WATERHEMP CONTROL FROM LAYERED CONVENTIONAL HERBICIDE PROGRAMS IN 2021

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Objective was to evaluate glyphosate-resistant waterhemp control in soybean with preemergence and early-postemergence conventional residual herbicide combinations across industry and compare against micro-rate residual herbicide program treatments developed by Next Gen Ag LLC in 2019 and 2020 in efficacy and cost.

MATERIALS AND METHODS

Experiments were conducted on natural glyphosate-resistant waterhemp populations near Renville, Minnesota, in 2021. Plot area was worked by Next Gen Ag LLC with field cultivator at 3" depth. Golden Harvest 'GH1362E3' soybeans were seeded 1.25 inches deep in 30-inch rows at 150,000 seeds per acre on April 27. Preemergence (PRE) herbicide treatments were applied April 29 and early-postemergence (EPOST) treatments were applied at soybean second trifoliate (V2) on May 26 (Table 1). Treatments were applied with bicycle sprayer in 15 GPA spray solution through AIXR11002 air-induction flat fan nozzles pressurized with CO_2 at 25 PSI to the center two rows of four row plots 35 feet in length. Field area had high levels of glyphosate-resistant waterhemp populations. Ammonium sulfate (AMS) in Roundup PowerMax or Flexstar GT containing treatments was a liquid formulation from Winfield Solutions called Class Act NG. Crop Oil Concentrate (COC) was added to Cobra containing treatments and Methelyated Seed Oil (MSO) to Flexstar containing treatments.

Waterhemp control was evaluated May 15, May 26, June 9, June 22, and July 7 at 15, 26, 39, 52, and 67 days after treatment "A" (DAA) (Table 1). Waterhemp evaluations were a visual estimate of percent fresh weight reduction in center two treated rows compared to adjacent untreated strips. Experimental design was randomized complete block with 4 replications. Data were analyzed with GLM procedure of SAS (Statistical Analysis Software 2021, version 10.0, SAS Institute, Inc.) at alpha=0.10 and differences are determined with 90% confidence in repeatability.

Table 1. Application information for Renville, MN, soybean trial in 2021.

Location	Renville	
Application Code	A	B
Date	April 30	May 26
Time of Day	10:00 AM	5:00 PM
Air Temperature (F)	47	64
Relative Humidity (%)	50	34
Wind Velocity (mph)	6	4.5
Wind Direction	NE	N
Soil Temp. (F at 6")	49	71
Soil Moisture	Good	Fair
Cloud Cover (%)	70	60
Soybean Growth Stage (avg)	-	V2
Lambsquarters Height	-	4"
Waterhemp Height	-	2"

RESULTS AND DISCUSSION

Rainfall between "A" and "B" applications was 0.40 inches, well below average, which resulted in abnormally dry conditions (Table 1). As a result, soybean emergence was erratic, waterhemp emergence was delayed until 25 days after planting, and lambsquarters (a cool season, early emerging weed) became well established creating some difficulty in waterhemp control evaluations. One day after "B" application a 0.90 inch rainfall event occurred activating both PRE and EPOST residual herbicides. Accumulated rainfall from "B" application to trial conclusion (July 7) was 2.0 inches, also abnormally dry. Lack of rainfall, intense waterhemp pressure, and drought stress impact on waterhemp created a "worst case" scenario for evaluating residual herbicide treatments. Crop injury did not occur; thus, will not be discussed.

