TOLERANCE AND WEED CONTROL FROM SPIN-AID IN SUGARBEET IN 2023

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Summary

1. No sugarbeet vegetative injury or yield component differences were observed across hybrids representing diverse sugarbeet genetics.
2. A single Spin-Aid application will not control kochia or common ragweed.
3. Apply ethofumesate PRE before Spin-Aid applications, especially for kochia control.
4. Time Spin-Aid applications according to weed size, rather than sugarbeet size. Spin-Aid at 16 fl oz/A plus ethofumesate on cotyledon to 2-lf sugarbeet followed by 24-32 fl oz/A Spin-Aid plus ethofumesate on 4- to 6-lf sugarbeet.

Introduction

Glyphosate resistant (GR) kochia is reemerging as an important weed management challenge in the Red River Valley and is spreading into west central Minnesota (Peters et al. 2022). We advise producers to grow crops (and select herbicides) that control kochia in the rotation since kochia seed is viable for up to two years (Dille et al. 2017). Wheat commonly grown before sugarbeet in the Red River Valley is competitive with kochia and enables use of herbicides enabling effective kochia control. However, adapting kochia biotypes and delayed spring planting has made kochia control challenging.

Growers lack effective herbicide options to control GR kochia in sugarbeet. Phenmedipham was registered in 1970 and sold under the trade name 'Betanal' from 1970 through 1981. Phenmedipham selectively controls small kochia by moving acropetally to the edges of leaves. Phenmedipham effectively controls kochia when applied in direct sunlight and when air temperatures are 70 F or greater.

Belchim Crop Protection USA markets phenmedipham using the trade name 'Spin-Aid' for control of broadleaf weeds POST on spinach and recently completed the acquisition of the sugarbeet registration from Bayer Crop Science. Belchim Crop Protection secured a 24 (c) local needs registration for Spin-Aid which provided Minnesota and North Dakota sugarbeet growers with a postemergence herbicide option for kochia and common lambsquarters control before the 2023 growing season.

Field and greenhouse experiments were conducted to determine how to best integrate Spin-Aid into a weed control program (Peters et al. 2023). Two-times Spin-Aid applications up to 32 fl oz/A partially controlled kochia less than 1-inch tall (Figure 1). Further, Spin-Aid use rate was determined by sugarbeet growth stage at timing of application. Finally, mixing Spin-Aid with ethofumesate seemed to improve kochia control as compared with Spin-Aid alone.

We learned from growers and academicians with previous experience with phenmedipham in sugarbeet. Betanal historically was applied as a single application or 2-times applications at up to 96 fl oz/A for kochia control. Sugarabeet injury was variety dependent and increased when ethofumesate was applied preemergence ahead of Betanal. The label and previous experience indicated improved control of common lambsquarters under moisture stress from Roundup PowerMax mixed with phenmedipham. The label also indicated phenmedipham might provide a second effective mode of action and mixture partner for common ragweed control with Stinger HL. Field experiments in 2023 and greenhouse experiments in 2023-24 were designed to fill in knowledge gaps.

