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Cereal response to PGR pre-emergence. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat, durum, 'CDC Copeland' barley, and a mixed cultivars of oats were planted near Fargo on May 11. Treatments were applied pre-emergence on May 12 with 72°F, 36% relative humidity, 0% cloud cover, and dry soil at 60°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/2 All inj	6/16 All inj	6/29 All inj	7/14 Wht	7/14 Dur	7/14 Bar	7/14 Oat
	oz ae/A	%	%	%	%	%	%	%
MCPA	8	0	0	0	0	0	0	0
MCPA	24	0	0	0	0	0	0	0
2,4-D	8	0	0	0	0	0	0	0
2,4-D	24	0	0	0	0	0	0	0
Dicamba	4	0	0	0	0	0	0	0
Dicamba	12	0	5	18	20	16	13	11
Fluroxypyr	2	0	0	0	0	0	0	0
Fluroxypyr	6	0	0	0	0	0	0	0
Clopyralid	2	0	0	0	0	0	0	0
Clopyralid	6	0	0	0	0	0	0	0
Halauxifen&Florasulam	0.15	0	0	0	0	0	0	0
Halauxifen&Florasulam	0.45	0	0	0	0	0	0	0
Untreated Check	0	0	0	0	0	0	0	0
CV		0	0	112	73	122	327	333
LSD 0.5		.	.	2	2	2	5	4

Cereals were not injured by any herbicide at 3X rate except dicamba. Dicamba at 1X rate did not cause symptoms. Injury with dicamba at 12 oz/A did not express visible symptoms until after the three-leaf stage when there was enough tissue to see splayed growth orientation. This was minor on June 16 but more prominent on June 29 when height differentiation also was observed. This injury persisted through the season but at a diminishing level.

Small grain response to glyphosate. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat, 'CDC Copeland' barley, mixed cultivars of oats, and durum were seeded in bioassay strips near Fargo on May 11. Treatments were applied to 5 leaf crops on June 16 with 84°F, 28% relative humidity, 20% cloud cover, 3 to 5 mph wind velocity at 270°, and damp subsoil at 77°F. Treatments were mixed with a stock solution of 10 ml glyphosate 4.5:90 ml H2O. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through TT11001 nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates

Treatment	Rate	6/29 wht	6/29 dur	6/29 bar	6/29 oat	7/14 wht	7/14 dur	7/14 bar	7/14 oat
	oz ae/A	%	%	%	%	%	%	%	%
Stockglyt+NIS+AMS	0.025+0.25%+12	0	0	0	0	0	0	0	0
Stockglyt+NIS+AMS	0.05+0.25%+12	0	0	1	1	0	0	0	0
Stockglyt+NIS+AMS	0.1+0.25%+12	8	9	5	7	9	5	3	4
Stockglyt+NIS+AMS	0.2+0.25%+12	58	60	40	38	74	69	61	34
Stockglyt+NIS+AMS	0.3+0.25%+12	69	68	56	56	74	70	74	55
Stockglyt+NIS+AMS	0.4+0.25%+12	90	86	76	70	94	93	94	74
Stockglyt+NIS+AMS	0.5+0.25%+12	91	86	84	73	97	94	96	80
Untreated	0	0	0	0	0	0	0	0	0
CV		11	12	13	16	6	8	5	11
LSD P=.05		6	7	6	7	4	5	3	5

Previous work demonstrated the extreme susceptibility of wheat to glyphosate. In this study, durum, barley, and oat cereal crops also are very susceptible to glyphosate. Glyphosate at 0.1 oz/A resulted in less than 10% injury, but 0.2 oz/A caused greater than 60% injury to hard red wheat, durum, and barley on July 14, while oat was injured 34%. Injury substantially increased as rate increased from 0.2 oz/A.

Wheat response to glyphosate-4.5 at 4L, Location 1. 'Bolles' wheat was seeded near Fargo on May 4. Treatments were applied to 4 to flag leaf wheat on June 16 with 83°F, 36% relative humidity, 80% cloud cover, and 4 mph wind velocity at 270° and dry soil at 76°F. Treatments were measured from a stock solution of 10 ml glyphosate 4.5:90 ml of H_2O. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/29 wht	7/14 wht	Yield
	oz ae/A	%	%	bu/A
Glyt+NIS+AMS	0.025+0.25%+12	0	0	38
Glyt+NIS+AMS	0.05+0.25%+12	0	0	38
Glyt+NIS+AMS	0.1+0.25%+12	5	4	28
Glyt+NIS+AMS	0.15+0.25%+12	10	10	22
Glyt+NIS+AMS	0.2+0.25%+12	40	49	10
Glyt+NIS+AMS	0.25+0.25%+12	66	68	4
Glyt+NIS+AMS	0.3+0.25%+12	78	79	3
Glyt+NIS+AMS	0.35+0.25%+12	86	90	0
Untreated	0	0	0	37
CV		11	16	22
LSD P=.05		5	8	6

Wheat response was consistent with previous years. Glyphosate at 0.1 oz/A elicited minimal wheat response of about 5%. This was observed primarily as stunting but slight chlorosis could be detected. Although minimal visible injury, grain yield was almost 25% less than for untreated wheat. Wheat yield was reduced more than 70% with glyphosate at 0.2 oz/A.

Wheat response to glyphosate-4.5 at 4L, Location 2. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 12. Treatments were applied to 4 leaf wheat on June 16 with 83°F, 28% relative humidity, and 20% cloud cover, 2 to 4 mph wind velocity at 270° and damp subsoil at 77°F. The spray solution was mixed from a stock solution of 10 ml glyphosate 4.5:90 ml H_2O. The treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/29 wht	7/14 wht	Yield
	oz ae/A	%	%	bu/A
Glyt+NIS+AMS	0.025+0.25%+12	0	0	54
Glyt+NIS+AMS	0.05+0.25%+12	3	0	51
Glyt+NIS+AMS	0.1+0.25%+12	10	8	39
Glyt+NIS+AMS	0.15+0.25%+12	20	14	35
Glyt+NIS+AMS	0.2+0.25%+12	64	64	12
Glyt+NIS+AMS	0.25+0.25%+12	79	79	3
Glyt+NIS+AMS	0.3+0.25%+12	84	86	1
Glyt+NIS+AMS	0.35+0.25%+12	90	94	2
Untreated		0	0	54
CV		8	9	17
LSD P=.05		5	5	7

Wheat response was consistent with previous years. Glyphosate at 0.1 oz/A elicited minimal wheat response of 10% or less. This was observed primarily as stunting but slight chlorosis could be detected. Grain yield with this treatment was more than 25% less than untreated wheat. Wheat yield was 78% less when treated with glyphosate at 0.2 oz/A than the untreated.

Wheat response toglyphosate-4.5 at 4L, Location 3. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Prosper, North Dakota on May 8. Treatments were applied to 6 leaf wheat on June 19 with 65°F, 63% relative humidity, 10% cloud cover, and 5 mph wind velocity at 315° and moist soil at 66°F. The spray solution was a mixture of 10 ml glyphosate 4.5:90 ml H_2O. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates. Harvest for yield was August 24.

Treatment	Rate	7/03 wht inj	7/20 wht inj	8/24 Yield
				bu/A
Glyt+NIS+AMS	0.025+0.25%+12	0	0	32
Glyt+NIS+AMS	0.05+0.25%+12	2	1	32
Glyt+NIS+AMS	0.1+0.25%+12	7	7	24
Glyt+NIS+AMS	0.15+0.25%+12	16	21	13
Glyt+NIS+AMS	0.2+0.25%+12	31	43	6
Glyt+NIS+AMS	0.25+0.25%+12	59	69	4
Glyt+NIS+AMS	0.3+0.25%+12	81	82	2
Glyt+NIS+AMS	0.35+0.25%+12	90	89	1
Untreated	0	0	0	36
CV		10	10	11
LSD P=.05		5	5	3

Wheat response was consistent with previous years. Glyphosate at 0.1 oz/A elicited minimal visible wheat response of 7%. This was observed primarily as stunting but slight chlorosis could be detected. Wheat suffered nearly 50% injury with glyphosate at 0.2 oz/A. Yield response to glyphosate seemed greater than in previous years. Wheat that did not express visible symptoms at 0.025 oz/A glyphosate produced 11% less grain than untreated wheat. Although wheat exposed to 0.1 oz/A glyphosate appeared slightly stunted, grain yield was 33% less than the untreated. And 83% yield loss was sustained at 0.2 oz/A glyphosate.

Barley tolerance to soil-applied herbicides. (Minot). The objective of this study was to evaluate barley tolerance to herbicides applied preemergence. The purpose is to find other herbicides that may be used in barley to control annual grasses where Group 1 resistance is a problem. Barley was planted on May 10 and herbicides were applied on May 11. Soil conditions were very dry for the first month after application. Only 0.19 and 0.24 inches of rain fell on May 15 and 16, respectively. About 0.34 and 0.72 inches of rain fell on June 9 and June 14, respectively. Overall, we received only about 1/3 of normal rainfall for the season.

Only Pre-Pare caused moderate crop injury in this study. Barley yield was slightly lower in the Pre-Pare treatment. None of the other treatments caused more than 6% injury.

Table. Barley tolerance to soil-applied herbicides. (1708)

		Injury				Density	Yield	Test wt.	Protein	Plumps	Thins
Treatment	Rate	Jun-3	Jun-10	Jul-10	Jul-28	May-30	Aug-7	Aug-7	Aug-7	Aug-7	Aug-7
		----------%----------				m of row	bu/A	lb/bu	--------%--------		
Untreated		0	0	0	0	32.4	52.1	43.1	13.5	77.7	21.0
Zidua	3 oz	0	0	0	0	33.7	62.8	43.1	13.4	77.0	21.7
Warrant	1.5 qt	0	0	0	0	32.0	55.8	43.1	13.3	78.7	20.3
Dual II Magnum	1.67 pt	0	0	4	3	31.8	59.5	43.0	13.3	78.0	21.0
Pre-Pare	0.3 oz	23	23	20	22	31.4	49.9	42.6	13.6	84.3	14.7
Prowl H2O	3 pt	0	0	0	0	32.2	59.2	43.1	13.2	79.3	19.7
Valor	2 oz	0	0	5	6	33.2	57.6	42.4	13.0	83.3	16.0
Outlook	18 oz	0	0	5	4	29.1	61.5	43.5	12.8	81.0	18.0
Fierce	3 oz	0	0	6	5	30.7	63.4	43.0	13.5	78.7	19.7
LSD (0.05)		1.7	1.7	6.4	7.3	NS	NS	NS	NS	NS	NS
CV		37.1	37.1	82.6	96.2	7.4	17.5	2.1	7.6	9.2	34.3

[a] *All treatments applied preemergence.*

Foxtail barley control with Varro and Olympus. (Minot). The objective of the study was to evaluate foxtail barley control with Varro and Olympus applied preemergence (PRE) or postemergence (POST). PRE treatments were applied May 5 and POST treatments were applied June 26. Glyphosate was applied PRE to all treatments, except the untreated check.

All treatments provided good to excellent foxtail barley control. Roundup and Huskie Complete alone tended to provide slightly less control.

Table. Foxtail barley control with Varro and Olympus. (1725)

			Weed Control		
			Foxtail barley		
Treatment[b]	Rate	Timing	May-13	Jun-10	Jul-3
			----------%----------		
Untreated			0	0	0
Varro + Carnivore[a]	6.85 oz + 1 pt	6-leaf	67	96	89
Varro + Carnivore + Olympus[a]	6.85 oz + 1 pt + 0.2 oz	6-leaf	67	98	93
Olympus / Varro + Carnivore[a]	0.2 oz / 6.85 oz + 1 pt	PRE / 6-leaf	70	97	93
Olympus / Varro + Carnivore + Olympus[a]	0.2 oz / 6.85 oz + 1 pt +0.2 oz	PRE / 6-leaf	65	98	94
Huskie Complete[a]	13.7 oz	3-4 leaf	67	96	84
Huskie Complete + Olympus[a]	13.7 oz + 0.2 oz	3-4 leaf	67	97	92
Olympus / Huskie Complete[a]	0.2 oz / 13.7 oz	PRE / 6-leaf	65	97	93
Olympus / Huskie Complete + Olympus[a]	0.2 oz / 13.7 oz + 0.2 oz	PRE / 6-leaf	67	97	94
Roundup WeatherMax + AMS	24 oz + 2.5 gal/100 gal	PRE	65	95	81
LSD (0.05)			5.3	2.3	7.2

[a] *Applied with AMS (1.47 gal/100 gal)*

[b] *Glyphosate applied PRE to all treatments, except untreated check*

Thiencarbazone control of Downy Brome. Dr. Howatt, Mettler, and Harrington. Wheat was seeded April 6 near Valley City. Treatments were applied pre-emergence to tillering downy brome on April 14 with 49°F, 100% relative humidity, 100% cloud cover and fog, 3 to 7 mph wind velocity at 135°, and damp soil at 45°F. Post treatments were applied to 2 leaf wheat and fully tillered downy brome on May 3 with 68°F, 54% relative humidity, 20% cloud cover 2 mph wind velocity at 0°, and dry soil at 60°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 38 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with three replicates.

Treatment	Rate	Timing	5/25 dobr	6/20 dobr
	oz ai/A		%	%
Glyt4.5+AMS/ Thcz+Brox&MCPA&Flox+AMS	18+11/ 0.07+8+8	PRE/ 2 LF	98	98
Glyt4.5+AMS/ Thcz+Prcz+Brox&MCPA&Flox+AMS	18+11/ 0.07+0.14+8+8	PRE/ 2 LF	96	99
Glyt4.5+Prcz+AMS/ Thcz+Brox&MCPA&Flox+AMS	18+0.14+11/ 0.07+8+8	PRE/ 2 LF	96	99
Glyt4.5+Prcz+AMS/ Thcz+Prcz+Brox&MCPA&Flox+AMS	18+0.14+11/ 0.07+0.14+8+8	PRE/ 2 LF	88	99
Glyt4.5+AMS/ Brox&Pyst&Thcz+AMS	18+11/ 3+8	PRE 2 LF	96	99
Glyt4.5+AMS/ Prcz+Brox&Pyst&Thcz+AMS	18+11/ 0.14+3+8	PRE/ 2 LF	99	99
Glyt4.5+Prcz+AMS/ Brox&Pyst&Thcz+AMS	18+0.14+11/ 3+8	PRE/ 2 LF	90	99
Glyt4.5+Prcz+AMS/ Prcz+Brox&Pyst&Thcz+AMS	18+0.14+11/ 0.14+3+8	PRE/ 2 LF	83	98
Glyt4.5+AMS	18+11	PRE	87	99
Glyt4.5+Prcz+AMS	18+0.14+11	PRE	90	97
Untreated Check			0	0
CV			6	1
LSD P=.05			8	2

Glyphosate applied PRE gave 87 to 98% control of downy brome on May 25. Addition of propoxycarbazone resulted in 83 to 96% control with an average of 89% compared with 95% for glyphosate alone. While propoxycarbazone seemed to slow symptom development and plant death, the eventual result for either PRE treatment provided near 99% control.

