Glyphosate: spray volume-herbicide rate study, Reynolds. Ramsdale, Brad K., Sam J. Lockhart, and Calvin G. Messersmith. The experiment was established on fallow ground with a heavy infestation of quackgrass and wild buckwheat. Plots were 12 ft wide by 30 ft long. Treatments were applied on June 24 with an all-terrain vehicle equipped with a four-nozzle boom (20-inch spacing). Conditions at treatment were 85 F, 60% RH, wind 5-8 mph, and 20% clouds. The quackgrass was 18 to 24 inches tall and in the boot to heading stage, and the wild buckwheat was 8- to 12-inch and in the bud stage at time of treatment. Experimental design was a randomized complete block with four replicates. Weed control was evaluated visually where 0 equaled no visible injury and 100 equaled complete death.

				July 8		July 22	
Treatment[a]	Rate	Volume	Tip[b]	Quackgrass	Wild buckwheat	Quackgrass	Wild buckwheat
	(lb ae/A)	(gpa)		(%)	(%)	(%)	(%)
Glyphosate	0.095	5	TT 11001	14	9	20	6
Glyphosate	0.095	10	TT 11002	4	4	5	1
Glyphosate	0.095	20	TT 11004	3	1	5	1
Glyphosate + NIS	0.095 + 0.5%	5	TT 11001	14	10	18	5
Glyphosate + NIS	0.095 + 0.5%	10	TT 11002	13	8	19	2
Glyphosate + NIS	0.095 + 0.5%	20	TT 11004	11	6	14	1
Glyphosate	0.19	5	TT 11001	53	34	79	38
Glyphosate	0.19	10	TT 11002	40	21	60	33
Glyphosate	0.19	20	TT 11004	11	16	33	13
Glyphosate + NIS	0.19 + 0.5%	5	TT 11001	44	33	69	39
Glyphosate + NIS	0.19 + 0.5%	10	TT 11002	25	19	55	19
Glyphosate + NIS	0.19 + 0.5%	20	TT 11004	28	28	41	20
Glyphosate	0.38	5	TT 11001	94	70	97	79
Glyphosate	0.38	10	TT 11002	86	66	95	71
Glyphosate	0.38	20	TT 11004	71	50	88	58
Glyphosate + NIS	0.38 + 0.5%	5	TT 11001	93	64	96	71
Glyphosate + NIS	0.38 + 0.5%	10	TT 11002	78	55	92	66
Glyphosate + NIS	0.38 + 0.5%	20	TT 11004	75	60	91	64
LSD (5%)				15	12	10	10

[a] Glyphosate = Roundup UltraMax; NIS = Atplus GTM-10 nonionic surfactant.
[b] TT = Turbo TeeJet nozzles by Spraying Systems Co. Treatments were applied at 15 psi and 3.5 mph.

Overall, glyphosate control of quackgrass and wild buckwheat increased as spray volume decreased from 20 to 5 gpa. Glyphosate at 0.19 lb/A applied in 5 gpa spray volume increased quackgrass control by up to 46% compared to application in 20 gpa. The addition of 0.5% NIS generally did not enhance glyphosate efficacy regardless of spray volume, indicating sufficient surfactant was present in the glyphosate formulation at these rates.

Spray nozzle and adjuvant effects on acifluorfen efficacy. Ramsdale, Brad K., Sam J. Lockhart, and Calvin G. Messersmith. The experiment was conducted to examine the influence of drift-reducing nozzles and adjuvants on acifluorfen efficacy. Bioassay species were planted as 6-ft-wide strips side-by-side. Plots 12 ft wide were laid out perpendicular to the strips so that each plot contained all three assay species. Treatments were applied at 10 gpa with an all-terrain vehicle equipped with a four-nozzle boom (20-inch spacing) offset to one side. Experimental design was a randomized complete block with four replicates. Weed control was evaluated visually where 0 equaled no visible injury and 100 equaled complete death of assay species.

Experiment location	Fargo	Casselton
Planting date	May 22	May 24
Treatment date	June 18	June 20
Air temperature (F)	75	72
Relative humidity (%)	65	40
Wind (mph)	12-15	5
Sky (% clouds)	80	40
Flax		
variety	'Neche'	'Neche'
height (inch)	5-7	6-8
Sunflower		
variety	F_2 oilseed	F_2 oilseed
height (inch)	5-7	6-8
Tame buckwheat		
variety	'Mancan'	'Mancan'
height (inch)	5-7	8-10

The Extended Range nozzle at 40 psi represented a standard flat-fan nozzle application. Acifluorfen provided 90% or greater control of flax and tame buckwheat for all treatments, which minimized differences among treatments. Acifluorfen applied through three types of drift-reducing nozzles provided similar sunflower control compared to application through an Extended Range nozzle regardless of adjuvant. Acifluorfen was most effective when applied with a methylated vegetable oil adjuvant and least effective with a nonionic surfactant. Sunflower control by acifluorfen plus the basic pH blend adjuvant was generally similar to acifluorfen plus petroleum oil.

Table 1. Spray nozzle and adjuvant effects on acifluorfen efficacy, Fargo, ND

					June 27			July 8
Treatment[ab]	Rate	Nozzle[c]	Pressure	Speed	Sunflower	Tame buckwheat	Flax	Sunflower
	(lb ai/A)		(psi)	(mph)	(%)	(%)	(%)	(%)
Acifluorfen + PO	0.13 + 1.5 pt	XR 11002	40	6	74	97	98	35
Acifluorfen + PO	0.13 + 1.5 pt	TT 11002	20	4.2	71	95	97	38
Acifluorfen + PO	0.13 + 1.5 pt	AI 11002	60	7.1	74	97	96	35
Acifluorfen + PO	0.13 + 1.5 pt	TDXL-110-02	60	7.1	74	98	98	39
Acifluorfen + MVO	0.13 + 1.5 pt	XR 11002	40	6	84	96	99	58
Acifluorfen + MVO	0.13 + 1.5 pt	TT 11002	20	4.2	86	99	99	61
Acifluorfen + MVO	0.13 + 1.5 pt	AI 11002	60	7.1	82	99	98	60
Acifluorfen + MVO	0.13 + 1.5 pt	TDXL-110-02	60	7.1	83	99	98	55
Acifluorfen + NIS	0.13 + 0.25%	XR 11002	40	6	65	96	98	25
Acifluorfen + NIS	0.13 + 0.25%	TT 11002	20	4.2	64	94	96	24
Acifluorfen + NIS	0.13 + 0.25%	AI 11002	60	7.1	68	96	98	31
Acifluorfen + NIS	0.13 + 0.25%	TDXL-110-02	60	7.1	72	95	96	35
Acifluorfen + BB	0.13 + 1%	XR 11002	40	6	75	99	99	45
Acifluorfen + BB	0.13 + 1%	TT 11002	20	4.2	78	99	99	44
Acifluorfen + BB	0.13 + 1%	AI 11002	60	7.1	75	99	99	45
Acifluorfen + BB	0.13 + 1%	TDXL-110-02	60	7.1	74	97	98	36
LSD (5%)					6	3	2	7

[a] PO = Herbimax petroleum oil concentrate; MVO = Scoil methylated vegetable oil; NIS = Activator 90 nonionic surfactant; BB = Quad 7 basic pH blend adjuvant.
[b] All treatments were applied at 10 gpa.
[c] XR = Extended Range; TT = Turbo TeeJet; AI = AI TeeJet; TDXL = TurboDrop XL.

Table 2. Spray nozzle and adjuvant effects on acifluorfen efficacy, Casselton, ND.

					July 1			July 9
Treatment[ab]	Rate	Nozzle[c]	Pressure	Speed	Sunflower	Tame buckwheat	Flax	Sunflower
	(lb ai/A)		(psi)	(mph)	(%)	(%)	(%)	(%)
Acifluorfen + PO	0.13 + 1.5 pt	XR 11002	40	6	55	97	99	31
Acifluorfen + PO	0.13 + 1.5 pt	TT 11002	20	4.2	53	94	99	26
Acifluorfen + PO	0.13 + 1.5 pt	AI 11002	60	7.1	61	96	99	35
Acifluorfen + PO	0.13 + 1.5 pt	TDXL-110-02	60	7.1	56	97	99	35
Acifluorfen + MVO	0.13 + 1.5 pt	XR 11002	40	6	73	99	99	44
Acifluorfen + MVO	0.13 + 1.5 pt	TT 11002	20	4.2	69	99	99	41
Acifluorfen + MVO	0.13 + 1.5 pt	AI 11002	60	7.1	73	99	99	48
Acifluorfen + MVO	0.13 + 1.5 pt	TDXL-110-02	60	7.1	73	99	99	49
Acifluorfen + NIS	0.13 + 0.25%	XR 11002	40	6	44	94	99	21
Acifluorfen + NIS	0.13 + 0.25%	TT 11002	20	4.2	39	90	99	18
Acifluorfen + NIS	0.13 + 0.25%	AI 11002	60	7.1	44	92	99	25
Acifluorfen + NIS	0.13 + 0.25%	TDXL-110-02	60	7.1	51	93	99	26
Acifluorfen + BB	0.13 + 1%	XR 11002	40	6	66	99	99	39
Acifluorfen + BB	0.13 + 1%	TT 11002	20	4.2	63	99	99	34
Acifluorfen + BB	0.13 + 1%	AI 11002	60	7.1	66	99	99	39
Acifluorfen + BB	0.13 + 1%	TDXL-110-02	60	7.1	69	99	99	39
LSD (5%)					8	4	NS	8

[a] PO = Herbimax petroleum oil concentrate; MVO = Scoil methylated vegetable oil; NIS = Activator 90 nonionic surfactant; BB = Quad 7 basic pH blend adjuvant.
[b] All treatments were applied at 10 gpa.
[c] XR = Extended Range; TT = Turbo TeeJet; AI = AI TeeJet; TDXL = TurboDrop XL.

Spray nozzle and adjuvant effects on bentazon efficacy. Ramsdale, Brad K., Sam J. Lockhart, and Calvin G. Messersmith. The experiment was conducted to examine the influence of drift-reducing nozzles and adjuvants on bentazon efficacy. Bioassay species were planted as 6-ft-wide strips side-by-side. Plots 12 ft wide were laid out perpendicular to the strips so that each plot contained all bioassay species. Treatments were applied at 10 gpa with an all-terrain vehicle equipped with a four-nozzle boom (20-inch spacing) offset to one side. Experimental design was a randomized complete block with four replicates. Weed control was evaluated visually where 0 equaled no visible injury and 100 equaled complete death of assay species.

