Yellow Section: Camelina, Canola, Carrot, Chickpea, Cover Crops, Dry Bean, Dry Pea, Faba Bean, Flax, Hemp, Potato, Sunflower, Pumpkin, and Turf.

Fall-established cover crop tolerance to soybean herbicides, Carrington, 2020. Greg Endres, Kirk Howatt and Mike Ostlie. The trial was conducted at the NDSU Carrington Research Extension Center with support from the North Dakota Soybean Council to evaluate the tolerance of six late-summer planted, cool-season cover crops on ground previously treated with eight soybean herbicides that have soil residual. Experimental design was a randomized complete block with split-plot arrangement (whole plot = cover crop and subplot = herbicide) and three replicates. The field trial was established on an irrigated, conventionally-tilled, Heimdal-Emrick loam soil with 3.3% organic matter and 7.9 pH (0- to 6-inch depth). 'AG03X7' dicamba-tolerant soybean was planted at 200,000 seeds/A on May 29 in 22-inch rows. A hand-held boom sprayer was used delivering 17 gpa at 35 psi through TeeJet turbo 02 nozzles to the center 6.7 ft of 10- by 30-ft strips. PRE herbicides [metribuzin (Sencor), sulfentrazone (Spartan), flumioxazin (Valor), pyroxasulfone (Zidua), and imazethapyr (Pursuit)] were applied at standard rates on May 30 with 53 F, 41% RH, and 8 MPH wind on dry soil; 1 inch of irrigated water was applied on June 4. POST herbicides [dicamba (Engenia), fomesafen (Flexstar) and glufosinate (Liberty 280)] were applied on June 29 with 73 F, 83% RH, and 8 mph wind to second trifoliate (V2) stage soybean; 1 inch of irrigated water was applied on August 1. Irrigation water plus rain totaled 21.8 inches during May 30 to October 9. Soybean at the full seed formation (R6) stage was terminated by mowing on August 24. Cover crops were planted August 27 into the soybean stubble with a no-till drill in 7.5-inch rows: 'Tradition' barley, 'ND Dylan' winter rye, 'ND Dawn' field pea, 'ND Hammond' flax, 'Jackhammer' radish and turnip. Barley at 3-4 leaf (tillering), winter rye at 3 leaf (tillering), field pea at 2-3 inch height, flax at 0.5-1 inch height, and radish and turnip at 2-4 leaf stages were visually evaluated on September 24 [28 days after planting (DAP)] for biomass and stand reduction. A second evaluation occurred on October 8 (42 DAP) of barley at 4 leaf; rye at 3-5 leaf, field pea at 3-5 inch height, flax at 2-4 inch height, and radish and turnip at 2-5 leaf stages.

Cover crop injury generally was low (Table). Radish and turnip were tolerant of all herbicides. Sencor, Valor, Liberty 280 and Spartan/Flexstar did not inure cover crops. Plant injury exceeding ≥10%: barley = Flexstar; winter rye = Pursuit, Engenia and Flexstar; and flax = Spartan.

Table.

Herbicide			Cover crop injury[1]											
			24-Sep						8-Oct					
Treatment	Rate	Application timing[2]	Barley	Winter rye	Field pea	Flax	Radish	Turnip	Barley	Winter rye	Field pea	Flax	Radish	Turnip
	fl oz product/A		%											
Sencor 75 DF	0.33 lb	PRE	0	0	0	0	0	0	0	0	0	0	0	0
Spartan 4F	10		7	0	0	0	0	0	0	0	0	12	0	0
Valor SX	3 oz		0	0	0	0	0	0	0	0	0	0	0	0
Zidua SC	4		7	0	0	0	0	0	0	0	0	0	0	0
Pursuit	3		0	12	8	0	0	0	0	0	0	0	0	0
Engenia + CA Ridion	12.8 + 2% v/v	POST	0	12	0	0	0	0	0	0	0	0	0	0
Flexstar + HSMOC	12 + 24		10	0	0	0	0	0	0	12	0	0	0	0
Liberty 280 + AMS	32 + 3 lb		0	0	0	0	0	0	0	0	0	0	0	0
Spartan 4F/Flexstar + HSMOC	10/12 + 24	PRE/POST	0	0	0	0	0	0	0	0	0	0	0	0
LSD (0.10)			NS						NS					

[1]Biomass and/or stand reduction.

[2]PRE=May 30; POST=June 29.

Row crop tolerance to preplant-applied dicamba, Carrington, 2020.
(Greg Endres and Mike Ostlie)

The field trial was initiated at the NDSU Carrington Research Extension Center to provide a preliminary examination of the impact of preplant-applied dicamba, used for early season weed control, on selected row crops. Experimental design was a randomized complete block (split-plot arrangement: main plot=planting date; subplot=crop) and four replications. The irrigated trial was established under a center-pivot on a Heimdal-Emrick loam soil with 3.2% organic matter, 7.9 pH (0-6 inch soil depth), and 0.33 dS/m soluble salts (0-6 inch soil depth). Dicamba (Sterling Blue; 4SL; dga-salt; Winfield) was applied at 0.12 lb ai/A (4 fl oz product/A) on June 15 across the trial site with a CO_2-hand-boom plot sprayer delivering 14 gal/A at 35 psi through Lurmark flat fan 015E80 nozzles. One inch of water was applied by irrigation during each of the following dates: June 19, 23 and 27; and July 13. Daily rainfall received June 15 to July 15 $\geq$0.10 inch: June 20=0.10 and 30=0.73 inches; July 2=0.51, 7=0.24, and 8=0.61 inches (NDAWN). Spring-seeded winter wheat was the existing cover crop on the trial site and was terminated with glyphosate on June 20. Soybean (PFS19B04), pinto bean (ND-Palomino), and sunflower (Mycogen 8N270CLDM) were direct-planted in 28-inch rows on June 24 and July 7 (9 and 22 days after dicamba application, respectively). Total water received after dicamba application and one week after first planting date=3.8 inches; and one week after second planting date=6.2 inches.

All crops had rapid plant emergence after both planting dates, ranging from 5-7 days (Table). Plant stand counts were taken 2-3 weeks after planting and were at or above recommended density for all crops. Stand averages (plants/acre): soybean=162,990; pinto bean=76,160, and sunflower=43,420. Plant response was visually evaluated 2, 4, and 6 weeks after planting (WAP). At 2 WAP, pinto bean generally had larger than normal unifoliate leaves. Also, at 2 WAP with the first planting date, pinto bean commonly had misshapen growing points. Soybean and sunflower appeared to have normal growth and appearance 2 WAP. All crops had normal growth and appearance when evaluated 4 and 6 WAP.

Table.

Treatment		Crop	
		Emergence	Stand
Planting date	Crop	Date	plt/A
24-Jun	soybean	29-Jun	185,060
	pinto bean	30-Jun	81,140
	sunflower	30-Jun	49,820
7-Jul	soybean	13-Jul	140,930
	pinto bean	13-Jul	71,180
	sunflower	14-Jul	37,010
CV (%)		0.1	19.1
LSD (0.10)		1	NS

Crop Safety in Tank Mix Options Cultivar 1. Dr. Howatt and Mettler. '68K' canola was seeded near Fargo on May 15, 2020. A blanket application of trifluralin was applied to all plots on May 15 with incorporation at 58°F, 58% relative humidity, 5% cloud-cover, 2 mph wind velocity at 90°, and damp soil surface at 50°F. Pre-emergence herbicides were applied to treatments 7,8,14 and 15 on May 15, 2020 at 59°F, 53% relative humidity, 5% cloud-cover, 4 mph wind velocity at 25°, and damp soil surface at 55°F. The POST application was applied to 3 to 4 leaf canola on June 12 with 60°F, 75% relative humidity, 50% cloud-cover, 8 mph wind velocity at 45°, and dry soil surface. Pre-emergence herbicides, bolded in the table below, were applied with a backpack sprayer delivering 17 gpa at 40 psi through 11002 TT nozzles. POST herbicides 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. Crop injury evaluations were conducted 14, 21, 28, days after planting (DAP) and 7, 17 and 27 days after post-application (DAT). Plots were harvested on August 25, 2020.

	Treatment	Rate	5/29 Canola	6/5 Canola	6/12 Canola	6/19 Canola	6/29 Canola	710 Canola	8/25 Yield
		------OZ AI/A, %V------	----------%----------						--bu/A--
1	Handweeded Check	0	0	0	5	0	0	0	21
2	Thif&Trib-D + Clet-2EC + COC	0.214+1.5+1%	0	0	5	6	6	2	23
3	Thif-V + Clet + COC	0.214+1.5+1%	0	0	6	8	6	11	27
4	Thif-V + Clpy + Clet + COC	0.214+1.43+1.5+1%	0	0	6	4	9	4	26
5	Thif-V + Clpy + Immx + MSO	0.214+1.43+0.29+1%	0	0	1	2	1	0	27
6	Thif-V + Clpy + Immx+Clet+COC	0.214+1.43+0.29+1.5+1%	0	0	6	3	8	11	30
7	Trib-C / Thif+V + Clet + COC	0.107 / 0.214+1.5+1%	0	0	6	5	6	10	31
8	Trib-C / Thif-V +Clpy+Immx MSO	0.107 / 0.214+1.43+0.29+1%	0	0	3	3	1	0	29
9	Thif&Trib-D + Clet + COC	0.427+3+2%	0	0	11	6	45	32	23
10	Thif-V + Clet + COC	0.427+3+2%	0	0	7	5	34	30	23
11	Thif-V + Clpy + Clet + COC	0.427+2.85+3+2%	0	0	6	7	34	27	32
12	Thif-V + Clpy + Immx + MSO	0.427+2.85+0.58+2%	0	0	3	6	5	0	33
13	Thif-V + Clpy + Immx+Clet+COC	0.427+2.85+0.58+3+2%	0	0	8	6	25	24	28
14	Trib-C / Thif-V + Clet + COC	0.214 / 0.427+3+2%	0	0	10	10	24	27	30
15	Trib-C / Thif-V Clpy+Immx+MSO	0.214 / 0.427+2.85+0.58+2%	0	0	5	11	8	1	29
CV			0	0	33	35	26	28	20
LSD P=0.5			.	.	3	3	5	5	8

At 14 and 21 DAP there was no injury observed due to the pre-emergence herbicides. The injury present on June 12, 28 DAP, when the post-emergence herbicides were applied, represents injury from a delayed pre-emergence herbicide response, environmental conditions and damage that occurred due to flea beetle. There was no significant injury observed (<10%) 7 days after treatment (DAT). The first 7 herbicide treatments are basically a 1x rate of the second set of 7. The 1x treatments maintained near 10% injury or less with treatment 5 and 8 resulting in the least of amount of injury. The 2x rate of those treatments (12 and 15) were also rather safe. The remaining 2x treatments resulted in greater than 25% injury 17 and 27 days after post-herbicide application.

Despite the increased canola injury that was observed from the 2x rates, yield was not negatively affected. There were no statistical differences in yield.

Crop Safety in Tank Mix Options Cultivar 2. Dr. Howatt and Mettler. 'EXP98 canola', an experimental cultivar, was seeded near Fargo on May 15, 2020. A blanket application of trifluralin was applied to all plots on May 15 with incorporation at 58°F, 58% relative humidity, 5% cloud-cover, 2mph wind velocity at 90°, and damp soil surface at 50°F. Pre-emergence herbicides were applied to treatments 7,8,14 and 15 on May 15 at 61°F, 46% relative humidity, 5% cloud-cover, 2 mph wind velocity at 25°, and damp soil surface at 58°F. The POST application was applied to 3 to 4 leaf canola on June 12 with 57°F, 81% relative humidity, 50% cloud-cover, 7 mph wind velocity at 30°, and dry soil surface at 64°F. Pre-emergence herbicides (bolded in the table below) were applied with a backpack sprayer delivering 17 gpa at 40 psi through 11002 TT nozzles. POST herbicides 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. Crop injury evaluations were conducted 14, 21, 28, days after planting (DAP) and 7, 17 and 27 days after post-application (DAT). Plots were harvested on August 25 2020.

			5/29	6/5	6/12	6/19	6/29	7/10	8/25
	Treatment	Rate	Canola	Canola	Canola	Canola	Canola	Canola	Yield
		------OZ AI/A, %V------	----------%----------						--bu/A--
1	Handweeded Check	0	0	0	5	3	0	0	19
2	Thif&Trib-D + Clet-2EC + COC	0.214+1.5+1%	0	0	10	6	17	12	15
3	Thif-V + Clet + COC	0.214+1.5+1%	0	0	9	8	13	6	16
4	Thif-V + Clpy + Clet + COC	0.214+1.43+1.5+1%	0	0	6	5	11	2	21
5	Thif-V + Clpy + Immx + MSO	0.214+1.43+0.29+1%	0	0	8	6	8	8	16
6	Thif-V + Clpy + Immx + Clet + COC	0.214+1.43+0.29+1.5+1%	0	0	7	5	17	7	16
7	**Trib-C** / Thif+V + Clet + COC	**0.107** / 0.214+1.5+1%	0	0	9	7	19	8	19
8	**Trib-C** / Thif-V + Clpy + Immx + MSO	**0.107** / 0.214+1.43+0.29+1%	0	0	7	4	5	3	14
9	Thif&Trib-D + Clet + COC	0.427+3+2%	0	0	12	11	40	50	11
10	Thif-V + Clet + COC	0.427+3+2%	0	0	11	7	30	32	16
11	Thif-V + Clpy + Clet + COC	0.427+2.85+3+2%	0	0	10	7	27	25	14
12	Thif-V + Clpy + Immx + MSO	0.427+2.85+0.58+2%	0	0	11	11	21	27	14
13	Thif-V + Clpy + Immx + Clet + COC	0.427+2.85+0.58+3+2%	0	0	12	10	30	27	13
14	**Trib-C** / Thif-V + Clet + COC	**0.214** / 0.427+3+2%	0	0	14	10	35	24	16
15	**Trib-C** / Thif-V + Clpy + Immx + MSO	**0.214** / 0.427+2.85+0.58+2%	0	0	11	14	15	24	11
	CV		0	0	21	28	24	39	35
	LSD P=0.5		.	.	3	3	7	10	8

At 14 and 21 DAP there was no injury observed due to the pre-emergence herbicides. The injury present on June 12, 28 DAP, when the post-emergence herbicides were applied, represents injury from a delayed pre-emergence herbicide response, environmental conditions and damage that occurred due to flea beetle. There was no significant injury observed (<10%) 7 days after treatment (DAT) apart from treatment 14 that resulted in 14% injury. The first 7 herbicide treatments are basically a 1x rate of the second set of 7. The 1x treatments maintained 20% injury or less with treatment 5 and 8 resulting in the least of amount of injury. Similar observations were made on the 68K cultivar. The 2x rate of those treatments (12 and 15) experienced more injury than the 68K cultivar. All 2x treatments resulted in near 25% injury or greater 27 DAT.

