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Weed Control in Soybean with Imazethapyr Applied Alone or in Tank Mix with Saflufenacil/Dimethenamid-P

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Saflufenacil/dimethenamid-P is a relatively new prepackaged herbicide mixture that has the potential to provide enhanced weed control in soybean when tank-mixed with reduced doses of imazethapyr. Six field experiments were conducted over a 3-yr period (2011, 2012, and 2013) near Ridgetown and Exeter, Ontario, Canada, to determine the dose of imazethapyr, applied PRE, that must be added to saflufenacil/dimethenamid-P (245 g ai ha^{-1}) to provide effective weed control in soybean. The predicted dose of imazethapyr PRE for 80% control of common lambsquarters, common ragweed, green foxtail, and velvetleaf 8 wk after soybean emergence (WAE) was 66, 180, 137, and 48 g ai ha^{-1}, respectively. In contrast, when tank-mixed with saflufenacil/dimethenamid-P (245 g ha^{-1}), the dose of imazethapyr PRE needed for 80% control of common lambsquarters, common ragweed, green foxtail, and velvetleaf was reduced to 11, 80, 48, and 18 g ha^{-1}, respectively. The control of common lambsquarters, common ragweed, green foxtail, and velvetleaf was improved by 21, 23, 34, and 27%, respectively when saflufenacil/dimethenamid-P (245 g ha^{-1}) was added to imazethapyr PRE. Imazethapyr at 104 g ha^{-1} resulted in soybean yield that was 95% of the weed-free control; however, when tank-mixed with saflufenacil/dimethenamid-P (245 g ha^{-1}) only 54 g ha^{-1} of imazethapyr was required for the same yield level. Based on this study, PRE application of saflufenacil/dimethenamid-P with reduced doses of imazethapyr has the potential to improve soybean yield and provide acceptable weed control ($\geq$ 80%); however, the extent that imazethapyr dose can be reduced is dependent upon weed community composition.

Nomenclature: Saflufenacil/dimethenamid-P; imazethapyr; common lambsquarters, *Chenopodium album* L. CHEAL; common ragweed, *Ambrosia artemisiifolia* L. AMBEL; green foxtail, *Setaria viridis* (L.) Beauv. SETVI; velvetleaf, *Abutilon theophrasti* Medik. ABUTH; soybean, *Glycine max* (L.) Merr.
Key words: Dose response, preemergence herbicides, residual herbicides, tank mixing.

Soybean is Ontario's most important row crop with more than 1 million hectares planted annually (Kulasekera 2014). Widespread soybean adoption has been attributed to the development of earlier-maturing cultivars, amenability to no-till regimes, and flexibility in herbicide choice (OMAFRA 2009). Unlike most cereal crops, which are seeded in rows spaced 18 cm apart, soybean row spacing varies from 18 to 75 cm (OMAFRA 2009; Wax and Pendleton 1968). This potentially increases the comparative time from seedling emergence to canopy closure. Accordingly, weed control in soybean is critical during the vegetative to early reproductive growth stages (Mulugeta and Boerboom 2000; Swanton et al. 2009; Van Acker et al. 1993).

Saflufenacil is a relatively new herbicide in the pyrimidinedione class, registered for use in several crops including soybean and corn (*Zea mays* L.) (OMAFRA 2013). Saflufenacil provides selective broadleaf weed control by inhibiting protoporphyrinogen oxidase (PPO) and can be applied preplant, PPI, or PRE (Geier et al. 2009; Grossmann et al. 2011). Saflufenacil absorption occurs readily through the root and shoot tissues, followed by translocation that occurs primarily via the xylem; selectivity is conferred by physical placement and rapid metabolism in tolerant crop species (Bowe et al. 2008). Saflufenacil can be applied alone or tank-mixed with additional mode(s) of action to improve efficacy and increase the spectrum of weeds controlled.

