Presence of Metribuzin Resistant Pigweed and Common Lambsquarters in Potato Production areas of the Columbia Basin

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Metribuzin is the most widely used herbicide in potato production. Metribuzin and rimsulfuron are the only herbicides labeled in potatoes that have postemergence activity on broadleaf weeds and both have modes of action (photosystem II inhibitor and ALS inhibitor, respectively) that weeds are prone to developing resistance to. Although herbicide resistant weeds have been suspected in potato fields in Washington State, no previous effort has been made to document resistance. Poor weed control may result from 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 application. These studies were conducted to confirm if herbicide resistant weeds were present in potato production areas and if present, to determine their level of resistance.

Seed was collected from escape weeds in potato fields throughout the Columbia Basin in 2010. A total of 27 pigweed biotypes and 25 common lambsquarters biotypes were collected from potato fields. 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. No evidence of pigweed or common lambsquarters resistance to rimsulfuron was found. Grass species were tested for susceptibility to clethodim and sethoxydim herbicides (ACCase inhibitors). No evidence of grass resistance to ACCase inhibitors was found. Only results on pigweed species and common lambsquarters to metribuzin are reported here.

Weed seed of each biotype was planted in 10 cm diameter containers replicated 4 to 6 times and grown in the greenhouse. Weed seedlings were thinned to eight plants per pot prior to applying postemergence metribuzin. Seedlings were treated with metribuzin when they reached the 3 to 4 leaf stage and 1 to 2 inches tall. A bench sprayer equipped with a single flat fan nozzle (80015 E) calibrated to deliver 25 GPA was used to apply herbicide treatments to plants.

Initially, each weed biotype was treated with a 0.175 lb ai/a (½ X) rate of metribuzin. A known susceptible biotype of each species was included in each experiment as a control. Weed biotypes that were not completely killed were further tested with a range of six to eight doses of the metribuzin 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 ED_{50} (estimated dose required to reduce growth or shoot weight by 50% relative to untreated plants) 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 (ED_{90}) was also calculated from the dose response curve. The relative resistance or resistance index (RI) of each biotype to the susceptible control was

calculated by the ratio of the ED_{50} values of the resistant biotype to that 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 considered resistant to metribuzin (Table 1). Dose response analysis based on ED_{50} values for dry weight at 2 weeks after treatment indicated that a 2 to 28 fold greater metribuzin dose was required to provide 50% reduction in dry weight of the resistant biotypes compared to the susceptible control (Table 1 and Fig. 1). All confirmed metribuzin resistant biotypes tested cross resistant to terbacil, a photosystem II inhibitor herbicide commonly used in mint production.

All 27 pigweed biotypes collected from potato were susceptible to rimsulfuron (Matrix) at 0.012 lb ai/a (½ X field use rate). 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. Linuron, which will be labeled on potatoes in Washington in 2013, controlled the metribuzin resistant biotypes well at a 0.25 lb ai/a rate in greenhouse trials.