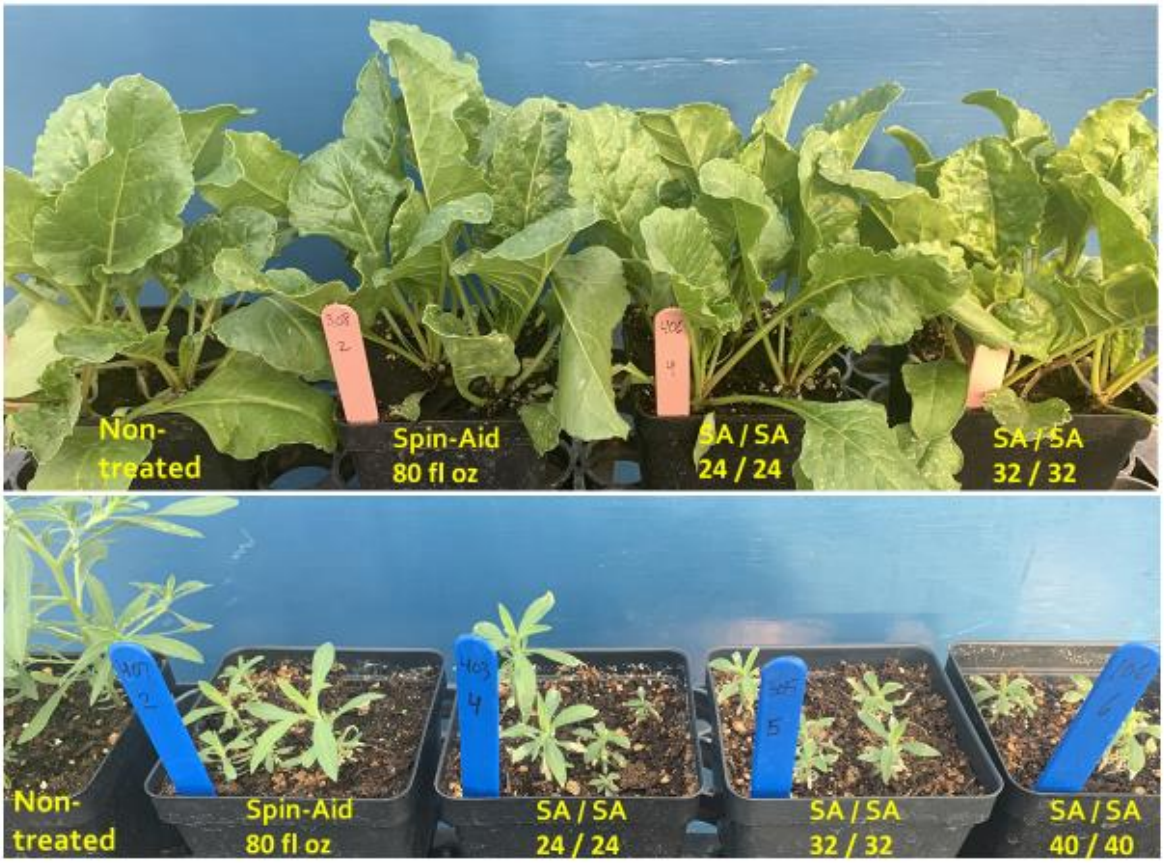

Figure 1. Sugarbeet tolerance or kochia control in response to Spin-Aid singly or repeat Spin-Aid applications after 7 days (sugarbeet) or after 6 days (kochia), greenhouse, 2023.

Objective

Determine selective kochia, common lambsquarters and common ragweed control from Spin-Aid alone, 2- or 3-times Spin-Aid applications, or Spin-Aid following ethofumesate applied PRE. Spin-Aid was applied singly or mixed with ethofumesate and/or Roundup PowerMax3.

Materials and Methods

Tolerance experiments. Sugarbeet tolerance experiments were conducted near Crookston, MN and Hickson, ND in 2023 to evaluate potential variety response from high rates of Spin-Aid. Primary tillage in the fall was followed by secondary tillage using a cultivator with rolling baskets to prepare the seedbed for sugarbeet planting at both locations. Fertilization followed local practices for sugarbeet. Sugarbeet was seeded in 22-inch rows at populations ranging from approximately 63,000 to 65,000 seeds per acre or approximately 4.5- to 4.4-inch spacing, respectively, between seeds. A soil residual herbicide was applied across the experimental area at both locations to control waterhemp. Treatments in Table 1 were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO2 at 35 psi to the center four rows of six row plots 40 feet in length. Weeds, insects and diseases were managed throughout the growing season.

Table 1. Sugarbeet hybrid and Spin-Aid rate at the 2- to 4-lf stage.

Factor A	Factor B	
Sugarbeet Hybrid[a]	Spin-Aid rate (pt/A)[b]	Sugarbeet stage (lvs)
CR 137	PowerMax3/PowerMax3	2-4 /10 days
CR 793	4.5	2-4
CR 793	9	2-4
CR 130	4.5	2-4
CR 130	9	2-4
CR 137	4.5	2-4
CR 137	9	2-4

[a]Crystal Sugarbeet Seed
[b]Noble Methylated Seed Oil (MSO) at 1 pt/A with Spin-Aid or Prefer 90 NIS and Amsol liquid AMS at 0.25%+2.5% v/v with Spin-Aid or Roundup PowerMax3

Sugarbeet counts (middle 2 rows x 20' plot length) at 2- to 4-lf stage and preharvest and % visible necrosis and growth reduction injury (0 to 100% scale, 0 is no visible necrosis or growth reduction injury compared to a glyphosate control and 100% complete loss of plant / stand compared to the glyphosate control) were collected 7 days after 2-lf stage application and 3, 7, and 14 days after 2- to 4-lf stage application. Root yield, % sucrose, % purity, and recoverable sucrose were calculated after harvest.

