WEED MANAGEMENT RESEARCH IN ALFALFA SEED PRODUCTION IN WASHINGTON STATE

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ABSTRACT

Weed control is an important component of producing high quality and high yielding alfalfa seed. Alfalfa seed is produced with wider row and lower plant populations than alfalfa forage requiring greater weed management inputs. Flumioxazin (Chateau) was evaluated for weed control in alfalfa seed and forage production in 2007 and 2008. February dormant applications of flumioxazin plus paraquat to alfalfa planted the previous fall inhibited early growth and forage yields of the first cutting of alfalfa in 1 of 2 years. Alfalfa forage yield of the second cutting was not reduced by flumioxazin. Established alfalfa treated with flumioxazin in February produced seed yields similar to treating with other currently registered preemergence herbicides or paraquat alone. Forage yield of established alfalfa treated with flumioxazin in February was similar to that treated with currently registered herbicides. Alfalfa exhibited good tolerance to asulam (Asulox) in forage and seed production trials in 2007 and 2008. Carfentrazone (Aim) has promise as a 'set back' herbicide for alfalfa seed production.

INTRODUCTION

Weed control is important in alfalfa seed production in order to produce high quality seed and maximize yields. During seed cleaning and conditioning, large amounts of valuable alfalfa seed can be lost when removing weed seeds. Several weeds such as dodder can never be removed entirely, which may result in not being able to sell the alfalfa seed. All management factors such as field selection, crop rotation, tillage, seed source, cultivation, irrigation, herbicides and harvest methods must be used together (integrated) to effectively control weeds.

Most alfalfa seed producers in Washington State plant alfalfa in August and may leave the field in seed production for several years. Cultural practices for alfalfa seed production are significantly different than for hay production. Alfalfa grown for seed is planted in much thinner stands than that grown for forage. This a practice enhances seed production by reducing the number of aborted flowers, reducing competition between plants and lodging, reducing foliar diseases, and allows pollinators to work more efficiently. Normal row spacing ranges from 20 to 30 inches. Wider row spacing and lower plant populations used in seed production necessitate more intensive weed management practices than in forage production. Alfalfa stands tend to thicken with time and stands are normally thinned in the spring by cross-cultivating.

Preemergence or preplant incorporated herbicides registered for new seedings of alfalfa in Washington include benefin (Balan), EPTC (Eptam), and trifluralin (Treflan). Early postemergence herbicides with preemergence activity include pendimethalin (Prowl), imazethapyr (Pursuit), and imazamox (Raptor). Postemergence broadleaf herbicides include 2,4-

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DB (Butyrac), bromoxynil (Buctril), and bentazon (Basagran). Postemergence grass control can be achieved with sethoxydim (Poast), fluazifop (Fusilade), clethodim (Select), and quizalofop (Assure II) in both new seedings and established stands.

Several herbicides are available for weed control in established alfalfa seed fields in Washington State. Paraquat (Gramoxone) is often used in the fall to dessicate weeds and alfalfa to facilitate burning later in the winter. Selective soil-residual herbicides [hexazinone (Velpar), terbacil (Sinbar), pendimethalin (Prowl), metribuzin (Sencor), trifluralin (Treflan), norflurazon (Zorial), pronamide (Kerb), imazethapyr (Pursuit), simazine (Simazine 4L) and diuron (Karmex)] can be applied in the late autumn or very early spring to dormant established alfalfa for control of annual grasses and/or broadleaf weeds.

Currently, we are conducting field trials to identify additional herbicides that can be selectively used for weed control in alfalfa and determining the effects of cultural practices (plant and row spacing) and irrigation on weed establishment, herbicide efficacy, and weed seed viability and decline. This presentation will focus on tolerance of alfalfa to flumioxazin (Chateau) and several other promising herbicides, carfentrazone (Aim) and asulam (Asulox), that may be registered in the near future for alfalfa seed production.

RESEARCH TRIALS

Fall-seeded alfalfa tolerance to flumioxazin in 2007 and 2008. Flumioxazin (Chateau) is protox inhibitor with activity on numerous broadleaf weeds including prickly lettuce and kochia, two weeds that often escape current control measures in new alfalfa seedings. Tolerance of fall-seeded alfalfa was tested in 2006-07 and 2007-08 by planting alfalfa (var. 'Perfect' in 2006 and var. 'Hybriforce 400' in 2007 on three dates; August 15, September 5, and September 26 in order to establish three distinct growth stages of alfalfa entering the winter. The soil was a Warden sandy loam soil with 1.0% O.M. located at the WSU-Prosser IAREC. Alfalfa was seeded with a drill at 25 lbs seed/acre and sprinkler irrigated with hand lines both years.

