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Enhancing Extension Education and Recommendations on Vegetation Management for the Georgia DOT

Final Report

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16. Abstract: The influence of mowing and herbicide application timing appears to affect bermudagrass release and grassy weed control, but the effects on broadleaf weeds was inconsistent. Timing applications of Milestone, Plateau, Perspective, and Pastora in spring or fall enhanced bermudagrass cover more consistently than summer applications. Spring and fall applications also provided more consistent control of buckhorn plantain than summer applications. MSMA was the most effective herbicide for broomsedge control compared to Pastora, Outrider, and Plateau. Broomsedge cover was reduced the most when MSMA was applied in conjunction with spring or fall mowing. Summer applications of MSMA followed by mowing in fall may be the best control program for broomsedge if treatments cannot be applied in fall or spring. Johnsongrass was effectively controlled with Outrider, Pastora, and Plateau, but these treatments caused substantial injury to tall fescue. MSMA was less effective for Johnsongrass control than the DOT standard, Outrider, but was the least injurious to tall fescue.

Our findings also suggest that new herbicide combinations should be considered by the Georgia DOT, such as Milestone + Esplanade. This combination consistently provided greater bermudagrass release than the DOT standard, Milestone alone, and had superior control of broadleaf weeds. Esplanade did not cause significant injury to tall fescue in limited testing, and the herbicide may be applicable in areas of mixed stands when tall fescue is a desirable species. Esplanade has postemergence activity on buckhorn plantain but is not a standalone herbicide. The mixture with Milestone enhances the speed of plantain control in fall and effectively controlled Italian ryegrass by the following spring. Tank-mixtures with other herbicides, such as 2,4-D and dicamba, also had better control of buckhorn plantain than these herbicides applied without Esplanade.

The mobile application, “Georgia Roadside Management”, was released in October 2014. The application contains pictures and information of important weeds and grasses in vegetation management with recommendations for control. The program contains a pesticide database listed by common and trade names of all products used in the DOT spray programs. The application is routinely updated so agronomists can have access to real-time extension recommendations from the University of Georgia. This technology provides quick access to information for DOT

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EXECUTIVE SUMMARY

The greatest challenge in grassy roadside management in Georgia is weed control. The presence of weeds reduces aesthetics, safety, and visibility for drivers on highways, interstates, and other roads. Weed competition with desirable grasses may also result in significant soil erosion that could reduce safety and stability of roadside vegetation. Additionally, roadsides are mowed infrequently, usually once or twice per year, which may thin grass canopies and reduce competition with weeds.

Agronomists throughout Georgia modify mowing programs and herbicide selection for the time of year, targeted weeds, and desired grasses under maintenance. Herbicides are applied for controlling weeds but are also used for growth regulation to reduce mowing requirements and seedhead development of desirable grasses. The use of herbicides for growth regulation of grasses and weed control reduces annual mowing costs to approximately $7 million per year. Herbicide use saves substantial amounts of money every year for the state and is especially important during times of economic stress when labor and management capabilities are limited for agronomists. The objective of the proposed research is to improve efficacy of Georgia DOT weed management practices by evaluating herbicide selection and vegetation management practices on emerging weeds on Georgia roadsides.

The results of this research found mowing and herbicide application timing appears to affect bermudagrass release and grassy weed control, but the effects on broadleaf weeds was inconsistent. Timing applications of Milestone, Plateau, Perspective, and Pastora in spring or fall enhanced bermudagrass cover more consistently than summer applications. Spring and fall applications also provided more consistent control of buckhorn plantain than summer applications. MSMA was the most effective herbicide for broomsedge control compared to Pastora, Outrider, and Plateau. Broomsedge cover was reduced the most when MSMA was applied in conjunction with spring or fall mowing. Summer applications of MSMA followed by mowing in fall may be the best control program for broomsedge if treatments cannot be applied in fall or spring. Johnsongrass was effectively controlled with Outrider, Pastora, and Plateau, but these treatments caused substantial injury to tall fescue. MSMA was less effective for Johnsongrass control but was the least injurious to tall fescue.

Our findings also suggest that new herbicide combinations should be considered by the Georgia DOT, such as Milestone + Esplanade. This combination consistently provided greater bermudagrass release than Milestone alone and had superior control of broadleaf weeds. Esplanade did not cause significant injury to tall fescue in limited testing, and the herbicide may be applicable in areas of mixed stands when tall fescue is a desirable species. Esplanade has postemergence activity on buckhorn plantain but is not a standalone herbicide. The mixture with Milestone enhances the speed of plantain control in fall and effectively controlled Italian ryegrass by the following spring. Tank-mixtures with other herbicides, such as 2,4-D and dicamba, also had better control of buckhorn plantain than these herbicides applied without Esplanade.

The mobile application, "Georgia Roadside Management", was released in October 2014. The application contains pictures and information of important weeds and grasses in vegetation management with recommendations for control. The program contains a pesticide database listed by common and trade names of all products used in the DOT spray programs. The application is routinely updated so agronomists can have access to real-time extension recommendations from the University of Georgia. This technology provides quick access to information for DOT agronomists for enhancing education and productivity.

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INTRODUCTION

Georgia has over 18,000 miles of primary and secondary roads with approximately 720,000 acres of roadside vegetation under management. Bahiagrass, bermudagrass, and tall fescue are the major grasses grown for roadsides in the state. These species have good drought and stress tolerances on low-maintenance roadsides but have differential growth and management requirements that influence potential for long-term successful culture.

The greatest challenge in grassy roadside management in Georgia is weed control. The presence of weeds reduces aesthetics, safety, and visibility for drivers on highways, interstates, and other roads. Weed competition with desirable grasses may also result in significant soil erosion that could reduce safety and stability of roadside vegetation. Additionally, roadsides are mowed infrequently, usually once or twice per year, which may thin grass canopies and reduce competition with weeds.

Agronomists throughout Georgia modify mowing programs and herbicide selection for the time of year, targeted weeds, and desired grasses under maintenance. Herbicides are applied for controlling weeds but are also used for growth regulation to reduce mowing requirements and seedhead development of desirable grasses. The average mowing cost for grassy roadside management by the Georgia Department of Transportation is $20 million per year (Dorsey, personal communication). The use of herbicides for growth regulation of grasses and weed control reduces annual mowing costs to approximately $7 million per year. Herbicide use saves substantial amounts of money every year for the state and is especially important during times of economic stress when labor and management capabilities are limited for agronomists.

Herbicide selection may also be limited due to economics and herbicide tolerance of the desirable species. Agronomists often select a spray program under financial limitations to meet demands for vegetation management. These programs are often limited to repeated use of similar herbicides or application timings that are ineffective for controlling the targeted weed and may lead to problems with resistant populations.

Vegetation management along roadsides also includes controlling species that emerge in pavement of transition areas. Maintenance and repair of paved areas damaged from weeds are costly and warrant more effective management strategies for control. Improving the efficacy of residual herbicides for controlling vegetation in these areas could reduce time, money, and labor required to replace pavement in transition areas. New technologies with potential for improving herbicide residual activity have promising implications for long-term weed control in these areas and warrant further investigation for the Georgia DOT.

OBJECTIVE

The objective of the proposed research is to improve efficacy of Georgia DOT weed management practices by evaluating herbicide selection and vegetation management practices on emerging weeds on Georgia roadsides. The proposed work also included the incorporation of new technologies for practical application in the field and for enhancing education of agronomists managing roadsides in Georgia.

