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Tolerance of Tall Fescue to Postemergence Grass Herbicides

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Abstract. **Field experiments were conducted with the objective of determining the response of tall fescue (*Festuca arundinacea* Schreb. 'Clemfine') to various amounts of single and sequential treatments of sethoxydim and fluazifop at 0.10, 0.20, or 0.30 kg·ha^{-1} and xylafop, haloxyfop, fenoxaprop, and poppenate at 0.07, 0.15, or 0.30 kg·ha^{-1}. These herbicides are known to control grass weeds such as crabgrass (*Digitaria* spp.) and goosegrass [*Eleusine indica* (L.) Gaertn.] Turf color was acceptable following single and sequential fenoxaprop applications through 49 days after treatment (DAT). Turf density was not affected by single applications, but was slightly reduced by sequential applications. Single and sequential applications of poppenate provided acceptable turf color in 1985, except at 14 DAT at the high rate. In 1987, turf color was acceptable at 49 DAT. Turf density was reduced with the 0.30 kg·ha^{-1} single poppenate application. Sequential applications of poppenate also reduced turf density. Fenoxaprop provided acceptable turf color and density for either single or sequential applications, while poppenate provided acceptable turf color for single application at 49 DAT. Unacceptable turf color and density were observed for both years with single and sequential applications of fluazifop, sethoxydim, haloxyfop, and xylafop. Chemical names used: 2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one (sethoxydim); (±)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxyl]phenoxy]propanoic acid (fluazifop); 2-[4-[[3-chloro-5-(trifluoromethyl)-2-pyridinyl]oxy]-phenoxyl]propanoic acid (haloxyfop); (2-[4-[(6-chloro-2-quinoxalinyl)-oxy]phenoxyl]propanoic acid (xylafop); (±)-2-[4-[(6-chloro-2-benzoxazolyl)oxy]phenoxy]propanoic acid (fenoxaprop); and methyl 3-hydroxy-4-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]-pentanoate (poppenate).**

Tall fescue is a cool-season perennial grass used in the southeastern United States for limited-wear areas such as lawns, industrial sites, and roadsides. Tall fescue's desirable characteristics include low fertility requirements, rapid establishment from seed, and adaptation to a wide range of soil types and pH ranges. Tall fescue's deep root system also provides a measure of drought resistance, specifically drought avoidance. Because of tall fescue's upright, bunch-type growth habit and slow summer growth rate, weeds often invade these areas. Control of established crabgrass, dallisgrass (*Paspalum dilatatum* Poir.), and goosegrass is difficult to achieve in tall fescue without turf injury. Traditionally, the organic arsenical herbicides have been used for grass weed control in tall fescue; however, due to the need for repeat applications, a certain degree of turf injury accompanied this control.

Previous research with several postemergence grass herbicides has demonstrated inconsistent performance or poor turfgrass tolerance (4, 6, 7). A single application of fenoxaprop-ethyl did not injure seedlings of tall fescue or perennial ryegrass, while it reduced crabgrass populations (4). Fenoxaprop-ethyl controlled crabgrass with one or two applications at 0.20 kg·ha^{-1}, but goosegrass control was inconsistent and no dallisgrass control was obtained. Sethoxydim, poppenate, xylafop, and haloxyfop provided more consistent goosegrass and crabgrass control (1–3, 7). Acceptable tall fescue tolerance to fluazifop-butyl has been reported for rates ranging from 1.12 to 3.36 kg·ha^{-1} (7). Similar amounts of sethoxydim caused discoloration and density reduction.

Xylafop, fluazifop, haloxyfop, and fenoxaprop are classified in the polycyclic alkanoic acids herbicide family and sethoxydim in the cyclohexanone family, while poppenate is currently unclassified (5). The primary site of action for these herbicides is believed to involve inhibition or disruption of lipid metabolism.

The recent introduction of several grass specific herbicides and lack of information on tall fescue's tolerance to these herbicides led to this study, the objective of which was to determine the response of tall fescue to various rates of single and sequential applications of six postemergence grass herbicides.