Wheat did not show response to PRE treatments. POST treatments were applied to evaluate residual activity in case of later weed emergence and to evaluate wheat response to split exposure to herbicide. There was not an additional flush of downy brome and wheat did not show visible sign of damage.

Wild Oat control and Wheat response to SA-066, Location 1. Dr. Howatt, Mettler, and Harrington. 'Bolles' wheat was seeded near Fargo on May 4. Treatments were applied to spike to 1 leaf wild oat on May 10 with 55°F, 56% relative humidity, less than 5% cloud cover, 7 mph wind velocity at 0° and dry soil at 58°F. Broadleaf weeds listed were not present at application. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/19 wimu	6/19 wibw	6/19 vema	6/19 corw	6/19 colq	6/30 wioa
SA-066	7.3	53	45	53	48	60	20
SA-066	12	58	63	71	59	66	20
Flucarbazone	0.21	50	43	55	45	15	66
Pyroxasulfone&Carfentrazone	2.25	25	10	39	28	41	0
Metribuzin	4	8	0	50	28	10	23
Untreated Check	0	0	0	0	0	0	0
CV		59	55	57	81	76	34
LSD P=.05		28	22	38	42	37	11

Wheat did not show visible response to herbicide treatments. Weed emergence was quite variable across the study leading to difficulty in evaluation and large LSDs. SA-066 control of broadleaf weeds was fairly comparable to flucarbazone. Control of broadleaf weeds with SA-066 was 45 to 70% under extreme low moisture conditions. Control of common lambsquarters with SA-066 averaged 63% which was better than provided by flucarbazone at 15%. However, wild oat control with flucarbazone was 66% while SA-066 only gave 20% control.

Wild Oat control and Wheat response to SA-066, Location2. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Prosper, North Dakota on May 8. Treatments were applied to spike to 1 leaf wild oat on May 10 with 49°F, 65% relative humidity, less than 5% cloud cover, 7 mph wind velocity, at 0°and dry soil at 54°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/07 wioa	6/20 wioa	7/03 wioa
	oz ai/A	%	%	%
SA-066	7.3	32	35	25
SA-066	12	32	35	20
Flucarbazone	0.21	60	70	60
Pyroxasulfone&Carfentrazone	2.25	30	32	5
Metribuzin	4	0	0	0
Untreated	0	0	0	0
CV		18	14	29
LSD P=.05		7	6	8

Wheat did not show visible response to herbicides. Flucarbazone provided 60% control of wild oat. SA-066 gave 25% control, but other treatments could not be discerned from the untreated.

Wild Oat control and Wheat response to SA-066, Location 3. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Prosper, North Dakota on May 8. Treatments were applied to spike to 1 leaf wild oat on May 10 with 49°F, 65% relative humidity, less than 5% cloud cover, 8 mph wind velocity at 0°, and dry soil at 54°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment is a randomized complete block design with four replicates.

Treatment	Rate	6/07 wioa	6/21 wioa	7/03 wioa
	oz ai/A	%	%	%
SA-066	7.3	76	57	32
SA-066	12	80	70	42
Flucarbazone	0.21	92	89	83
Pyroxasulfone&Carfentrazone	2.25	77	62	45
Metribuzin	4	10	7	20
Check	0	0	0	0
CV		17	18	22
LSD P=.05		15	13	12

Wheat did not show visible response to herbicides. As the season progressed, new emergence was observed which tended to diminish control ratings at subsequent evaluation dates. Flucarbazone provided the best control of the later emerging plants and resulted in 83% control on July 3. Control of wild oat with SA-066 or pyroxasulfone was about half that value.

Wild Oat control and Wheat response to SA-066, Location 4. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 6. Treatments were applied to spike to 1 leaf wild oat on May 10 with 52°F, 60% relative humidity, Less than 5% cloud cover, and 5 mph wind velocity at 0° and dry soil at 55°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/05 wioa	6/19 wioa	6/30 wioa
	oz ai/A	%	%	%
SA-066	7.3	55	30	33
SA-066	12	63	38	33
Flucarbazone	0.21	88	76	63
Pyroxasulfone&Carfentrazone	2.25	64	40	25
Metribuzin	4	0	0	28
Untreated	0	0	0	0
CV		9	10	25
LSD P=.05		6	4	11

Wheat did not show visible response to herbicides. As the season progressed, plants stunted by most herbicide treatments recovered from injury and produced sufficient biomass to result in low control ratings. Metribuzin symptomology did not appear on plants until June 30. At this evaluation, flucarbazone provided the best control at 63%. Control of wild oat with other herbicides was about half that value.

Control of volunteer corn. Dr. Howatt, Mettler, and Harrington. An experiment to evaluate control of volunteer corn with wheat herbicides. The trial included quizalofop for comparison and was established in an area without crop where corn has grown the previous year. Additional corn seed was not added to the trial area. Treatments were applied to V3 volunteer corn on June 20 with 64°F, 63% relative humidity, 0% cloud cover, 5 mph wind velocity at 10°, and dry soil at 65°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	7/04 vol corn	7/19 vol corn
	oz ai/A	%	%
Quizalofop+PO	0.67+24	98	100
Fenoxaprop	1.32	97	99
Clodinfop NG	0.8	95	99
Pinoxaden	0.86	60	28
Halauxifen&Florasulam+BB	0.15+1%	28	25
Thif&Fluroxypyr+BB	2+1%	56	43
Mets&Thif&Fluroxypyr+BB	1.38+1%	71	69
Flucarbazone2.0+BB	0.32+1%	83	92
Propoxycarbazone+BB	0.14+1%	79	89
Pyroxsulam-TM+BB	0.21+1%	69	64
Imazamox+BB	0.5+1%	71	75
Bromoxynil&Pyrasulfotole	3.8	18	10
CoAct+Brox&Bcpy+PO	1+3.5+24	5	10
Untreated Check	0	0	0
CV		9	9
LSD P=.05		8	7

Quizalofop provided rapid and complete control of corn. Fenoxaprop and clodinafop produced very similar speed of control to quizalofop. Pinoxaden, another ACCase inhibitor (group 1), only gave 28% control on July 19. ALS inhibitors generally gave poor control of corn. All are much slower to produce symptoms than ACCase herbicides so control values were generally greater for the second evaluation. Of ALS herbicides, flucarbazone provided 92% control and propoxycarbazone gave 89% control. These two are in the same chemical family as thiencarbazone, which was not included here because it is registered for use in corn. Other ALS herbicides gave 75% control or less.

Bio-stimulant with herbicide. Dr. Howatt, Mettler, and Harrington. 'Bolles' wheat was planted near Fargo on May 4. Initial treatments were applied to 4 leaf jointing wheat on June 16 with 62°F, 85% relative humidity, 79% cloud cover, 1 mph wind velocity at 27°, and moist soil at 64°F. In cases where treatment was split in time, the second application was applied to wheat in anthesis on June 30 with 63°F, 87% relative humidity, 45% cloud cover, 5 mph wind velocity at 340°, and moist soil at 68°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates. Harvest for yield was on August 24

Treatment	Rate	6/19 wht	6/23 wht	6/30 wht	7/3 wht	7/6 wht	7/14 wht	7/18 maturity delay	8/01 wht	8/24 Yield
	oz ai/A	%	%	%	%	%	%	days	%	bu/A
Fenx&Brox&Pyst+SA-068/Metcon&Pyraclo	5.4+16/2	0	0	0	0	0	0	0	0	38
Fenx&Brox&Pyst+SA-068/Metcon&Pyraclo	5.4+32/2	0	0	0	0	0	0	0	0	39
Fenx&Brox&Pyst+SA-068/Metcon&Pyraclo	5.4+48/2	0	0	0	0	0	0	0	0	42
Fenx&Brox&Pyst/Metcon&Pyraclo+SA-068	5.4/2+16	0	0	0	0	0	0	0	0	42
Fenx&Brox&Pyst/Metcon&Pyraclo+SA-068	5.4/2+32	0	0	0	0	0	0	0	0	43
Fenx&Brox&Pyst/Metcon&Pyraclo+SA-068	5.4/2+48	0	0	0	0	0	0	0	0	43
Fenx&Brox&Pyst+Metcon&Pyraclo+SA-068	5.4+2+32	0	0	0	0	0	0	0	0	42
Fenx&Brox&Pyst/Metcon&Pyraclo	5.4/2	0	0	0	0	0	0	0	0	44
CV		0	0	0	0	0	0	0	0	6
LSD P=.05		.	.	.	.	.	.	.	.	4

Wheat did not show visible response to SA-068 at either application timing. Also, the combination of SA-068 with herbicide, fungicide, or herbicide and fungicide did not elicit adverse vegetative effect. Wheat that received 16 or 32 fl oz/A of SA-068 at the four-leaf stage produced slightly less grain than other treatments; however, 32 fl oz of SA-068 with herbicide and fungicide did not affect yield.

Barley response to PGR premix. Dr. Howatt, Mettler, and Harrington. 'Tradition' barley was seeded near Fargo on May 6, 2017. Four-leaf treatments were applied to 5 leaf barley, 2 inch redroot pigweed, 2 to 5 inch common lambsquarters, 5 inch common cocklebur, and 18 inch curly dock on June 16 with 82°F, 29 % relative humidity, 35% cloud cover, 6.5 mph wind velocity at 25.5°, and soil temperature of 78°F. Six-leaf treatments were applied to boot stage barley, 10 to 14 inch common cocklebur, 8 to 10 inch common ragweed, 6 to 8 inch redroot pigweed, 8 to 10 inch common lambsquarters, and flowering Venice mallow on June 26 with 67°F, 42% relative humidity, 3 mph wind velocity at 330°, and 64°F dry soil. Treatments were applied with a backpack sprayer delivering 8.5 gal per acre at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block with four replicates. Harvest for yield was on August 23.

Treatment	Rate	Growth Stage	6/23 crop inj	6/29 crop inj	7/6 crop inj	7/24 crop inj	8/1 mat del	8/23 Yield
	oz ai/A		%	%	%	%		bu/A
2,4-D&Dica&Flox+NIS	4.8+0.5%	4L	3	4	0	0	0	77
2,4-D&Dica&Flox+NIS	9.5+0.5%	4L	6	7	7	0	0	70
MCPA&Dica&Flox+NIS	4.8+0.5%	4L	5	5	1	0	0	63
MCPA&Dica&Flox+NIS	9.5+0.5%	4L	9	10	9	0	0	59
2,4-D&Dica+NIS	8+0.5%	4L	11	11	10	0	0	55
2,4-D&Dica&Flox+NIS	4.8+0.5%	6L	-	5	5	0	0	55
2,4-D&Dica&Flox+NIS	9.5+0.5%	6L	-	10	12	0	0	38
MCPA&Dica&Flox+NIS	4.8+0.5%	6L	-	5	4	0	0	63
MCPA&Dica&Flox+NIS	9.5+0.5%	6L	-	11	18	0	0	36
2,4-D&Dica+NIS	8+0.5%	6L	-	13	15	0	0	39
Untreated Check	0		0	0	0	0	0	56
CV			38	28	39	0	0	9
LSD P=.05			2	3	4	.	.	13

Herbicide treatments gave excellent control of weeds. Control was not recorded because the study was established to evaluate crop response. An area was selected with low anticipated weed population but more emergence occurred than expected. This competition should be considered when interpreting grain yield.

Injury through the season was observed primarily as shorter plants although slight chlorosis was occasionally noticed. High rates of the three-way premixes gave more response than low rates (both rates included in label). 2,4-D&dica at an equivalent high rate on the label gave similar injury to the MCPA premix. The low rates of three-way premixes gave similar injury that was 5% or less across application times. At high rates, 2,4-D&dica&flox tended to cause less injury than other premixes and injury was greater at the later application timing than earlier.

Yield was greatest with 2,4-D&dica&flox applied at the earlier barley stage. In general, yield followed similar relationships as discussed for injury, with less injury corresponding to more yield. Early application resulted in more yield than later application. Low rate resulted in more yield than high rate. And 2,4-D&dica&flox resulted in more yield than the other two premixes. Yield of the control with weed competition was consistent with late application of the low rate of premixes. This possibly indicated that injury effect on yield was minimal and that yield was more related to duration of weed competition. Plant maturity was not delayed on August 1.

Wheat response to PGR premix. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 12 . Treatments (4 leaf) were applied on 4 L, jointing wheat on June 16 with 82°F, 29% relative humidity, 35% cloud cover, 6.5 mph wind velocity at 225°, and moist soil at 64°F. The treatments (6 leaf) were applied to boot stage wheat on June 26 with 67°F, 41% relative humidity, 0% cloud cover, 3 to 4 mph wind velocity at 330° and dry soil at 64°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates. Harvest for yield was August 23.

