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RESEARCH

Weed Control and Turf Safety of Single and Sequential Applications of Herbicides Over Spring Seedings

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Abstract

Weed control is important during establishment of cool-season grasses, especially when seeded in spring near summer annual weed germination. Our objectives were to determine (i) turf safety and weed control from sequential applications of newly-released herbicides on tall fescue at three seeding dates (May, June, July) and (ii) turf safety and weed control from newly-released herbicides applied at seeding or shortly after emergence of spring-seeded Kentucky bluegrass or tall fescue. No herbicides tested negatively affected turfgrass establishment and usually improved turf establishment by reducing weed competition. Mesotrione consistently provided effective weed control and turf cover from either single or sequential applications over different locations, years, seeding dates, and turf species. Quinclorac or siduron applied as single or sequential applications or quinclorac+carfentrazone as a single application provided effective weed control and turf cover depending on seeding date and application regime. Although spring seeding can be achieved with high maintenance, it is strongly recommended to seed cool season grasses at the optimal time from late summer to early fall.

Weed control is important when seeding cool-season grasses in spring near the period of summer annual weed germination. If left untreated, spring seedings can fail due to competition from undesirable species. Siduron has been the industry standard, due to its safety (low level of herbicide injury) to seedlings of cool-season grasses and adequate control of warm-season summer annual grassy weeds (16,20,23). However, siduron only has short-term residual control and requires repeat applications for season-long control (21). Within the last five years, new herbicides have been labeled with turf safety applied shortly before and after seeding. Quinclorac is permitted for application immediately before seeding and 4 weeks after emergence (WAE) of many cool-season turfgrass species for preemergence (PRE) or postemergence (POST) control of crabgrass (*Digitaria* spp.) and some broadleaf weeds (1),

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Abbreviations: AS, at seeding; KBG, Kentucky bluegrass; POST, postemergence; PRE, preemergence; PRYE, perennial ryegrass; TF, tall fescue; WAE, weeks after emergence.

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but research has indicated turfgrass safety earlier than 4 WAE (19,21,25). Mesotrione is labeled for Kentucky bluegrass (*Poa pratensis* L.) (KBG), tall fescue (*Festuca arundinacea* Shreb.) (TF), or perennial ryegrass (*Lolium perenne* L.) (PRYE), at seeding or 4 WAE (4). Mesotrione can be used for both PRE and POST control of grassy and broadleaf weeds during establishment of TF or KBG with limited impact on turf safety (5,6,10,15,19,25,26). Carfentrazone is labeled for creeping bentgrass (*Agrostis stolonifera* L.), TF, KBG, or PRYE 1 WAE or more, and provides POST control of many broadleaf weeds (2,18). Aminocyclopyrachlor was labeled for applications at any time during seeding and establishment of cool-season grasses, but was removed from the market in 2011 (3). Though siduron or quinclorac have been extensively evaluated for use during establishment of KBG or TF, (13,14,16,19,20,21,22,23,25), the effect of application strategies on weed control and seedling safety of the newer herbicides carfentrazone, aminocyclopyrachlor, and mesotrione is not well documented.

In 2 years we completed six experiments over two locations on weed control in spring seedings. Our first objective was to determine turf safety and weed control following sequential applications of siduron, quinclorac, or mesotrione on TF when seeded on three dates in May, June, or July. Our second objective was to determine turf safety and weed control following aminocyclopyrachlor, carfentrazone, mesotrione, quinclorac, quinclorac+carfentrazone, or siduron applications applied immediately after seeding or shortly after emergence of spring-seeded TF or KBG.

Establishment and Arrangement of Experimental Areas

Research was conducted at the John Seaton Anderson Turfgrass Research Facility near Mead, NE, in 2010 and 2011, and at the Wm. H. Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN, in 2011. The soil type in Nebraska was a Tomek silty clay loam (fine, montmorillonitic, mesic Typic Argiudoll) with a pH of 6.8 and 2.5% organic matter. The soil type in Indiana was a Starks-Fincastle (fine-silty, mixed, mesic, Aeric Ochraqualf) with a pH of 6.7 and 3.5% organic matter. Site preparation and maintenance practices were consistent for all studies, with an application of glyphosate at 2 lb ai/A 1 week before the initial seeding date. Immediately before initial seeding, areas were tilled to 6 in., and dragged with a steel drag mat to level the seeding surface. For studies where additional later seedings were made, individual plots were tilled by hand with a hoe to 6 in., and raked to a level seeding bed.