Flumioxazin was applied at 0.125 and 0.25 lb ai/a (2X proposed labeled rate) with 0.5 lb ai/a paraquat (Gramoxone) to dormant alfalfa February 4, 2007 and February 19, 2008. An additional treatment of paraquat alone at 0.5 lb ai/a was included in 2007-08 study. Herbicides were applied with a bicycle sprayer in a spray volume of 25 gpa and included COC at 1% (v/v) spray solution. Treatments were replicated 4 times in a split plot design with alfalfa planting date as main plots and herbicide treatments as split plots. Alfalfa hay was harvested May 15 or 23 and June 20, 2007 and May 21 and July 9, 2008 with a sickle bar mower and the hay yield determined after oven drying at 60 C.

Alfalfa height ranged from 2.5 to 15.7 cm in mid November 2006 and from 2.5 to 19.6 cm in 2007 depending on planting date (Table 1). Flumioxazin had little or no effect on alfalfa stand in both years (data not shown). In 2007, flumioxazin plus paraquat injured the late planting of alfalfa the most (about 30%) in early April with the 2X rate of 0.25 lb ai/a causing more injury than 0.125 lb ai/a. In 2008, flumioxazin plus paraquat injured the two later plantings of alfalfa the most (about 8 to 11%) in early April, whereas the early planting date was injured less than

5%. Paraquat alone also injured alfalfa, but slightly less than the combination of flumioxazin plus paraquat.

Table 1. Effect of alfalfa planting date on growth of newly seeded alfalfa near Prosser, WA in 2006 and 2007.

	Nov. 13, 2006		Nov. 13, 2007	
	Height	Root length	Height	Root length
Planting date	(cm)	(cm)	(cm)	(cm)
August 15	15.7	26.1	19.6	28.2
September 5	4.6	14.7	4.6	10.9
September 26	2.5	8.8	2.5	6.4

Alfalfa hay yield of the first two cuttings decreased with later planting dates in both years (Table 2). Yield from the first cutting in averaged 2.7-2.9, 1.8-1.9, and 1.6-1.7 ton dry/acre from the early, mid, and late planting dates, respectively. In 2007, averaged over the three planting dates, flumioxazin at 0.125 and 0.25 lb ai/a reduced first cutting hay yield 18 and 25%, respectively, compared to nontreated checks (Table 2). Flumioxazin had no effect on hay yield from the second cutting. Early planted alfalfa yielded 31% more than late planted alfalfa on the second cutting in 2007. In 2008, planting date did not affect the hay yield of the second cutting, which averaged 1.5 ton dry/acre. In 2008, there was no effect of herbicide treatment on hay yield in the first two cuttings (Table 2).

Table 2. Effect of alfalfa planting date and flumioxazin (Chateau) and paraquat (Gramoxone) applied in February on early season hay yield of fall-seeded alfalfa near Prosser, WA in 2007 and 2008.

	Alfalfa hay yield			
	2007		2008	
	1st cutting	2nd cutting	1st cutting	2nd cutting
	May 15[1]	June 20	May 21	July 9
Planting date	----------(ton dry hay/acre)----------			
August 15	2.7	1.7	2.9	1.6
September 5	1.8	1.6	1.9	1.5
September 26	1.6	1.3	1.7	1.6
Lsd (0.05)	0.29	0.19	0.56	n.s.
Herbicide (lb ai/a)[1]				
Flumioxazin[2] (0.125)	1.9	1.5	2.2	1.5
Flumioxazin (0.25)	1.8	1.5	2.0	1.5
Paraquat (0.5)	--	--	2.2	1.5
Nontreated	2.4	1.6	2.4	1.6
Lsd (0.05)	0.11	n.s.	n.s.	n.s.

[1]Late planted alfalfa (Sept. 26) was cut May 23, 2007.
[2]Both flumioxazin treatments included paraquat at 0.5 lb ai/a and COC at 1% (v/v) spray solution.

Based on these results on early season forage yields, we would speculate that flumioxazin applied in February to an alfalfa seed field planted in August or early September would likely have little or no negative impact on alfalfa seed yield the following summer. Further studies measuring actual seed yields of newly seeded alfalfa following flumioxazin application are needed to confirm this.