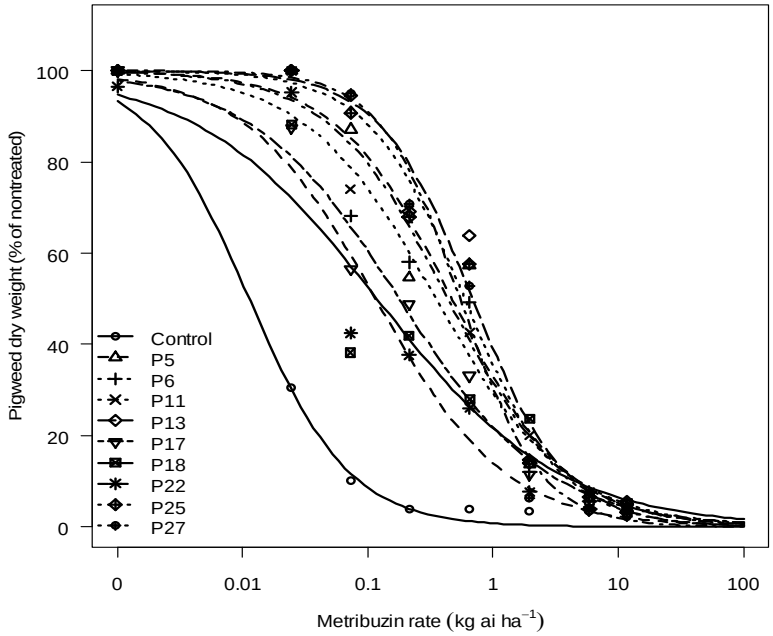
Weed seed was also collected from escape weeds in mint fields in 2010. Pigweed from mint fields in the Columbia Basin were screened for resistance to terbacil, a photosystem II inhibitor herbicide that has a similar mode of action to metribuzin. Nine of 22 pigweed biotypes from mint tested resistant to terbacil. In subsequent tests, all terbacil resistant pigweed biotypes were also resistant to metribuzin. Triazine (metribuzin) and uracil (terbacil) herbicides inhibit photosystem 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.

Interestingly, all pigweed biotypes collected from the mint growing region in the Yakima valley were susceptible to terbacil. This may be due to more common rotation to winter wheat and less rotation to potato, alfalfa, and field corn in rotations, in which photosystem II herbicides (metribuzin, hexazinone, and atrazine) are frequently used.

Table 1. Pigweed response to metribuzin (column 2), ED_{50} dose (column 3), and resistance index (RI) (column 4) of pigweed biotypes collected from potato fields in the Columbia Basin. All biotypes were redroot pigweed (*Amaranthus retroflexis*) unless indicated in parenthesis as Powell amaranth.

Biotype	Injury (2 WAT) to 0.28 kg ai/ha	ED_{50}	RI
	(% Injury)	(kg ai/ha)	
Susc. Control	98	0.07	1
P1	90-100	--	--
P7	88-100	--	--
P3	100	--	--
P8	100	--	--
P9	87-99	--	--
P15	99	--	--
P16 (Powell)	86-99	--	--
P19 (Powell)	89-100	--	--
P21	92	--	--
P23	94	--	--
P24	87	--	
P26	81	--	--
P22 (Powell)	**59**	**0.12**	**1.7**
P18	**64**	**0.12**	**1.7**
P17 (Powell)	**51**	**0.18**	**2.6**
P6	**16**	**0.35**	**5**
P11	**21**	**0.43**	**6**
P5	**27**	**0.47**	**7**
P27	**7**	**0.54**	**8**
P25	**4**	**0.59**	**8**
P12	**6**	**0.61**	**9**
P4	**5**	**0.63**	**9**
P13 (Powell)	**6**	**0.68**	**10**
P20 (Powell)	**4**	**1.42**	**20**
P10	**10**	**1.69**	**24**
P2	**5**	**1.84**	**26**
P14 (Powell)	**4**	**1.93**	**28**

Figure 1. Dose response of nine pigweed biotypes collected from Washington potato fields to metribuzin compared to a susceptible control.



Common lambsquarters (*Chenopodium album*)

