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Andrew Jensen, Editor. ajensen@potatoes.com; 509-760-4859

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Metribuzin-Resistant Weeds in Potato Production Areas of the Columbia Basin

Rick Boydston, USDA-ARS, Prosser, WA

Weeds infest all crops, including potatoes resulting in reduced tuber yield and quality. In the past 65 years herbicides have simplified weed management in most crops. The two most commonly used postemergence applied herbicides in potatoes, metribuzin and rimsulfuron, have modes of action that are the most likely to develop weed resistance. Metribuzin is a photosystem II inhibitor herbicide to which 69 weed species have developed resistance. Rimsulfuron is an ALS inhibitor herbicide, to which 116 different weed species have developed resistance. Although herbicide-resistant weeds have been suspected in potato fields in Washington, no previous effort has been made to document resistance. Poor weed control may be caused by a number of factors other than herbicide resistance, such as improper herbicide choice or rate, improper application or incorporation of herbicide, poor timing of herbicide application, and weather conditions not favorable for herbicide activity prior to or following herbicide application. It is important to determine if a weed control failure is in fact due to herbicide resistance or other factors.

The Washington State Potato Commission funded a two-year project in 2010 and 2011 to investigate and document herbicide resistant weeds in potato fields. Seed was collected from escape weeds in potato fields (5 species, 57 biotypes), mint fields (9 species, 43 biotypes), dry bean (2 species, 2 biotypes), and sweet corn (1 species, 1 biotype) throughout the Columbia Basin in 2010. A biotype is a group of plants within a species that has biological traits that are not common to the population as a whole. Potato fields sampled ranged from Paterson (furthest SW) to Quincy (furthest NW) and from Bruce (furthest NE) to Ice Harbor (furthest SE). Redroot pigweed (*Amaranthus retroflexis*), Powell amaranth (*A. powellii*), and common lambsquarters (*Chenopodium album*) were the most prevalent weeds observed in late summer. All seed collection sites were georeferenced. Broadleaf weeds were tested for susceptibility to metribuzin and rimsulfuron herbicides. Grass species were tested for susceptibility to clethodim and sethoxydim herbicides.

Weed seed was cleaned and planted in greenhouse flats. Each biotype was planted in 10 cm diameter containers replicated 4 to 6 times and grown in the greenhouse. Pigweed and common lambsquarters seedlings were thinned to eight plants per pot prior to applying postemergence herbicides. Broadleaf weeds were treated with postemergence applied herbicides when they reached the 3 to 4 leaf stage and 1 to 2 inches tall. Grass weeds were treated when they reached the 3 to 4 leaf stage and were 3 to 4 inches tall. A single nozzle (80015 E) bench sprayer calibrated to deliver 25 GPA was used to apply herbicide treatments to plants.

Initially, each weed biotype was treated with a ½X and 1X labeled rate of the specific herbicide. A known susceptible biotype of each species was included in each experiment as a control. Weed biotypes that were not completely killed by the ½X or 1X rate of the herbicide were further tested with a range of six to eight doses of the herbicide to determine the dose response of the resistant biotype compared to the susceptible control. The number of surviving seedlings, dry weights, and visual control rating were recorded at two weeks after herbicide application.

Dose-response curves of each weed biotype were compared to the susceptible biotype (indigenous population) of the same species. The dose required to reduce growth or shoot weight by 50% relative to untreated plants (also known as GR_{50}) of the resistant and susceptible populations was determined using the log logistic analysis package of the 'R' statistical program. The dose required to provide 90% control (I_{90}) was also calculated from the dose response curve. The relative resistance of each biotype to the susceptible control was calculated by ratio of the calculated I_{90} of the resistant biotype to the I_{90} of the susceptible biotype.