PROCEDURES

Evaluation of mowing, herbicide selection, and application timings on problem weed control and the release of roadside turfgrass.

Nine field experiments were conducted from 2012 to 2015 to evaluate the effects of mowing timing, herbicide application timing, and herbicide selection on the control and establishment of invasive weeds. These trials were conducted in simulated roadsides at the University of Georgia Griffin Campus. Local soil was a Cecil sandy clay loam with a pH ranging approximately 6.2 and 2.2% organic matter. Trial locations were selected based on the history of weed infestations.

Treatments and mowing timings. Treatments were a factorial combination of three mowing timings (spring, summer, or fall), three herbicide application timings (spring, summer, and fall), and five herbicide treatments. All possible combinations of mowing timing, herbicide treatment, and herbicide application timing were evaluated. The herbicides selected for each experiment are listed in data tables. Seasonal herbicide application timings were timed three weeks after the last mowing timing. Herbicide application dates and mowing dates are listed in tables. In separate experiments, the effect of three mowing frequencies was evaluated against seasonal application timing (spring, summer, or fall) of five herbicide treatments. All possible combinations of mowing frequency, herbicide, and herbicide application timing were evaluated.

The experimental design for each experiment was a split-block with four replications. Weed cover was evaluated monthly on percent scale where 0 equaled no cover and 100 equaled complete plot cover. Bermudagrass and fescue cover were also evaluated on percent scale. Data were subjected to analysis of variance with the General

Linear Model procedure in SAS (v. 9.4, SAS Institute, Cary, NC). Means were separated with Fisher's LSD test at $\alpha = 0.05$.

TABLE 1. Dates of mowing and herbicide applications in field experiments, 2012-2015.

Experiment	Timing	Mowing	Herbicide timing
1	Spring	4/17/12	5/7/12
	Summer	6/18/12	7/10/12
	Fall	9/10/12	10/3/12
2	Spring	4/17/12	5/7/12
	Summer	6/18/12	7/10/12
	Fall	9/10/12	10/3/12
3	Spring	4/17/12	5/7/12
	Summer	6/18/12	7/10/12
	Fall	9/10/12	10/3/12
4	Spring	4/26/13	5/15/13
	Summer	6/20/13	7/12/13
	Fall	8/19/13	9/4/13
5	Spring	4/25/13	5/16/13
	Summer	6/20/13	7/12/13
	Fall	8/14/13	9/4/13
6	Spring	4/25/13	5/16/13
	Summer	6/20/13	7/12/13
	Fall	8/14/13	9/4/13
7	Spring	5/7/14	6/2/14
	Summer	6/30/14	7/21/14
	Fall	9/22/14	10/13/14

Evaluation of Indaziflam for Controlling Italian Ryegrass and Broadleaf Weeds

Indaziflam (Esplanade) is a cellulose synthesis inhibitor developed by Bayer. The herbicide provides preemergence (PRE) and early postemergence (POST) control of annual grasses and broadleaf weeds. Indaziflam offers end-users a new mechanism of action for PRE weed control in roadsides and may improve resistance management programs. Indaziflam is currently not labeled for tall fescue due to injury concerns, but applications under roadside settings have received limited investigation.

A field experiment was conducted from September 2013 to April 2014 on a tall fescue roadside in Griffin, GA (Experiment 1). Another experiment was conducted on a bermudagrass roadside off of I-75 in Jackson, GA (Experiment 2). Soil composition at the Griffin site was a Cecil sandy clay loam with approximately 6.0 pH and 2.5% organic matter. The tall fescue roadside in Griffin was mowed monthly with a rotary mower at 4 inch height. The bermudagrass roadside was once per year with tractor mowers set for ~4 inch height.

Treatments (Table 1) were applied on September 11, 2013 or November 7, 2013 and are delineated as the early and late timing, respectively. All treatments included a nonionic surfactant at 0.25 %v/v. Herbicide treatments were applied with a CO_2-pressured backpack sprayer calibrated to deliver 25 gallons per acre using three 8004 flat-fan nozzles to 5 x 10-ft plots. The experimental design was a randomized complete block with four replications of 5 x 10-ft and 5 x 15-ft plots in Griffin and Jackson, respectively. Weed control was visually evaluated on a percent scale where 0 equaled no control and 100 equaled complete control. Data were subjected to analysis of variance and means were separated using Fisher's LSD test at $\alpha = 0.05$.

Evaluation of Indaziflam with Postemergence Herbicides for Postemergence Buckhorn Plantain Control

Greenhouse Experiments. The objective of these experiments was to evaluate the influence of application placement and rate on buckhorn plantain injury from indaziflam. Buckhorn plantain was collected from bareground areas (free of turfgrass) at the University of Georgia Griffin Campus in December 2013 and January 2014. Soil was a Cecil sandy clay loam with a 6.0 pH and 2.5% organic matter. Plants at the rosette growth stage at 2.5 inch height were collected with field soil using a sampler measuring 79 cm^2 surface area and 10-cm depth. Plants plus field soil were placed in pots with similar dimensions to the sampler in a greenhouse set for 23/17° C (day/night). Plants were irrigated as needed and were allowed to resume active growth before treatments.

Treatments were the factorial combination of two indaziflam (Specticle Flo, Bayer Environmental Science, Research Triangle Park, NC 27709) rates, 27.5 and 55 g ai ha^{-1} (Equivalent to ~1.75 and 3.5 oz/acre of Esplanade), and three application placements: foliar only, soil only, and foliar + soil. A nontreated control was also included. Foliar only and foliar + soil treatments were applied with a CO_2-pressured sprayer calibrated to deliver 40 gallons per acre with a single 9504E flat-fan nozzle. Cotton balls were placed at the soil surface for foliar-only treatments and were removed at 1 h after treatment (HAT). Soil only treatments were applied with a pipette around the perimeter of the canopy to deliver a surface application of the aforementioned rates in 10 mL of tap water. Plants were not irrigated for 48 h but received irrigation thereafter as needed to prevent soil moisture deficiencies.

Aboveground biomass was harvested at 4 WAT with shears, oven-dried at 60 C for 72 h, and then weighed. Percent shoot mass reductions were calculated relative to the nontreated by replication. The experimental design was a randomized complete block with four replications and the experiment was repeated. Data were subjected to analysis of variance with the General Linear Model procedure in SAS (SAS v. 9.0, SAS Institute Inc., Cary, NC 27513). Means were separated with Fisher's LSD test at $\alpha = 0.05$. Experiment by treatment interaction was not detected, and thus results were pooled over runs.

Field Experiments. The objective of the field experiments was to evaluate buckhorn plantain control with five POST herbicides applied with or without indaziflam. Experiments were conducted at the University of Georgia in Griffin, GA from March to June 2013 and April to June 2014 in bermudagrass turf (33°15'47"N 84°16'57"W). Plots used in 2014 were adjacent to plots in 2013. Soil was a Cecil sandy clay loam with a 6.0 pH and 2.5% organic matter. Bermudagrass was an unknown cultivar mowed weekly during active growth at a 5 cm height with a rotary mower and clippings were returned. Buckhorn plantain was actively growing and at the rosette stage on the day of applications.