Table 2. Waterhemp control, Renville, MN.							
		Waterhemp Control					Sponsor
Treatment[a]	Rate	A+15[c]	A+26	A+39	A+52	A+67	
	oz/A* or fl oz/A	----------%----------					
Zidua Pro / Outlook + Flexstar	4.5 / 14 + 16	100	64	91	93	91	BASF
Zidua Pro / Zidua SC + Flexstar	6 / 2.5 + 16	100	71	91	91	89	BASF
Zidua Pro / Zidua SC + Flexstar GT	6 / 2.5 + 56	100	49	81	76	74	BASF
Warrant / Warrant Ultra	48 / 64	100	74	88	88	85	Bayer
Warrant + Metribuzin / Warrant Ultra	64 + *5.33 / 48	100	69	89	86	89	Bayer
War[b] + Metribuzin / War Ultra + RU	64 + *5.33 / 48 + 32	100	71	98	95	93	Bayer
Sonic / Flexstar + EverpreX	*5 / 12 + 16	100	48	83	76	75	Corteva
Kyber / Flexstar + EverpreX	16 / 12 + 16	100	88	98	96	95	Corteva
Kyber / Flex + EverpreX + Durango	16 / 12 + 16 + 24	100	71	99	96	96	Corteva
Authority Supreme / Flexstar	10 / 11	100	66	88	83	76	FMC
Authority Edge / Flexstar	14 / 11	90	56	74	70	43	FMC
Authority Edge / Flexstar GT	14 / 56	98	11	80	75	60	FMC
Broadaxe / Prefix	28 / 32	95	22	58	48	5	Syngenta
Boundary / Flexstar + Dual II Magnum	28.8 / 16 + 16	88	17	84	79	68	Syngenta
Boundary / Flex GT + Dual II Magnum	28.8 / 56 + 16	85	1	78	68	63	Syngenta
Valor SX + Mauler / Cobra + Perpetuo	*2 + 8 / 10 + 6	90	12	89	81	75	Valent
Fierce / Cobra + Perpetuo	*3 / 10 + 6	100	50	90	85	75	Valent
Fierce / Cobra + Perpetuo + RU	*3 / 10 + 6 + 32	100	32	90	88	86	Valent
Di. Charge / Charg Ba + Avalanche Ult	12 / 24 + 24	95	42	80	79	70	Winfield
Presidual / Charg Ba + Avalanche Ult	24 / 24 + 24	100	8	60	63	25	Winfield
Di. Charged / Charg Ba + Flex GT	12 / 24 + 56	100	66	95	91	91	Winfield
Valor SX + Warrant / Zidua + Flexstar	*1.5 + 30 / *2 + 7.5	100	47	84	89	85	NGA
Valor SX + Warrant / Zidua + Flexstar	*2 + 40 + *2.5 + 10	95	37	90	85	86	NGA
Valor SX + Warrant / Zidua + Flex GT	*2 + 40 / *2.5 + 56	93	91	95	93	95	NGA
Blanket + Valor SX / Warrant + Flex	6 + *1.5 / 30 + 7.5	100	45	84	85	65	NGA
Blanket + Valor SX / War + Flex GT	6 + *1.5 / 30 + 56	98	32	78	71	58	NGA
Blanket + Valor SX / Warrant + Flex	8 + *2 / 40 +10	93	15	85	83	78	NGA
Blanket + Valor SX / War + Flex GT	8 + *2 / 40 +56	95	50	93	88	89	NGA
Blanket + Valor SX / Warrant + Flex	10 + *2 / 48 +12	98	55	94	90	90	NGA
Blanket + Valor SX / War + Flex GT	10 + *2 / 48 +56	93	45	90	89	88	NGA
Authority MTZ / Zidua + RU	*12 / *2.5 + 32	93	15	40	45	18	Farmer
Blanket / Warrant + RU	8 / 24 + 32	93	8	30	23	10	Farmer
Sharpen + Warrant / Warrant + RU	1 + 24 / 40 + 32	95	40	43	43	15	Farmer
Sharpen + Warrant / Zidua + RU	1 + 24 / *2.5 + 32	93	37	63	48	0	Farmer
Authority Edge / RU	9 / 32	95	12	18	20	0	Farmer
Authority Edge + Sonic / Flexstar GT	9 + *5 / 56	93	59	91	90	90	Farmer
Fierce / Flexstar GT	*3 / 56	98	39	76	76	65	Farmer
Sharpen + Auth Edge / Warrant + RU	1 + 9 / 24 + 32	95	24	20	25	15	Farmer
Fierce / Warrant Ultra + RU	*3 / 48 + 32	98	50	83	88	85	Farmer
Prefix + Me-Too-Lachlor / RU	32 + 16 / 32	95	15	30	28	20	Farmer
LSD (0.1)		**7**	**21**	**13**	**16**	**25**	

