

Indaziflam and Pyroxasulfone on Turfgrass Establishment for Seed looking at Crop Tolerance and Weed Efficacy

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The study objective was to evaluate the weed efficacy and crop tolerance of indaziflam (Alion) and pyroxasulfone (Zidua) for preemergence control of annual grass weeds in turfgrass varieties commonly grown for seed in the Pacific Northwest (PNW). For study 1 and 2, the weeds targeted for control were downy brome (*Bromus tectorum*), rattail fescue (*Vulpia myuros*), alkali grass (*Puccinellia distans*) and annual bluegrass (*Poa annua*). For study 3, rattail fescue (*Vulpia myuros*) was the only weed targeted for control. Mesotrione (Callisto) was included as an industry standard.

Studies 1 and 3 were established at the USDA Central Ferry Farm located on the Snake River about 60 miles southwest of Pullman, WA. Study 2 was established at the Palouse Conservation Field Station (PCFS) near Pullman, WA. All studies were planted at 4 lb seed A⁻¹ using a double-disk grain drill modified to provide very little closing pressure. Study 3 was fertilized at a rate of 45 lb nitrogen A⁻¹ (studies 1 and 2 were not fertilized). Plots on studies 1 and 3 (study 2 was not irrigated) were sprinkler irrigated 0.5" every other day for an hour. Plots were 7' by 30' long for study 1 and 3, and 8' by 50' for study 2. Treatments on all studies were applied using a backpack sprayer calibrated to deliver 15 GPA through four 11003 VS flat fan nozzles, detailed in Tables 1, 2a, 2b, 3a, 4a, and 4b. Treatments were applied preemergence (PRE) at planting (Application A), and postemergence (Application B) to turfgrass at the 3-leaf stage. All studies were conducted in a randomized complete block design with 4 replications.

All studies were carbon-seeded to smooth, crop residue-free seedbeds using a spray unit of four 8008 flat nozzles behind the drill with no screens situated 3-4" above the ground. Proper agitation to keep the carbon in suspension was required. Four rows were planted per variety. Activated carbon was mixed with water at 0.5 lb gal⁻¹ (1:2 ratio). The following turfgrass varieties were carbon-seeded on 12-inch row spacing: Study 1, two elite Kentucky bluegrass varieties (Dauntless and Diva) and two varieties of perennial ryegrass (Playfast and Prominent), study 2: two elite Kentucky bluegrass varieties (Dauntless and Diva) and three varieties of perennial ryegrass (Pillar, Playfast and Prominent) and for study 3: one elite Kentucky bluegrass variety (Dauntless) and three varieties of perennial ryegrass (Pillar, Playfast and Prominent). For study 1 and 2, carbon was applied at 135 lb A⁻¹ in a 3-inch band (equal to a 1,020 lb A⁻¹ broadcast application) and for study 3, carbon was applied at 45 lb A⁻¹ in a 1-inch band (equal to a 540 lb A⁻¹ broadcast application). Similarly, two rows of downy brome, rattail fescue, alkali grass, and annual bluegrass for study 1 and study 2, and four rows of rattail fescue for study 3 were planted with twelve-inch row spacing without the carbon band over the seeded row.

Seedlings in one-meter row of each turfgrass variety and weed species mentioned above were assessed for density for all studies at the 2-leaf and 5-leaf stage to determine stand establishment of turfgrass varieties and weed control detailed in Tables 2a, 2b, 3a, 4a, and 4b. Two-meter rows (at random per plot) of turfgrass biomass and rattail fescue biomass were taken on July 22, 2019 (4 weeks after postemergence application) for study 3 detailed in Table 4c. Collected biomass samples were placed in an oven at 60°C and allowed to dry for 48 hours. Biomass was weighed in grams. All data was analyzed by using analysis of variance (ANOVA) to compare group means in SAS 9.4 software, with treatments as the fixed effect and block as random. Studies were analyzed separately.



Results

For study 1, indaziflam, pyroxasulfone, and mesotrione applied at any rate had no effect on turfgrass densities at the 2-leaf or 5-leaf stage compared to the nontreated control (Table 2a). Weed densities for downy brome, alkali grass, and annual bluegrass were not affected by any treatment due to late germination. Rattail fescue density at 2-leaf or 5-leaf stage were significantly affected by PRE applications of indaziflam and pyroxasulfone alone at the lowest and highest rates having zero germination compared to the nontreated control at 14 plants per meter-row detailed in Tables 2a and 2b. Indaziflam in combination with mesotrione, pyroxasulfone in combination with mesotrione, and mesotrione alone applied POST to rattail fescue were no different (4 - 10 plants m⁻¹) from the nontreated (14 plants m⁻¹) detailed in Tables 2a and 2b. Study 1 was terminated after geese fed on the study at an early stage, which prevented the establishment of turfgrass species.