Despite the increased canola injury that was observed from the 2x rates, yield was not negatively affected. There were no statistical differences in yield.

Crop Safety in Tank Mix Options Cultivar 3. Dr. Howatt and Mettler. 'EXP99' canola, an experimental cultivar, was seeded near Fargo on May 15, 2020. A blanket application of trifluralin was applied to all plots on May 15 with incorporation at 58°F, 58% relative humidity, 5% cloud-cover, 2mph wind velocity at 90°, and damp soil surface at 50°F. Pre-emergence herbicides were applied to treatments 7,8,14 and 15 on May 15 at 61°F, 46% relative humidity, 5% cloud-cover, 2 mph wind velocity at 25°, and damp soil surface at 58°F. The POST application was applied to 3-5 leaf canola on June 12 with 58°F, 77% relative humidity, 60% cloud-cover, 7 mph wind velocity at 45°, and dry soil surface at 61°F. Pre-emergence herbicides (bolded in the table below) were applied with a backpack sprayer delivering 17 gpa at 40 psi through 11002 TT nozzles. POST herbicides 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. Crop injury evaluations were conducted 14, 21, 28, days after planting (DAP) and 7, 17 and 27 days after post-application (DAT). Plots were harvested on August 25 2020.

	Treatment	Rate	5/29 Canola	6/5 Canola	6/12 Canola	6/19 Canola	6/29 Canola	710 Canola	8/25 Yield
		------OZ AI/A, %V------	----------%----------						--bu/A--
1	Handweeded Check	0	0	0	0	0	0	0	33
2	Thif&Trib-D + Clet-2EC + COC	0.214+1.5+1%	0	0	9	1	6	2	35
3	Thif-V + Clet + COC	0.214+1.5+1%	0	0	8	4	12	15	35
4	Thif-V + Clpy + Clet + COC	0.214+1.43+1.5+1%	0	0	4	1	4	1	34
5	Thif-V + Clpy + Immx + MSO	0.214+1.43+0.29+1%	0	0	2	0	3	1	39
6	Thif-V + Clpy + Immx + Clet + COC	0.214+1.43+0.29+1.5+1%	0	0	7	3	4	6	36
7	**Trib-C** / Thif+V + Clet + COC	**0.107** / 0.214+1.5+1%	0	0	6	3	10	11	37
8	**Trib-C** / Thif-V + Clpy + Immx + MSO	**0.107** / 0.214+1.43+0.29+1%	0	0	2	0	2	1	34
9	Thif&Trib-D + Clet + COC	0.427+3+2%	0	0	13	11	45	40	30
10	Thif-V + Clet + COC	0.427+3+2%	0	0	10	3	40	35	32
11	Thif-V + Clpy + Clet + COC	0.427+2.85+3+2%	0	0	10	4	26	30	34
12	Thif-V + Clpy + Immx + MSO	0.427+2.85+0.58+2%	0	0	5	6	4	2	39
13	Thif-V + Clpy + Immx + Clet + COC	0.427+2.85+0.58+3+2%	0	0	10	8	21	20	33
14	**Trib-C** / Thif-V + Clet + COC	**0.214** / 0.427+3+2%	0	0	9	8	27	29	32
15	**Trib-C** / Thif-V + Clpy + Immx + MSO	**0.214** / 0.427+2.85+0.58+2%	0	0	9	9	9	6	31
	CV		0	0	32	59	20	32	12
	LSD P=0.5		.	.	3	4	4	6	6

At 14 and 21 DAP there was no injury observed due to the pre-emergence herbicides. The first 7 herbicide treatments are basically a 1x rate of the second set of 7. The injury present on June 12, 28 DAP, when the post-emergence herbicides were applied, represents injury from a delayed pre-emergence herbicide response, environmental conditions and damage that occurred due to flea beetle.

There was no significant injury observed (<10%) 7 days after treatment (DAT) apart from treatment 14 that resulted in 14% injury. The 1x treatments maintained 15% or less with treatment 3 and 7 resulting in the most of amount of injury. The remaining 1x treatments (2,4,5,6, and 8) had 5% injury or less 27 DAT. The 2x rate of those treatments (12 and 15) also resulted in minimal injury. All 2x treatments resulted in near 20% injury or greater 17 and 27 DAT.

Despite the increased canola injury that was observed from the 2x rates, yield was not negatively affected. There were no statistical differences in yield. The EXP99 cultivar in this experiment yielded the most when compared to the other cultivars (EXP98 and 68K) at the same location and with the same treatment list.

Control on Volunteer Canola. Dr. Howatt and Mettler. Canola cultivars '68K', 'EXP98', and 'EXP99' were seeded near Fargo on May 15, 2020. A blanket application of trifluralin was applied to all plots on May 15 with incorporation at 58°F, 58% relative humidity, 5% cloud-cover, 2mph wind velocity at 90°, and damp soil surface at 50°F. Treatments were applied to bolting canola on June 16 with 60°F, 75% relative humidity, 50% cloud-cover, 7 mph wind velocity at 45°, and dry soil surface 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. Percent of volunteer canola control was evaluated 13 and 25 days after treatment (DAT). 0% control would have had no effect on the canola while 100% would mean total plant death.

			6/29	7/10
	Treatment	Rate	Canola	Canola
		------ OZ AI/A, %V ------	---------%--------	
1	Clet + Thif&Trib-D + COC	1.5 + 0.225 + 1%	0	0
2	Flcz-3 + Thif&Trib-D + BB	0.44 + 0.225 + 1%	0	0
3	Pxlm + Thif&Trib-D + BB	0.21 + 0.225 + 1%	0	0
4	Thcz + Thif&Trib-D + BB	0.072 + 0.225 + 1%	0	0
5	Nico-P + Thif&Trib-D + BB	0.5 + 0.225 + 1%	0	0
6	Clet + Brox&MCPA + COC	1.5 + 8 + 1%	88	89
7	Clet + Haux + COC	1.5 + 0.075 + 1%	14	1
8	Clet + Haux&Flas + COC	1.5 + 0.15 + 1%	41	40
9	Clet + Brox&Pyst + COC	1.5 + 3.4 + 1%	94	98
10	Clet + Saff + COC	1.5 + 0.36 + 1	93	95
11	Clet + Metr + COC	1.5 + 4 + 1%	52	42
12	Clet + Bent-4L + COC	1.5 + 8 + 1%	80	77
13	Clet + Fome-R + COC	1.5 + 3 + 1%	84	85
14	Clet + Fome-F + COC	1.5 + 2.8 + 1%	98	98
15	Clet + Topr + COC	1.5 + 0.175 + 1%	84	86
16	Glyt	16	99	98
17	Gluf + AMS	9.3 + 32	89	89
	CV		7	7
	LSD P=0.5		5	5

During evaluations cultivars did not have a distinctively different response to any herbicide applications and therefore a single percent control value was given to represent all canola cultivars. The first 5 treatments looked at the same rate of Draft, a combination of Thif&Trib, to evaluated for any antagonism with the grass herbicides. There was no reduced control with the addition of the grass herbicides. Clethodim was added to control the grasses present in the plots for the remaining treatments (6-15). Treatment 6, 9, 10, 13, 14, 15, 16 and 17 all resulted in greater than 80% control at both evaluations. Halauxifen (Elevore), metribuzin and Pixxaro EC (Haux&Flas) resulted in poor control.

Herbicide Combinations in Flax. Dr. Howatt and Mettler. 'ND gold' flax was seeded on May 12, 2020. Preemergent applications were applied on May 12 with 55°F, 23% relative humidity, 80% cloud-cover, 7 mph wind velocity at 225°, and damp soil surface at 52°F. POST treatments were applied to 4-inch flax on June 12 with 65°F, 65% relative humidity, 50% cloud-cover, 7 mph wind velocity at 45°, and dry soil surface at 64°F. Treatments were applied with a backpack sprayer delivering 17 gpa at 40 psi through 11002 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 Flax	6/25 Flax	7/10 Flax
	OZ AI/A, % V/V	----------%----------		
Untreated Check		2	5	0
Meso (Callisto)	2	7	6	0
Meso	3	1	2	0
Suen (Spartan)	2.5	6	5	0
Suen	3.5	13	11	0
Meso + Suen	2 +2.5	3	7	0
Meso + Suen	2 + 3.5	17	13	1
Meso + Suen	3 + 2.5	2	4	0
Meso + Suen	3 + 3.5	6	7	0
Quiz + Brox&MCPA + PO	1 + 7.2 + 20	8	10	2
Quiz + Brox&MCPA	1 + 7.2	6	4	3
Quiz + CoAct + Brox&Bcpy + PO	1 + 0.91 + 3 + 20	21	32	22
Quiz + Clpy&MCPA (Talinor)	1 + 9.75	7	6	4
Meso + Suen + Quiz + Brox&MCPA +PO	2 + 2.5 + 1 + 7. 2 + 20	8	9	3
Meso + Suen + Quiz + Thif-sg + PO	2 + 2.5 + 1 + 0.05 + 20	12	13	4
CV		22	29	104
LSD P=0.05		5	3	11

Control of Volunteer Flax in Small Grains. Dr. Howatt and Mettler. 'ND gold' flax was seeded on May 12, 2020. Treatments were applied to 6-inch flax on June 12 with 65°F, 65% relative humidity, 50% cloud-cover, 7 mph wind velocity at 45°, and dry soil surface at 64°. 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 OZ AI/A, % V/V	6/25 Flax	7/10 Flax
		-------%-------	
Flox + Fenx (Tacoma)	1 + 1	67	70
Flox (Starane Ultra) + Fenx	1.5 + 1	69	69
Flox&Haux + Fenx	1.8 + 1	77	96
Haux (Elevore) + Fenx	0.075 + 1	74	89
Haux&Flas + Fenx	0.15 + 1	71	89
Carf + Fenx + NIS	0.128 + 1 + 0.25%	60	32
2,4-De (Salvo) + Fenx	6 + 1	35	2
NUP17063 + Fenx	6 + 1	17	2
Brox&MCPA&Flox (Carnivore)+ Fenx	8 + 1	72	67
Clpy&Flox&MCPA (Weld) + Fenx	8 + 1	77	66
Brox&Flox&2,4-D (Kochiavore) + Fenx	8 + 1	72	74
Pxlm (Teammate) + BB	0.21 + 1%	65	82
Flcz-3 + BB	0.35 + 1%	57	76
Thcz + BB	0.07 + 1%	59	72
Flox + 2, 4-De + Fenx	1 + 4 + 1	61	65
CV		5	14
LSD P=0.05		5	13

Control of Volunteer Flax in Row Crops. Dr. Howatt and Mettler. ‘ND gold’ flax was seeded on May 12, 2020 near Fargo. Treatments were applied to 6-inch flax on June 12 with 66°F, 58% relative humidity, 30% cloud-cover, 8 mph wind velocity at 45°, and dry soil surface 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.

		6/25	7/10
	Rate	Flax	Flax
Treatment	OZ AI/A, % V/V	-------%-------	
Fenx + Dica	1 + 4	64	47
Immx + MSO + UAN	0.5 + 20 + 16	52	0
Fenx + Bent + MSO	1 + 8 + 20	6	2
Immx + Bent + MSO	0.5 + 8 + 20	9	0
Fenx + Bent + MSO	1 + 16 + 20	7	2
Fenx + Trib-sg + NIS	1 + 0.25 + 0.25%	64	35
Fenx + Atra + MSO	1 + 4 + 20	25	0
Fenx + Metr + MSO	1 + 4 + 20	17	5
Fenx + Fome-R + MSO	1 + 3 + 20	93	86
Fenx + Clsm + MSO	1 + 0.25 + 20	60	27
Fenx + Halo + NIS	1 + 0.4 + 0.25%	1	0
Fenx + Beta	1 + 7.8	18	10
Fenx + Rims	1 + 0.3	52	27
CV		8	55
LSD P=0.05		4	15

Sonalan in Hemp. Dr. Howatt and Mettler. Hemp variety X-59 was seeded near Fargo on May 29, 2020. Treatments were applied pre-emergence on May 29 with 61°F, 39% relative humidity, 15 % cloud-cover, 8 mph wind velocity at 345°, and dry soil surface at 62°F. Treatments were applied with a backpack sprayer delivering 17 gpa at 40 psi through 11002 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. Soil texture at this location is a silty clay with 3% sand, 48% silt and 49% clay. Evaluations for crop injury were conducted 14 and 28 days after treatment. Yield was obtained on September 14 2020.

Treatment	Rate	6/15 Hemp	6/30 Hemp	9/14 Yield
	-------OZ AI/A-------	----------%----------		--lb/acre--
Untreated Check		0	0	1203
Ethalfluralin (HH)	12	0	14	1992
Ethalfluralin (combine)	12	0	9	1540
Ethalfluralin	18	0	7	1376
Halosulfuron 1x	0.5	0	13	1326
Halosulfuron 2x	1	0	8	1647
Trifluralin 1x	12	0	8	1388
Trifluralin 2x	24	0	25	1298
Pendimethalin 1x	16	0	6	1420
Pendimethalin 2x	32	0	5	1645
CV		0	24	21
LSD P=0.05		.	3	443

This experiment compares an already Canadian labeled granular active ingredient ethalfluralin in the product Edge™ to similar and fairly safe pre-emergence herbicides at a 1x and 2x rate. No hemp injury was present at the first, 14 DAT evaluation. Pendimethalin was the safest herbicide followed closely by ethalfluralin. Trifluralin resulted in 25% hemp injury at the 2x rate. Other hemp experiments conducted in 2020 also show that Trifluralin at the 2x rate can cause significantly more injury than the 1x rate.