[a]PRE treatment applications contained no additional adjuvants.
[b]Flex=Flexstar; Flex GT=Flexstar GT; War=Warrant; RU=Roundup PowerMax; Di. Charged=Dimetric Charged; Charg Ba=Charger Basic
[c]A+[number]=Days after "A" application.

Weed control ranged from 85-100% and averaged 96.4% at A+15 (May 15) and was evaluated as overall weed control due to delayed waterhemp emergence as a result of drought conditions (Table 2). Rainfall of 0.20 inches occurred on May 14 and initiated a majority of waterhemp emergence. Waterhemp control ranged from 1-91% and averaged 42.6% at A+26 (May 26). First significant rainfall event occurred May 27 (0.90 inches) and activated the treatment residual herbicides for subsequent evaluations. Waterhemp control ranged from 18-98% and averaged 76.8% at A+39 (June 9) and demonstrated the combination of effects resulting from the non-residual EPOST herbicide activity and

residual herbicide activity on 2" emerged, or emerging waterhemp. Waterhemp control ranged from 20-96% and averaged 74.2% at A+52 (June 22). Waterhemp control ranged from 0-96% and averaged 64.4% at A+67 (July 7). Decrease in control at A+52 and A+67 can be attributed to continued drought conditions (0.30 inches additional since A+39) and natural biological herbicide degradation.

Due to the extensive number of treatments in this study, only a few will be discussed based on three distinctive categories. Seventeen treatments will appear in Table 3, 'Top 15 by Waterhemp Control', fifteen treatments will appear in Table 4, 'Top 15 by Treatment Cost', and fifteen treatments will appear in Table 5, 'Lambsquarters Control, Marshall, MN'. The Marshall, MN, location was at SMSU research farm and contained only 15 treatments and only lambsquarters was evaluated in the absence of waterhemp pressure. Same treatments may appear in multiple tables.

Table 3. Top 15 by Waterhemp Control, Renville, MN.

		WAHP Control		WAHP	COST	Cost	Sponsor
Treatment[a]	**Rate**	**A+52[c]**	**A+67**	**$**	**A+67**		
	oz/A* or fl oz/A	-----%----		Rank #/40		$	
Kyber / Flex[b] + EverpreX + Durango	16 / 12 + 16 + 24	96	96	1	34	48.25	Corteva
Valor SX + Warrant / Zidua + Flex GT	*2 + 40 / *2.5 + 56	93	95	2	38	42.91	NGA
Kyber / Flexstar + EverpreX	16 / 12 + 16	96	95	2	27	53.84	Corteva
War + Metribuzin / War Ultra + RU	64 + *5.33 / 48 + 32	95	93	4	23	40.74	Bayer
Zidua Pro / Outlook + Flexstar	4.5 / 14 + 16	93	91	5	16	35.30	BASF
Di. Charge / Charg Ba + Avalanche Ult	12 / 24 + 24	91	91	5	26	41.67	Winfield
Blanket + Valor SX / Warrant + Flex	10 + *2 / 48 +12	90	90	7	17	36.26	NGA
Authority Edge + Sonic / Flexstar GT	9 + *5 / 56	90	90	7	27	53.09	Farmer
Blanket + Valor SX / War + Flex GT	8 + *2 / 40 +56	88	89	9	28	31.40	NGA
Zidua Pro / Zidua SC + Flexstar	6 / 2.5 + 16	91	89	9	29	43.37	BASF
Warrant + Metribuzin[3] / Warrant Ultra	64 + *5.33 / 48	86	89	9	8	44.17	Bayer
Blanket + Valor SX / War + Flex GT	10 + *2 / 48 +56	89	88	12	33	47.75	NGA
Valor SX + Warrant / Zidua + Flexstar	*2 + 40 + *2.5 + 10	85	86	13	25	41.55	NGA
Fierce / Cobra + Perpetuo + RU	*3 / 10 + 6 + 32	88	86	13	40	60.07	Valent
Valor SX + Warrant / Zidua + Flexstar	*1.5 + 30 / *2 + 7.5	89	85	15	12	32.85	NGA
Warrant / Warrant Ultra	48 / 64	88	85	15	4	25.41	Bayer
Fierce / Warrant Ultra + RU	*3 / 48 + 32	88	85	15	24	40.88	Farmer