Efficacy experiments. Weed control experiments were conducted near Manvel, ND and Beltrami, MN in 2023 to evaluate kochia, common ragweed, and common lambsquarters control in sugarbeet. Treatments are in Table 2. Experiments evaluated sugarbeet tolerance and efficacy from Spin-Aid plus ethofumesate either singly or two-times applications. Experiments near Manvel were prepared for planting and planted by our grower cooperator. The experimental area near Beltrami, MN was prepared for planting by applying the appropriate fertilizer and tillage. Sugarbeet was seeded in 22-inch rows at approximately 64,000 seeds per acre with 4.5 inch spacing between seeds. Dual Magnum at 1 pt/A was applied across the experimental area to control waterhemp. Treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 35 psi to the center four rows of six row plots 40 feet in length.

Sugarbeet growth reduction injury and kochia, common ragweed, and common lambsquaters control was evaluated approximately 7 and 14 days after treatment (DAT) with a 0 to 100% scale (0% denoting no sugarbeet injury or kochia, common ragweed, and common lambsquarters control and 100% denoting complete loss of sugarbeet stature/stand or kochia, common ragweed and lambsquaters control). All evaluations were a visible estimate of injury or control in the four treated rows compared to the adjacent, two-row, untreated strip. Experimental design was randomized complete block with four replications. Data were analyzed in this report as a RCBD with the ANOVA procedure of ARM, version 2023.3 software package.

Table 1. Spin-Aid rate and weed species stage at application, 2023.

Herbicide treatment[a]	**Rate (fl oz/A)**	**Weed species stage (inch)**
Spin-Aid + etho[b]	16 + 4	<2
Spin-Aid + etho	24 + 4	<2
Spin-Aid + etho	32 + 4	<2
Spin-Aid + etho	48 + 5	<2
Spin-Aid + etho	72 + 8	<2
Spin-Aid + etho	96 + 11	<2
Spin-Aid + etho / Spin-Aid + etho	24 + 4 / 24 + 4	<2 + 7 days
Spin-Aid + etho / Spin-Aid + etho	32 + 4 / 32 + 4	<2 + 7 days
Spin-Aid + etho / Spin-Aid + etho	48 + 5 / 48 + 5	<2 + 7 days
Etho / Spin-Aid + etho	6 / 48 + 5	PRE/ 2
Etho / Spin-Aid + etho	6 / 96 + 11	PRE / 2

[a]Spin-Aid plus Noble methylated seed oil (MSO) at 1.25% v/v.
[b]Etho=ethofumesate.

Results and Discussion

Tolerance experiments. Betanal was used at rates up to 96 fl oz/A for kochia control in the 1970s. Extension Sugarbeet Agronomists observed varietal response from Betanal and suggested an experiment with hybrids representing germplasm diversity (personal communication with Drs. Dexter and Cattanach). Historical research with phenmedipham observed increased growth reduction amongst different sugarbeet varieties. Spin-Aid at 4.5 pt/A (72 fl oz) or 9.0 pt/A (144 fl oz/A) injured sugarbeet (Table 2). However, injury was not dependent on sugarbeet hybrid. Likewise, Spin-Aid rate did not influence yield components measured across diverse sugarbeet hybrids.

Table 2. Sugarbeet growth reduction and yield components in response to Spin-Aid and sugarbeet genetics, across two locations, 2023.

Factor A		Sugarbeet Growth Reduction				
Sugarbeet Hybrid[a]	**Factor B Spin-Aid rate[b]**	**10 DAAA[c]**	**39 DAAA**	**Root Yield**	**Sucrose**	**Recoverable Sucrose**
	-pt/A-	----------%----------		--TPA--	--%--	--lb/A--
CR 137	glyphosate	3	3	40.4	18.1	13,376
CR 137	4.5	31	7	37.2	17.8	12,208
CR 137	9	42	10	38.6	18.1	12,780
CR 793	4.5	28	11	38.7	17.7	12,838
CR 793	9	42	13	38.2	17.9	12,424
CR 130	4.5	24	5	40.0	18.1	13,337
CR 130	9	38	8	40.4	18.2	13,591
P-Value (0.05)		**0.0941**	**0.3462**	**0.1498**	**0.7457**	**0.1771**

[a]Crystal Sugarbeet Seed
[b]Spin-Aid applications applied with Noble (MSO) at 1.5 pt/A.
[c]DAAA= Days after application A.

