OPTIMUM HERBICIDE STRATEGY FOR MANAGING MIXED WEED POPULATIONS IN THE SOUTHERN U.S.

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ABSTRACT

In a mixed weed population, an optimum herbicide strategy maximizes turf canopy coverage and health. The objective was to study the effect of postemergence herbicides alone and in mixtures on populations of green kyllinga (*Kyllinga brevifolia* Rottb.), tropical signalgrass (*Urochloa subquadripara* (Trin.) R.D. Webster), and 'Tifgreen' bermudagrass turf (*Cynodon transvaalensis* Burtt-Davy x *C. dactylon* (L.) Pers.) Initial coverage was green kyllinga, 43%; tropical signalgrass, 29%; and bermudagrass, 28%. There were 12 herbicide treatments, including a water control, in five replications. Treatments were bentazon, 1.12 kg ha^{-1}; halosulfuron, 0.07 kg ha^{-1}; imazaquin, 0.56 kg ha^{-1}; and MSMA, 2.52 kg ha^{-1} applied alone and in all binary combinations, plus MSMA + metribuzin at 0.28 kg ha^{-1}. Halosulfuron and imazaquin rates were reduced in half in mixtures. There were two sets of applications separated by 11 weeks, each with two applications split by 10-11 days. Treatments with halosulfuron or imazaquin were applied only once per set of applications. Only treatments with halosulfuron, imazaquin, or MSMA + metribuzin injured ($P < 0.05$) green kyllinga. Only treatments with MSMA injured tropical signalgrass. Only MSMA + metribuzin and MSMA + halosulfuron injured green kyllinga and tropical signalgrass, but did not maximize bermudagrass coverage. The optimum treatments, bentazon + MSMA and MSMA alone, increased bermudagrass coverage to 97% and 94%, respectively, compared with 43% for the water control. Although imazaquin did not injure bermudagrass, it reduced bermudagrass coverage to 13%. In removing kyllinga, imazaquin had opened a niche that was colonized by tropical signalgrass at the expense of bermudagrass. The optimum herbicide strategy must consider not only injury to weeds but competition among weeds.

Keywords

Bermudagrass; competition; turfgrass; *Cynodon; Kyllinga; Urochloa*

INTRODUCTION

Turfgrass managers must make weed control decisions based on the presence of multiple weed species infesting or potentially infesting turf areas. Herbicides traditionally have a moderate breadth of efficacy, affecting multiple weed species within groups, such as grasses, sedges, and broadleaf weeds. Some newer herbicides have a narrower range of activity, thus the turf manager must decide how to target weed-specific herbicides against mixed weed populations.

Green kyllinga (*Kyllinga brevifolia*) is a rhizomatous perennial weed which has proliferated in highly maintained, irrigated turf on golf courses, particularly in the southeastern United States and California [Bryson et al., 1997], as well as Hawaii. Close mowing height of green kyllinga growing in a monoculture reduces shoot numbers per plant and plant spread [Summerlin et al., 2000], but in typical mixed culture with 'Tifway' bermudagrass turf (*Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burtt-Davy), close mowing increases green kyllinga infestation [Lowe et al., 2000]. Several postemergence herbicides, including halosulfuron and imazaquin control green kyllinga [Molin et al., 1997] and are used along with bentazon, MSMA, and MSMA + metribuzin tank mix in bermudagrass golf turf in Florida, with variable success. Among these chemicals, other tank mixtures are possible. It is not known which herbicides, alone or in mixtures, control green kyllinga in a subtropical area such as southern Florida.