Weed biotypes with confirmed resistance were further tested for susceptibility to herbicides with other modes of action that are labeled in potato. Seeds were planted in 10 cm diameter pots and treated with normal labeled rates of each herbicide either preemergence (trifluralin, pendimethalin, EPTC, metolachlor, dimethenamid-P, flumioxazin) or postemergence (rimsulfuron). A normal susceptible biotype was included as a control for comparison in each experiment.

Results

Redroot pigweed (*Amaranthus retroflexis*) and Powel amaranth (*A. powellii*)

Fifteen of 27 pigweed biotypes tested were resistant to metribuzin (Tables 1 and 2). Dose response analysis based on I_{90} values (dose required to provide 90% control) indicated that a 2 to 142 fold herbicide dose was required to provide 90% control of the resistant biotypes compared to the susceptible control (Table 1).

Weed seed was also collected from escape weeds in mint fields in 2010. Pigweed from mint fields in the Columbia Basin were screened for resistance to terbacil, a photosystem II inhibitor herbicide that has a similar mode of action to metribuzin. Nine of 22 pigweed biotypes from mint tested resistant to terbacil. In subsequent tests, all terbacil resistant pigweed biotypes were also resistant to metribuzin. Likewise, the 15 metribuzin resistant pigweed biotypes from potato and sweet corn fields were confirmed cross-resistant to terbacil. Triazine (metribuzin) and uracil (terbacil) herbicides inhibit P.S. II in plants by binding to the Qb protein in the chloroplast and inhibit electron transport. These two herbicide families have overlapping binding sites and similar mutations in the Qb protein typically confer resistance to both herbicide families.

All 27 pigweed biotypes collected from potato, sweet corn, and dry bean fields were susceptible to rimsulfuron (Matrix) at 0.012 lb ai/a (1/2x field use rate).

In greenhouse studies, flumioxazin (Chateau), EPTC (Eptam), dimethenamid-P (Outlook), s-metolachlor (Dual Magnum), ethalfluralin (Sonalan), and trifluralin (Treflan) applied preemergence at normal use rates all controlled metribuzin-resistant pigweed biotypes. Susceptibility of metribuzin-resistant pigweed to pendimethalin (Prowl) at 0.75 lb ai/a was less than that of other preemergence herbicides, but the metribuzin-resistant pigweed biotypes were suppressed by pendimethalin equal to the normal susceptible biotype.

Common lambsquarters (*Chenopodium album*)

Eight of 25 common lambsquarters biotypes collected from potato fields in the Columbia Basin were resistant to metribuzin (Table 2). The lowest dose of 0.022 lb ai/a metribuzin resulted in 92% control of the susceptible biotype. Dose response analysis based on I_{90} values indicated that approximately 40 to 68 times as much herbicide was required to provide 90% control the resistant biotypes compared to the susceptible control (Table 2). All metribuzin-resistant common lambsquarters biotypes from potato tested cross-resistant to terbacil.

All 27 common lambsquarters biotypes were tested for susceptibility to rimsulfuron (Matrix) applied POST at 0.0117 lb ai/a (1/2x field use rate) plus methylated seed oil (MSO). No biotypes were completely killed with rimsulfuron at this low rate and control ranged from 57 to 93% at 2 WAT. All lambsquarters biotypes collected appeared equal to or slightly more susceptible than the susceptible control, suggesting that none of these biotypes may be considered resistant to rimsulfuron. Common lambsquarters is semi-tolerant to rimsulfuron and higher doses are required to kill the weed compared to more highly susceptible species, such as pigweed. Trials are being repeated at a higher dose and applied preemergence.

One additional common lambsquarters biotype was collected from a potato field in 2011 and is currently being tested for resistance.

Hairy Nightshade (*Solanum physalifolium* – formerly *S. sarrachoides*)

Four hairy nightshade biotypes collected from potato fields in the Columbia Basin were susceptible to rimsulfuron (Matrix) applied POST at 0.0117 lb ai/a (1/2x field use rate) plus methylated seed oil (MSO). All hairy nightshade biotypes collected appeared equal to or slightly more susceptible than the susceptible control biotype, suggesting that none of these biotypes are resistant to rimsulfuron.

