MSU Weed Science

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Economics of Weed Control Programs for non-GMO Soybean, 2023

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A field trial sponsored by the Michigan Soybean Committee (MSC) was conducted in 2023 at the MSU Agronomy Research Farm in Lansing to compare weed control, soybean injury, soybean yield, and economic returns of potential programs in non-GMO (conventional) soybean. Soil-applied (PRE) herbicide programs were designed to provide control of dominant weed species found in Michigan soybean fields. Twenty different soil-applied (PRE) herbicide programs were applied immediately after soybean planting and were evaluated ~21 and 28 days after planting (DAP). At the 28 DAP evaluation, the PRE herbicide programs were scouted for weed escapes and postemergence (POST) herbicides were applied. POST herbicide treatments needed to be sprayed approximately 7 to 14 days earlier than normal, due to the lack of precipitation (0.41-inches) for herbicide incorporation within 28 d of the PRE herbicide application. POST herbicide treatments were selected based on weeds that escaped control. For example, if common ragweed was the escaped weed a herbicide like Flexstar or Cobra was applied. Herbicide rates were adjusted to weed size. In some cases, when both broadleaf and grass weeds needed to be controlled separate POST applications were made for the broadleaf and grass herbicides 7 d apart (+7d), to alleviate the chances for POST grass antagonisms. All treatments were evaluated one week after the POST application for soybean injury. There was one PRE treatment where a POST herbicide was not applied to show the importance of a PRE followed by POST herbicide program. Site characteristics and herbicide application timings are described in Table 1. Table 2 describes the herbicide programs evaluated. The maximum soybean yield was 68.3 bu/A and yield loss due to weeds was high. The weedy (untreated) yield was 25.7 bu/A, resulting in a yield loss of 42.6 bu/A (62%). Tables 3 & 4 contain the data for soybean injury, weed control, herbicide program costs, soybean yield, and economic returns.

Table 1. Site description.

Crop	Soybean
Variety	ZFS 1326
Soil Texture	loam
Soil pH	6.7
Soil Organic Matter	2.0
Dominant Weeds	ANGR, CHEAL, AMBEL[1], ABUTH
Planting Date	May 9
Application Timings:	
PRE	May 9
POST	June 9
+ 7 d after POST	June 16
Evaluation Times	21 & 35 d after planting 7 d after POST & 7 and 28 d after LPOS

Abbreviations: ANGR = giant foxtail, CHEAL = c. lambsquarters, AMBEL = c. ragweed, ABUTH = velvetleaf.

[1]The c. ragweed population at this location is ALS-resistant (Group 2).

Table 2. non-GMO soybean herbicide programs evaluated in 2023.

