Efficacy and Sugarbeet Tolerance with Postemergence Dimethenamid-P

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ABSTRACT

Field experiments were conducted from 1998 to 2000 to evaluate crop tolerance and weed control from dimethenamid-P alone and in tank-mix combinations applied postemergence (POST) to sugarbeet *(Beta vulgaris* L.*)* at Ontario, Oregon. In the tolerance trials dimethenamid-P was applied to four- to six-leaf sugarbeet in 1998 and 1999 and to two- to four-leaf sugarbeet in 2000. Significant ($P < 0.05$) herbicide injury to sugarbeet was observed in 1998 and 2000 at both 12 and 28 days after treatment (DAT). Sugarbeet injury was not significant for any herbicide treatment in 1999. Dimethenamid-P applied at 2.87 kg ha^{-1} caused the greatest sugarbeet injury in 1998. Injury in 2000 from tank-mix combinations of dimethenamid-P at 0.72 kg ha^{-1} plus desmedipham-phenmedipham with and without triflusulfuron was greater than from dimethenamid-P at 2.87 kg ha^{-1} at 12 DAT and similar at 28 DAT. Sugarbeet yield from plots treated with dimethenamid-P at 2.87 kg ha^{-1} was less than all other treatments in 1998. In 1999, plots treated with dimethenamid-P at 1.43 kg ha^{-1} produced greater root and estimated recoverable sucrose yields than untreated plots or those treated with dimethenamid-P at 0.72 kg ha^{-1}. Sugarbeet yields did not differ among treatments in 2000. In the weed control trials dimethenamid-P at 0.72 kg ha^{-1} was applied to two- to four- or four- to six-leaf sugarbeet. Dimethenamid-P added to desmedipham-phenmedipham increased late season barn-

yardgrass control by 34 and 32% in 1998 and 1999, respectively. Late season barnyardgrass control increased 22% in 1998 and 85% in 1999 when dimethenamid-P was added to desmedipham-phenmedipham plus triflusulfuron. Sugarbeet root yields in plots treated with POST combinations plus dimethenamid-P ranged from 7.4 to 9.6 Mg ha^{-1} higher than those same POST combinations without dimethenamid-P in 1998 and 1999. Sugarbeet root yields were greater ($P < 0.1$) when dimethenamid-P was applied with desmedipham-phenmedipham in 1998 and 1999 and with desmedipham-phenmedipham plus triflusulfuron in 1999. Desmedipham-phenmedipham plus triflusulfuron plus dimethenamid-P applied to two- to four-leaf sugarbeet provided significantly ($P < 0.15$) greater root yield than the same treatment without dimethenamid-P in 1998. The trend toward higher root yields was likely due to greater redroot pigweed, hairy nightshade, and barnyardgrass control in 1998 and greater barnyardgrass control in 1999 from dimethenamid-P.

Additional Key Words: desmedipham, dimethenamid, dimethenamid-P, phenmedipham, sethoxydim, triflusulfuron, barnyardgrass, common lambsquarters, hairy nightshade, redroot pigweed, (*Beta vulgaris* L).

Dimethenamid-P is an *N*-thienyl chloroacetamide herbicide and is the more active stereoisomer of the racemic compound dimethenamid (Couderchet et al, 1997). Dimethenamid-P may be applied preplant surface, preplant incorporated, preemergence or postemergence for the control of annual grasses and certain small-seeded broadleaf weeds in corn (*Zea mays* L.), dry bean (*Phaseolus vulgaris* L.), peanut (*Arachis hypogaea* L.), grain sorghum [*Sorghum bicolor* (L.) Moench.], soybean [*Glycine max* (L.) Merr.], and several grass species grown for seed (BASF Product Label).

Dimethenamid and dimethenamid-P are often applied preplant incorporated (PPI) to several crops; however PPI applications to sugarbeet have resulted in increased crop injury compared to postemergence (POST) applications (Dexter, 1999). Dimethenamid-P has little or no POST activity. Susceptible weeds are controlled by dimethenamid-P when timely applications are made prior to weed emergence. Therefore, if dimethenamid-P is to be applied POST to a crop, emerged weeds must be controlled prior to or simultaneously with the dimethenamid-P application. Crop tolerance and weed control from POST applications of dimethenamid and dimethenamid-P have been evaluated in several horticultural crops (Kaufman et al., 2001; Lee and Waters, 1998; McReynolds and Abraham, 1999; Peachey and Mallory-Smith, 1999; Waters and Lee, 1999) and agronomic crops such as potato *(Solanum tuberosum* L.*)* (Hutchinson et al., 2001; Tonks et al., 1999), and sugarbeet (Dexter, 1998; Morishita and Wille, 2000; Wille and Morishita, 2000).