Field studies were conducted at Clemson, S.C. on a mature stand of 'Clemfine' tall fescue located on an amended Cecil soil series (clayey, kaolinitic, thermic Typic Hapludults). Soil tests indicated adequate levels of P, K, Mg, and Ca. Soil pH was 6.1; therefore, lime was not added before the experiment. Mid-October and mid-February nitrogen fertilizations were at 1.12 kg N/ha (20N–0P–0K). Plots were watered to avoid stress and mowed at 6.5-cm height. Treatments consisted of sethoxydim and fluazifop applied at 0.1, 0.2, or 0.3 kg·ha^{-1}, and haloxyfop, xylafop, fenoxaprop, and poppenate applied at 0.07, 0.15, or 0.3 kg·ha^{-1}. Herbicides were applied as single application treatments in June 1985, and on an adjacent site in Apr. 1987, while sequential treatments received an additional application 4 weeks following the first.

Experimental design was a randomized complete block with 0.5 × 1.0-m plots replicated three times. A CO$_2$-pressurized backpack sprayer delivering 187 liters·ha^{-1} was used to apply the herbicides. Each treatment received crop oil concentrate (BASF Wyandotte, Parsippany, N.J.) at 2.4 liters·ha^{-1}. Ratings of turf response to herbicides included color and stand density. A scale (1 to 9) was used to visually estimate turf color with 1 as complete kill (brown), 6.5 as acceptable, and 9 as best. A scale (0 to 100) was used to visually estimate stand density with 0 as bare ground and 100 as total vegetative coverage.

Data were subjected to analysis of variance (ANOVA) with observations appearing to be distributed over limits not associated with normally distributed data. Therefore, data were transformed using arcsin and analysis resulted in similar responses as with ANOVA; thus, data will be discussed by ANOVA results. Treatment means were separated using the Waller–Duncan K-ratio *t* test at the 5% level of probability.

Tall fescue color was acceptable (>6.5) with all single applications of fenoxaprop in both years (Table 1). Turfgrass density was also similar to that of the untreated plots 49 days after treatment (DAT) with single applications of fenoxaprop. Turf color was acceptable with single applications of poppenate at 0.07 and 0.15 kg·ha^{-1} 14 DAT and at all rates 28 and 49 DAT in 1985. However, in 1987, turf color was acceptable only at 49 DAT with all single applications of poppenate. Density was similar to the untreated check with poppenate except 0.30 kg·ha^{-1} in 1987 (Table 1). In general, these herbicides target the site of rapid metabolic activity. Thereby, turf may be injured when applications are made during periods of rapid growth. In 1987, applications were made during April, a period of rapid fescue growth; whereas, in 1985, June applications were made when growth had slowed. All other herbicides severely discolored and reduced tall fescue density in both years. Previous researchers had reported results with fenoxaprop similar to this study (4, 7). Tall fescue tolerance of poppenate has not been previously reported. Further investigations concerning climatic

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Table 1. Tall fescue color and density ratings following single herbicide application at several days after treatment (DAT), 1985 and 1987.

Herbicide	Rate (kg·ha^{-1})	Color^z						Density^y	
		14 DAT		28 DAT		49 DAT		49 DAT	
		1985	1987	1985	1987	1985	1987	1985	1987
					Rating				
Untreated	---	8.0	9.0	8.2	8.5	8.3	7.7	92	80
Fenoxaprop	0.07	7.3	8.5	7.6	8.2	7.4	7.2	80	68
	0.15	7.8	7.7	8.2	7.0	8.3	7.0	90	67
	0.30	8.0	7.4	8.2	6.8	8.3	6.5	93	65
Poppenate	0.07	7.8	6.3	7.8	6.1	8.0	7.3	87	62
	0.15	7.0	5.7	7.7	4.0	8.0	7.0	87	68
	0.30	6.2	5.0	6.5	3.7	7.4	7.2	78	60
Fluazifop	0.10	5.3	4.3	3.8	3.2	5.8	5.0	65	42
	0.20	5.0	4.2	1.7	2.3	2.3	4.7	27	42
	0.30	4.7	4.0	2.3	1.7	3.7	4.3	38	25
Sethoxydim	0.10	4.8	3.7	2.0	2.8	3.0	3.3	37	25
	0.20	4.8	2.7	1.3	1.7	1.3	2.5	13	23
	0.30	5.0	2.8	1.3	1.5	1.3	1.0	20	5
Haloxyfop	0.07	4.7	3.8	1.5	2.7	1.7	1.2	27	13
	0.15	4.8	3.0	1.3	1.3	1.3	4.2	17	8
	0.30	4.8	2.7	1.2	1.2	1.0	1.2	10	7
Xylafop	0.07	4.7	2.5	1.5	2.0	1.7	2.5	27	13
	0.15	4.3	2.5	1.0	1.2	1.0	1.2	12	8
	0.30	4.3	1.7	1.0	1.0	1.0	1.0	12	5
LSD (0.05)		0.71	1.6	0.72	1.3	1.0	2.6	13	18

^{z}Rated visually on a scale of 1 to 9; 9 = best with a minimum home lawn acceptability rating of 6.5. Data are the means of four observations.