Saflufenacil/dimethenamid-P is a packaged herbicide mixture registered for use in soybean at a maximum dose of 245 g ha^{-1} (25 : 220 g ai ha^{-1} of saflufenacil : dimethenamid-P) in Ontario (OMAFRA 2013). Dimethenamid-P belongs to the chloroacetamide herbicide class whose mode of action inhibits very long chain fatty acid (VLCFA) biosynthesis (Böger 2003). Saflufenacil/dimethenamid-P can be applied preplant or PRE and provides season-long control of annual grass and broadleaf weeds; however, the length of residual activity is dependent upon application rate and application timing, as well as soil

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Table 1. Soil characteristics for each trial site in Ontario, Canada, including soil texture; percent composition of sand, silt, clay, and organic matter (OM); and cation exchange capacity (CEC).

Year	Trial site	Location	Soil texture	Sand	Silt	Clay	OM	pH	CEC
				%					m eq 100 g^{-1}
2011	11-1	Ridgetown	Clay loam	34	31	35	4.1	6.5	13
	11-2	Ridgetown	Clay loam	36	31	33	4.2	6.8	20
2012	12-1	Ridgetown	Sandy loam	57	24	20	2.7	6.7	10
	12-2	Ridgetown	Clay loam	26	36	38	5.9	7.2	31
2013	13-1	Ridgetown	Sandy clay loam	59	20	22	2.4	7.4	9
	13-2	Exeter	Clay loam	35	43	22	3.6	7.6	27

and moisture factors (Miller et al. 2012b; Moran et al. 2011). Miller et al. (2012a) determined that the biologically effective dose of saflufenacil/dimethenamid-P was 224 to 374 g ai ha^{-1} for common lambsquarters, common ragweed, and green foxtail 4 wk after treatment when adequate moisture was present. In Ontario, the maximum field dose of saflufenacil/dimethenamid-P for use in corn is 735 g ai ha^{-1}, three times higher than the maximum dose for soybean (OMAFRA 2013). A lower dose is required in soybean to minimize the potential for injury; however, applying less herbicide also can result in reduced length of residual weed control (Miller et al. 2012). Full-season weed control can be achieved through the addition of a tank-mix partner (Soltani et al. 2007a).

Imazethapyr is an acetolactate synthase- (ALS) inhibiting herbicide registered for use in soybean at 75 to 100 g ha^{-1} in Ontario (OMAFRA 2013). Imazethapyr provides selective control of various grass and broadleaf weeds and can be applied preplant, PPI, PRE, and POST (Cantwell et al. 1989). Herbicides in this mode of action group are inhibitors of a common enzyme that leads to synthesis of branch chain amino acids leucine, valine, and isoleucine (LaRossa et al. 1987). ALS inhibitors typically have residual activity and are used in almost all major crops including soybean, corn, wheat (*Triticum aestivum* L.), and pasture (Vencill et al. 2012).

Saflufenacil/dimethenamid-P has shown efficacious weed control in soybean (Miller et al. 2012); however, tank mixing or the inclusion a POST herbicide application might be required for full season weed control. Therefore the objectives of this study were: (1) to determine if there is a benefit to adding imazethapyr in tank mix with saflufenacil/dimethenamid-P compared to application of saflufenacil/dimethenamid-P alone; and (2) to establish at what dose imazethapyr must be applied to provide 80 and 90% weed control based on a regression analysis.

Materials and Methods

Study Sites. Field studies were conducted in 2011, 2012, and 2013 at the University of Guelph, Ridgetown Campus, located near Ridgetown (42.453°N, 81.921°W) and in 2013 at the Huron Research Station (43.317°N, 81.501°W), located near Exeter, Ontario, Canada. Seedbed preparation at all sites consisted of fall moldboard plowing followed by two passes of a field cultivator with rolling basket harrows in the spring. All sites were fertilized according to soil test results. Soil characteristics are listed in Table 1.