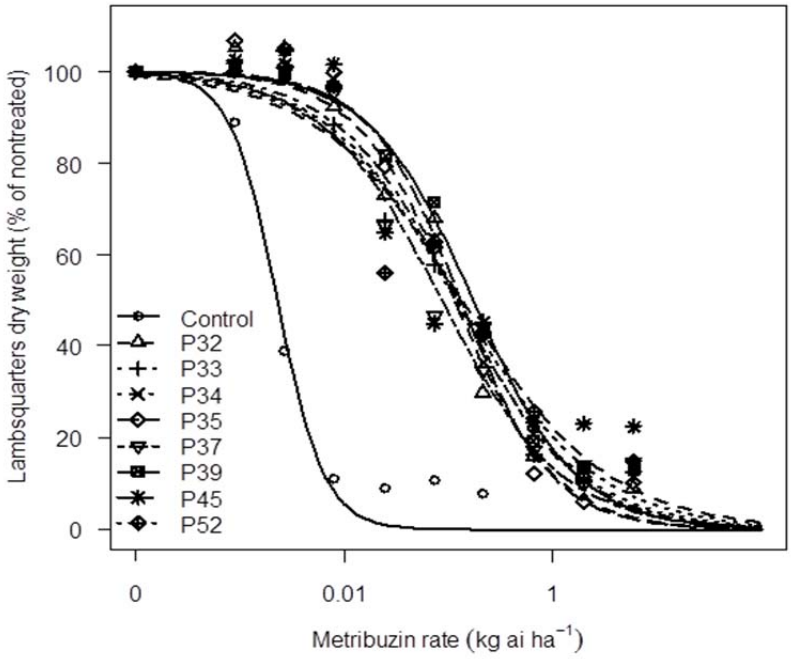
Eight of 25 common lambsquarters biotypes collected from potato fields in the Columbia Basin were resistant to metribuzin (Table 2 and Fig. 2). The lowest dose of 0.022 lb ai/a metribuzin resulted in 92% control of the susceptible biotype. Dose response analysis based on ED_{50} values indicated that approximately 50 to 127 fold more herbicide was required to provide 50% reduction in dry weight of the resistant biotypes compared to the susceptible control (Table 2). All metribuzin resistant common lambsquarters biotypes from potato tested cross resistant to terbacil. In addition, all metribuzin resistant common lambsquarters biotypes were collected from potato fields that also contained metribuzin resistant pigweed. Herbicide use practices on those fields likely led to the selection of resistant biotypes of both species.

All common lambsquarters biotypes were tested for susceptibility to rimsulfuron (Matrix) applied POST at 0.0117 lb ai/a (½ X 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.

Table 2. Common lambsquarters response to metribuzin (column 2), ED_{50} dose (column 3), and resistance index (RI) (column 4) of lambsquarters biotypes collected from potato fields in the Columbia Basin.

Biotype	Injury (2 WAT) to 0.28 kg ai/ha	ED_{50}	RI
	(% Control)	(kg ai/ha)	
Susc. Control	100	~ 0.0022	1
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**	**0.11**	**50**
P34	**12**	**0.12**	**55**
P33	**7**	**0.12**	**55**
P35	**9**	**0.13**	**59**
P37	**10**	**0.14**	**64**
P39	**5**	**0.22**	**100**
P52	**5**	**0.24**	**109**
P45	**5**	**0.28**	**127**

Figure 2. Dose response of eight common lambsquarters biotypes collected from Washington potato fields to metribuzin compared to a susceptible control.



Summary

Fifty five percent of pigweed biotypes and 32% of common lambsquarters biotypes collected from potato fields were resistant to metribuzin. Metribuzin resistant biotypes of both species were cross resistant to terbacil. No resistance to rimsulfuron was observed in the pigweed or common lambsquarters biotypes collected. These results confirm the presence of metribuzin resistant weeds in the Columbia Basin potato growing region.

Atrazine used in corn production and hexazinone and metribuzin used in alfalfa production have 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 different modes of action (rimsulfuron, ethalfluralin, EPTC, s-metolachlor, dimethenamid-p, trifluralin, and flumioxazin). Rotation and tank mixing of herbicides with different modes of action should be used to manage and delay development of herbicide resistant weed populations. Diverse crop rotations, cultural weed control practices, cultivation, and a diverse and varied approach to weed management are keys to preventing herbicide resistant weed populations from evolving. The mode of action group is now listed on many herbicide labels to help growers monitor mode of action they are using. A publication, 'Guide for Herbicide Rotation in the PNW, publication #437' is also available.