Grassy weeds are commonly part of the mixed weed population along with green kyllinga, and because both MSMA and metribuzin also control grassy weeds, this is an example demonstrating the problem of using herbicides and their mixtures to manage mixed weed populations. Tropical signalgrass (*Urochloa subquadripara*) is an emerging serious weed problem on golf courses and sod farms in Florida. It is highly susceptible to MSMA but tolerant of diclofop [(±)-2-[4-(2,4-dichlorophenoxy) phenoxy)pro-panoic acid] [Busey, unpublished data]. In southern Florida, tropical signalgrass is a weak perennial that spreads by stolons. The objective was to study the effect of postemergence herbicides and mixtures on populations of green kyllinga and tropical signalgrass infesting a stand of 'Tifgreen'

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hybrid bermudagrass turf.

MATERIALS AND METHODS

Twelve herbicide treatments, including tank mixtures and a water control, were applied to a weedy turf field area at Fort Lauderdale Research and Education Center in Davie, Broward County, Florida. Soil was Margate fine sand (siliceous, hyperthermic, Mollic Psammaquent) with pH 6.5 and 3.8% OM. Irrigation, mowing, and fertilization practices were performed to maintain a dense stand. The field area had been planted and was maintained as 'Tifgreen' (T-328) hybrid bermudagrass, at 13 mm cutting height. Experimental design was a randomized complete block with five replications. Plots (244 cm x 122 cm) were assigned to the replicated coterminous blocks, to provide similar initial weed densities of green kyllinga and tropical signalgrass. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 289 L/ha at 276 kPa with 11002 flat-fan nozzles.

The herbicide treatments were bentazon [3-(1-methylethyl)-(1*H*)-2,1,3-benzothiadiazin-4(3*H*)-one 2,2-dioxide], at 1.12 kg ha^{-1}; halosulfuron [methyl 5-[[(4,6-dimethyloxy-2-pyrimidinyl)amino]carbonylaminosulfonyl]-3-chloro-1-methyl-1-*H*-pyrazole-4-carboxylate], at 0.07 kg ha^{-1}; imazaquin [2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1 *H*-imidazol-2-yl]-3-quinolinecarboxylic acid], at 0.56 kg ha^{-1}; and MSMA (monosodium methanearsenate) at 2.52 kg ha^{-1}, applied individually and in all possible mixtures. Bentazon and MSMA were always mixed at the same concentration as in their individual applications, but halosulfuron and imazaquin concentrations were reduced by half in mixtures, to reduce the risk of injurying the turf. Another tank mixture was MSMA at 2.52 kg ha^{-1} + metribuzin [4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4*H*)-one] at 0.28 kg ha^{-1}.

Herbicide treatments were applied in two sets of split applications, 11 Feb and 21 Feb 2000, and 27 Apr and 8 May 2000. The same herbicides were reapplied to the same plots in each set of applications. In each set of split applications the mixtures involving only bentazon, MSMA, and metribuzin were applied on both split dates, whereas all treatments involving halosulfuron and imazaquin were applied only on the first date in each set of applications.

Plots were evaluated visually for percent injury to green kyllinga, tropical signalgrass, and bermudagrass, during the period of active injury, 3 Mar and 13 March 2000 for the first set of applications, and 30 April, 5 May, and 12 May 2000 for the second set of applications. Injury was evaluated for each species in each plot on the basis of percent canopy that was chlorotic or dead. Canopy coverage of green kyllinga, tropical signalgrass, and bermudagrass was evaluated visually before the first set of herbicide applications, on 2 Feb 2000, and after the end of periods of visible injury, 18 April for the first set of applications, and 6 June 2000 for the second set of applications. On 18 May and 6 June 2000, overall turfgrass quality was evaluated visually, with 9=best possible and 1=worst possible color, density, and uniformity. Individual dates of evaluation were treated as repeated measures within application sets, thus they were averaged as subsamples-in-time, prior to statistical analysis. Injury values were similarly pooled across the two sets of applications, except the green kyllinga injury from the second set of applications was ignored, because of missing values for plots with no green kyllinga. Data were analyzed by ANOVA, using treatment X block interaction for comparison of treatment means, and means were separated by the Waller-Duncan Bayesian k-ratio t-test, $k=100$, $P = 0.05$ [Sokal and Rohlf, 1981]. Because herbicide treatments varied in the number of split applications and the rates of application, depending on whether tank mixtures were used, the data were not amenable to analysis by orthogonal contrasts, so herbicide treatment was considered a class variable. Efficacy of herbicides was evaluated in comparison with the water control treatment.