Efficacy experiments. Sugarbeet injury ranged from 1% to 57%, 10 days after application C (DAAC) following Spin-Aid plus ethofumesate application at the 2-lf stage (Table 3). Sugarbeet injury was necrosis injury, sugarbeet stature reduction, and thinning of sugarbeet stand, especially at Spin-Aid rates in excess of 48 fl oz/A. Based on experience, sugarbeet injury greater than 35% likely will affect yield components. Two-times Spin-Aid and ethofumesate application at 24, 32, and 48 fl oz/A with ethofumesate at 4 fl oz/A did not or tended to not increase sugarbeet injury as compared with Spin-Aid and ethofumesate singly. Likewise, Spin-Aid following ethofumesate PRE did not cause additional sugarbeet injury, 10 DAAC.

Common lambsquarters control ranged from 42% to 95% and 25% to 96%, 10 and 20 DAAC, respectively (Table 3). Common lambsquarters control increased as Spin-Aid rate increased; however, common lambsquarters control was best when Spin-Aid was applied in repeat applications. Split Spin-Aid applications were the same Spin-Aid rate; however, were applied at the 2-lf sugarbeet stage plus 5-days in these experiments. We learned in the greenhouse that sugarbeet safety improves when Spin-Aid rate increases as sugarbeet stage increases (data not presented). The safe rate for cotyledon, 2-lf, and 4-lf sugarbeet is 16, 24, and 32 fl oz/A, respectively.

Table 3. Sugarbeet growth reduction and common lambsquarters control, 2023[a].

Herbicide treatment[b]	Rate	Sugarbeet Growth Reduction	Common Lambsquarters Control 10 DAAC[c]	Common Lambsquarters Control 20 DAAC
	--fl oz/A--	----------%----------		
Spin-Aid + etho	16 + 4	1 a	42 de	33 c
Spin-Aid + etho	24 + 4	5 ab	38 e	25 c
Spin-Aid + etho	32 + 4	23 bcd	60 cd	58 b
Spin-Aid + etho	48 + 5	22 bcd	69 bc	60 b
Spin-Aid + etho	72 + 8	57 f	89 ab	88 a
Spin-Aid + etho	96 + 11	55 f	94 a	95 a
Spin-Aid + etho / Spin-Aid + etho	24 + 4 / 24 + 4	33 cde	88 ab	93 a
Spin-Aid + etho / Spin-Aid + etho	32 + 4 / 32 + 4	30 cde	85 ab	84 a
Spin-Aid + etho / Spin-Aid + etho	48 + 5 / 48 + 5	40 def	95 a	96 a
Etho / Spin-Aid + etho	6 / 48 + 5	15 abc	71 bc	60 b
Etho / Spin-Aid + etho	6 / 96 + 11	45 ef	86 ab	81 a
P-Value (0.05)		**0.0005**	**0.0012**	**<0.0001**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]Spin-Aid applications applied with Noble (MSO) at 1.5 pt/A.
[c]DAAA= Days after application A.

Kochia control from Spin-Aid mixed with ethofumesate ranged from 30% to 90%, 10 DAAC (Table 4). Control tended to increase as Spin-Aid and ethofumesate rate increased, especially 20 DAAC. Kochia control was greatest or tended to be greatest from split Spin-Aid applications. We observed the greatest numeric control of kochia with ethofumesate PRE followed by a single Spin-Aid at 96 fl oz/A application (Table 4).

Table 4. Kochia and common ragweed control, 2023[a].