Grass weeds (barnyardgrass *Echinochloa crus-galli*, green foxtail *Setaria viridis*, and wild proso millet *Panicum miliaceum*)

Three different grass species were collected from mint and potato fields; green foxtail (11 biotypes), barnyardgrass (5 biotypes), and wild proso millet (1 biotype) and were screened for susceptibility to clethodim (Select) and sethoxydim (Poast), two postemergence grass herbicides with similar mode of action.

All of the grass weed biotypes collected from mint and potato fields were susceptible to either the 0.5 or 1 x field use rate of clethodim and sethoxydim and the response was similar to that of the susceptible control biotypes. None of these grass populations appear to be resistant to this group of postemergence grass herbicides.

Kochia (*Kochia scoparia*)

The response of three kochia biotypes collected from mint fields to mint herbicides has not been tested yet. Seed of an additional kochia biotype was collected from a potato field in 2011 and tests are underway.

Summary

Fifty five percent of pigweed biotypes and 32% of common lambsquarters biotypes collected from potato fields and one sweet corn field were resistant to metribuzin. No resistance to rimsulfuron was observed in the pigweed biotypes collected.

All common lambsquarters biotypes collected have shown similar or greater susceptibility to rimsulfuron as a standard susceptible biotype.

Barnyardgrass, green foxtail, and wild proso millet biotypes collected in potato and mint fields were susceptible to normal rates of clethodim and sethoxydim.

These results confirm the presence of metribuzin-resistant weeds in the Columbia Basin potato growing region. All metribuzin resistant pigweed and common lambsquarters biotypes were cross resistant to terbacil, the main herbicide used in mint production. Atrazine herbicide used in corn production has the same mode of action as metribuzin and should be rotated or tank mixed with herbicides having a different mode of action. All pigweed biotypes resistant to metribuzin were controlled preemergence by normal use rates of other potato herbicides with other modes of action (rimsulfuron, ethalfluralin, EPTC, s-metolachlor, dimethenamid-p, trifluralin, and flumioxazin). This information could be used to improve management of herbicide-resistant weed populations and to delay development of herbicide resistance.

Rotating and combining methods of weed control (cultivation, herbicides, and cultural practices) and rotating herbicide mode of action are important tools to delay or prevent herbicide-resistant weed populations from evolving. The mode of action group is now listed on many herbicide labels to help growers monitor modes of action they are using. A publication, ‘Guide for Herbicide Rotation in the PNW, publication #437’ is also available.

Table 1. Response of 27 pigweed biotypes collected from Washington potato fields to postemergence applied metribuzin in the greenhouse. Second and third columns are control observed in initial screen. I_{50} = dose required to reduce growth by 50% and I_{90} = dose required to reduce growth by 90% and were calculated from dose response studies. Numbers in parenthesis are relative resistance to susceptible control.

Biotype	Percent Injury (2 WAT)		I_{50}	I_{90}
	(.175 lb ai/a)	(.35 lb ai/a)	(lb ai/a)	(lb ai/a)
Susc. CK	98	100	0.013	0.036
P1	90-100	100	--	--
P7	88-100	100	--	--
P3	100	100	--	--
P8	100	100	--	--
P9	87-99	100	--	--
P15	99	99	--	--
P16	86-99	100	--	--
P19	89-100	100	--	--
P21	92	--	--	--
P23	94	--	--	--
P24	87	--	--	--
P26	81	--	--	--
P22	**59**	**--**	**0.04 (3x)**	**0.08 (2x)**
P18	**64**	**72**	**0.06 (5x)**	**0.9 (25x)**
P17	**51**	**87**	**0.09 (7x)**	**1.2 (33x)**
P27	**7**	**--**	**0.6 (46x)**	**1.8 (50x)**
P6	**16**	**46**	**0.5 (38x)**	**1.9 (53x)**
P11	**21**	**28**	**0.6 (46x)**	**2.0 (56x)**
P25	**4**	**--**	**0.8 (62x)**	**2.1 (58x)**
P13	**6**	**20**	**0.6 (46x)**	**2.1 (58x)**
P12	**6**	**18**	**1.2 (92x)**	**2.4 (67x)**
P20	**4**	**13**	**1.3 (100x)**	**2.6 (72x)**
P5	**27**	**56**	**0.4 (31x)**	**2.7 (75x)**
P4	**5**	**34**	**1.3 (100x)**	**3.4 (94x)**
P10	**10**	**14**	**1.3 (100x)**	**3.4 (94x)**
P14	**4**	**27**	**1.4 (108x)**	**4.0 (111x)**
P2	**5**	**18**	**1.4 (108x)**	**5.1 (142x)**