Tank-mixtures of dimethenamid applied POST with certain herbicides have resulted in synergistic control of grass weeds (Scott et al., 1995) through enhanced foliar absorption (Scott et al., 1998b). Furthermore, dimethenamid tank-mixed with glyphosate applied to glyphosate tolerant soybean increased control of barnyardgrass *(Echinochola crus-galli* L.*)* and johnsongrass *(Sorghum halepense* L.*)* compared with glyphosate applied alone by controlling late season grasses that emerged prior to row closure (Scott et al., 1998b). The addition of dimethenamid-P to standard sugarbeet herbicide programs may reduce the amount of graminicide or the number of POST applied grass treatments required for season long control of annual grasses. Additionally, dimethenamid-P may assist currently registered herbicides in providing season long control and/or suppression of several broadleaf weeds including nightshade *(Solanum* spp.*)* and pigweed *(Amaranthus* spp.*)* species (Ahrens, 1994; Gaeddert et al., 1997; Tonks et al., 1999).

The objectives of this research were to evaluate both crop tolerance and weed control with POST applications of dimethenamid-P applied alone and in combination with desmedipham-phenmedipham, triflusulfuron, and sethoxydim in furrow irrigated sugarbeet.

MATERIALS AND METHODS

General Experimental Procedures

Field experiments were conducted in 1998, 1999, and 2000 at the Oregon State University Malheur Experiment Station, Ontario, Oregon. The soil for all three years was an Owyhee silt loam (coarse-silty, mixed, mesic Xerollic Camborthids). The experimental site in 1998 had a soil pH of 7.0 with an organic matter content of 2.4% and a cation exchange capacity (CEC) of 22 meq/100 g soil. The site in 1999 had pH 7.9, an organic matter content of 1.4%, and a CEC of 18. The site in 2000 had pH of 7.0, an organic matter content of 1.5%, and a CEC of 22. Plots consisting of four 56 cm rows measuring 8.23 m in length were established under furrow irrigation on April 15, 1998, April 7, 1999, and

April 11, 2000. Sugarbeet was planted at a population of 352,300 seeds ha^{-1} with seeds spaced at 5.0 cm. Plots were hand thinned to 20.0 cm spacing (88,000 plants ha^{-1}) on May 14, 1998, May 20, 1999, and May 10, 2000. The sugarbeet varieties grown were Hilleshog MonoHy 'WS-PM 9' in 1998 and 'WS-PM 21' in 1999 and 2000. Herbicide treatments were applied broadcast utilizing a backpack sprayer calibrated to deliver 180 L ha^{-1} at 207 kPa using 8002 or 11002 flat fan nozzles. Plots were fertilized each season according to soil test recommendations. Experimental plots were harvested on October 14, 6, or 3 in 1998, 1999, and 2000, respectively. Sugarbeet foliage was removed with a rotating rubber defoliator and the crowns were clipped with rotating scalping knives. Roots were harvested from the entire length of the center two rows in each plot using a one-row, wheel-type harvester. The total sugarbeet weight from each plot was used to calculate root yield. Root yields were adjusted for a 5 percent tare. In the tolerance trials, one sample of sixteen beets was taken from each plot for quality analysis. The samples were evaluated to determine beet pulp sucrose content and purity. The percent sucrose extraction was estimated using empirical equations (Carruthers et al., 1962).

Sugarbeet injury, yield, and weed control data were subjected to analysis of variance using the general linear model (GLM) procedure of SAS (SAS Institute Inc., 1999-2001) and are presented by year where significant (P 0.05) year interactions occurred. Sugarbeet injury, weed control, and yield means were separated using Fisher's protected LSD test (P = 0.05). Sugarbeet root yield means in the weed control trials were separated using a significance level of P = 0.1.

Herbicide Tolerance

A randomized complete block experimental design with four replicates was used. Field experiments were conducted from 1998 to 2000 to evaluate sugarbeet tolerance to POST applications of dimethenamid-P alone or in combination with several herbicides currently registered for use in sugarbeet. Dimethenamid-P was applied at 0.72, 1.43, and 2.87 kg ai ha^{-1}. At the time these experiments were conducted, the proposed labeled rate of dimethenamid-P in sugarbeet was 0.72 kg ha^{-1}. Early season weed control in all years was accomplished utilizing a pre-mix of desmedipham-phenmedipham (1:1 ratio) applied broadcast across the entire experimental area. In 1998 and 1999, desmedipham-phenmedipham at 0.37 and 0.28 kg ha^{-1}, respectively, was applied to cotyledon sugarbeet with a second application seven days later to two-leaf sugarbeet. In 2000, a single application of desmedipham-phenmedipham at 0.37 kg ha^{-1} was applied to cotyledon sugarbeet. Weeds not controlled by herbicide applications were removed by hand to minimize any weed competition. Sugarbeet injury was visually evaluated on a scale from 0 (no injury) to 100% (plant death) at 12 and 28 DAT and thereafter at approximately two week intervals.

