KOCHIA CONTROL IN SUGARBEET

Thomas J. Peters[1] and Alexa L. Lystad[2]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist and [2]Research Specialist
North Dakota State University & University of Minnesota, Fargo, ND

Summary

1. Apply ethofumesate preplant incorporated (PPI) or preemergence (PRE) at 6 to 7.5 pt/A in sugarbeet fields where kochia is identified as the most important weed control challenge in sugarbeet.
2. Consult with your Agriculturalist, ag-retailer or crop consultant to determine if your field is a glyphosate-resistant kochia biotype.
3. Time herbicide applications to kochia growth stage to optimize control.
4. Betamix improved control from PowerMax + ethofumesate postemergence (POST) in these experiments. However, we highly recommend you carefully manage Betamix rate based on sugarbeet growth stage to ensure sugarbeet safety, especially when Betamix follows ethofumesate soil applied.
5. Kochia control from crops in sequence with sugarbeet are often more effective than sugarbeet herbicides for kochia control.

Introduction

Kochia is an invasive annual broadleaf native to Asia. Kochia was introduced into the United States at the end of the 1800s as an ornamental from Europe (Friesen et al. 2009). Kochia is found in grasslands and pastures, along roadsides and ditch banks, and in cultivated fields in North Dakota and northwestern Minnesota. Kochia has been ranked among the most serious weed species in the United States due to its high rate of spread (Forcella 1985). In North Dakota and Minnesota, kochia is a major concern because it is competitive with many crop species. Traits including early-season emergence, rapid growth, and drought tolerance confer upon kochia a unique competitive ability, especially in slow growing crops like sugarbeet. Kochia was ranked in a Weed Science Society of America member's survey as one of the top six most troublesome weeds in row crops production (Van Wychen 2016) and has been documented to cause yield loss in sugarbeet (Mesbah et al. 1994).

Herbicides are a major component of kochia control programs. The outcome of relying on herbicides combined with kochia's competitive characteristics and high genetic diversity, has created weed population shifts and led to the evolution of herbicide-resistant populations. These resistant populations are often found in sugarbeet. Kochia has evolved resistance to at least four herbicide sites of action, including (ALS) inhibitors, synthetic auxins, photosystem II (PSII) inhibitors, and EPSP synthase inhibitors or glyphosate. Glyphosate-resistant kochia is widespread and concerning to farmers since glyphosate is relied upon in many cropping systems.

Objective

The objectives of this research were to 1) evaluate non-glyphosate herbicide options in sugarbeet or crops grown in sequence with sugarbeet in North Dakota and; 2) provide kochia control options in Minnesota and North Dakota fields when corn, soybean, or wheat is seeded in sequence with sugarbeet.

Material and Methods

Experiments were conducted on natural kochia populations near Hickson, ND and Manvel, ND in 2020. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage. Sugarbeet was seeded in 22-inch rows at about 62,000 seeds per acre with 4.7 inch spacing between seeds.

Treatment list can be found in Table 1. All treatments were applied with a bicycle sprayer through appropriate nozzles and CO_2 pressure to deliver 17 gpa spray solution to the center four rows of six row plots 35 feet in length. Herbicides were immediately incorporated using a field cultivator set 3 to 4 inches deep. The entire experimental area received field cultivation after PPI treatments were applied to remove the variability that could otherwise be caused by the incorporating tillage.

Table 1. Herbicide treatment, rate, and application timing.

Herbicide Treatment	Rate (fl oz/A)	Sugarbeet or kochia growth stage (lvs/ size)
Ethofumesate	32	PPI
Ethofumesate	64	PPI
Ethofumesate	96	PPI
Ethofumesate	32	PRE
Ethofumesate	64	PRE
Ethofumesate	96	PRE
Ethofumesate	16	2 lf
Ethofumesate	32	2 lf
Ethofumesate + Roundup PowerMax	16 + 28	2 lf
Ethofumesate + Roundup PowerMax	32 + 28	2 lf
Ethofumesate + Roundup PowerMax	4 +28 / 4 + 28 / 4 + 22	Dime size / 10 day / 10 day
Ethofumesate + Roundup PowerMax + Betamix	4+28+10 / 4+28+12 / 4 + 22+16	Dime size / 10 day /10 day
+ Ultra Blazer	16	10 lf
Ethofumesate + Roundup PowerMax + Ultra Blazer	4 + 28 + 16	10 lf

[1]Treatments with ethofumesate POST applied with HSMOC (High Surfactant Methylated Oil Concentrate) at 1.5 pt/A.
[2]Treatments with Roundup PowerMax plus ethofumesate applied with HSMOC at 1.5 pt/A plus N-Pak AMS at 2.5% v/v.
[3]Treatments with Ultra Blazer applied with Prefer 90 NIS at 0.25% v/v plus N-Pak AMS at 2.5% v/v.