Experimental Design. Herbicide treatments were designed to determine the dose of imazethapyr that must be added to saflufenacil/dimethenamid-P applied PRE to provide acceptable weed control in soybean. There were 15 treatments, which consisted of an nontreated (weedy) control and weed-free control, saflufenacil/dimethenamid-P (Integrity™, BASF, Mississauga, Ontario, Canada) at 245 g ai ha^{-1} (25 : 220 g ai ha^{-1} of saflufenacil : dimethenamid-P), imazethapyr (Pursuit™, BASF, Mississauga, Ontario, Canada) applied at 6.25, 12.5, 25, 50, 100, and 200 g ai ha^{-1} alone, and tank mixed with 245 g ai ha^{-1} saflufenacil/dimethenamid-P. Treatments were arranged as a randomized complete block design with four replications. Plots measured 10 m long by 3 m wide at Ridgetown and 11 m long by 3 m wide at Exeter. Locally adapted glyphosate-resistant soybean cultivars were chosen for each site on the basis of their maturity ranking and yield potential (Table 2). Soybean cultivars were seeded 3 to 4 cm deep, in rows spaced 75 cm apart, at approximately 380,000 seeds ha^{-1}.

Herbicide applications were made using CO_2-pressurized backpack sprayer calibrated to deliver 200 L ha^{-1} aqueous solution at 207 kPa. Boom length was 1.5 m long with four 'ULD120-02' ultra-low drift nozzles (Hypro, New Brighton, MN) spaced 50 cm apart. Herbicides were applied to the soil surface 0 to 3 d after seeding (Table 2).

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Table 2. Agronomic details including glyphosate-resistant soybean cultivar used as well as dates of seeding, seedling emergence, and herbicide application date for each year at each location in Ontario, Canada.

Year	Trial site	Location	Soybean cultivar	Seeding	Emergence	Preemergence
2011	11-1	Ridgetown	Dekalb 32-60RY	June 3	June 8	June 6
	11-2	Ridgetown	Dekalb 32-60RY	June 3	June 8	June 6
2012	12-1	Ridgetown	Dekalb 32-61RY	May 18	May 24	May 18
	12-2	Ridgetown	Dekalb 32-61RY	May 24	June 2	May 25
2013	13-1	Ridgetown	Dekalb 32-11RY	May 15	May 22	May 16
	13-2	Exeter	Dekalb 28-60RY	May 8	May 21	May 9

Weed-free control plots were maintained by hoeing and hand weeding as needed during the growing season.

Data Collection. Soybean injury was visually estimated on a scale of 0 (no injury) to 100% (complete plant death) at 2 and 4 wk after crop emergence (WAE). Weed control was evaluated relative to the nontreated control at 4 and 8 WAE on a scale of 0 (no control) to 100% (complete control). Weed density and dry weight per square meter were determined 6 WAE by counting and cutting plants, separated by species, at the soil surface from two 0.5 m^2 quadrats per plot. Plants were dried at 60 C to constant moisture and then weighed. The soybean crop was harvested with a small plot combine, weight and moisture were recorded, and yields were adjusted to 13% moisture.

Statistical Analysis. Data were analyzed using nonlinear regression (PROC NLIN) in SAS (Statistical Analysis Systems, Ver. 9.2, SAS Institute Cary, NC). The weed-free control and the saflufenacil/dimethenamid-P treatments were not included in regression analysis. Weed density and dry weight were converted to a percent of the nontreated control and yield was converted to a percent of the weed-free control prior to analysis. All parameters were regressed against imazethapyr dose, designated as DOSE in the equations. Data for percent weed control (dose-response) was regressed using a four-parameter log-logistic model shown in Equation 1:

$$y = C + (D - C) / \{1 + \exp[-b(\ln \mathrm{DOSE} - \ln I_{50})]\} \quad [1]$$

where C is the lower asymptote, D is the upper asymptote, b is the slope and I_{50} is the dose which gives a response halfway between C and D (Seefeldt et al. 1995). For percent density and dry weight, the inverse exponential equation (Equation 2) was used:

$$y = f + g * [\exp(-h * \mathrm{DOSE})] \quad [2]$$

where f is the lower asymptote, g is the magnitude of the response and h is the slope of the response (Seefeldt et al. 1995).