^{y}Rated visually on a scale of 0% to 100% green ground cover.

conditions, cultivar response, and application timings are needed to determine poppenate's potential for safe use in tall fescue. Included in this are tall fescue's tolerance to poppenate at various amounts applied during periods of high temperatures (>29C) and tolerance during different stages of maturity. Other authors have reported tall fescue tolerant to fluazifop applications ranging from 1.12 to 3.36 kg·ha^{-1} (7). The severe discoloration and density reduction observed in this study indicate variation in cultivars for fluazifop tolerance and date of application interactions.

Sequential applications of fenoxaprop resulted in acceptable (>6.5) color both years (Table 2). Turf density was reduced with sequential fenoxaprop applications compared to the untreated in 1985. The highest level (0.30 kg·ha^{-1}) of fenoxaprop also reduced density in 1987. Poppenate sequential applications resulted in unacceptable color in 1987 but not in 1985, when the applications were made in early season. Compared to the untreated check, density was reduced with poppenate sequential applications in 1985 and 1987, except at 0.15 kg·ha^{-1} in 1985 and 0.07 kg·ha^{-1} in 1987. All other herbicides discolored severely and reduced the density of tall fescue turf. Other researchers have not reported the effects of sequential applications of postemergence grass herbicides to tall fescue. Sequential herbicide applications may be necessary to control grassy weeds such as goosegrass and crabgrass, which germinate throughout the southern United States' long growing season.

Single and sequential fenoxaprop applications did not reduce tall fescue color below acceptable levels 49 DAT. Slight density reductions were noted with sequential applications. Poppenate applications caused more discoloration and density reduction in 1987 than in 1985. This could be a response to application dates that correspond to different growth stages of the tall fescue. 'Clemfine' tall fescue was not tolerant to fluazifop, sethoxydim, haloxyfop, or xylafop.

Table 2. Tall fescue color and density ratings 21 days following two sequential herbicide applications of equal rates, 1985 and 1987.

Herbicide	Rate (kg·ha^{-1})	Color^z		Density^y	
		1985	1987	1985	1987
			Rating		
Untreated	---	8.3	7.3	93	82
Fenoxaprop	0.07	7.7	6.7	83	76
	0.15	7.7	6.7	83	72
	0.30	7.5	6.5	83	60
Poppenate	0.07	7.2	5.3	80	71
	0.15	7.7	4.8	85	55
	0.30	7.2	1.8	80	52
Fluazifop	0.10	2.7	1.3	33	17
	0.20	1.3	1.2	12	12
	0.30	1.3	1.2	13	5
Sethoxydim	0.10	1.0	1.0	5	10
	0.20	1.0	1.0	5	5
	0.30	1.0	1.0	5	5
Haloxyfop	0.07	1.0	1.0	7	7
	0.15	1.0	1.0	8	5
	0.30	1.0	1.2	5	5
Xylafop	0.07	1.0	1.0	8	5
	0.15	1.0	1.0	7	5
	0.30	1.0	1.0	5	5
LSD (0.05)	---	0.7	0.7	10	12

^{z}Rated visually on a scale of 1 to 9; 9 = best with a minimum home lawn acceptability rating of 6.5. Data are the means of four observations.

^{y}Rated visually on a scale of 0% to 100% of green ground cover.

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Using Glyphosate to Control Eastern Dodder on Citrus in Jordan

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Abstract. **Glyphosate [41% a.i. isopropylamine salt of *N*-(phosphonomethyl) glycine] at 0, 50, 75, 100, 150, and 200 mg·liter^{-1} was sprayed on mature lemon and tangerine trees to control a heavy infestation of eastern dodder (*Cuscuta monogyna* Vahl.). All concentrations completely eliminated the weed from the tree canopies. At the higher concentrations, the herbicide appeared to slightly reduce leaf size, cause some minor fruit deformation, and increase the number of abnormal shoots.**