Immediately before seeding turf species, plots were seeded with weed species to help ensure consistent weed pressure among years or locations. Weed species introduced into research areas included 5.8 lb/A common ragweed (*Ambrosia artemisiifolia* L.), 0.85 lb/A common purslane (*Portulaca oleracea* L.), and 22.3 lb/A large crabgrass (*Digitaria sanguinalis* L.). Following seeding of weeds and turfgrasses, plots were lightly raked with a leaf rake in two directions to ensure proper seed soil contact. Yellow nutsedge (*Cyperus esculentus* L.) tubers were then inserted by hand into each plot to a 0.75 in. depth at 26,135 tubers/A. (Azlin Seed Service, Leland, Mississippi, U.S.), (Herbiseed, New Farm, Twyford, U.K.). Starter fertilizer (11N–52P–0K) was applied at 84 lb/A immediately after seeding and no other fertilizer was applied during the experiments. Irrigation was applied as needed to keep the surface 0.5 in. moist during germination and to wet to the depth of rooting as the stands matured. Areas were mowed at 2 in. once seedlings reached approximately 2.5 in and weekly thereafter. All POST herbicide applications were based on emergence as defined as a uniform stand of one-to two-leaf seedlings of the desired turfgrass covering over 50% of the untreated plot. Herbicides were applied with a CO_2–powered backpack sprayer in 88 gal/A water at 30 PSI, with spray boom containing three 8002VS flat fan nozzles (TeeJet Spraying Systems, Wheaton, IL).

Experiments were arranged in a randomized complete block design with three replications. Individual plots measured 5 by 5 ft. Homogeneity of error variance between years or locations within each study was tested using Bartlett's test and thus data were not combined over years or locations because errors were not homogenous. Analysis of variance was conducted using PROC ANOVA (ver. 9.2, SAS Institute Inc., Cary, NC). Mean separation was determined using Fisher's least significant difference (LSD) at a 0.05 level of probability.

Investigating Sequential Herbicide Applications on Tall Fescue Over Three Seeding Dates

Sequential herbicide application experiments were completed in Nebraska in 2010 and 2011. TF was seeded at 305 lb/A and consisted of 25% each of 'Firenza', 'Inferno', 'Lexington', and 'Avenger'. A 3 by 4 factorial design was used with three seeding dates and four herbicides. Seeding dates were 6 May ± 1 d, 3 June ± 4 d, and 1 July ± 5 d in 2010 and 2011. Treatments within each seeding date included an untreated check, mesotrione at 0.156 lb ai/A applied immediately at seeding (AS) followed by 0.156 lb ai/A 4 WAE, siduron at 3 lb ai/A AS followed by 2 lb ai/A 4 WAE, and quinclorac at 0.75 lb ai/A AS followed by 0.75 lb ai/A 4 WAE. A non-ionic surfactant (Induce; Helena Holding Company, Collierville, TN) at 0.25% v/v was included in the 4 WAE application of mesotrione and methylated seed oil (MSO Concentrate; Loveland Industries, Greeley, CO) at 0.187 gal/A was included in the 4 WAE application of quinclorac according to label recommendation (1,3). Individual plant counts of yellow nutsedge and percent ground cover of TF, broadleaf weeds, crabgrass, or bare soil were visually rated at 4, 6, 8, 10, and 12 WAE, but only data from 8 WAE is presented.

Table 1. ANOVA for percent cover after three herbicides applied at seeding, and 4 wk after emergence of tall fescue (TF), crabgrass (CG), broadleaf weeds (BL), bare soil (BS), or yellow nutsedge (YN) count, in 2010 or 2011 rated 8 wk after application.

Source of variation	2010 TF	2010 CG	2010 BL	2010 BS	2010 YN	2011 TF	2011 CG	2011 BL	2011 BS	2011 YN
Seeding date (SD)	**	**	**	**	NS[z]	**	**	**	**	NS
Herb (H)	**	**	**	**	NS	**	**	**	NS	**
SD*H	**	**	**	*	NS	**	**	**	**	*

*, ** significant at 0.05 or 0.01 levels, respectively.

[z] NS, nonsignificant.