Treatment	Rate	Growth Stage	6/23 wht	6/29 wht	7/6 wht	8/01 mat del	8/23 Yield
	oz ae/A		%	%	%	days	bu/A
2,4-D&Dica&Flox+NIS	4.8+0.5%	4L	3	6	5	0	35
2,4-D&Dica&Flox+NIS	9.5+0.5%	4L	3	10	9	0	35
MCPA&Dica&Flox+NIS	4.8+0.5%	4L	6	5	6	0	31
MCPA&Dica&Flox+NIS	9.5+0.5%	4L	7	10	12	0	30
2,4-D&Dica+NIS	8+0.5%	4L	11	13	12	0	30
2,4-D&Dica&Flox+NIS	4.8+0.5%	6L	-	3	2	0	25
2,4-D&Dica&Flox+NIS	9.5+0.5%	6L	-	7	8	0	18
MCPA&Dica&Flox+NIS	4.8+0.5%	6L	-	3	1	0	26
MCPA&Dica&Flox+NIS	9.5+0.5%	6L	-	6	6	0	24
2,4-D&Dica+NIS	8+0.5%	6L	-	9	7	0	16
Untreated Check	0		0	0	0	0	36
CV			52	33	40	0	22
LSD P=.05			2	3	3	.	9

Broadleaf weeds were not present in high numbers but were easily controlled by herbicides. The high rate of each herbicide caused about twice the injury of the low rate. Injury was primarily stunting with some discoloration. Contrary to previous studies, the early application timing caused more stunting within each herbicide and rate than the later application. This could have occurred because stem elongation was nearly complete before the treatments could be applied. Plant maturity and senescence was not delayed on August 1 but treatments did affect yield. Yield with early application did not reduce yield according to the LSD, but wheat treated with 2,4-D&dicamba& fluroxypyr tended to have better yield than wheat treated with other premixes. Yield with early application was not affected by rate of a given product. Yield of wheat with each treatment at the later timing was less than the untreated. The difference from untreated was more with high rates of herbicides.

Antagonism of yellow foxtail control with PGR premixes. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 6. Treatments were applied to 4 to 5 leaf wheat and 2 to 3 leaf yellow foxtail on June 16 with 88°F, 46% relative humidity, 10% cloud cover, 3 mph wind velocity at 225°, and dry soil at 78°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with three replicates.

Treatment	Rate	6/23 wht	6/30 wht	6/30 yeft	7/14 yeft	8/01 yeft
	oz ai/A	%	%	%	%	%
2,4-D&Dica&Flox+Pxdn	4.8+0.8	1	0	95	98	98
2,4-D&Dica&Flox+Pxdn	9.5+0.8	7	0	93	99	96
MCPA&Dica&Flox+Pxdn	4.8+0.8	2	0	96	98	98
MCPA&Dica&Flox+Pxdn	9.5+0.8	5	0	96	98	97
Pxdn	0.8	0	0	95	99	98
2,4-D&Dica&Flox+Flcz2.0+NIS	4.8+0.32+0.5%	4	0	63	80	82
2,4-D&Dica&Flox+Flcz2.0+NIS	9.5+0.32+0.5%	3	0	70	87	88
MCPA&Dica&Flox+Flcz2.0+NIS	4.8+0.32+0.5%	1	0	63	78	80
MCPA&Dica&Flox+Flcz2.0+NIS	9.5+0.32+0.5%	5	0	72	78	85
Flcz2.0+NIS	0.32+0.5%	1	0	60	78	80
CV		44	0	4	4	4
LSD P=.05		2	.	6	6	6

Wheat response to dicamba premixes was short-lived but resulted in as much as 7% stunting with high rate of herbicide. The dicamba premixes did not affect foxtail control with pinoxaden. Flucarbazone control of yellow foxtail was increased with the high rate of the 2,4-D premix at each evaluation. The high rate of MCPA premix also tended to improve foxtail control at initial and final evaluations.

Antagonism of Wild Oat control with PGR premixes. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 6. Treatments were applied to 3 leaf wheat and 1 to 4 leaf wild oat on June 5 with 88°F, 35% relative humidity, 25% cloud cover, 2 mph wind velocity at 135°, and dry soil at 77°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/19 wioa	7/03 wioa	7/19 wioa
	oz ae/A	%	%	%
2,4-D&Dica&Flox+Pxdn	4.8+0.8	75	79	70
2,4-D&Dica&Flox+Pxdn	9.5+0.8	68	71	56
MCPA&Dica&Flox+Pxdn	4.8+0.8	75	81	64
MCPA&Dica&Flox+Pxdn	9.5+0.8	76	65	50
Pxdn	0.8	80	90	89
2,4-D&Dica&Flox+Flcz2.0+NIS	4.8+0.32+0.5%	75	87	70
2,4-D&Dica&Flox+Flcz2.0+NIS	9.5+0.32+0.5%	74	81	45
MCPA&Dica&Flox+Flcz2.0+NIS	4.8+0.32+0.5%	74	79	53
MCPA&Dica&Flox+Flcz2.0+NIS	9.5+0.32+0.5%	70	78	56
Flcz2.0+NIS	0.32+0.5%	73	87	76
CV		6	4	12
LSD P=.05		6	5	11

Premixes of PGR herbicides tended to antagonize wild oat control with pinoxaden early in the season, but the effect was more pronounced at evaluations in July. Pinoxaden alone provided 89% control on July 19. Control with addition of either premix was reduced to 70% or less. High rates of either premix caused more antagonism than low rates.

Symptom development of flucarbazone on wild oat was not affected by addition of PGR premixes June 19. On July 3, antagonism of flucarbazone control was detected with either rate of the MCPA premix or the high rate of the 2,4-D premix. This result also was apparent on July 19.

ACCase premix control of grasses exp 2. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 6. Treatments were applied to 4 to 5 leaf wheat and 3 leaf yellow foxtail on June 16 with 72°F, 62% relative humidity, 25% cloud cover, 3 mph wind velocity at 270°, and moist soil at 66°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with three replicates. Harvest for yield was August 23.

Treatment	Rate	6/23 yeft	6/30 yeft	7/14 yeft	8/1 yeft	8/23 yield
	oz ai/A	%	%	%	%	bu/A
Pxdn&Fenx-AB	1.29	78	89	98	99	35
Pxdn&Fenx-AB+Brox&MCPA	1.29+8	73	84	94	96	43
Thcz+Brox&MCPA+NIS	0.07+8+0.25%	40	63	83	85	37
Pxlm&Flas&Flox+NIS	1.68+0.25%	33	62	80	80	38
Flcz2.0+Brox&MCPA+NIS+AMS	0.44+8+0.25%+16	33	63	78	82	38
Prcz&Mess+Brox&MCPA+NIS+AMS	0.2+8+0.25%+24	20	62	77	70	41
Fenx+Brox&MCPA	1+8	63	73	83	80	36
Untreated		0	0	0	0	34
CV		9	6	4	5	19
LSD P=.05		6	7	6	6	12

Herbicides did not cause visible injury to wheat. Pinoxaden&fenoxaprop gave an average 75% control 7 days after application while fenoxaprop gave only 63% control. Remaining treatments gave control typical of ALS inhibitors. As the season progressed, pinoxaden&fenoxaprop maintained the highest level of control, 97% averaged across treatments on August 1. Tankmixing with bromoxynil&MCPA tended to result in less control but was not different according to LSDs. Control with fenoxaprop did not perform as well and resulted in 80% control, which was generally similar to control with ALS inhibitors. Differences in weed control did not influence grain yield.

Thiencarbazone control of annual grasses. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 6. Treatments were applied to 4 to 5 leaf wheat, 3 inch tall and flowering wild mustard, and 2 to 3 leaf yellow and green foxtail on June 16 with 82°F, 40% relative humidity, 20% cloud cover, 1.5 mph wind velocity at 27°, and moist soil at 70°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with three replicates.

Treatment	Rate	6/23 fxtl	7/7 fxtl	7/7 wimu	8/1 yeft	8/1 grft
	oz ai/A	%	%	%	%	%
Thcz+Brox&MCPA+AMS	0.07+8+8	30	63	99	90	85
Thcz+Clpy&Flox&MCPA+AMS	0.07+6.5+8	33	82	99	96	89
Thcz+Brox&Pyrasulfotole+AMS	0.07+3.4+8	30	77	99	93	82
Thcz+Clpy&Flox+2,4-De+AMS	0.07+3+3.8+8	30	75	99	93	86
Thcz+Clpy&Flox+MCPA+AMS	0.07+3+4+8	30	82	99	94	87
Thcz+Clpy&Flox+Thif-sg+ Trib-sg+AMS	0.07+3+0.24+ 0.06+8	30	89	99	94	92
Thcz+Prcz+Brox&Pyst+AMS	0.07+0.14+3.4+8	30	83	99	92	85
Brox&Pyrasulfotole&Thcz+AMS	3+8	33	82	99	94	83
Fenx&Brox&Pyrasulfotole	5.4	33	88	99	89	83
Untreated Check	0	0	0	0	0	0
CV		11	5	0	4	5
LSD P=.05		5	7	.	5	7

Wheat did not express visible injury to herbicides. June 23 was 7 days after treatment. This was too soon to expect much symptom development. Foxtail was chlorotic throughout the vegetation but still essentially the same size as untreated plants. Control on July 7 was 89% with thiencarbazone plus clopyralid&fluroxypyr+thifensulfuron+tribenuron. Other studies have demonstrated that tribenuron can enhance control of yellow foxtail. This might be the reason here as well. Least control was obtained when thiencarbazone was tankmixed with bromoxynil&MCPA, 63%.

Head development of foxtail plants allowed separate evaluation of the species on August 1. Thiencarbazone control of yellow foxtail generally exceeded 90% across all treatments while control of green foxtail remained less than 90%. Very little separation occurred among treatments for yellow foxtail control. However, the largest green foxtail control value was the treatment that included tribenuron. The tankmix with bromoxynil&MCPA gave less green foxtail control than the treatment containing tribenuron, as did treatments containing bromoxynil&pyrasulfotole. Bromoxynil has been noted to antagonize grass control in other studies.

Grass Herbicides in Cereals. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 6. Treatments were applied to 3 to 4 leaf wheat and 1 to 4 leaf wild oat on June 5 with 73°F, 55% relative humidity, 0% cloud cover, and 3 mph wind velocity at 1.5° and dry soil at 66°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/19 wioa	7/03 wioa
	oz ai/A	%	%
Flucarbazone+Brox&MCPA+BB	0.32+8+1%	86	84
Prcz+Broxl&MCPA+BB	0.42+8+1%	68	70
Pxlm+Brox&MCPA+BB	0.21+8+1%	66	65
Pxlm&Flas&Flox+BB	1.68+1%	70	66
Pxlm&Clopyralid&Flox+BB	3.2+1%	68	65
Pxlm&fluroxpyr+BB	2.11+1%	79	71
Thcz+Brox&MCPA+BB	0.07+8+1%	76	78
Brox&Pyst&Thcz+UAN	3+16	65	66
Fenoxaprop+Brox&MCPA	1.32+8	50	40
Clodinafop+Brox&MCPA	0.8+8	84	84
Pinoxaden+Brox&MCPA	0.86+8	86	91
Pinoxaden&Fenx-AG+Brox&MCPA	1.28+8	88	93
Fenoxaprop&Brox&Pyst	5.4	56	48
Brox&MCPA	8	0	0
CV		7	7
LSD P=.05		7	7

Wheat did not show visible response to herbicides. The pinoxaden&fenoxaprop premix provided the highest control of wild oat at 93%, although this was not better than pinoxaden. Treatments with fenoxaprop as the sole grass herbicide gave less than 50% control. This poor control likely was influenced by antagonism from the broadleaf herbicides because fenoxaprop alone gave nearly 90% control of wild oat in treatments of other studies.

Flucarbazone gave the best control of wild oat among ALS herbicides at 84%. Thiencarbazone treatments averaged 72% control, but the single active formulation (Varro) plus bromoxynil&MCPA gave better control than thiencarbazone premix (Huskie Complete). Treatments that included pyroxsulam gave similar control regardless of formulation, 67% average.

ACC-ase premix control of Wild Oat. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 6. Treatments were applied to 3 leaf wheat and 1 to 4 leaf wild oat on June 5 with 84°F, 37% relative humidity, 50% cloud cover, and 5 mph wind velocity at 70° and dry soil at 70°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates. Harvest for yield was on August 24.

Treatment	Rate	6/12 wioa	6/19 wioa	7/03 wioa	7/19 wioa	8/24 Yield
	oz ai/A	%	%	%	%	bu/A
Pxdn&Fenx-AB	1.29	75	88	78	87	39
Pxdn&Fenx-AB+Brox&MCPA	1.29+8	69	86	81	80	32
Thcz+Brox&MCPANIS	0.07+8+0.25%	43	76	79	81	36
Pxlm&Flas&Flox+NIS	1.68+0.25%	38	73	69	70	34
Flcz+Brox&MCPA+NIS+AMS	0.44+8+0.25%+16	45	76	84	86	41
Prcz&Mess+Brox&MCPA+NIS+AMS	0.2+8+0.25%+24	35	74	78	81	34
Pxdn+Brox&MCPA	0.86+8	70	81	86	83	32
Untreated Check	0	0	0	0	0	22
CV		9	3	6	5	28
LSD P=.05		6	3	6	5	14

Wheat did not show visible response to herbicides. Pinoxaden&fenoxaprop provided 87% control of wild oat, but addition of bromoxynil&MCPA only gave 80% control. Other herbicides generally gave 70 to 80% control but flucarbazone provided 86% control. Grain yield was quite variable due to environment.

Wild Oat control with Pyroxsulam. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 6. Treatments were applied to 3 to 4 leaf wheat and 1 to 4 leaf wild oat on June 5 with 84°F, 37% relative humidity, 50 % cloud cover, and 5 mph wind velocity at 70° and dry soil at 70°F. Treatment were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/08 wht	6/12 wht	6/12 wioa	619 wioa	7/03 wioa
	oz ai/A	%	%	%	%	%
Pxlm&Flas&Flox+Act 90+AMS	1.68+0.5%+24	4	0	45	74	74
Pxlm&Flox+Act 90+AMS	2.1+0.5%+24	5	0	45	74	76
Pxlm&Flox+2,4-D+AMS	2.1+5.6+24	4	0	50	79	80
Pxlm&Clpy&Flox+Act 90+AMS	3.2+0.5%+24	4	0	40	75	78
Pxlm&Clpy&Flox+2,4-D+AMS	3.2+5.6+24	4	0	45	75	74
Pxlm+Clpy&Flox&MCPA+Act 90+AMS	0.21+8.5+0.125%+24	4	0	38	73	75
Brox&Pyst&Thcz+Act 90	3+0.5%	2	0	40	74	76
Pxdn+Clpy&Flox+AMS	0.86+3+24	0	0	78	86	81
Flcz 2.0+Clpy&Flox+Act 90+AMS	0.33+3+0.25%+24	2	0	43	78	88
Untreated Check	0	0	0	0	0	0
CV		38	0	11	4	5
LSD P=.05		1	.	7	4	5

All treatments with ALS grass herbicides resulted in minor wheat stunting on June 8 that was not observed June 12 or later. Pinoxaden control of wild oat was uncharacteristically low at 81% on July 3. Flucarbazone provided the best control at 88%. Formulations of pyroxsulam gave similar control with average of 76%.