Experiment location	Fargo	Casselton
Planting date	May 22	May 24
Treatment date	June 18	June 20
Air temperature (F)	75	72
Relative humidity (%)	65	40
Wind (mph)	12-15	5
Sky (% clouds)	80	40
Sunflower		
variety	F_2 oilseed	F_2 oilseed
height (inch)	5-7	6-8

The Extended Range nozzle at 40 psi represented a standard flat-fan nozzle application. Sunflower control by bentazon plus petroleum oil applied through Turbo TeeJet nozzles was less than when applied through Extended Range nozzles at Fargo. However, bentazon efficacy was generally similar for all nozzles when applied with methylated vegetable oil or basic pH blend adjuvants. Bentazon applied through three types of drift-reducing nozzles provided similar sunflower control compared to application through an Extended Range nozzle at Casselton. Bentazon was generally most effective when applied with a methylated vegetable oil adjuvant. Sunflower control by bentazon plus the basic pH blend adjuvant was generally similar to bentazon plus petroleum oil.

Table 1. Spray nozzle and adjuvant effects on bentazon efficacy, Fargo, ND.

Treatment[ab]	Rate	Nozzle[c]	Pressure	Speed	Sunflower control	
					June 27	July 8
	(lb ai/A)		(psi)	(mph)	(%)	(%)
Bentazon + PO	0.5 + 1.5 pt	XR 11002	40	6	71	33
Bentazon + PO	0.5 + 1.5 pt	TT 11002	20	4.2	39	11
Bentazon + PO	0.5 + 1.5 pt	AI 11002	60	7.1	56	25
Bentazon + PO	0.5 + 1.5 pt	TDXL-110-02	60	7.1	64	25
Bentazon + MVO	0.5 + 1.5 pt	XR 11002	40	6	71	33
Bentazon + MVO	0.5 + 1.5 pt	TT 11002	20	4.2	66	29
Bentazon + MVO	0.5 + 1.5 pt	AI 11002	60	7.1	75	39
Bentazon + MVO	0.5 + 1.5 pt	TDXL-110-02	60	7.1	75	38
Bentazon + BB	0.5 + 1%	XR 11002	40	6	60	26
Bentazon + BB	0.5 + 1%	TT 11002	20	4.2	63	26
Bentazon + BB	0.5 + 1%	AI 11002	60	7.1	59	26
Bentazon + BB	0.5 + 1%	TDXL-110-02	60	7.1	60	26
LSD (5%)					14	9

[a] PO = Herbimax petroleum oil concentrate; MVO = Scoil methylated vegetable oil; BB = Quad 7 basic pH blend adjuvant.
[b] All treatments were applied at 10 gpa.
[c] XR = extended range; TT = Turbo TeeJet; AI = AI TeeJet; TDXL = TurboDrop XL.

Table 2. Spray nozzle and adjuvant effects on bentazon efficacy, Casselton, ND.

Treatment[ab]	Rate	Nozzle[c]	Pressure	Speed	Sunflower control	
					July 1	July 9
	(lb ai/A)		(psi)	(mph)	(%)	(%)
Bentazon + PO	0.5 + 1.5 pt	XR 11002	40	6	81	50
Bentazon + PO	0.5 + 1.5 pt	TT 11002	20	4.2	76	49
Bentazon + PO	0.5 + 1.5 pt	AI 11002	60	7.1	74	44
Bentazon + PO	0.5 + 1.5 pt	TDXL-110-02	60	7.1	78	46
Bentazon + MVO	0.5 + 1.5 pt	XR 11002	40	6	86	58
Bentazon + MVO	0.5 + 1.5 pt	TT 11002	20	4.2	86	56
Bentazon + MVO	0.5 + 1.5 pt	AI 11002	60	7.1	85	56
Bentazon + MVO	0.5 + 1.5 pt	TDXL-110-02	60	7.1	84	54
Bentazon + BB	0.5 + 1%	XR 11002	40	6	88	55
Bentazon + BB	0.5 + 1%	TT 11002	20	4.2	81	53
Bentazon + BB	0.5 + 1%	AI 11002	60	7.1	77	49
Bentazon + BB	0.5 + 1%	TDXL-110-02	60	7.1	78	50
LSD (5%)					NS	NS

[a] PO = Herbimax petroleum oil concentrate; MVO = Scoil methylated vegetable oil; BB = Quad 7 basic pH blend adjuvant.
[b] All treatments were applied at 10 gpa.
[c] XR = extended range; TT = Turbo TeeJet; AI = AI TeeJet; TDXL = TurboDrop XL.

Spray nozzle and adjuvant effects on fomesafen (Flexstar formulation) efficacy. Ramsdale, Brad K., Sam J. Lockhart, and Calvin G. Messersmith. The experiment was conducted to examine the influence of drift-reducing nozzles and adjuvants on fomesafen (Flexstar formulation) efficacy. Bioassay species were planted as 6-ft-wide strips side-by-side. Plots 12 ft wide were laid out perpendicular to the strips so that each plot contained all three assay species. Treatments were applied at 10 gpa with an all-terrain vehicle equipped with a four-nozzle boom (20-inch spacing) offset to one side. Experimental design was a randomized complete block with four replicates. Weed control was evaluated visually where 0 equaled no visible injury and 100 equaled complete death of assay species.

Experiment location	Fargo	Casselton
Planting date	May 22	May 24
Treatment date	June 18	June 20
Air temperature (F)	75	72
Relative humidity (%)	65	40
Wind (mph)	12-15	5
Sky (% clouds)	80	40
Flax		
variety	'Neche'	'Neche'
height (inch)	5-7	6-8
Sunflower		
variety	F_2 oilseed	F_2 oilseed
height (inch)	5-7	6-8
Tame buckwheat		
variety	'Mancan'	'Mancan'
height (inch)	5-7	8-10

The Extended Range nozzle at 40 psi represented a standard flat-fan nozzle application. Fomesafen (Flexstar formulation) at 0.13 lb/A provided complete control of flax and tame buckwheat for all treatments. Sunflower control by fomesafen at Fargo was not affected by nozzle type when applied with petroleum oil, methylated vegetable oil, or nonionic surfactant. However, fomesafen plus basic pH blend adjuvant provided greater sunflower control when applied through Extended Range nozzles than drift-reducing nozzles. Sunflower control by fomesafen at Casselton was not affected by nozzle type when applied with petroleum oil, methylated vegetable oil, or basic pH blend adjuvants. However, fomesafen plus nonionic surfactant provided greater sunflower control when applied through Extended Range nozzles than drift-reducing nozzles. Fomesafen efficacy was generally similar regardless of adjuvant.

Table 1. Spray nozzle and adjuvant effects on fomesafen (Flexstar formulation) efficacy, Fargo, ND.

					June 27			July 8
Treatment[ab]	Rate	Nozzle[c]	Pressure	Speed	Sunflower	Tame buckwheat	Flax	Sunflower
	(lb ai/A)		(psi)	(mph)	(%)	(%)	(%)	(%)
Fomesafen + PO	0.13 + 1.5 pt	XR 11002	40	6	80	99	99	49
Fomesafen + PO	0.13 + 1.5 pt	TT 11002	20	4.2	79	99	99	48
Fomesafen + PO	0.13 + 1.5 pt	AI 11002	60	7.1	81	99	99	50
Fomesafen + PO	0.13 + 1.5 pt	TDXL-110-02	60	7.1	83	99	99	53
Fomesafen + MVO	0.13 + 1.5 pt	XR 11002	40	6	86	99	99	60
Fomesafen + MVO	0.13 + 1.5 pt	TT 11002	20	4.2	84	99	99	52
Fomesafen + MVO	0.13 + 1.5 pt	AI 11002	60	7.1	87	99	99	58
Fomesafen + MVO	0.13 + 1.5 pt	TDXL-110-02	60	7.1	89	99	99	63
Fomesafen + NIS	0.13 + 0.25%	XR 11002	40	6	80	99	99	49
Fomesafen + NIS	0.13 + 0.25%	TT 11002	20	4.2	79	99	99	49
Fomesafen + NIS	0.13 + 0.25%	AI 11002	60	7.1	84	99	99	55
Fomesafen + NIS	0.13 + 0.25%	TDXL-110-02	60	7.1	87	99	99	56
Fomesafen + BB	0.13 + 1%	XR 11002	40	6	92	99	99	65
Fomesafen + BB	0.13 + 1%	TT 11002	20	4.2	80	99	99	50
Fomesafen + BB	0.13 + 1%	AI 11002	60	7.1	83	99	99	54
Fomesafen + BB	0.13 + 1%	TDXL-110-02	60	7.1	83	99	99	53
LSD (5%)					6	NS	NS	8

[a] PO = Herbimax petroleum oil concentrate; MVO = Scoil methylated vegetable oil; NIS = Activator 90 nonionic surfactant; BB = Quad 7 basic pH blend adjuvant.
[b] All treatments were applied at 10 gpa.
[c] XR = Extended Range; TT = Turbo TeeJet; AI = AI TeeJet; TDXL = TurboDrop XL.

Table 2. Spray nozzle and adjuvant effects on fomesafen (Flexstar formulation) efficacy, Casselton, ND

					July 1			July 9
Treatment[ab]	Rate	Nozzle[c]	Pressure	Speed	Sunflower	Tame buckwheat	Flax	Sunflower
	(lb ai/A)		(psi)	(mph)	(%)	(%)	(%)	(%)
Fomesafen + PO	0.13 + 1.5 pt	XR 11002	40	6	85	99	99	65
Fomesafen + PO	0.13 + 1.5 pt	TT 11002	20	4.2	88	99	99	71
Fomesafen + PO	0.13 + 1.5 pt	AI 11002	60	7.1	76	99	99	55
Fomesafen + PO	0.13 + 1.5 pt	TDXL-110-02	60	7.1	76	99	99	55
Fomesafen + MVO	0.13 + 1.5 pt	XR 11002	40	6	91	99	99	76
Fomesafen + MVO	0.13 + 1.5 pt	TT 11002	20	4.2	87	99	99	70
Fomesafen + MVO	0.13 + 1.5 pt	AI 11002	60	7.1	88	99	99	66
Fomesafen + MVO	0.13 + 1.5 pt	TDXL-110-02	60	7.1	88	99	99	66
Fomesafen + NIS	0.13 + 0.25%	XR 11002	40	6	97	99	99	91
Fomesafen + NIS	0.13 + 0.25%	TT 11002	20	4.2	80	99	99	60
Fomesafen + NIS	0.13 + 0.25%	AI 11002	60	7.1	84	99	99	61
Fomesafen + NIS	0.13 + 0.25%	TDXL-110-02	60	7.1	80	99	99	60
Fomesafen + BB	0.13 + 1%	XR 11002	40	6	94	99	99	79
Fomesafen + BB	0.13 + 1%	TT 11002	20	4.2	84	99	99	65
Fomesafen + BB	0.13 + 1%	AI 11002	60	7.1	90	99	99	68
Fomesafen + BB	0.13 + 1%	TDXL-110-02	60	7.1	83	99	99	60
LSD (5%)					11	NS	NS	15

[a] PO = Herbimax petroleum oil concentrate; MVO = Scoil methylated vegetable oil; NIS = Activator 90 nonionic surfactant; BB = Quad 7 basic pH blend adjuvant.
[b] All treatments were applied at 10 gpa.
[c] XR = Extended Range; TT = Turbo TeeJet; AI = AI TeeJet; TDXL = TurboDrop XL.