Tolerance of a commercial established alfalfa seed crop to flumioxazin - 2008. Alfalfa, tolerance to flumioxazin applied to dormant alfalfa was tested on a grower field near Touchet, WA in 2008. An established alfalfa seed field grown under sprinkler irrigation was selected and herbicides were applied by the grower with his field sprayer. An area of 10.4 acres of the field was treated with simazine plus pendimethalin and an area of 4.6 acres was treated with flumioxazin at 0.125 lb ai/a plus pendimethalin in February, 2008. Treatments were not replicated. Normal production practices were followed throughout the growing season and the seed crop was harvested with a combine equipped with a GPS yield monitoring system. The section of the field treated with simazine produced 1228 lb seed/acre versus 1134 lb seed/acre on the section treated with flumioxazin. Weed control was excellent and similar among the two herbicide treatments with the exception of wild oats, which were only present in the flumioxazin treated area.

Tolerance of established alfalfa to flumioxazin and hexazinone – 2008. Hexazinone (Velpar) plus paraquat, flumioxazin (Chateau) plus paraquat, and paraquat alone were applied February 26, 2008 to an established 2-year-old stand of alfalfa, var. Perfect at theWSU-Roza unit near Prosser, WA. (Table 3). Herbicides were applied with a bicycle sprayer delivering 25 gpa. Treatments were replicated six times in a RCB design.

Hexazinone plus paraquat injured alfalfa the greatest in mid March, averaging 8.3% injury, but the injury was transient, dissipated after several weeks, and no injury was observed later in April. Very little or no injury was observed with flumioxazin plus paraquat or paraquat alone treatments in March, averaging only 0 and 1%, respectively.

Table 3. Control of winter annual mustards and alfalfa forage yield of the first cutting after treating with three herbicide treatments applied February 26, 2008 near Prosser, WA.

Herbicide	Rate	Control May 14, 2008 Flixweed & Shepherd's Purse	1st Cutting May 29, 2008 Alfalfa Hay
	lb ai/a	%	Ton dry/a
Hexazinone (Velpar)+ paraquat (Gramoxone)	0.75 + 0.5	100	2.1
Flumioxazin (Chateau) + paraquat (Gramoxone)	0.125 + 0.5	83	2.2
Paraquat (Gramoxone)	0.5	48	2.0
LSD (0.05)		2.77	0.234

Herbicides applied to dormant alfalfa in February 26, 2008.

Hexazinone plus paraquat completely controlled all winter annual weeds across all irrigation levels prior to the first cutting of alfalfa in late May (Table 3). Flumioxazin plus paraquat

controlled winter annual weeds well with the exception of flixweed and shepherd's purse and averaged 83% control of these two species. Paraquat alone treatment resulted in the greatest number of flixweed and shepherd's purse prior to the first cutting of alfalfa, averaging 48% control (Table 3).

Tolerance of established alfalfa to spring-applied herbicides - 2008. Alfalfa tolerance to ten herbicide treatments was evaluated on a Warden silt loam soil at the WSU-Roza unit near Prosser, WA. Alfalfa, var. Perfect was seeded in May of 2006. Chateau (flumioxazin) and Spartan (sulfentrazone) were applied to dormant alfalfa with Gramoxone (paraquat) on February 27, 2008. A treatment of paraquat alone was included for comparison. The remaining herbicide treatments were applied March 25, 2007 when alfalfa was 2 to 4 inches tall. Herbicides were applied with a backpack sprayer delivering 20 gpa. Plots were 5 feet by 20 feet and treatments replicated three times in a RCB design. Alfalfa injury was visually rated four times and hay yield determined on May 29, 2008. Hay was harvested from a 28 inch by 20 foot swath from the center of each plot. Hay was weighed, air dried, and yields are reported as dry tons/acre.

Dormant applications of Chateau and Spartan with Gramoxone did not injure alfalfa and hay yields were equal to alfalfa treated with Gramoxone alone which averaged 2.45 tons dry wt/acre (Table 4). Early postemergence applications of Resource (flumiclorac) and Blizzard (fluthiacet-methyl) injured alfalfa initially, but by late April no injury was evident and hay yields were equal to nontreated checks which averaged 2.5 tons dry wt/acre (Table 4).

Table 4. Alfalfa injury and forage yield of first cutting after treating with eleven herbicide treatments applied either PRE (February 27, 2008) or POST (March 25, 2008) near Prosser, WA.