Investigating Single Herbicide Applications at Three Timings At and After Seeding of Tall Fescue or Kentucky Bluegrass

Experiments were completed in Nebraska and Indiana in 2011, with separate but adjacent experiments of TF and KBG at each location. Plots were seeded 17 May ± 2 d, with TF at 305 lb/A or KBG at 87 lb/A. The seed lot of TF was the same as described previously and the KBG seed lot included 25% each of 'Blue Chip Plus KB', Blue Sapphire', 'NuBlue Plus', and 'Everest'. Both locations used a lightweight seed blanket to prevent seed movement, which was removed at emergence.

A 6 by 3 factorial design was used with six herbicides and three application dates. Herbicide treatments included mesotrione at 0.25 lb ai/A, siduron at 6 lb ai/A, quinclorac at 0.75 lb ai/A, quinclorac at 0.50 lb ai/A + carfentrazone at 0.029 lb ai/A, aminocyclopyrachlor at 0.07 lb ai/A, or carfentrazone at 0.031 lb ai/A. Application dates were AS, 0 WAE, or 2 WAE. Individual plant counts of yellow nutsedge and percent ground cover of TF, KBG, broadleaf weeds, crabgrass, or bare soil was visually rated at 2, 4, 6, and 8 WAE, but only 8 WAE is presented.

Effects of Sequential Herbicide Applications on Tall Fescue Over Three Seeding Dates

Significant seeding date × herbicide interactions occurred on almost all dependent variables measured (Table 1). No herbicide treatment reduced cover of TF compared to untreated, regardless of year or seeding date (Table 2). Conversely, herbicides usually improved TF cover by reducing weed competition. In the May seedings, all four herbicides applied provided ≥79% TF cover in both years with only mesotrione improving cover over the untreated plots in 2011 (Table 2). This is a reflection of relatively quick and effective establishment of TF in the May seeding. Willis et al. (25) also found little differences in TF cover in April seedings treated with sequential applications of siduron, quinclorac, or mesotrione applied shortly after seeding. Cover of TF in the June seedings was lower than in the May seedings, likely because of increased weed pressure. For instance, TF cover at 8 WAE in the untreated plots of the June seeding was 37% in 2010 and 10% in 2011, while total weed cover in untreated plots ranged from 61

Table 2. Percent cover[x] of tall fescue (TF), crabgrass (CG), broadleaf weeds (BL), bare soil (BS), or yellow nutsedge (YN) count[z], in 2010 or 2011 rated 8 wk after emergence of TF seeded in May, June, or July and treated with sequential applications of herbicides made at seeding and 4 wk after emergence.

Seeding date	Herbicide	2010 TF	2010 CG	2010 BL	2010 BS	2010 YN	2011 TF	2011 CG	2011 BL	2011 BS	2011 YN
		% cover[x]				count[z]	% cover[x]				count[z]
May	Quinclorac	88[y]	0	10	2	10	94[y]	1	6	0	8
	Mesotrione	92	0	2	6	4	96	1	2	2	4
	Siduron	90	0	8	2	11	89	5	6	0	9
	Untreated	87	0	14	0	11	79	13	7	2	8
June	Quinclorac	72	0	27	2	9	38	2	52	8	9
	Mesotrione	95	0	2	3	4	82	4	9	5	3
	Siduron	88	0	12	0	7	26	37	19	18	10
	Untreated	37	23	38	2	10	10	70	19	1	10
July	Quinclorac	15	1	28	55	6	13	1	58	27	9
	Mesotrione	25	1	3	71	0	58	1	9	31	2
	Siduron	28	20	23	29	7	7	82	8	4	9
	Untreated	15	62	22	1	9	5	85	9	1	10
LSD(0.05)		13.0	11.6	9.5	7.5	NS	15.8	15.4	10.5	16.3	1.5

[x] Cover was rated visually on a scale of 0 to 100%.

[y] Means over three replications.

[z] Individual plant counts of yellow nutsedge.

Table 3. ANOVA for percent cover after single herbicide applications made at seeding, zero weeks after emergence, or 2 wk after emergence of tall fescue (TF), Kentucky bluegrass (KBG), crabgrass (CG), broadleaf weeds (BL), or bare soil (BS) in Nebraska or Indiana rated 8 wk after application.

	Nebraska TF				Indiana TF			
Source of variation	TF	CG	BL	BS	TF	CG	BL	BS
Application timing (AT)	**	**	**	NS[z]	*	**	**	NS
Herbicide (H)	**	**	**	NS	**	**	**	NS
AT * H	**	**	NS	NS	*	*	**	NS
	Nebraska KBG				Indiana KBG			
Source of variation	KBG	CG	BL	BS	KBG	CG	BL	BS
AT	NS	NS	NS	NS	**	NS	**	NS
H	**	**	**	NS	**	**	**	NS
AT * H	**	**	NS	NS	**	**	**	NS

*, ** significant at 0.05 or 0.01 levels, respectively.