Spray nozzle and adjuvant effects on lactofen efficacy. Ramsdale, Brad K., Sam J. Lockhart, and Calvin G. Messersmith. The experiment was conducted to examine the influence of drift-reducing nozzles and adjuvants on lactofen efficacy. Bioassay species were planted as 6-ft-wide strips side-by-side. Plots 12 ft wide were laid out perpendicular to the strips so that each plot contained all three assay species. Treatments were applied at 10 gpa with an all-terrain vehicle equipped with a four-nozzle boom (20-inch spacing) offset to one side. Experimental design was a randomized complete block with four replicates. Weed control was evaluated visually where 0 equaled no visible injury and 100 equaled complete death of assay species.

Experiment location	Fargo	Casselton
Planting date	May 22	May 24
Treatment date	June 18	June 20
Air temperature (F)	75	72
Relative humidity (%)	65	40
Wind (mph)	12-15	5
Sky (% clouds)	80	40
Flax		
variety	'Neche'	'Neche'
height (inch)	5-7	6-8
Sunflower		
variety	F_2 oilseed	F_2 oilseed
height (inch)	5-7	6-8
Tame buckwheat		
variety	'Mancan'	'Mancan'
height (inch)	5-7	8-10

The Extended Range nozzle at 40 psi represented a standard flat-fan nozzle application. Overall, efficacy of lactofen at 0.13 lb/A was generally similar regardless of nozzle type or adjuvant. Lactofen applied with drift-reducing nozzles was occasionally less, but also occasionally was more effective, than with the standard flat-fan nozzle. Lactofen efficacy was generally greater with petroleum oil at 1.5 pt/A than the nonionic surfactant at 0.25% v/v.

Table 1. Spray nozzle and adjuvant effects on lactofen efficacy, Fargo, ND.

					June 27			July 8
Treatment[ab]	Rate	Nozzle[c]	Pressure	Speed	Sunflower	Tame buckwheat	Flax	Sunflower
	(lb ai/A)		(psi)	(mph)	(%)	(%)	(%)	(%)
Lactofen + PO	0.13 + 1.5 pt	XR 11002	40	6	87	99	99	71
Lactofen + PO	0.13 + 1.5 pt	TT 11002	20	4.2	83	99	99	61
Lactofen + PO	0.13 + 1.5 pt	AI 11002	60	7.1	78	99	99	59
Lactofen + PO	0.13 + 1%	XR 11002	40	6	90	99	99	69
Lactofen + PO	0.13 + 1%	TT 11002	20	4.2	75	99	99	58
Lactofen + PO	0.13 + 1%	AI 11002	60	7.1	86	99	99	65
Lactofen + NIS	0.13 + 0.25%	XR 11002	40	6	76	99	99	54
Lactofen + NIS	0.13 + 0.25%	TT 11002	20	4.2	80	99	99	55
Lactofen + NIS	0.13 + 0.25%	AI 11002	60	7.1	74	99	99	54
LSD (5%)					7	NS	NS	8

[a] PO = Herbimax petroleum oil concentrate; NIS = Activator 90 nonionic surfactant.
[b] All treatments were applied at 10 gpa.
[c] XR = Extended Range; TT = Turbo TeeJet; AI = AI TeeJet.

Table 2. Spray nozzle and adjuvant effects on lactofen efficacy, Casselton, ND.

					July 1			July 9
Treatment[ab]	Rate	Nozzle[c]	Pressure	Speed	Sunflower	Tame buckwheat	Flax	Sunflower
	(lb ai/A)		(psi)	(mph)	(%)	(%)	(%)	(%)
Lactofen + PO	0.13 + 1.5 pt	XR 11002	40	6	65	98	99	36
Lactofen + PO	0.13 + 1.5 pt	TT 11002	20	4.2	64	98	99	38
Lactofen + PO	0.13 + 1.5 pt	AI 11002	60	7.1	68	94	98	46
Lactofen + PO	0.13 + 1.5 pt	TDXL-110-02	60	7.1	81	99	99	59
Lactofen + PO	0.13 + 1%	XR 11002	40	6	65	98	99	38
Lactofen + PO	0.13 + 1%	TT 11002	20	4.2	61	96	99	38
Lactofen + PO	0.13 + 1%	AI 11002	60	7.1	64	92	99	40
Lactofen + PO	0.13 + 1%	TDXL-110-02	60	7.1	72	99	99	49
Lactofen + NIS	0.13 + 0.25%	XR 11002	40	6	58	93	99	30
Lactofen + NIS	0.13 + 0.25%	TT 11002	20	4.2	49	84	99	26
Lactofen + NIS	0.13 + 0.25%	AI 11002	60	7.1	59	90	99	33
Lactofen + NIS	0.13 + 0.25%	TDXL-110-02	60	7.1	65	94	99	41
LSD (5%)					11	6	NS	10

[a] PO = Herbimax petroleum oil concentrate; NIS = Activator 90 nonionic surfactant.
[b] All treatments were applied at 10 gpa.
[c] XR = Extended Range; TT = Turbo TeeJet; AI = AI TeeJet; TDXL = TurboDrop XL.

Spray nozzle and adjuvant effects on fomesafen (Reflex formulation) efficacy. Ramsdale, Brad K., Sam J. Lockhart, and Calvin G. Messersmith. The experiment was conducted to examine the influence of drift-reducing nozzles and adjuvants on fomesafen (Reflex formulation) efficacy. Bioassay species were planted as 6-ft-wide strips side-by-side. Plots 12 ft wide were laid out perpendicular to the strips so that each plot contained all three assay species. Treatments were applied at 10 gpa with an all-terrain vehicle equipped with a four-nozzle boom (20-inch spacing) offset to one side. Experimental design was a randomized complete block with four replicates. Weed control was evaluated visually where 0 equaled no visible injury and 100 equaled complete death of assay species.

Experiment location	Fargo	Casselton
Planting date	May 22	May 24
Treatment date	June 18	June 20
Air temperature (F)	75	72
Relative humidity (%)	65	40
Wind (mph)	12-15	5
Sky (% clouds)	80	40
Flax		
variety	'Neche'	'Neche'
height (inch)	5-7	6-8
Sunflower		
variety	F_2 oilseed	F_2 oilseed
height (inch)	5-7	6-8
Tame buckwheat		
variety	'Mancan'	'Mancan'
height (inch)	5-7	8-10

The Extended Range nozzle at 40 psi represented a standard flat-fan nozzle application. Fomesafen (Reflex formulation) at 0.13 lb/A applied with drift-reducing nozzles was equally or more effective than when applied with an Extended Range nozzle regardless of adjuvant. Overall, fomesafen efficacy was greatest with methylated vegetable oil. Fomesafen plus basic pH blend adjuvant was more effective than fomesafen plus nonionic surfactant or petroleum oil, which provided similar species control.

Table 1. Spray nozzle and adjuvant effects on fomesafen (Reflex formulation) efficacy, Fargo, ND.

					June 27			July 8
Treatment[ab]	Rate	Nozzle[c]	Pressure	Speed	Sunflower	Tame buckwheat	Flax	Sunflower
	(lb ai/A)		(psi)	(mph)	(%)	(%)	(%)	(%)
Fomesafen + PO	0.13 + 1.5 pt	XR 11002	40	6	60	89	96	28
Fomesafen + PO	0.13 + 1.5 pt	TT 11002	20	4.2	59	85	92	25
Fomesafen + PO	0.13 + 1.5 pt	AI 11002	60	7.1	63	90	91	31
Fomesafen + PO	0.13 + 1.5 pt	TDXL-110-02	60	7.1	70	94	95	36
Fomesafen + MVO	0.13 + 1.5 pt	XR 11002	40	6	94	99	99	79
Fomesafen + MVO	0.13 + 1.5 pt	TT 11002	20	4.2	90	99	99	68
Fomesafen + MVO	0.13 + 1.5 pt	AI 11002	60	7.1	89	99	99	65
Fomesafen + MVO	0.13 + 1.5 pt	TDXL-110-02	60	7.1	89	99	99	65
Fomesafen + NIS	0.13 + 0.25%	XR 11002	40	6	63	88	95	34
Fomesafen + NIS	0.13 + 0.25%	TT 11002	20	4.2	65	88	93	33
Fomesafen + NIS	0.13 + 0.25%	AI 11002	60	7.1	73	89	93	41
Fomesafen + NIS	0.13 + 0.25%	TDXL-110-02	60	7.1	65	90	94	31
Fomesafen + BB	0.13 + 1%	XR 11002	40	6	79	97	99	51
Fomesafen + BB	0.13 + 1%	TT 11002	20	4.2	81	95	99	50
Fomesafen + BB	0.13 + 1%	AI 11002	60	7.1	76	97	98	45
Fomesafen + BB	0.13 + 1%	TDXL-110-02	60	7.1	76	97	99	43
LSD (5%)					9	5	4	12

[a] PO = Herbimax petroleum oil concentrate; MVO = Scoil methylated vegetable oil; NIS = Activator 90 nonionic surfactant; BB = Quad 7 basic pH blend adjuvant.
[b] All treatments were applied at 10 gpa.
[c] XR = Extended Range; TT = Turbo TeeJet; AI = AI TeeJet; TDXL = TurboDrop XL.

Table 2. Spray nozzle and adjuvant effects on fomesafen (Reflex formulation) efficacy, Casselton, ND

					July 1			July 9
Treatment[ab]	Rate	Nozzle[c]	Pressure	Speed	Sunflower	Tame buckwheat	Flax	Sunflower
	(lb ai/A)		(psi)	(mph)	(%)	(%)	(%)	(%)
Fomesafen + PO	0.13 + 1.5 pt	XR 11002	40	6	35	89	99	23
Fomesafen + PO	0.13 + 1.5 pt	TT 11002	20	4.2	36	90	95	15
Fomesafen + PO	0.13 + 1.5 pt	AI 11002	60	7.1	39	91	98	19
Fomesafen + PO	0.13 + 1.5 pt	TDXL-110-02	60	7.1	39	95	98	24
Fomesafen + MVO	0.13 + 1.5 pt	XR 11002	40	6	79	99	99	68
Fomesafen + MVO	0.13 + 1.5 pt	TT 11002	20	4.2	73	98	99	58
Fomesafen + MVO	0.13 + 1.5 pt	AI 11002	60	7.1	80	98	99	65
Fomesafen + MVO	0.13 + 1.5 pt	TDXL-110-02	60	7.1	79	98	99	63
Fomesafen + NIS	0.13 + 0.25%	XR 11002	40	6	38	94	97	19
Fomesafen + NIS	0.13 + 0.25%	TT 11002	20	4.2	40	93	98	30
Fomesafen + NIS	0.13 + 0.25%	AI 11002	60	7.1	40	91	97	26
Fomesafen + NIS	0.13 + 0.25%	TDXL-110-02	60	7.1	41	94	99	28
Fomesafen + BB	0.13 + 1%	XR 11002	40	6	59	97	99	43
Fomesafen + BB	0.13 + 1%	TT 11002	20	4.2	60	96	99	39
Fomesafen + BB	0.13 + 1%	AI 11002	60	7.1	51	94	99	33
Fomesafen + BB	0.13 + 1%	TDXL-110-02	60	7.1	69	99	99	40
LSD (5%)					12	4	NS	16

[a] PO = Herbimax petroleum oil concentrate; MVO = Scoil methylated vegetable oil; NIS = Activator 90 nonionic surfactant; BB = Quad 7 basic pH blend adjuvant.
[b] All treatments were applied at 10 gpa.
[c] XR = Extended Range; TT = Turbo TeeJet; AI = AI TeeJet; TDXL = TurboDrop XL.

