Title: Evaluating chemical fallow systems for weed control efficacy

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Interim Report:

Specific objectives:
1) Determine weed control efficacy of chemical-fallow treatments
2) Determine comparative wheat injury chemical-fallow.

Keywords: Chemical fallow, Russian thistle, mayweed chamomile

Statement of problem: Chemical fallow as practiced in the Pacific Northwest depends heavily on repeated applications of glyphosate. Russian thistle and other broadleaf weeds often establish despite repeated postemergence herbicide application. More effective chemical fallow programs must be established to make the system more efficient and to prevent the development of glyphosate-resistant weeds.

Agronomic zone of interest: Low, intermediate, and high rainfall zones

Production systems being investigated: Winter wheat – chemical fallow

Abstract of Research Findings: Research was conducted near Lind and Pullman, WA in the low and high rainfall production zones, respectively, to determine the efficacy of various herbicides in a chemical fallow system. There wasn't a clear domination of any species at either location. The most common species at Lind were Russian thistle, prickly lettuce, and horseweed, while the most common species at Pullman were prickly lettuce, mayweed chamomile, and wild buckwheat. Weed density and biomass were measure on July 14 and August 1 at the two respective locations. At Lind, broadleaf weed populations and biomass tended to lessen with repeated glyphosate applications which were different from 2004 results although results with residual herbicides were consistent with 2004 results. The lowest weed density and biomass were with paraquat plus dirun and glyphosate plus metribuzin which was incontrast to 2004 results and most likely reflected a more diverse weed population with variable control. Results from the Pullman location in 2005 also conflict those from 2004 in that repeated applications of glyphosate were among the poorer treatments at that location. Residual herbicides were also consistent between years as was found at Lind. Again, differences between years at Pullman were likely due to a more varied species makeup of the weed population. Also, timing of application of glyphosate at Pullman may not have been optimal and an additional application in the glyphosate as needed treatment may have provided results more consistent with 2004. Weed control with treatments containing dicamba were among treatments providing poor weed control at both

locations with the exception of the highest dicamba rate of 0.5 lbs ae/a. Wheat yields from Pullman following 2004 chem fallow treatments indicated yield increased with decreased weed biomass as recorded in August of 2004. However, there was an indication that residual herbicides may have had a negative impact on yield.

Results and Interpretations:

Procedures:
Objective 1: Field sites were identified and established in the fall of 2004 on the Rob Dewald Farm near the WSU Dryland Research Station at Lind (low rainfall) and on the Sheryl and Eric Zakarison Farm near the USDA-ARS Palouse Conservation Field Station (high rainfall). The same 21 treatments were initially included in the design for both locations. Treatments included combinations of glyphosate across three timings and glyphosate tankmixed or in sequence with residual herbicides. An additional treatment was to apply glyphosate as needed at the discretion of the principal investigator. It was assumed that glyphosate would effectively control grasses. Sulfentrazone, flumioxazin, and isoxaflutole were expected to provide residual control only and were applied without glyphosate on February 16 and April 1, 2005 at Lind and Pullman, respectively. Dicamba and metribuzin were expected to provide foliar and residual control were tankmixed with glyphosate on April 13 and June 9, 2005 at the same respective locations. Weed density and biomass were measure on July 14 and August 1&2 at the same respective locations. All weeds in each plot were counted, clipped at the soil surface, weighed, oven-dried for 48 hrs, and weighed again. Thus, the weed parameters measured and analyzed included, number of plants per plot, fresh weight per plot, and dry weight per plot. Only broadleaf weeds were present as grass weeds were eliminated by glyphosate or parquet plus diuron at both locations. In comparison with results from 2004 weed populations were more diverse at both locations. At Lind, Russian thistle was not nearly the dominating species that it was in the previous year's research. Weed populations were primarily a mixture of Russian thistle, prickly lettuce, and horseweed at Lind and a mixture of prickly lettuce, mayweed chamomile, and wild buckwheat at the Pullman location. Statistical analysis of data was performed on a log + 1 transformation of each data point because treatment variances of raw data were determined to be not homogenous. A fall glyphosate application of glyphosate was made across the entire plot site at the high rainfall location due to a high population of grass weeds. This effectively created two treatments of sequential applications of fall and late spring glyphosate. The originally designed fall and late spring glyphosate treatment was dropped from the data analysis.

Objective 2. Corners of experimental area were marked for relocation. Cooperating farmers will plant winter wheat in the fall of 2005. Plots will be remarked after crop establishment and stand counts or other evaluation taken. For chem fallow 2003-04 studies, winter wheat stand counts were taken in the fall of 2004. Yields were taken only at the high rainfall location.