Treatments were the factorial combination of two indaziflam rates, 0 or 55 g ai ha^{-1}, with five POST herbicides. Postemergence herbicides included 2,4-D amine (3.8L, E.I. DuPont de Nemours and Co., Wilmington, Delaware 19898) at 1 kg ae ha^{-1}, 2,4-D + dicamba + MCPP (Trimec Classic 2.7SL, PBI Gordon Corp., Kansas City, MO 64101) at 1.5 kg ae ha^{-1}, fluroxypyr (Spotlight 1.5L, Dow Agrosciences LLC, Indianapolis, IN 46268) at 0.5 kg ai ha^{-1}, metsulfuron-methyl (Manor 60%, Nufarm, Morrisville, NC

27560) at 0.02 kg ai ha^{-1}, or simazine (Princep 4L, Syngenta Crop Protection, Greensboro, NC 27409) at 1.12 kg ai ha^{-1}. The indaziflam rate chosen is the highest recommended rate for PRE weed control for single applications in turfgrass (Anonymous 2013). Application rates of POST herbicides were chosen from labeled recommendations for bermudagrass. A non-ionic surfactant (Chem Nut 80-20, Chem Nut Inc., Albany, GA 31706) was included with metsulfuron treatments at 0.25% vol/vol.

Treatments were applied with a CO_2 pressured sprayer calibrated to deliver 374 L ha^{-1} with a single 9504E flat-fan nozzle. Application dates were March 19 in 2013 and April 9 in 2014. The fields were not irrigated but rainfall was received within 5 d after treatment. In 2013, 4.6-cm of precipitation was received from March 22 to 24. In 2014, 3.2-cm of precipitation was received from April 14 to 15.

Buckhorn plantain control was rated at 1, 2, 3, 4, 5, and 9 WAT in both years. Control was rated on a percent scale where 0 equaled no visual injury and 100 equaled complete desiccation relative to the nontreated. Bermudagrass injury was also rated on a percent scale where 0 equaled no injury and 100 equaled dead turf. The experimental design was a randomized complete block with four replications of 0.9 x 3-m plots. Data were subjected to analysis of variance with the General Linear Model procedure in SAS. Means were separated with Fisher's LSD test at $\alpha = 0.05$. Year by treatment interactions were not detected, and thus, results were pooled over years.

FINDINGS

Evaluation of mowing, herbicide selection, and application timings on problem weed control and the release of roadside turfgrass.

The interaction of herbicide selection and application timing was significant for bermudagrass cover in Experiment 1 (Table 2). However, the effect of mowing timing was not significant. The Milestone + Esplanade treatment applied in spring increased bermudagrass cover ~20% at 2 and 6 months after treatment (MAT) from the nontreated. Spring treatments of Perspective also increased bermudagrass cover ~20% from the nontreated at 2 MAT, but cover was similar to the nontreated on other evaluation dates. Summer treatments provided erratic levels of bermudagrass cover across treatments, but Perspective and Pastora increased cover on one evaluation date. Fall treatments of Plateau increased bermudagrass cover 14 to 17% at 2, 4, and 6 MAT. Milestone + Esplanade and Pastora increased bermudagrass cover from the nontreated by ~10% at 2 MAT, but bermudagrass cover was similar on other evaluation dates.

In Experiment 1, Milestone alone, Milestone + Esplanade, and Pastora provided 100% control of catsear dandelion at all application timings. Spring and fall applications of Perspective provided complete control of catsear dandelion, but summer applications gave 79% control. Mowing timing did not influence catsear dandelion cover or control from herbicides.

TABLE 2. Bermudagrass cover in roadside turf treated with herbicides at three application timings and three mowing timings, 2012-2013, Griffin, GA.

		Bermudagrass Cover (Month After Treatment)			
Timing[a]	Herbicide	0	2	4	6
		——— % ———			
Fall	Milestone	28	32	34	29
	Milestone + Esplanade	31	36	40	38
	Pastora	33	39	46	41
	Perspective	16	19	23	21
	Plateau	35	40	49	45
	Nontreated	25	27	33	28
	$LSD_{0.05}$	4	7	14	14
Spring	Milestone	24	26	22	27
	Milestone + Esplanade	25	46	53	55
	Pastora	21	31	24	35
	Perspective	22	51	43	48
	Plateau	19	27	25	26
	Nontreated	19	29	40	39
	$LSD_{0.05}$	6	16	15	15
Summer	Milestone	27	35	40	35
	Milestone + Esplanade	23	39	43	38
	Pastora	28	53	56	55
	Perspective	35	57	58	51
	Plateau	30	40	39	34
	Nontreated	26	36	40	35
	$LSD_{0.05}$	NS	21	19	19
Mowing					
Fall		26	39	42	40
Spring		25	34	37	36
Summer		28	38	39	38
	$LSD_{0.05}$	NS	NS	NS	NS

[a]The dates for spring, summer, and fall herbicide application timings were May 7, July 10, and October 3, 2012, respectively. Fall, spring, and summer mowing was performed on April 17, June 18, and September 10, 2012, respectively. Herbicide products and application rates were Milestone (2 lb/gal aminopyralid) at 7 fl oz/acre, Dow Agrosciences, Indianapolis, IN; Esplanade (1.7 lb/gal indaziflam) at 7 fl oz/acre; Bayer Environmental Science, Research Triangle Park, NC; Pastora (71% nicosulfuron + metsulfuron) at 1.3 oz/acre; Perspective (55% aminocyclopyrachlor + chlorsulfuron), E. I. DuPont de Nemours and Co., Wilmington, DE; Plateau (2 lb/gal imazapic) at 4 oz/acre, BASF Corp., Research Triangle Park, NC. Treatments included non-ionic surfactant (Chem Nut 80-20, mixture of alkyl and arlkylaryl polyoxyethylene glycol, 80%, Chem Nut Inc., Albany, GA 31706) at 0.25% vol/vol.

TABLE 3. Catsear dandelion cover at four months after herbicide treatments to bermudagrass in a field experiment, 2012-2013, in Griffin, GA.

Timing[a]	Herbicide		Catsear Dandelion Cover
			%
Fall	Milestone		0
	Milestone + Esplanade		0
	Pastora		0
	Perspective		0
	Plateau		9
	Nontreated		3
		$LSD_{0.05}$	2
Spring	Milestone		0
	Milestone + Esplanade		0
	Pastora		0
	Perspective		0
	Plateau		16
	Nontreated		9
		$LSD_{0.05}$	4
Summer	Milestone		0
	Milestone + Esplanade		0
	Pastora		0
	Perspective		3
	Plateau		27
	Nontreated		14
		$LSD_{0.05}$	6
	Mowing		
	Fall		5
	Spring		4
	Summer		5
		$LSD_{0.05}$	NS

[a]The dates for spring, summer, and fall herbicide application timings were May 7, July 10, and October 3, 2012, respectively. Fall, spring, and summer mowing was performed on April 17, June 18, and September 10, 2012, respectively. Herbicide products and application rates were Milestone (2 lb/gal aminopyralid) at 7 fl oz/acre, Dow Agrosciences, Indianapolis, IN; Esplanade (1.7 lb/gal indaziflam) at 7 fl oz/acre; Bayer Environmental Science, Research Triangle Park, NC; Pastora (71% nicosulfuron + metsulfuron) at 1.5 oz/acre; Perspective (55% aminocyclopyrachlor + chlorsulfuron), E. I. DuPont de Nemours and Co., Wilmington, DE; Plateau (2 lb/gal imazapic) at 4 oz/acre, BASF Corp., Research Triangle Park, NC. Treatments included non-ionic surfactant (Chem Nut 80-20, mixture of alkyl and arlkylaryl polyoxyethylene glycol, 80%, Chem Nut Inc., Albany, GA 31706) at 0.25% vol/vol.