The analysis of yield above includes the hand harvested (HH) ethalfluralin treatment, which is not directly comparable to all combined treatments. When that treatment is removed from the analysis there is no statistical differences in yield between any of the treatments. There was a 40% yield difference between the combine and hand harvested ethalfuralin comparison. Numerically, halosulfuron and pendimethalin at the 2x yielded the most, followed by the 12oz ai/a rate of ethalfuralin. The LSD is similar to other hand harvested experiments showing just how variable hemp yield can be in small plot research. The percent injury from the herbicides in this experiment appear to have no effect on yield.

Volunteer Hemp Control in Row Crops Location 1. Dr. Howatt and Mettler. Hemp variety X-59 was seeded near Fargo on May 29, 2020. Treatments were applied to 3 to 4 leaf hemp between 3 to 8 inches on June 24 with 76°F, 50% relative humidity, 0% cloud-cover, 7 mph wind velocity at 45°, and dry soil surface at 75°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. A single evaluation was made approximately 14 days after treatment.

Treatment	Rate OZ AI/A, % V/V	7/7 Hemp -------%-------
Untreated Check		0
Immx + NIS + UAN (Raptor)	0.5 + 0.25 + 32	60
Trib-sg + NIS (Express SG)	0.18 + 0.25	71
Atra + PO (Aatrex 4L)	4 + 20	30
Metr + PO (Sencor)	4 +20	47
Bent 4L + PO (Basagran)	12 + 20	89
Gluf + AMS (Liberty 280)	9.3 + 32	94
Fome-R + PO (Reflex)	3 + 20	37
Oxff-GT + PO (Goal Tender)	3 + 20	30
Meso + PO (Callisto)	1.5 + 20	71
Topr + PO (Impact)	0.25 +20	57
CV		10
LSD P=0.05		8

Hemp is resilient and has the ability to overcome a variety of herbicides. The industry needs to have the ability to control volunteer hemp in succeeding crops. Glufosinate (Group 10) and bentazon (Group 14) resulted in the greatest amount of injury or control of volunteer hemp. Aztrazine (Group 5), oxyfluorfen (Group 14), and fomesafen (Group 14) had the lowest success in controlling volunteer hemp. In other post-emergence hemp experiments conducted this year, oxyfluorfen has proven to be very damaging to hemp (> 80% control), but control is sporadic and environment dependent. Glyphosate has been established as an effective means of controlling volunteer hemp if applied before the hemp gets too large, and therefore was not included as a treatment. No crop was planted in this experiment, so perhaps better control of hemp would be observed with crop competition present.

Volunteer Hemp Control in Row Crops Location 2. Dr. Howatt and Mettler. Hemp variety 'CFX-2' was seeded near Casselton on May 27, 2020. Treatments were applied to 2 to 6-inch hemp on June 24 with 68°F, 68% relative humidity, 0% cloud-cover, 3 mph wind velocity at 0°, and dry soil surface 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. A single evaluation was made approximately 14 days after treatment (DAT).

Treatment	Rate OZ AI/A, % V/V	7/9 Hemp -------%-------
Untreated Check		0
Immx + NIS + UAN (Raptor)	0.5 + 0.25 + 32	11
Trib-sg + NIS (Express SG)	0.18 + 0.25	27
Atra + PO (Aatrex 4L)	4 + 20	20
Metr + PO (Sencor)	4 +20	85
Bent 4L + PO (Basagran)	12 + 20	93
Gluf + AMS (Liberty 280)	9.3 + 32	97
Fome-R + PO (Reflex)	3 + 20	54
Oxff-GT + PO (Goal Tender)	3 + 20	7
Meso + PO (Callisto)	1.5 + 20	67
Topr + PO (Impact)	0.25 +20	30
CV		15
LSD P=0.05		10

Hemp is resilient and if not adequately controlled by 14 DAT has the ability to overcome a variety of herbicides. Note that CFX-2 cultivar was planted at location 2 rather than X-59. X-59 is known to be a little more herbicide susceptible. Similar to location 1, Glufosinate (Group 10) and bentazon (Group 14) resulted in the greatest amount of injury or control of volunteer hemp. Metribuzin (Group 5) had 85% control at this location compared to only 47% control at location 1. Imazamox and tribenuron, the Group 2 herbicides have variable levels of control across locations as well. Group 2 herbicides and oxyfluorfen resulted in the lowest volunteer hemp control in this experiment.

Hemp Cultivar Response to Bromoxynil. Dr. Howatt and Mettler. Hemp varieties ‘CFX-2’, ‘Katani’, ‘Grandi’, ‘Altair’, ‘X-59’ were seeded near Fargo on May 29, 2020. A blanket treatment of sonolan was applied preemergence on May 29 with 61°F, 44% relative humidity, 15% cloud-cover, 8 mph wind velocity at 0°, and dry soil surface at 62°F. The first POST application was applied to cotyledon hemp on June 16 at 74°F, 69% relative humidity, 0% cloud-cover, 4 mph wind velocity at 135°, and dry soil surface at 72°F. The second POST timing was applied to 2 leaf hemp around 2 to 6 inches on June 19 with 57°F, 57% relative humidity, 20% cloud-cover, 3 mph wind velocity at 315°, and dry soil surface at 70°F. The third POST timing was applied to 4 leaf hemp on June 24 with 76°F, 53% relative humidity, 0% cloud-cover, 5 mph wind velocity at 0°, and moist soil surface at 70°F. POST 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 OZ AI/A	Growth Stage	6/25 Hemp ---%---
Nontrt			0
Brox-2	4	COTY	24
Brox-2	8	COTY	77
Brox-2	4	2L	17
Brox-2	8	2L	49
Brox-2	4	4L	3
Brox-2	8	4L	9
CV			41
LSD P=0.05			14

Visible hemp injury ratings were made about 10 days after the cotyledon stage application and just a day after the 4 leaf pair application. Injury was only observed in the X-59 cultivar, a more susceptible line. Greater injury occurred at the cotyledon stage as compared to the later application timings. With a second evaluation timing, it would be expected that the injury would reduce over time as seen in our other hemp experiments. This experiment suggests that applying bromoxynil to 4 leaf pair hemp and larger would be safe. Hemp is a very resilient crop, and has been observed to not reduce yield even after 35% visible injury due to herbicides. The experiment was conducted because bromoxynil appears to be one of the safest post-emergence herbicides on hemp.

Hemp Cultivar Response to Bromoxynil. Dr. Howatt and Mettler. Hemp varieties ‘CFX-2’, ‘Katani’, ‘Grandi’, ‘Altair’, ‘X-59’ were seeded near Casselton on May 27, 2020. A blanket treatment of sonolan was applied preemergence on May 27 with 72°F, 54% relative humidity, 0% cloud-cover, 2 mph wind velocity at 270°, and dry soil surface at 62°F. The first POST application was applied to cotyledon hemp on June 5 at 84°F, 45% relative humidity, 5% cloud-cover, 7 mph wind velocity at 315°, and dry soil surface at 72°F. The second POST timing was applied to 2 leaf hemp on June 12 with 71°F, 52% relative humidity, 15% cloud-cover, 8 mph wind velocity at 45°, and dry soil surface at 68°F. The third POST timing was applied to 4 leaf hemp around 2 to 6 inches tall on June 24 with 69°F, 68% relative humidity, 0% cloud-cover, 3 mph wind velocity at 0°, and moist soil surface at 70°F. POST 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. Percent hemp injury evaluations only took place on June 25, 20 days after the first application timing. The experiment was lost due to wet soil conditions shortly after the last application was applied.

Treatment	Rate OZ AI/A	Growth Stage	6/25 Hemp -------%-------
Nontrt			0
Brox-2	4	COTY	0
Brox-2	8	COTY	0
Brox-2	4	2L	0
Brox-2	8	2L	0
Brox-2	4	4L	2
Brox-2	8	4L	8
CV			92
LSD P=0.05			2

Visible hemp injury was only observed on the X-59 cultivar at the 4 leaf pair timing, represented in the table above. Other research indicates that the X-59 is one of the more susceptible cultivars to bromoxynil. Bromoxynil in this experiment was considered a rather safe application to hemp. Experiment Hemp2015 is the second location of this experiment, where more injury occurred due to the application of bromoxynil.

Industrial Hemp response to post-emergent herbicides location 1. Dr. Howatt and Mettler. Hemp cultivar X-59 was seeded near Fargo on May 29, 2020. Treatments were applied to hemp with 3 leaf pairs that was 4 inches tall on June 19 with 76°F air temperature, 40% relative humidity, 30% cloud-cover, 2-4 mph wind velocity at 225°, and dry soil surface at 71°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 10-foot-wide area the length of 12 by 30-foot plots. The experiment was a randomized complete block design with four replicates. Hemp injury evaluations were made at 7 and 21 days after treatment was applied. Yield was obtained from the 1x treatments on September 8, 2020.

Treatment	Rate**	7/29 Hemp	7/9 Hemp	9/8 Yield
	-- oz ai/a --	----------%----------		--lbs/acre--
Untreated Check	0	1	1	897
Hand-weeded	0	0	2	2057
Cloransulam + NIS + AMS (1x)	0.26 + 0.25 + 8.5	78	71	358
Cloransulam + NIS + AMS (2x)	0.52 + 0.25 + 8.5	83	85	-
Imazamox + NIS + AMS (1x)	0.5 + 0.25 + 8.5	65	56	842
Imazamox + NIS + AMS (2x)	1.0 0.25 + 8.5	75	64	-
Clopyralid (1x)	1.5	8	10	975
Clopyralid (2x)	3.0	5	9	-
Quinclorac + MSO (1x)	4.14 + 2.2	8	30	1231
Quinclorac + MSO (2x)	8.3 + 2.2	12	45	-
Bromoxynil (1x)	4	34	11	2115
Bromoxynil (2x)	8	55	26	-
Atrazine + PO (1x)	8 + 1.0	43	23	1236
Atrazine + PO (2x)	16 + 1.0	71	41	-
Oxyfluorfen + NIS (1x)	16 + 0.25	93	84	1694
Oxyfluorfen + NIS (2x)	32 + 0.25	96	91	-
CV		15	18	28
LSD P=0.05		10	11	511

** AMS was applied at 8.5 pounds per 100 gallons, and adjuvants as % v/v

In general, post applications of herbicides to industrial hemp are rather injurious. In terms of visible injury symptoms, clopyralid at the 1x and 2x rates and bromoxynil at the 1x rate are fairly safe having been evaluated to have 10% injury or less 21 DAT. Bromoxynil at the 2x rate and quinclorac and atrazine had less than 30% injury 21 DAT. Hemp injury symptoms increased from 7 DAT to 21 DAT with applications of quinclorac, and remained the same for applications of cloransulam and imazamox. Bromoxynil and atrazine treatments decreased in hemp injury over time. Cloransulam, imazamox, clopyralid, quinclorac, and atrazine all negatively affected yield compared to the hand-weeded check. Oxyfluorfen had greater than 80% injury yet the yield was not different than the hand-weeded check. This proves hemp's resilience to bounce back after herbicide injury. Based on hemp injury and yield, according to this experiment the only viable option for post-emergent weed control in hemp is bromoxynil.

Industrial Hemp response to pre-emergent herbicides location 1. Dr. Howatt and Mettler. Hemp cultivar X-59 was seeded near Fargo on May 29, 2020. All treatments were applied pre-emergence on May 29 right after planting, except for trifluralin which was applied and incorporated using a roto tiller prior to planting. Conditions were as follows, 61°F air temperature, 46% relative humidity, 25 % cloud-cover, 10 mph wind velocity at 0°, and dry soil surface at 64°F. Treatments were applied with a backpack sprayer delivering 17 gpa at 40 psi through 11002 TT nozzles to a 10-foot-wide area the length of 12 by 30-foot plots. The experiment was a randomized complete block design with four replicates. Soil texture at this location is a silty clay with 3% sand, 48% silt and 49% clay. Hemp injury evaluations were made a 7, 14 and 28 days after hemp emerged. Yield was obtained from the 1x treatments on September 8, 2020.

Treatment	Rate	6/13 Hemp	6/23 Hemp	7/3 Hemp	9/8 Yield
	-- oz ai/a --	----------%----------			--- lb/acre---
Untreated Check	0	0	3	0	1806
Hand-weeded	0	0	3	1	2441
Imazethapyr (1x)	0.63	4	18	17	2267
Imazethapyr (2x)	1.26	7	35	36	-
Pendimethalin (1x)	16	0	9	6	1732
Pendimethalin (2x)	32	0	10	6	-
Trifluralin (1x)	12	2	14	9	2028
Trifluralin (2x)	24	1	8	8	-
Quinclorac (1x)	4.14	0	6	5	1835
Quinclorac (2x)	8.3	1	7	6	-
Saflufenacil (1x)	0.54	11	11	6	2336
Saflufenacil (2x)	1.08	19	30	19	-
Acetochlor (1x)	15	15	16	15	2011
Acetochlor (2x)	30	32	41	28	-
Pyroxasulfone (1x)	1.66	4	9	5	1952
Pyroxasulfone (2x)	3.1	5	6	5	-
CV		43	42	60	16
LSD P=0.05		4	8	9	490

Pendimethalin, trifluralin, quinclorac, saflufenacil, acetochlor and pyroxasulfone at the 1x rate were rather safe to hemp resulting near 15% or less injury at all evaluation timings. Saflufenacil and acetochlor were injurious to hemp at the 2x rate. Pendimethalin, quinclorac and pyroxasulfone resulted in the least amount of hemp injury overall. All herbicide treatment injury symptoms apart from imazethapyr reduced in intensity over time. Similar to 2019, the 2x or overlap rate of acetochlor (>30% injury) is concerning, and could eliminate acetochlor as a viable pre-emergent herbicide for use in industrial hemp. When comparing to the hand-weeded check, pendimethalin, quinclorac and pyroxasulfone negatively impacted yield.

Industrial Hemp response to post-emergent herbicides location 2. Dr. Howatt and Mettler. Hemp cultivar 'X-59' was seeded near Hillsboro on June 2, 2020. Treatments were applied to hemp with 2 leaf pairs that were 2-4" inches tall on June 19 with 88°F air temperature, 37% relative humidity, 30% cloud-cover, 4-5 mph wind velocity at 225°, and dry soil surface at 71°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 10-foot-wide area the length of 12 by 30-foot plots. The experiment was a randomized complete block design with four replicates. Hemp injury evaluations were made at 7 and 21 days after treatment was applied. Yield was obtained from the 1x treatments on September 2, 2020.

