ROTATIONAL CROP TOLERANCE TO SOIL RESIDUAL HERBICIDES PREVIOUSLY APPLIED TO SEEDLING KENTUCKY BLUEGRASS UNDER COLUMBIA BASIN PRODUCTION CONDITIONS

D.A. Ball and G.H. Clough

Introduction

A two year field study was established under Columbia Basin irrigated conditions to evaluate the soil persistence of three HPPD (p-hydroxphenypyruvate dioxygenase) inhibitor herbicides that may have potential use for weed control in grass seed production systems. These herbicides need to be evaluated for their potential to persist in soil under Columbia Basin irrigated growing conditions if they are to fit into local grass seed production systems. Excessive herbicide persistence in soil could cause injury to subsequent crops of onion, canola, winter and spring pea, dry bean, or alfalfa.

The results presented in this report summarize Kentucky bluegrass (KBG) crop response to various HPPD inhibitor herbicide treatments applied to newly seeded KBG, and on tolerance of the above mentioned crops grown in rotation with KBG under irrigated Columbia Basin conditions. Of the herbicides evaluated in this study, only Callisto® (mesotrione) is currently registered for use in KBG seed production. Other herbicide products evaluated are not registered for use in grass seed production, but were evaluated on an experimental basis. Mention of any herbicide product in this study is not meant to imply product endorsement or recommendation for commercial use. Read and follow all herbicide product labels prior to any use.

Methods and Materials

The experiment was located at the Hermiston Agricultural Research and Extension Center, Hermiston, OR. Kentucky bluegrass var. 'Barduke' was seeded on September 9, 2009. Preemergence (PRE) herbicide treatments were applied immediately after seeding on September 9, 2009. Postemergence (EPOST and MPOST) treatments were applied on October 6, 2009 and February 22, 2010, respectively. Conditions at time of applications are summarized in Table 1. All herbicides were applied at twice the typical field use rate to accentuate any potential carryover injury to the rotational crops (Table 2). All treatments were applied with a hand-held CO_2 plot sprayer delivering 17 gpa at 30 psi. Plots were 8 ft by 30 ft in size, in an RCB arrangement, with 4 replications. Soil at the site was a sandy loam (67.4% sand, 26.3% silt, 6.3% clay, 1.3% organic matter, 7.1 pH, and CEC of 9.5 meq/100g). Visual estimates of KBG crop injury were made at periodic intervals after application of herbicide treatments (Table 2). Plots were swathed in late June 2010 and harvested on July 7, 2010 with a Hege plot combine and further cleaned with a 'Clipper' seed cleaner. Final KBG clean seed yields were converted to lb/A (Table 2).

Table 1. Conditions at time of herbicide applications to seedling Kentucky bluegrass.

	Sept. 9, 2009	Oct. 6, 2009	Feb. 22, 2010
Timing	PRE	EPOST	MPOST
Kentucky bluegrass growth stage	Preemergence	2-3 leaf, no tillers	2 inch height, tillering
Air temp (F)	58	57	42
Relative humidity (%)	68	56	76
Wind velocity (mph)	W@ 1	NW@2	calm
Cloud cover (%)	100	0	0
Soil moisture conditions	Moist	Wet	Moist surface
Soil temp 1 inch (F)	69	66	59

Results and Discussion

When evaluated at 16 and 37 days after LPOST application, visible injury to seedling KBG (chlorosis) was evident in plots receiving a Laudis™ (tembotrione) application (Table 2). Other treatments exhibited slight to no visible crop injury when evaluated (Table 2). Note that all herbicides were applied at twice the typical field use rate to accentuate any potential carryover injury to the rotational crops. Visible KBG crop injury was not evident during any late-season observations (data not shown). All herbicide treatments provided complete control (100%) of henbit, prickly lettuce, and tumble mustard (data not shown). Differences in clean seed yield of KBG were evident (Table 2) and most likely due to differences in timing of weed control, and possibly due to moderate, mid-season crop injury from Laudis treatments.

Table 2. Herbicide treatment application details and seedling KBG visible crop injury and clean seed yields.

Treatment	Rate	Timing[1]	Crop injury March 10	Crop injury March 31	Clean seed yield July 7
	(fl oz/A)		(%)	(%)	(lb/A)
Untreated			0	0	386 bc
Callisto	12	PRE	0	0	502 a
Callisto	12	EPOST	0	0	420 bc
Callisto	12	LPOST	11	5	424 b
Laudis	6	EPOST	0	0	394 bc
Laudis	6	LPOST	30	16	361 c
Impact	1.5	EPOST	0	0	426 b
Impact	1.5	LPOST	1	0	382 bc
LSD (0.05)			1.9	1.3	59.4

[1] PRE – Preemergence treatment applied September 9, 2009. EPOST – Early postemergence treatments applied October 6, 2009. LPOST treatments applied February 22, 2010. All EPOST and LPOST treatments contained a crop oil concentrate (COC) at 1% v/v and a 32% liquid N solution at 2.5% v/v.