For study 2, indaziflam, pyroxasulfone, and mesotrione applied at any rate had no effect on turfgrass densities at the 2-leaf stage compared to the nontreated control. Weed densities for downy brome, alkali grass, annual bluegrass, and rattail fescue were not affected by any treatment. The study was terminated prior to POST treatments due to failure of establishment of turfgrass species and lack of rainfall in the fall of 2018.

For study 3, indaziflam, pyroxasulfone, and mesotrione applied at any rate had no effect on Dauntless, Pillar, and Prominent turfgrass densities at the 2-leaf or 5-leaf stage compared to the nontreated control. However, Playfast density at the 2-leaf or 5-leaf stage were affected by pyroxasulfone PRE alone applied at the highest rate [(8 plants m⁻¹ (2-leaf); 10 plants m⁻¹ (4-leaf)] compared to the nontreated control (25 plants m⁻¹) detailed in Tables 4a and 4b. Rattail fescue density at 2-leaf and 5-leaf stage showed 100% control (0 plants m⁻¹) with PRE applications of indaziflam and pyroxasulfone alone at the lowest and highest rates compared to the nontreated control (37 - 36 plants m⁻¹) detailed in Tables 4a and 4b. Based on dry biomass, indaziflam, pyroxasulfone, and mesotrione applied at any rate did not have an effect on Dauntless and Pillar compared to the nontreated control (Dauntless plants established a lower density which is reflected on the biomass collected). However, biomass of Playfast and prominent decreased significantly with PRE and POST applications of pyroxasulfone alone or in combination with mesotrione detailed in Table 4c. Rattail fescue biomass decreased significantly (100%) with PRE and POST applications of indaziflam and pyroxasulfone alone or applied in combination with mesotrione.

Table 1. Treatment application details

	Study 1	Study 2	Study 3	
Study Application	PRE	PRE	PRE	POST
Location (WA)	Central Ferry	Pullman	Central Ferry	
Date	10/1/2018	10/15/2018	5/28/2019	6/26/2019
Air temperature (°F)	81	60.3	85	76.7
Soil temperature (°F)	75	42	65	60
Wind velocity (mph, direction)	2.3, SW	3.6, SE	0.7, SW	3.6, NE
Cloud Cover	0%	0%	0%	0%

Table 2a. Density of turfgrass varieties (*Dauntless*, *Diva*, *Playfast* and *Prominent*) and grass weeds (annual bluegrass, alkali grass, downy brome and rattail fescue) species for study 1 at the 2-leaf stage after PRE application. POST applications were applied later to 3-leaf turfgrass. ICB1019. Central Ferry, WA 2018. Means followed by the same letter are not significantly different ($\alpha=0.05$).

STUDY 1			Density (After PRE at 2-leaf stage)							
			Fall 2018, Central Ferry							
Active Ingredient ^a	Rate	Application Description	Turfgrass Varieties				Invasive Annual Grass Weeds			
			Kentucky bluegrass		Perennial ryegrass		Annual bluegrass	Alkali grass	Downy brome	Rattail fescue
			Dauntless	Diva	Playfast	Prominent				
<i>lb ai A⁻¹</i>			<i># m⁻²</i>							
Nontreated	-	-	0	0	1	13	0	0	0	14 a
Indaziflam	0.007	PRE	0	0	7	8	0	0	0	0 d
Indaziflam	0.013	PRE	0	0	2	10	0	0	0	0 d
Indaziflam	0.007	PRE								
Indaziflam	0.007	POST	0	0	3	2	0	0	0	0 d
Mesotrione	0.188	POST								
NIS		POST								
Indaziflam	0.007	POST								
Mesotrione	0.188	POST	0	0	1	4	3	0	0	12 ab
NIS		POST								
Indaziflam	0.013	POST								
Mesotrione	0.188	POST	0	0	6	6	0	0	0	5 cd
NIS		POST								
Pyroxasulfone	0.080	PRE	0	0	3	8	0	0	0	0 d
Pyroxasulfone	0.160	PRE	0	0	4	5	0	0	0	0 d
Pyroxasulfone	0.080	PRE								
Pyroxasulfone	0.080	POST	0	0	2	3	0	0	0	0 d
Mesotrione	0.188	POST								
NIS		POST								
Pyroxasulfone	0.080	POST								
Mesotrione	0.188	POST	0	0	1	3	0	0	0	7 bc
NIS		POST								
Pyroxasulfone	0.160	POST								
Mesotrione	0.188	POST	0	0	1	0	0	0	0	10 abc
NIS		POST								
Mesotrione	0.188	POST	0	0	1	3	0	0	0	4 cd
NIS		POST								
<i>LSD (p-value = 0.05):</i>			<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>6.11</i>