Treatment	Rate**	7/29 Hemp	7/9 Hemp	9/2 Yield
	-- oz ai/a --	--------%---------		--lbs/acre--
Untreated Check	0	2	0	810
Hand-weeded	0	18	4	1717
Cloransulam + NIS + AMS (1x)	0.26 + 0.25 + 8.5	89	86	234
Cloransulam + NIS + AMS (2x)	0.52 + 0.25 + 8.5	90	93	-
Imazamox + NIS + AMS (1x)	0.5 + 0.25 + 8.5	71	54	1819
Imazamox + NIS + AMS (2x)	1.0 0.25 + 8.5	75	63	-
Clopyralid (1x)	1.5	27	7	1173
Clopyralid (2x)	3.0	11	8	-
Quinclorac + MSO (1x)	4.14 + 2.2	35	32	987
Quinclorac + MSO (2x)	8.3 + 2.2	23	37	-
Bromoxynil (1x)	4	55	41	1428
Bromoxynil (2x)	8	81	66	-
Atrazine + PO (1x)	8 + 1.0	76	51	1566
Atrazine + PO (2x)	16 + 1.0	93	80	-
Oxyfluorfen + NIS (1x)	16 + 0.25	97	95	211
Oxyfluorfen + NIS (2x)	32 + 0.25	99	99	-
CV		19	27	23
LSD P=0.05		13	16	328

** AMS was applied at 8.5 pounds per 100 gallons, and adjuvants as % v/v

Hemp injury from clopyralid and quinclorac at the 1x and 2x rates are within the range of being fairly safe. The remaining treatments are not visually pleasing due to the hemp injury, including bromoxynil. X-59 is probably the most susceptible cultivar to bromoxynil. Cloransulam, quinclorac, clopyralid and oxyfluorfen negatively affected yield compared to the hand-weeded check. This is one of the only experiments where imazamox did not negatively impact yield. Atrazine at the 1x rate typically has yielded similarly to the hand-weeded check or has had a slight negative impact. The visible injury from atrazine may not be easily overcome. According to this there are no prime candidates for post-emergent applications in industrial hemp, without sacrificing yield or the aesthetics of the crop. However, there are options better than the untreated alternative.

Important to note, that results are not consistent across locations, as the oxyfluorfen treatment severely impacted yield at the Prosper location. Atrazine did have a neutral yield response at both the Hillsboro and Prosper locations while obtaining good weed control.

Industrial Hemp response to pre-emergent herbicides location 2. Dr. Howatt and Mettler. Hemp cultivar 'X-59' was seeded near Hillsboro on June 2, 2020. All treatments were applied pre-emergence on June 2 right after planting, except for trifluralin which was applied and incorporated using a roto tiller prior to planting. Conditions were as follows, 72°F air temperature, 53% relative humidity, 90% cloud-cover, 0-1 mph wind velocity, and dry soil surface at 72°F. Treatments were applied with a backpack sprayer delivering 17 gpa at 40 psi through 11002 TT nozzles to a 10-foot-wide area the length of 12 by 30-foot plots. The experiment was a randomized complete block design with four replicates. Soil texture at this location is a sandy loam with 60% sand, 29% silt and 11% clay. Hemp injury evaluations were made a 7, 14 and 28 days after hemp emerged. Yield was obtained from the 1x treatments on September 2, 2020.

Treatment	Rate	6/15 Hemp	6/23 Hemp	7/4 Hemp	9/2 Yield
	-- oz ai/a --	----------%----------			--lb/acre--
Untreated Check	0	0	2	0	1486
Hand-weeded	0	0	3	1	2175
Imazethapyr (1x)	0.63	5	16	5	2355
Imazethapyr (2x)	1.26	9	16	7	-
Pendimethalin (1x)	16	10	8	4	1987
Pendimethalin (2x)	32	11	13	9	-
Trifluralin (1x)	12	6	10	5	2101
Trifluralin (2x)	24	6	11	9	-
Quinclorac (1x)	4.14	7	6	9	1485
Quinclorac (2x)	8.3	12	12	25	-
Saflufenacil (1x)	0.54	12	12	6	2345
Saflufenacil (2x)	1.08	19	18	12	-
Acetochlor (1x)	15	19	16	14	2153
Acetochlor (2x)	30	35	43	41	-
Pyroxasulfone (1x)	1.66	12	13	7	2046
Pyroxasulfone (2x)	3.1	15	18	20	-
CV		31	45	59	14
LSD P=0.05		5	9	9	403

Imazethapyr, pendimethalin and trifluralin were rather safe to hemp resulting in near 15% injury or less at both rates and all evaluation timings. Saflufenacil and pyroxasulfone had less than 20% injury. The 2x rate of acetochlor was the most injurious. All yields except for quinclorac were statistically similar to the hand-weeded check. Quinclorac negatively affected yield at 2 of 3 locations in 2020. Between that and the limited weed control spectrum, quinclorac may not be a viable option for use in hemp. At the conclusion of pre-emergent experiments in 2020 the most likely herbicides for further evaluation are pendimethalin, trifluralin and pyroxasulfone. Saflufenacil and imazethapyr are borderline candidates has they tend to cause greater hemp injury, but typically do not negatively impact yield. Acetochlor is likely ruled out due to some negative impacts on yield, but also the higher injury observed at the 2x, overlap rate.

Industrial Hemp response to post-emergent herbicides location 3. Dr. Howatt and Mettler. Hemp cultivar 'X-59' was seeded near Prosper on May 29, 2020. Treatments were applied to hemp with 3 to leaf pairs that was 2-6 inches tall on June 19 with 81°F air temperature, 50% relative humidity, 50% cloud-cover, 3-5 mph wind velocity at 270°, and dry soil surface at 83°F. Treatments were applied with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 TT nozzles to a 10-foot-wide area the length of 12 by 30-foot plots. The experiment was a randomized complete block design with four replicates. Hemp injury evaluations were made at 7 and 21 days after treatment was applied. Yield was obtained from the 1x treatments on September 3, 2020.

Treatment	Rate**	7/6 Hemp	7/16 Hemp	9/18 Yield
	-- oz ai/a --	--------%---------		-lbs/acre-
Untreated Check	0	6	3	2035
Hand-weeded	0	4	8	2350
Cloransulam + NIS + AMS (1x)	0.26 + 0.25 + 8.5	83	75	1220
Cloransulam + NIS + AMS (2x)	0.52 + 0.25 + 8.5	86	80	-
Imazamox + NIS + AMS (1x)	0.5 + 0.25 + 8.5	79	61	1618
Imazamox + NIS + AMS (2x)	1.0 0.25 + 8.5	79	68	-
Clopyralid (1x)	1.5	21	13	2407
Clopyralid (2x)	3.0	13	6	-
Quinclorac + MSO (1x)	4.14 + 2.2	16	31	2091
Quinclorac + MSO (2x)	8.3 + 2.2	17	43	-
Bromoxynil (1x)	4	40	23	2153
Bromoxynil (2x)	8	46	28	-
Atrazine + PO (1x)	8 + 1.0	44	17	2229
Atrazine + PO (2x)	16 + 1.0	76	56	-
Oxyfluorfen + NIS (1x)	16 + 0.25	97	97	651
Oxyfluorfen + NIS (2x)	32 + 0.25	98	99	-
CV		24	24	19
LSD P=0.05		17	15	517

** AMS was applied at 8.5 pounds per 100 gallons, and adjuvants as % v/v

Clopyralid at the 1x and 2x rates were the safest treatments, maintaining injury levels below 25%. Clopyralid did not negatively impact yield compared to the untreated or hand-weeded checks. Cloransulam and Oxyfluorfen resulted in 75% or greater hemp injury at both rates and timings. This amount of visible injury will not allow for commercial use of these products on hemp. Yield was also significantly reduced in the cloransulam, oxyfluorfen and imazamox treatments. Hemp injury from quinclorac and atrazine at the 1x rate ranged from 17 to 31% injury at 21 DAT which is within that acceptable range, if one was able tolerant the early season injury at 7 DAT.

Industrial Hemp response to pre-emergent herbicides location 3. Dr. Howatt and Mettler. Hemp cultivar 'X-59' was seeded near Prosper on May 29, 2020. All treatments were applied pre-emergence on May 29 right after planting, except for trifluralin which was applied and incorporated using a roto tiller prior to planting. Conditions were as follows, 52°F air temperature, 62% relative humidity, 9 mph wind velocity at 0°, and dry soil surface at 60°F. Treatments were applied with a backpack sprayer delivering 17 gpa at 40 psi through 11002 TT nozzles to a 10-foot-wide area the length of 12 by 30-foot plots. The experiment was a randomized complete block design with four replicates. Soil texture at this location is a silt loam with 23% sand, 53% silt and 25% clay. Hemp injury evaluations were made a 7, 14 and 28 days after hemp emerged. Yield was obtained from the 1x treatments on September 3, 2020.

Treatment	Rate	6/13 Hemp	6/22 Hemp	7/3 Hemp	9/3 Yield
	-- oz ai/a --	----------%----------			--lb/acre--
Untreated Check	0	11	10	2	1391
Hand-weeded	0	16	9	1	1650
Imazethapyr (1x)	0.63	30	19	8	1628
Imazethapyr (2x)	1.26	28	24	18	-
Pendimethalin (1x)	16	19	10	7	1649
Pendimethalin (2x)	32	23	12	12	-
Trifluralin (1x)	12	24	16	8	1676
Trifluralin (2x)	24	25	22	19	-
Quinclorac (1x)	4.14	13	12	6	1627
Quinclorac (2x)	8.3	28	24	11	-
Saflufenacil (1x)	0.54	48	41	19	1521
Saflufenacil (2x)	1.08	74	74	55	-
Acetochlor (1x)	15	51	40	26	1363
Acetochlor (2x)	30	70	74	69	-
Pyroxasulfone (1x)	1.66	28	21	11	1420
Pyroxasulfone (2x)	3.1	25	31	25	-
CV		34	28	47	28
LSD P=0.05		16	11	12	642

The Prosper location during the days of emergence experienced heavy rain and high winds. If emergence was delayed due to the herbicide, the plants were smaller and more vulnerable during this event. This location may not be directly comparable to other locations of this experiment, but can still indicate crop safety relative to each other, but perhaps at a higher magnitude. At 28 DAT, imazethapyr, pendimethalin, trifluralin, quinclorac and pyroxasulfone all had less than 25% injury at both rates. Saflufenacil and acetochlor has significant injury at the 2x rate. All yields were statistically similar to the hand-weeded check.

Cover Crop Tolerance of Soybean Herbicides. Dr. Howatt and Mettler. ND17009GT soybean was planted near Fargo, ND on May 20, 2020. Pre-emergence treatments were applied on June 1 at 91°F, 37% relative humidity, 5% cloud-cover, 4 mph wind velocity at 225°, and dry soil surface at 80°F. POST application treatments were applied to V2 soybeans, 2 to 4 leaf yellow foxtail, 2 to 4 leaf venice mallow, and 2 to 4 leaf redroot pigweed on June 24 at 79°F, 40% relative humidity, 10% cloud-cover, 3 mph wind velocity at 45°, and dry soil surface at 78°F. A pre-plant burndown of Paraquat was applied on August 27, 2020 with 76°F, 69% relative humidity, 10% cloud-cover, 3mph wind velocity at 45°, and dry soil surface at 78°F. Pre-treatments were applied with a backpack sprayer delivering 17 gpa at 40 psi through 11002 TT nozzles to a 7-foot-wide area the length of 10 by 30 foot plots. POST treatments were applied at 8.5 gpa at 40 psi through 11001 TT nozzles. The experiment was a randomized complete block design with four replicates. Soybean was mowed on August 11, 2020, and cover crops were planted on September 9, 2020. Cover crops included winter rye, barley, fieldpea/lentils, Flax, forage radish+turnip, and canola (Cibus var. C5507).

			9/18	9/25	10/2	10/9	10/16	11/5
	Treatment	Rate	All	All	All	All	All	All
		----OZ AI/A, %V----	----------%----------					
1	Untreated Check							
2	Metr-4F	0.25	0	0	0	0	0	0
3	Suen (Spartan)	6	0	0	0	0	0	0
4	Flum (Valor EZ)	1.5	0	0	0	0	0	0
5	Pysf-SC	2.6	0	0	0	0	0	0
6	Imep	0.75	0	0	0	0	0	0
7	Suen / Fome-F + MSO	6 / 2.82 + 24	0	0	0	0	0	0
8	Dica-E + CARidion	8 + 2	0	0	0	0	0	0
9	Fome-F + MSO	2.82 + 24	0	0	0	0	0	0
10	Gluf + AMS	9.4 + 48	0	0	0	0	0	0
11	Immx + MSO + UAN	0.625 +24 + 2.5	0	0	0	0	0	0
	CV		0	0	0	0	0	0
	LSD P=0.5		.	.	.	.	.	.

*All: all cover crop species.

Mustard and Buckwheat Response to PRE Herbicides Location 1. Dr. Howatt and Mettler. Tinley Mustard and Koma Buckwheat (last pass of 3-4 rep Mancan) were planted near Fargo on May 12, 2020. Pre-emergence treatments were applied on May 12 with 56°F, 24% relative humidity, 80% cloud-cover, 5 mph wind velocity at 225°, and damp soil surface at 52°F. Treatments were applied with a backpack sprayer delivering 17 gpa at 40 psi through 11002 TT nozzles to a 7-foot wide area the length of 10 by 30 foot plots. Soil texture at this location is a silty clay with 3% sand, 48% silt and 49% clay. The experiment was a randomized complete block design with four replicates. Visible Crop injury evaluations were conducted 21 and 35 days after treatment.

Treatment	Rate	6/2 Mustard	6/2 Buckwheat	6/15 Mustard	6/15 Buckwheat
	OZ AI/A	----------%----------			
Untreated Check		0	0	0	0
Imazethapyr	0.5	0	0	60	32
Pendimethalin-h	20	0	0	3	2
Metribuzin-F	4	0	0	7	6
Sulfentrazone	4	0	0	27	63
Saflufenacil	0.72	0	0	42	25
S-Metolachlor	26	0	0	8	2
Dimethenamid-P	16	0	0	15	15
Pyroxasulfone	2.5	0	0	7	7
Mesotrione	2.5	0	0	50	6
CV		0	0	31	46
LSD P=0.5		.	.	10	11

Herbicides did not develop visible injury symptoms until the 35 DAT evaluations.