After seed harvest in July 2010, KBG straw was swathed, baled, and removed from plots. Plot areas were overhead sprinkler irrigated, disked, rototilled, and planted to an autumn seeded crop of canola, winter pea, winter onion, or alfalfa (Table 3). Plot areas designated for spring planted rotational crops were seeded to winter wheat as an overwintering cover crop. In spring of 2011, the winter wheat was killed with glyphosate and rototilled to prepare a final seedbed. Spring seeded pea, onion, dry beans, and carrot were seeded at typical planting dates for those crops. Rotational crop planting details are summarized in Table 3. Observations of any visible injury to rotational crops have been made approximately at bi-weekly intervals since rotational crop planting. There has been no evidence of any visible crop injury at any time since planting the rotational crops (data not shown). The time intervals between herbicide applications to KBG and planting of rotational crops are summarized in Table 4.

Crops replanted the following season after herbicide treated KBG included fall planted alfalfa, canola, onion, and winter pea, and spring planted pea, onion, carrot, and dry bean (see Table 4 for recropping intervals after herbicide applications to KBG). Observation of all crops evaluated throughout the growing season in this study failed to identify any visible growth inhibition from previous herbicide treatment at any time after application to seedling KBG (Tables 5-12). Similarly, final crop yield estimates did not reveal any yield reductions due to herbicide treatments applied to a previous crop of KBG grown for seed (Tables 5-11). From visual observations and yield estimates indicating a lack of any rotational crop response, we are preliminarily optimistic that the herbicides evaluated in this trial, even when applied at twice the recommended application rates may not pose a carryover threat to the tested rotational crops grown under irrigated Columbia Basin conditions. However, these results should be considered preliminary only, and cannot be used to make recropping decisions. The Callisto label specifies the legal rotational crop restrictions, and should be followed. The other herbicides evaluated in this trial, Laudis and Impact® (topramezone), are not registered for use in KBG. The results of this trial are not meant to be considered a recommendation for commercial use.

Table 3. Rotational crop planting details.

Crop	Variety	Planting date	Seeding rate	Seedbed preparation	Maintenance herbicides
Alfalfa	BarAlfa 32	Sept. 2, 2010	25 lb/A	Disk/rototill	Raptor/Select
Canola	DKW 13-69 (RR)	Sept. 2, 2010	6 lb/A	Disk/rototill	Roundup
Fall Onion	Highkeeper	Sept. 2, 2010		Disk/rototill	Dacthal/Select/ Goal + Buctril
Winter Pea	Austrian	Sept. 29, 2010		Disk/rototill	None
Spring Pea	Tonic	April 1, 2011	210 lb/A	Disk/rototill	MCPA + Basagran
Spring Onion	Renegade	April 7, 2011	-	Disk/rototill	Fusilade
Carrot	Red Core Chatenay	May 17, 2011	-	Disk/rototill	Lorox
Dry Bean	-	May 20, 2011	-	Disk/rototill	Raptor + Basagran

Table 4. Time intervals between herbicide applications to Kentucky bluegrass and rotational crop planting date.

Crop	PRE	EPOST	LPOST	PRE	EPOST	LPOST
	Days after herbicide application (DAA)			Months after herbicide application (MAA)[1]		
Alfalfa	358	331	192	11.8	10.9	6.3
Canola	358	331	192	11.8	10.9	6.3
Fall Onion	358	331	192	11.8	10.9	6.3
Winter Pea	385	358	219	12.7	11.8	7.2
Spring Pea	569	542	403	18.7	17.8	13.2
Spring Onion	575	548	409	18.9	18.0	13.4
Carrot	615	588	449	20.2	19.3	14.8
Dry Bean	618	591	452	20.3	19.4	14.9

[1] Months after herbicide application calculated by dividing DAA by 365 and multiplying by 12.

Table 5. Alfalfa crop response to herbicide treatments applied to Kentucky bluegrass and harvested dry weight (1st cutting). Harvested June 20, 2011.