Sugarbeet injury was evaluated as a visual estimate of percent growth reduction (0 to 100% scale, 0 is no visible injury and 100 is complete loss of plant / stand) of the middle 4 rows per plot compared with the adjacent untreated rows. Weed control was evaluated as a visual estimate of percent fresh weight reduction (0 is no injury and 100 is complete control) in the four treated rows compared to the adjacent untreated rows 7, 14, and 21 days (+/- 3 days) after application. Experimental design was randomized complete block with 6 replications. All data were analyzed with the ANOVA procedure of ARM, version 2020.2 software package.

Results

Sugarbeet injury ranged from 0 to 80% and 0 to 25% in Manvel, ND and Hickson, ND, respectively (Table 2). Sugarbeet stands were variable in both experiments. Increased rates of ethofumesate plus PowerMax or ethofumesate plus PowerMax plus Betamix caused unacceptable sugarbeet injury across locations. The first POST application was applied to 2-lf sugarbeet with 10 fl oz of Betamix in mixtures with PowerMax plus ethofumesate. The rate of Betamix was too great in this combination which was made evident by 45% sugarbeet injury compared with 29% from repeat applications of PowerMax and ethofumesate at Manvel, ND.

Table 2. Sugarbeet growth reduction at Manvel, ND and Hickson, ND in 2020.[1]

			Sugarbeet Growth Reduction	
Treatment	Rate	Sugarbeet or kochia growth stage	Manvel, ND	Hickson, ND
	--fl oz/A--	--lvs/size--	----------%----------	
Ethofumesate	32	PPI	0 a	0 a
Ethofumesate	64	PPI	3 ab	15 bc
Ethofumesate	96	PPI	7 ab	15 bc
Ethofumesate	32	PRE	0 a	0 a
Ethofumesate	64	PRE	3 ab	0 a
Ethofumesate	96	PRE	-[2]	0 a
Ethofumesate	16	2 lf	23 abc	0 a
Ethofumesate	32	2 lf	3 ab	0 a
Ethofumesate + Roundup PowerMax	16 + 28	2 lf	15 ab	13 abc
Ethofumesate + Roundup PowerMax	32 + 28	2 lf	55 cd	20 bc
Ethofumesate + Roundup PowerMax	4 +28 / 4 + 28 / 4 + 22	Dime size / 10 day / 10 day	29 abc	8 ab
Ethofumesate + Roundup PowerMax + Betamix	4+28+10 / 4+28+12 / 4 + 22+16	Dime size / 10 day /10 day	45 bc	25 c
Ultra Blazer	16	10 lf	60 cd	0 a[3]
Ethofumesate + Roundup PowerMax + Ultra Blazer	4 + 28 + 16	10 lf	80 d	0 a[3]
			----------*P*-value----------	
			0.0001	0.0015

[1]Means within a main effect not sharing any letter are significantly different by the LSD at the 5% level of significance.
[2]Treatments contained too much variability across experiments.
[3]Evaluation made before treatment effects could be observed.

Kochia control with herbicide treatments was unacceptable at Hickson and Manvel in 2020. Kochia control from ethofumesate applied PPI or PRE ranged from 13% to 40% control (Table 3) across locations. A rate response was observed with kochia control from ethofumesate applications. Ethofumesate at 96 fl oz/A, applied as either a PPI or PRE, provided greater kochia control than ethofumesate at 32 or 64 fl oz/A across locations. There was no difference between ethofumesate applied before or after planting, although there was a slight numeric advantage to ethofumesate applied PPI.

Table 3. Kochia control 14 days after the last application, across environments, 2020.[1]

Treatment	Rate	Sugarbeet or kochia growth stage	Kochia Control
	--fl oz/A--	--lvs/size--	---------%---------
Ethofumesate	32	PPI	18 c
Ethofumesate	64	PPI	21 bc
Ethofumesate	96	PPI	40 bc
Ethofumesate	32	PRE	13 c
Ethofumesate	64	PRE	23 bc
Ethofumesate	96	PRE	33 bc
Ethofumesate	16	2 lf	41 bc
Ethofumesate	32	2 lf	47 bc
Ethofumesate + Roundup PowerMax	16 + 28	2 lf	95 a
Ethofumesate + Roundup PowerMax	32 + 28	2 lf	93 a
Ethofumesate + Roundup PowerMax	4 +28 / 4 + 28 / 4 + 22	Dime size / 10 day / 10 day	97 a
Ethofumesate + Roundup PowerMax + Betamix	4+28+10 / 4+28+12 / 4 + 22+16	Dime size / 10 day /10 day	98 a
Ultra Blazer	16	10 lf	54 b
Ethofumesate + Roundup PowerMax + Ultra Blazer	4 + 28 + 16	10 lf	91 a
			---*P*-value---
			0.0003

[1]Means within a main effect not sharing any letter are significantly different by the LSD at the 5% level of significance.