Glyphosate with water conditioners and hard water, Fargo. Ramsdale, Brad K., Sam J. Lockhart, and Calvin G. Messersmith. 'Jerry' oat, 'Sunrise' proso millet, and 'Oxen' wheat were planted as 6-ft-wide strips side-by-side on August 9, 2002. Plots 10 ft wide were laid out perpendicular to the strips so that each plot contained all three assay species. Treatments were applied at 8.5 gpa on September 6 with a CO_2-pressurized bicycle-wheel-type plot sprayer equipped with four 8001 flat-fan nozzles at 20-inch spacing. Conditions at treatment were 77 F, 70% RH, wind at 15 mph, and sky clear. Plant size at treatment were oat at 8- to 10-inch and tillering, and wheat and proso millet at 6- to 8-inch and tillering. Experimental design was a randomized complete block with four replicates. Glyphosate was applied at a reduced rate to better detect treatment effects on glyphosate efficacy. The spray water conditioners were added to the spray mixture either before or after the glyphosate to determine whether mixing sequence affected glyphosate efficacy. Weed control was evaluated visually where 0 equaled no visible injury and 100 equaled complete death of assay species.

			September 16			September 24		
Treatment[ab]	Rate	Herbicide added	Oat	Wheat	Proso millet	Oat	Wheat	Proso millet
	(lb ae/A)		(%)	(%)	(%)	(%)	(%)	(%)
Glyphosate	0.06	Before	38	48	60	43	54	60
Glyphosate + AMS	0.06 + 1%	Before	66	84	88	68	86	93
Glyphosate + Choice	0.06 + 0.75%	Before	55	68	74	60	77	82
Glyphosate + Quest	0.06 + 0.75%	Before	61	78	83	69	85	88
Glyphosate + Bronc Max	0.06 + 0.75%	Before	51	73	81	55	81	87
Glyphosate + Insure-GL	0.06 + 0.25%	Before	50	66	69	53	66	74
Glyphosate + Transport	0.06 + 0.75%	Before	55	75	83	56	80	88
Glyphosate + AMS	0.06 + 1%	After	66	84	93	70	88	95
Glyphosate + Choice	0.06 + 0.75%	After	56	66	75	60	74	79
Glyphosate + Quest	0.06 + 0.75%	After	56	73	81	59	79	91
Glyphosate + Bronc Max	0.06 + 0.75%	After	65	80	86	71	86	94
Glyphosate + Insure-GL	0.06 + 0.25%	After	51	69	69	54	74	78
Glyphosate + Transport	0.06 + 0.75%	After	63	80	86	65	83	88
LSD (5%)			8	8	6	11	9	6

[a] The spray water used for herbicide treatments contained 1550 mg/L $CaCO_3$.
[b] Glyphosate = Roundup UltraMax.

Glyphosate control of grass species was generally best when glyphosate was applied with AMS, Bronc Max, Quest, or Transport. Glyphosate applied with Choice or Insure-GL water conditioners provided greater species control compared to glyphosate alone, but were generally less than the other treatments. Mixing order did not influence glyphosate as efficacy was similar whether glyphosate was added before or after the water conditioner.

Glyphosate: ammonium sulfate concentration with hard water, Fargo. Ramsdale, Brad K., Sam J. Lockhart, and Calvin G. Messersmith. The spray water used for herbicide treatments contained 1550 mg/L $CaCO_3$. 'Jerry' oat, 'Sunrise' proso millet, and 'Robust' barley were planted as 10-ft-wide strips side-by-side on May 22, 2002. Plots 10 ft wide were laid out perpendicular to the strips so that each plot contained all three assay species. Treatments were applied on June 21 with a CO_2-pressurized bicycle-wheel-type plot sprayer equipped with four 8001 flat-fan nozzles at 20-inch spacing. Conditions at treatment were 70 F, 55% RH, wind at 10 mph, and sky 100% clouds. Oat, proso millet and barley at treatment were 6- to 8-inch and tillering. Experimental design was a randomized complete block with four replicates. Glyphosate was applied at a reduced rate to better detect treatment effects on glyphosate efficacy. Weed control was evaluated visually where 0 equaled no visible injury and 100 equaled complete death of assay species.

			July 4			July 16			
Treatment[a]	Rate	AMS rate	Barley	Proso millet	Oat	Barley	Proso millet	Oat	Ave
	(lb ae/A)	(w/v)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Glyt + Tween 20	0.03	None	45	43	53	33	30	39	41
Glyt + Tween 20	0.03	0.5%	84	82	81	83	71	73	79
Glyt + Tween 20	0.03	1%	90	93	89	90	85	88	89
Glyt + Tween 20	0.03	2%	93	94	94	94	88	89	92
Glyt + Tween 20	0.06	None	88	88	89	80	69	84	83
Glyt + Tween 20	0.06	0.5%	98	98	97	98	97	95	97
Glyt + Tween 20	0.06	1%	96	98	97	98	96	95	97
Glyt + Tween 20	0.06	2%	96	99	98	99	96	98	98
Glyt + Tween 20	0.09	None	98	97	96	98	87	93	95
Glyt + Tween 20	0.09	0.5%	98	98	99	99	99	98	99
Glyt + Tween 20	0.09	1%	99	99	99	99	98	98	99
Glyt + Tween 20	0.09	2%	99	99	99	99	98	99	99
Glyt + Tween 20	0.12	None	98	98	98	99	98	98	98
Glyt + Tween 20	0.12	0.5%	99	99	99	99	99	99	99
Glyt + Tween 20	0.12	1%	99	99	99	99	98	99	99
Glyt + Tween 20	0.12	2%	99	99	99	99	99	99	99
Glyt Ultra	0.06	None	76	73	73	71	60	66	70
Glyt Ultra	0.06	0.5%	95	97	95	98	94	97	96
Glyt Ultra	0.06	1%	95	97	95	96	97	92	95
Glyt Ultra	0.06	2%	97	95	97	99	98	97	97
LSD (5%)			8	9	9	10	10	11	10

[a] Glyt = glyphosate as the Roundup Custom® formulation; Glyt-Ultra = glyphosate as the Roundup Ultra® formulation; AMS = spray-grade ammonium sulfate; Tween 20 = nonionic surfactant, applied at 0.5% v/v.

Glyphosate at 0.5 oz ae/A applied with antagonistic well water was more effective with 1 or 2% w/v AMS compared to glyphosate alone or with 0.5% w/v AMS. Glyphosate as Roundup Ultra responded similarly to ammonium sulfate concentration as Roundup Custom plus nonionic surfactant. These results suggest that 1% w/v AMS (8.5 lb AMS per 100 gal water) was sufficient to overcome antagonism from spray water with a very high level of salts.

Adjuvant-fertilizer blend and spray water quality effects on glyphosate efficacy. Ramsdale, Brad K., Sam J. Lockhart, and Calvin G. Messersmith. The experiment was conducted to examine the effects of various commercial adjuvant-fertilizer blends and spray water quality on glyphosate efficacy. Bioassay species were planted as 6- to 10-ft-wide strips side-by-side. Plots 10 ft wide were laid out perpendicular to the strips so that each plot contained all three assay species. Treatments were applied with a CO_2-pressurized bicycle-wheel-type plot sprayer equipped with four 8001 flat-fan nozzles at 20-inch spacing. Experimental design was a randomized complete block with four replicates. Glyphosate was applied at a reduced rate of 0.06 lb ae/A to better detect treatment effects on glyphosate efficacy. The adjuvant-fertilizer blends were applied at a rate to provide 8.5 lb AMS per 100 gal water. Weed control was evaluated visually where 0 equaled no visible injury and 100 equaled complete death of assay species.

Experiment location	Fargo	Prosper
Planting date	May 22	May 24
Treatment date	June 25	June 21
Sprayer		
gpa	8.5	8.5
psi	35	35
Air temperature (F)	85	65
Relative humidity (%)	45	60
Wind (mph)	5	8-10
Sky (% clouds)	50	100
Oat		
variety	'Jerry'	'Jerry'
growth stage	tillering	tillering
height (inch)	8-12	8-10
Barley		
variety	'Robust'	'Robust'
growth stage	tillering	tillering
height (inch)	8-12	8-10
Proso millet		
variety	'Sunrise'	'Sunrise'
growth stage	tillering	4- to 6-leaf
height (inch)	4-8	2-6

Spray water quality did not adversely affect glyphosate efficacy for these adjuvant-fertilizer blends, indicating that all contained a sufficient amount of ammonium sulfate (AMS) to overcome the antagonistic salts in the hard water source. Glyphosate (Roundup Custom), which does not include a surfactant, was most effective when applied with adjuvants that contained surfactant, which included L-283, Surfate, Class Act Next Generation, Bronc Plus, and One-Ap XL. Drift retardant-AMS blends, which do not contain a surfactant, were generally the least effective. However, glyphosate with Placement Pro-Pak or Array was generally more effective than with the other drift retardant-AMS blends, except with One-Ap XL which also contains surfactant. Thus, with glyphosate (Roundup Custom) that does not contain a surfactant, adjuvant-fertilizer blends that contained surfactant were the most effective adjuvants for glyphosate.

Table 1. Adjuvant-fertilizer blend and spray water quality effects on glyphosate efficacy, Fargo, ND.