RESULTS AND DISCUSSION

Initial canopy coverages before herbicide applications were green kyllinga, 43%; tropical signalgrass, 29%; and bermudagrass, 28%. There was no treatment difference among plots in species composition prior to herbicides.

Herbicide treatments differed ($P < 0.05$) in injury to green kyllinga (Table 1). Only treatments using halosulfuron, imazaquin, or MSMA + metribuzin caused significant injury to green kyllinga, compared with the water control. Halosulfuron + MSMA was as effective against green kyllinga as was halosulfuron alone, whereas imazaquin + MSMA caused less injury to green kyllinga than imazaquin alone. (Both halosulfuron and imazaquin rates were reduced by half in mixtures.) Green kyllinga canopy coverage after the first set of applications was reduced ($P < 0.05$) by all treatments involving halosulfuron or imazaquin, compared with the water control. Bentazon, alone and in combination with MSMA, did not reduce green kyllinga coverage. MSMA + metribuzin, which showed the greatest injury to green kyllinga, did not reduce green kyllinga coverage, compared with the water control. After the second set of applications, green kyllinga effectively vanished from all plots, as a result of seasonal warming.

Herbicide treatments differed ($P < 0.01$) in injury to tropical signalgrass (Table 1). Only treatments using MSMA caused significant injury to tropical signalgrass, compared with the water control. As in the case of green kyllinga control, the MSMA + metribuzin mixture caused the greatest injury to tropical signalgrass and was more effective ($P < 0.05$) than all other treatments. Tank mixture with either halosulfuron or

Table 1. Effect of 12 herbicide treatments on injury and canopy coverage of two weeds, green kyllinga and tropical signalgrass, and one turfgrass, 'Tifgreen' bermudagrass, at Fort Lauderdale Research and Education Center, Davie, Florida, Feb-June 2000. Means of five replications.

	Canopy coverage (%) before treatment			Injury (%) after the first set of applications			Canopy coverage (%) after the first set of applications			Canopy coverage (%) after the second set of applications			Turf quality
Herbicide treatments	*Kyllinga*	*Urochloa*	*Cynodon*	*Kyllinga*	*Urochloa*	*Cynodon*	*Kyllinga*	*Urochloa*	*Cynodon*	*Kyllinga*	*Urochloa*	*Cynodon*	(9=best)
Bentazon + MSMA	35	29	36	38	45	8	15	17	67	0	1	97	7.8
MSMA	39	29	32	32	54	2	14	32	50	0	4	94	7
MSMA + metribuzin	50	24	26	82	69	51	25	9	48	2	9	73	5
Halosulfuron + MSMA	46	30	24	52	23	4	10	47	44	0	42	56	5.8
Imazaquin + MSMA	39	26	35	32	27	9	12	47	42	0	41	55	5.6
Water control	52	19	29	10	1	1	28	38	35	0	50	43	5.3
Halosulfuron	40	23	37	58	7	0	5	40	55	0	62	37	4.7
Bentazon	49	31	20	16	2	0	16	55	29	0	59	36	5.4
Bentazon + halosulfuron	37	26	37	50	1	0	11	41	47	0	64	35	5.4
Imazaquin + halosulfuron	45	35	20	28	2	0	8	56	35	0	73	27	5.5
Bentazon + imazaquin	40	40	20	50	1	0	11	63	27	0	78	22	5.3
Imazaquin	45	31	24	52	1	0	6	66	27	0	88	13	5.5
Statistics:													
F	1.08	1.3	1.24	2.55	35.61	66.7	2.57	5.57	2.19		13.52	10.98	3.71
P	0.396	0.258	0.29	0.014	< 0.001	< 0.001	0.013	< 0.001	0.033	n/a	< 0.001	< 0.001	< 0.001
MSD *	ns	ns	ns	41	10	4	14	20	29		18	22	1.4