				Alfalfa Injury								Alfalfa Hay Yield	
				3/31/08		4/14/08		4/23/08		4/28/08		5/29/08	
	Treatment	Rate (lb ai/a)	Applic.	----------%----------								dry T/a	
1	Chateau (flumioxazin) Gramoxone Inteon (paraquat)	0.13 0.5	PRE	0	c	0	f	0	f	0	d	2.66	ab
2	Spartan (sulfentrazone) Gramoxone Inteon (paraquat)	0.19 0.5	PRE	0	c	1	f	0	f	0	d	2.54	ab
3	Gramoxone Inteon (paraquat)	0.5	PRE	0	c	0	f	0	f	0	d	2.45	b
4	Resource (flumiclorac)	0.04	POST	6	b	10	c	7	c	0	d	2.53	ab
5	Blizzard (fluthiacet-methyl)	0.004	POST	15	a	8	d	4	d	0	d	2.44	b
6	Firstrate (chloransulam)	0.021	POST	0	c	0	f	1	ef	2	d	2.44	b
7	Python (flumetsulam)	0.056	POST	0	c	15	b	11	b	16	b	2.37	b
8	Sandea (halosulfuron)	0.026	POST	0	c	52	a	63	a	80	a	1.38	c
9	Raptor (imazamox)	0.039	POST	0	c	0	f	0	f	0	d	2.82	a
10	Harmony GT (thifensulfuron-methyl)	0.004	POST	0	c	4	e	3	de	4	c	2.55	ab
11	Nontreated Check			0	c	0	f	0	f	0	d	2.49	ab
			LSD (P=.05)	0.89		1.63		2.47		1.83		0.343	

Means followed by same letter do not significantly differ (P=.05, LSD)
All treatments (4-11) were treated with paraquat at 0.5 lb ai/a on February 27, 2008. All treatments received R-11 nonionic surfactant at 0.25% (v/v) spray solution.

Early postemergence applications of Raptor (imazamox), Harmony GT (thifensulfuron) and Firstrate (chloransulam) injured alfalfa less than 4% and yields were equal to the nontreated checks (Table 4). Early postemergence application of Python (flumetsulam) injured alfalfa 11 to 15% and tended to reduce hay yields slightly (Table 4). Sandea (halosulfuron) injured alfalfa and injury increased from early to late April. Sandea reduced hay yield of the first cutting by 45% (Table 4).

Commercial alfalfa seed tolerance to herbicides - 2007. An herbicide trial was conducted on a commercial alfalfa seed field near Lowden, WA in 2007. The soil was a silt loam with 2.2% O.M. and pH 7.9 and the field was sprinkler irrigated with hand lines. Treatments were applied March 15, 2007 when alfalfa was 2 inches tall. Additional herbicide treatments were applied April 5, 2007 when alfalfa was 5 to 10 in. tall. Herbicides were applied with a bicycle sprayer delivering 20 gpa and treatments were replicated four times in a RCB design. The entire trial was treated with pendimethalin (Prowl H2O) at 2 lb ai/a. Paraquat (Gramoxone) was included at 0.5 lb ai/a with most treatments with the exception of carfentrazone (Aim), and several asulam (Asulox) treatments. Plots measured 7.5 by 30 ft. and seed was collected from the center of each plot in an area of 16.25 ft^2 on August 9, 2007 after the grower had desiccated the field with paraquat.

Alfalfa injury following the March herbicide applications was greatest (12 to 17%) with flumioxazin (Chateau) at 0.125 and 0.25 lb ai/a at 2 WAT (Table 5). The alfalfa recovered quickly and injury was 5% or less by mid April. Alfalfa bloom in late May was not delayed by flumioxazin treatments and seed yield from these treatments was not reduced compared to paraquat alone (Table 5). Two sequential applications of carfentrazone at 0.016 or 0.032 lb ai/a dessicated the majority of the alfalfa emerged. Alfalfa regrew without any injury symptoms following each carfentrazone application and alfalfa bloom was delayed relative to other treatments in late May (Table 5). By June 21, 2007 all plots were in full bloom.

Table 5. Alfalfa injury, bloom, and seed yield following eleven herbicide treatments near Lowden, WA in 2007.