[a]PRE treatment applications contained no additional adjuvants.
[b]Flex=Flexstar; Flex GT=Flexstar GT; War=Warrant; RU=Roundup PowerMax; Di. Charged=Dimetric Charged; Charg Ba=Charger Basic
[c]A+[number]=Days after "A" application.

Active ingredients metribuzin (Sonic or generics) or flumioxazin (Valor SX or generics) existed in 12 of the top 17 treatments for waterhemp control at A+67 (Table 3). The exceptions were Zidua Pro, ranked #5 and #9, and Warrant, ranked #15. Both metribuzin and flumioxazin are know to have a tendency to improve the activity of other tank mixed residuals and these results support the theory especially in an exceptionally dry growing season. Kyber is a pre-mix of metribuzin + flumioxazin + pyroxasulfone (Zidua or generics) similar to Fierce MTZ. Kyber inclusive treatments ranked #1 and #2 with the addition of glyphosate (Roundup or generics) to the EPOST adding 1% more waterhemp control. A micro-rate tank mix of Valor SX (2) + Warrant (40) + Zidua (2.5) + Flexstar GT (56) ranked #2 as the most affordable treatment in the top three. A similar treatment with no glyphosate and 62.5% of the fomesafen (Flexstar or generics) load ranked #13 in waterhemp control at a similar cost. Corteva, NGA, Bayer, BASF, Winfield, and Valent all had treatments rank in the top 15 for waterhemp control. Only one treatment in the top 15 for waterhemp control contained a single active ingredient PRE. Waterhemp control in the top 15 ranged from 85-96% and averaged 89.6%.

Bayer (rank #15), NGA (rank #9), and NGA (rank #15) had the most affordable treatments in the top 15 estimated at $25.41, $31.40, and $32.85, respectively. BASF and Bayer provided the most affordable treatment ranked in the top five for waterhemp control at A+67 with estimated costs of $35.30 and $40.74, respectively. Valent (rank #13), Corteva (rank #2), and a farmer entry (rank #7) had the most expensive treatments in the top 15 estimated at $60.07, $53.84, and $53.09, respectfully. Cost per treatment in the top 15 for waterhemp control ranged from $25.41 to $60.07 and averaged $42.32.

Table 4. Top 15 by Cost Waterhemp Control, Renville, MN.							
		WAHP Control		WAHP	COST	Cost	Sponsor
Treatment[a]	Rate	A+52[c]	A+67	A+67	$		
	oz/A* or fl oz/A	-----%----		Rank #/40		$	
Authority Edge / RU[b]	9 / 32	20	0	39	1	22.90	Farmer
Blanket + Valor SX / Warrant + Flex	6 + *1.5 / 30 + 7.5	85	65	26	2	23.93	NGA
Blanket / Warrant + RU	8 / 24 + 32	23	10	37	3	25.18	NGA
Warrant / Warrant Ultra	48 / 64	88	85	15	4	25.41	Bayer
Prefix + Me-Too-Lachlor / RU	32 + 16 / 32	28	20	33	5	25.47	Farmer
Sharpen + Warrant / Warrant + RU	1 + 24 / 40 + 32	43	15	35	6	27.92	NGA
Blanket + Valor SX / Warrant + Flex	8 + *2 / 40 +10	83	78	18	7	31.08	NGA
Warrant + Metribuzin / Warrant Ultra	64 + *5.33 / 48	86	89	9	8	31.40	Bayer
Presidual / Charg Ba + Avalanche Ult	24 / 24 + 24	63	25	32	9	31.86	Winfield
Sonic / Flexstar + EverpreX	*5 / 12 + 16	76	75	20	10	32.28	Corteva
Broadaxe / Prefix	28 / 32	48	5	38	11	32.31	Syngenta
Valor SX + Warrant / Zidua + Flexstar	*1.5 + 30 / *2 + 7.5	89	85	15	12	32.85	NGA
Di. Charge / Charg Ba + Avalanche Ult	12 / 24 + 24	79	70	24	13	33.83	Winfield
Authority Edge / Flexstar	14 / 11	70	43	31	14	34.01	FMC
Authority Supreme / Flexstar	10 / 11	83	76	19	15	34.07	FMC