Mustard: Pendimethalin, metribuzin, s-metolachlor, pyroxasulfone and dimethenamid resulted in less than 15% injury and can be considered for further study. However, between both locations, pendimethalin proved to be the least injurious overall. Mesotrione, saflufenacil, and imazethapyr resulted in greater than 40% injury and shouldn't be considered for use in mustard.

Buckwheat: Buckwheat injury response was quite variable between locations. S-metolachlor (Group 15), pendimethalin (3), mesotrione (27), metribuzin (5), and pyroxasulfone (15) all resulted in less than 10% injury at this location. Moderate injury was observed from saflufenacil (14) and imazethapyr (2). S-metolachlor continuously safe across both locations.

Mustard and Buckwheat Response to Broadleaf Herbicides Location 1. Dr. Howatt and Mettler. Tinley Mustard and Koma Buckwheat (last pass of 3-4 rep Mancan) were planted near Fargo on May 12, 2020. Treatments were applied to 4 to 8-leaf mustard, 2 to 5-inch buckwheat on June 11 with 72°F, 49% relative humidity, 0% cloud-cover, 7 mph wind velocity at 270° and dry soil surface 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. Percent visible herbicide injury was evaluated 14 and 28 days after treatment (DAT).

Treatment	Rate	6/25 Must	6/25 Bckwt	7/10 Must	7/10 Bckwt
	--OZ AI/A, %V--	----------%----------			
Untreated Check		0	0	0	0
Ethometsulfuron (Muster) + NIS	0.25 + 0.25%	30	14	17	9
Cloransulam (FirstRate) + NIS + AMS	0.3 + 0.25% + 11	92	86	97	95
2,4-D amine 4 + PO	2 + 20	85	75	96	66
Clopyralid + PO (Stinger)	1.5 + 20	15	11	10	10
Halauxifen (Elevore)+ PO	0.08 + 20	25	34	11	69
Quinclorac (Facet) + PO	4 + 20	22	14	15	4
Metribuzin-4F + PO	4 + 20	72	50	70	37
Phenmedipham (Spin-aid) + PO	8 + 20	67	49	52	30
Desmedipham (Betanex)+ PO	10 + 20	67	60	57	32
Bentazon-4SL + PO	6 + 20	81	80	88	71
Pyridate (Tough) + PO	12 + 20	60	32	70	21
Fomesafen (Reflex) + PO	3 + 20	96	96	97	95
Flumiclorac (Resource) + PO	0.215 + 20	32	35	22	30
Carfentrazone (AIM)+ NIS	0.128 + 0.25%	54	95	40	92
Pyraflufen (ET) + NIS	0.02 + 0.25%	34	84	16	66
CV		11	19	10	11
LSD P=0.5		8	14	7	7

Mustard and Buckwheat Response to Grass Herbicides Location 1. Dr. Howatt and Mettler. Tinley Mustard and Koma Buckwheat (last pass of 3-4 rep Mancan) were planted near Fargo on May 12, 2020. First application treatments were applied to 4 to 8-leaf mustard and 2 to 5-inch buckwheat on June 11 at 72°F, 49% relative humidity, 0% cloud-cover, 7 mph wind velocity at 270°, and dry soil surface at 70°F. The second application treatments were applied to 15" mustard (bloom), 8" buckwheat (late bud) on June 24 at 76°F, 53% relative humidity, 0% cloud-cover, 5 mph wind velocity at 0° and dry soil surface at 70°F. The third application treatments were applied to 18 to 22" mustard (full bloom), 12" buckwheat (bloom) on June 30 with 78°F, 79% relative humidity, 80% cloud-cover, 4 mph wind velocity at 115° and damp soil surface at 74°F. Desiccation occurred on September 9 at 50°F, 70% relative humidity, 0% cloud-cover, 2 mph wind velocity at 225°, and dry soil surface at 52°F to obtain uniform maturity and ease harvest. 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. Yield was unable to be obtained as broadleaf weeds made the plots impassible with the plot combine.

		6/19	6/19	6/25	6/25	7/10	7/10	7/15	7/15	7/23	7/23
	Rate	Must	Bwht	Must	Bwht	Must	Bwht	Must	Bwht	Must	Bwht
Treatment	OZ AI/A, % V/V	----------%----------									
Untreated Check		0	0	0	0	0	0	0	0	0	0
Clethodim SM + NIS	1.5 + 0.25	0	0	9	0	0	0	0	0	0	0
Fluazifop + PO	3 + 20	0	0	0	0	0	0	0	0	0	0
Quizalofop + PO	0.9 + 20	0	0	0	0	0	0	0	0	0	0
Sethoxydim + PO	5 + 20	0	0	0	0	0	0	0	0	0	0
Quizalofop + PO	1.8 + 20	0	0	5	0	0	0	0	0	0	0
Clethodim SM + NIS	1.5 + 0.25	0	0	0	0	0	0	0	0	0	0
Quizalofop + PO	0.9 + 20	0	0	0	0	0	0	0	0	0	0
Quizalofop + PO	1.8 + 20	0	0	0	0	0	0	0	0	0	0
Clethodim SM + NIS	1.5 + 0.25	0	0	0	0	0	0	0	0	0	0
Quizalofop + PO	0.9 + 20	0	0	0	0	0	0	0	0	0	0
CV		0	0	64	0	0	0	0	0	0	0
LSD P=0.05		.	.	1	.	.	.	.	.	.	.

Out of all the evaluations, clethodim, and quizalofop resulted in very minor injury on mustard at a single evaluation. No injury was observed on buckwheat. As expected, herbicides used to control grassy weeds should not show visible injury to broadleaf crops. Yield data would have been complementary and needed to confirm no negative response to yield due to the herbicide, but was unattainable.

Mustard and Buckwheat Response to Incorporated Herbicides Location 1. Dr. Howatt and Mettler. Tinley Mustard and Koma Buckwheat (last pass of 3-4 rep Mancan) were planted near Fargo on May 12, 2020. Pre-emergence treatments were applied on May 12 and incorporated immediately after application. Air temperature at application was 59°F, 23% relative humidity, 80% cloud-cover, 5 mph wind velocity at 225° and damp soil surface at 54°F. Treatments were applied with a backpack sprayer delivering 17 gpa at 40 psi through 11002 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. Soil texture at this location is a silty clay with 3% sand, 48% silt and 49% clay. Percent visible injury was evaluated at 21 and 28 days after treatment

Treatment	Rate	6/2 Mustard	6/2 Buckwheat	6/15 Mustard	6/15 Buckwheat
	OZ AI/A	----------%----------			
Untreated Check		0	0	0	0
Pendimethalin (No Incrop)	20	0	0	2	10
Pendimethalin	20	0	0	3	16
Trifluralin	12	0	0	42	40
Ethalfluralin	12	0	0	9	31
Triallate	16	0	0	6	1
EPTC	48	0	0	24	30
CV		0	0	44	55
LSD P=0.05		.	.	8	15

Mustard: Pendimethalin, ethalfluralin and triallate all resulted in less than 10% injury 28 days after treatment. Incorporation of pendimethalin did not have any influence on the degree of injury observed. EPTC and trifluralin was the most injurious.

Buckwheat: Triallate and pendimethalin (unincorporated) were statistically not any different than the untreated check. Pendimethalin incorporated did show slightly more injury than the unincorporated. EPC, ethalfluralin and trifluralin resulted in the most injury, between 30 and 40%. A few of these herbicides are showing promise and should be studied further for their use and registration on buckwheat.

Mustard and Buckwheat Response to PRE Herbicides Location 2. Dr. Howatt and Mettler. Tinley Mustard and Koma Buckwheat were planted near Hillsboro on June 2, 2020. Pre-emergence treatments were applied on June 2 after planting. Air temperature at application was 68°F, 34% relative humidity, 50% cloud-cover, 3 mph wind velocity at 270° and dry soil surface at 74°F. Treatments were applied with a backpack sprayer delivering 17 gpa at 40 psi through 11002 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. Soil texture at this location is a sandy loam with 60% sand, 29% silt and 11% clay. Evaluations for percent visible crop injury was made at 14, 28 and 35 days after treatment. Mustard was not evaluated due to heavy flea beetle damage.

Treatment	Rate	6/15 must	6/15 bwht	6/30 must	6/30 bwht	7/8 bwht
	OZ AI/A	----------%----------				
Untreated Check		0	0	0	0	0
Imazethapyr	0.5	65	53	86	74	90
Pendimethalin-h	20	11	26	9	23	70
Metribuzin-F	4	76	46	80	29	20
Sulfentrazone	4	48	50	39	34	29
Saflufenacil	0.72	91	69	99	59	65
S-Metolachlor	26	26	23	25	8	1
Dimethenamid-P	16	50	33	35	14	8
Pyroxasulfone	2.5	79	55	86	31	16
Mesotrione	2.5	86	66	99	54	21
CV		20	29	30	55	31
LSD P=0.05		15	18	24	26	14

Mustard: Pendimethalin was fairly safe on mustard at both the 14 and 28 DAT. S-metolachlor had 25% injury at both evaluations. All other herbicides resulted in significant injury.

Buckwheat: Significant injury occurred on nearly all treatments 14 DAT. S-metolachlor and pendimethalin were the least injurious at around 25% injury. Visible injury generally decreased by 28 DAT. Imazethapyr, pendimethalin and saflufenacil continued to show more injury as evaluations continued. Group 15 herbicides, s-metolachlor and dimethenamid were rather safe on buckwheat by 35 DAT. Pyroxasulfone (Group 15), metribuzin (Group 5), mesotrione (Group 27) and sulfentrazone (Group 14) resulted in light to moderate herbicide injury (15-30%) by 35 DAT. Saflufenacil (Group 14), pendimethalin (Group 3) and imazethapyr (Group 2) resulted in significant injury to the point where those herbicides do not warrant additional research for use in buckwheat.

Mustard and Buckwheat Response to Broadleaf Herbicides Location 2. Dr. Howatt and Mettler. Tinley Mustard and Koma Buckwheat were planted near Hillsboro on June 2, 2020. Treatments were applied to 2 to 6-leaf (1 to 3-inch) mustard, 4 to 6-leaf (2 to 5-inch) buckwheat on June 24 with 72°F, 65% relative humidity, 0% cloud-cover, 2 mph at 30°, and dry soil surface at 72°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. Percent visible herbicide injury was evaluated 14 days after treatment. Flea beetles caused significant injury resulting in the loss of mustard plants and thus no evaluation.

Treatment	Rate	7/8 Buckwheat
	OZ AI/A, % V/V	----------%----------
Untreated Check		0
Ethometsulfuron (Muster) + NIS	0.25 + 0.25%	26
Cloransulam (FirstRate) + NIS + AMS	0.3 + 0.25% + 11	94
2,4-D amine 4 + PO	2 + 20	69
Clopyralid + PO (Stinger)	1.5 + 20	4
Halauxifen (Elevore)+ PO	0.08 + 20	81
Quinclorac (Facet) + PO	4 + 20	6
Metribuzin-4F + PO	4 + 20	66
Phenmedipham (Spin-aid) + PO	8 + 20	77
Desmedipham (Betanex)+ PO	10 + 20	25
Bentazon-4SL + PO	6 + 20	76
Pyridate (Tough) + PO	12 + 20	81
Fomesafen (Reflex) + PO	3 + 20	95
Flumiclorac (Resource) + PO	0.215 + 20	67
Carfentrazone (AIM)+ NIS	0.128 + 0.25%	98
Pyraflufen (ET) + NIS	0.02 + 0.25%	94
CV		8
LSD P=0.05		7

Similar to location 1, ethometsulfuron (2), clopyralid (4) and quinclorac (4) were the three safest herbicides at both the locations. In addition, at this location desmedipham only resulted in 25% injury, whereas it caused 60% injury at the first location. All other herbicides resulted in greater than 60% injury at this location.

Mustard and Buckwheat Response to Grass Herbicides Location 2. Dr. Howatt and Mettler. Tinley Mustard and Koma Buckwheat were planted near Hillsboro on June 2, 2020. First application treatments were applied to 1 to 3-inch mustard, 2 to 5-inch buckwheat on June 24 at 72°F, 65% relative humidity, 0% cloud-cover, 2 mph wind velocity at 30°, and dry soil surface at 72°F. Heavy flea beetle damage on the mustard, so buckwheat is the only crop left. The second application treatments were applied to 6 to 8-inch buckwheat (flower buds) on June 30 at 82°F, 80% relative humidity, 60% cloud-cover, 6 mph wind velocity at 135° and dry soil surface at 83°F. The third application treatments were applied to 14 to 18-inch buckwheat (full bloom) on July 8 with 81°F, 72% relative humidity, 40% cloud-cover, 3 mph wind velocity at 270° and damp soil surface 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.

			6/30	7/8	7/15	7/23	9/15
Treatment	Rate	Timing	bwht	bwht	bwht	bwht	Yield
			----------%----------				-lb/acre-
Untreated Check			0	0	0	0	1352
Clethodim SM + NIS	1.5 + 0.25	4-6 L	0	0	0	0	1127
Fluazifop + PO	3 + 20	4-6 L	0	0	0	0	1388
Quizalofop + PO	0.9 + 20	4-6 L	0	0	0	0	1202
Sethoxydim + PO	5 + 20	4-6 L	0	0	0	0	1338
Quizalofop + PO	1.8 + 20	4-6 L	0	0	0	0	1236
Clethodim SM + NIS	1.5 + 0.25	Bud	0	0	0	0	1415
Quizalofop + PO	0.9 + 20	Bud	0	0	0	0	958
Quizalofop + PO	1.8 + 20	Bud	0	0	0	0	1218
Clethodim SM + NIS	1.5 + 0.25	Bloom	0	0	0	0	1245
Quizalofop + PO	0.9 + 20	Bloom	0	0	0	0	1268
CV			0	0	0	0	20
LSD P=0.05			.	.	.	.	7

Herbicides did not cause any visible injury response to buckwheat nor did it negatively impact yield. This experiment was planted at 15 lbs per acre with yield ranging from 950-to 1415 pounds per acre. Commercial seeding rates are 40-50 lbs/acre with typical yields in Western Minnesota ranging from 1200 to 1600 pounds per acre.