Grass herbicide efficacy in Sentrallas tank-mix. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 6. Treatments were applied to 3 leaf wheat and 1 to 4 leaf wild oat on June 5 with 88°F, 35% relative humidity, 25% cloud cover, 2 mph wind velocity at 135°, and dry soil at 77°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/12 wioa	6/19 wioa	7/03 wioa
	oz/A	%	%	%
Thif&Flox+Trib-sg+NIS	1.94+0.13+0.25%	18	35	40
Thcz+Thif&Flox+Trib-sg+NIS	0.07+1.94+0.13+0.25%	38	78	89
Pxlm+Thif&Flox+Trib-sg+NIS	0.21+1.94+0.13+0.25%	45	75	80
Clfp-ng+Thif&Flox+Trib-sg+NIS	1+1.94+0.13+0.25%	63	84	84
Flcz2.0+Thif&Flox+Trib-sg+NIS	0.44+1.94+0.13+0.25%	48	79	96
Prcz&Mess+Thif&Flox+Trib-sg+NIS	0.2+1.94+0.13+0.25%	40	75	83
Thif&Flox+NIS	1.94+0.25%	13	50	38
Trib-sg+NIS	0.13+0.25%	20	61	60
Untreated Check	0	0	0	0
CV		14	8	9
LSD P=.05		6	7	8

Herbicides did not cause visible wheat response at any evaluation. Response of wild oat to thifensulfuron or tribenuron was surprising because there previously had been no improvement of wild oat control with grass herbicides by thifensulfuron and tribenuron, but these have been known to antagonize control of wild oat with group 1 (ACCase) herbicides. Response was primarily chlorotic discoloration and height reduction with apparent reduced seed set.

Control of wild oat with clodinafop was less than expected. Control of wild oat with the group 2 (ALS) herbicides was generally typical of expectation; however, control with pyroxsulam was less than typically experienced.

Wild Oat control with new Flucarbazone formulations. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 6. Treatments were applied to 3 to 4 leaf wheat and wild oat on June 5 with 83°F, 37% relative humidity, 50% cloud cover, 5 mph wind velocity at 90°, and dry soil at 70°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates. Harvest for yield August 24.

Treatment	Rate	6/19 wioa	7/3 wioa	7/19 wioa	8/24 Yield
	oz ai/A	%	%	%	bu/A
Flcz2.0+NIS+AMS	0.33+0.25%+16	76	92	91	32
Flcz2.0+NIS+AMS	0.44+0.25%+16	75	93	94	27
X1581ac+NIS+AMS	0.44+0.25%+16	74	93	93	26
X1581af+NIS+AMS	0.44+0.25%+16	75	93	89	28
X1581ag+NIS+AMS	0.44+0.25%+16	76	93	92	29
X1581ag+Thif&TribA+NIS+AMS	0.44+0.2+0.25%+16	76	92	88	23
X2678aa+NIS+AMS	8.4+0.25%+16	76	93	90	40
X2682aa+NIS+AMS	8.4+0.25%+16	76	92	87	28
X2678aa+Thif&TribA+NIS+AMS	8.4+0.2+0.25%+16	78	93	89	34
X2682aa+Thif&TribA+NIS+AMS	8.4+0.2+0.25%+16	75	95	89	36
Thcz+NIS+AMS	0.07+0.25%+16	79	94	93	40
Pxlm&Clpy&Flox+NIS+AMS	3.2+0.25%+16	76	87	85	33
CoAct+Pxdn+Brox&Bcpy	3.4+0.86+3.6	79	88	89	36
Pxlm+NIS+AMS	0.21+0.25%+16	75	83	80	29
Untreated Check	0	0	0	0	16
CV		3	3	4	25
LSD P=.05		4	3	5	11

X1581ag was the formulation recently announced as Everest 3.0. Wheat did not show visible response to herbicides. Flucarbazone formulations and tankmixes generally provided similar control to thiencarbazone or pinoxaden, around 90%. Average of treatments with pyroxsulam was 82% control with better control obtained with the premix (PerfectMatch) than dry pyroxsulam (TeamMate).

Grass control with new Flucabazone formulations. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 6. Treatments were applied to 4 to 5 leaf wheat, 2 to 3 leaf wild oat and yellow foxtail, and 3 inch wild mustard, wild buckwheat, redroot pigweed and common lambsquarters on June 16 with 72°F, 62% relative humidity, 50% cloud cover, 2.4 mph wind velocity at 270°, and moist soil at 66°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with three replicates. Harvest for yield was August 23.

Treatment	Rate	6/30 wioa	6/30 yeft	6/30 wimu	6/30 wibw	6/30 rrpw	6/30 colq	7/14 wioa
	oz ai/A	%	%	%	%	%	%	%
Flcz2.0+NIS+AMS	0.33+0.25%+16	87	63	83	82	85	53	95
Flcz2.0+NIS+AMS	0.44+0.25%+16	87	63	83	85	85	72	97
X1581ac+NIS+AMS	0.44+0.25%+16	87	67	88	80	87	43	93
X1581af+NIS+AMS	0.44+0.25%+16	88	67	85	80	91	43	94
X1581ag+NIS+AMS	0.44+0.25%+16	88	70	87	77	90	68	95
X1581ag+Thif&TribA+NIS+AMS	0.44+0.2+0.25%+16	87	65	83	83	89	80	98
X2678aa+NIS+AMS	8.4+0.25%+16	87	65	90	85	85	57	95
X2682aa+NIS+AMS	8.4+0.25%+16	90	70	87	88	85	80	97
X2678aa+Thif&TribA+NIS+AMS	8.4+0.2+0.25%+16	88	67	92	88	87	77	95
X2682aa+Thif&TribA+NIS+AMS	8.4+0.2+0.25%+16	87	70	90	88	88	80	95
Thcz+NIS+AMS	0.07+0.25%+16	87	67	80	80	87	77	96
Pxlm&Clpy&Flox+NIS+AMS	3.2+0.25%+16	85	62	80	80	87	68	96
CoAct+Pxdn+Brox&Bcpy	3.4+0.86+3.6	87	40	92	83	91	87	-
Pxlm+NIS+AMS	0.21+0.25%+16	88	60	82	77	82	57	96
Untreated Check	0	0	0	0	0	0	0	0
CV		3	7	4	5	4	15	4
LSD P=.05		4	7	5	6	6	16	6

Treatment	Rate	7/14 yeft	8/01 wibw	8/01 rrpw	8/01 colq	8/01 wioa	8/01 yeft	8/23 Yield
	oz ai/A	%	%	%	%		%	bu/A
Flcz2.0+NIS+AMS	0.33+0.25%+16	83	87	89	43		82	46
Flcz2.0+NIS+AMS	0.44+0.25%+16	87	92	93	78		90	52
X1581ac+NIS+AMS	0.44+0.25%+16	87	83	92	81		92	55
X1581af+NIS+AMS	0.44+0.25%+16	88	92	98	78		96	54
X1581ag+NIS+AMS	0.44+0.25%+16	88	87	89	65		95	50
X1581ag+Thif&TribA+NIS+AMS	0.44+0.2+0.25%+16	96	99	99	99		93	52
X2678aa+NIS+AMS	8.4+0.25%+16	82	92	94	82		83	48
X2682aa+NIS+AMS	8.4+0.25%+16	92	98	98	92		87	51
X2678aa+Thif&TribA+NIS+AMS	8.4+0.2+0.25%+16	85	99	99	99		92	50
X2682aa+Thif&TribA+NIS+AMS	8.4+0.2+0.25%+16	91	99	99	99		91	50
Thcz+NIS+AMS	0.07+0.25%+16	92	96	96	95		92	50
Pxlm&Clpy&Flox+NIS+AMS	3.2+0.25%+16	88	99	99	99		92	48
CoAct+Pxdn+Brox&Bcpy	3.4+0.86+3.6	98	99	99	99		99	39
Pxlm+NIS+AMS	0.21+0.25%+16	87	94	98	94		85	52
Untreated Check	0	0	0	0	0		0	42
CV		4	4	3	5	.	4	9
LSD P=.05		5	5	4	6	.	6	8

No change

X1581ag was the formulation recently announced as Everest 3.0. Wheat response to herbicides was not present at any evaluation. Weed control of the new formulation generally was comparable to flucarbazone 2.0.

Comparison of Flucarbazone premix to tank-mixes. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 6. Treatments were applied to 3 leaf wheat and 1 to 4 leaf wild oat on June 5 with 87°F, 35% relative humidity, 10% cloud cover, and 6.4 mph wind velocity at 90°, and dry soil. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates. Harvest for yield was on August 24.

Treatment	Rate	6/19 wioa	7/3 wioa	7/19 wioa	8/24 Yield
	oz ai/A	%	%	%	bu/A
X1581ag+NIS+AMS	0.44+0.25%+16	76	95	95	40
X1581ag+Thif&TribA+NIS+AMS	0.44+0.2+0.25%+16	76	94	95	35
X1581ag+Thif&TribA+Clpy&Flox+NIS+AMS	0.44+0.2+3+0.25%+16	75	93	90	36
X1581ag+Flox-C+Brox+NIS+AMS	0.44+1.5+4+0.25%+16	74	90	93	34
X1581ag+Flox-C+Brox+MCPAe+NIS+AMS	0.44+1.5+4+4+0.25%+16	74	92	87	38
X2678aa+NIS+AMS	8.4+0.25%+16	74	93	90	37
X2682aa+NIS+AMS	8.4+0.25%+16	74	92	89	38
X2678aa+Thif&TribA+NIS+AMS	8.4+0.2+0.25%+16	76	95	92	39
X2682aa+Thif&TribA+NIS+AMS	8.4+0.2+0.25%+16	75	94	93	35
X1973ab+NIS+AMS	17.5+0.25%+16	73	93	88	35
Pxlm&Clpy&Flox+NIS+AMS	3.2+0.25%+16	71	83	81	32
CoAct+Pinoxaden+Brox&Bcpy	3.4+0.86+3.6	85	90	95	45
Brox&Pyst&Thcz+NIS	3+0.25%	75	94	94	41
CoAct+X1581ag+Brox&Bcpy+NIS	3.4+0.44+3.6+0.25%	74	91	81	33
Untreated Check	0	0	0	0	20
CV		4	4	3	11
LSD P=.05		4	5	4	6

X1581ag was the formulation recently announced as Everest 3.0. Wheat did not show visible symptoms to herbicide application. Pinoxaden gave better control on June 19 than other treatments because of differences in activity of sites of action. One month later, pinoxaden resulted in 95% control. This was similar to most X1581 tankmix treatments. Bromoxynil&bicyclopyrone was the most antagonistic to X1581, resulting in only 81% wild oat control. Other numbered premixes gave less control unless tribenuron was included in the tankmix. Pinoxaden resulted in 45 bu/A grain yield while wheat in other treatments generally produced 35 to 40 bu/A, likely because of difference in speed of control.

Comparison of Flucarbazone premix to tank-mixes, Exp 2. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 6. Treatments were applied to 4 to 5 leaf wheat, 3 inch to flowering wild mustard, 4 inch common lambsquarters, 3 leaf yellow foxtail, and 4 inch wild buckwheat on June 16 with 74°F, 45% relative humidity, 0% cloud cover, 2.5 mph wind velocity at 270°, and moist soil at 66°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with three replicates. Harvest for yield was on August 23.

Treatment	Rate	6/30 yeft	6/30 wibw	6/30 wimu	7/14 yeft	7/14 wibw
	oz ai/A	%	%	%	%	%
X1581ag+NIS+AMS	0.44+0.25%+16	63	78	87	78	89
X1581ag+Thif&TribA+NIS+AMS	0.44+0.2+0.25%+16	72	82	90	90	95
X1581ag+Thif&TribA+Clpy&Flox+NIS+AMS	0.44+0.2+3+0.25%+16	63	82	84	82	96
X1581ag+Flox-C+Brox+NIS+AMS	0.44+1.5+4+0.25%+16	67	88	92	78	99
X1581ag+Flox-C+Brox+MCPAe+NIS+AMS	0.44+1.5+4+4+0.25%+16	73	90	90	93	99
X2678aa+NIS+AMS	8.4+0.25%+16	70	85	92	78	99
X2682aa+NIS+AMS	8.4+0.25%+16	72	91	93	89	99
X2678aa+Thif&TribA+NIS+AMS	8.4+0.2+0.25%+16	65	93	95	93	99
X2682aa+Thif&TribA+NIS+AMS	8.4+0.2+0.25%+16	67	89	93	87	99
X1973ab+NIS+AMS	17.5+0.25%+16	68	88	92	78	99
Pxlm&Clpy&Flox+NIS+AMS	3.2+0.25%+16	62	87	85	86	99
CoAct+Pinoxaden+Brox&Bcpy	3.4+0.86+3.6	87	92	95	98	99
Brox&Pyst&Thcz+NIS	3+0.25%	65	88	90	85	99
CoAct+X1581ag+Brox&Bcpy+NIS	3.4+0.44+3.6+0.25%	72	92	93	85	98
Untreated Check	0	0	0	0	0	0
CV		6	4	3	4	2
LSD P=.05		7	6	5	6	4

Treatment	Rate	7/14 wimu	8/01 yeft	8/01 colq	8/23 Yield
	oz ai/A	%	%	%	bu/A
X1581ag+NIS+AMS	0.44+0.25%+16	94	85	77	43
X1581ag+Thif&TribA+NIS+AMS	0.44+0.2+0.25%+16	99	95	99	46
X1581ag+Thif&TribA+Clpy&Flox+NIS+AMS	0.44+0.2+3+0.25%+16	98	88	99	46
X1581ag+Flox-C+Brox+NIS+AMS	0.44+1.5+4+0.25%+16	99	77	96	46
X1581ag+Flox-C+Brox+MCPAe+NIS+AMS	0.44+1.5+4+4+0.25%+16	99	88	99	47
X2678aa+NIS+AMS	8.4+0.25%+16	99	87	95	42
X2682aa+NIS+AMS	8.4+0.25%+16	98	88	98	42
X2678aa+Thif&TribA+NIS+AMS	8.4+0.2+0.25%+16	99	89	99	43
X2682aa+Thif&TribA+NIS+AMS	8.4+0.2+0.25%+16	99	92	98	44
X1973ab+NIS+AMS	17.5+0.25%+16	99	80	99	44
Pxlm&Clpy&Flox+NIS+AMS	3.2+0.25%+16	99	82	99	41
CoAct+Pinoxaden+Brox&Bcpy	3.4+0.86+3.6	99	94	99	38
Brox&Pyst&Thcz+NIS	3+0.25%	99	78	95	45
CoAct+X1581ag+Brox&Bcpy+NIS	3.4+0.44+3.6+0.25%	99	78	99	42
Untreated Check	0	0	0	0	37
CV		1	4	3	10
LSD P=.05		2	6	4	7

X1581ag was the formulation recently announced as Everest 3.0. Wheat response to herbicides was not present at any evaluation. Additional broadleaf herbicide with X1581 resulted in better broadleaf weed control. Addition of tribenuron also tended to improve yellow foxtail control.