[a]PRE treatment applications contained no additional adjuvants.
[b]Flex=Flexstar; Flex GT=Flexstar GT; War=Warrant; RU=Roundup PowerMax; Di. Charged=Dimetric Charged; Charg Ba=Charger Basic
[c]A+[number]=Days after "A" application.

Waterhemp control at A+67 in the top 15 treatments by cost ranged from 0-89% and averaged 49.4% with three treatments exceeding 85% (Table 4). Warrant (64) + Metribuzin (5.33) fb Warrant Ultra (64) provided 89% waterhemp control (#9) at an estimated cost of $31.40 (#8). Valor SX (1.5) + Warrant (30) fb Zidua (2) + Flexstar (7.5) provided 85% waterhemp control (#15) at an estimated cost of $32.85 (#12). Warrant (48) fb Warrant Ultra (64) provided 85% waterhemp control (#15) at an estimated cost of $25.41 (#4). Estimated cost per treatment in the top 15 by cost ranged from $22.90 to $34.07 and averaged $29.63.

Table 5. Application information for Marshall, MN, soybean trial in 2021.		
Location	Marshall	
Application Code	A	B
Date	May 8	June 2
Time of Day	9:00 AM	2:00 PM
Air Temperature (F)	50	87
Relative Humidity (%)	43	20
Wind Velocity (mph)	9	10
Wind Direction	SE	SW
Soil Temp. (F at 6")	47	70
Soil Moisture	Fair	Fair
Cloud Cover (%)	90	50
Soybean Growth Stage (avg)	-	V2
Lambsquarters Height	-	4"
Waterhemp Height	-	-

Rainfall in Marshall, MN, was greater (+1.20 inches) between the "A" and "B" applications compared to the Renville, MN, location in 2021 (Table 5). Lambsquarters populuations were moderate and waterhemp pressure was very low; thus, only lambsquarters could effectively be evaluated. No glyphosate inclusive treatments present in this supporting study.

Table 6. Lambsquarters control, Marshall, MN.							
		Lambsquarters Control					
Treatment[a]	**Rate**	**A+16[c]**	**A+25**	**A+44**	**A+59**	**Cost**	**Sponsor**
	oz/A* or fl oz/A	----------%----------				$	
Zidua Pro / Outlook + Flexstar	4.5 / 14 + 16	90	85	89	91	35.30	BASF
Warrant + Metribuzin / Warrant Ultra	64 + *5.33 / 48	78	26	30	18	31.40	Bayer
Kyber / Flexstar + EverpreX	16 / 12 + 16	90	61	88	83	42.91	Corteva
Authority Edge / Flexstar	14 / 11	90	68	88	84	34.01	FMC
Broadaxe / Prefix	28 / 32	90	50	90	80	32.31	Syngenta
Fierce / Cobra + Perpetuo	*3 / 10 + 6	78	13	70	55	52.60	Valent
Di. Charge[b] / Charg Ba + Avalanche Ult	12 / 24 + 24	70	21	80	75	33.83	Winfield
Valor SX + Warrant / Zidua + Flexstar	*1.5 + 30 / *2 + 7.5	95	77	78	70	32.85	NGA
Blanket + Valor SX / Warrant + Flex	6 + *1.5 / 30 + 7.5	98	64	81	74	23.93	NGA
Blanket + Valor SX / Warrant + Flex	8 + *2 / 40 +10	93	96	95	96	31.08	NGA
Sharpen + Warrant / Warrant + RU	1 + 24 / 40 + 32	93	69	85	79	25.06	Farmer
Authority Edge + Sonic / Flexstar	9 + *5 / 10	90	79	90	88	40.80	Farmer
Sharpen + Auth Edge / Warrant + Flex	1 + 9 / 24 + 10	95	96	71	95	34.06	Farmer
Prefix + Me-Too-Lachlor / RU	32 + 16 / 32	90	83	91	75	22.61	Farmer
Authority Edge / Flexstar	9 / 10	93	82	85	89	23.92	Farmer
LSD (0.1)		**20**	**37**	**20**	**19**		