The most efficacious treatment with the least amount of sugarbeet injury in the experiment across locations were POST applications of PowerMax (Manvel and Hickson contained glyphosate sensitive kochia populations) plus ethofumesate in a single or repeat applications (Table 3). PowerMax plus ethofumesate plus Betamix provided excellent kochia control. However, was too injurious to the sugarbeet crop.

Ethofumesate POST at 32 fl oz/A gave a disappointing lack of early kochia control. Kochia was at least 1-inch tall at application which apparently was too large for POST control from ethofumesate. Ultra Blazer, an herbicide not yet approved for in season sugarbeet production, provided greater than 83% control but resulted in unacceptable sugarbeet injury at Manvel, ND (data not presented). Ultra Blazer provided less kochia control at the Hickson, ND site. Ultra Blazer was applied to smaller sugarbeet than intended due to the robust kochia density. The result was good kochia control but an unacceptable level of sugarbeet injury. Sugarbeet must be at least the 8-lf stage before Ultra Blazer applications are made. These results suggest Ultra Blazer in sugarbeet will only be useful for POST control of kochia following ethofumesate soil applied or PowerMax and ethofumesate POST. These data reinforce the necessity for focusing on kochia control in preceding crops to minimize kochia infestations during a sugarbeet cropping season.

Kochia control in crops in sequence with sugarbeet. Researchers selected their preferred programs for kochia control in corn, soybean, sugarbeet, wheat and fallow in 2010 and 2011. Preferred programs were a combination of soil residual and POST programs applied singly or used in sequence in a kochia control program. Kochia control was arranged by crop and location across years (Figure 1). Herbicide programs labeled for kochia control in corn or soybean demonstrated less variability in kochia control compared with fallow, wheat, and sugarbeet (Sbettala et al. 2019). The potential for kochia control failure was relatively low in corn, regardless of the herbicide program evaluated, whereas there was no herbicide program evaluated in sugarbeet that provided greater than 86% kochia control at any field location with the median control of 40% across all sites (Figure 1).

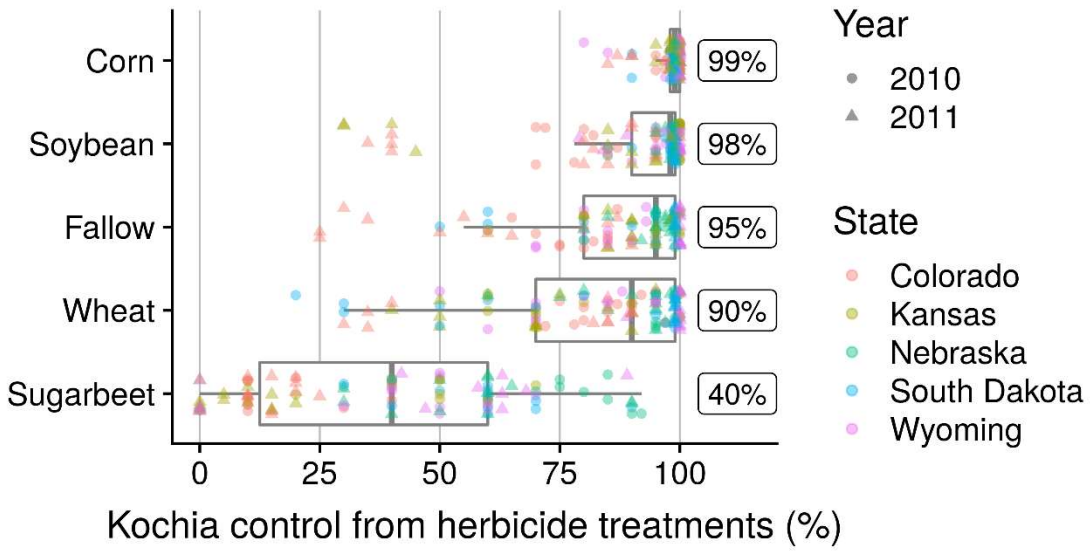

Figure 1. Kochia control 30 days after final application of herbicide treatment labeled for corn, soybean, fallow, wheat and sugarbeet. Each point represents a plot in a field. Number are the median kochia control from herbicide treatments.

Effective long-term kochia management in sugarbeet will likely depend on rotation with crops such as corn and soybean for which effective herbicides are available. However, rotations with these crops create challenges as kochia control programs in corn and soybean will often not permit the planting of sugarbeet the following year. Corn and soybean herbicide treatments included combinations of PRE plus POST herbicide applications. Corn, wheat, and to an extent, soybean, have dense canopies forming early in the growing season, allowing them to compete with kochia. In contrast, sugarbeet is a poor competitor with kochia because it has a slow developing and short canopy structure.