Treatment[a]	Rate	Spray water[b]	July 9			July 18			
			Barley	Proso millet	Oat	Barley	Proso millet	Oat	Ave
	(lb ae/A)		(%)	(%)	(%)	(%)	(%)	(%)	(%)
Glyt + L-283	0.06 + 1%	Soft	97	96	94	97	95	97	96
Glyt + L-283	0.06 + 2%	Soft	98	98	99	99	99	99	99
Glyt + Surfate	0.06 + 1%	Soft	98	97	98	99	98	99	98
Glyt + Class Act NG	0.06 + 2.5%	Soft	99	99	97	99	99	99	99
Glyt + Bronc Plus	0.06 + 3%	Soft	99	98	97	99	99	99	99
Glyt + Cornbelt Gardian Plus	0.06 + 2.5%	Soft	85	85	82	82	86	79	83
Glyt + Corral AMS	0.06 + 2.5%	Soft	69	74	69	65	70	63	68
Glyt + Surf Plus	0.06 + 2.5%	Soft	76	85	78	75	78	69	77
Glyt + Array	0.06 + 9	Soft	89	91	87	88	89	81	88
Glyt + Placement Pro-Pak	0.06 + 1%	Soft	94	94	94	95	95	97	95
Glyt + One-Ap XL	0.06 + 10	Soft	99	99	98	99	98	99	99
Glyt + L-283	0.06 + 1%	Hard	97	96	97	98	96	97	97
Glyt + L-283	0.06 + 2%	Hard	97	97	96	98	97	98	97
Glyt + Surfate	0.06 + 1%	Hard	95	94	94	94	93	96	94
Glyt + Class Act NG	0.06 + 2.5%	Hard	98	97	96	99	96	98	97
Glyt + Bronc Plus	0.06 + 3%	Hard	98	98	96	98	98	97	98
Glyt + Cornbelt Gardian Plus	0.06 + 2.5%	Hard	87	89	83	88	88	78	86
Glyt + Corral AMS	0.06 + 2.5%	Hard	78	83	80	78	78	75	79
Glyt + Surf Plus	0.06 + 2.5%	Hard	74	79	73	74	74	68	74
Glyt + Array	0.06 + 9	Hard	89	91	84	90	90	81	88
Glyt + Placement Pro-Pak	0.06 + 1%	Hard	91	88	91	92	88	92	90
Glyt + One-Ap XL	0.06 + 10	Hard	98	97	93	97	97	97	97
LSD (5%)			6	6	6	5	7	6	6

[a] Glyt = glyphosate as Roundup Custom; L-283 (NDSU experimental), Surfate, Class Act NG (Next Generation), and Bronc Plus = surfactant-ammonium sulfate blends; Cornbelt Gardian Plus, Corral AMS, Surf Plus, Array, and Placement Pro-Pak = drift retardant-ammonium sulfate blends; One-Ap XL = surfactant, drift retardant, ammonium sulfate blend.

[b] Spray water: Soft = Fargo city water, 100 ppm $CaCO_3$; Hard = well water, 1550 ppm $CaCO_3$.

Table 2. Adjuvant-fertilizer blend and spray water quality effects on glyphosate efficacy, Prosper, ND.

Treatment[a]	Rate	Spray water[b]	July 5			July 16			
			Barley	Proso millet	Oat	Barley	Proso millet	Oat	Ave
	(lb ae/A)		(%)	(%)	(%)	(%)	(%)	(%)	(%)
Glyt + L-283	0.06 + 1%	Soft	91	88	89	89	68	81	84
Glyt + L-283	0.06 + 2%	Soft	93	94	96	93	80	91	91
Glyt + Surfate	0.06 + 1%	Soft	93	89	93	92	76	86	88
Glyt + Class Act NG	0.06 + 2.5%	Soft	99	96	97	99	88	94	96
Glyt + Bronc Plus	0.06 + 3%	Soft	91	89	90	86	76	80	85
Glyt + Cornbelt Gardian Plus	0.06 + 2.5%	Soft	95	90	88	92	75	71	85
Glyt + Corral AMS	0.06 + 2.5%	Soft	77	80	76	66	55	56	68
Glyt + Surf Plus	0.06 + 2.5%	Soft	83	86	78	78	64	58	75
Glyt + Array	0.06 + 9	Soft	80	81	81	70	59	63	72
Glyt + Placement Pro-Pak	0.06 + 1%	Soft	89	83	88	87	55	78	80
Glyt + One-Ap XL	0.06 + 10	Soft	97	98	96	98	91	92	95
Glyt + L-283	0.06 + 1%	Hard	94	93	94	94	81	89	91
Glyt + L-283	0.06 + 2%	Hard	92	91	92	89	76	84	87
Glyt + Surfate	0.06 + 1%	Hard	97	92	93	96	79	85	90
Glyt + Class Act NG	0.06 + 2.5%	Hard	96	97	98	96	88	94	95
Glyt + Bronc Plus	0.06 + 3%	Hard	97	94	95	96	86	90	93
Glyt + Cornbelt Gardian Plus	0.06 + 2.5%	Hard	85	81	77	80	58	59	73
Glyt + Corral AMS	0.06 + 2.5%	Hard	91	86	81	88	68	64	80
Glyt + Surf Plus	0.06 + 2.5%	Hard	80	75	71	73	50	53	67
Glyt + Array	0.06 + 9	Hard	93	89	90	91	72	76	85
Glyt + Placement Pro-Pak	0.06 + 1%	Hard	95	84	91	92	66	83	85
Glyt + One-Ap XL	0.06 + 10	Hard	94	94	94	93	83	89	91
LSD (5%)			7	6	6	9	14	12	9

[a] Glyt = glyphosate as Roundup Custom; L-283 (NDSU experimental), Surfate, Class Act NG (Next Generation), and Bronc Plus = surfactant-ammonium sulfate blends; Cornbelt Gardian Plus, Corral AMS, Surf Plus, Array, and Placement Pro-Pak = drift retardant-ammonium sulfate blends; One-Ap XL = surfactant, drift retardant, ammonium sulfate blend.

[b] Spray water: Soft = Fargo city water, 100 ppm $CaCO_3$; Hard = well water, 1550 ppm $CaCO_3$.

C

Surfactant and ammonium sulfate effects on glyphosate efficacy in a hard water carrier.
Ramsdale, Brad K., Sam J. Lockhart, and Calvin G. Messersmith. The experiment was conducted to examine the effects of various commercial surfactants and ammonium sulfate on glyphosate efficacy using a hard water spray carrier. Bioassay species were planted as 6- to 10-ft-wide strips side-by-side. Plots 10 ft wide were laid out perpendicular to the strips so that each plot contained all three assay species. Treatments were applied with a CO_2-pressurized bicycle-wheel-type plot sprayer equipped with four 8001 flat-fan nozzles at 20-inch spacing. Experimental design was a randomized complete block with four replicates. Glyphosate was applied at a reduced rate of 0.06 lb ae/A to better detect treatment effects on glyphosate efficacy. Each adjuvant was applied alone and with ammonium sulfate (AMS) at 1% w/v, except for adjuvants that contain AMS in the formulation. The spray water used for herbicide treatments contained 1550 ppm $CaCO_3$. Weed control was evaluated visually where 0 equaled no visible injury and 100 equaled complete death of assay species.

Experiment location	Fargo	Prosper
Planting date	May 22	May 24
Treatment date	June 25	June 21
Sprayer		
gpa	8.5	8.5
psi	35	35
Air temperature (F)	85	65
Relative humidity (%)	45	60
Wind (mph)	5	8-10
Sky (% clouds)	50	100
Oat		
variety	'Jerry'	'Jerry'
growth stage	tillering	tillering
height (inch)	8-12	8-10
Barley		
variety	'Robust'	'Robust'
growth stage	tillering	tillering
height (inch)	8-12	8-10
Proso millet		
variety	'Sunrise'	'Sunrise'
growth stage	tillering	4- to 6-leaf
height (inch)	4-8	2-6

All treatments were applied with a hard water carrier. Glyphosate efficacy was best when applied with surfactants plus ammonium sulfate (AMS) or surfactant-AMS blends. Glyphosate efficacy, when applied without AMS, tended to be greater when applied with Liberate, Atplus GTM-10, Purity 100, and LI-700 than with other surfactants. However, results varied across location, evaluation date, and species.

Table 1. Surfactant and ammonium sulfate effects on glyphosate efficacy in a hard water carrier, Fargo, ND.

Treatment[ab]	Rate	July 9			July 18			
		Barley	Proso millet	Oat	Barley	Proso millet	Oat	Ave
	(lb ae/A)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Glyt + Activator 90	0.06 + 0.5%	65	64	84	78	70	90	75
Glyt + Active-It	0.06 + 0.5%	59	59	81	65	64	85	69
Glyt + Cornbelt Premier 90	0.06 + 0.5%	63	65	89	68	70	89	74
Glyt + Induce	0.06 + 0.5%	64	65	85	70	73	90	75
Glyt + LI-700	0.06 + 0.5%	75	71	84	80	76	87	79
Glyt + Liberate	0.06 + 0.5%	88	75	89	91	81	92	86
Glyt + Preference	0.06 + 0.5%	66	65	83	76	75	91	76
Glyt + Purity 100	0.06 + 0.5%	73	81	93	80	85	93	84
Glyt + R-11	0.06 + 0.5%	70	66	84	76	73	86	76
Glyt + Atplus GTM-10	0.06 + 0.5%	80	84	88	85	88	91	86
Glyt + Activator 90 + AMS	0.06 + 0.5% + 1%	98	98	99	99	98	99	99
Glyt + Active-It + AMS	0.06 + 0.5% + 1%	99	99	99	99	99	99	99
Glyt + Cornbelt Premier 90 + AMS	0.06 + 0.5% + 1%	99	99	99	99	99	99	99
Glyt + Induce + AMS	0.06 + 0.5% + 1%	99	99	99	99	99	99	99
Glyt + LI-700 + AMS	0.06 + 0.5% + 1%	99	99	99	99	99	99	99
Glyt + Liberate + AMS	0.06 + 0.5% + 1%	99	99	99	99	99	99	99
Glyt + Preference + AMS	0.06 + 0.5% + 1%	98	98	99	99	99	99	99
Glyt + Purity 100 + AMS	0.06 + 0.5% + 1%	99	99	99	99	99	99	99
Glyt + R-11 + AMS	0.06 + 0.5% + 1%	98	98	98	98	98	99	98
Glyt + Atplus GTM-10 + AMS	0.06 + 0.5% + 1%	98	98	99	99	99	99	99
Glyt + L-283	0.06 + 1%	98	97	98	99	96	99	98
Glyt + L-283	0.06 + 2%	99	99	99	99	99	99	99
Glyt + Class Act NG	0.06 + 2.5%	99	99	99	99	99	99	99
Glyt-UM	0.06	73	66	78	81	73	75	74
Glyt-UM + AMS	0.06 + 1%	98	99	98	98	99	99	99
LSD (5%)		8	8	7	6	7	5	7

[a] The spray water used for herbicide treatments contained 1550 ppm $CaCO_3$.

[b] Glyt = glyphosate as Roundup Custom; Glyt-UM = glyphosate as Roundup UltraMax; AMS = spray grade ammonium sulfate; Activator 90, Active-It, Cornbelt Premier 90, Induce, LI-700, Liberate, Preference, Purity 100, R-11, and Atplus GTM-10 = surfactants; L-283 (NDSU experimental) and Class Act NG (Next Generation) = surfactant-AMS blends.