* Minimum significant difference by the Waller-Duncan k-ratio t-test, k = 100, P≈ 0.05.

imazaquin showed reduced injury of MSMA to tropical signalgrass, probably because the mixture was only applied once per set of applications. After the first set of applications, canopy coverage of tropical signalgrass was reduced ($P < 0.05$), compared with the water control, only by bentazon + MSMA and MSMA + metribuzin. After the second set of applications, those treatments plus the MSMA-only treatment reduced tropical signalgrass coverage. Bentazon + imazaquin and imazaquin alone increased tropical signalgrass coverage after the first set of applications, compared with the water control. After the second set of applications, imazaquin+halosulfuron joined those treatments in increasing tropical signalgrass canopy coverage, compared with the water control.

Only the treatment with MSMA + metribuzin caused severe bermudagrass injury, 51% (Table 1). Bentazon + MSMA and imazaquin + MSMA injured bermudagrass ($P < 0.05$), but the visual effect was slight. No treatment in the first set of applications, even the injurious MSMA + metribuzin tank mixture, reduced the bermudagrass coverage compared with the water control. After the first set of applications, only bentazon + MSMA increased the bermudagrass coverage. After the second set of applications, only MSMA, MSMA+bentazon, and MSMA+metribuzin significantly increased bermudagrass coverage compared with the water control (Table 1). After the second set of applications, several plots, especially MSMA + metribuzin plots, had incomplete coverage, based on the total coverage of all species. Halosulfuron + MSMA and imazaquin + MSMA did not affect bermudagrass coverage, probably because they were applied only once per set of applications. Imazaquin reduced bermudagrass coverage to only 13% compared with 43% for the water control.

The optimum herbicide treatment for maximizing bermudagrass coverage was bentazon + MSMA. Based on weed injuries, this treatment would have been discarded as a management strategy in the mixed weed population. It was only 10th in injury to green kyllinga, and 3rd place in injury to tropical signalgrass, plus it caused slight injury to bermudagrass. An herbicide strategy for controlling the most prevalent weed, green kyllinga, without injuring the bermudagrass, would involve imazaquin or halosulfuron, alone or in mixture. These herbicides often injured green kyllinga, and always reduced its coverage (Table 1). Unfortunately, three of such treatments actually increased tropical signalgrass canopy coverage, and imazaquin reduced bermudagrass coverage.

Imazaquin, alone or in combinations with bentazon or halosulfuron, was effective in reducing green kyllinga populations compared with the water control, with no effect on tropical signalgrass. While not injuring the bermudagrass directly, the demise of green kyllinga was associated with an increase in tropical signalgrass. Meanwhile MSMA, in the absence of bentazon, halosulfuron, or imazaquin, was effective in reducing tropical signalgrass populations, with no effect on green kyllinga. Because the study was done in a season when green kyllinga was in natural gradual decline, its accelerated demise from imazaquin appeared to open a niche for colonization by tropical signalgrass, which competed with bermudagrass.

CONCLUSIONS

In a mixed weed population, the optimum herbicide strategy should maximize the canopy coverage and health of the desired turf species. In the case of this experiment's mixed weed population, the optimum herbicide strategy would not have been determined from short-term evaluation of weed injury, nor absence of injury to the turf. Rather, based on long-term evaluation of canopy effects, the optimum herbicide strategy must consider the replacement of green kyllinga by tropical signalgrass. While on first consideration the optimum herbicide strategy would involve the selection of herbicides and mixtures that injure multiple weed species, without hurting the turf, the effects on the turf canopy are confounded by competition among weeds.

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