Broadspectrum weed control with Pyroxsulam, Exp 2. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Prosper North Dakota on May 8. Treatments were applied to 1 to 3 inch wild buckwheat, 3 to 4 leaf wild oat, and 1 to 2 inch common lambsquarters on June 12 with 80°F, 19% relative humidity, 10 to 12 mph wind velocity at 90°, and dry soil at 80°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/15 wht	6/20 wht	6/20 wioa	6/20 colq	6/20 wibw	6/26 wioa
	oz ai/A	%	%	%	%	%	%
Pxlm&Flas&Flox+Act 90+AMS	1.68+0.5%+24	4	3	71	69	65	76
Pxlm&Flox+Act 90+AMS	2.1+0.5%+24	4	3	65	65	45	71
Pxlm&Flox+2,4-D+AMS	2.1+5.6+24	5	3	71	75	65	76
Pxlm&Clpy&Flox+Act 90+AMS	3.2+0.5%+24	3	3	66	68	50	71
Pxlm&Clpy&Flox+2,4-D+AMS	3.2+5.6+24	4	3	68	74	60	73
Pxlm+Clpy&Flox&MCPA+Act 90+AMS	0.21+8.5+0.125%+24	4	3	70	66	63	75
Brox&Pyst&Thcz+Act 90	3+0.5%	4	3	66	83	80	73
Pxdn+Clpy&Flox+AMS	0.86+3+24	0	0	84	69	45	85
Flcz 2.0+Clpy&Flox+Act 90+AMS	0.33+3+0.25%+24	0	0	68	50	50	74
Untreated Check	0	0	0	0	0	0	0
CV		32	0	8	12	16	5
LSD P=.05		1	.	8	11	12	5

Treatment	Rate	6/26 colq	6/26 wibw	7/12 wht	7/12 wioa	7/12 colq	7/12 wibw
	oz ai/A	%	%	%	%	%	%
Pxlm&Flas&Flox+Act 90+AMS	1.68+0.5%+24	73	70	0	95	91	83
Pxlm&Flox+Act 90+AMS	2.1+0.5%+24	73	55	0	89	79	75
Pxlm&Flox+2,4-D+AMS	2.1+5.6+24	76	71	1	92	99	87
Pxlm&Clpy&Flox+Act 90+AMS	3.2+0.5%+24	71	60	0	86	91	89
Pxlm&Clpy&Flox+2,4-D+AMS	3.2+5.6+24	76	66	1	93	99	94
Pxlm+Clpy&Flox&MCPA+Act 90+AMS	0.21+8.5+0.125%+24	71	70	0	79	99	78
Brox&Pyst&Thcz+Act 90	3+0.5%	85	85	2	95	99	94
Pxdn+Clpy&Flox+AMS	0.86+3+24	80	78	0	90	48	81
Flcz 2.0+Clpy&Flox+Act 90+AMS	0.33+3+0.25%+24	60	60	1	92	59	81
Untreated Check	0	0	0	0	0	0	0
CV		5	7	265	5	7	5
LSD P=.05		5	7	1	6	8	5

Shorter wheat was observed in all plots that received pyroxsulam or thiencarbazone. This injury was observed within a few days of application but was mild in severity. The injury could not be discerned from untreated wheat on June 26, but slight height difference was observed in a few plots July 12. Formulations of pyroxsulam gave similar wild oat control at early and mid season evaluations. On July 12, the single active formulation of pyroxsulam (Teammate) only gave 79% control, but fluid formulations gave 86 to 95% control with greater control from the premix containing florasulam (GoldSky) or addition of 2,4-D. On this date, broadleaf weed control was best with pyroxsulam&clopyralid&fluroxypyr+2,4-D or bromoxynil&pyrasulfotole& thiencarbazone. After this date, dry weather and crop competition greatly reduced weed presence.

Grass herbicide efficacy in Sentrallas tank-mix. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 6. Treatments were applied to 4 to 5 leaf wheat, 3 leaf yellow foxtail, 3 inch to flowering wild mustard, and 4 inch wild buckwheat on June 16 with 81°F, 40% relative humidity, 20% cloud cover, 1.5 mph wind velocity at 270°, and moist soil at 70°F. Treatments were applied using a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with three replicates.

Treatment	Rate	6/23 yeft	6/30 yeft	6/30 wibw	6/30 wimu	7/14 yeft	7/14 wibw	7/14 wimu
	oz/A	%	%	%	%	%	%	%
Thif&Flox+Trib-sg+NIS	1.94+0.13+0.25%	17	23	80	83	70	97	99
Thcz+Thif&Flox+Trib-sg+NIS	0.07+1.94+0.13+0.25%	40	70	87	87	88	99	99
Pxlm+Thif&Flox+Trib-sg+NIS	0.21+1.94+0.13+0.25%	37	65	83	85	88	96	98
Clfp-ng+Thif&Flox+Trib-sg+NIS	1+1.94+0.13+0.25%	37	67	82	83	92	99	99
Flcz2.0+Thif&Flox+Trib-sg+NIS	0.44+1.94+0.13+0.25%	43	72	85	87	85	98	99
Prcz&Mess+Thif&Flox+Trib-sg+NIS	0.2+1.94+0.13+0.25%	23	47	87	85	68	96	99
Thif&Flox+NIS	1.94+0.25%	7	0	83	83	33	99	99
Trib-sg+NIS	0.13+0.25%	23	27	78	83	43	99	99
Untreated Check	0	0	0	0	0	0	0	0
CV		23	10	4	3	6	3	1
LSD P=.05		10	7	5	4	7	5	1

Herbicides did not cause visible wheat response. While suppression of yellow foxtail with tribenuron and, sometimes, thifensulfuron has been observed in previous studies, the extent of response in this study to the combination in the first treatment was not expected. The degree of stunting and pale chlorosis was re-evaluated for verification after reviewing the treatment list. Weather at this location was characterized as dry through most of the growing season, which may have influenced a typical response. Even individually, thifensulfuron or tribenuron, gave up to 40% chlorosis response.

The broadleaf herbicide package tended to increase yellow foxtail control with group 2 (ALS) herbicides when considering general expectations of prior trials. Conversely, control with clodinafop was less than would be expected of clodinafop. But the result was not surprising because clodinafop and other group 1 (ACCase) herbicides have been antagonized by several broadleaf herbicides in other studies. Control with herbicides expected to control yellow foxtail gave 85 to 92% control.

Thiencarbazone control of Wild Oat. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Fargo on May 6. Treatments were applied to 3 to 4 leaf wheat and 1 to 4 leaf wild oat on June 5 with 73°F, 55% relative humidity, 0% cloud cover, 3 mph wind velocity at 115°, and dry soil at 66°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/13 wioa	6/19 wioa	6/26 wioa	7/13 wioa
	oz ai/A	%	%	%	%
Thcz+Brox&MCPA+AMS	0.07+8+8	35	58	74	80
Thcz+Clpy&Flox&MCPA+AMS	0.07+6.5+8	38	68	79	84
Thcz+Brox&Pyrasulfotole+AMS	0.07+3.4+8	45	76	86	88
Thcz+Clpy&Flox+2,4-De+AMS	0.07+3+3.8+8	40	68	82	87
Thcz+Clpy&Flox+MCPA+AMS	0.07+3+4+8	40	66	79	80
Thcz+Clpy&Flox+Thif-sg+Trib-sg+AMS	0.07+3+0.24+0.06+8	43	66	76	82
Thcz+Prcz+Brox&Pyst+AMS	0.07+0.14+3.4+8	40	65	74	81
Brox&Pyrasulfotole&Thcz+AMS	3+8	35	60	80	73
Fenx&Brox&Pyrasulfotole	5.4	70	79	53	50
Untreated Check	0	0	0	0	0
CV		9	10	6	8
LSD P=.05		5	8	6	8

Wheat did not show response to herbicides. Fenoxaprop initially gave better control than thiencarbazone because of expected differences of symptom development for the two sites of action. However, fenoxaprop seemed to be antagonized by broadleaf herbicide activity and final control was only 50%. Thiencarbazone provided 73 to 88% control depending on mixture. The single active formulation (Varro) with broadleaf herbicides added in tankmix generally gave better control than the premix (Huskie Complete). This was interesting because the highest control value of 88% was achieved with thiencarbazone+bromoxynil&pyrasulfotole, the same ingredients that are included in the thiencarbazone premix.

Grass and broadleaf weed control in spring wheat, Carrington, 2017.
Greg Endres and Mike Ostlie.

The field experiment was conducted at the NDSU Carrington Research Extension Center in cooperation with Bayer CropScience and Dow AgroSciences to examine weed efficacy and crop tolerance with Varro and broadleaf herbicide tank mixtures. Experimental design was a randomized complete block with three replicates. 'Glenn' HRS wheat was seeded on May 2 in conventionally tilled soil. Herbicide treatments were applied with a CO_2-hand-boom plot sprayer delivering 10 gal/A at 35 psi through 8001 flat fan nozzles to the center 6.7 ft of 10- by 25-ft plots. Treatments were applied on May 31 with 73 F, 23% RH and 6 mph wind to 3-leaf wheat, 3- to 4-leaf yellow and green foxtail, and 0.5- to 1.5-inch tall common lambsquarters.

No wheat plant response was noted on June 7 [seven days after treatment (DAT)] including visual evaluations of foliage chlorosis/necrosis and biomass reduction. Visual evaluation of foxtail 20 DAT (June 20) ranged from 77-82% and 61 DAT (July 31; wheat maturity) ranged from 74-78% with all treatments, except Huskie Complete. Common lambsquarters control was excellent (95-98%) 20 DAT with Varo plus Bison, Carnivore, and Carnivore plus Olympus; and Huskie Complete. All treatments generally provided excellent control (88-99%) of common lambsquarters 61 DAT.

Table.

			Weed control[1]					
Herbicide			7-Jun		20-Jun		31-Jul	
Number	Treatment[2]	Rate	fota	colq	fota	colq	fota	colq
		fl oz product/A	%					
1	Untreated check	x	0	0	0	0	0	0
2	Varro + Bison	6.9 + 16	68	95	78	95	76	96
3	Varro + Weld	6.9 + 18	73	73	78	80	78	96
4	Varro + Carnivore	6.9 + 16	67	95	77	98	75	88
5	Varro + WideMatch + 2,4-D ester	6.9 + 16 + 8	75	72	80	89	74	98
6	Varro + WideMatch + MCPA ester	6.9 + 16 + 8	72	70	82	87	75	95
7	Varro + WideMatch + Affinity Tankmix	6.9 + 16 + 0.6 oz wt	70	69	81	90	76	99
8	Varro + Carnivore + Olympus	6.9 + 16 + 0.2 oz wt	67	93	82	97	77	94
9	Huskie Complete	13.7	68	96	71	98	68	97
C.V. (%)			5.7	3.6	5.3	4.4	4.6	5.3
LSD (0.05)			6	5	6	6	5	8

[1]fota=yellow and green foxtail; colq=common lambsquarters.

[2]All herbicide treatments included ammonium sulfate at 8 oz wt/A.

Canada thistle control with Varro tank mixes in wheat. (Minot). The objective of the study was to evaluate Varro plus various tank mix partners for Canada thistle and perennial sowthistle control. All treatments were applied postemergence on June 2. Canada thistle and perennial sowthistle were approximately 1-12 and 1-10 inches tall at application, respectively.

Express alone, Varro + Express, Varro + Starane + 2,4-D + Express, and Varro + WideMatch + MCPA ester provided 79-83% control of Canada thistle and perennial sowthistle based on the late season evaluation on August 3. Treatments containing Huskie provided poor control of both weeds.