Treatment	Rate	Timing[1]	Alfalfa crop injury November	Alfalfa crop injury May 4	Dry weight (1st cutting) June 20
	(fl oz/A)		---------- (%) ----------		(dry tons/A)
Untreated			0	0	2.6
Callisto	12	PRE	0	0	2.1
Callisto	12	EPOST	0	0	2.6
Callisto	12	LPOST	0	0	2.1
Laudis	6	EPOST	0	0	2.0
Laudis	6	LPOST	0	0	2.0
Impact	1.5	EPOST	0	0	2.0
Impact	1.5	LPOST	0	0	2.3
LSD (0.05)			NS	NS	NS

[1] PRE – Preemergence treatment applied September 9, 2009. EPOST – Early postemergence treatments applied October 6, 2009. LPOST treatments applied February 22, 2010. All EPOST and LPOST treatments contained a crop oil concentrate (COC) at 1% v/v and a 32% liquid N solution at 2.5% v/v.

Table 6. Winter canola crop response to herbicide treatments in Kentucky bluegrass and harvested dry seed yields.

Treatment	Rate	Timing[1]	Canola crop injury November	Canola crop injury May 4	Clean seed yield July 5, 2011
	(fl oz/A)		---------- (%) ----------		(lb/A)
Untreated			0	0	2908
Callisto	12	PRE	0	0	2979
Callisto	12	EPOST	0	0	2610
Callisto	12	LPOST	0	0	2677
Laudis	6	EPOST	0	0	2657
Laudis	6	LPOST	0	0	2627
Impact	1.5	EPOST	0	0	2773
Impact	1.5	LPOST	0	0	2695
LSD (0.05)			NS	NS	NS

[1] PRE – Preemergence treatment applied September 9, 2009. EPOST – Early postemergence treatments applied October 6, 2009. LPOST treatments applied February 22, 2010. All EPOST and LPOST treatments contained a crop oil concentrate (COC) at 1% v/v and a 32% liquid N solution at 2.5% v/v.

Table 7. Winter pea crop response to herbicide treatments in Kentucky bluegrass and harvested dry seed yields.

Treatment	Rate	Timing[1]	Winter pea crop injury November	Winter pea crop injury May 4	Clean seed yield July 20, 2011
	(fl oz/A)		---------- (%) ----------		(lb/A)
Untreated			0	0	1496
Callisto	12	PRE	0	0	1453
Callisto	12	EPOST	0	0	1527
Callisto	12	LPOST	0	0	1547
Laudis	6	EPOST	0	0	1471
Laudis	6	LPOST	0	0	1304
Impact	1.5	EPOST	0	0	1480
Impact	1.5	LPOST	0	0	1752
LSD (0.05)			NS	NS	NS

[1] PRE – Preemergence treatment applied September 9, 2009. EPOST – Early postemergence treatments applied October 6, 2009. LPOST treatments applied February 22, 2010. All EPOST and LPOST treatments contained a crop oil concentrate (COC) at 1% v/v and a 32% liquid N solution at 2.5% v/v.

Table 8. Spring pea crop response to herbicide treatments in Kentucky bluegrass and harvested dry seed yields.

Treatment	Rate	Timing[1]	Spring pea crop injury May 4	Spring pea crop injury June	Clean seed yield July 20, 2011
	(fl oz/A)		---------- (%) ----------		(lb/A)
Untreated			0	0	3083
Callisto	12	PRE	0	0	3640
Callisto	12	EPOST	0	0	3117
Callisto	12	LPOST	0	0	3250
Laudis	6	EPOST	0	0	3152
Laudis	6	LPOST	0	0	3397
Impact	1.5	EPOST	0	0	2960
Impact	1.5	LPOST	0	0	3406
LSD (0.05)			NS	NS	NS

[1] PRE – Preemergence treatment applied September 9, 2009. EPOST – Early postemergence treatments applied October 6, 2009. LPOST treatments applied February 22, 2010. All EPOST and LPOST treatments contained a crop oil concentrate (COC) at 1% v/v and a 32% liquid N solution at 2.5%.

Table 9. Fall-planted fresh onion bulb yield response to herbicide treatments in Kentucky bluegrass. Onions harvested July 5, 2011.