Discussion: In 2005 weed density was roughly equal to those observed in 2004 at both locations (Tables 1 &2) . However, biomass level was similar at Pullman (Table 1) between the two years, but much less on average at Lind (Table 2) in 2005 than in 2004. Generally, smaller plants were present at Lind in 2005 compared to 2004 which reflected less dominance by Russian thistle.

At Lind, residual chemistry was more generally effective in reducing plant density than repeated applications of glyphosate although at a greater per acre cost (Table 3), but three applications of glyphosate had weed density and biomass not different than the treatments providing greatest control (Table 2). Paraquat plus diuron and glyphosate plus metribuzin were also among the treatments providing good weed control. These results differed from 2004 in that sulfentrazone and combinations of sulfentrazone with flumioxazin and isoxaflutole provided much greater control than repeated applications of glyphosate, paraquat plus diuron, and glyphosate plus metribuzin. The varying results between the years was most likely due to the background weed population being less dominated by Russian thistle which the foliar treatments provided poorer control than residual treatments. Somewhat conflicting to this is the relatively higher weed density and biomass with glyphosate plus dicamba treatments.

Results from Pullman also differed from 2004 results. Residual herbicides were consistent between the two years, but foliar herbicides generally had poorer control in 2005 (Table 1) than in 2004 at this location. One main difference between years is the difference in application timings. The late spring application was applied on April 28 in 2004, but was delayed until June 1 in 2005. There was no glyphosate application past the late spring application in 2005 while there was an additional application in 2004 made on June 22. The repeated application of glyphosate treatment had fewer weed density and biomass in 2004 with four applications of glyphosate and the late application on June 22, 2004. However, due to environmental conditions the repeated glyphosate treatment included only 3 application timings with the last one being on June 1, 2005. Not surprisingly, growers might use the term obvious, it is more important to direct repeated glyphosate applications in a timely manner rather than on shear number of applications.

While residual herbicides provided more consistent control over the two years, postemergence applications can be effective depending on environmental conditions and weed spectrum. Thus, while herbicide treatments were consistently effective, repeated applications of glyphosate is attractive from a grower standpoint due to cost and the potential to provide effective weed control if applied at the proper timing.

Winter wheat yield results from 2005 harvest following chemical fallow treatments are shown in Table 4 for Pullman only. Winter wheat stand counts were taken in the fall of 2004 at both locations and found to be not significantly different between treatments (data not shown). Yield at Pullman mainly related to weed control during the fallow year. However, the higher rates of the residual herbicides sulfentrazone and isoxaflutole applied in 2004 resulted in 2005 wheat yields less than the best yielding treatment. Ironically, the best yielding treatment included residual chemistry in 2004 treatments. Experiment sites in both the high and rainfall areas have been marked and are planned to be evaluated for stand and yield for the wheat crop to be harvested in 2006.

Table 1. Weed density, fresh weight, and dry weight at Pullman, WA August 1, 2005.

Treatment	Rate	Application Date	Total Weed					
			Density		Fresh Weight		Dry Weight	
			Plants/A		Lbs/A		Lbs/A	
Glyphosate	0.375	06/01/05	7,200	ab	625	a-d	190	abc
Glyphosate; glyphosate	0.375; 0.375	04/01/05;06/01/05	5,050	a-d	220	b-g	70	b-f
Sulfentrazone; glyphosate	0.188; 0.375	04/01/05;06/01/05	7,345	a-e	155	g-j	30	gh
Sulfentrazone; glyphosate	0.141; 0.375	04/01/05;06/01/05	1,934	cf	95	e-h	50	efg
Flumioxazin; glyphosate	0.080; 0.375	04/01/05;06/01/05	2,150	def	135	e-h	45	d-g
Flumioxazin; glyphosate	0.064; 0.375	04/01/05;06/01/05	7,270	a-d	125	d-h	40	d-g
Isoxaflutole; glyphosate	0.080; 0.375	04/01/05;06/01/05	2,470	c-f	110	hij	35	gh
Isoxaflutole; glyphosate	0.064; 0.375	04/01/05;06/01/05	1,825	def	170	c-h	45	c-g
Flumioxazin; sulfentrazone; glyphosate	0.064; 0.141; 0.375	04/01/05; 04/01/05; 06/01/05	2,510	ef	40	jk	10	h
Isoxaflutole; sulfentrazone; glyphosate	0.064; 0.141; 0.375	04/01/05; 04/01/05; 06/01/05	2,435	def	25	ijk	5	h
Dicamba; glyphosate	0.5; 0.375	06/01/05; 06/01/05	2,080	f	50	k	20	h
Dicamba; glyphosate	0.375; 0.375	06/01/05; 06/01/05	5,590	a-d	100	f-i	30	fg
Dicamba; glyphosate	0.25; 0.375	06/01/05; 06/01/05	9,350	ab	385	a-f	120	a-e
Dicamba; glyphosate	0.125; 0.375	06/01/05; 06/01/05	6,770	abc	300	a-f	90	a-f
Metribuzin; glyphosate	0.5; 0.375	06/01/05; 06/01/05	9,025	ab	1,340	ab	410	ab
Metribuzin; glyphosate	0.375; 0.375	06/01/05; 06/01/05	8,350	ab	1,030	abc	315	ab
Metribuzin; glyphosate	0.25; 0.375	06/01/05; 06/01/05	8,275	ab	1,510	a	485	a
Paraquat + diuron	0.5 + 0.25	06/01/05	11,750	a	1,385	a	475	a
Paraquat + diuron; Paraquat + diuron	0.5 + 0.25; 0.5 + 0.25	04/01/05;06/01/05	9745	a	1095	a	390	a