In Experiment 2, herbicide selection by application timing interaction was significant (Table 4). The effect of mowing was also significant, but the interactions with herbicide treatments were not. Milestone + Esplanade and Plateau at all application timings enhanced bermudagrass cover, ranging ~15 to 50% greater than the nontreated. Fall applications of Perspective and Pastora enhanced bermudagrass cover ~40% from the nontreated at 4 MAT, but cover was similar to the nontreated when applied in spring and summer. Milestone treatments alone did not improve bermudagrass cover from the nontreated at any application timing. Averaged over herbicide applications, bermudagrass that was mowed three times had 8% less coverage than a single mowing.

TABLE 4. Bermudagrass cover at four months after herbicide treatments in a field experiments, 2012-2013, in Griffin, GA.

Application Timing	Herbicide		Bermudagrass Cover (%)
Fall	Milestone		49
	Milestone + Esplanade		59
	Pastora		78
	Perspective		77
	Plateau		80
	Nontreated		32
		$LSD_{0.05}$	20
Spring	Milestone		61
	Milestone + Esplanade		84
	Pastora		73
	Perspective		60
	Plateau		75
	Nontreated		60
		$LSD_{0.05}$	14
Summer	Milestone		57
	Milestone + Esplanade		84
	Pastora		79
	Perspective		66
	Plateau		82
	Nontreated		55
		$LSD_{0.05}$	12
	Mowings		
	One		71
	Two		68
	Three		63
		$LSD_{0.05}$	7

[a]The dates for spring, summer, and fall herbicide application timings were May 7, July 10, and October 3, 2012, respectively. Fall, spring, and summer mowing was performed on April 17, June 18, and September 10, 2012, respectively. Herbicide products and application rates were Milestone (2 lb/gal aminopyralid) at 7 fl oz/acre, Dow Agrosciences, Indianapolis, IN; Esplanade (1.7 lb/gal indaziflam) at 7 fl oz/acre; Bayer Environmental Science, Research Triangle Park, NC; Pastora (71% nicosulfuron + metsulfuron) at 1.5 oz/acre; Perspective (55% aminocyclopyrachlor + chlorsulfuron), E. I. DuPont de Nemours and Co., Wilmington, DE; Plateau (2 lb/gal imazapic) at 4 oz/acre, BASF Corp., Research Triangle Park, NC. Treatments included non-ionic surfactant (Chem Nut 80-20, mixture of alkyl and arlkylaryl polyoxyethylene glycol, 80%, Chem Nut Inc., Albany, GA 31706) at 0.25% vol/vol.

In Experiment 3, an interaction of mowing and herbicide application timings was detected for broomsedge cover at 4 MAT (Table 5). However, interactions with herbicide selection were not detected. Treatments of Outrider, Pastora and Plateau provided poor control (<50%) of broomsedge (data not shown), and thus results were pooled over MSMA and Roundup treatments. MSMA and Roundup Pro had similar efficacy on broomsedge and averaged 78% control. When mowing operations were performed in fall, broomsedge cover was reduced 3x greater when herbicides were applied in fall and summer, compared to spring. Following spring mowing, spring herbicide applications were more effective in reducing broomsedge cover than fall applications. Summer herbicide applications, following spring mowing, had similar broomsedge cover to other application timings. When the plots were mowed in summer, herbicide application timing was insignificant on broomsedge cover. These results suggest timing mowing broomsedge in fall or spring followed by herbicide applications after three weeks has the most potential to reduce broomsedge than other timings. Summer herbicide applications should be followed by fall mowing, but other mowing timings were inconsistent for broomsedge cover reductions.

The interaction of mowing, herbicide, and application timings was not significant, and thus results were pooled over main effects. Tall fescue cover was reduced 55 to 70% from the nontreated following treatments of Outrider, Pastora, Plateau, and Roundup. MSMA was the only herbicide that did not reduce tall fescue cover from the nontreated. Pooled over mowing and herbicide treatments, tall fescue cover was greatest following summer herbicide applications and was reduced by half when treatments were applied in spring. The effect of mowing timing was insignificant for tall fescue cover.

TABLE 5. Broomsedge cover at four months after treatments with herbicides at three application timings with three mowing operations, 2013-2014, Griffin, GA.

Mowing[a]	Application Timing		Broomsedge Cover
Fall	Fall		4
	Spring		10
	Summer		3
		$LSD_{0.05}$	6
Spring	Fall		14
	Spring		4
	Summer		10
		$LSD_{0.05}$	7
Summer	Fall		10
	Spring		8
	Summer		10
		$LSD_{0.05}$	NS
	Herbicide[bc]		
	MSMA		3
	Roundup Pro		5
	Nontreated		18
		$LSD_{0.05}$	4

[a]The dates for spring, summer, and fall herbicide application timings were May 15, July 12, and September 4, 2013, respectively. Fall, spring, and summer mowing was performed on April 26, June 20, and August 19, 2013, respectively.

[b]Herbicide products and rates were Target 6 Plus (6 lb/gal, MSMA) at 2 lb ai/acre, Outrider (75% sulfosulfuron) at 1 oz/acre, Monsanto, St. Louis, MO; Pastora (71% nicosulfuron + metsulfuron) at 1.5 oz/acre, E. I. DuPont de Nemours and Co., Wilmington, DE; Plateau (2 lb/gal imazapic) at 4 oz/acre, BASF Corp., Research Triangle Park, NC; Roundup Pro (3 lb ae/gal glyphosate) at 16 oz/acre, Monsanto, St. Louis, MO. Treatments except MSMA and Roundup Pro included a non-ionic surfactant (Chem Nut 80-20, Chem Nut Inc., Albany, GA 31706) at 0.25% vol/vol.

[c]Herbicides not included in the analysis were Pastora, Plateau, and Outrider due to no differences from the nontreated.

TABLE 6. Tall fescue cover at four months after herbicide treatments in a field experiment, 2013-2014, Griffin, GA.

Herbicide[a]		Tall fescue cover (%)
MSMA		33
Outrider		6
Pastora		6
Plateau		6
Roundup		13
Nontreated		29
	$LSD_{0.05}$	6
Application Timing[b]		
Fall		14
Spring		11
Summer		21
	$LSD_{0.05}$	4
Mowing[b]		
Fall		16
Spring		16
Summer		15
	$LSD_{0.05}$	NS

[a]Herbicide products and rates were Target 6 Plus (6 lb/gal, MSMA) at 2 lb ai/acre, Outrider (75% sulfosulfuron) at 1 oz/acre, Monsanto, St. Louis, MO; Pastora (71% nicosulfuron + metsulfuron) at 1.5 oz/acre, E. I. DuPont de Nemours and Co., Wilmington, DE; Plateau (2 lb/gal imazapic) at 4 oz/acre, BASF Corp., Research Triangle Park, NC; Roundup Pro (3 lb ae/gal glyphosate) at 16 oz/acre, Monsanto, St. Louis, MO. Treatments except MSMA and Roundup Pro included a non-ionic surfactant (Chem Nut 80-20, Chem Nut Inc., Albany, GA 31706) at 0.25% vol/vol.

[b]The dates for spring, summer, and fall herbicide application timings were May 15, July 12, and September 4, 2013, respectively. Fall, spring, and summer mowing was performed on April 26, June 20, and August 19, 2013, respectively.