		Alfalfa injury		Alfalfa bloom	Alfalfa seed yield
Herbicide[1] (lb ai/a)		March 28, 2007	April 19, 2007	May 23, 2007	Aug. 9, 2007
		----(%)-----		(%)	(lb/acre)
1. Diuron (1.5) + paraquat (0.5)	PRE	3	0	13	1929
2. Flumioxazin (.125) + paraquat (0.5)	PRE	17	3	8	1731
3. Flumioxazin (.25) + paraquat (0.5)	PRE	13	5	12	1700
4. Hexazinone (0.67) + paraquat (0.5)	PRE	4	1	14	1183
5. Hexazinone (1.34) + paraquat (0.5)	PRE	5	0	15	1796
6. Asulam (1.25) + (1.25)	PRE + POST	0	0	23	1681
7. Carfentrazone (.016) + (.016)	PRE + POST	5	86	0	1449
8. Carfentrazone (.032) + (.032)	PRE +	5	89	0	1368

	POST				
9. Paraquat (0.5) + Asulam[2] (1.25)	PRE + POST	0	0	13	1828
10. Paraquat (0.5) + Imazamox (0.04)	PRE + POST	0	1	14	--
11. Paraquat (0.05)	PRE	0	0	20	1664
Lsd (0.05)		7.3	3.5	8.4	388.8

Pendimethalin at 2 lb ai/a applied to the entire trial on March 15, 2007.
PRE treatments were applied March 15, 2007 and POST treatments were applied April 5, 2007
All treatments included R-11 nonionic surfactant at 0.25% spray volume.

Alfalfa seed yield ranged from 1183 to 1928 lbs/acre and was statistically similar among most treatments, but was lower in plots treated with the low rate of hexazinone and the two carfentrazone treatments (Table 5). We suspect the lower yield observed with the 0. 67 lb ai/a rate of hexazinone was not real, since the 1.34 lb ai/a rate yielded well and both hexazinone rates controlled weeds well. Carfentrazone treatments may have yielded lower in part, due to poor control of mayweed and wild oat or due to delay of alfalfa flowering in relation to pollinator activity.

Alfalfa "Set back" Herbicide Trial – 2008. Some alfalfa seed producers in certain regions intentionally set back early emerged alfalfa in the spring to delay growth so that alfalfa bloom coincides with maximum pollinator activity. Set back is normally accomplished by disking or other mechanical tillage. Herbicide treatments were compared to the grower's mechanical setback treatment (disking and skew treader on April 16, 2008) in a commercial seed production field near Moses Lake, WA in 2008. Three herbicides; carfentrazone (Aim), fluthiacet (Blizzard), and paraquat (Gramoxone) were applied on April 17, 2008 when alfalfa was 6-8 inches tall. The grower had previously applied metribuzin (Sencor) plus paraquat on March 15, 2008 for general weed control. Herbicides were applied with a backpack sprayer equipped with flat fan nozzles delivering 20 gpa. All treatments included nonionic surfactant at 0.25% (v/v) spray solution. Treatments were replicated four times in a RCB design. Plots were 7.5 by 30 feet long. Alfalfa seed was harvested on August 12, 2008 by cutting a 40 inch by 15 foot swath with a sickle bar mower, air drying on tarps for 5 weeks, and running the harvested foliage through a belt thresher. Seed was cleaned and weighed.

Carfentrazone killed the alfalfa the most completely (96%) followed by mechanical setback (89%), paraquat (78%), and fluthiacet (69%) at 2 WAT (Table 6). Alfalfa bloom was delayed most by carfentrazone and mechanical setback and least by fluthiacet in late May (Table 6). Alfalfa seed yield in August was low (averaging only 390 lbs/acre) and was variable and did not differ statistically among setback treatments (Table 6). Based on these results and 2007 trials, carfentrazone is a good candidate as a setback herbicide.

Table 6. Alfalfa desiccation, percent bloom, height, and seed yield after 'setback' herbicide or tillage treatments near Moses Lake, WA in 2008.

				Alfalfa desiccation 5/1/08		Alfalfa bloom 5/23/08		Alfalfa height 5/23/08		Alfalfa Seed Yield 8/12/08	
	Treatment	Rate	Unit	%		%		inches		lb/acre	
1	Carfentrazone (Aim)	0.032	lb ai/a	96	a	0.0	b	16	c	418	a
	NIS (R-11)	0.25	% v/v								
2	Paraquat (Gramoxone Inteon)	0.5	lb ai/a	78	c	1.3	b	18	b	449	a
	NIS (R-11)	0.25	% v/v								
3	Fluthiacet (Blizzard)	0.009	lb ai/a	69	d	10.0	a	19	b	322	a
	NIS (R-11)	0.25	% v/v								
4	Mechanical set back			89	b	0.5	b	16	c	431	a
5	Nontreated (no setback)			0	e	12.5	a	24	a	369	a
			LSD (P=.05)	3.04		2.51		1.44		95.04	

Means within a column followed by same letter do not significantly differ (P=.05, LSD)