Herbicide treatment[b]	Rate	Kochia Control 10 DAAC[c]	Kochia Control 20 DAAC	Common Ragweed Control 10 DAAC	Common Ragweed Control 20 DAAC
	--fl oz/A--	----------%----------			
Spin-Aid + etho	16 + 4	40 cde	30 c	8 c	5 e
Spin-Aid + etho	24 + 4	30 e	15 c	18 c	0 e
Spin-Aid + etho	32 + 4	33 de	68 a	18 c	5 e
Spin-Aid + etho	48 + 5	71 abcd	63 ab	15 c	28 d
Spin-Aid + etho	72 + 8	73 abc	72 a	43 b	40 cd
Spin-Aid + etho	96 + 11	65 abcd	70 a	60 ab	58 abc
Spin-Aid + etho / Spin-Aid + etho	24 + 4 / 24 + 4	74 abc	83 a	58 ab	50 bc
Spin-Aid + etho / Spin-Aid + etho	32 + 4 / 32 + 4	80 ab	75 a	70 a	65 ab
Spin-Aid + etho / Spin-Aid + etho	48 + 5 / 48 + 5	90 a	78 a	68 a	74 a
Etho / Spin-Aid + etho	6 / 48 + 5	58 bcde	33 bc	.[d]	.
Etho / Spin-Aid + etho	6 / 96 + 11	88 a	80 a	.	.
P-Value (0.05)		**0.0027**	**0.0008**	**<0.0001**	**<0.0001**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]Spin-Aid applications applied with Noble (MSO) at 1.5 pt/A.
[c]DAAA= Days after application A.
[d]Data missing. This experiment was implemented later in the season, so we were unable to evaluate ethofumesate PRE.

The 1980 Sugarbeet Production Guide lists Betanal as providing fair to good control on common ragweed. Control was improved when ethofumesate was mixed with Betanal. We observed similar common ragweed control in the field; common ragweed control ranging from 0% to 74%, 20 DAAC. Common ragweed control increased as Spin-Aid rate increased, similar to common lambsquarters and kochia control. We observed greatest common ragweed control from split Spin-Aid applications, especially Spin-Aid at 32 to 48 fl oz/A plus ethofumesate.

Greenhouse research with Spin-Aid continues and has focused on one-, two-, or three-times Spin-Aid + ethofumesate applications for kochia control, starting on 5-lf kochia, less than 1-inch in diameter (we call it dime size) and cotyledon to 2-lf sugarbeet. It will be paramount that our producers target small kochia. Spin-Aid translocates acropetally from the targeted leaves to leaf margins but movement is greater in common lambsquarters and wild mustard than kochia or common ragweed (Hendrick et al. 1974). Conditions at application affect Spin-Aid selective control; activity is less during cool temperatures and low light conditions as compared with warm temperature and direct sunlight conditions (Abbaspoor and Streibig 2007). Risk of injury is increased by temperatures over 80 F and sudden changes from a cool, cloudy environment to a hot, sunny environment (Betamix Best Management Practices (BMPs)). Applications in late afternoon/early evening, when temperatures are decreasing improves sugarbeet safety (Betamix BMPs).

Further investigation suggests Spin-Aid applied three times may improve kochia control as compared with Spin-Aid applied 2-times (Figure 2). In the greenhouse, Spin-Aid at 16 fl oz/A plus ethofumesate at 4 fl oz/A on cotelydon sugarbeet followed by Spin-Aid at 24 fl oz/A plus ethofumesate at 4 fl oz/A, 5 days after application A (DAAA) followed by Spin-Aid at 32 fl oz/A plus ethofumesate at 4 fl oz/A, 5 days after application B (DAAB) provided 80% kochia control. Control was greater when Spin-Aid was applied at 32 or 40 fl oz/A the second or third application, respectively. Our greenhouse experiments were conducted with Spin-Aid and ethofumesate plus an MSO adjuvant. We recommend Roundup PowerMax3 integrated into the treatment the first (application A) and third (application C) applications to increase control. Further experiments will explore Spin-Aid mixed with Stinger HL for common ragweed control.

Figure 2. Selective control from Spin-Aid + ethofumesate in a 3-spray program, greenhouse, 2024.

Conclusion

Target kochia less than 1-inch tall kochia (dime size). Align Spin-Aid rate to sugarbeet growth stage, especially if kochia has emerged. Plan for repeat Spin-aid applications on 5-day intervals for GR kochia control. Account for ethofumesate applied PRE in POST program (Table 5).

Table 5. Kochia control in sugarbeet.

Sugarbeet Stage (leaf stage)	Alone Spin-Aid + ethofumesate (fl oz/A)	Following soil residual herbicide Spin-Aid + ethofumesate (fl oz/A)
Cotyledon	16 + 4	12 + 4
2 lf	24 + 4	16 + 4
4-lf	32 + 4	24 + 4
6-lf	40 + 4	32 + 4

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