Eastern dodder is a parasitic flowering annual with one style, bilobed capitate stigma, and generally thicker stems than other *Cuscuta* spp. (8). In Palestine and Jordan, its wild hosts include *Ziziphus spina-christi* L.(Desf.), *Nerium oleander* L., *Melia azedarach* L., *Alhagi maurorum* Fisch., *Amaranthus retro-flexus* L., *Retama raetam* Forssk.(Webb), *Ricinus communis* L., and *Sorghum halepense* L. (5, 8). Of the economic plants, *Citrus* spp., *Vitis vinifera* L., and *Olea europaea* L. have also served as hosts for this parasite (1). After the seeds germinate, dodder's aerial stems first attach to weeds then climb into the low growing branches of the host citrus tree. Reported as injurious to citrus in California, dodder rapidly parasitizes and weakens its host by directly removing nutrients and reducing photosynthesis as it overgrows and shades the tree canopy (6, 10). Eliminating weeds under trees, pruning low hanging branches, and keeping roadsides and fencelines weed-free reduce serious dodder infestations in the orchard. In Jordan, however, chemical controls, like wiping dodder's leaves with kerosene or spraying with paraquat, have either failed to control the parasite or harmed the trees. Pre-emerge control with 1-methylethyl 3-chlorophenylcarbamate (chlorpropham), 2,6-dichlorobenzonitrile (dichlobenil) or dimethyltetrachloroterephthalate (DCPA), reported successful on agronomic crops, has not been used in Jordan (2, 3). An infestation of dodder on lemon, *Citrus limon* Burm., and Clementine tangerine, *Citrus reticulata* Blanco, trees in an orchard near South Shuna in the Jordan Valley offered an opportunity to test the effectiveness of glyphosate, which controlled *C. campestris* Yanck. and *C. indicora* Choisy on alfalfa in the United States (4).

In Dec. 1985, heavily infested lemon and tangerine trees were sprayed with glyphosate solution at 0, 50, 75, 100, 150, and 200 mg a.i./liter (Fig. 1). The leaves were sprayed to wetness using a Birchmeier compressed air knapsack sprayer, which required 2 to 3 liters of solution per tree. The treatments were replicated three times on the lemon trees but only one treatment per tree was applied to the tangerines because of the limited number of infested trees. Visual observations of treatment effects on the dodder and the trees were made monthly. About 3 weeks before the last evaluation, the orchard owner removed some of the dead dodder vines and piled them under the trees. The results of the final evaluation for herbicide efficacy and phytotoxicity, made in May, are reported here.

Efficacy was expressed as the percent of dodder killed. Phytotoxicity was estimated visually based on appearance or size of average fruit, leaves, and shoots on untreated trees in the orchard. Reduction in leaf size was rated on a scale where 0 = none and 5 = severe, i.e., ≥ 75% of leaves on new shoots are reduced at least 50% in size; for fruit deformation, 0 = none and 5 = severe, i.e., fruit axis curved, fruit stunted, and/or peel verrucose, blemished, or discolored. Eight to 10 branches 10 to 15 mm in diameter from the north and south halves of each tree canopy were evaluated. The percent of new shoots affected, i.e., having small, deformed, or discolored leaves or fruit; the percent of leaf and fruit abscission; and the number of flowering shoots were estimated. In each canopy half, a sample of six to eight fruit diameters and 10 to 12 new shoot lengths were measured.

All the evaluations and measurements of the lemon trees were subjected to regression analysis against the concentrations of glyphosate (7). For the analyses, ratings and percentages were transformed using $y' = \text{arc sin}\sqrt{y}$. For the regressions, shoot and fruit measurements were first averaged for each half-tree. The means of the three replicates for all values were used as the dependent variable with each evaluator's results considered an independent estimate. Initially, each half of the canopy was analyzed separately to detect any possible influence of light or other microclimatic effects on the treatments. However, since canopy location had no effect on any of the criteria, the ratings and measurements from the north and south were averaged for the regression analyses. The data for the tangerines were not analyzed because of the limited number of trees treated.

Glyphosate at all rates eliminated 100% of the dodder relative to the control trees, which remained heavily infested. However, some treated trees became reinfested by new growth from seeds. While some of these seedlings probably came from residual seed in the soil, the large number that arose from under the piles of dead vines suggests that they germinated from new seed borne on the vines. Although glyphosate killed the vines, apparently it did not kill all of the seeds, as was the case with alfalfa (4).

At glyphosate concentrations above 100 mg·liter^{-1}, leaf size appeared slightly reduced and fruit deformation slightly increased (Fig. 2). However, the percentage of shoots showing abnormal growth increased linearly with glyphosate concentration. None of the glyphosate treatments had any significant effect on leaf and fruit abscission, the number of shoots flowering, fruit size, or new shoot length. There was no evidence of typical glyphosate injury on the fo-

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