In Experiment 4, all treatments (Milestone, Milestone + Esplanade, Pastora, Perspective, and Plateau) provided <50% control of broomsedge at all application timings at 4 MAT. Milestone and Plateau applied alone provided <50% control of buckhorn plantain when in fall, spring, and summer. The tank-mixture of Milestone with Esplanade provided 100% control of buckhorn plantain at all application timings and was similar to Perspective. Pastora applied in spring and fall provided 100% and 85% control of buckhorn plantain at 4 MAT, but applications in summer provided poor (69%) control. Hierarchical rank of mowing timings on broomsedge cover was fall > spring ≥ and summer. Conversely, hierarchical rank of mowing timings on buckhorn plantain cover from high to low was fall > spring > summer.

In Experiment 5, Milestone + Esplanade, Pastora, and Perspective provided 100% control of buckhorn plantain at all application timings (Table 7). Milestone applied in spring provided no control of buckhorn plantain, but applications in summer and fall provided 80 and 85% control, respectively. Plateau provided fair control of buckhorn plantain in fall (71%), but other application timings provided poor control (<70%). Broomsedge control was <50% from all herbicides at the three application timings. Mowing operations did not influence buckhorn plantain control.

In Experiment 6, herbicides (MSMA, Outrider, Pastora, Plateau, and Roundup Pro) applied in fall provided no control of Johnsongrass at 3 and 6 months after treatment. All herbicides applied in spring controlled Johnsongrass at 3 MAT, but MSMA was similar to the nontreated at 6 MAT. Outrider applied in spring controlled Johnsongrass 78% at 6 MAT, while other treatments were statistically similar. Summer applications of Outrider, Pastora, and Plateau provided 80 to 100% control of

Johnsongrass at 6 MAT, but caused substantial injury (65 to 88%) to tall fescue at 3 MAT. MSMA was the least injurious treatment on tall fescue, and injury never exceeded 14% at all three timings. Spring applications of herbicides were the least injurious of all application timings.

TABLE 7. Broomsedge and buckhorn plantain ground cover at four months after herbicide and mowing treatments in a field experiment, 2013-2014, Griffin, GA.

Application Timing	Herbicide	Broomsedge	Buckhorn Plantain
		——— % cover ———	
Fall	Milestone	19	20
	Milestone + Esplanade	16	3
	Pastora	30	3
	Perspective	12	0
	Plateau	11	13
	Nontreated	23	20
	$LSD_{0.05}$	8	3
Spring	Milestone	19	5
	Milestone + Esplanade	13	0
	Pastora	18	0
	Perspective	21	0
	Plateau	12	12
	Nontreated	16	9
	$LSD_{0.05}$	NS	3
Summer	Milestone	22	17
	Milestone + Esplanade	15	0
	Pastora	10	6
	Perspective	9	0
	Plateau	25	13
	Nontreated	18	19
	$LSD_{0.05}$	9	4
	Mowing		
	Fall	12	10
	Spring	19	6
	Summer	21	7
	$LSD_{0.05}$	4	1

[a]The dates for spring, summer, and fall herbicide application timings were May 16, July 12, and September 4, 2013, respectively. Fall, spring, and summer mowing was performed on April 25, June 20, and August 14, 2013, respectively. Herbicide products and application rates were Milestone (2 lb/gal aminopyralid) at 7 fl oz/acre, Dow Agrosciences, Indianapolis, IN; Esplanade (1.7 lb/gal indaziflam) at 7 fl oz/acre; Bayer Environmental Science, Research Triangle Park, NC; Pastora (71% nicosulfuron + metsulfuron) at 1.5 oz/acre; Perspective (55% aminocyclopyrachlor + chlorsulfuron), E. I. DuPont de Nemours and Co., Wilmington, DE; Plateau (2 lb/gal imazapic) at 4 oz/acre, BASF Corp., Research Triangle Park, NC. Treatments included non-ionic surfactant (Chem Nut 80-20, mixture of alkyl and arlkylaryl polyoxyethylene glycol, 80%, Chem Nut Inc., Albany, GA 31706) at 0.25% vol/vol.

TABLE 8. Buckhorn plantain cover at four months after herbicide treatments in a field experiment, 2013-2014, in Griffin, GA.

Application Timing[a]	Herbicide		Buckhorn Plantain Cover
			%
Fall	Milestone		1
	Milestone + Esplanade		0
	Pastora		0
	Perspective		0
	Plateau		2
	Nontreated		7
		$LSD_{0.05}$	2
Spring	Milestone		5
	Milestone + Esplanade		0
	Pastora		0
	Perspective		0
	Plateau		3
	Nontreated		5
		$LSD_{0.05}$	3
Summer	Milestone		1
	Milestone + Esplanade		0
	Pastora		0
	Perspective		0
	Plateau		2
	Nontreated		5
		$LSD_{0.05}$	2

[a]The dates for spring, summer, and fall herbicide application timings were May 16, July 12, and September 4, 2013, respectively. Herbicide products and application rates were Milestone (2 lb/gal aminopyralid) at 7 fl oz/acre, Dow Agrosciences, Indianapolis, IN; Esplanade (1.7 lb/gal indaziflam) at 7 fl oz/acre; Bayer Environmental Science, Research Triangle Park, NC; Pastora (71% nicosulfuron + metsulfuron) at 1.5 oz/acre; Perspective (55% aminocyclopyrachlor + chlorsulfuron), E. I. DuPont de Nemours and Co., Wilmington, DE; Plateau (2 lb/gal imazapic) at 4 oz/acre, BASF Corp., Research Triangle Park, NC. Treatments included non-ionic surfactant (Chem Nut 80-20, mixture of alkyl and arlkylaryl polyoxyethylene glycol, 80%, Chem Nut Inc., Albany, GA 31706) at 0.25% vol/vol.

TABLE 9. Johnsongrass cover and tall fescue injury following herbicide and mowing treatments in a field experiment, 2014-2015, in Griffin, GA. Abbreviation: MAT, months after treatment.

		Johnsongrass Cover		Tall Fescue Injury	
Application Timing[a]	Herbicide	3 MAT	6 MAT	1 MAT	3 MAT
			%		
Fall	MSMA	5	2	0	0
	Outrider	5	3	19	43
	Pastora	9	5	28	60
	Plateau	4	2	27	77
	Roundup Pro	8	4	33	73
	Nontreated	4	2		
	$LSD_{0.05}$	NS	NS	5	10
Spring	MSMA	8	9	50	8
	Outrider	3	2	58	31
	Pastora	4	4	57	27
	Plateau	5	5	55	26
	Roundup Pro	4	4	43	30
	Nontreated	12	9		
	$LSD_{0.05}$	4	5	6	14
Summer	MSMA	4	2	59	4
	Outrider	2	1	59	88
	Pastora	3	0	54	66
	Plateau	5	1	48	65
	Roundup Pro	11	3	28	37
	Nontreated	11	4		
	$LSD_{0.05}$	5	3	9	17
	Mowing				
	Fall	3	1	43	41
	Spring	6	4	38	46
	Summer	8	6	43	40
	$LSD_{0.05}$	2	2	4	NS

[a]The dates for spring, summer, and fall herbicide application timings were June 2, July 21, and October 13, 2014, respectively. Fall, spring, and summer mowing was performed on May 7, June 30, and September 22, 2014, respectively. Herbicide products and rates were Target 6 Plus (6 lb/gal, MSMA), Outrider (75% sulfosulfuron) at 1 oz/acre, Monsanto, St. Louis, MO; Pastora (71% nicosulfuron + metsulfuron) at 1.5 oz/acre, E. I. DuPont de Nemours and Co., Wilmington, DE; Plateau (2 lb/gal imazapic) at 4 oz/acre, BASF Corp., Research Triangle Park, NC; Roundup Pro (3 lb ae/gal glyphosate) at 16 oz/acre, Monsanto, St. Louis, MO. Treatments except MSMA and Roundup Pro included a non-ionic surfactant (Chem Nut 80-20, Chem Nut Inc., Albany, GA 31706) at 0.25% vol/vol.