Biotypes in boldface tested resistant to metribuzin.
P20 – collected from sweet corn. P26 – collected from dry bean field.

Table 2. Response of 27 common lambsquarters biotypes collected from Washington potato fields to postemergence applied metribuzin in the greenhouse. Second column is control observed in initial screen. I_{50} = dose required to reduce growth by 50% and I_{90} = dose required to reduce growth by 90% and were calculated from dose response studies. Numbers in parenthesis are relative resistance to susceptible control.

Biotype	Initial Screen Percent Injury (2 WAT)	I_{50}	I_{90}
	(0.175 lb ai/a)	(lb ai/a)	(lb ai/a)
Susc. CK	100	<0.022	~0.022
P31	100	--	--
P36	100	--	--
P38	100	--	--
P40	100	--	--
P41	100	--	--
P42	100	--	--
P43	100	--	--
P44	100	--	--
P46	100	--	--
P47	100	--	--
P48	100	--	--
P49	100	--	--
P50	100	--	--
P51	100	--	--
P53	100	--	--
P54	100	--	--
P55	100	--	--
P32	**19**	**0.13**	**0.86 (39x)**
P34	**12**	**0.17**	**0.86 (39x)**
P35	**9**	**0.22**	**1.0 (45x)**
P37	**10**	**0.25**	**1.1 (50x)**
P39	**5**	**0.38**	**1.2 (55x)**
P33	**7**	**0.21**	**1.3 (59x)**
P52	**5**	**0.43**	**1.3 (59x)**
P45	**5**	**0.44**	**1.5 (68x)**
P56	na	--	--
P57	na	--	--

Biotypes in boldface tested resistant to metribuzin.
P57 – collected from dry bean field.
na – not tested yet due to small quantity seed or poor germination.

Potato Psyllid Identification Workshops Scheduled

Zebra chip (ZC) and potato psyllid are on a lot of our minds this spring. To help industry prepare for psyllid monitoring and scouting, several training sessions have been scheduled. The workshops in Washington and Idaho will have an open format, and we ask people to come any time that fits their schedule during each session. This will allow more personal attention and access to specimens and samples as people come and go. The workshop in Oregon requires pre-registration. To register for the Oregon event, please contact Annette Teraberry (Annette.teraberry@oregonstate.edu) or 541-567-8321.

Dates, times, and locations for these sessions are:

Washington

May 1, 1:30 – 4 pm, Moses Lake, Potato Commission office, 108 S Interlake Rd.

May 2, 9:30 – noon, Pasco, Franklin County Extension office, 404 W. Clark Ave.

Idaho

May 15, 9:30 – noon, Parma Research and Extension Center, 29603 U of I Lane, Parma

May 16, 9:30 – noon, Miller Research LLC, 426 East 200 North, Rupert

May 17, 9:30 – noon, Idaho Falls R & E Center, 1776 Science Center Dr.

Oregon

May 8, 9:00 – 10:00 am, Hermiston Ag. Research and Extension Center, 2121 South First Street