In 1998 and 1999 herbicide treatments applied at the four- to six-leaf stage of sugarbeet development included dimethenamid at 1.31 kg ha^{-1}; dimethenamid-P at 0.72, 1.43, and 2.87 kg ha^{-1}; dimethenamid-P at 0.72 kg ha^{-1} plus desmedipham-phenmedipham at 0.37 kg ha^{-1}; and dimethenamid-P at 0.72 kg ha^{-1} plus desmedipham-phenmedipham at 0.37 kg ha^{-1} plus triflusulfuron at 0.018 kg ha^{-1}. In 2000 these treatments were applied approximately ten days earlier to two- to four-leaf sugarbeet. Additionally, the treatment of dimethenamid applied alone at 1.31 kg ha^{-1} was omitted in 2000. Cotyledon applications were made on April 27, 1998 and on April 24 in 1999 and 2000. Applications to two- to four-leaf sugarbeet were made on May 8, 1, and 5 in 1998, 1999, and 2000, respectively. Four- to six- leaf applications were made on May 18 in 1998 and 1999.

Herbicide Efficacy

The experimental design was a randomized complete block with three replicates. Field experiments were conducted in 1998 and 1999 to determine weed control in sugarbeet with dimethenamid-P alone and in combination with several herbicides currently registered for use in sugarbeet. Desmedipham-phenmedipham at 0.28 kg ha^{-1} was applied to all plots, except those designated as untreated, at the cotyledon stage of sugarbeet development on April 27, 1998 and April 24, 1999. Applications to two- to four-leaf sugarbeet were made on May 8, 1998 and May 10, 1999 and consisted of dimethenamid at 1.31 kg ha^{-1}; dimethenamid-P at 0.72 kg ha^{-1}; dimethenamid-P plus desmedipham-phenmedipham; desmedipham-phenmedipham; dimethenamid-P plus desmedipham-phenmedipham plus triflusulfuron at 0.018 kg ha^{-1}; desmedipham-phenmedipham plus triflusulfuron; and dimethenamid-P plus desmedipham-phenmedipham followed by sethoxydim at 0.21 kg ha^{-1} plus crop oil concentrate at 1.0% v/v applied to four- to six-leaf sugarbeet on May 15, 1998 and May 16, 1999. Weed control was evaluated throughout the growing season beginning after the last herbicide application and was based on a rating scale of 0 (no effect) to 100% (death of all weeds).

RESULTS AND DISCUSSION

Monthly precipitation was above average in April and May, 1998 and June, 1999 (Table 1). The 1998 growing season began cooler and wetter than normal. April had 29% fewer and May had 80% fewer

Table 1. Summary of monthly precipitation, total growing degree days, and soil temperature at the Malheur Experiment Station, Ontario, OR in 1998, 1999, and 2000.

	Precipitation			Degree days			Soil temperature					
							April		May		June	
Year	April	May	June	April	May	June	Max	Min	Max	Min	Max	Min
	------ mm ------			---- (10-30 C) ----			--------------- C ---------------					
1998	36	116	9	112	68	571	11	8	15	13	18	15
1999	6	7	26	72	329	459	9	7	13	11	19	17
2000	18	7	7	194	342	536	13	10	16	13	20	17
Average[†]	29	39	22	157	344	529	16	9	21	14	26	18

[†] Average precipitation over 55 years, degree day cumulative average over 14 years, and maximum and minimum soil temperature average over 33 years.

growing degree days (10 to 30 C) than the fourteen year average from 1986 to 2000 (Table 1). Precipitation in May 1998 was 116 mm which was the highest monthly total ever recorded at the Malheur Experiment Station. The average monthly maximum soil temperatures for April, May, and June were below average in all three years of the study. Sugarbeet plots were severely injured by hail on July 4, 1998.

Herbicide Tolerance

Sugarbeet Injury. Sugarbeet injury from herbicide treatment was characterized by general plant stunting and slight yellowing in some cases. Significant ($P < 0.05$) herbicide injury was observed in 1998 and 2000 at both 12 and 28 days after treatment (DAT) (Table 2). In general, dimethenamid-P applied alone at 2.87 kg ha^{-1} caused the greatest sugarbeet injury. Sugarbeet injury was not significant for any herbicide treatment in 1999.