PRE TREATMENT	POST TREATMENT	ABBREVIATED FORM
Boundary (2.4 pt)	Flexstar (1 pt) + Harmony (0.125 oz) + COC (1%) + AMS (2.5 lb) fb. SelectMax (9 fl oz) + NIS (0.25%) + AMS (2.5 lb) (+7d)	Boundary fb. Flex + Harm fb. Select (+7d)
BroadAxe XC (32 fl oz)	Flexstar (1 pt) + Perpetuo (6 fl oz) + COC (1%) + AMS (1.5 lb) fb. SelectMax (9 fl oz) + NIS (0.25%) + AMS (2.5 lb) (+7d)	Broadaxe fb. Flex + Perp fb. Select (+7d)
Sonic (6 oz) + Boundary (1.5 pt)	Flexstar (1 pt) + Harmony (0.125 oz) + COC (1%) + AMS (2.5 lb) fb. SelectMax (9 fl oz) + NIS (0.25%) + AMS (2.5 lb) (+7d)	Sonic + Boun fb. Flex + Harm fb. Select (+7d)
Surveil (3.5 oz) + Metribuzin (6 oz)	Raptor (5 fl oz) + Flexstar (1 pt) + COC (1%) + AMS (2.5 lb)	Surveil + Metri fb. Raptor + Flex
Dimetric Charged (12 fl oz)	Flexstar (1 pt) + Harmony (0.125 oz) + SelectMax (12 fl oz) + NIS (0.25%) + AMS (2.5 lb)	Dimet Charg fb. Flex + Harm + Select (12)
Valor EZ (2.5 fl oz) + Prowl H_2O (2 pt)	Flexstar (1 pt) + COC (1%) + AMS (2.5 lb) fb. Raptor (5 fl oz) + COC (1%) + AMS (2.5 lb) (+7d)	Valor EZ + Prowl fb. Flex fb. Raptor (+7d)
Fierce EZ (7.5 fl oz)	Raptor (5 fl oz) + Basagran (12.8 fl oz) + Flexstar (1 pt) + COC (0.5%) + AMS (2.5 lb)	Fierce EZ fb. Raptor + Basa + Flex
Fierce MTZ (16 fl oz)	Raptor (5 fl oz) + Cobra (10 fl oz) + COC (1%) + AMS (2.5 lb)	Fierce MTZ fb. Raptor + Cobra
Fierce XLT (4 oz)	Harmony (0.125 oz) + Cobra (10 fl oz) + COC (1%) + AMS (2.5 lb) + SelectMax (9 fl oz) + NIS (0.25%) + AMS (2.5 lb) (+7d)	Fierce XLT fb. Harm + Cobra fb. Select (+7d)
Tendovo (2.35 qt)	Flexstar (1 pt) + SelectMax (12 fl oz) + COC (1%) + AMS (2.5 lb)	Tendovo fb. Flex + Select (12)
Authority Edge (9 fl oz)	Flexstar (1 pt) + COC (1%) + AMS (2.5 lb) fb. Harmony (0.125 oz) + SelectMax (9 fl oz) + NIS (0.25%) + AMS (2.5 lb) (+7d)	Auth Edge fb. Flex fb. Harm + Select (+7d)
Authority Edge (7 fl oz) + Metribuzin (6 oz)	Cobra (10 fl oz) + Perpetuo (6 fl oz) + COC (1%) + AMS (2.5 lb) fb. SelectMax (9 fl oz) + NIS (0.25%) + AMS (2.5 lb) (+7d)	Auth Edge + Metri fb. Cobra + Perp fb. Select
Zidua PRO (6 fl oz)	Varisto (21 fl oz) + COC (1%) + AMS (2.5 lb)	Zidua PRO fb. Varisto
Zidua PRO (6 fl oz) + Metribuzin (6 oz)	SelectMax (9 fl oz) + COC (1%) + AMS (2.5 lb) fb. Flexstar (1 pt) + Harmony (0.125 oz) + COC (1%) + AMS (2.5 lb) (+7d)	Zidua PRO + Metri fb. Select fb. Flex + Harm (+7d)
Valor XLT (2.5 oz) + Valor EZ (1.5 fl oz) + Metribuzin (8 oz)	**NO POST**	Valor XLT + Valor EZ + Metri
Prefix (2 pt) + Metribuzin (6 oz)	Synchrony XP (0.375 oz) + Cobra (10 fl oz) + NIS (0.25%) + AMS (2.5 lb) fb. SelectMax (9 fl oz) + NIS (0.25%) + AMS (2.5 lb) (+7d)	Prefix + Metri fb. Synch + Cobra fb. Select (+7d)
Warrant Ultra (50 fl oz) + Metribuzin (6 oz)	Synchrony XP (0.375 oz) + Cobra (10 fl oz) + SelectMax (12 fl oz) + NIS (0.25%) + AMS (2.5 lb)	Warr Ultra + Metri fb. Synch + Cobra + Select (12)
Matador-S (3 pt)	Cobra (10 fl oz) + SelectMax (12 fl oz) + NIS (0.25%) + AMS (2.5 lb)	Matador fb. Cobra + Select
Up-Stage (21 fl oz) + Preview 2.1 (25 fl oz)	Ultra Blazer (1.5 pt) + COC (2 pt)	Up-Stage + Preview fb. Ultra Blazer
Up-Stage (21 fl oz) + Moccasin MTZ (42 fl oz)	Basagran (1.6 pt) + Ultra Blazer (1 pt) + COC (2 pt)	Up-Stage + Mocc MTZ fb. Basa + UBlazer

Table 3. Weed control at the time of POST (28 DAP) herbicide application[1].

PRE TREATMENT	Weed control (at POST – 28 DAP)			
	ANGR	CHEAL	AMBEL[2]	ABUTH
	% control			
Boundary (2.4 pt)	96	99	83	91
BroadAxe XC (32 fl oz)	94	99	66	76
Sonic (6 oz) + Boundary (1.5 pt)	89	99	85	93
Surveil (3.5 oz) + Metribuzin (6 oz)	77	95	77	92
Dimetric Charged (12 fl oz)	90	94	76	90
Valor EZ (2.5 fl oz) + Prowl H_2O (2 pt)	97	94	78	84
Fierce EZ (7.5 fl oz)	98	95	87	93
Fierce MTZ (16 fl oz)	91	97	85	88
Fierce XLT (4 oz)	94	95	80	93
Tendovo (2.35 qt)	94	100	88	98
Authority Edge (9 fl oz)	91	98	75	89
Authority Edge (7 fl oz) + Metribuzin (6 oz)	95	100	85	90
Zidua PRO (6 fl oz)	96	98	90	98
Zidua PRO (6 fl oz) + Metribuzin (6 oz)	87	97	84	97
Valor XLT (2.5 oz) + Valor EZ (1.5 fl oz) + Metribuzin (8 oz)	93	97	91	96
Prefix (2 pt) + Metribuzin (6 oz)	94	95	89	92
Warrant Ultra (50 fl oz) + Metribuzin (6 oz)	90	96	83	84
Matador-S (3 pt)	91	100	79	98
Up-Stage (21 fl oz) + Preview 2.1 (25 fl oz)	99	100	93	100
Up-Stage (21 fl oz) + Moccasin MTZ (42 fl oz)	98	100	92	100