^a A Nonionic surfactant (NIS) was applied at a rate of 0.25% V/V

Table 2b. Density of turfgrass varieties (*Dauntless*, *Diva*, *Playfast* and *Prominent*) and grass weeds (annual bluegrass, Alkali grass, Downy brome and Rattail fescue) species for study 1 at the 5-leaf stage after both PRE and POST applications. POST applications were applied to 3-leaf turfgrass. ICB1019. Central Ferry, WA 2019. Means followed by the same letter are not significantly different ($\alpha=0.05$).

STUDY 1			Density (After PRE & POST at 5-leaf stage)							
			Spring 2019, Central Ferry							
Active Ingredient ^a	Rate	Application Description	Turfgrass Varieties				Invasive Annual Grass Weeds			
			Kentucky bluegrass		Perennial ryegrass		Annual bluegrass	Alkali grass	Downy brome	Rattail fescue
			Dauntless	Diva	Playfast	Prominent				
<i>lb ai A⁻¹</i>			<i># m⁻²</i>							
Nontreated	-	-	5	1	7	12	5	5	6	14 a
Indaziflam	0.007	PRE	4	0	5	5	0	3	4	0 d
Indaziflam	0.013	PRE	6	0	5	5	1	0	6	0 d
Indaziflam	0.007	PRE								
Indaziflam	0.007	POST	0	0	3	4	1	0	0	0 d
Mesotrione	0.188	POST								
NIS		POST								
Indaziflam	0.007	POST								
Mesotrione	0.188	POST	8	0	6	4	4	10	8	12 ab
NIS		POST								
Indaziflam	0.013	POST								
Mesotrione	0.188	POST	0	0	3	4	0	5	0	5 cd
NIS		POST								
Pyoxasulfone	0.080	PRE	3	0	4	6	0	2	3	0 d
Pyoxasulfone	0.160	PRE	1	0	4	6	0	0	0	0 d
Pyoxasulfone	0.080	PRE								
Pyoxasulfone	0.080	POST	3	0	3	5	0	0	3	0 d
Mesotrione	0.188	POST								
NIS		POST								
Pyoxasulfone	0.080	POST								
Mesotrione	0.188	POST	0	0	2	2	0	2	0	7 bc
NIS		POST								
Pyoxasulfone	0.160	POST								
Mesotrione	0.188	POST	8	0	3	3	2	3	8	8 abc
NIS		POST								
Mesotrione	0.188	POST	1	0	4	3	3	1	1	6 bcd
NIS		POST								
<i>LSD (p-value = 0.05):</i>			<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>6.41</i>

^a Nonionic surfactant (NIS) was applied at a rate of 0.25% V/V

Table 3a. Density of turfgrass varieties (*Dauntless*, *Diva*, *Pillar*, *Playfast* and *Prominent*) and grass weeds (annual bluegrass, alkali grass, downy brome and rattail fescue) species for study 2 at the 2-leaf stage after PRE application. POST applications were applied later to 3-leaf turfgrass. ICB1119 Palouse Conservation Field Station, WA 2018. Means followed by the same letter are not significantly different ($\alpha=0.05$).