Desmedipham-phenmedipham applied to sugarbeet at the cotyledon and two- to four-leaf stages caused slight injury (3 to 9%) to the weed free control at 12 and 28 DAT in 1998 and 28 DAT in 1999. Sugarbeet injury at 12 DAT in 1998 ranged from 6 to 29%, with the greatest injury observed with dimethenamid-P at 2.87 kg ha^{-1} (Table 2). All other treatments displayed injury similar to the weed free control 12 DAT. Injury evaluations 28 DAT ranged from 3 to 21%, again the highest observed injury occurred with dimethenamid-P at 2.87 kg ha^{-1} however, dimethenamid-P, applied at 1.43 kg ha^{-1} produced similar injury. Injury evaluations in 1999 ranged from 0 to 6% 12 DAT and from 4 to 9% 28 DAT and were not significant for either evaluation date. Sugarbeet injury in 2000 ranged from 0 to 25% observed 12 DAT and from 0 to 23% observed 28 DAT. Injury 12 DAT was greater from dimethenamid-P plus desmedipham-phenmedipham with and without triflusulfuron compared to dimethenamid-P alone, regardless of application rate (Table 2). Dimethenamid-P at 0.72 kg ha^{-1} caused 20% less injury 12 DAT than dimethenamid-P at 0.72 kg ha^{-1} plus desmedipham-phenmedipham, and 19% less injury than dimethenamid-P at 0.72 kg ha^{-1} plus desmedipham-phenmedipham plus triflusulfuron. However, injury from these tank mix combinations 28 DAT were comparable to dimethenamid-P applied at 1.43 and 2.87 kg ha^{-1}. Injury associated with dimethenamid-P at 2.87 kg ha^{-1} increased 4% at 28 DAT over that recorded 12 DAT and was the only treatment for which an increase between the two evaluations was observed. By 59 DAT sugarbeet injury from all treatments was similar to the weed free control in 2000 (data not shown).

Sugarbeet treated with dimethenamid-P at 2.87 kg ha^{-1} displayed significantly ($P < 0.05$) greater injury 44 DAT (July 1) than all other

Table 2. Sugarbeet injury with dimethenamid-P in a tolerance trial at Ontario, OR in 1998, 1999, and 2000.

			Sugarbeet injury					
			1998		1999		2000‡	
Treatment†	Rate	Timing	12 DAT	28 DAT	12 DAT	28 DAT	12 DAT	28 DAT
	kg ha-1	crop stage	%					
Weed free control	- -	- -	9	3	0	6	0	0
Dimethenamid	1.31	4-6 lf	6	6	3	4	- -	- -
Dimethenamid-P	0.72	4-6 lf	14	9	1	8	5	6
Dimethenamid-P	1.43	4-6 lf	15	14	4	5	9	8
Dimethenamid-P	2.87	4-6 lf	29	21	2	6	19	23
Dimethenamid-P + Desm-phenmedipham	0.72 0.37	4-6 lf 4-6 lf	13	9	5	6	25	13
Dimethenamid-P + Desm-phenmedipham + Triflusulfuron	0.72 0.37 0.018	4-6 lf 4-6 lf 4-6 lf	9	10	6	9	24	18
LSD (0.05)			11	10	NS	NS	4	12

† To assist in maintaining weed free plots, the following applications were made across the entire experimental area: 1998 desm-phenmedipham at 0.37 kg ha^{-1} applied to cotyledon and 2-4 leaf sugarbeet; 1999 desm-phenmedipham at 0.28 kg ha^{-1} applied to cotyledon and 2-4 leaf sugarbeet; 2000 desm-phenmedipham at 0.37 kg ha^{-1} applied to cotyledon sugarbeet. Additionally, hand weeding was utilized to maintain weed free plots following herbicide application.

‡ Dimethenamid at 1.31 kg ha^{-1} was omitted in 2000 and all dimethenamid-P treatments were applied to 2-4 leaf sugarbeet versus 4-6 leaf sugarbeet as was done in previous years.

treatments in 1998 (data not shown). Precipitation in May 1998 was approximately four times greater than average and may have increased the duration of exposure and injury from the high rate treatment of dimethenamid-P. Herbicides often are more available for plant uptake in soils with high moisture content (Jones et al., 1990; Tripp and Baldwin, 1988). Research has shown soybean injury from dimethenamid at greater than labeled rates in combination with excessive soil moisture (Osborne et al., 1995). Decreased soil temperature in conjunction with above normal soil moisture resulted in increased corn seedling injury from the chloroacetamide herbicides alachlor and metolachlor (Boldt and Barret, 1989). Sugarbeet injury from herbicide treatment was not different from the weed free control 77 DAT in 1998 (data not shown). Rainfall in April and May 1999 was well below average possibly reducing the availability of dimethenamid-P in the soil resulting in less sugarbeet injury than was observed in 1998. Sugarbeet injury in 2000 was greatest with herbicide combinations with dimethenamid-P and dimethenamid-P at 2.87 kg ha^{-1} (Table 2). Injury with these treatments in 2000 may have been greater due to the fact that treatments including dimethenamid-P were applied to two- to four-leaf sugarbeet compared to four- to six-leaf sugarbeet as in the previous years. Additionally, injury with these treatments in 2000 may have been influenced by light dew that was present on the leaf surface at the time of application or by a light rain (< 0.25 mm) immediately following herbicide application.