Table. Canada Thistle Control with Varro Tank Mixes. (1732)

			Weed Control[b]			
			Cath		Pest	
Treatment	Rate	Timing	Jun-23	Aug-3	Jun-23	Aug-3
			——————%——————			
Untreated			0	0	0	0
Varro[a]	6.85 oz	POST	3	3	19	10
Varro + Starane Ultra + 2,4-D Ester[a]	6.85 oz + 0.3 pt + 0.5 pt	POST	37	40	65	60
Varro + Huskie[a]	6.85 oz + 11 oz	POST	32	32	50	37
Varro + Express[a]	6.85 oz + 0.25 oz	POST	67	83	68	83
Varro + Starane Ultra + 2,4-D Ester + Express[a]	6.85 oz + 0.3 pt + 0.5 pt + 0.25 oz	POST	75	81	81	80
Varro + Huskie + Express[a]	6.85 oz + 11 oz + 0.25 oz	POST	40	22	58	27
Varro + Huskie + Express + MCPA Ester[a]	6.85 oz + 11 oz + 0.25 oz + 0.5 pt	POST	56	35	81	40
Varro + WideMatch + MCPA Ester[a]	6.85 oz + 1 pt + 0.5 pt	POST	85	79	86	80
Express + NIS	0.25 oz + 0.25%	POST	65	82	64	81
LSD (0.05)			6.1	17.9	7.0	16.0

[a]Applied with AMS (1.47 gal)

[b]Cath=Canada thistle; Pest=Perennial sowthistle

Halauxifen control of broadleaf weeds. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Prosper, North Dakota on May 8. Treatments were applied to 2 to 4 inch common lambsquarters, 2 to 5 inch wild buckwheat, and 2 to 4 inch common ragweed on June 12 with 80°F, 19% relative humidity, 0% cloud cover, 10 to 12 mph wind velocity at 90°, and dry soil at 80°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/26 colq	6/26 corw	6/26 wibw	7/12 wht	7/12 colq	7/12 corw	7/12 wibw
	oz ai/A	%	%	%	%	%	%	%
Pxdn+Haux&Flas+NIS+AMS	0.86+0.15+0.25%+24	63	61	60	0	95	96	91
Pxdn+Clpy&Flox+Haux&Flas+ NIS+AMS	0.86+3+0.15+ 0.25%+24	48	63	63	3	93	97	94
Pxdn+Clpy&Flox+Thif-sg+Trib-sg+ NIS+AMS	0.86+3+0.08+0.02+ 0.25%+24	65	25	70	1	97	92	94
Pxdn+Clpy&Flox+Thif-sg+Trib-sg+ NIS+AMS	0.86+3+0.05+0.05+ 0.25%+24	43	30	60	1	93	90	90
Pxdn+Clpy&Flox	0.86+3	28	43	43	1	48	89	88
Pxdn+Flox&Flas	0.86+1.48	33	40	45	0	23	58	78
Pxdn+Brox&Pyst+AMS	0.86+3.48+24	93	93	95	3	99	99	98
Pxdn+Clpy&Flox&MCPA	0.86+8.5	70	69	55	2	96	90	85
Pxdn	0.86	0	0.	0	2	0	0	0
CV		12	11	8	89	6	6	6
LSD P=.05		9	8	7	2	6	7	7

Wheat response to herbicide treatments was not observed June 26, but wheat in some plots was slightly shorter than check strips between plots on July 12. Halauxifen and florasulam provided greater than 90% control of lambsquarters, ragweed, and wild buckwheat. Only bromoxynil and pyrasulfotole provided better control of wild buckwheat. Clopyralid&fluroxypyr gave less than 50% control of lambsquarters. Addition of thifensulfuron and tribenuron or using the premix that also included MCPA improved lambsquarters control to 93% or better. Fluroxypyr&florasulam gave less than 80% control of each weed, and only 23% control of lambsquarters. Weed control was checked again August 1 and determined to be similar to July 12.

Halauxifen control of broadleaf weeds, Exp 2. Howatt, Mettler, and Davidson. 'Bolles' wheat was seeded near Fargo on May 4. Treatments were applied to 4 leaf and jointing wheat, 6 inch wild buckwheat, 1 to 3 inch common ragweed and common lambsquarters, flowering wild mustard, and 1 inch common mallow on June 16 with 62°F, 85% relative humidity, 99% cloud cover, 1 mph wind velocity at 220°, and moist soil at 64°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/30 wibw	6/30 wimu	6/30 corw	6/30 vema	6/30 colq	7/14 wibw	7/14 wimu	7/14 corw	7/14 vema	7/14 colq
	oz ai/A	%	%	%	%	%	%	%	%	%	%
Pxdn+Haux&Flas+ NIS+AMS	0.86+0.15+ 0.25%+24	88	93	43	83	66	96	98	98	98	98
Pxdn+Clpy&Flox+ Haux&Flas+NIS+AMS	0.86+3+ 0.15+0.25%+24	88	95	66	88	74	99	99	99	99	99
Pxdn+Clpy&Flox+Thif-sg+ Trib-sg+NIS+AMS	0.86+3+0.08+ 0.02+0.25%+24	84	86	65	89	80	99	99	99	99	99
Pxdn+Clpy&Flox+Thif-sg+ Trib-sg+NIS+AMS	0.86+3+0.05+ 0.05+0.25%+24	93	95	74	78	73	99	99	99	99	99
Pxdn+Clpy&Flox	0.86+3	71	73	63	38	74	95	98	95	98	98
Pxdn+Flox&Flas	0.86+1.48	84	95	84	81	40	98	99	99	99	99
Pxdn+Brox&Pyst+AMS	0.86+3.48+24	97	99	96	93	97	99	99	99	99	99
Pxdn+Clpy&Flox&MCPA	0.86+8.5	79	88	81	76	80	99	99	99	98	99
Pxdn	0.86	0	0	0	0	0	0	0	0	0	0
CV		2	2	5	3	6	1	1	1	1	1
LSD P=.05		3	3	4	3	6	2	1	1	1	1

Wheat did not show injury with any treatment. Bromoxynil&pyrasulfotole provided the best control of weeds on June 30 with rating for each species at or above 93%. Control with halauxifen&florasulam was poor for ragweed or lambsquarters. Addition of clopyralid&fluroxypyr improved control of these species with halauxifen&florasulam, but not better than control of these species with clopyralid&fluroxypyr alone. Conversely, clopyralid&fluroxypyr did not adequately control wild buckwheat, wild mustard, or Venice mallow, but addition of halauxifen&florasulam supplemented control of these species. By July 14, all herbicide treatments gave 95% control or better of each weed. Halauxifen&florasulam or clopyralid&fluroxypyr gave slightly less control than other broadleaf herbicide treatments.

Control of waterhemp. Dr. Howatt, Mettler, and Harrington. The trial was established in a non-cropped area to evaluate single active ingredients used in cereals for waterhemp control. Waterhemp seed was obtained from an area with glyphosate resistance and spread on the field in spring. Treatments were applied to 3 to 5 inch common lambsquarters, redroot pigweed, and waterhemp on June 20 with 68°F, 45% relative humidity, 30% cloud cover, 5 mph wind velocity at 30°and dry soil at 65°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	7/4 wahe	7/4 colq	7/19 wahe	7/19 colq
	oz ai/A	%	%	%	%
MCPA	6	38	69	48	97
2,4-D	6	64	73	93	98
Dica	1.5	66	53	81	78
Flox	1.5	0	0	0	0
Clpy	1.5	0	0	0	0
Haux&Flas+BB	0.15+1%	74	54	74	70
Brox	4	64	60	69	48
Carf+BB	0.128+1%	79	74	93	76
Thif-sg+BB	0.2+1%	89	80	96	93
Trib-sg+BB	0.2+1%	78	83	81	97
Flcz2.0+BB	0.32+1%	84	48	94	43
Pxlm+BB	0.21+1%	84	66	87	75
Thcz+BB	0.07+1%	86	53	93	61
Immx+BB	0.5+1%	81	75	89	74
Untreated Check	0	0	0	0	0
CV		7	9	6	8
LSD P=.05		6	7	5	7

Redroot pigweed was essentially controlled by all herbicides. Waterhemp control was greater than 90% with 2,4-D, carfentrazone, thifensulfuron, flucarbazone, and thiencarbazone, with reasonable activity from pyroxsulam and imazamox. Many locations have waterhemp with ALS resistance so effectiveness of these treatments would be less certain with exceptions of 2,4-D and carfentrazone. 2,4-D also provided 98% control of common lambsquarters.

Broadleaf weed control in wheat. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Prosper, North Dakota on May 8. Treatments were applied to 6 to 10 inch common lambsquarters, 5 to 8 inch wild buckwheat, 3 to 6 inch common ragweed, and 1 to 6 inch waterhemp on June 12 with 80°F, 19% relative humidity, 0% cloud cover, 10 to 12 mph wind velocity at 90°and dry soil at 80°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/26 wht	6/26 colq	6/26 corw	6/26 wibw	6/26 wahe	7/11 colq	7/11 corw	7/11 wibw	7/11 wahe
	oz ai/A	%	%	%	%	%	%	%	%	%
Pxdn+Clpy&Flox	0.86+3	0	65	40	48	71	78	83	86	69
Pxdn+2,4-D&Dica&Flox	0.86+9.5	8	76	73	68	80	99	97	89	91
Pxdn+Clpy&Flox&MCPA	0.86+8	0	74	55	53	57	99	90	85	85
Pxdn+Brox&2,4-D&Flox	0.86+8	0	85	83	76	88	99	81	94	93
Pxdn+Clpy&Flox+Thif-sg	0.86+2+0.2	0	75	66	69	78	90	84	85	80
Pxdn+Carf+Flox+ NIS	0.86+0.128+1.5+ 0.25%	0	81	66	75	89	84	78	76	80
Pxdn+Carf+2,4-D+NIS	0.86+0.128+4+0.25%	0	86	84	84	88	99	80	71	86
Pxdn+Haux&Flas+NIS	0.86+0.15+0.25%	0	73	70	66	77	94	90	90	90
Pxdn+Brox&Flox	0.86+7.5	0	76	88	89	76	94	97	93	84
Pxdn+Brox&MCPA5	0.86+8	0	94	95	95	94	97	83	88	84
Pxdn+Brox&Pyst	0.86+3.4	0	68	69	79	88	95	88	90	88
Pxdn+CoAct+ Brox&Bycp+PO	0.86+0.91+ 3+1%	0	95	95	95	95	99	89	91	90
Pxdn+Thif-sg+Trib-sg+ MCPA+NIS	0.86+ 0.24+0.06+ 4+0.25%	0	83	50	69	90	98	40	75	80
Pxdn+Flox&Thif+NIS	0.86+1.72+0.25%	0	86	60	74	93	93	73	83	78
Pxdn+Flox&Mets&Thif+ NIS	0.86+1.37+ 0.25%	0	65	55	63	69	88	78	80	84
	0	0	0	0	0	0	0	0	0	0
CV		154	6	8	8	5	5	8	6	6
LSD P=.05		1	6	7	8	6	6	9	7	7

Only 2,4-D&diamba&fluroxypyr resulted in wheat stunting, but the shorter stature was not readily evident at the second evaluation. However, this treatment provided excellent control across weeds present, 94% combined average. Other treatments that performed well, 90 to 92% combined average, across weed species were clopyralid&fluroxypyr&MCPA, bromoxynil&2,4-D&fluroxypyr, halauxifen&florasulam, bromoxynil&fluroxypyr, bromoxynil&pyrasulfotole, and bromoxynil&bicyclopyrone.

Broadleaf weed control in wheat, Exp 2. Dr. Howatt, Mettler, and Harrington. The trial was established in a non-cropped area. Waterhemp seed was obtained from an area that had resistance to glyphosate and spread on the field. Treatments were applied to 3 to 5 inch redroot pigweed, waterhemp, and common lambsquarters on June 20 with 68°F, 45% relative humidity, 40% cloud cover, 4 mph wind velocity at 30°, and dry soil at 65°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	7/4 wahe	7/4 colq	7/19 wahe	7/19 colq
	oz ai/A	%	%	%	%
Pxdn+Clpy+Flox	0.86+3	48	50	50	48
Pxdn+2,4-D&Dica&Flox	0.86+9.5	85	83	97	98
Pxdn+Clpy+Flox&MCPA	0.86+8	74	84	75	97
Pxdn+Brox&2,4-D&Flox	0.86+8	81	88	58	90
Pxdn+Clpy+Flox+Thif-sg	0.86+0.86+0.2	50	43	43	38
Pxdn+Carf+Flox+NIS	0.86+0.128+1.5+0.25%	87	70	89	51
Pxdn+Carf+2,4-D+NIS	0.86+0.128+4+0.25%	92	85	98	99
Pxdn+Haux&Flas+NIS	0.86+0.15+0.25%	55	48	53	33
Pxdn+Brox&Flox	0.86+7.5	70	66	40	30
Pxdn+Brox&MCPA5	0.86+8	69	81	38	90
Pxdn+Brox&Pyst	0.86+3.4	90	85	99	90
Pxdn+CoAct+Brox&Bcpy+PO	0.86+0.91+3+1%	89	80	83	56
Pxdn+Thif-sg+Trib-sg+MCPA+NIS	0.86+0.24+0.06+4+0.25%	90	85	94	99
Pxdn+Flox&Thif+NIS	0.86+1.72+0.25%	90	85	95	94
Pxdn+Flox&Mets&Thif+NIS	0.86+1.37+0.25%	89	83	95	94
Untreated Check	0	0	0	0	0
CV		9.19	7.78	9.4	6.28
LSD P=.05		9.47	7.72	9.23	6.18

Redroot pigweed was essentially completely controlled by each herbicide treatment, 97% or better. Near complete control also was achieved on other species with carfentrazone+2,4-D or the premix of 2,4-D&dicamba&fluroxypyr. Other herbicides that provided excellent control of each species were bromoxynil&pyrasulfotole, thifensulfuron+tribenuron(Afinity Tankmix)&MCPA, fluroxypyr&thifensulfuron, and fluroxypyr&metsulfuron&thifensulfuron. Without crop competition, weeds that were not adequately controlled produced substantial regrowth before the second evaluation.

Bicyclopyrone control of broadleaf weeds. Dr. Howatt, Mettler, and Harrington. 'Bolles' wheat was seeded near Fargo on May 4. Treatments were applied to 4 leaf and jointing wheat, 6 inch wild buckwheat, 1 to 3 inch common ragweed and common lambsquarters, flowering wild mustard, and 1 inch common mallow on June 16 with 62°F, 85% relative humidity, 99% cloud cover, 1 mph wind velocity at 220°, and moist soil at 64°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates. CoAct was added to mixture first in all treatments that contained the adjuvant. Harvest for yield was on August 23.