[z] NS, nonsignificant.

to 89% in June seedings compared to 14 to 20% in May seedings (Table 2). Mesotrione or siduron provided ≥88% TF cover in the June seeding in 2010, but in 2011, mesotrione provided 82% cover while other herbicide treatments produced ≤38% TF cover (Table 2). For the July seeding, TF cover was 5 to 15% in the untreated plots at 8 WAE and poor TF cover was likely due to poor germination and/or survival of seedlings as bare soil accounted for up to 71% cover at 8 WAE (Table 2). Herbicides had no effect in July 2010 seedings with turf cover ranging from 15 to 28%, but mesotrione provided 58% TF cover in the July 2011 seeding while all other treatments provided ≤13% (Table 2).

Data interpretation from seeding studies is often difficult due to interactions between reduced weed competition from effective herbicide treatments and potential damage to seedling turf from the same treatments (12). However, risking slight herbicide damage to turfgrass seedlings could be compensated for by reduced weed competition. Our results suggest a fast germination and establishing turf like TF can reduce weed competition, reducing the need for herbicide applications after emergence and/or improving the efficacy of herbicide that is applied with aggressively growing and competitive turf. Though the herbicides we evaluated can control weeds and enhance establishment when seeding TF by early June, seeding in July in Nebraska should likely be delayed until the optimum seeding window begins in mid-August.

Crabgrass was the dominant weed with up to 85% cover in the untreated plots. Thus, the successful establishment of TF was largely a reflection of crabgrass control in these experiments. Siduron, quinclorac, and mesotrione resulted in similar cover (≤5%) of crabgrass in the May seedings in both years and the June seeding in 2010. These results are likely due to rapid establishment of TF as reflected in ≤23% crabgrass cover in the untreated plots (Table 2). However, siduron applied in the June seeding of 2011 as well as July seedings of both years resulted in 20 to 82% crabgrass cover, compared to ≤4% crabgrass cover in the mesotrione- or quinclorac-treated plots (Table 2). Hart et al. (13) showed similar results on newly-seeded creeping bentgrass where sequential applications of quinclorac consistently provided effective weed control and turf safety.

Mesotrione was the only herbicide to exhibit some control of yellow nutsedge, with ≤4 plants per plot in 2011 (Table 2). Both PRE and POST control of yellow nutsedge from mesotrione have been previously reported by McCurdy et al. (17). Sequential applications were evaluated in our studies and were effective on yellow nutsedge, which coincides with Dernoeden and Fu's (11) research indicating improved control of yellow nutsedge over the untreated plots with sequential applications (PRE and early POST) of mesotrione compared to single applications.

Mesotrione also consistently resulted in the lowest broadleaf weed cover (2 to 9%) regardless of year or seeding date (Table 2). In the May 2010 seeding, mesotrione was the only herbicide to reduce broadleaf weed cover compared to the untreated plots. Mesotrione or siduron resulted in ≤12% cover of broadleaf weeds in June 2010 which was lower than the untreated plots and quinclorac (Table 2). Quinclorac or mesotrione consistently provided control of ragweed, but quinclorac had little effect on purslane in this study and it became the dominant broadleaf weed in the quinclorac-treated plots (data not shown).

Effects of Single Herbicide Applications at Three Timings At and After Seeding of Tall Fescue or Kentucky Bluegrass

Significant application timing × herbicide interactions occurred on almost all dependent variables measured (Table 3). Mesotrione or siduron applied AS, or mesotrione, quinclorac, or quinclorac+carfentrazone applied 0 WAE produced the highest TF cover (≥77%) in Nebraska (Table 4). Success of TF establishment in Nebraska was reflective of crabgrass control as these same treatments resulted in the lowest crabgrass cover (2 to 14%).

Weed pressure in Indiana was more severe and thus poorer TF establishment occurred with only three treatments producing >50% cover at 8 WAE (Table 4). Mesotrione or siduron applied AS or mesotrione

Table 4. Percent cover[x] of tall fescue (TF), crabgrass (CG), broadleaf weeds (BL), or bare soil (BS) in Nebraska or Indiana in a tall fescue seeding rated 8 wk after emergence when seeded in May and treated with single applications of herbicides made at seeding (AS), zero weeks after emergence (0 WAE), or 2 wk after emergence (2 WAE).