Sugarbeet Yield. The year interactions with sugarbeet root yield, percent sucrose, or estimated recoverable sucrose were not significant. However, due to variables such as hail and above normal precipitation in 1998, data were analyzed individually by year. Sugarbeet injury from dimethenamid-P at 2.87 kg ha^{-1} resulted in lower root and estimated recoverable sucrose yields in 1998 (Table 3). This treatment caused greater sugarbeet injury than other treatments on July 1 (data not shown), and may have rendered the sugarbeets more susceptible to a damaging hail on July 4. Injury from dimethenamid-P at 2.87 kg ha^{-1} resulted in a significant reduction in sugarbeet root and estimated recoverable sucrose yields under the growing conditions (i.e. cool soil temperatures, excess precipitation, and hail) in 1998. Plots treated with dimethenamid-P at 1.43 kg ha^{-1} produced greater root and estimated recoverable sucrose yields than the weed free control or those treated with dimethenamid-P at 0.72 kg ha^{-1} in 1999 (Table 3). Yield differences based on herbicide treatments did not correlate to injury ratings since sugarbeet injury was not significant in 1999. The weed free control and dimethenamid-P at 0.72 kg ha^{-1} produced the lowest root yields in 1999, possibly due to weed competition as a result of untimely weed removal.

Table 3. Sugarbeet root yield, percent sucrose content, and estimated recoverable sucrose in a tolerance trial at Ontario, OR in 1998, 1999, and 2000.

		Sugarbeet yield								
		1998			1999			2000‡		
Treatment†	Rate	Root yield	Sucrose	ERS§	Root yield	Sucrose	ERS	Root yield	Sucrose	ERS
	kg ha^{-1}	Mg ha^{-1}	%	kg ha^{-1}	Mg ha^{-1}	%	kg ha^{-1}	Mg ha^{-1}	%	kg ha^{-1}
Weed free control		93.5	14.86	12,608	90.1	17.77	14,936	95.9	15.87	13,772
Dimethenamid	1.31	93.9	15.25	13,092	94.6	17.74	15,696	- -	- -	- -
Dimethenamid-P	0.72	93.5	14.87	12,679	90.8	17.70	15,018	96.2	15.91	13,901
Dimethenamid-P	1.43	94.4	15.00	12,853	96.8	17.68	16,024	98.4	16.14	14,418
Dimethenamid-P	2.87	85.2	14.77	11,477	93.7	17.45	15,252	93.5	16.12	13,737
Dimethenamid-P + Desm-phen	0.72 0.37	90.6	15.47	12,797	93.0	18.00	15,681	97.5	16.11	14,230
Dimethenamid-P + Desm-phen + Triflusulfuron	0.72 0.37 0.018	92.8	14.88	12,449	93.5	17.77	15,524	98.4	16.04	14,259
LSD (0.05)		4.5	0.36	744	5.4	0.43	941	NS	NS	NS

† To assist in maintaining weed free plots, the following applications were made across the entire experimental area: 1998 desm-phenmedipham at 0.37 kg ha^{-1} applied to cotyledon and 2-4 leaf sugarbeet; 1999 desm-phenmedipham at 0.28 kg ha^{-1} applied to cotyledon and 2-4 leaf sugarbeet; 2000 desm-phenmedipham at 0.37 kg ha^{-1} applied to cotyledon sugarbeet. Additionally, hand weeding was utilized to maintain weed free plots following herbicide application.

‡ The treatment of dimethenamid-P applied alone at 1.31 kg ha^{-1} was omitted in 2000.

§ Estimated Recoverable Sucrose.

Sugarbeet yields were not different among treatments in 2000. Although sugarbeet injury from dimethenamid-P at 2.87 kg ha^{-1}, dimethenamid-P at 0.72 kg ha^{-1} plus desmedipham-phenmedipham, and dimethenamid-P at 0.72 kg ha^{-1} plus desmedipham-phenmedipham plus triflusulfuron was greater than the weed free control at both 12 and 28 DAT in 2000, none of these treatments resulted in decreased sugarbeet yield. The sugarbeet variety planted in 1998 was different than the variety grown in 1999 and 2000. Increased sugarbeet injury and the subsequent lower yield associated with dimethenamid-P applied at 2.87 kg ha^{-1} may be due to differences between the two cultivars regarding susceptibility to dimethenamid-P. Several crops have been evaluated for variable cultivar response to herbicide treatment (Newsom and Shaw, 1992; Rowe et al., 1990). Differences in soybean and dry edible bean cultivar susceptibility have been observed with dimethenamid in conjunction with above normal soil moisture (Osborne et al., 1995; Poling, 1999).