Mustard and Buckwheat Response to Incorporated Herbicides Location 2. Dr. Howatt and Mettler. Tinley Mustard and Koma Buckwheat were planted near Casselton on May 27, 2020. Pre-emergence treatments were applied on May 27 and incorporated immediately after application (except treatment 2, with no incorporation). Air temperature at application was 73°F, 42% relative humidity, 0% cloud-cover, 2 mph wind velocity at 270° and dry soil surface at 63°F. Treatments were applied with a backpack sprayer delivering 17 gpa at 40 psi through 11002 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. Soil texture at this location is a silty clay loam with 6% sand, 54% silt and 40% clay.
Percent visible injury was evaluated at 7 and 14 DAT. Significant crop injury occurred due to wet soil condition, which is explained by the injury that was observed on the untreated check.

Treatment	Rate	6/3 Buckwheat	6/15 Buckwheat	6/15 Mustard
	OZ AI/A	----------%----------		
Untreated Check		0	20	21
Pendimethalin (No Incorp)	20	77	31	36
Pendimethalin	20	88	29	33
Trifluralin	12	88	28	29
Ethalfluralin	12	90	36	38
Triallate	16	72	28	31
EPTC	48	87	48	49
CV		8	22	18
LSD P=0.05		15	10	9

Due to the environmental conditions at this research location, herbicides may appear more injurious due to the additional stress on the plants.

Mustard: EPTC was the most injurious at 48%, followed by ethalfluralin at 36%. The remaining treatments caused relatively the same amount of injury to mustard. If one removed the 20% environmental injury of the untreated check, herbicides ranged from 8 to 28% injury. Triallate and trifluralin being the safest.

Buckwheat: Initially heavy injury was observed in part due to environmental conditions. Similar to mustard, when removing the 21% injury of the untreated check, herbicide injury ranged from 10 to 30%. EPTC pendimethalin(unincorporated) were the most injurious. Triallate and trifluralin were observes to have the least amount of injury.

Pinto bean response following winter rye cover crop, Carrington, 2020.
(Greg Endres and Mike Ostlie)

The study is being conducted at the NDSU Carrington Research Extension Center with support from Northarvest Dry Bean Growers Association to examine soil cover and moisture, weed management, and pinto bean performance with winter rye grown as a preplant cover crop. Experimental design was a randomized complete block with four replications. The dryland trial was established on a conventionally tilled Heimdal-Emrick loam soil with 3.7% organic matter, 6.9 pH, 0.34 dS/m soluble salt (0-6-inch depth), 17 ppm P, 331 ppm K, and 0.87 ppm Zn. 'ND Dylan' rye was direct seeded into soybean stubble in 7-inch rows at targeted rate of 60 lb/A on October 8, 2019. Estimated growth stage based on Haun wheat scale on November 8 was 0.3 leaf (NDAWN). 'ND Palomino' pinto bean was planted into tilled soil, rye residue or living rye in 30-inch rows with a JD Flex planter on June 4, 2020. NDAWN monthly rain (inches): May=1.18; June=1.23; July=5.00; August=1.06; September=0.13; and 5-month total=8.6.

Rye treatments (trts) were designated by termination method and timing:

1. Conventional production system check: Tillage (2x roto-till) on October 28, 2019 (20 days after seeding rye [DBBP]); followed by preemergence (PRE) Roundup PowerMax (glyphosate; 28.4 fl oz/A) plus NIS+AMS (Class Act NG; 2.5% v/v) plus Spartan Elite (sulfentrazone+S-metolachlor; 20 fl oz/A) on June 5, 2020 (1 day after bean planting [DABP]; boot- to early headed rye; 0.27 inches of rain received during June 6-7).
2. Preplant PP Roundup PowerMax plus NIS+AMS on April 29 (36 DBBP; 2- to 3-leaf rye).
3. PP Roundup PowerMax plus NIS+AMS on April 29 followed by PRE Roundup PowerMax plus NIS+AMS plus Spartan Elite on June 5.
4. PP Roundup PowerMax plus NIS+AMS on May 15 (20 DBBP; tillering stage rye [3- to 5-inch height]).
5. PRE Roundup PowerMax plus NIS+AMS on June 5.
6. PRE Roundup PowerMax plus NIS+AMS (Blue Diamond at 0.5% v/v) on June 15 (11 DABP; flowering rye).

Herbicide trts were applied with a CO_2-pressurized hand-boom sprayer delivering 14 gpa through TJ Turbo 02 flat-fan nozzles at 35 psi. Beyond (4 fl oz/A) plus SelectMax (16 fl oz/A) plus Destiny HC (24 fl oz/A) were post-emergence to all trial plots for general weed control with pinto bean at V1 growth stage on June 25.

Killing frosts occurred on September 8 (low of 29 degrees F; NDAWN) and September 9 (27 degrees). Trts 1-4 bean plants had mature seed and were hand-pulled for field drying on September 9, while trts 5 and 6 plants generally had immature seed and were hand-pulled on September 14. Seed harvested with a plot combine: trts 1-4=September 11; trts 5-6=September 17.

Delaying rye termination until near or after pinto bean planting (trts 5 and 6) delayed bean plant emergence about three weeks compared plant development with the conventional production check and earlier rye termination trts (Table 1). Topsoil moisture was depleted by the extended growth of the rye and delay in adequate rainfall to replenish soil moisture (0.3 inches June 6-8 and 1.3 inches June 29-July 2 [NDAWN]). In addition, plant flowering and maturity were delayed 9-14 days with extended delay in rye termination. Initial trts 5 and 6 plant stands were greatly reduced when measured June 24 but were adequate on July 9 (73,800-74,200 plants/A) after the late June rain. Bean canopy closure also was reduced with the extended delay in rye termination. In addition, potential yield loss with direct harvest increased slightly with trts 5 and 6.

Table 1. Pinto bean response to rye cover crop, Carrington, 2020.

	Plant[a]							Seed			
Trt no.	Emergence	Stand (24-Jun; V1)[b]	Flower (R1)	Canopy closure (%) 10-Aug		Maturity (R9)	Direct harvest[c]	Yield	Test weight	Count	Protein
	DOY	plt/A	DOY	visual	canopeo	DOY	%	lb/A	lb/bu	no./lb	%
1	164	93,692	204	82	86	243	94	2,309	60.0	1,473	22.8
2	163	93,692	204	83	84	244	94	2,204	60.4	1,479	22.4
3	163	90,524	203	83	85	243	94	2,405	60.3	1,464	22.5
4	163	94,145	203	85	89	244	95	2,259	60.2	1,548	22.2
5	185	25,347	213	49	66	253	91	1,014	55.9	1,463	22.7
6	185	6,789	217	43	58	254	89	569	54.2	1,637	22.6
Mean	171	67,365	207	71	78	247	93	1,793	58.7	1,511	22.5
CV (%)	0.2	14.2	0.4	10.2	8.0	1.0	2.9	15.5	0.5	4.2	2.6
LSD (0.10)	1	11,835	1	9	8	2	3	345	0.3	79	NS

[a]DOY (day of year): 171=June 19; 207=July 25; 247=Sept 3.

[b]Plant stand on July 9: trt 5=73,777 plt/A; trt 6=74,229 plt/A.

[c]A relative score to estimate the percent of beans that would successfully be direct/straight harvested.

Bean seed yield among early rye termination trts (2-4) ranged from 2,200 to 2,400 lb/A and were similar to yield with the conventional check. Yield was reduced 56% and 75%, respectively, with trts 5 and 6 compared to yield with the conventional check. Late plant establishment and development with trts 5 and 6 resulted in immature seed damaged by the September 8-9 frosts. Test weight also was reduced with trts 5 and 6, and smaller seed occurred with trt 6.

Rye ground cover measured at bean planting and mid-season indicated significantly greater amounts with delay of rye termination (trts 5 and 6) (Table 2). However, early season topsoil moisture (June 5 and 25 measurements) was greater with trts 1-4 compared to the late rye termination trts.

Table 2. Ground cover, soil moisture, and weed control with rye cover crop for pinto bean, Carrington, 2020.

	Rye ground cover (%)			Soil moisture[a]				Weed control[b]				
	Line transect	Canopeo	Residue					Vol rye	Fota	Colq	Fota	Colq
Trt no.	5-Jun		24-Jul	5-Jun	25-Jun	17-Jul	17-Aug	25-Jun			9-Jul	
	%											
1	13	5	0	19.9	19.2	19.4	11.4	99	95	85	96	83
2	43	3	4	21.3	22.0	19.4	13.4	78	81	66	75	68
3	38	2	1	19.6	21.1	19.8	13.1	99	97	95	98	95
4	40	1	1	20.4	21.6	21.2	12.8	99	75	81	71	81
5	78	55	41	15.1	11.0	21.2	17.8	98	99	97	99	91
6	68	57	50	12.9	11.0	20.3	19.2	97	99	97	99	91
Mean	46	20	16	18.1	17.6	20.2	14.6	95	91	87	90	84
CV (%)	43.4	25.2	50.9	6.6	8.9	7.8	17.4	2.8	5.5	12.2	5.5	13.5
LSD (0.10)	25	6	10	1.5	1.9	NS	3.2	3	6	13	6	14

[a]Measured with Extech Instruments MO750 soil moisture meter at 4-inch soil depth.

[b]Visual evaluation: Vol rye=voluunteer rye; Fota=green and yellow foxtail; Colq=common lambsquarters.

Rye control visually evaluated on June 25 (before POST herbicide application across the trial) was excellent (97-99%) except with trt 2. Foxtail and common lambsquarters control on June 25 and July 9 was good to excellent (83-99%) with glyphosate plus PRE herbicide (trts 1 and 3) or the delay in rye termination with glyphosate until near or after

bean planting (trts 5 and 6). Weed control generally was reduced with trts 2 and 4 (68-81%) due to the early rye termination with glyphosate that reduced impact on weeds during early bean establishment.

In summary, pinto bean seed yield with selected rye cover crop trts was similar to yield with the conventional check. Delay in terminating rye until near or after dry bean planting ('planting green') allowed the rye to deplete topsoil moisture that was needed to timely establish bean plants, and negatively impacted bean plant development, canopy closure, yield and test weight. The delay in rye termination did provide benefits of increase ground cover during the crop season and weed control similar to a PRE herbicide.

North Dakota State University

Sonalan, Eptam, and Permit on Dry Bean

Trial ID: 20S-HILLS-DRY-01 Location: Hillsboro, ND Trial Year: 2020
Protocol ID: 20S-HILLS-DRY-01 Investigator (Creator): Dr. Joe Ikley
Project ID: ETH-20-16 Study Director: Dr. Joe Ikley
Sponsor Contact: Alan Helm, Gowan

General Trial Information
Study Director: Dr. Joe Ikley
Investigator: Dr. Joe Ikley

Trial Status: E established
ARM Trial Created On: May-11-2020

Conducted Under GLP: No
Conducted Under GEP: No

Contacts
Role: STYDIR study director
Study Director: Dr. Joe Ikley
Role: INVEST investigator
Investigator: Dr. Joe Ikley
Role: SPONSR sponsor
Sponsor: Alan Helm, Gowan

Site and Design
Treated Plot Width: 6.67 FT
Treated Plot Length: 30 FT
Treated Plot Area: 200.1 FT2 **Treatments:** 10
Replications: 3 **Study Design:** RACOBL Randomized Complete Block (RCB)

Soil Description
Description Name: Hillsboro
% Sand: 60 **% OM:** 3.1 **Texture:** SL sandy loam
% Silt: 29 **pH:** 6.2 **Soil Name:** Gardena sandy loam
% Clay: 11 **CEC:** 17.4

Application Description

	A	B	C	D
Application Date	Jun-2-2020	Jun-2-2020	Jul-1-2020	Jul-10-2020
Appl. Start Time	11:50 AM	2:30 AM	12:35 PM	1:00 AM
Appl. Stop Time	12:15 PM	2:40 AM	12:40 PM	1:20 AM
Interval to Prev. Appl.	9 HOURS		29 DAYS	9 DAYS
Application Method	SPRAY	SPRAY	SPRAY	SPRAY
Application Timing	PPI	PREEM	POST	POST
Application Placement	BROSOI	BROSOI	BROFOL	BROFOL
Applied By	Stith, J	Stith, J	Stith, J	Stith, J
Appl. Entry Date	Sep-3-2020	Sep-3-2020	Sep-3-2020	Sep-3-2020
Air Temperature Start, Stop	85, 85 F	98, 99 F	78, 78 F	82, 82 F
% Relative Humidity Start, Stop	42, 40	17, 17	78, 78	76, 76
Wind Velocity+Dir. Start	1.5 MPH, NW	1.5 MPH, NW	6 MPH, SSE	6 MPH, SSE
Wind Velocity+Dir. Stop	2 MPH, NW	0.5 MPH, NW	6 MPH, SSE	6 MPH, SSE
Wind Velocity+Dir. Max	3 MPH, NW	2 MPH, NW	8 MPH, SSE	8 MPH, SSE
Wet Leaves (Y/N)	N, no	N, no	N, no	N, no
Soil Temperature	80 F	82 F	75 F	77 F
Soil Moisture	NORMAL	NORMAL	SLIWET	SLIWET
Soil Surface Condition	SMOOTH	SMOOTH	SMOOTH	SMOOTH
% Cloud Cover	30	10	80	60

North Dakota State University

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Project ID: ETH-20-16 Study Director: Dr. Joe Ikley
Sponsor Contact: Alan Helm, Gowan

Application Equipment

	A	B	C	D
Appl. Equipment	Walter	Walter	Walter	Walter
Equipment Type	BACCAI	BACCAI	BACCAI	BACCAI
Operation Pressure	28 PSI	28 PSI	28 PSI	28 PSI
Nozzle Model	11002	11002	8002	8002
Nozzle Type	TEEJAI	TEEJAI	FLAFAN	FLAFAN
Nozzle Spacing	20 IN	20 IN	20 IN	20 IN
Boom Length	6.67 FT	6.67 FT		
Boom Height	18 IN	18 IN	18 IN	18 IN
Ground Speed	3 MPH	3 MPH	3 MPH	3 MPH
Carrier	WATER	WATER	WATER	WATER
Application Amount	15 GAL/AC	15 GAL/AC	15 GAL/AC	15 GAL/AC
Mix Size	1119 mL	1119 mL	1119 mL	1119 mL
Propellant	COMCO2	COMCO2	COMCO2	COMCO2

Notes

Context	Date	By	Notes
STATUS	May-11-2020	Dr. Joe Ikley	Automatically added by ARM: Trial Status updated to 'S' during trial creation.
STATUS	Sep-3-2020	Dr. Joe Ikley	Automatically added by ARM: Trial Status updated to 'E' when Planting Date entered.