Treatment	Rate	Timing[1]	Onion bulb yield					
			Medium	Jumbo	Colossal	Under	Cull	Total
	(fl oz/A)		---------- (fresh tons/A) ----------					
Untreated			2.6	3.9	1.7	0.2	0.15	8.45
Callisto	12	PRE	2.2	3.6	4.0	0.1	0.29	10.21
Callisto	12	EPOST	4.1	2.9	1.9	0.2	0.06	9.24
Callisto	12	LPOST	2.7	2.4	1.5	0.3	0.12	6.94
Laudis	6	EPOST	2.4	2.4	2.2	0.1	0.23	7.31
Laudis	6	LPOST	3.7	3.3	1.7	0.2	0.10	9.00
Impact	1.5	EPOST	2.3	3.3	2.2	0.1	0.15	7.98
Impact	1.5	LPOST	2.2	2.2	1.2	0.3	0.05	5.91
LSD (0.05)			NS	NS	NS	NS	NS	NS

[1] PRE – Preemergence treatment applied September 9, 2009. EPOST – Early postemergence treatments applied October 6, 2009. LPOST treatments applied February 22, 2010. All EPOST and LPOST treatments contained a crop oil concentrate (COC) at 1% v/v and a 32% liquid N solution at 2.5% v/v.

Table 10. Spring-planted fresh onion bulb yield response to herbicide treatments in Kentucky bluegrass.

Treatment	Rate	Timing[1]	Onion bulb yield					
			Medium	Jumbo	Colossal	Under	Cull	Total
	(fl oz/A)		---------- (fresh tons/A) ----------					
Untreated			2.2	32.0	7.3	1.2	0.5	43.2
Callisto	12	PRE	2.6	28.4	9.2	0.4	1.1	41.7
Callisto	12	EPOST	2.3	31.0	7.5	0.5	0.3	41.6
Callisto	12	LPOST	2.6	30.7	9.3	0.3	1.3	44.2
Laudis	6	EPOST	2.2	30.1	6.8	0.1	1.0	40.2
Laudis	6	LPOST	2.3	29.4	8.1	0.1	1.6	41.5
Impact	1.5	EPOST	2.3	31.3	8.2	1.1	0.6	43.6
Impact	1.5	LPOST	4.0	25.4	4.5	0.4	1.2	35.5
LSD (0.05)			NS	NS	NS	NS	NS	NS

[1] PRE – Preemergence treatment applied September 9, 2009. EPOST – Early postemergence treatments applied October 6, 2009. LPOST treatments applied February 22, 2010. All EPOST and LPOST treatments contained a crop oil concentrate (COC) at 1% v/v and a 32% liquid N solution at 2.5% v/v.

Table 11. Fresh market carrot response to herbicide treatments in Kentucky bluegrass and fresh carrot root yields.

Treatment	Rate	Timing[1]	Carrot crop injury	Carrot crop injury	Fresh carrot yield		
			June	July	Marketable	Cull	Total
	(fl oz/A)		---------- (%) ---------		---------- (tons/A) ----------		
Untreated			0	0	22	9.0	31.3
Callisto	12	PRE	0	0	25	8.5	33.9
Callisto	12	EPOST	0	0	23	9.2	32.7
Callisto	12	LPOST	0	0	24	9.8	33.8
Laudis	6	EPOST	0	0	26	8.0	34.0
Laudis	6	LPOST	0	0	25	8.7	33.7
Impact	1.5	EPOST	0	0	27	6.6	33.7
Impact	1.5	LPOST	0	0	25	10.4	35.3
LSD (0.05)			NS	NS	NS	NS	NS

[1] PRE – Preemergence treatment applied September 9, 2009. EPOST – Early postemergence treatments applied October 6, 2009. LPOST treatments applied February 22, 2010. All EPOST and LPOST treatments contained a crop oil concentrate (COC) at 1% v/v and a 32% liquid N solution at 2.5%.

Table 12. Dry pinto bean response to herbicide treatments in Kentucky bluegrass and dry bean seed yields.

Treatment	Rate	Timing[1]	Pinto bean crop injury	Pinto bean crop injury	Dry bean seed yield[2]
			June	July	
	(fl oz/A)		---------- (%) ----------		(lb/A)
Untreated			0	0	-
Callisto	12	PRE	0	0	-
Callisto	12	EPOST	0	0	-
Callisto	12	LPOST	0	0	-
Laudis	6	EPOST	0	0	-
Laudis	6	LPOST	0	0	-
Impact	1.5	EPOST	0	0	-
Impact	1.5	LPOST	0	0	-
LSD (0.05)			NS	NS	-

[1] PRE – Preemergence treatment applied September 9, 2009. EPOST – Early postemergence treatments applied October 6, 2009. LPOST treatments applied February 22, 2010. All EPOST and LPOST treatments contained a crop oil concentrate (COC) at 1% v/v and a 32% liquid N solution at 2.5%.

[2] Dry bean yield not calculated due to variable irrigation conditions.