Application timing	Herbicide	Nebraska				Indiana			
		TF	CG	BL	BS	TF	CG	BL	BS
		% cover[x]				% cover[x]			
AS	Quinclorac	60[y]	30	9	1	8[y]	43	32	17
	Aminocyclopyrachlor	52	43	3	2	2	91	3	5
	Carfentrazone	55	37	8	1	2	96	1	1
	Quinclorac + carfentrazone	58	33	8	1	5	88	3	5
	Mesotrione	79	14	5	1	61	35	4	0
	Siduron	77	14	8	1	56	35	8	2
0 WAE	Quinclorac	80	9	10	1	2	0	77	21
	Aminocyclopyrachlor	64	30	2	4	17	57	11	15
	Carfentrazone	53	41	4	1	3	91	4	2
	Quinclorac + carfentrazone	85	10	3	1	17	0	67	16
	Mesotrione	93	2	5	0	80	0	18	2
	Siduron	60	34	5	2	22	64	4	10
2 WAE	Quinclorac	58	35	7	0	6	68	15	11
	Aminocyclopyrachlor	67	29	1	3	5	57	33	5
	Carfentrazone	55	40	4	2	5	74	5	16
	Quinclorac + carfentrazone	58	35	2	5	0	73	23	3
	Mesotrione	55	37	4	4	22	27	43	9
	Siduron	50	42	7	2	2	90	2	7
LSD(0.05)		15.6	16.7	NS	NS	31.1	47.2	27.5	NS
Untreated[z]		52	38	8	2	2	92	7	0

[x] Cover was rated visually on a scale of 0 to 100%.

[y] Means over three replications.

[z] Untreated means were not included in the factorial analysis and thus are shown for reference only.

applied 0 WAE resulted in 56 to 80% TF cover in Indiana compared to ≤22% cover in the rest of the treatments (Table 4). Crabgrass was the primary weed species in Indiana with 92% crabgrass cover in the untreated plots at 8 WAE. Mesotrione applied 0 WAE produced 0% crabgrass cover and thus also resulted in the most TF cover at 80% (Table 4). Quinclorac and quinclorac+carfentrazone applied 0 WAE also produced 0% crabgrass cover, but those treatments resulted in up to 77% cover of broadleaf weeds (Table 4), consisting primarily of prostrate pigweed (*Amaranthus blitoides* S. Wats.), prostrate spurge (*Euphorbia supine* Raf.), and white clover (*Trifolium repens L.*) in addition to the weeds we introduced, although when those same three treatments were applied 2 WAE, crabgrass control was reduced. Mesotrione resulted in 27% crabgrass cover while quinclorac + carfentrazone and quinclorac resulted in 68 to 73% crabgrass cover, respectively (Table 4).

Highest KBG cover was achieved with seven treatments in Nebraska, led by mesotrione applied at 0 WAE (72%) or AS (67%); quinclorac applied 0 WAE (67%), 2 WAE (57%), or AS (52%); aminocyclopyrachlor applied 2 WAE (57%); and siduron applied AS (58%) (Table 5). Like TF, KBG cover in Nebraska was largely governed by crabgrass control as these same seven treatments reduced crabgrass to ≤35% cover (Table 5). Interestingly, aminocyclopyrachlor was considered a POST broadleaf herbicide and still reduced crabgrass cover to 32% when applied 2 WAE. Similar results occurred in early findings from Blume et al. (8) who found slight reductions in crabgrass from aminocyclopyrachlor applications over newly-seeded KBG. Establishment of KBG in Indiana was poor with only three treatments providing >7% KBG cover by 8 WAE led by siduron applied AS (38%) and mesotrione applied AS (17%) or 0 WAE (19%) (Table 5). Poor establishment was likely due to exceptionally hot temperatures in 2011. Additionally, crabgrass pressure was intense on this site in Indiana with 97% crabgrass cover at 8 WAE in the untreated plots. Mesotrione applied 0 WAE resulted in only 2% cover of crabgrass, but unfortunately 75% cover of broadleaf weeds (Table 5).

Though KBG and TF were in adjacent studies and data cannot be statistically compared, our data indicate grass species can also determine success of a spring or summer seeding. In areas like central Indiana and eastern Nebraska where TF and KBG are equally suited for lawns, TF may be a better choice than

Table 5. Percent cover[x] of Kentucky bluegrass (KBG), crabgrass (CG), broadleaf weeds (BL), or bare soil (BS) in Nebraska or Indiana in a Kentucky bluegrass seeding rated 8 wk after emergence when seeded in May and treated with single applications of herbicides made at seeding (AS), zero weeks after emergence (0 WAE), or 2 wk after emergence (2 WAE).