Abbreviations: ANGR = giant foxtail, CHEAL = c. lambsquarters, AMBEL[2] = c. ragweed, ABUTH = velvetleaf, P = POST, LP = Late POST.

[1]POST herbicide selection was based on weed control that was less than 90% for the different weed species.

[2]The common ragweed population at this location is resistant to the Group 2 (ALS-inhibiting) herbicides.

Table 4. Soybean injury, weed control, program costs, soybean yield, and economic returns for non-GMO herbicide programs, 2023.

Herbicide Programs[1]	Soybean Injury		Prior to harvest (35 d after +7d)				All Weeds	Costs[2]	Yield	Economic Returns[3]
	28 DAP	7 DAT	ANGR	CHEAL	AMBEL	ABUTH				
	(%)	(%)	% control				(≥90%)	($/A)	(bu/A)	($/A)
Boundary fb. Flex + Harm fb. Select (+7d)	2	**24**	**97**	**93**	**93**	**99**	**YES**	$86.68	**63.0***	**$811.07***
Broadaxe fb. Flex + Perp fb. Select (+7d)	2	**25**	**100**	**98**	79	**95**	NO	$100.72	56.9	$710.11
Sonic + Boun fb. Flex + Harm fb. Select (+7d)	1	**28**	**95**	**100**	**95**	**100**	**YES**	$92.13	**63.6***	**$814.17***
Surveil + Metri fb. Raptor + Flex	0	**19**	86	**100**	80	**100**	NO	$85.60	**61.4***	**$789.35***
Dimet Charg fb. Flex + Harm + Select (12)	0	**26**	**96**	**90**	**92**	**100**	**YES**	$79.96	**62.2***	**$806.39***
Valor EZ + Prowl fb. Flex fb. Raptor (+7d)	2	**18**	**98**	**95**	**90**	**100**	**YES**	$94.87	**60.6***	**$768.68***
Fierce EZ fb. Raptor + Basa + Flex	0	**28**	**94**	**97**	**95**	**100**	**YES**	$93.26	**62.3***	**$794.52***
Fierce MTZ fb. Raptor + Cobra	2	**23**	**94**	**95**	87	**100**	NO	$106.30	58.4	$725.90
Fierce XLT fb. Harm + Cobra fb. Select (+7d)	2	**29**	**95**	**94**	81	**97**	NO	$99.16	58.1	$728.77
Tendovo fb. Flex + Select (12)	3	**18**	**95**	**100**	64	**99**	NO	$88.25	**61.5***	**$788.13***
Auth Edge fb. Flex fb. Harm + Select (+7d)	2	**15**	**93**	**100**	78	**100**	NO	$103.31	**60.4***	$757.39
Auth Edge + Metri fb. Cobra + Perp fb. Select	0	**25**	**99**	**100**	86	**100**	NO	**$117.43****	57.2	$698.38
Zidua PRO fb. Varisto	2	**7**	**98**	**100**	77	**100**	NO	$81.51	56.7	$726.47
Zidua PRO + Metri fb. Select fb. Flex + Harm (+7d)	1	0	**99**	**96**	86	**100**	NO	$97.58	**60.6***	**$765.97***
Valor XLT + Valor EZ + Metri	2	0	74	**90**	69	**90**	NO	$36.76	53.2	$721.34
Prefix + Metri fb. Synch + Cobra fb. Select (+7d)	2	**21**	**97**	88	**90**	**100**	NO	$88.65	**65.2***	**$840.45***
Warr Ultra + Metri fb. Synch + Cobra + Select (12)	2	**24**	**94**	**98**	84	**98**	NO	$86.62	58.8	$751.28
Matador fb. Cobra + Select	3	**22**	**99**	**95**	74	**96**	NO	$75.18	**59.7***	**$775.55***
Up-Stage + Preview fb. Ultra Blazer	2	**18**	**98**	**100**	89	**98**	NO	$74.31	**68.3****	**$898.97****
Up-Stage + Mocc MTZ fb. Basa + UBlazer	3	**12**	**95**	**100**	89	**100**	NO	$71.12	**66.3***	**$873.66***
Untreated	0	0	0	0	0	0	NO	---	25.7	$366.23

