penetration (Blomberg and Wax 1978). It is becoming increasingly apparent, however, that these materials can also enter the plant via the root system and that the entry route

Table 9. Evaluation of a spring application of 0.56 kg/ha mefluidide + 17.5 g/ha chlorsulfuron + 2.24 kg/ha 2,4-D amine + 0.25% X-77 surfactant (by volume of total spray mixture) (234 l/ha with commercial Swinglok equipment), applied by the Indiana Department of Highways, under actual highway use conditions. Application was on April 18, 1984. Evaluations were on August 24, 1984, 4 months after application.

	Fescue[a]			Bluegrass[a]			Weeds
	Seed heads			Seed heads			
	per ft^{2b}	Height (cm)	Blade height (cm)	Per ft^{2b}	Height (cm)	Blade height (cm)	per 100 m^2
Median							
Unsprayed	17 ± 1	99 ± 7	38 ± 10	12 ± 4	53 ± 2	33 ± 7	434
Sprayed	2 ± 3	51 ± 13	36 ± 8	2 ± 1	33 ± 8	25 ± 7	33
Control	90%			83%			92%
Pavement to ditch							
Unsprayed	15 ± 3	94 ± 7	46 ± 8	7 ± 2	53 ± 2	36 ± 7	520
Sprayed	1.6 ± 1.1	61 ± 7	36 ± 7	9.7 ± 0.6	36 ± 7	28 ± 2	77
Control	90%			90%			87%

[a] Based on measurements from four different locations selected at random. Heights are average maximum heights from 10–20 plants per location ± SD among different locations. Rates are of active ingredient. Initial height of bluegrass was 8.5–10 cm. Initial height of fescue was 15–18 cm.
[b] 9.29 Square decimeters.

through the soil may be less influenced by the presence or absence of surfactants.

Large-scale tests of 0.56 kg/ha of mefluidide plus surfactant and 2,4-D amine (schedule A, Table 8) were applied in 1982 and 1983. Both years, schedule A was effective in controlling seed heads in fescue and was effective in vegetation management on improved dual-lane and interstate highways.

Schedule B, with the addition of chlorsulfuron as an additive, is even more effective. Nearly complete control of fescue seed heads is obtained. Schedule B is also very effective in the control of broadleaf weeds. It is comparable to schedule A for most species (better than 90% control), and schedule B is more effective than schedule A for control of wild carrot (*Daucus carota*).

The most cost-effective mixture is schedule C. This has been examined in detail in small-plot studies in 1983 and 1984 and is scheduled for evaluation in large-scale tests in 1985.

With any of the schedules, only spring applications are recommended. The materials can be applied in the fall for seed head control the following spring, but much higher rates are required, and the fall applications do not appear economical. For schedules A and B, the materials are applied from green-up until the seed heads just emerge from the boot. With schedule A, the seed heads will sometimes elongate beyond the point where they are at the time of application. This does not seem to happen with schedules B and C, however. With schedules B and C, the seed heads and grass remain nearly at the stage where they are at the time the application is made.

The relative costs of the three schedules have been calculated based on current prices of materials and mowing and application estimates. Both schedules A and B are competitive with one-cycle mowing ($20+ per acre), but schedule C is considerably less expensive to apply than it is to mow once.

References

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