Application timing	Herbicide	Nebraska				Indiana			
		KBG	CG	BL	BS	KBG	CG	BL	BS
		% cover[x]				% cover[x]			
AS	Quinclorac	52[y]	35	11	2	1[y]	73	19	6
	Aminocyclopyrachlor	42	52	4	3	0	92	2	6
	Carfentrazone	28	60	9	2	0	98	0	2
	Quinclorac + carfentrazone	43	47	6	4	0	97	1	2
	Mesotrione	67	23	8	2	17	48	16	19
	Siduron	58	27	14	1	38	33	24	4
0 WAE	Quinclorac	67	22	11	0	2	47	46	6
	Aminocyclopyrachlor	42	52	4	3	0	96	1	2
	Carfentrazone	28	63	6	2	0	98	1	1
	Quinclorac + carfentrazone	20	68	6	6	0	90	7	3
	Mesotrione	72	14	12	1	19	2	75	4
	Siduron	40	47	12	1	0	97	2	1
2 WAE	Quinclorac	57	32	11	1	2	85	9	4
	Aminocyclopyrachlor	57	32	6	6	0	88	3	9
	Carfentrazone	28	60	12	0	0	84	2	13
	Quinclorac + carfentrazone	48	43	7	2	0	93	3	4
	Mesotrione	43	47	9	1	7	35	33	25
	Siduron	30	60	8	2	0	96	1	3
LSD(0.05)		22.3	21.2	NS	NS	11.5	22.8	13.9	NS
Untreated[z]		22	67	7	4	0	97	3	0

[x] Cover was rated visually on a scale of 0 to 100%.

[y] Means over three replications.

[z] Untreated means were not included in the factorial analysis and thus are shown for reference only.

Table 6. Percent broadleaf cover[x] in Nebraska in a Kentucky bluegrass or tall fescue seeding 8 wk after emergence when seeded in May and treated with single applications of herbicides made at seeding (AS), zero weeks after emergence (0 WAE), or 2 wk after emergence (2 WAE).

Herbicide	Kentucky bluegrass	Tall fescue
	% cover[x]	% cover[x]
Quinclorac	11[y]	9[y]
Aminocyclopyrachlor	5	2
Carfentrazone	9	5
Quinclorac + Carfentrazone	6	4
Mesotrione	10	5
Siduron	11	6
LSD(0.05)	2.9	2.2
Untreated[z]	7	8

[x] Cover was rated visually on a scale of 0 to 100%.

[y] Means over three replications and three application dates.

[z] Untreated means were not included in the factorial analysis and thus are shown for reference only.

KBG. If spring- or summer-seeding must be done, TF should be considered given its rapid germination and establishment, allowing it to favorably compete with germinating weeds. Though they did not compare KBG and TF in their work, Stier and Koeritz (24) also indicate that late spring seedings of TF provided acceptable quality of turf by July.

Though yellow nutsedge, purslane, or ragweed did not establish well in Nebraska or Indiana, aminocyclopyrachlor and quinclorac+carfentrazone resulted in the lowest cover of broadleaves in Nebraska TF or KBG when averaged over application timing (Table 6). No differences in yellow nutsedge counts were seen regardless of location or application timing (data not shown).

Late summer or fall are commonly recommended as the preferred seasons to plant cool-season grasses, primarily to overcome competition from summer annual weeds (7,9,22). Though spring seeding of cool-season turf is intensive because of irrigation and weed management requirements, our results reinforce that seeding earlier in the spring is more effective than seeding in the early summer. Additionally, the newly-labeled herbicides we tested can improve establishment of cool-season grasses seeded in spring or summer. None of the herbicide treatments used in this study inhibited establishment of desired turf, but some herbicides were more effective on individual weed species than others. Our single applications study showed that multiple applications are likely needed to achieve satisfactory weed control in spring seedings. Overall, mesotrione was the most consistent in controlling the weed species in our study over all dates and locations, and multiple applications of mesotrione can improve weed control and establishment of desired turf. Quinclorac and quinclorac+carfentrazone were effective in controlling crabgrass and most broadleaves, although quinclorac alone provided little to no control of purslane.

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