TABLE 10. Buckhorn plantain cover and tall fescue injury following herbicide and mowing treatments in a field experiment, 2014-2015, in Griffin, GA. Abbreviation: MAT, months after treatment.

Application Timing[a]		Buckhorn Plantain Cover	
		3 MAT	6 MAT
		%	
Fall		2	2
Spring		5	5
Summer		7	4
	$LSD_{0.05}$	2	1
Herbicide			
MSMA		5	3
Outrider		9	7
Pastora		1	1
Plateau		4	4
Roundup Pro		5	3
Nontreated		6	4
	$LSD_{0.05}$	2	2
Mowing			
Fall		4	3
Spring		5	3
Summer		6	4
	$LSD_{0.05}$	2	NS

[a]The dates for spring, summer, and fall herbicide application timings were June 2, July 21, and October 13, 2014, respectively. Fall, spring, and summer mowing was performed on May 7, June 30, and September 22, 2014, respectively. Herbicide products and rates were Target 6 Plus (6 lb/gal, MSMA), Outrider (75% sulfosulfuron) at 1 oz/acre, Monsanto, St. Louis, MO; Pastora (71% nicosulfuron + metsulfuron) at 1.5 oz/acre, E. I. DuPont de Nemours and Co., Wilmington, DE; Plateau (2 lb/gal imazapic) at 4 oz/acre, BASF Corp., Research Triangle Park, NC; Roundup Pro (3 lb ae/gal glyphosate) at 16 oz/acre, Monsanto, St. Louis, MO. Treatments except MSMA and Roundup Pro included a non-ionic surfactant (Chem Nut 80-20, Chem Nut Inc., Albany, GA 31706) at 0.25% vol/vol.

Evaluation of new herbicides for winter weed control.

Esplanade (indaziflam) alone at both timings provided 95 to 100% control of Italian ryegrass and buckhorn plantain (Table 1). The addition of POST herbicides did not improve control of these weeds from Esplanade alone. Esplanade did not provide POST control of catsear dandelion, but tank-mixtures with other herbicides improved control to ≥80%. Tall fescue was injured less than 5% by Esplanade at both rates and timings (Table 1).

Esplanade in combination with Derigo (foramsulfuron + iodosulfuron + thiencarbazone) provided nearly complete control of tall fescue by April and was more injurious than Accord + Milestone (glyphosate + aminopyralid) applied in September. The Milestone combination with Esplanade injured tall fescue by 10% or less at both timings (Picture 1). Bermudagrass release in April was inconsistent from Esplanade alone at the two application timings and rates (Figure 1). However, the addition of POST herbicides with Esplanade improved bermudagrass cover ~2 to 5x greater than the nontreated when applied in November. Weed control from Esplanade + Milestone provided 25% bermudagrass ground cover and was 5x greater than the nontreated at both application timings (Picture 2).

Overall, Esplanade effectively controlled Italian ryegrass and buckhorn plantain in a bermudagrass roadside. Esplanade was safe in tall fescue and may be applied with Milestone for PRE and POST weed control. Further research is needed in tall fescue to evaluate injury potential from spring applications in Georgia.

TABLE 11. Buckhorn plantain, catsear dandelion, and annual ryegrass control in bermudagrass and tall fescue roadsides with Esplanade (indaziflam), Derigo (foramsulfuron + iodosulfuron + thiencarbazone), Milestone (aminopyralid), or Accord (glyphosate) combinations in two field experiments. Applications were made in September 11 or November 7, 2013, delineated early and late timing, respectively.

			Tall Fescue Roadside (Griffin)			Bermudagrass Roadside (Jackson)	
Timing	Herbicide	Rate	Buckhorn Plantain	Catsear Dandelion	Tall Fescue Injury	Ryegrass Control	Buckhorn Plantain Control
		oz/acre	——— % control ———		%	——— % ———	
September	Esplanade	3.5	100	0	3	95	86
		5	98	0	0	96	88
	Esplanade + Derigo	3.5 + 3	85	70	97	96	62
		5 + 3	100	100	99	99	88
	Esplanade + Milestone	3.5 + 5	98	100	10	98	84
		5 + 5	95	97	0	95	85
	Milestone + Accord	5 + 9	84	59	59	60	84
November	Esplanade	51	100	0	0	98	90
		73	100	19	3	97	92
	Esplanade + Derigo	3.5 + 3	100	80	100	100	91
		5 + 3	100	81	100	99	92
	Esplanade + Milestone	3.5 + 5	100	100	0	97	92
		5 + 5	100	100	0	100	93
	Milestone + Accord	5 + 9	98	100	97	87	86
		$LSD_{0.05}$	12	34	16	11	12

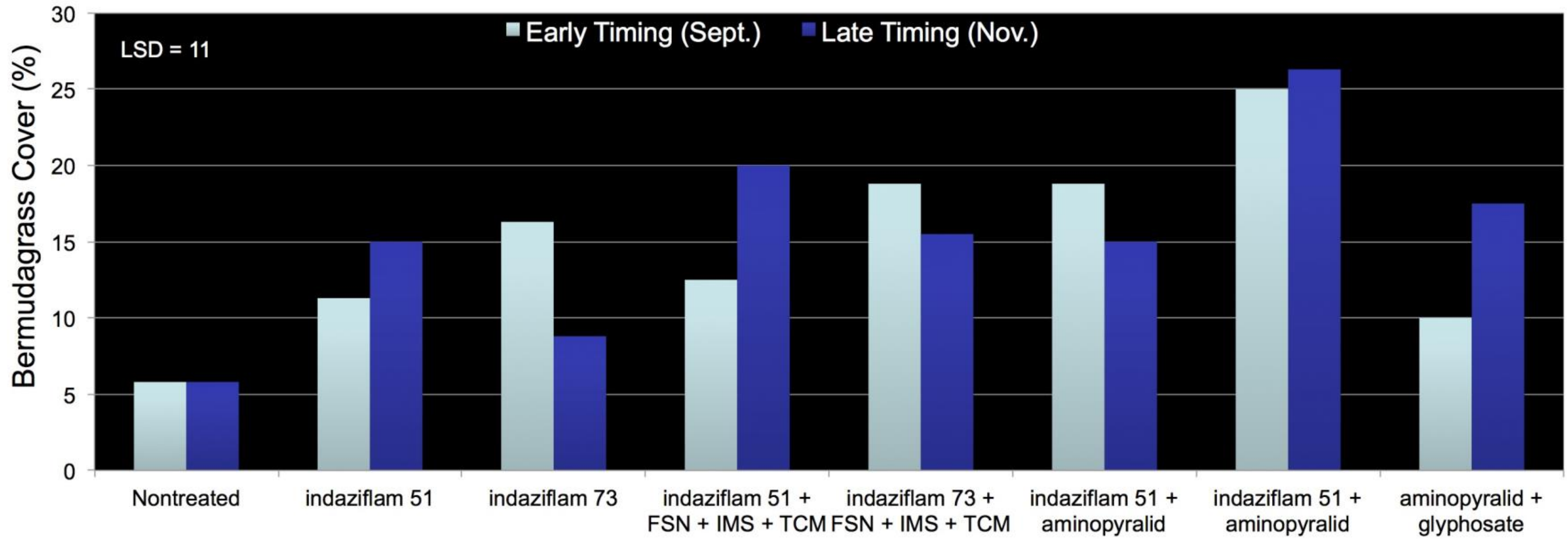

FIGURE 1. Bermudagrass cover in April following treatments with Esplanade (indaziflam), Derigo (foramsulfuron + iodosulfuron + thiencarbazone), Milestone (aminopyralid), or Accord (glyphosate) combinations in two field experiments. Applications were made in September or November 2013, delineated early and late timing, respectively. Rates are listed as grams of active ingredient per hectare.