Means followed by the same letter do not significantly differ (p=0.05 LSD) for Log + 1 transformed data. Data shown are not transformed.

Table 2. Weed density, fresh weight, and dry weight at Lind, WA July 14, 2005.

Treatment	Rate	Application Date	Total Weed					
			Density		Fresh Weight		Dry Weight	
			Plants/A		Lbs/A		Lbs/A	
Glyphosate	0.375	04/13/05	1,435	ab	15	abc	5	a-d
Glyphosate; glyphosate	0.375; 0.375	11/23/04; 04/13/05	1,470	ab	80	a	20	ab
Glyphosate; glyphosate	0.375; 0.375	02/16/05; 04/13/05	360	d-h	55	abc	10	a-d
Glyphosate; glyphosate; glyphosate	0.375; 0.375; 0.375	02/16/05; 04/13/05; 05/03/05	180	f-i	15	c-f	5	c-f
Sulfentrazone; glyphosate	0.188; 0.375	02/16/05; 04/13/05	430	c-g	5	c-f	0	def
Sulfentrazone; glyphosate	0.141; 0.375	02/16/05; 04/13/05	1,110	abc	10	abc	5	a-d
Flumioxazin; glyphosate	0.080; 0.375	02/16/05; 04/13/05	1,005	a-d	10	abc	5	b-e
Flumioxazin; glyphosate	0.064; 0.375	02/16/05; 04/13/05	715	a-e	10	a-d	0	c-f
Isoxaflutole; glyphosate	0.080; 0.375	02/16/05; 04/13/05	180	e-i	5	c-f	0	c-f
Isoxaflutole; glyphosate	0.064; 0.375	02/16/05; 04/13/05	215	f-i	40	bcd	5	b-e
Flumioxazin; sulfentrazone; glyphosate	0.064; 0.141; 0.375	02/16/05; 02/16/05; 04/13/05	500	b-f	5	cde	0	c-f
Isoxaflutole; sulfentrazone; glyphosate	0.064; 0.141; 0.375	02/16/05; 02/16/05; 04/13/05	180	e-i	0	c-f	0	c-f
Dicamba; glyphosate	0.5; 0.375	04/13/05; 04/13/05	215	e-i	5	c-f	0	def
Dicamba; glyphosate	0.375; 0.375	04/13/05; 04/13/05	465	c-g	5	cde	0	c-f
Dicamba; glyphosate	0.25; 0.375	04/13/05; 04/13/05	1,075	a-d	35	abc	10	abc
Dicamba; glyphosate	0.125; 0.375	04/13/05; 04/13/05	2,040	a	85	ab	20	a
Metribuzin; glyphosate	0.5; 0.375	04/13/05; 04/13/05	180	f-i	0	def	0	ef
Metribuzin; glyphosate	0.375; 0.375	04/13/05; 04/13/05	35	hi	0	ef	0	ef
Metribuzin; glyphosate	0.25; 0.375	04/13/05; 04/13/05	180	ghi	0	def	0	ef
Paraquat + diuron	0.5 + 0.25	04/13/05	0	i	0	f	0	f
Paraquat + diuron; Paraquat + diuron	0.5 + 0.25; 0.5 + 0.25	02/16/05; 04/13/05	145	ghi	5	c-f	5	c-f

Means followed by the same letter do not significantly differ (p=0.05 LSD) for Log + 1 transformed data. Data shown are not transformed.

Table 3. Cost of applications at Lind and Pullman, WA. Provided by North Dakota State University 2005 Weed Control Guide (http://www.ag.ndsu.nodak.edu/weeds/w253/w253w.htm).