Treatment	Rate	6/23 wibw	6/23 wimu	6/23 corw	6/23 vema	6/23 colq	6/30 wibw	6/30 wimu	6/30 corw	6/30 vema	6/30 colq	7/14 wibw	7/14 wimu	7/14 corw	7/14 vema	7/14 colq	8/23 Yield
	oz ai/A	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	bu/A
Pxdn+Brox&Bcpy+CoAct+PO	0.86+3+0.92+1%	81	88	75	75	73	91	97	86	96	94	97	99	99	99	99	43
Pxdn+Brox&Bcpy+CoAct+PO	0.86+3.5+1.07+1%	94	88	81	91	78	95	99	91	94	89	99	99	99	99	99	43
Pxdn+Brox&Bcpy+CoAct+PO	0.86+4+1.2+1%	95	95	93	89	85	98	99	97	97	98	99	99	99	99	99	40
Pxdn+Brox&Pyst+NIS	0.86+2.84+0.25%	90	94	93	94	76	94	97	94	94	94	99	99	99	99	99	44
Pxdn+Clpy&Flox	0.86+3	50	48	58	45	33	79	85	84	80	70	96	97	96	99	94	40
Pxdn+Thif-sg+Trib-sg+ Clpy&Flox+NIS	0.86+0.24+0.06+ 3+0.25%	71	84	75	65	63	89	97	84	88	86	99	99	96	99	99	41
Pxdn+Thif-sg+Trib-sg+MCPA	0.86+0.24+0.06+5.6	61	85	20	70	68	89	91	33	66	92	98	99	94	99	99	43
Brox&Pyst&Thcz+NIS	3+0.25%	84	89	88	80	66	95	98	95	93	95	99	99	99	99	98	42
Pxlm&Clpy&Flox+NIS	3.2+0.25%	61	76	71	50	45	80	89	65	84	85	96	99	99	99	99	39
Pxdn	0.86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43
CV		5	6	5	6	7	4	3	6	5	4	2	1	1	1	1	9
LSD P=.05		5	6	5	6	6	5	4	6	6	5	3	1	2	1	2	6

Wheat did not express visible injury to treatments. Initial evaluation, identified rapid and excellent control of most species with the high rate of bromoxynil&bicyclopyrone or bromoxynil&pyrasulfotole. Common lambsquarters was the most difficult to control for these treatments, but none of the other treatments gave better lambsquarters control. By July 14, all broadleaf herbicides resulted in 94% control or better of all species. Clopyralid&fluroxypyr gave slightly less control than other broadleaf herbicide treatments. Weed pressure was light and did not appear to limit wheat growth or yield. Herbicides did not cause damage that resulted in less yield.

Talinor (bicyclopyrone+bromoxynil) crop safety in durum. Dr. Keene. Durum 'Joppa' was seeded at the Williston Research Extension Center dryland research farm on April 21. Treatments were applied to jointing durum (Zadoks 32) on June 11 at 10:00 am with 65°F, 0% cloud cover, and 7 mph WNW wind velocity. Treatments were applied with a backpack sprayer delivering 10 gpa at 25 psi through XR11002 nozzles to a 7 foot wide area the length of 10 by 30 ft plots. The experiment was a randomized complete block design with 3 replicates.

Treatment	Rate floz/a	6/14 Inj	6/23 Inj	7/5 Inj	7/5 Saskr control	7/31 Yield bu/a
Untreated check	--	0	0	0	0	23
Talinor+Coact+COC	13.7+2.75+1v/v	4	2	2	94	22
Talinor+Coact+COC	16+3.2+1v/v	5	5	3	98	22
Talinor+Coact+COC	18.2+3.6+1v/v	8	9	3	97	21
Huskie+NIS	11+0.25v/v	3	3	2	97	22
Widematch	16	2	1	1	95	22
AffintyTankmix+Widematch+NIS	0.6ozwt+16+0.25v/v	4	0	1	93	22
AffinityTankmix+MCPAester	0.6ozwt+12	3	1	0	93	20
StaraneFlex	13.5	3	0	1	92	23
CV		63	129	107	36	12
LSD p=.05		2	2	2	8	5

Weather was exceptionally dry during establishment and throughout the 2017 growing season at Williston. Additional crop injury ratings were planned but were not conducted because the crop began to turn color shortly after the final reported injury rating was taken. Few weeds were present in the study location, so data from this study should be considered a more accurate reflection of crop safety than weed control efficacy.

Talinor application did result in visible crop injury, mostly in the form of light chlorotic spotting, on durum leaves. The highest Talinor rate (18.2 floz/a) resulted in significantly more visible injury than the other two rates tested at 3 day and 14 day after application. For all treatments, injury symptoms decreased in severity as the crop matured.

Yield averaged across the study was 22 bu/ ac at 13.5% moisture. Despite some differences in crop injury shortly after herbicide application, there was no significant difference in yield among treatments. Small grain yields were uniformly low at this location in 2017 due to drought stress, and this may have overwhelmed any more subtle differences due to herbicide injury. Weed competition was not a driver of yields in this study, as evidenced by the weed check exhibiting a similar yield to all herbicide treatments.

Broadleaf weed control in wheat with Talinor. (Minot). The objective of the study was to evaluate Talinor for broadleaf weed control in wheat compared to standard treatments. Herbicides treatments were applied postemergence on June 4 at the 4-leaf wheat stage.

None of the treatments caused visible crop injury two weeks after application. Talinor, Huskie, and Huskie Complete generally provided fair control of kochia, lambsquarters, and wild buckwheat. WideMatch and PerfectMatch provided good control of kochia and wild buckwheat. Affinity TM + WideMatch provided good to excellent control of all weeds.

Table. Broadleaf weed control with Talinor. (1720)

			Wheat				Weed Control[c]					
			Injury		Yield	Test wt.	Koch		Colq		Wibw	
Treatment	Rate	Timing	Jun-20	Jul-7	Aug-1	Aug-1	Jun-20	Jul-7	Jun-20	Jul-7	Jun-20	Jul-7
			-------%-------		bu/a	lb/bu	----------%----------					
Untreated			0	0	21.2	38.7	0	0	0	0	0	0
Coact+ + Talinor[a]	2.75 oz + 13.7 oz	POST	0	0	52.9	59.1	68	65	74	70	73	70
Coact+ + Talinor[a]	3.2 oz + 16 oz	POST	0	0	49.3	58.9	80	77	87	79	81	73
Coact+ + Talinor[a]	3.6 oz + 18.2 oz	POST	0	0	49.6	59.4	83	78	87	80	82	77
Huskie[b]	11 oz	POST	0	0	50.7	58.8	73	67	78	78	72	73
WideMatch	16 oz	POST	0	0	51.6	60.6	87	83	28	28	88	89
Affinity TM + WideMatch[b]	0.6 oz + 16 oz	POST	0	0	54.9	60.2	89	86	95	99	95	99
Affinity TM + MCPA-Ester	0.6 oz + 12 oz	POST	0	0	34.5	57.8	20	10	93	99	95	99
Huskie Complete	13.7 oz	POST	0	0	46.5	59.8	64	67	75	75	80	80
PerfectMatch	16 oz	POST	0	0	47.4	60.2	83	85	77	81	86	90
LSD (0.05)			NS	NS	13.4	NS	8.9	9.8	11.1	7.3	7.8	8.3
CV			0	0	17.0	18.6	8.0	9.3	9.3	6.2	6.0	6.5

[a] *Applied with COC (1%)*

[b] *Applied with NIS (0.25%)*

[c] *Koch=kochia; Colq=Common lambsquarters; Wibw=Wild buckwheat*

Bicyclopyrone control of kochia. Dr. Howatt, Mettler, and Harrington. 'Tradition' barley was seeded near Rodgers, North Dakota on May 6. Treatments were applied to 3 to 3.5 leaf barley and 1 to 6 inch kochia on June 8 with 76°F, 43% relative humidity, less than 5% cloud cover, 4.4 mph wind velocity at 80°, and dry soil at 70°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with three replicates. CoAct was added to the mixture first in all treatments that contained the adjuvant.

Treatment	Rate	6/20 koch	7/4 koch	7/17 koch
	oz ai/A	%	%	%
Pxdn+Brox&Bcpy+CoAct+PO	0.86+3+0.92+1%	97	96	98
Pxdn+Brox&Bcpy+CoAct+PO	0.86+3.5+1.07+1%	99	99	99
Pxdn+Brox&Bcpy+CoAct+PO	0.86+4+1.2+1%	99	99	98
Pxdn+Brox&Pyst+NIS	0.86+2.84+0.25%	98	98	94
Pxdn+Clpy&Flox	0.86+3	80	87	90
Pxdn+Thif-sg+Trib-sg+Clpy&Flox+NIS	0.86+0.24+0.06+3+0.25%	82	88	97
Pxdn+Thif-sg+Trib-sg+MCPA	0.86+0.24+0.06+5.6	13	0	0
Brox&Pyst&Thcz+NIS	3+0.25%	96	96	95
Pxlm&Clpy&Flox+NIS	3.2+0.25%	83	86	88
Pxdn	0.86	0	0	0
CV		6	2	3
LSD P=.05		8	2	4

Barley did not express visible injury from treatments. Treatments that included bromoxynil provided rapid destruction of kochia resulting in 96% control or better on June 20. On July 17, treatments with pyrasulfotole were rated as slightly less control than treatments with bicyclopyrone because more plants remained or had started to produce shoots at axillary meristem. Clopyralid&fluroxypyr or the premix with pyroxsulam gave 88 to 90% control. The addition of thifensulfuron+tribenuron improved on this activity even though presence of ALS-resistant kochia was high.

PGR premix control of Kochia. Dr. Howatt, Mettler, and Harrington. 'Tradition' barley was seeded near Rogers, North Dakota on May 6. Treatments were applied to 3 to 4 leaf barley and 1 to 6 inch kochia on June 8 with 76°F, 48% relative humidity, less than 5% cloud cover, 4.4 mph wind velocity at 70°, and dry soil at 70°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with three replicates.

Treatment	Rate	6/20 koch	7/4 koch	7/17 koch
	oz ae/A	%	%	%
2,4-D&Dica&Flox+NIS+Pxdn	4.8+0.5%+0.86	78	85	86
2,4-D&Dica&Flox+NIS+Pxdn	9.5+0.5%+0.86	78	93	94
MCPA&Dica&Flox+NIS+Pxdn	4.8+0.5%+0.86	82	85	93
MCPA&Dica&Flox+NIS+Pxdn	9.5+0.5%+0.86	89	91	97
2,4-D&Dica&Flox+Thif-sg+Trib-sg+ NIS+Pxdn	7.2+0.15+0.07+ 0.5%+0.86	90	93	98
MCPA&Dica&Flox+Thif-sg+Trib-sg+ NIS+Pxdn	7.2+0.15+0.07+ 0.5%+0.86	92	89	95
Clpy&Flox&MCPA+Thif-sg+NIS+Pxdn	8.7+0.2+0.5%+0.86	75	80	89
Pxdn	0.86	0	0	0
CV		4	4	4
LSD P=.05		5	6	6

Herbicides did not appear to affect barley but substantial variation due to environment and weather was apparent that might have confounded evaluation. Kochia control initially was more related to product than rate. In July, a rate response was present for kochia control with premixes containing dicamba. The amount of fluroxypyr in the low rate of each premix would not be recommended for kochia control, 0.75 oz ae/A. Even the high rate only gives as much fluroxypyr as the standard rate of clopyralid&fluroxypyr. But the low rate also contains 1 oz/A dicamba to give combined activity on kochia for 86 to 93% control. The high rates gave better control but risk of crop injury is greater and has been demonstrated to result in less yield in other studies if applied to boot stage cereal crop.

Control of large kochia. Dr. Howatt, Mettler, and Harrington. 'Tradition' barley was seeded near Rogers, North Dakota on May 6. Treatments were applied to flag leaf barley and 6 to 12 inch kochia on June 20 with 77°F, 42% relative humidity, 30% cloud cover, 2 mph wind velocity at 340°, and dry soil at 78°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with three replicates.

Treatment	Rate	fluroxypyr	6/27 koch	7/4 koch	7/17 koch
	oz/A	oz/A	%	%	%
Pxdn&Flox+Thif&Flox	2.4+1.4	2.6	43	68	82
Pxdn+Thif&Flox	0.86+1.4	1.12	40	67	73
Pxdn&Flox	2.4	1.5	47	70	83
Pxdn+Flox[a]	0.86+2	2	47	70	87
Pxdn+Brox&Flox	0.86+7.5	1.5	70	82	83
Pxdn+Dica[a]+Flox	0.86+1+2	2	60	83	95
Pxdn	0.86	0	0	0	0
CV			9	6	4
LSD P=.05			7	6	5

[a]Flox was Starane Ultra formulation from Dow AgroSciences, LLC; dica was Clarity formulation from BASF Corp.

Barley did not display response to herbicide treatments at any evaluation. Initial control of kochia was much better with bromoxynil and fluroxypyr because of desiccation on leaves which was caused by bromoxynil. However, eventual symptoms and plant condition were consistent with exposure to fluroxypyr. Control was lowest with fluroxypyr at 1.12 oz/A. This treatment also had thifensulfuron, but the kochia in this region expresses high proportion of ALS-resistant biotype. Treatment 1 had fluroxypyr from two products to total 3.6 oz/A, but this did not give better control than treatments with 1.5 oz/A. Addition of dicamba to fluroxypyr improved control of kochia to 95%. These plants had more compacted growth and were almost void of green color while kochia exposed to other herbicide treatments still had 50 to 90% green tissue. The study was terminated after the July 17 evaluation to prevent kochia seed set.

Control of large broadleaf weeds. Dr. Howatt, Mettler, and Harrington. 'Glenn' hard red spring wheat was seeded near Prosper, North Dakota on May 8. Treatments were applied to 6 leaf wheat, 8 to 12 inch common lambsquarters and wild buckwheat, and 4 to 8 inch common ragweed on June 19 with 65°F, 69% relative humidity, 10% cloud cover, 5 mph wind velocity at 315°, and moist soil at 66°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 7 foot wide area the length of 10 by 30 foot plots. The experiment was a randomized complete block design with four replicates.

Treatment	Rate	6/26 wht inj	6/26 colq	6/26 corw	6/26 wibw	7/3 wht inj	7/3 colq	7/3 corw
	oz/A	%	%	%	%	%	%	%
Pxdn&Flox+Thif&Flox	2.4+1.4	0	10	40	53	4	53	68
Pxdn+Thif&Flox	0.86+1.4	3	13	40	40	4	60	76
Pxdn&Flox	2.4	5	13	45	45	6	43	63
Pxdn+Flox[a]	0.86+2	4	15	55	43	4	48	74
Pxdn+Brox&Flox	0.86+7.5	6	33	68	66	12	80	84
Pxdn+Dica[a]+Flox	0.86+1+2	4	38	53	50	6	80	84
Pxdn	0.86	1	0	0	0	4	0	0
CV		61	31	15	17	32	12	9
LSD P=.05		3	8	9	11	3	9	9

Treatment	Rate	7/3 wibw	7/20 wht inj	7/20 colq	7/20 corw	7/20 wibw	8/7 all
	oz/A	%	%	%	%	%	
Pxdn&Flox+Thif&Flox	2.4+1.4	70	0	95	94	99	
Pxdn+Thif&Flox	0.86+1.4	79	0	91	93	99	
Pxdn&Flox	2.4	66	2	81	88	99	No change
Pxdn+Flox	0.86+2	75	2	91	94	99	
Pxdn+Brox&Flox	0.86+7.5	84	5	97	98	99	
Pxdn+Dica+Flox	0.86+1+2	84	4	94	96	99	
Pxdn	0.86	0	0	0	0	0	
CV		5	76	5	4	.	.
LSD P=.05		5	2	4	4	0	.