[a]PRE treatment applications contained no additional adjuvants.
[b]Flex=Flexstar; Flex GT=Flexstar GT; War=Warrant; RU=Roundup PowerMax; Di. Charged=Dimetric Charged; Charg Ba=Charger Basic
[c]A+[number]=Days after "A" application.

Lambsqarters control at A+59 ranged from 18-96% and averaged 76.8% (Table 6). Five treatments provided >85% lambsquarters control ranging from 88-96% and averaged 91.8%. Residual micro-rates treatments ranked #1 (96%) and #2 (95%) followed by BASF at #3 (91%), and two farmer sponsored treatments ranked #4 (89%) and #5 (88%). Pyroxasulfone (Zidua or generic) and sulfentrazone (Spartan or generic) were included in four of the five top treatments for lambsquarters control, however, pyroxasulfone was not included in the #1 ranked tank mix and sulfentrazone was not included in the #3 ranked tank mix. Authority Edge (pyroxasulfone + sulfentrazone) was a component of #2, #4, and #5 ranked treatments.

Lambsquarters control top five treatments estimated cost ranged from $23.92 to $40.80 and averaged $33.03 (Table 6). Estimated treatment cost for the top five lambsquarters control were $31.08, $34.06, $35.30, $23.92, and $40.80, respectively.

CONCLUSION

Seven different industry partners submitted three treatments each to be compared to nine different Next Gen Ag LLC developed residual micro-rate treatments and ten farmer entries. Average control and estimated treatment cost in the top 15 waterhemp control treatments were 89.6% and $42.32, respectively. Average control and estimated treatment cost in the top 15 by cost treatments were 49.4% and $29.63. In general, the more expensive the treatment the better the waterhemp control which seems logical based on marketing tendencies of crop protection companies. Metribuzin and flumioxazin tended to provide the greatest waterhemp control slightly ahead of pyroxasulfone. Pyroxasulfone and sulfentrazone tended to provide the greatest lambsquarters control. Crop safety was not an issue.

Three treatments appeared on both "Top 15" charts. Growers should consider these three treatments to be the best "bang for their buck" in relation to the entries within the study. These treatments include: Warrant (64) + Metribuzin (5.33) fb Warrant Ultra (64) provided 89% waterhemp control (#9) at an estimated cost of $31.40 (#8); Valor SX (1.5) + Warrant (30) fb Zidua (2) + Flexstar (7.5) provided 85% waterhemp control (#15) at an estimated cost of $32.85 (#12); and, Warrant (48) fb Warrant Ultra (64) provided 85% waterhemp control (#15) at an estimated cost of $25.41 (#4). Crop safety of micro-rate PRE combinations will continue to be evaluated, however, at the reduced product rates the program should logically be considered safe in soybean. Valor SX can be applied with Warrant at 2 ounces per acre according to label, however be aware "splash up" rain events may result in some crop injury. Next Gen Ag LLC is not liable for any decisions made on the basis of this study or publication.