This research suggests that POST applications of dimethenamid-P alone at rates of 0.72 and 1.43 kg ha^{-1} or at 0.72 kg ha^{-1} in combination with desmedipham-phenmedipham with or without triflusulfuron can be safely applied to sugarbeet at the two- to four- and four- to six-leaf stages producing minor early season crop injury with no subsequent reduction in yield.

Herbicide Efficacy

Weed Control. Redroot pigweed *(Amaranthus retroflexus* L.*)*, common lambsquarters *(Chenopodium album* L.*)*, hairy nightshade *(Solanum sarrachoides* Sendter*)*, and barnyardgrass were the predominant weed species present in the experimental area. In both years dimethenamid and dimethenamid-P applied alone provided variable weed control due to the lack of POST activity (Table 4, 5). Barnyardgrass control with these treatments in 1998 was 58 to 60% 14 DAT due to the inability to control barnyardgrass that emerged prior to application. However, late-season barnyardgrass control 80 DAT was 93% due to residual control with both dimethenamid and dimethenamid-P. Previous research has shown control of late emerging barnyardgrass in glyphosate-tolerant soybean (Scott et al., 1998a) from POST applications of dimethenamid. In 1998, all treatments containing desmedipham-phenmedipham applied to two- to four-leaf sugarbeet provided greater control of redroot pigweed, common lambsquarters, and hairy nightshade at 14, 36, and 47 DAT and barnyardgrass at 14 DAT compared to either dimethenamid or dimethenamid-P alone (Table 4). Desmedipham-phenmedipham plus dimethenamid-P provided 10 and 28% greater control of redroot pigweed and hairy nightshade 47 DAT, respectively,

Table 4. Weed control in sugarbeet with dimethenamid-P at Ontario, OR 1998.

			Weed control										
			Redroot pigweed			Common lambsquarters			Hairy nightshade			Barnyardgrass	
			14	36	47	14	36	47	14	36	80	14	80‡
Treatment†	Rate	Timing	DAT§										
	kg ha⁻¹	crop stage	%										
Untreated control	- -	- -	0	0	0	0	0	0	0	0	0	0	0 c
Dimethenamid	1.31	2-4 lf	48	42	47	48	33	37	48	30	17	58	93 a
Dimethenamid-P	0.72	2-4 lf	53	60	30	53	47	37	53	33	37	60	93 a
Desm-phenmedipham +	0.28	2-4 lf	95	95	92	95	93	92	95	95	95	95	95 a
Dimethenamid-P	0.72	2-4 lf											
Desm-phenmedipham	0.28	2-4 lf	82	80	85	80	82	83	75	78	57	77	61 b
Desm-phenmedipham +	0.28	2-4 lf	95	95	92	92	95	92	95	95	95	95	95 a
Triflusulfuron +	0.018	2-4 lf											
Dimethenamid-P	0.72	2-4 lf											
Desm-phenmedipham +	0.28	2-4 lf	87	95	85	95	92	88	82	85	57	90	73 b
Triflusulfuron	0.018	2-4 lf											
Desm-phenmedipham fb	0.28	2-4 lf	95	95	95	92	95	92	80	87	72	95	95 a
Dimethenamid-P +	0.72	4-6 lf											
Sethoxydim +	0.21	4-6 lf											
COC	1.0% v/v	4-6 lf											
LSD (0.05)			9	15	24	10	15	15	9	10	33	9	- -

† All plots except the untreated control received a cotyledon application of desmedipham-phenmedipham at 0.28 kg ha⁻¹ on April 27.
‡ ANOVA performed on arcsine square root % transformed data. Transformed mean separation applied to non-transformed data.
§ Days after treatment, following the 2-4 leaf application on May 8. The 4-6 leaf application was made on May 15, 1998.

Table 5. Weed control in sugarbeet with dimethenamid-P at Ontario, OR 1999.