Regression equations were used to calculate predicted imazethapyr dose (g ai ha^{-1}) required to provide 50, 80, and 95% percent control of weed species or a 50, 80, and 95% reduction in percent weed density or dry weight (ED_{50}, ED_{80}, and ED_{95}), or the dose which gave 90, 95, and 98% yield of the weed-free control (ED_{90}, ED_{95}, and ED_{98}). If any imazethapyr dose was predicted to be higher than 200 g ai ha^{-1}, it was simply expressed as "> 200" because it would be unsuitable to extrapolate outside the range of doses evaluated in these experiments.

Contrasts (PROC MIXED) were used to compare imazethapyr alone vs. imazethapyr plus 245 g ai ha^{-1} saflufenacil/dimethenamid-P (25 : 220 g ai ha^{-1} of saflufenacil : dimethenamid-P), for all imazethapyr doses combined as well as for each dose of imazethapyr, to determine when there was a benefit to adding saflufenacil/dimethenamid-P.

Results and Discussion

Crop Injury. No soybean injury was observed 2 WAE from the PRE application of saflufenacil/dimethenamid-P, imazethapyr, or tank mix of saflufenacil/dimethenamid-P plus imazethapyr (data not shown). There was minimal injury at Exeter 2013, 4 WAE of 2 and 6% with 100 and 200 g ha^{-1} imazethapyr, respectively (data not shown). This is consistent with Mahoney et al. (2014) who reported soybean injury of up to 12% attributed to PRE application of saflufenacil (50 g ai ha^{-1}) plus dimethenamid-P (1,386 g ai ha^{-1}), though the injury was transient and did not significantly depress soybean yield.

Crop Yield. Soybean yield was significantly higher when treated with imazethapyr plus saflufenacil/

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Table 3. Regression parameter estimates (± SE) and predicted imazethapyr dose for visual weed control evaluations at 4 and 8 WAE, and soybean yield as percent of the nontreated control as well as contrasts comparing the level of weed control across all doses of imazethapyr (I) (6.25 to 200 g ai ha^{-1}) without and with saflufenacil/dimethenamid-P (S/D) added at a dose of 245 g ai ha^{-1} in studies conducted in Ontario, Canada in 2011 to 2013.[a]

				Parameter estimates[c] (± SE)				Predicted imazethapyr dose[d]			
Weed	WAE	Treatment	I vs. I + S/D[b]	*C*	*D*	*b*	I_{50}	ED_{50}	ED_{80}	ED_{95}	Benefit of + S/D[e]
			%	—— % ——			—— g ai ha^{-1} ——				g ai ha^{-1}
CHEAL	4	I	72 vs. 90*	0 (0)	98 (5)	1.5 (0.3)	14 (2)	15	40	161	< 50
		I + S/D		0 (3)	98 (2)	1.9 (0.5)	4 (1)	4	9	24	
	8	I	66 vs. 87*	1 (6)	100 (0)	1.1 (0.2)	20 (3)	19	66	> 200	< 50
		I + S/D		0 (0)	99 (2)	1.7 (0.4)	5 (1)	5	11	30	
AMBEL	4	I	41 vs. 66*	1 (5)	100 (0)	1.2 (0.2)	53 (8)	53	164	> 200	< 50
		I + S/D		0 (3)	100 (0)	0.8 (0.1)	7 (1)	7	44	> 200	
	8	I	36 vs. 59*	0 (4)	95 (15)	1.5 (0.4)	59 (16)	64	180	—	< 50
		I + S/D		0 (5)	100 (0)	0.7 (0.1)	13 (3)	13	80	> 200	
SETVI	4	I	43 vs. 76*	3 (4)	100 (0)	1.5 (5.2)	44 (5)	43	106	> 200	< 100
		I + S/D		0 (4)	100 (0)	0.8 (0.1)	6 (1)	6	35	> 200	
	8	I	33 vs. 67*	2 (4)	100 (0)	1.6 (0.2)	58 (6)	57	137	> 200	< 100
		I + S/D		0 (4)	100 (0)	0.9 (0.1)	11 (2)	11	48	> 200	
ABUTH	4	I	65 vs. 91*	0 (0)	97 (4)	1.9 (0.3)	19 (2)	19	42	140	< 50
		I + S/D		0 (0)	100 (4)	1.0 (0.3)	3 (1)	3	13	63	
	8	I	62 vs. 89*	0 (0)	96 (4)	1.9 (0.3)	21 (2)	22	48	198	< 50
		I + S/D		0 (0)	99 (6)	1.0 (0.3)	4 (1)	4	18	98	
								ED_{90}	ED_{95}	ED_{98}	
Yield		I	87 vs. 93*	67 (2)	100 (0)	1.1 (0.2)	21 (4)	45	104	> 200	< 50
		I + S/D		67 (2)	100 (0)	0.6 (0.2)	3 (2)	12	54	> 200	