FIGURE 2. Picture of Indaziflam + aminopyralid treatments in tall fescue on April 23, 2014.

FIGURE 3. Picture of Indaziflam + aminopyralid treatments in bermduagrass on April 23, 2014.

Evaluation of Indaziflam with Postemergence Herbicides for Postemergence Buckhorn Plantain Control.

Greenhouse experiments. Indaziflam rate by application placement interaction was not detected for dry shoot mass reductions at 4 WAT, and thus results are presented by main effect (Table 12). Dry shoot mass of the nontreated plants averaged 3.2 g (± 0.5) after 4 wk. Buckhorn plantain shoot mass was reduced 61, 72, and 75% from the nontreated following foliar, soil, and foliar + soil placements, respectively. Foliar + soil application placements reduced dry mass greater than foliar only treatments. However, reductions from soil only treatments were similar to foliar only and foliar + soil placements. Differences between indaziflam rates were not detected for shoot mass reductions (Table 12).

Results confirm that indaziflam has herbicidal effects on buckhorn plantain. Shoot mass reductions ranging >60% from the nontreated has significant implications for a herbicide used primarily for PRE weed control in turfgrass. These findings corroborate previous observations of buckhorn plantain injury from indaziflam in field experiments in roadside turf.

Field experiments. The interaction of indaziflam by POST herbicide treatment was not significant on any rating date for buckhorn plantain control (Table 13). However, results are presented across all possible combinations to help illustrate the differences in control. From 1 to 4 WAT, all herbicides applied without indaziflam provided poor control (<64%) of buckhorn plantain. The addition of indaziflam in tank-mixtures with all herbicides improved control by an average of 14 to 34% from treatments without indaziflam. Applications of 2,4-D, 2,4-D + dicamba + MCPP, or metsulfuron with indaziflam increased buckhorn plantain control to 75, 82, and 79% at 4 WAT, respectively, and were significantly greater than treatments without indaziflam.

At 9 WAT, exclusive applications of 2,4-D, 2,4-D + dicamba + MCPP, or metsulfuron averaged 59% control of buckhorn plantain. The addition of indaziflam improved control from these herbicides, ranging 81 to 98%, and would likely be acceptable in most turfgrass systems. Fluroxypyr applied alone provided <37% control of buckhorn plantain on all dates. The addition of indaziflam improved control from fluroxypyr alone by ≈2x on most dates and final control from the tank-mixture was 58%.

Simazine alone also provided poor control of buckhorn plantain on all dates. The tank-mixture of indaziflam with simazine provided poor control from 1 to 5 WAT, but final control measured 74% at 9 WAT and was 2x greater than simazine alone. Simazine is most commonly used for controlling winter annual weeds in spring and efficacy is limited on buckhorn plantain. Phytotoxic effects of indaziflam appear to increase buckhorn plantain control from simazine alone and may help overcome the limitations in efficacy caused by cool temperatures in spring.

Spring applications of synthetic auxins, sulfonylureas, and triazines often provide slow control of perennial broadleaf weeds. Efficacy of POST herbicides are reduced under cool temperatures in spring, compared to summer, and sequential treatments are often required. Buckhorn plantain control with indaziflam in spring is noteworthy and would be desirable if turfgrass injury is acceptable when applied with other herbicides. In these experiments, bermudagrass injury was not detected on any observation date and treatments did not reduce spring greenup from the nontreated (data not shown). Indaziflam alone controlled buckhorn plantain 34% at 9 WAT (Table 13). This level of control would be unacceptable and exclusive applications are not efficacious enough as a standalone POST herbicide for controlling mature buckhorn plantain.

TABLE 12. Dry shoot mass reductions from the nontreated at 4 wk after treatment for buckhorn plantain treated with indaziflam in two greenhouse experiments, 2014, in Griffin, GA. Results were pooled over experimental runs.

Placement		Shoot mass reduction (% of nontreated)[a]
Foliar		61
Soil		72
Foliar + Soil		75
	$LSD_{0.05}$	14
Rate		
27.5		67
55		72
	$LSD_{0.05}$	NS

[a]Dry mass of the nontreated averaged 3.2 g (± 0.5).

TABLE 13. Buckhorn plantain control in a bermudagrass lawn following applications of indaziflam alone or in tank-mixtures with herbicides in two field experiments, 2013-2014, Griffin, GA. Results were pooled over years.

		Control (WAT)[a]					
Indaziflam	Herbicide[b]	1	2	3	4	5	9
g ai ha^{-1}		———	———	——— %	———	———	———
0	2,4-D	19	26	38	45	51	49
	2,4-D + dicamba + MCPP	25	35	49	63	86	62
	fluroxypyr	19	31	37	34	37	13
	metsulfuron	10	14	29	49	72	66
	simazine	13	13	6	15	17	36
55	2,4-D	22	35	53	75	75	81
	2,4-D + dicamba + MCPP	18	47	61	82	95	98
	fluroxypyr	28	48	62	68	74	58
	metsulfuron	16	31	56	79	86	88
	simazine	13	14	16	30	40	74
	none	12	19	30	40	44	34
	$LSD_{0.05}$	9	10	15	18	21	35
	Indaziflam	NS	*	*	*	*	*
	Herbicide	*	*	*	*	*	*
	Indaziflam x herbicide	NS	NS	NS	NS	NS	NS

(Table 13 continued)

[a]WAT = weeks after treatment. Application dates were March 19 in 2013 and April 9 in 2014.

[b]Herbicides and rates applied were: 2,4-D amine (3.8L, E.I. DuPont de Nemours and Co., Wilmington, Delaware 19898) at 1 kg ae ha^{-1}, 2,4-D + dicamba + MCPP (Trimec Classic 2.7SL, PBI Gordon Corp., Kansas City, MO 64101) at 1.5 kg ae ha^{-1}, fluroxypyr (Spotlight 1.5L, Dow Agrosciences LLC, Indianapolis, IN 46268) at 0.5 kg ai ha^{-1}, metsulfuron-methyl (Manor 60%, Nufarm, Morrisville, NC 27560) at 0.02 g ai ha^{-1}; or simazine (Princep 4L, Syngenta Crop Protection, Greensboro, NC 27409). A non-ionic surfactant (Chem Nut 80-20, Chem Nut Inc., Albany, GA 31706) was included with metsulfuron treatments at 0.25% vol/vol. Treatments were applied with a CO_2 pressured sprayer calibrated to deliver 374 L ha^{-1} with a single 9504E flat-fan nozzle.

EDUCATION

Trainings. A field day was hosted at the University of Georgia Griffin Campus in October 2014 for the Georgia Department of Transportation managers, spray technicians, and agronomists. Training sessions were also conducted during the grant period through seminars on weed science, herbicide selection, calibration, and issues affecting vegetation managers.