Dr. Joseph Ikley, North Dakota Extension Weed Control Specialist, has provided his preferred kochia control programs in corn, soybean, and wheat. Recommendations are presented as product per acre. Please use the North Dakota Weed Control Guide to verify herbicide rates and crop rotation restrictions for soils and crop sequences on your farm.

Corn

1) Verdict (16-18 fl oz) + atrazine[1] (0.38 to 0.5 lb) or Harness MAXX (2 qt) + atrazine (0.38 to 0.5 lb) PRE fb PowerMax + Status (5 fl oz) POST (requires RR corn)
2) Acuron[2] (1.25 qt) or Acuron Flexi (1.25 qt) fb Acuron (1.25 qt) or Acuron Flexi (1.25 qt) + PowerMax (requires RR corn)
3) Capreno (3 fl oz) + PowerMax + atrazine (0.38 to 0.5 lb) EPOST (V2 to V4 corn, (less than 3-inch kochia) (requires RR Corn)

Soybean

1) Authority Edge[3] (full rate for soil type) fb PowerMax + dicamba or Liberty (dicamba use requires Xtend soybeans, Liberty use requires Enlist, LibertyLink, LLGT27, or XtendFlex soybeans)
2) Fierce MTZ[4] (full rate for soil type) fb PowerMax + dicamba or Liberty (dicamba use requires Xtend soybeans, Liberty use requires Enlist, LibertyLink, LLGT27, or XtendFlex soybeans)
3) Authority MTZ[5] (full rate for soil type) fb PowerMax + dicamba or Liberty (dicamba use requires Xtend soybeans, Liberty use requires Enlist, LibertyLink, LLGT27, or XtendFlex soybeans

[1]Atrazine requires a second cropping season after herbicide application crop rotation restriction to sugarbeet.
[2]Acuron/Flexi requires an 18 month after application crop rotation restriction to sugarbeet.
[3] Authority Edge requires up to 36 months after application crop rotation restriction to sugarbeet.
[4] Fierce MTZ requires up to 18 months after application crop rotation restriction to sugarbeet.
[5] Authority MTZ requires up to 24 months after application crop rotation restriction to sugarbeet.

Wheat

1) Huskie FX[6] (full rate)
2) Starane NXT[7] (full rate)
3) Talinor[8] (full rate)

Recommendations

Ethofumesate should be applied preplant or preemergence at 6 to 7.5 pt/A in sugarbeet fields where kochia is identified as the most important weed control challenge in sugarbeet. Herbicide applications should be timed to kochia growth stage rather than sugarbeet. The addition of Betamix improved control from PowerMax + ethfofumesate POST in these experiments. However, we highly recommend you carefully manage Betamix rate based on sugarbeet growth stage to ensure sugarbeet safety, especially when Betamix follows soil applied (PPI or PRE) ethofumesate. Experiments will be conducted in 2021 to evaluated soil applied applications of ethofumesate. Betamix, Ultra Blazer, and ethofumesate rates and timings must be further evaluated to reduce sugarbeet injury.

Acknowledgements

We wish to thank Mr. Scott Johnson, Manvel, ND and Mr. Neil Rockstad, Hendrum, MN along with KayJay Ag Services for agreeing to collaborate on this research. However, we needed to drop the Hendrum, MN location do to travel restrictions associated with COVID-19 in 2020. We also thank our summer student employees Ryan Borgen and Brad Stewart.

References

Forcella F (1985) Final distribution is related to rate of spread in alien weeds. Weed Res 25:81–191

Friesen LF, Morrison IN, Rashid A, Devine MD (1993) Response of a chlorsulfuron-resistant biotype of Kochia scoparia to sulfonylurea and alternative herbicides. Weed Sci. 41:100-106

Mesbah A, Miller SD, Fornstrom KJ, Legg DE (1994) Kochia (Kochia scoparia) and green foxtail (Setaria viridis) interference in sugarbeets (Beta vulgaris). Weed Technol 8:754–759

Sbatella GM, Adjesiwor AT, Kniss AR, Stahlman PW, Westra P, Moechnig M, Wilson RG (2019) Herbicide options for glyphosate-resistant kochia (Bassia scoparia) management in the Great Plains. Weed Technol. 33: 658–663

Van Wychen L (2016) 2016 Survey of the Most Common and Troublesome Weeds in Broadleaf Crops, Fruits & Vegetables in the United States and Canada. Weed Science Society of America National Weed Survey Dataset. http://wssa.net/wp-content/uploads/2016-Weed-Survey_Broadleaf-crops. xlsx. Accessed: November 2, 2020

[6] Huskie FX requires a 9 month after application crop rotation restriction to sugarbeet.
[7] Starane NXT requires a 9 month after application crop rotation restriction to sugarbeet.
[8] Talinor requires a 15 month after application crop rotation restriction to sugarbeet.