[a] Abbreviations: CHEAL, common lambsquarters; AMBEL, common ragweed; SETVI, green foxtail; ABUTH, velvetleaf; WAE, weeks after soybean emergence; I, imazethapyr; S/D, saflufenacil/dimethenamid-P.

[b] Percent weed control or yield for all doses of imazethapyr combined, without and with saflufenacil/dimethenamid-P added. *Denotes significance at $P < 0.01$.

[c] Dose-response parameters (Equation 1): *b*, slope; *C*, lower asymptote; *D*, upper asymptote; I_{50}, dose required for 50% response.

[d] Predicted imazethapyr dose (Equation 1): ED_{50}, ED_{80}, and ED_{95} are the doses required to give weed control of 50, 80, and 95%, respectively, for a given weed species; ED_{90}, ED_{95}, and ED_{98} are the doses required to give yields of 90, 95, and 98%, respectively, of the nontreated control.

[e] The dose of imazethapyr below which there was a significant ($P < 0.05$) benefit (increase in weed control or yield) with the addition of saflufenacil/dimethenamid-P vs. imazethapyr alone.

dimethenamid-P compared to imazethapyr alone (Table 3). To establish a 95% yield, relative to the weed-free control, a predicted dose of 104 g ai ha^{-1} imazethapyr was required, yet only 54 g ha^{-1} was needed for saflufenacil/dimethenamid-P tank mixtures (Table 3). Despite the benefit of tank mixing saflufenacil/dimethenamid-P, even at the maximum imazethapyr dose evaluated (200 g ha^{-1}), 98% soybean yield could not be achieved (Table 3). Mahoney et al. (2014) reported no impact on soybean yield for PPO and VLCFA tank mixes, except for those containing PPO-inhibiting herbicide flumioxazin, which were significantly increased. In contrast, Burke et al. (2002) noted that peanut (*Arachis hypogaea* L.) yields could be negatively affected with increased rates (up to 105 g ai ha^{-1}) of flumioxazin.

Weed Control. For regression analysis, weeds that were present in four of the six environments were analysed. These included common lambsquarters, common ragweed, green foxtail, and velvetleaf (Table 3). Environment by herbicide treatment interaction was not statistically significant for all variables evaluated; therefore environments were pooled for all variables.