Mobile Application Development. Green industry professionals often spend a significant amount of time away from their computers and rely on mobile technologies in their daily regimens. Mobile phones with email, internet, and application programs help end-users communicate and access real-time information. Advanced "smart" phones, such as the Blackberry and iPhone, have become important tools for professionals and allow greater work flexibility while traveling or away from the office. These advanced mobile devices, along with iPods and tablet computers, have significant potential in providing a new platform to enhance university education.

Mobile applications are relatively new features to smart phones and iPods that have grown in popularity over the last two years. Applications include games, real-time programs, and reference material for quick access to information. In 2009, an application called "Turfgrass Management" was developed by faculty at the University of Georgia. This program was the first mobile application that was specifically designed and created for university education. "Turfgrass Management" is a comprehensive program that contains pictures, information, and recommendations for managing turfgrass, weeds, diseases, and insects.

A similar application was developed specifically for agronomists at the Georgia DOT (Figure 4). The application contains pictures and information of important weeds and grasses in vegetation management with recommendations for control. The program contains a pesticide database listed by common and trade names of all products used in the DOT spray programs. The application is routinely updated so agronomists can have access to real-time extension recommendations from the University of Georgia. The DOT training manual and updates are included in the application, along with presentations and publications for enhancing education on weed control for end-users.

FIGURE 4. Screenshot of the Georgia Roadside Management application developed for agronomists at the Georgia DOT.

FIGURE 5. Listing of a herbicide recommendation example in Georgia Roadside Management application developed for agronomists at the Georgia DOT.

FIGURE 6. Listing of herbicides available for the DOT in the application.

FIGURE 7. Search options for the herbicide categories in the application based on GDOT activity codes.

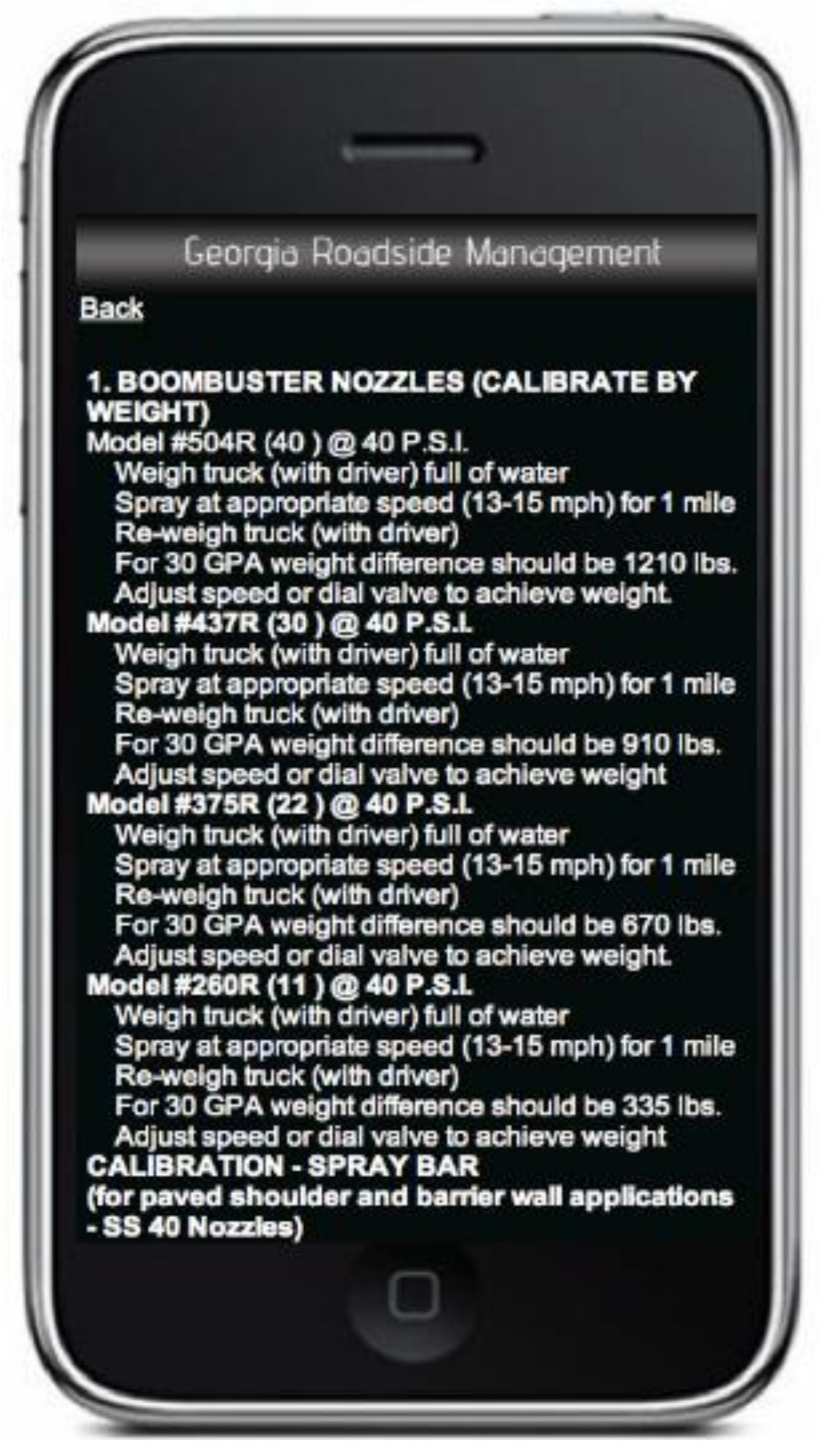

FIGURE 8. Example of instructions for calibration of GDOT equipment in the application under “publications”.

CONCLUSIONS

The influence of mowing and herbicide application timing appears to affect bermudagrass release and grassy weed control, but the effects on broadleaf weeds was inconsistent. Timing applications of Milestone, Plateau, Perspective, and Pastora in spring or fall enhanced bermudagrass cover more consistently than summer applications. Spring and fall applications also provided more consistent control of buckhorn plantain than summer applications. MSMA was the most effective herbicide for broomsedge control compared to Pastora, Outrider, and Plateau. Broomsedge cover was reduced the most when MSMA was applied in conjunction with spring or fall mowing. Summer applications of MSMA followed by mowing in fall may be the best control program for broomsedge if treatments cannot be applied in fall or spring. Johnsongrass was effectively controlled with Outrider, Pastora, and Plateau, but these treatments caused substantial injury to tall fescue. MSMA was less effective for Johnsongrass control than the current DOT standard, Outrider (sulfosulfuron), but was least injurious to tall fescue.

Our findings also suggest that new herbicide combinations should be considered by the Georgia DOT, such as Milestone + Esplanade. This combination consistently provided greater bermudagrass release than the standard DOT herbicide, Milestone alone, and had superior control of broadleaf weeds. Esplanade did not cause significant injury to tall fescue in limited testing, and the herbicide may be applicable in areas of mixed stands when tall fescue is a desirable species. Esplanade has postemergence activity on buckhorn plantain but is not a standalone herbicide. The mixture with Milestone enhances the speed of plantain control in fall and effectively controlled Italian ryegrass by the following spring. Tank-mixtures with other herbicides, such as 2,4-D and dicamba, also had better control of buckhorn plantain than these herbicides applied without Esplanade.

The mobile application, “Georgia Roadside Management”, was released in October 2014. The application contains pictures and information of important weeds and grasses in vegetation management with recommendations for control. The program contains a pesticide database listed by common and trade names of all products used in the DOT spray programs. The application is routinely updated so agronomists can have access to real-time extension recommendations from the University of Georgia. This technology provides quick access to information for DOT agronomists for enhancing education and productivity.