STUDY 2			Density (After PRE at 2-leaf stage)								
			Fall 2018, Palouse Conservation Field Station								
Active Ingredient ^a	Rate	Application Description	Turfgrass Varieties					Invasive Annual Grass Weeds			
			Kentucky bluegrass			Perennial ryegrass		Annual bluegrass	Alkali grass	Downy brome	Rattail fescue
			Dauntless	Diva	Pillar	Playfast	Prominent				
			lb ai A ⁻¹					# m ⁻¹			
Nontreated			2	1	2	3	6	1	7	1	2
Indaziflam	0.007	PRE	10	2	5	7	5	5	2	1	0
Indaziflam	0.013	PRE	8	2	7	11	5	5	0	0	0
Indaziflam	0.007	PRE									
Indaziflam	0.007	POST	2	1	4	8	11	3	0	0	1
Mesotrione	0.188	POST									
NIS		POST									
Indaziflam	0.007	POST									
Mesotrione	0.188	POST	8	3	4	5	3	1	2	2	1
NIS		POST									
Indaziflam	0.013	POST									
Mesotrione	0.188	POST	11	3	4	9	8	0	2	0	0
NIS		POST									
Pyroxasulfone	0.080	PRE	8	5	9	6	2	0	0	1	0
Pyroxasulfone	0.160	PRE	9	2	2	6	9	0	0	0	1
Pyroxasulfone	0.080	PRE									
Pyroxasulfone	0.080	POST	4	4	3	3	9	3	4	1	0
Mesotrione	0.188	POST									
NIS		POST									
Pyroxasulfone	0.080	POST									
Mesotrione	0.188	POST	5	1	6	4	5	1	2	1	4
NIS		POST									
Pyroxasulfone	0.160	POST									
Mesotrione	0.188	POST	10	2	4	6	9	2	3	1	1
NIS		POST									
Mesotrione	0.188	POST	8	1	6	10	5	5	3	0	0
NIS		POST									
<i>LSD (p-value = 0.05):</i>			<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>

^a Nonionic surfactant (NIS) was applied at a rate of 0.25% V/V

Table 4a. Density of turfgrass varieties (*Dauntless*, *Pillar*, *Playfast* and *Prominent*) and rattail fescue for study 3 at the 2-leaf stage after PRE application. POST applications were applied later to 3-leaf turfgrass. ICB2419. Central Ferry, WA 2019. Means followed by the same letter are not significantly different ($\alpha=0.05$).

STUDY 3			Density (After PRE at 2-leaf stage)				
			Spring 2019, Central Ferry				
Active Ingredient ^a	Rate	Application Description	Turfgrass Varieties				Invasive Annual Grass Weed
			Kentucky bluegrass		Perennial ryegrass		Rattail fescue
			Dauntless	Pillar	Playfast	Prominent	
			----- # m ⁻¹ -----				
Nontreated			16	34	26 abc	43	37 ab
Indaziflam	0.007	PRE	23	34	20 abcd	42	0 c
Indaziflam	0.013	PRE	11	23	14 cd	41	0 c
Indaziflam	0.007	PRE					
Indaziflam	0.007	POST	2	39	31 a	43	0 c
Mesotrione	0.188	POST					
NIS		POST					
Indaziflam	0.007	POST					
Mesotrione	0.188	POST	6	48	16 bcd	36	13 bc
NIS		POST					
Indaziflam	0.013	POST					
Mesotrione	0.188	POST	19	43	30 a	48	32 ab
NIS		POST					
Pyoxasulfone	0.080	PRE	5	22	16 bcd	35	0 c
Pyoxasulfone	0.160	PRE	4	32	8 d	31	0 c
Pyoxasulfone	0.080	PRE					
Pyoxasulfone	0.080	POST	2	33	19 abcd	39	0 c
Mesotrione	0.188	POST					
NIS		POST					
Pyoxasulfone	0.080	POST					
Mesotrione	0.188	POST	12	27	29 ab	47	38 bc
NIS		POST					
Pyoxasulfone	0.160	POST					
Mesotrione	0.188	POST	11	44	21 abc	37	33 ab
NIS		POST					
Mesotrione	0.188	POST	8	43	25 abc	50	42 a
NIS		POST					
			NS	NS	13.34	NS	25.78

^a Nonionic surfactant (NIS) was applied at a rate of 0.25% V/V

Table 4b. Density of turfgrass varieties (*Dauntless*, *Pillar*, *Playfast* and *Prominent*) and rattail fescue for study 3 at the 5-leaf stage after both PRE & POST applications. ICB2419 Central Ferry, WA 2019. Means followed by the same letter are not significantly different ($\alpha=0.05$).