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Table 2. Surfactant and ammonium sulfate effects on glyphosate efficacy in a hard water carrier, Prosper, ND.

		July 5			July 16			
Treatment[ab]	Rate	Barley	Proso millet	Oat	Barley	Proso millet	Oat	Ave
	(lb ae/A)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Glyt + Activator 90	0.06 + 0.5%	39	34	66	30	19	50	40
Glyt + Active-It	0.06 + 0.5%	39	35	55	29	19	39	36
Glyt + Cornbelt Premier 90	0.06 + 0.5%	46	45	60	33	23	43	42
Glyt + Induce	0.06 + 0.5%	49	48	61	43	39	51	49
Glyt + LI-700	0.06 + 0.5%	63	56	74	65	38	61	60
Glyt + Liberate	0.06 + 0.5%	76	63	80	79	40	73	69
Glyt + Preference	0.06 + 0.5%	38	38	53	31	20	40	37
Glyt + Purity 100	0.06 + 0.5%	59	50	71	49	34	60	54
Glyt + R-11	0.06 + 0.5%	44	43	61	34	28	44	42
Glyt + Atplus GTM-10	0.06 + 0.5%	66	68	69	64	59	60	64
Glyt + Activator 90 + AMS	0.06 + 0.5% + 1%	93	78	93	94	63	91	85
Glyt + Active-It + AMS	0.06 + 0.5% + 1%	92	83	89	94	65	87	85
Glyt + Cornbelt Premier 90 + AMS	0.06 + 0.5% + 1%	97	92	97	98	80	97	94
Glyt + Induce + AMS	0.06 + 0.5% + 1%	98	83	93	98	65	94	89
Glyt + LI-700 + AMS	0.06 + 0.5% + 1%	99	97	98	99	90	97	97
Glyt + Liberate + AMS	0.06 + 0.5% + 1%	99	94	98	99	85	97	95
Glyt + Preference + AMS	0.06 + 0.5% + 1%	96	90	95	96	79	95	92
Glyt + Purity 100 + AMS	0.06 + 0.5% + 1%	99	97	98	99	91	98	97
Glyt + R-11 + AMS	0.06 + 0.5% + 1%	95	91	93	96	82	93	92
Glyt + Atplus GTM-10 + AMS	0.06 + 0.5% + 1%	95	91	93	97	84	91	92
Glyt + L-283	0.06 + 1%	93	86	90	93	68	88	86
Glyt + L-283	0.06 + 2%	93	89	91	93	80	87	89
Glyt + Class Act NG	0.06 + 2.5%	96	89	93	97	78	93	91
Glyt-UM	0.06	71	41	61	69	19	46	51
Glyt-UM + AMS	0.06 + 1%	89	81	85	84	64	70	79
LSD (5%)		9	12	9	12	15	11	11

[a] The spray water used for herbicide treatments contained 1550 ppm $CaCO_3$.

[b] Glyt = glyphosate as Roundup Custom; Glyt-UM = glyphosate as Roundup UltraMax; AMS = spray grade ammonium sulfate; Activator 90, Active-It, Cornbelt Premier 90, Induce, LI-700, Liberate, Preference, Purity 100, R-11, and Atplus GTM-10 = surfactants; L-283 (NDSU experimental) and Class Act NG (Next Generation) = surfactant-AMS blends.

Neutralizing antagonistic salts with AMADS. (Howatt, Roach, and Davidson-Harrington) The experiment was established and treatments applied to 6-inch Canada thistle, 8-inch dandelion, 6-inch wild buckwheat, 6-inch prickley lettuce, 3- to 4-leaf yellow foxtail, and 3-to 4-inch common lambsquarters on June 13 with 58 F, 95% cloudcover, and 7 mph northwest wind. Treatments were hand broadcast with a backpack sprayer delivering 8.5 gpa at 35 psi through 11001 flat fan nozzles. The experiment was a randomized complete block design with four replicates.

Table. Neutralizing antagonistic salts with AMADS.

		Jun 20						Jun 29					
Treatment	Rate	Cath	Dali	Wibu	Prle	Yeft	Colq	Cath	Dali	Wibu	Prle	Yeft	Colq
	oz/A	%											
Glyphosate+Liberate	4+0.25%	15	10	7	15	50	7	20	15	20	15	79	10
Glyphosate+Liberate	8+0.25%	27	37	22	40	84	12	45	30	37	42	91	30
Glyphosate&AMADS+Liberate	4&29+0.25%	37	45	35	60	96	40	84	80	62	84	95	91
Glyphosate&AMADS+Liberate	8&59+0.25%	55	54	54	70	97	87	91	84	77	85	95	94
Glyphosate+Liberate+AMS	4+0.25%+23	32	17	27	32	72	35	63	61	54	55	72	40
Glyphosate+Liberate+AMS	8+0.25%+23	37	35	40	41	71	40	63	58	61	59	72	60
Untreated	0	0	0	0	0	0	0	0	0	0	0	0	0
CV		41	55	66	45	36	93	44	42	68	43	35	51
LSD (P=.05)		18	23	26	25	36	44	34	29	45	31	37	35

Water used as spray carrier contained mainly calcium and magnesium antagonistic cations and had a calcium carbonate equivalency greater than 6300 ppm. Increasing glyphosate rate from 4 to 8 oz/A without AMADS or AMS tended to increase weed control but did not overcome antagonism. AMADS was more effective than AMS at eliminating antagonism and resulted in the highest weed control ratings. When AMADS or AMS were included in the treatment, the effect of increasing rate from o 8 oz/A glyphosate was minimal for most weed species.

Adjuvants with glyphosate&AMADS. (Howatt, Roach, and Davidson-Harrington) Siberian foxtail millet, Robust barley, and Jerry oat were seeded in adjacent strips. Treatments were applied to 3-leaf foxtail millet, 4-leaf barley, and 6-leaf oat on June 20 with 70 F, 34% relative humidity, 30% cloudcover, 6 mph northwest wind, and soil temperature of 65 F. Treatments were hand broadcast with a backpack sprayer delivering 8.5 gpa at 40 psi through 11001 flat fan nozzles to a 7 ft wide area the length of 10 by 30 ft plots. The experiment was a randomized complete block design with four replicates.

Table. Adjuvants with glyphosate&AMADS.

Treatment[a]	Rate	Jun 27		
		Foxtail millet	Barley	Oat
	oz ae/A		%	
Glyphosate&AMADS	3&22	99	99	99
Glyphosate&AMADS+LI700	3&22+0.25%	99	99	99
Glyphosate&AMADS+Activator 90	3&22+0.25%	99	99	99
Glyphosate&AMADS+Class Act NG	3&22+2.5%	99	99	99
Glyphosate&AMADS+AMS	3&22+10	99	99	99
Glyphosate&AMADS+Silwet LI700	3&22+0.125%	99	99	99
Glyphosate&AMADS+Herbimax	3&22+0.25G	99	99	99
Glyphosate&AMADS+Scoil	3&22+0.25G	99	99	99
Glyphosate&AMADS+L283	3&22+1%	99	99	99
Untreated	0	0	0	0
LSD 5%		1	1	1

[a] L283 was an experimental adjuvant blend from NDSU.

Glyphosate&AMADS at 3&22 oz/A provided complete control of 3- to 6-leaf grasses on June 27, which was 7 days after application. A lower rate was needed to evaluate the effect of additional adjuvant.

Glyphosate with adjuvants. Zollinger, Richard K. and Jerry L. Ries. An experiment was conducted near Wahpeton, ND, to evaluate weed control from glyphosate with adjuvants in Roundup Ready soybean. Pioneer '91B33' was planted on May 7, 2002. POST treatments were applied June 18 at 10:00 am with 74 F air, 75 F soil surface, 65% relative humidity, 100% clouds, 8 to 14 mph SSE wind, dry soil surface, damp subsoil, good crop vigor, and no dew present to V2 soybean. Weed species present were: 1 to 4 inch (1 to 30/ft^2) yellow foxtail; 1 to 3 inch (1 to 5/yd^2) redroot pigweed; 1 to 4 inch (1 to 30/ft^2) common lambsquarters; 1 to 3 inch (1 to 5/yd^2) common ragweed; and 1 to 3 inch (1 to 3/yd^2) common cocklebur. Treatments were applied to the center 6.67 feet of the 10 by 40 foot plots with a hooded bicycle-wheel-type plot sprayer delivering 8.5 gpa at 40 psi through 8001 flat fan nozzles. The experiment had a randomized complete block design with three replicates per treatment.

All treatments controlled yellow foxtail and common cocklebur. Glyphosate was used at reduced rates for adjuvant separation. Considerable variability exists among adjuvants. In general, the greatest adjuvant enhancement occurred with WC018 when combined with glyphosate at 0.5 pt/A, giving similar or greater weed control than glyphosate at 1 pt/A + NIS/fertilizer pre-mix (Class Act NG). (Dept. of Plant Sciences, North Dakota State University, Fargo).

Table. Glyphosate with adjuvants (Zollinger and Ries).

		July 2			July 16		
Treatment[1]	Rate	Rrpw	Colq	Corw	Rrpw	Colq	Corw
	(product/A)	------- % control ------			------ % control ------		
Glyphosate+	1pt+						
Class Act NG	2.5% v/v	83	73	80	87	83	87
Glyphosate+	0.5pt+						
Class Act NG	1.25% v/v	78	67	80	83	73	68
Class Act NG	2.5% v/v	83	70	80	85	77	75
Class Act NG+Placement	2.5% v/v+2fl oz	77	60	73	82	65	72
AG 01026	2.5% v/v	77	60	70	80	58	63
AG 02029	1.25% v/v	77	58	68	88	82	77
AG 02030	1.75% v/v	80	67	73	87	70	68
Liberate	0.25% v/v	63	33	53	65	28	40
Blendmaster	1% v/v	70	53	63	72	57	53
Bronc Max	1% v/v	67	47	57	78	42	53
Bronc Plus Dry	12lb/100gal	77	60	67	87	63	73
One-Ap XL	9lb/100gal	70	58	63	88	68	70
WC018	2.5% v/v	92	88	90	90	88	86
WC019	2.5% v/v	70	53	63	43	53	50
L-132	1% v/v	70	43	53	73	37	53
LSD (0.05)		5	8	9	8	9	10

[1]Glyphosate = Roundup Ultra; Class Act NG = surfactant + fertilizer; Placement = drift retardant; AG 01026, AG 02029 and AG 02030 = proprietary adjuvants from Agrilliance; Liberate = surfactant; Blendmaster = water conditioning agent + surfactant; Bronc Max = ammonium sulfate fertilizer + water conditioning agent; Bronc Plus Dry = ammonium sulfate fertilizer + surfactant; One-Ap XL = surfactant + ammonium sulfate fertilizer + deposition + defoamer; WC018 and WC019 = proprietary adjuvant from West Central Inc.; L-132 = petroleum oil concentrate.