			Weed control									
			Redroot pigweed			Common lambsquarters			Hairy nightshade			Barnyard-grass[‡]
			19	35	47	19	35	47	19	35	47	76
Treatment[†]	Rate	Timing	DAT[§]									
	kg ha^{-1}	crop stage	%									
Untreated control	- -	- -	0	0	0	0	0	0	0	0	0	0 d
Dimethenamid	1.31	2-4 lf	40	68	62	37	75	83	32	70	68	65 bc
Dimethenamid-P	0.72	2-4 lf	13	58	65	95	92	96	22	57	55	78 b
Desm-phenmedipham +	0.28	2-4 lf	72	77	75	77	88	96	68	82	83	75 b
Dimethenamid-P	0.72	2-4 lf										
Desm-phenmedipham	0.28	2-4 lf	58	68	69	82	85	92	68	73	76	43 c
Desm-phenmedipham +	0.28	2-4 lf	73	77	78	83	90	90	75	77	82	85 ab
Triflusulfuron +	0.018	2-4 lf										
Dimethenamid-P	0.72	2-4 lf										
Desm-phenmedipham +	0.28	2-4 lf	77	78	75	92	95	95	72	80	82	0 d
Triflusulfuron	0.018	2-4 lf										
Desm-phenmedipham fb	0.28	2-4 lf	62	73	74	92	95	95	75	80	78	98 a
Dimethenamid-P +	0.72	4-6 lf										
Sethoxydim +	0.21	4-6 lf										
COC	1.0% v/v	4-6 lf										
LSD (0.05)			25	9	6	23	9	9	32	15	14	- -

[†] All plots except the untreated control received a cotyledon application of desmedipham-phenmedipham at 0.28 kg ha^{-1} on April 24.
[‡] ANOVA performed on arcsine square root % transformed data. Transformed mean separation applied to non-transformed data.
[§] Days after treatment, following the 2-4 leaf application on May 10, 1999. The 4-6 leaf application was made on May 16, 1999

than dimethenamid-P applied alone in 1999 (Table 5). In 1998, the addition of dimethenamid-P to desmedipham-phenmedipham increased redroot pigweed control by 13 and 15% 14 and 36 DAT, respectively. Common lambsquarters control increased 15% 14 DAT when dimethenamid-P was applied with desmedipham-phenmedipham. Hairy nightshade control was 20, 17, and 38% greater 14, 36, and 80 DAT, respectively, when dimethenamid-P was applied with desmedipham-phenmedipham. The addition of dimethenamid-P to desmedipham-phenmedipham plus triflusulfuron increased hairy nightshade control by 13% 14 DAT and 38% 80 DAT in 1998. Redroot pigweed, common lambsquarters, and hairy nightshade control were not improved from the addition of dimethenamid-P to desmedipham-phenmedipham or desmedipham-phenmedipham plus triflusulfuron in 1999 (Table 5). The lack of increased weed control from the addition of dimethenamid-P in 1999 compared to 1998 may be due to differences in rainfall events between the two years. In 1998 the first significant rainfall (> 3.0 mm) following dimethenamid-P application occurred on May 11, 3 days after the two- to four-leaf application. On May 22, 1998 a significant rain event occurred 7 days following the four- to six-leaf application. However, in 1999 the first significant rainfall occurred on June 4, 25 and 19 days after the two- to four- and four- to six-leaf applications, respectively. The length of time between dimethenamid-P application and a significant rainfall in 1999 may have allowed weeds to emerge before the herbicide was sufficiently incorporated. Dimethenamid-P added to desmedipham-phenmedipham increased late season barnyardgrass control by 34% in 1998 and 32% in 1999. Late season barnyardgrass control increased 22% in 1998 and 85% in 1999 when dimethenamid-P was added to desmedipham-phenmedipham plus triflusulfuron. Similar results were observed with green foxtail control in sugarbeet from the addition of dimethenamid to standard treatments (Dexter, 1998). In 1998, barnyardgrass control 80 DAT was 93 to 95% with all treatments containing dimethenamid or dimethenamid-P with or without sethoxydim (Table 4). However, in 1999, the addition of sethoxydim improved barnyardgrass control by 33, 20, and 23% over dimethenamid, dimethenamid-P, and desmedipham-phenmedipham plus dimethenamid-P, respectively. The lack of precipitation in 1999 may have reduced the ability of dimethenamid-P to effectively control barnyardgrass. In general, those treatments not containing dimethenamid, or dimethenamid-P with or without sethoxydim provided variable late season barnyardgrass control in both years (Figure 1).

Sugarbeet Yield. Due to a significant (P 0.05) year interaction, root yields were analyzed separately by year (Table 6).