Treatment	Rate	Lind	Pullman
Glyphosate	0.375	$ 7.70	15.40
Glyphosate; glyphosate	0.375; 0.375	$ 15.40	23.10
Glyphosate; glyphosate; glyphosate	0.375; 0.375; 0.375	$ 23.10	NA
Sulfentrazone; glyphosate	0.188; 0.375	$ 21.90	29.60
Sulfentrazone; glyphosate	0.141; 0.375	$ 19.10	26.80
Flumioxazin; glyphosate	0.080; 0.375	$ 20.70	28.40
Flumioxazin; glyphosate	0.064; 0.375	$ 18.73	26.43
Isoxaflutole; glyphosate	0.080; 0.375	$ 28.62	36.32
Isoxaflutole; glyphosate	0.064; 0.375	$ 25.04	32.74
Flumioxazin; sulfentrazone; glyphosate	0.064; 0.141; 0.375	$ 27.13	34.83
Isoxaflutole; sulfentrazone; glyphosate	0.064; 0.141; 0.375	$ 33.44	41.14
Dicamba; glyphosate	0.5; 0.375	$ 20.20	27.90
Dicamba; glyphosate	0.375; 0.375	$ 17.08	24.78
Dicamba; glyphosate	0.25; 0.375	$ 13.95	21.65
Dicamba; glyphosate	0.125; 0.375	$ 10.83	18.53
Metribuzin; glyphosate	0.5; 0.375	$ 21.70	29.40
Metribuzin; glyphosate	0.375; 0.375	$ 18.20	25.90
Metribuzin; glyphosate	0.25; 0.375	$ 14.70	22.40
Paraquat + diuron	0.5 + 0.25	$ 10.24	17.94
Paraquat + diuron; Paraquat + diuron	0.5 + 0.25; 0.5 + 0.25	$ 20.48	28.18

Cost figures include $3.00/A per application timing and cost of recommended adjuvants. Pullman costs reflect the added cost of a fall application of 0.375 lbs. glyphosate/A with 8.5 lbs ammonium sulfate per 100 gallons spray solution applied at 10 gallons of solution/A. Costs are intended to serve as a comparison, actual grower costs may vary.

Table 4. Winter wheat yields following chemical fallow treatments at Pullman, WA

Treatment	Rate	Application Date	Wheat Yield August 2005
			Bu/A
Glyphosate	0.375	04/28/04	97
Glyphosate; glyphosate	0.375; 0.375	03/30/04; 04/28/04	104
Glyphosate; glyphosate; glyphosate	0.375; 0.375; 0.375	03/30/04; 04/28/04; 06/22/04	105
Sulfentrazone; glyphosate	0.188; 0.375	03/30/04; 04/28/04	101
Sulfentrazone; glyphosate	0.141; 0.375	03/30/04; 04/28/04	115
Flumioxazin; glyphosate	0.080; 0.375	03/30/04; 04/28/04	108
Flumioxazin; glyphosate	0.064; 0.375	03/30/04; 04/28/04	110
Isoxaflutole; glyphosate	0.080; 0.375	03/30/04; 04/28/04	96
Isoxaflutole; glyphosate	0.064; 0.375	03/30/04; 04/28/04	113
Flumioxazin; sulfentrazone; glyphosate	0.064; 0.141; 0.375	03/30/04; 03/30/04; 04/28/04	119
Isoxaflutole; sulfentrazone; glyphosate	0.064; 0.141; 0.375	03/30/04; 03/30/04; 04/28/04	116
Dicamba; glyphosate	0.5; 0.375	04/28/04; 04/28/04	114
Dicamba; glyphosate	0.375; 0.375	04/28/04; 04/28/04	113
Dicamba; glyphosate	0.25; 0.375	04/28/04; 04/28/04	112
Dicamba; glyphosate	0.125; 0.375	04/28/04; 04/28/04	106
Metribuzin; glyphosate	0.5; 0.375	04/28/04; 04/28/04	106
Metribuzin; glyphosate	0.375; 0.375	04/28/04; 04/28/04	98
Metribuzin; glyphosate	0.25; 0.375	04/28/04; 04/28/04	109
Paraquat + diuron	0.5 + 0.25	04/28/04	113
Paraquat + diuron; Paraquat + diuron	0.5 + 0.25; 0.5 + 0.25	03/30/04; 04/28/04	111
LSD (p=0.05)			14

Cooperation with Other Scientists Conducting Related Activity: Consulted with Dennis Tonks and Aaron Esser in establishing experiments and other experiments not reported here. We have discussed expanded future chemical fallow project with Dan Ball and Donn Thill with experimental objectives and design based heavily on results of this and other studies.

Publications and Presentation: Results were discussed at various grower meetings through the winter of 2004-05 and these data were used in a presentation by Dr. Dennis Tonks at the Western Society of Weed Science Annual Meeting in Vancouver, BC in March of 2005.