The addition of saflufenacil/dimethenamid-P to imazethapyr improved the control of common lambsquarters, common ragweed, green foxtail, and velvetleaf by 18, 25, 33, and 26% 4 WAE, respectively; improved weed control was similarly observed at 8 WAE (Table 3). For the weed species evaluated, the ED_{50} of imazethapyr was 3.8 to 7.6 and 3.8 to 5.5 times higher when applied alone, relative to coapplication with saflufenacil/dimethenamid-P at 4 and 8 WAE, respectively (Table 3). A predicted imazethapyr dose of 40, 164, 106, and 42 g ha^{-1} was needed for 80% control of common lambsquarters, common ragweed, green foxtail, and

Table 4. Regression parameter estimates and predicted imazethapyr dose from inverse exponential models of percent weed density and dry weight 6 WAE, as well as contrasts comparing the level of weed density and dry weight across all doses of imazethapyr (6.25 to 200 g ai ha^{-1}) without and with saflufenacil/dimethenamid-P added at a dose of 245 g ai ha^{-1} in studies conducted in Ontario, Canada in 2011 to 2013.[a]

Weed	Variable	Treatment	I vs. I + S/D[b]	Parameter estimates[c] (± SE)			Predicted imazethapyr dose[d]			Benefit of + S/D[e]
				f	g	h	ED_{50}	ED_{80}	ED_{95}	
			%	%			g ai ha^{-1}			g ai ha^{-1}
CHEAL	Density	I	25 vs. 6	3 (5)	96 (8)	0.06 (0.01)	11	28	60	< 100
		I + S/D		5 (2)	95 (4)	0.40 (0.07)	2	5	15	
	Dry weight	I	21 vs. 7*	4 (5)	97 (9)	0.09 (0.02)	9	21	50	< 100
		I + S/D		2 (2)	97 (4)	0.22 (0.03)	3	8	16	
AMBEL	Density	I	45 vs. 23*	12 (8)	81 (10)	0.03 (0.01)	30	93	—	< 50
		I + S/D		20 (5)	80 (10)	0.25 (0.09)	4	24	—	
	Dry weight	I	30 vs. 17*	9 (5)	81 (8)	0.05 (0.01)	15	44	—	< 50
		I + S/D		11 (3)	87 (7)	0.18 (0.04)	4	13	—	
SETVI	Density	I	40 vs. 18*	18 (6)	79 (9)	0.05 (0.01)	18	73	—	< 100
		I + S/D		13 (3)	86 (7)	0.21 (0.04)	4	12	—	
	Dry weight	I	27 vs. 11*	6 (4)	97 (8)	0.07 (0.01)	11	28	—	< 50
		I + S/D		6 (2)	94 (4)	0.22 (0.03)	3	9	—	
ABUTH	Density	I	37 vs. 25*	19 (9)	82 (15)	0.07 (0.03)	14	62	—	< 50
		I + S/D		17 (7)	82 (15)	0.14 (0.06)	6	24	—	
	Dry weight	I	22 vs. 9*	7 (5)	92 (10)	0.09 (0.02)	8	21	—	< 25
		I + S/D		4 (3)	96 (7)	0.21 (0.04)	4	9	22	

[a] Abbreviations: CHEAL, common lambsquarters; AMBEL, common ragweed; SETVI, green foxtail; ABUTH, velvetleaf; WAE, weeks after soybean emergence; I, imazethapyr; S/D, saflufenacil/dimethenamid-P.

[b] Percent weed density or dry weight for all doses of imazethapyr combined, without and with saflufenacil/dimethenamid-P added. *Denotes significance at $P < 0.01$.

[c] Exponential to maximum parameters (Equation 2): f, lower asymptote; g, magnitude of response; h, slope of response.

[d] Predicted imazethapyr dose (Equation 2): ED_{50}, ED_{80}, and ED_{95} are the doses required to give a 50, 80, and 95% reduction in percent density or dry weight, respectively, for a given weed species.