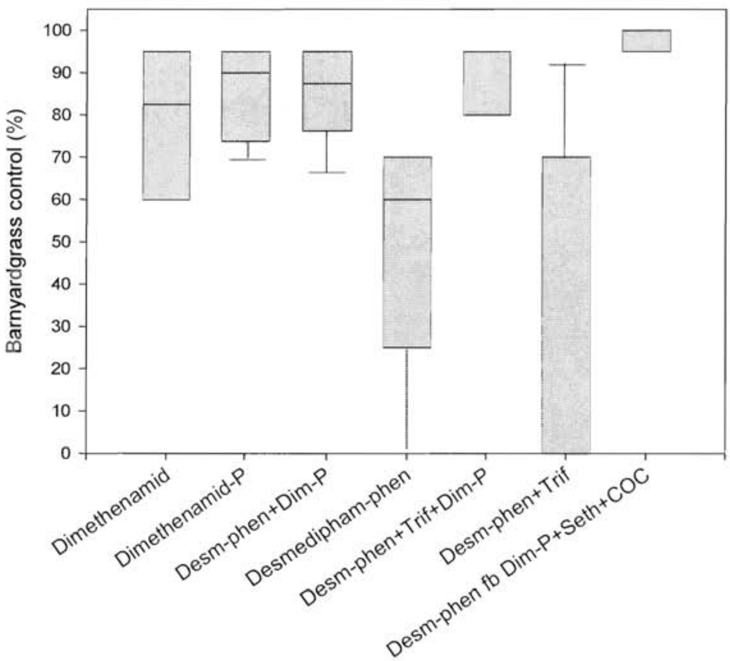

Figure 1. Box plots combining data from 1998 and 1999 illustrating variability of late season barnyardgrass control 76 and 80 DAT in 1998 and 1999, respectively, with treatments not containing dimethenamid, or dimethenamid-P with or without sethoxydim.

Sugarbeet root yields were 35.2 to 67 Mg ha^{-1} higher in 1998 and 29.4 to 52.2 Mg ha^{-1} higher in 1999 in plots receiving herbicide treatment compared to the untreated control. Treatments consisting of desmedipham-phenmedipham with or without triflusulfuron, sethoxydim, and dimethenamid-P provided greater root yields than dimethenamid or dimethenamid-P applied alone. Sugarbeet root yields in plots treated with POST combinations plus dimethenamid-P ranged from 7.4 to 9.6 Mg ha^{-1} higher than those same POST combinations without dimethenamid-P in 1998 and 1999 (Table 6). Sugarbeet root yields were greater ($P < 0.1$) when dimethenamid-P was applied with desmedipham-phenmedipham in 1998 and 1999 and with desmedipham-phenmedipham plus triflusulfuron in 1999. Desmedipham-phenmedipham plus triflusulfuron plus dimethenamid-P applied to two- to four-leaf sugarbeet provided significantly ($P < 0.15$) greater root yield than the same treatment without dimethenamid-P in 1998. The trend towards higher root yields was likely due to greater redroot pigweed, hairy nightshade, and

Table 6. Sugarbeet root yield in a weed control trial with dimethenamid-P at Ontario, OR in 1998 and 1999.

			Injury[‡]		Root yield	
Treatment[†]	Rate	Timing	1998	1999	1998	1999
	kg ha^{-1}	crop stage	%		Mg ha^{-1}	
Untreated control	- -	- -	0	0	22.2	32.5
Dimethenamid	1.31	2-4 lf	0	0	57.4	68.6
Dimethenamid-P	0.72	2-4 lf	2	0	63.9	61.9
Desm-phenmedipham +	0.28	2-4 lf	17	7	89.2	80.7
Dimethenamid-P	0.72	2-4 lf				
Desm-phenmedipham	0.28	2-4 lf	5	0	79.6	71.9
Desm-phenmedipham +	0.28	2-4 lf	15	28	89.2	84.0
Triflusulfuron +	0.018	2-4 lf				
Dimethenamid-P	0.72	2-4 lf				
Desm-phenmedipham +	0.28	2-4 lf	5	18	81.8	75.1
Triflusulfuron	0.018	2-4 lf				
Desm-phenmedipham fb	0.28	2-4 lf	10	10	87.2	84.7
Dimethenamid-P +	0.72	4-6 lf				
Sethoxydim +	0.21	4-6 lf				
COC	1.0 % v/v	4-6 lf				
LSD (0.05)			6	4	10.3	10.5
LSD (0.1)			- -	- -	8.5	8.6

[†] All plots except the untreated control received a cotyledon application of desmedipham-phenmedipham at 0.28 kg ha^{-1} on April 27, 1998 or April 24, 1999.

[‡] Injury was evaluated 10 DAT on May 29, 1998 and 14 DAT on May 20, 1999.

barnyardgrass control in 1998 and greater barnyardgrass control in 1999 from dimethenamid-P (Table 4, 5). Increases in soybean yield have been attributed to residual control of late-season barnyardgrass from POST applications of dimethenamid (Scott et al., 1998a). Yield did not increase in either year from the addition of sethoxydim to dimethenamid-P applied to four- to six-leaf sugarbeet (Table 6).

This research suggests that POST applications of dimethenamid-P at 0.72 kg ha^{-1} applied to two- to four-leaf sugarbeet may be useful in providing residual control of emerging annual grasses, such as barnyardgrass, up through row closure. The results further suggest that POST applications of dimethenamid-P may improve redroot pigweed and hairy nightshade control in sugarbeet.

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