RU Weathermax with adjuvants. Zollinger, Richard K. and Jerry L. Ries. An experiment was conducted near Wahpeton, ND, to evaluate weed control from glyphosate with adjuvants. Pioneer '91B33' soybean was planted on May 7, 2002. POST treatments were applied June 18 at 9:30 am with 74 F air, 75 F soil surface, 65% relative humidity, 100% clouds, 8-14 mph SSE wind, dry soil surface, damp subsoil, good crop vigor, and no dew present to V2 soybean. Weed species present were: 1 to 4 inch (5 to 20/yd^2) yellow foxtail; 1 to 3 inch (1 to 5/yd^2) redroot pigweed; 1 to 4 inch (1 to 30/ft^2) common lambsquarters; and 1 to 3 inch (1 to 5/yd^2) common ragweed. Treatments were applied to the center 6.67 feet of the 10 by 40 foot plots with a bicycle-wheel-type plot sprayer and attached wind screen delivering 8.5 gpa at 40 psi through 8001 flat fan nozzles. The experiment had a randomized complete block design with three replicates per treatment.

Yellow foxtail was controlled by all treatments. Redroot pigweed and common lambsquarters control by various adjuvants used with a full surfactant load formulation of glyphosate varied by adjuvants but range was much narrower with common ragweed. Common lambsquarters was the species most difficult to control. Dri-Gard, a drift reducing adjuvant had the greatest weed control. (Dept. of Plant Sciences, North Dakota State University, Fargo).

Table. Glyphosate with adjuvants (Zollinger and Ries).

		July 2			July 16		
Treatment[1]	Rate	Rrpw	Colq	Corw	Rrpw	Colq	Corw
	(product/A)	-------- % control ---------			-------- % control ---------		
RU Weathermax	10.7fl oz	77	65	80	83	72	77
RU Weathermax+ AMS	10.7fl oz+ 8.5lb/100gal	73	63	80	88	72	86
RU Weathermax	5.35fl oz	43	30	47	73	33	67
RU Weathermax+ AMS	5.35fl oz+ 8.5lb/100gal	53	37	53	77	37	68
Class Act NG	1.25% v/v	67	60	67	87	57	70
Class Act NG	2.5% v/v	83	77	83	88	75	78
Class Act NG+Placement	2.5% v/v+2fl oz	83	77	83	85	75	73
Placement Propak	1% v/v	67	58	65	83	57	73
AG 02001	1% v/v	57	47	63	75	40	72
Valid	0.125% v/v	50	43	53	70	32	67
Bronc Max	1% v/v	55	50	60	80	52	73+
Cayuse Plus	0.75% v/v	62	60	63	85	58	70
Guardian Plus	2.5gal/100gal	63	57	63	82	55	78
Dri-Gard	9lb/100gal	73	67	77	92	65	85
In-Place	0.1pt	13	10	13	13	10	13
L-132	1% v/v	40	30	40	70	28	62
Engame+Liberate	19.6fl oz+0.25% v/v	83	73	80	78	70	68
LSD (0.05)		20	22	17	20	23	19

[1]AMS = ammonium sulfate; Class Act NG = surfactant and fertilizer; Placement = drift retardant; Placement Propak = ammonium sulfate fertilizer + drift retardant; AG 02001 = proprietary adjuvant from Agrilliance; Valid = drift retardant + deposition + defoamer; Bronc Max = ammonium sulfate fertilizer + water conditioning agent; Cayuse Plus = surfactant + fertilizer; Gardian Plus = ammonium sulfate + deposition + defoamer; Dri-Gard = ammonium sulfate + deposition + foamer; L-132 = petroleum oil concentrate; Liberate = surfactant.

Glyphosate with adjuvants-Carrington. Oltmans and Zollinger. An experiment was conducted near Carrington, ND to evaluate weed control from glyphosate formulations applied with adjuvants. NDSU 'RG200RR' soybean was planted May 17, 2002. POST treatments were applied June 26, 2002 at 11:15 am to 12:15 pm with 80 F air, 77 F soil at a 2 to 4 inch depth, 50% relative humidity, no clouds, 3 to 6 mph NW wind, dry soil surface, moist subsoil, excellent crop vigor, and no dew present to 3 trifoliate soybean. Weed species present were: 1 to 4 inch, (5-10 plants/ft^2) foxtail; and 1 to 3 inch, (15-25 plants/ft^2) prostrate pigweed. Treatments were applied to the center 6.67 feet of the 10 by 40 ft plots with a bicycle-wheel-type plot sprayer delivering 8.5 gpa at 40 psi through 8001 flat fan nozzles. The experiment had a randomized complete block design with four replicates per treatment.

Treatment	Rate	July 9, 2002		July 25, 2002	
		Fxtl[a]	Prpw	Fxtl	Prpw
	(product/A)	% control			
Roundup UltraMax+AMS	13floz+8.5lb/100gal	97	90	95	86
Roundup UltraMax+AMS	6.5floz+8.5lb/100gal	85	79	91	71
Roundup UltraMax+Corral AMS Liquid	6.5floz+2.5%v/v	96	75	94	74
Roundup UltraMax+Class Act Next Generation	6.5floz+2.5%v/v	93	84	91	68
Roundup UltraDry+AMS	9.2floz+8.5lb/100gal	99	96	95	89
Roundup UltraDry+AMS	4.6loz+8.5lb/100gal	94	79	95	71
Roundup UltraDry+Corral AMS Liquid	4.6floz+2.5%v/v	92	75	93	70
Roundup UltraDry+Class Act Next Generation	4.6floz+2.5%v/v	96	93	94	86
Touchdown+AMS	16floz+8.5lb/100gal	97	96	95	88
Touchdown+AMS	8floz+8.5lb/100gal	95	89	91	68
Touchdown+Corral AMS Liquid	8floz+2.5%v/v	92	81	94	70
Touchdown+Class Act Next Generation	8floz+2.5%v/v	94	94	94	84
Roundup Original+AMS+NIS	16floz+8.5lb/100gal+0.5%v/v	97	93	95	86
Roundup Original+AMS+NIS	8floz+8.5lb/100gal+0.5%v/v	91	83	91	69
Roundup Original+Corral AMS Liquid+NIS	8floz+2.5%v/v+0.5%v/v	89	84	93	72
Roundup Original+Class Act Next Generation	8floz+2.5%v/v	92	87	95	79
Roundup Custom+AMS+NIS	12floz+8.5lb/100gal+0.5%v/v	93	62	91	85
Roundup Custom+AMS+NIS	6floz+8.5lb/100gal+0.5%v/v	48	53	60	30
Roundup Custom+Corral AMS Liquid+NIS	6floz+2.5%v/v+0.5%v/v	89	80	93	79
Roundup Custom+Class Act Next Generation	6floz+2.5%v/v	84	71	94	76
Untreated		0	0	0	0
LSD (0.05)		8	13	5	12

[a]Fxtl = Grft and Yeft

Treatments were developed according to the adjuvant load in glyphosate formulations. Roundup UltraMax, Roundup UltraDry, and Touchdown do not require additional surfactant; Roundup Original requires some additional surfactant; and Roundup Custom has no surfactant in the formulation. All glyphosate treatments on July 9 had 84% foxtail control or greater, except Roundup Custom at 1/4 the labeled rate plus AMS plus NIS with 48% control. All glyphosate treatments had 89% prostrate pigweed control or lower, except five treatments (Roundup UltraDry, Touchdown, and Roundup Original at 1/2 the labeled rate, and Roundup UltraDry and Touchdown at 1/4 the labeled rate plus Class Act Next Generation), which had 93% control or greater. All glyphosate treatments on July 25 had 91% foxtail control or greater, except Roundup Custom at 1/4 the labeled rate plus AMS plus NIS with 60% control. All glyphosate treatments on July 25 had 79% prostrate pigweed control or lower, except all glyphosate formulations applied at 1/2 the labeled rate and Touchdown and Roundup UltraDry at 1/4 the labeled rate plus Class Act Next Generation, with control ranging from 84 to 89%. The presence of prostrate pigweed may limit the use of reduced glyphosate rates, if the right formulation and adjuvant are not selected, because of inadequate control.

Glyphosate with adjuvants-Prosper. Oltmans and Zollinger. An experiment was conducted near Prosper, ND to evaluate weed control from glyphosate formulations applied with adjuvants. Asgrow '0801' soybean was planted May 17, 2002. POST treatments were applied June 27, 2002 at 9:45 to 10:45 am with 85 F air, 70 F soil at a 2 to 4 inch depth, 56% relative humidity, 80% clouds, 2 to 6 mph NW wind, dry soil surface, moist subsoil, good crop vigor, and no dew present to 3 trifoliate soybean. Weed species present were: 1 to 8 inch, (1-5 plants/ft^2) foxtail; 1 to 9 inch, (5-10 plants/ ft^2) redroot pigweed; 1 to 5 inch, (1-5 plants/ ft^2) redroot pigweed; and 1 to 6 inch, (1-5 plants/ft^2) common ragweed. Treatments were applied to the center 6.67 feet of the 10 by 40 ft plots with a bicycle-wheel-type plot sprayer delivering 8.5 gpa at 40 psi through 8001 flat fan nozzles. The experiment had a randomized complete block design with four replicates per treatment.