STUDY 3			Density (After PRE & POST at 5-leaf stage)				
			Spring 2019, Central Ferry				
Active Ingredient ^a	Rate	Application Description	Turfgrass Varieties				Invasive Annual Grass Weed
			Kentucky bluegrass		Perennial ryegrass		Rattail fescue
			Dauntless	Pillar	Playfast	Prominent	
<i>lb ai A⁻¹</i>			<i># m⁻¹</i>				
Nontreated			3	35	25 abc	39	36 a
Indaziflam	0.007	PRE	5	32	22 abc	38	0 c
Indaziflam	0.013	PRE	4	33	18 bcd	40	0 c
Indaziflam	0.007	PRE					
Indaziflam	0.007	POST					
Mesotrione	0.188	POST	2	37	30 a	35	0 c
NIS		POST					
Indaziflam	0.007	POST					
Mesotrione	0.188	POST	5	45	19 bcd	39	4 c
NIS		POST					
Indaziflam	0.013	POST					
Mesotrione	0.188	POST	7	35	26 ab	39	6 c
NIS		POST					
Pyroxasulfone	0.080	PRE	2	28	16 cd	36	0 c
Pyroxasulfone	0.160	PRE	1	31	10 d	28	0 c
Pyroxasulfone	0.080	PRE					
Pyroxasulfone	0.080	POST					
Mesotrione	0.188	POST	3	30	16 cd	24	0 c
NIS		POST					
Pyroxasulfone	0.080	POST					
Mesotrione	0.188	POST	0	25	23 abc	32	7 c
NIS		POST					
Pyroxasulfone	0.160	POST					
Mesotrione	0.188	POST	2	51	18 bcd	35	6 c
NIS		POST					
Mesotrione	0.188	POST					
NIS		POST	4	41	24 abc	50	21 b
			NS	NS	9.82	NS	11.19

^a Nonionic surfactant (NIS) was applied at a rate of 0.25% V/V

Table 4c. Biomass for turfgrass varieties (Dauntless, Pillar, Playfast and Prominent) and weed (rattail fescue) biomass for study 3. ICB2419. Central Ferry, WA 2019. Means followed by the same letter are not significantly different ($\alpha=0.05$).

STUDY 3			Biomass (4 weeks after POST)				
			Spring 2019, Central Ferry				
Active Ingredient ^a	Rate	Application Description	Turfgrass Varieties				Invasive Annual Grass Weed
			Kentucky bluegrass		Perennial ryegrass		Rattail fescue
			Dauntless	Pillar	Playfast	Prominent	
			----- g m ⁻¹ -----				
Nontreated			0	5	5.0 bcde	7.0 bcde	2 a
Indaziflam	0.0065	PRE	0	3	5.4 bc	7.2 abcd	0 b
Indaziflam	0.013	PRE	0	33	4.5 cd	7.2 abcd	0 b
Indaziflam	0.0065	PRE					
Indaziflam	0.0065	POST					
Mesotrione	0.188	POST	0	2	9.5 a	8.4 abc	0 b
NIS		POST					
Indaziflam	0.0065	POST					
Mesotrione	0.188	POST	0	3	6.0 abc	12.0 a	0 b
NIS		POST					
Indaziflam	0.013	POST					
Mesotrione	0.188	POST	0	9	4.5 cd	3.8 cde	0 b
NIS		POST					
Pyroxasulfone	0.08	PRE	0	3	5.2 bc	9.4 ab	0 b
Pyroxasulfone	0.16	PRE	1	5	1.0 d	4.2 cde	0 b
Pyroxasulfone	0.08	PRE					
Pyroxasulfone	0.08	POST	0	4	1.3 de	2.8 de	0 b
Mesotrione	0.188	POST					
NIS		POST					
Pyroxasulfone	0.08	POST					
Mesotrione	0.188	POST	0	3	2.8 cd	2.3 e	0 b
NIS		POST					
Pyroxasulfone	0.16	POST					
Mesotrione	0.188	POST	1	1	1.3 de	2.3 e	0 b
NIS		POST					
Mesotrione	0.188	POST	0	6	8.5 ab	9.5 ab	2 a
NIS		POST					
			NS	NS	3.79	4.75	1.04

^a Nonionic surfactant (NIS) was applied at a rate of 0.25% V/V

Disclaimer

Some of the pesticides discussed in this presentation were tested under an experimental use permit granted by WSDA. Application of a pesticide to a crop or site that is not on the label is a violation of pesticide law and may subject the applicator to civil penalties up to \$7,500. In addition, such an application may also result in illegal residues that could subject the crop to seizure or embargo action by WSDA and/or the U.S. Food and Drug Administration. It is your responsibility to check the label before using the product to ensure lawful use and obtain all necessary permits in advance.