[e] The dose of imazethapyr below which there was a significant ($P < 0.05$) benefit (decrease in weed density or dry weight) with the addition of saflufenacil/dimethenamid-P vs. imazethapyr alone.

velvetleaf 4 WAE, respectively; however, when saflufenacil/dimethenamid-P was added as a tank-mix partner, the predicted imazethapyr dose was reduced to 9, 44, 35, and 13 g ha^{-1}, respectively (Table 3). Similarly, at 8 WAE the predicted dose of imazethapyr was at least 50% lower when applied in tank mix with saflufenacil/dimethenamid-P, compared to application of imazethapyr alone for the weeds evaluated (Table 3). Imazethapyr PRE application at the maximum field recommended dose (100 g ha^{-1}) did not provide 95% control of the species evaluated 4 and 8 WAE (Table 3). However, for tank mixes with saflufenacil/dimethenamid-P, common lambsquarters and velvetleaf were 95% controlled with 24 and 63 at 4 WAE and 30 and 98 g ha^{-1} imazethapyr at 8 WAE, respectively (Table 3).

Compared to only imazethapyr, common ragweed, green foxtail, and velvetleaf density and dry weight were significantly lower for imazethapyr plus saflufenacil/dimethenamid-P treatments; common lambsquarters dry weight likewise was lower but density was unaffected (Table 4). A predicted dose of 100 g ha^{-1} imazethapyr was associated with 80% reduction of density and dry weight for the weeds evaluated; however, tank mixing with saflufenacil/dimethenamid-P demonstrated the same decrease with a predicted maximum of only 24 g ha^{-1} imazethapyr (Table 4). Velvetleaf dry weight was particularly sensitive to tank-mixing imazethapyr with saflufenacil/dimethenamid-P; dry weight was significantly reduced, relative to application of only imazethapyr, for tank mixes containing < 25 g ha^{-1} imazethapyr (Table 4). In spite of the advantages of tank-mixing imazethapyr with saflufenacil/dimethenamid-P, a standard field application of imazethapyr alone was sufficient to reduce weed density and dry weight by at least 80% (Table 4).

In other studies, the dose of PPI-applied imazethapyr required to provide 95% control of common lambsquarters, common ragweed, and green foxtail was significantly reduced when tank-

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mixed with dimethenamid in dry bean (Soltani et al. 2007a). However, in a related study the comparative impact on imazethapyr alone and tank-mixed with dimethenamid was less pronounced for PRE application (Soltani et al. 2007b). Similarly, increased control has also been reported for tank-mixing PPO- and ALS-inhibiting herbicides in pasture (Datta et al. 2013) and in citrus (*Citrus* sp.) (Jhala et al. 2012). The corresponding increase in weed control might be attributed to enhanced absorption in sensitive plants (Camargo et al. 2012).

In summary, application of saflufenacil/dimethenamid-P in soybean at the maximum field dose (245 g ha^{-1}) in tank mix with reduced doses of imazethapyr provides improved control of common lambsquarters, common ragweed, green foxtail, and velvetleaf, compared to PRE imazethapyr alone. According to the results of this study, a predicted minimum imazethapyr dose of 30 and 98 g ha^{-1} has the potential to provide 95% control of common lambsquarters and velvetleaf when tank-mixed with 245 g ha^{-1} saflufenacil/dimethenamid-P, respectively. Although tank-mixing imazethapyr with saflufenacil/dimethenamid-P is insufficient for 95% control of common ragweed and green foxtail, 80 and 48 g ha^{-1} imazethapyr has the potential to provide upwards of 80% control, respectively. Furthermore, tank-mixing imazethapyr with saflufenacil/dimethenamid-P will significantly increase soybean yield compared to application of only imazethapyr. Application of more than one mode of action will reduce the selection pressure for resistant weed biotypes, whereas reducing herbicide dose has the potential to improve profit margins and reduce environmental concerns. Further research should therefore assess economic returns and environmental impacts, as well as include weed species not evaluated in this study. In conclusion, imazethapyr dose can be reduced when tank-mixed with the maximum dose of saflufenacil/dimethenamid-P for acceptable control (80%) of common lambsquarters, common ragweed, green foxtail, and velvetleaf when applied PRE in soybean. The degree that imazethapyr dose can be reduced will be affected greatly by weed community composition.

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