[a]Flox was Starane Ultra formulation from Dow AgroSciences, LLC; dica was Clarity formulation from BASF Corp.

Wheat injury was observed as shortened plants. This symptom was most pronounced when wheat was treated with pinoxaden plus bromoxynil and fluroxypyr, and the height difference remained evident through the entire season. However, plants remained consistent in development and maturity across the study, including check strips between plots and study border areas.

Symptoms and control were slow to develop, even for the treatment containing bromoxynil. Wild buckwheat could not be found by mid-July in plots treated with any of the broadleaf herbicides. The highest control values were associated with bromoxylin and fluroxypyr treatment. Dicamba plus fluroxypyr or thifensulfuron and fluroxypyr plus more fluroxypyr also provided 94% or better control of all three weeds. Fluroxypyr at 1.5 oz/A from pinoxaden and fluroxypyr gave 81% and 88% control of lambsquarters and ragweed, respectively, while fluroxypyr at 2 oz/A gave 91% and 94% of those weeds.

Postharvest Control of Kochia and Russian Thistle

Caleb Dalley, HREC, Hettinger, ND, 2017

Three field trials were conducted to evaluate herbicide options for controlling kochia following harvest. During 2017, drought conditions led to many small grain fields to be harvested for forage rather than grain. Following forage harvest kochia, Russian thistle and other weeds populations rapidly flourished in the absence of any crop cover. Herbicide options were explored in an effort to control these weeds. Three trials were conducted near Hettinger North Dakota. Two trials were located on a fields that had been planted to barley and harvested for hay forage, the other had been planted to cereal rye and had been grazed. All three fields had high populations of kochia, although one of the fields was primarily infested with Russian thistle. Results at all three location differed considerably. Herbicide treatments were applied using a tractor-mounted research sprayer using flat fan nozzles at a spray volume of 10 gallons per acre at 4 miles per hour.

Location previously planted to rye. Herbicide treatments were applied on August 18, 2017 to kochia that ranged from 2 to 18 inches in height with an average height of 4 inches. Weeds present at this site included kochia, redroot pigweed, common lambsquarters, and common mallow. At 7 DAT, all treatments containing Gramoxone control kochia 97 to 99%, regardless of addition of adjuvant or 2,4-D. The next best treatment was Sharpen which provided 81% control. These are both quick acting contact types of herbicides. Glyphosate alone controlled kochia 77% at 7 DAT and improved to 80% or more at later evaluations. The addition of dicamba and 2,4-D or Starane Ultra did not significantly improve control. Starane Ultra alone controlled kochia 68 to 77%. The addition of 2,4-D or dicamba improved control to 84 and 85%, respectively, at 45 DAT. Other treatments provided only fair control of kochia, and reduced growth compared to the untreated control.

Table 1. Kochia control in field planted to cereal rye and used for grazing cattle, 2017.

Treatment[a]		Kochia control				
	Rate	7 DAT[b]	14 DAT	21 DAT	30 DAT	45 DAT
	oz/A	%				
1 Untreated		0 f	0 f	0 d	0 f	0 h
2 Glyphosate+AMS[c]	48	55 e	78 bcd	82 b	85 b	85 bcd
3 Glyphosate+Clarity+2,4 D LV6+AMS	24+8+16	77 bc	80 b	82 b	84 b	84 d
4 Glyphosate+Sharpen+MSO+AMS	24+2	73 cd	71 e	78 b	76 cd	71 g
5 Sharpen+MSO+AMS	2	74 cd	74 cde	75 bc	70 de	70 g
6 Sharpen+Aim+MSO+AMS	2+2	81 b	76 b-e	81 b	74 cde	70 g
7 Glyphosate+Starane Ultra+AMS	24+11.2	76 bcd	79 bcd	80 b	80 bc	81 de
8 Starane Ultra	11.2	71 d	77 bcd	76 bc	68 e	75 efg
9 Starane Ultra+2,4 D LV6	11.2+16	78 bc	80 bc	80 b	79 bc	84 cd
10 Starane Ultra+Clarity	11.2+8	76 bcd	79 bcd	79 b	79 bc	85 bcd
11 Bison+ MSO + AMS	32	73 cd	73 de	70 c	73 cde	81 de
12 Carnivore + MSO + AMS	32	78 bc	80 b	83 b	79 bc	79 def
13 Distinct + MSO + AMS	8	76 bcd	78 bcd	81 b	77 cd	79 def
14 Glyphosate+Distinct+MSO+AMS	24+8	78 bc	79 bcd	79 b	85 b	81 de
15 Widematch	21.3	71 d	75 b-e	69 c	66 e	72 fg
16 Gramoxone SL	48	98 a	96 a	97 a	95 a	92 ab
17 Gramoxone SL + NIS	48	97 a	98 a	98 a	95 a	91 abc
18 Gramoxone SL + HSCO	48	99 a	97 a	98 a	95 a	96 a
19 Gramoxone SL + MSO	48	98 a	96 a	98 a	97 a	97 a
20 Gramoxone SL+2,4 D LV6 + NIS	48+16	98 a	97 a	97 a	97 a	96 a
LSD P=0.05		6.9	5.9	8.4	8.3	7.3
Standard Deviation		2.8	4.2	5.9	3.7	5.2
CV		4.58	5.38	7.5	5.9	6.6
Treatment F		158	95	49	84	62
Treatment Prob(F)		0.0001	0.0001	0.0001	0.0001	0.0001

[a]Abbreviations: DAT, days after treatment; AMS, ammonium sulfate; MSO, methylated soybean oil; HSOC, high surfactant oil concentrate; NIS, non-ionic surfactant.

[b]Means followed by different letters are significantly different (P=0.05, LSD)

[c]AMS was applied at a rate of 8.5 lbs/100 gallons in all treatments where specified; MSO was applied at 1% v/v; NIS and HSOC were applied at 0.5% v/v.

Location previously planted to barley. Herbicide treatments were applied on July 26, 2017 to kochia ranging from 2 to 12 inches, averaging 6 inches. This location was primarily infested with kochia and volunteer barley. The best treatment at all evaluation dates was Gramoxone, which controlled kochia 92% at 14 DAT. Glyphosate alone, even at 48 oz/A provided poor control of kochia. The only other treatments providing good kochia control were Distinct (dicamba + diflufenzopyr) providing 80% control 21 DAT and WideMatch (clopyralid + fluroxypyr) which provided 78% control 21 DAT. This field will need to be monitored for possible resistance to glyphosate as glyphosate seemed to have little impact on control.

Table 2. Kochia control following harvest of barley for hay at Hettinger, ND in 2017.

Treatment[a]	Rate	Kochia control		
		7 DAT[b]	14 DAT	21 DAT
	oz/A	%		
1 Untreated		0 i	0 l	0 k
2 Glyphosate	24	15 h	0 l	0 k
3 Glyphosate + AMS	24	25 g	20 k	10 j
4 Glyphosate + AMS	32	26 g	28 ijk	15 j
5 Glyphosate + AMS	48	27 g	33 hij	28 hi
6 Glyphosate + Sharpen+ AMS	24+2	31 g	20 k	15 j
7 Sharpen + HSOC + AMS	2	71 bc	60 de	36 fg
8 Sharpen + MSO + AMS	2	70 bc	61 cde	50 bcd
9 Glyphosate + Aim + AMS	24+2	46 f	25 jk	13 j
10 Aim + MSO + AMS	2	58 de	40 ghi	25 i
11 Sharpen+ Aim + MSO + AMS	2+2	71 bc	67 bcd	43 def
12 Glyphosate + Starane Ultra + AMS	24+8	58 de	53 ef	53 bc
13 Starane Ultra	8	54 ef	38 ghi	36 fg
14 Starane Ultra	1	65 cd	47 fg	36 fg
15 Starane Ultra+2,4 D LV6	8+8	58 de	43 fgh	45 cde
16 Starane Ultra+ Sterling Blue	8+4	64 cd	53 ef	55 b
17 Glyphosate + Bison + AMS	24+32	69 bc	65 cde	40 efg
18 Bison	32	68 bc	63 cde	28 hi
19 Carnivore	32	68 bc	53 ef	34 gh
20 Glyphosate + Carnivore + AMS	24	63 cde	54 ef	42 d-g
21 Distinct + MSO + AMS	8	71 bc	72 bcd	80 a
22 Glyphosate + Distinct + AMS + MSO	24+8	75 b	73 bc	81 a
23 WideMatch	21.3	65 cd	78 b	78 a
24 Gramoxone SL	48	88 a	92 a	85 a
LSD P=0.05		7.6	13.2	8.7
Standard Deviation		4.0	8.0	6.1
CV		8.5	17.2	16.2
Treatment F		56	26	62
Treatment Prob(F)		0.0001	0.0001	0.0001

[a]Abbreviations: DAT, days after treatment; AMS, ammonium sulfate; MSO, methylated soybean oil; HSOC, high surfactant oil concentrate; NIS, non-ionic surfactant.

[b]Means followed by different letters are significantly different (P=0.05, LSD).

[c]AMS was applied at a rate of 8.5 lbs/100 gallons in all treatments where specified; MSO was applied at 1% v/v; NIS was applied at 0.5% v/v.

Russian thistle location. Herbicide treatments were applied on August 22, 2017. Weeds present at this location included Russian thistle, kochia, common lambsquarters, and green foxtail. The primary weed, Russian thistle was 12 to 18 inches in height, which was not an ideal height for controlling. Other weeds were not as tall, but were above ideal heights for good control. At 7 DAT, as with the other locations, Gramoxone, with and without adjuvants or 2,4-D provided the greatest control of kochia, Russian thistle and common lambsquarters. Glyphosate alone or tank-mixed with dicamba and 2,4-D or Starane Ultra or Sharpen or Distinct provided excellent control of kochia, Russian thistle and common lambsquarters at 14 DAT and thereafter. Other treatments provide only fair or poor control of these three weeds. Weeds were above ideal height and it was encouraging that control was still possible with both glyphosate and Gramoxone tank-mixes.

Table 3. Post-harvest control of Russian thistle, kochia, and common lambsquarters following harvest of oats for hay at Hettinger, ND in 2017.

		Kochia				Russian thistle				Lambsquarters
Treatment[a]	Rate	7 DAT[b]	14 DAT	21 DAT	28 DAT	7 DAT	14 DAT	21 DAT	28 DAT	21 DAT
	oz/A	control (%)								
1 Untreated		0 g	0 d	0 c	0 d	0 h	0 g	0 e	0 e	0 f
2 Glyphosate + AMS[c]	48	54 c-f	95 ab	97 a	100 a	54 fg	100 a	100 a	100 a	100 a
3 Glyphosate+Clarity+2,4 D LV6+AMS	24+8+16	51 def	96 a	99 a	99 ab	63 ef	97 a	99 a	100 a	100 a
4 Glyphosate+Sharpen+MSO+AMS	24+2	67 bc	100 a	100 a	100 a	79 bc	100 a	100 a	100 a	100 a
5 Sharpen+ MSO + AMS	2	44 ef	66 c	70 b	71 c	76 bcd	81 bc	79 b	79 b	71 cd
6 Sharpen+Aim+MSO+AMS	2+2	45 def	69 c	66 b	65 c	72 cde	78 cd	75 bc	77 bc	68 cd
7 Glyphosate+Starane Ultra+AMS	24+11.2	60 cd	96 ab	98 a	99 ab	65 def	98 a	100 a	100 a	99 a
8 Starane Ultra	11.2	46 def	69 c	69 b	73 c	56 fg	61 ef	58 d	68 cd	54 de
9 Starane Ultra+2,4 D LV6	11.2+16	45 def	68 c	68 b	67 c	53 fg	59 ef	63 d	64 d	66 cde
10 Starane Ultra+ Sterling Blue	11.2+8	58 cde	70	68 b	70 c	64 def	64 ef	64 cd	69 cd	61 cde
11 Bison+ MSO + AMS	32	40 f	61 c	63 b	65 c	46 g	68 de	65 cd	69 cd	64 cde
12 Carnivore + MSO + AMS	32	45 def	69 c	64 b	69 c	46 g	58 ef	58 d	60 d	69 cd
13 Distinct + MSO + AMS	8	50 def	70 c	66 b	73 c	58 fg	55 f	56 d	63 d	59 de
14 Glyphosate+Distinct+MSO+AMS	24+8	46 def	86 b	92 a	96 ab	63 ef	95 a	99 a	98 a	97 a
15 Widematch	21.3	52 c-f	65 c	61 b	69 c	56 fg	63 ef	60 d	66 d	49 e
16 Gramoxone SL	48	95 a	98 a	99 a	98 ab	99 a	100 a	100 a	100 a	97 a
17 Gramoxone SL + NIS	48	99 a	98 a	99 a	100 a	99 a	100 a	100 a	100 a	95 ab
18 Gramoxone SL + HSCO	48	97 a	98 a	97 a	98 ab	99 a	100 a	100 a	100 a	96 a
19 Gramoxone SL + MSO	48	97 a	98 a	96 a	98 ab	99 a	100 a	100 a	100 a	95 ab
20 Gramoxone S+2,4 D LV6 + NIS	48+16	80 ab	91 ab	90 a	90 b	88 ab	91 ab	91 a	93 a	78 bc
LSD P=0.05		19.9	9.8	12.7	9.0	13.4	11.2	11.5	9.3	17.7
Standard Deviation		0.07	6.9	8.9	6.4	9.4	7.9	8.1	10.0	12.5
CV		10.0	8.8	11.5	8.0	14.2	10.1	10.4	8.2	16.5
Treatment F		29.2	47.8	28.9	55.3	25.7	41.8	40.8	56.8	16.4
Treatment Prob(F)		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

[a]Abbreviations: DAT, days after treatment; AMS, ammonium sulfate; MSO, methylated soybean oil; HSOC, high surfactant oil concentrate; NIS, non-ionic surfactant.

[b]Means followed by different letters are significantly different (P=0.05, LSD).

[c]AMS was applied at a rate of 8.5 lbs/100 gallons in all treatments where specified; MSO was applied at 1% v/v; NIS was applied at 0.5% v/v.