North Dakota State University

Sonalan, Eptam, and Permit on Dry Bean

Trial ID: 20S-HILLS-DRY-01 Location: Hillsboro, ND Trial Year: 2020
Protocol ID: 20S-HILLS-DRY-01 Investigator (Creator): Dr. Joe Ikley
Project ID: ETH-20-16 Study Director: Dr. Joe Ikley
Sponsor Contact: Alan Helm, Gowan

Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	1*	2*	3*	4*
	Pest Type					W, Weed	W, Weed	
	Pest Code					AMARE	POROL	
	Pest Scientific Name					Amaranthus retroflexus	Portulaca oleracea	
	Pest Name					Redroot pigweed	Common purslane	
	Crop Type, Code				C, PHSVX			C, PHSVX
	BBCH Scale				BVBE			BVBE
	Crop Scientific Name				Phaseolus vulgaris			Phaseolus vulgaris
	Crop Name				Garden bean			Garden bean
	Rating Date				Jun-17-2020	Jun-17-2020	Jun-17-2020	Jun-30-2020
	Rating Type				PHYTO	CONTRO	CONTRO	PHYTO
	Rating Unit/Min/Max				%, 0, 100	%, 0, 100	%, 0, 100	%, 0, 100
	Number of Subsamples				1	1	1	1
	Assessed By				Ikley, J	Ikley, J	Ikley, J	Ikley, J
	Data Entry Date				Sep-3-2020	Sep-3-2020	Sep-3-2020	Sep-3-2020
	Days After First/Last Applic.				15, 15	15, 15	15, 15	28, 28
	Plant-Eval Interval				15 DP-1	15 DP-1	15 DP-1	28 DP-1
	Days After Emergence				9 DE-1	9 DE-1	9 DE-1	22 DE-1
1	Untreated Check				0.0 -	0.0 -	0.0 -	0.0 -
2	SONALAN HFP	3	pt/a	A	1.7 -	99.0 -	99.0 -	0.0 -
3	EPTAM	4	pt/a	A	0.0 -	99.0 -	99.0 -	0.0 -
4	EPTAM	3	pt/a	A	8.3 -	99.0 -	99.0 -	1.7 -
	SONALAN HFP	2	pt/a	A				
	PERMIT	0.67	oz/a	B				
5	EPTAM	3	pt/a	A	10.0 -	99.0 -	99.0 -	1.7 -
	SONALAN HFP	2	pt/a	A				
	PERMIT	0.67	oz/a	C				
	PRIME OIL	1	% v/v	C				
6	EPTAM	3	pt/a	A	10.0 -	99.0 -	99.0 -	0.0 -
	SONALAN HFP	2	pt/a	A				
	PERMIT	0.67	oz/a	B				
	BASAGRAN	1	pt/a	D				
	RAPTOR	4	fl oz/a	D				
	PRIME OIL	1	% v/v	D				
7	EPTAM	3	pt/a	A	0.0 -	99.0 -	99.0 -	0.0 -
	SONALAN HFP	2	pt/a	A				
	PERMIT	0.67	oz/a	C				
	PRIME OIL	1	% v/v	C				
	BASAGRAN	1	pt/a	D				
	RAPTOR	4	fl oz/a	D				
	PRIME OIL	1	% v/v	D				
8	SONALAN HFP	2	pt/a	A	1.7 -	99.0 -	99.0 -	0.0 -
	EPTAM	3	pt/a	A				
	REFLEX	1	pt/a	B				
	PERMIT	0.67	oz/a	D				
	BASAGRAN	1	pt/a	D				
	PRIME OIL	1	% v/v	D				
9	DUAL II MAGNUM	1.33	pt/a	B	8.3 -	99.0 -	99.0 -	1.7 -
	REFLEX	1	pt/a	B				
	BASAGRAN	1	pt/a	D				
	RAPTOR	4	fl oz/a	D				

Means followed by same letter or symbol do not significantly differ (P=.05, Student-Newman-Keuls).
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.
* Adjusted means
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North Dakota State University

Sonalan, Eptam, and Permit on Dry Bean

Trial ID: 20S-HILLS-DRY-01 Location: Hillsboro, ND Trial Year: 2020
Protocol ID: 20S-HILLS-DRY-01 Investigator (Creator): Dr. Joe Ikley
Project ID: ETH-20-16 Study Director: Dr. Joe Ikley
Sponsor Contact: Alan Helm, Gowan

Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	1*	2*	3*	4*
	Pest Type					W, Weed	W, Weed	
	Pest Code					AMARE	POROL	
	Pest Scientific Name					Amaranthus retroflexus	Portulaca oleracea	
	Pest Name					Redroot pigweed	Common purslane	
	Crop Type, Code				C, PHSVX			C, PHSVX
	BBCH Scale				BVBE			BVBE
	Crop Scientific Name				Phaseolus vulgaris			Phaseolus vulgaris
	Crop Name				Garden bean			Garden bean
	Rating Date				Jun-17-2020	Jun-17-2020	Jun-17-2020	Jun-30-2020
	Rating Type				PHYTO	CONTRO	CONTRO	PHYTO
	Rating Unit/Min/Max				%, 0, 100	%, 0, 100	%, 0, 100	%, 0, 100
	Number of Subsamples				1	1	1	1
	Assessed By				Ikley, J	Ikley, J	Ikley, J	Ikley, J
	Data Entry Date				Sep-3-2020	Sep-3-2020	Sep-3-2020	Sep-3-2020
	Days After First/Last Applic.				15, 15	15, 15	15, 15	28, 28
	Plant-Eval Interval				15 DP-1	15 DP-1	15 DP-1	28 DP-1
	Days After Emergence				9 DE-1	9 DE-1	9 DE-1	22 DE-1
10	REFLEX	4	fl oz/a	C	0.0 -	0.0 -	0.0 -	0.0 -
	BASAGRAN	0.67	pt/a	C				
	RAPTOR	1	fl oz/a	C				
	SELECT MAX	2	fl oz/a	C				
	MSO ULTRA	1	pt/a	C				
	REFLEX	4	fl oz/a	D				
	BASAGRAN	0.67	pt/a	D				
	RAPTOR	1	fl oz/a	D				
	SELECT MAX	2	fl oz/a	D				
	MSO ULTRA	1	pt/a	D				
	LSD P=.05				13.05	.	.	2.71
	Standard Deviation				7.61	0.00	0.00	1.58
	CV				190.18	0.0	0.0	316.23
	Levene's F^				0.613	.	.	0.745
	Levene's Prob(F)				0.772	.	.	0.665
	Skewness^				0.7508	.	.	1.115*
	Kurtosis^				0.3574	.	.	1.8818*
	Replicate F				1.080	0.000	0.000	1.000
	Replicate Prob(F)				0.3606	1.0000	1.0000	0.3874
	Treatment F				1.062	0.000	0.000	0.778
	Treatment Prob(F)				0.4333	1.0000	1.0000	0.6390

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Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.
* Adjusted means
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North Dakota State University

Sonalan, Eptam, and Permit on Dry Bean

Trial ID: 20S-HILLS-DRY-01 Location: Hillsboro, ND Trial Year: 2020
Protocol ID: 20S-HILLS-DRY-01 Investigator (Creator): Dr. Joe Ikley
Project ID: ETH-20-16 Study Director: Dr. Joe Ikley
Sponsor Contact: Alan Helm, Gowan

Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	5*	6*	7*	8*
	Pest Type				W, Weed	W, Weed		W, Weed
	Pest Code				AMARE	POROL		AMARE
	Pest Scientific Name				Amaranthus retroflexus	Portulaca oleracea		Amaranthus retroflexus
	Pest Name				Redroot pigweed	Common purslane		Redroot pigweed
	Crop Type, Code						C, PHSVX	
	BBCH Scale						BVBE	
	Crop Scientific Name						Phaseolus vulgaris	
	Crop Name						Garden bean	
	Rating Date				Jun-30-2020	Jun-30-2020	Jul-7-2020	Jul-7-2020
	Rating Type				CONTRO	CONTRO	PHYTO	CONTRO
	Rating Unit/Min/Max				%, 0, 100	%, 0, 100	%, 0, 100	%, 0, 100
	Number of Subsamples				1	1	1	1
	Assessed By				Ikley, J	Ikley, J	Ikley, J	Ikley, J
	Data Entry Date				Sep-3-2020	Sep-3-2020	Sep-3-2020	Sep-3-2020
	Days After First/Last Applic.				28, 28	28, 28	35, 6	35, 6
	Plant-Eval Interval				28 DP-1	28 DP-1	35 DP-1	35 DP-1
	Days After Emergence				22 DE-1	22 DE-1	29 DE-1	29 DE-1
1	Untreated Check				0.0 c	0.0 c	0.0 b	0.0 c
2	SONALAN HFP	3	pt/a	A	90.0 b	88.3 b	0.0 b	93.0 ab
3	EPTAM	4	pt/a	A	93.3 ab	93.3 ab	0.0 b	86.7 b
4	EPTAM	3	pt/a	A	100.0 a	99.3 a	0.0 b	99.3 a
	SONALAN HFP	2	pt/a	A				
	PERMIT	0.67	oz/a	B				
5	EPTAM	3	pt/a	A	96.7 ab	94.7 ab	10.0 a	99.3 a
	SONALAN HFP	2	pt/a	A				
	PERMIT	0.67	oz/a	C				
	PRIME OIL	1	% v/v	C				
6	EPTAM	3	pt/a	A	99.3 a	96.7 a	0.0 b	99.3 a
	SONALAN HFP	2	pt/a	A				
	PERMIT	0.67	oz/a	B				
	BASAGRAN	1	pt/a	D				
	RAPTOR	4	fl oz/a	D				
	PRIME OIL	1	% v/v	D				
7	EPTAM	3	pt/a	A	98.7 ab	98.7 a	10.0 a	99.3 a
	SONALAN HFP	2	pt/a	A				
	PERMIT	0.67	oz/a	C				
	PRIME OIL	1	% v/v	C				
	BASAGRAN	1	pt/a	D				
	RAPTOR	4	fl oz/a	D				
	PRIME OIL	1	% v/v	D				
8	SONALAN HFP	2	pt/a	A	100.0 a	100.0 a	0.0 b	100.0 a
	EPTAM	3	pt/a	A				
	REFLEX	1	pt/a	B				
	PERMIT	0.67	oz/a	D				
	BASAGRAN	1	pt/a	D				
	PRIME OIL	1	% v/v	D				
9	DUAL II MAGNUM	1.33	pt/a	B	96.7 ab	96.7 a	0.0 b	96.3 a
	REFLEX	1	pt/a	B				
	BASAGRAN	1	pt/a	D				
	RAPTOR	4	fl oz/a	D				

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Sonalan, Eptam, and Permit on Dry Bean

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Protocol ID: 20S-HILLS-DRY-01 Investigator (Creator): Dr. Joe Ikley
Project ID: ETH-20-16 Study Director: Dr. Joe Ikley
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Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	5*	6*	7*	8*
	Pest Type				W, Weed	W, Weed		W, Weed
	Pest Code				AMARE	POROL		AMARE
	Pest Scientific Name				Amaranthus retroflexus	Portulaca oleracea		Amaranthus retroflexus
	Pest Name				Redroot pigweed	Common purslane		Redroot pigweed
	Crop Type, Code						C, PHSVX	
	BBCH Scale						BVBE	
	Crop Scientific Name						Phaseolus vulgaris	
	Crop Name						Garden bean	
	Rating Date				Jun-30-2020	Jun-30-2020	Jul-7-2020	Jul-7-2020
	Rating Type				CONTRO	CONTRO	PHYTO	CONTRO
	Rating Unit/Min/Max				%, 0, 100	%, 0, 100	%, 0, 100	%, 0, 100
	Number of Subsamples				1	1	1	1
	Assessed By				Ikley, J	Ikley, J	Ikley, J	Ikley, J
	Data Entry Date				Sep-3-2020	Sep-3-2020	Sep-3-2020	Sep-3-2020
	Days After First/Last Applic.				28, 28	28, 28	35, 6	35, 6
	Plant-Eval Interval				28 DP-1	28 DP-1	35 DP-1	35 DP-1
	Days After Emergence				22 DE-1	22 DE-1	29 DE-1	29 DE-1
10	REFLEX	4	fl oz/a	C	0.0 c	0.0 c	15.0 a	90.0 ab
	BASAGRAN	0.67	pt/a	C				
	RAPTOR	1	fl oz/a	C				
	SELECT MAX	2	fl oz/a	C				
	MSO ULTRA	1	pt/a	C				
	REFLEX	4	fl oz/a	D				
	BASAGRAN	0.67	pt/a	D				
	RAPTOR	1	fl oz/a	D				
	SELECT MAX	2	fl oz/a	D				
	MSO ULTRA	1	pt/a	D				
	LSD P=.05				6.08	5.34	4.70	6.79
	Standard Deviation				3.54	3.11	2.74	3.96
	CV				4.57	4.06	78.25	4.58
	Levene's F^				0.725	1.057	0.711	1.704
	Levene's Prob(F)				0.681	0.433	0.693	0.154
	Skewness^				-1.2087*	-0.4025	-1.9863*	-0.1075
	Kurtosis^				3.2799*	2.049*	11.1307*	2.6041*
	Replicate F				1.165	1.962	1.000	0.066
	Replicate Prob(F)				0.3343	0.1695	0.3874	0.9364
	Treatment F				400.538	509.813	13.444	180.345
	Treatment Prob(F)				0.0001	0.0001	0.0001	0.0001

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Protocol ID: 20S-HILLS-DRY-01 Investigator (Creator): Dr. Joe Ikley
Project ID: ETH-20-16 Study Director: Dr. Joe Ikley
Sponsor Contact: Alan Helm, Gowan

Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	9*	10*	11*	12*	13*
	Pest Type				W, Weed		W, Weed	W, Weed	
	Pest Code				POROL		AMARE	POROL	
	Pest Scientific Name				Portulaca oleracea		Amaranthus retroflexus	Portulaca oleracea	
	Pest Name				Common purslane		Redroot pigweed	Common purslane	
	Crop Type, Code					C, PHSVX			C, PHSVX
	BBCH Scale					BVBE			BVBE
	Crop Scientific Name					Phaseolus vulgaris			Phaseolus vulgaris
	Crop Name					Garden bean			Garden bean
	Rating Date				Jul-7-2020	Jul-15-2020	Jul-15-2020	Jul-15-2020	Jul-23-2020
	Rating Type				CONTRO	PHYTO	CONTRO	CONTRO	PHYTO
	Rating Unit/Min/Max				%, 0, 100	%, 0, 100	%, 0, 100	%, 0, 100	%, 0, 100
	Number of Subsamples				1	1	1	1	1
	Assessed By				Ikley, J	Ikley, J	Ikley, J	Ikley, J	Ikley, J
	Data Entry Date				Sep-3-2020	Sep-3-2020	Sep-3-2020	Sep-3-2020	Sep-3-2020
	Days After First/Last Applic.				35, 6	43, 5	43, 5	43, 5	51, 13
	Plant-Eval Interval				35 DP-1	43 DP-1	43 DP-1	43 DP-1	51 DP-1
	Days After Emergence				29 DE-1	37 DE-1	37 DE-1	37 DE-1	45 DE-1
1	Untreated Check				0.0 d	0.0 b	0.0 c	0.0 b	0.0 b
2	SONALAN HFP	3	pt/a	A	81.7 b	0.0 b	91.3 ab	78.3 a	0.0 b
3	EPTAM	4	pt/a	A	90.0 ab	0.0 b	86.7 b	80.0 a	0.0 b
4	EPTAM	3	pt/a	A	96.3 a	0.0 b	99.3 a	86.7 a	1.7 b
	SONALAN HFP	2	pt/a	A					
	PERMIT	0.67	oz/a	B					
5	EPTAM	3	pt/a	A	95.0 a	10.0 b	99.7 a	91.7 a	1.7 b
	SONALAN HFP	2	pt/a	A					
	PERMIT	0.67	oz/a	C					
	PRIME OIL	1	% v/v	C					
6	EPTAM	3	pt/a	A	96.7 a	6.7 b	99.3 a	90.0 a	3.3 b
	SONALAN HFP	2	pt/a	A					
	PERMIT	0.67	oz/a	B					
	BASAGRAN	1	pt/a	D					
	RAPTOR	4	fl oz/a	D					
	PRIME OIL	1	% v/v	D					
7	EPTAM	3	pt/a	A	94.7 a	10.0 b	99.7 a	91.3 a	0.0 b
	SONALAN HFP	2	pt/a	A					
	PERMIT	0.67	oz/a	C					
	PRIME OIL	1	% v/v	C					
	BASAGRAN	1	pt/a	D					
	RAPTOR	4	fl oz/a	D					
	PRIME OIL	1	% v/v	D					
8	SONALAN HFP	2	pt/a	A	99.3 a	3.3 b	100.0 a	93.3 a	1.7 b
	EPTAM	3	pt/a	A					
	REFLEX	1	pt/a	B					
	PERMIT	0.67	oz/a	D					
	BASAGRAN	1	pt/a	D					
	PRIME OIL	1	% v/v	D					
9	DUAL II MAGNUM	1.33	pt/a	B	91.7 ab	6.7 b	96.3 a	91.7 a	3.3 b
	REFLEX	1	pt/a	B					
	BASAGRAN	1	pt/a	D					
	RAPTOR	4	fl oz/a	D					

Means followed by same letter or symbol do not significantly differ (P=.05, Student-Newman-Keuls).
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.
* Adjusted means
Could not calculate LSD (% mean diff) for columns 2,3 because error mean square = 0.
^Calculated from residual.

North Dakota State University

Sonalan, Eptam, and Permit on Dry Bean

Trial ID: 20S-HILLS-DRY-01 Location: Hillsboro, ND Trial Year: 2020
Protocol ID: 20S-HILLS-DRY-01 Investigator (Creator): Dr. Joe Ikley
Project ID: ETH-20-16 Study Director: Dr. Joe Ikley
Sponsor Contact: Alan Helm, Gowan

Pest Type		W, Weed		W, Weed	W, Weed	
Pest Code		POROL		AMARE	POROL	
Pest Scientific Name		Portulaca oleracea		Amaranthus retroflexus	Portulaca oleracea	
Pest Name		Common purslane		Redroot pigweed	Common purslane	
Crop Type, Code			C, PHSVX			C, PHSVX
BBCH Scale			BVBE			BVBE
Crop Scientific Name			Phaseolus vulgaris			Phaseolus vulgaris
Crop Name			Garden bean			Garden bean
Rating Date		Jul-7-2020	Jul-15-2020	Jul-15-2020	Jul-15-2020	Jul-23-2020
Rating Type		CONTRO	PHYTO	CONTRO	CONTRO	PHYTO
Rating Unit/Min/Max		%, 0, 100	%, 0, 100	%, 0, 100	%, 0, 100	%, 0, 100
Number of Subsamples		1	1	1	1	1
Assessed By		Ikley, J	Ikley, J	Ikley, J	Ikley, J	Ikley, J
Data Entry Date		Sep-3-2020	Sep-3-2020	Sep-3-2020	Sep-3-2020	Sep-3-2020
Days After First/Last Applic.		35, 6	43, 5	43, 5	43, 5	51, 13
Plant-Eval Interval		35 DP-1	43 DP-1	43 DP-1	43 DP-1	51 DP-1
Days After Emergence		29 DE-1	37 DE-1	37 DE-1	37 DE-1	45 DE-1
Trt No.	Treatment Name	Rate Unit	Appl Code	9*	10*	11*	12*	13*
10	REFLEX	4 fl oz/a	C	66.7 c	20.0 a	99.0 a	94.7 a	15.0 a
	BASAGRAN	0.67 pt/a	C					
	RAPTOR	1 fl oz/a	C					
	SELECT MAX	2 fl oz/a	C					
	MSO ULTRA	1 pt/a	C					
	REFLEX	4 fl oz/a	D					
	BASAGRAN	0.67 pt/a	D					
	RAPTOR	1 fl oz/a	D					
	SELECT MAX	2 fl oz/a	D					
	MSO ULTRA	1 pt/a	D					
LSD P=.05				8.94	6.24	7.32	13.44	7.69
Standard Deviation				5.21	3.64	4.26	7.83	4.48
CV				6.42	64.21	4.89	9.82	168.09
Levene's F^				1.107	1.393	1.673	0.323	0.85
Levene's Prob(F)				0.401	0.256	0.162	0.957	0.581
Skewness^				0.3686	-0.0653	-0.5153	-0.3868	0.8109
Kurtosis^				3.0459*	3.021*	5.1567*	0.4197	3.3248*
Replicate F				0.545	2.329	0.090	8.719	4.272
Replicate Prob(F)				0.5893	0.1261	0.9145	0.0023	0.0303
Treatment F				100.118	9.538	157.842	39.871	3.060
Treatment Prob(F)				0.0001	0.0001	0.0001	0.0001	0.0208

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^Calculated from residual.

North Dakota State University

Sonalan, Eptam, and Permit on Dry Bean

Trial ID: 20S-HILLS-DRY-01 Location: Hillsboro, ND Trial Year: 2020
Protocol ID: 20S-HILLS-DRY-01 Investigator (Creator): Dr. Joe Ikley
Project ID: ETH-20-16 Study Director: Dr. Joe Ikley
Sponsor Contact: Alan Helm, Gowan

Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	14*	15*
	Pest Type				W, Weed	W, Weed
	Pest Code				AMARE	AMARE
	Pest Scientific Name				Amaranthus retroflexus	Amaranthus retroflexus
	Pest Name				Redroot pigweed	Redroot pigweed
	Crop Type, Code					
	BBCH Scale					
	Crop Scientific Name					
	Crop Name					
	Rating Date				Jul-23-2020	Aug-6-2020
	Rating Type				CONTRO	CONTRO
	Rating Unit/Min/Max				%, 0, 100	%, 0, 100
	Number of Subsamples				1	1
	Assessed By				Ikley, J	Ikley, J
	Data Entry Date				Sep-3-2020	Sep-3-2020
	Days After First/Last Applic.				51, 13	65, 27
	Plant-Eval Interval				51 DP-1	65 DP-1
	Days After Emergence				45 DE-1	59 DE-1
1	Untreated Check				0.0 d	0.0 d
2	SONALAN HFP	3	pt/a	A	93.0 b	88.3 b
3	EPTAM	4	pt/a	A	83.3 c	83.3 c
4	EPTAM	3	pt/a	A	99.0 a	100.0 a
	SONALAN HFP	2	pt/a	A		
	PERMIT	0.67	oz/a	B		
5	EPTAM	3	pt/a	A	99.0 a	99.7 a
	SONALAN HFP	2	pt/a	A		
	PERMIT	0.67	oz/a	C		
	PRIME OIL	1	% v/v	C		
6	EPTAM	3	pt/a	A	99.3 a	99.7 a
	SONALAN HFP	2	pt/a	A		
	PERMIT	0.67	oz/a	B		
	BASAGRAN	1	pt/a	D		
	RAPTOR	4	fl oz/a	D		
	PRIME OIL	1	% v/v	D		
7	EPTAM	3	pt/a	A	99.7 a	99.7 a
	SONALAN HFP	2	pt/a	A		
	PERMIT	0.67	oz/a	C		
	PRIME OIL	1	% v/v	C		
	BASAGRAN	1	pt/a	D		
	RAPTOR	4	fl oz/a	D		
	PRIME OIL	1	% v/v	D		
8	SONALAN HFP	2	pt/a	A	100.0 a	100.0 a
	EPTAM	3	pt/a	A		
	REFLEX	1	pt/a	B		
	PERMIT	0.67	oz/a	D		
	BASAGRAN	1	pt/a	D		
	PRIME OIL	1	% v/v	D		
9	DUAL II MAGNUM	1.33	pt/a	B	97.7 a	99.3 a
	REFLEX	1	pt/a	B		
	BASAGRAN	1	pt/a	D		
	RAPTOR	4	fl oz/a	D		

Means followed by same letter or symbol do not significantly differ (P=.05, Student-Newman-Keuls).
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* Adjusted means
Could not calculate LSD (% mean diff) for columns 2,3 because error mean square = 0.
^Calculated from residual.

North Dakota State University

Sonalan, Eptam, and Permit on Dry Bean

Trial ID: 20S-HILLS-DRY-01 Location: Hillsboro, ND Trial Year: 2020
Protocol ID: 20S-HILLS-DRY-01 Investigator (Creator): Dr. Joe Ikley
Project ID: ETH-20-16 Study Director: Dr. Joe Ikley
Sponsor Contact: Alan Helm, Gowan

Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	14*	15*
	Pest Type				W, Weed	W, Weed
	Pest Code				AMARE	AMARE
	Pest Scientific Name				Amaranthus retroflexus	Amaranthus retroflexus
	Pest Name				Redroot pigweed	Redroot pigweed
	Crop Type, Code					
	BBCH Scale					
	Crop Scientific Name					
	Crop Name					
	Rating Date				Jul-23-2020	Aug-6-2020
	Rating Type				CONTRO	CONTRO
	Rating Unit/Min/Max				%, 0, 100	%, 0, 100
	Number of Subsamples				1	1
	Assessed By				Ikley, J	Ikley, J
	Data Entry Date				Sep-3-2020	Sep-3-2020
	Days After First/Last Applic.				51, 13	65, 27
	Plant-Eval Interval				51 DP-1	65 DP-1
	Days After Emergence				45 DE-1	59 DE-1
10	REFLEX	4	fl oz/a	C	99.0 a	98.3 a
	BASAGRAN	0.67	pt/a	C		
	RAPTOR	1	fl oz/a	C		
	SELECT MAX	2	fl oz/a	C		
	MSO ULTRA	1	pt/a	C		
	REFLEX	4	fl oz/a	D		
	BASAGRAN	0.67	pt/a	D		
	RAPTOR	1	fl oz/a	D		
	SELECT MAX	2	fl oz/a	D		
	MSO ULTRA	1	pt/a	D		
	LSD P=.05				4.06	3.81
	Standard Deviation				2.37	2.22
	CV				2.72	2.56
	Levene's F^				0.352	0.546
	Levene's Prob(F)				0.945	0.824
	Skewness^				0.9159*	0.7442
	Kurtosis^				1.345	2.9337*
	Replicate F				3.016	1.429
	Replicate Prob(F)				0.0742	0.2655
	Treatment F				514.290	588.070
	Treatment Prob(F)				0.0001	0.0001

Means followed by same letter or symbol do not significantly differ (P=.05, Student-Newman-Keuls).
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.
* Adjusted means
Could not calculate LSD (% mean diff) for columns 2,3 because error mean square = 0.
^Calculated from residual.

North Dakota State University

Sonalan, Eptam, and Permit on Dry Bean

Trial ID: 20S-HILLS-DRY-01 Location: Hillsboro, ND Trial Year: 2020
Protocol ID: 20S-HILLS-DRY-01 Investigator (Creator): Dr. Joe Ikley
Project ID: ETH-20-16 Study Director: Dr. Joe Ikley
Sponsor Contact: Alan Helm, Gowan

Pest Type
W, Weed = Weed or volunteer crop
Pest Code
AMARE, Amaranthus retroflexus, Redroot pigweed = US
POROL, Portulaca oleracea, Common purslane = US
Crop Type, Code
C = EPPO species (Bayer) codes
PHSVX, BVBE, Phaseolus vulgaris, Garden bean = US
Rating Type
CONTRO = control / burndown or knockdown
Rating Unit/Min/Max
%, 0, 100 = percent
Assessed By
Ikley, J = Extension Agent
Plant-Eval Interval
15 DP-1 = 1 PHSVX Jun-2-2020
28 DP-1 = 1 PHSVX Jun-2-2020
35 DP-1 = 1 PHSVX Jun-2-2020
43 DP-1 = 1 PHSVX Jun-2-2020
51 DP-1 = 1 PHSVX Jun-2-2020
65 DP-1 = 1 PHSVX Jun-2-2020