Abbreviations: ANGR = giant foxtail, CHEAL = c. lambsquarters, AMBEL = c. ragweed, ABUTH = velvetleaf, fb. = followed by, P = POST, +7d = 7 d after POST.
[1]Many herbicide programs have long rotation restrictions to sensitive crops. Consult the Table 12 in the MSU Weed Control Guide for Field Crops (E0434) or the herbicide label for crop rotation restrictions.
[2]Herbicide costs = avg. of price lists; App. cost = $10.00/A; seeding rate = 150,000 seeds/A. Weed control costs = Herbicide $ + Additive $ + Application $.
[3]Crop selling price = $12.25/bu + non-GMO premium $2.00/bu (December 2023). Economic return = (Yield x Price) – Weed Control Costs.
**Highest yielding and highest economic returns. *Values are not significantly different from the highest value within that column.
Injury ratings in bold are significant.

General Observations and Interpretation:

Each year precipitation can impact outcomes of the various herbicide programs examined in the non-GMO soybean study. However, overall results between years remain fairly consistent. This year soybeans were planted, and PRE herbicides were applied on May 9. Rainfall this season was extremely low after planting. In fact, within 10 days of planting there was only 0.12-inches of precipitation and only an additional 0.41-inch during the time that the POST herbicide applications were made, ~45 DAP. The low rainfall led to reduced incorporation of the PRE herbicides and reduced activity of the POST herbicide applications. The lower than normal rainfall also resulted in slow soybean growth, so the POST herbicides were applied when the soybean were at V1 for the first POST herbicide application and V2-V3 for the follow up +7 d after POST application. The low initial rainfall led to poor incorporation of the PRE herbicides that resulted in lower than expected weed control and virtually no PRE herbicide injury. However, in general the PRE herbicide treatments did reduce the number of weeds present at the POST application, making the PRE application an important component of these herbicide programs. The most variability in control from the PRE herbicides was with common ragweed. However, in many cases all treatments did need a POST herbicide application for annual grass and in some cases, common lambsquarters and velvetleaf. All PRE herbicide treatments needed the first POST herbicide application. However, we left one of the PRE treatments to use as a yield comparison to see the benefits of the PRE treatment on early-season weed control. The POST herbicide applications resulted in soybean injury that ranged between 7-29%, 7 days after treatment (DAT). Treatments with the greatest injury included Perpetuo or Harmony combinations with a Group 14 herbicide, like Flexstar or Cobra. All PRE herbicide treatments needed a Group 1 herbicide for grass control with the exception of PRE treatments that contained Up-Stage (clomazone). Within 10 d after the POST grass herbicide application (+7d), there was consistent high amounts of rainfall throughout most of July and August (>10-inches) leading to additional weed emergence and incorporation of the PRE residual herbicides. Control of annual grasses was greater than 90% with all PRE followed by POST herbicide applications, with the exception where Raptor was used for POST grass control (86%), 42 DAT. Common lambsquarters and velvetleaf control were also ~90% or greater with PRE followed by POST applications, 42 DAT. Common ragweed control was the most variable from the POST herbicide applications, 74 to 95%. In some cases, there was regrowth from the axial buds of common ragweed. The variability in common ragweed control was a combination of the effectiveness of the PRE and also the POST herbicide treatment. Only 5 of the 20 herbicide programs provided greater than 90% control of all weed species. The soil-applied portion of these programs contained herbicides with both grass and broadleaf activity. The PRE followed by POST herbicide program costs including application costs of $10 per acre, ranged from $71.71 to $117.43 per acre. Soybean yield from the different PRE followed by POST treatments ranged from 56.7-68.3 bu/A, of these 14 of the 19 herbicide programs evaluated ranked amongst the highest yielding. The PRE only treatment yielded 53.2 bu/A, yielding 52% more soybean than the weedy control showing the importance of the PRE herbicide treatment for early-season weed control. All of the highest yielding programs, with the exception of the most expensive program were ranked amongst the highest economic returns. In general, it is important to plan on a two-pass program (PRE fb. POST) when growing non-GMO soybean. Throughout the years these programs have consistently provided better weed control, yield, and economic returns, even with the added herbicide and application cost.