		July 9, 2002			July 29, 2002		
Treatment	Rate	Fxtl[a]	Rrpw	Corw	Fxtl	Rrpw	Corw
	(product/A)	% control					
Roundup UltraMax+AMS	13floz+8.5lb/100gal	94	99	80	99	99	80
Roundup UltraMax+AMS	6.5floz+8.5lb/100gal	99	98	60	99	99	73
Roundup UltraMax+Corral AMS Liquid	6.5floz+2.5%v/v	99	99	73	99	99	73
Roundup UltraMax+Class Act Next Generation	6.5floz+2.5%v/v	91	99	65	99	99	84
Roundup UltraDry+AMS	9.2floz+8.5lb/100gal	98	96	85	99	99	78
Roundup UltraDry+AMS	4.6loz+8.5lb/100gal	96	99	74	99	99	74
Roundup UltraDry+Corral AMS Liquid	4.6floz+2.5%v/v	99	99	70	99	99	65
Roundup UltraDry+Class Act Next Generation	4.6floz+2.5%v/v	93	97	85	99	98	84
Touchdown+AMS	16floz+8.5lb/100gal	98	98	83	99	99	74
Touchdown+AMS	8floz+8.5lb/100gal	81	99	70	99	99	68
Touchdown+Corral AMS Liquid	8floz+2.5%v/v	99	99	77	99	99	73
Touchdown+Class Act Next Generation	8floz+2.5%v/v	99	99	71	99	99	88
Roundup Original+AMS+NIS	16floz+8.5lb/100gal+0.5%v/v	99	99	86	99	99	80
Roundup Original+AMS+NIS	8floz+8.5lb/100gal+0.5%v/v	99	99	71	99	99	69
Roundup Original+Corral AMS Liquid+NIS	8floz+2.5%v/v+0.5%v/v	99	99	60	98	98	71
Roundup Original+Class Act Next Generation	8floz+2.5%v/v	91	99	89	99	99	89
Roundup Custom+AMS+NIS	12floz+8.5lb/100gal+0.5%v/v	98	99	85	99	99	69
Roundup Custom+AMS+NIS	6floz+8.5lb/100gal+0.5%v/v	99	99	55	99	99	55
Roundup Custom+Corral AMS Liquid+NIS	6floz+2.5%v/v+0.5%v/v	97	99	74	99	99	74
Roundup Custom+Class Act Next Generation	6floz+2.5%v/v	81	99	74	96	96	30
Untreated		0	0	0	0	0	0
LSD (0.05)		10	2	9	1	2	13

[a]Fxtl = Grft and Yeft

Treatments were developed according to the adjuvant load in glyphosate formulations. Roundup UltraMax, Roundup UltraDry, and Touchdown do not require additional surfactant; Roundup Original requires some additional surfactant; and Roundup Custom has no surfactant in the formulation. All glyphosate treatments on July 9 had 91% foxtail control or greater, except Touchdown at 1/4 the labeled rate plus AMS and Roundup Custom at 1/4 the labeled rate plus Class Act Next Generation, both with 81% control. All glyphosate treatments had 97% redroot pigweed control or greater. All glyphosate treatments had 80% common ragweed control or lower, except six treatments (Roundup UltraDry, Touchdown, Roundup Original, and Roundup Custom at 1/2 the labeled rate, and Roundup UltraDry and Roundup Original at 1/4 the labeled rate plus Class Act Next Generation), with control ranging from 83 to 89%. All glyphosate treatments on July 29 had 96% foxtail and redroot pigweed control or greater. All glyphosate treatments had 80% common ragweed control or lower, except four treatments (Roundup UltraMax, Roundup UltraDry, Touchdown, and Roundup Original at 1/4 the labeled rate plus Class Act Next Generation), with control ranging from 84 to 89%. The presence of common ragweed may limit the use of reduced glyphosate rates, if the right formulation and adjuvant are not selected, because of inadequate control.

Glyphosate with adjuvants-Rothsay. Oltmans and Zollinger. An experiment was conducted near Rothsay, MN to evaluate weed control from glyphosate formulations applied with adjuvants. Wensman '2070' soybean was planted May 17, 2002. POST treatments were applied June 25, 2002 at 11:45 am to 12:45 pm with 90 F air, 74 F soil at a 2 to 4 inch depth, 60% relative humidity, 50% clouds, 0 to 5 mph W wind, moist soil surface, moist subsoil, good crop vigor, and no dew present to 3 to 4 trifoliate soybean. Weed species present were: 3 to 10 inch, (15-25 plants/ft^2) foxtail; and 3 to 13 inch, (20-30 plants/ft^2) marshelder. Treatments were applied to the center 6.67 feet of the 10 by 40 ft plots with a bicycle-wheel-type plot sprayer delivering 8.5 gpa at 40 psi through 8001 flat fan nozzles. The experiment had a randomized complete block design with four replicates per treatment.

		July 9, 2002		July 22, 2002	
Treatment	Rate	Fxtl[a]	Mael	Fxtl	Mael
	(product/A)	% control			
Roundup UltraMax+AMS	13floz+8.5lb/100gal	97	91	96	99
Roundup UltraMax+AMS	6.5floz+8.5lb/100gal	79	92	85	93
Roundup UltraMax+Corral AMS Liquid	6.5floz+2.5%v/v	95	96	95	93
Roundup UltraMax+Class Act Next Generation	6.5floz+2.5%v/v	90	96	89	99
Roundup UltraDry+AMS	9.2floz+8.5lb/100gal	98	99	99	99
Roundup UltraDry+AMS	4.6loz+8.5lb/100gal	91	98	80	97
Roundup UltraDry+Corral AMS Liquid	4.6floz+2.5%v/v	87	95	88	95
Roundup UltraDry+Class Act Next Generation	4.6floz+2.5%v/v	92	91	88	90
Touchdown+AMS	16floz+8.5lb/100gal	98	99	97	99
Touchdown+AMS	8floz+8.5lb/100gal	84	99	80	99
Touchdown+Corral AMS Liquid	8floz+2.5%v/v	86	96	73	99
Touchdown+Class Act Next Generation	8floz+2.5%v/v	95	99	93	96
Roundup Original+AMS+NIS	16floz+8.5lb/100gal+0.5%v/v	95	99	95	99
Roundup Original+AMS+NIS	8floz+8.5lb/100gal+0.5%v/v	96	97	96	92
Roundup Original+Corral AMS Liquid+NIS	8floz+2.5%v/v+0.5%v/v	90	97	87	94
Roundup Original+Class Act Next Generation	8floz+2.5%v/v	91	96	92	97
Roundup Custom+AMS+NIS	12floz+8.5lb/100gal+0.5%v/v	96	99	95	99
Roundup Custom+AMS+NIS	6floz+8.5lb/100gal+0.5%v/v	91	86	71	68
Roundup Custom+Corral AMS Liquid+NIS	6floz+2.5%v/v+0.5%v/v	87	81	77	79
Roundup Custom+Class Act Next Generation	6floz+2.5%v/v	88	90	76	94
Untreated		0	0	0	0
LSD (0.05)		10	7	12	6

[a]Fxtl = Grft and Yeft

Treatments were developed according to the adjuvant load in glyphosate formulations. Roundup UltraMax, Roundup UltraDry, and Touchdown do not require additional surfactant; Roundup Original requires some additional surfactant; and Roundup Custom has no surfactant in the formulation. All glyphosate treatments on July 9 had 84% foxtail control or greater, except Roundup UltraMax at 1/4 the labeled rate plus AMS with 79% control. All glyphosate treatments had 90% marshelder control or greater, except Roundup Custom at 1/4 the labeled rate plus Corral AMS Liquid or Class Act Next Generation, with 86 and 91% control, respectively. All glyphosate treatments on July 22 had 89% foxtail control or lower, except all glyphosate formulations applied at 1/2 the labeled rate, Roundup UltraMax at 1/4 the labled rate plus Corral AMS Liquid, Roundup Original at 1/4 the labeled rate plus AMS plus NIS, and Touchdown or Roundup Original at 1/4 the labeled rate plus Class Act Next Generation, with control ranging from 92 to 97%. All glyphosate treatments had 90% marshelder control or greater, except Roundup Custom at 1/4 the labeled rate plus AMS plus NIS or Corral AMS Liquid plus NIS, with 68 and 79% control, respectively. The presence of marshelder and foxtail may limit the use of reduced glyphosate rates, if the right formulation and adjuvant are not selected. The use of Roundup Custom at 1/4 the labeled rate plus adjuvant may not provided marshelder and foxtail control equal to other glyphosate formulations applied at 1/4 the labeled rate plus adjuvant.

Clethodim with adjuvants. Zollinger, Richard K. and Jerry L. Ries. An experiment was conducted near Prosper, ND, to evaluate grass control in soybean. Spring wheat was broadcast prior to study establishment at 15 lb/A. Asgrow 'AG0801' soybean was planted on May 17, 2002. POST treatments were applied June 18 at 5:20 pm with 81 F air, 82 F soil surface, 56% relative humidity, 80% clouds, 14 mph S wind, dry soil surface, damp subsoil, good crop vigor, and no dew present to V3 soybean. Weed species present were: 2 to 4 inch (5 to 30/ft^2) yellow foxtail; 1 to 4 inch (5 to 10/yd^2) volunteer wheat. Treatments were applied to the center 6.67 feet of the 10 by 40 foot plots with a hooded bicycle-wheel-type plot sprayer delivering 8.5 gpa at 40 psi through 8001 flat fan nozzles. The experiment had a randomized complete block design with three replicates per treatment.

No soybean injury was observed with any treatment or at any rating. All treatments controlled yellow foxtail and volunteer wheat regardless of mixture or adjuvant used. A lower rate of herbicide would be necessary to determine adjuvant enhancement. (Dept. of Plant Sciences, North Dakota State University, Fargo).

Table. Clethodim with adjuvants (Zollinger and Ries).

		June 25		July 2		July 16	
Treatment[1]	Rate	Yeft	V wht[2]	Yeft	V wht	Yeft	V wht
	(product/A)	--- % control ---		---% control ---		--- % control ---	
V-10117+PO	6fl oz+1pt	95	50	99	99	99	99
V-10117+V-10073	6fl oz+6fl oz	95	50	99	99	99	99
V-10117+V-10073	6fl oz+3fl oz	95	50	99	99	99	99
V-10117+V-10106	6fl oz+6fl oz	95	50	99	99	99	99
V-10117+V-10106	6fl oz+3fl oz	95	50	99	99	99	99
V-10117+V-10130	6fl oz+6fl oz	95	50	99	99	99	99
V-10117+V-10130	6fl oz+3fl oz	95	50	99	99	99	99
Select+PO	6fl oz+1pt	95	50	99	99	99	99
V-10117+	6fl oz+						
Scoil	1pt	96	53	99	99	99	99
Z-64	1.5pt	95	53	99	99	99	99
Soy-Stik	1pt	96	50	99	99	99	99
Destiny	1pt	96	50	99	99	99	99
MSO	1pt	96	50	99	99	99	99
Renegade	1.5pt	96	53	99	99	99	99
Quad 7	1% v/v	95	50	99	99	99	99
LSD (0.05)		3	4	0	0	0	0

[1]V-10117 = proprietary herbicide from Valent; PO = petroleum oil concentrate = Herbimax; V-10073, V-10106 and V-10130 = proprietary adjuvants from Valent; Scoil = methylated seed oil; Z-64 = methylated seed oil basic blend; Soy-Stik = methylated seed oil; Destiny = methylated seed oil; MSO = methylated seed oil = Scoil; Renegade = methylated seed oil; Quad 7 = basic blend.

[2]V wht = volunteer wheat.

Glyphosate tank-mixed with insecticides or fungicides. Ramsdale, Brad K., Sam J. Lockhart, and Calvin G. Messersmith. The experiment was conducted to examine the influence of various insecticides and fungicides on glyphosate efficacy. Bioassay species were seeded side-by-side with a small grain drill with one drill pass of each species per replicate, and plots 10 ft wide were laid out perpendicular to the strips so that each plot contained all seeded assay species. Treatments were applied at 8.5 gpa with a CO_2-pressurized bicycle-wheel-type plot sprayer equipped with four 8001 flat-fan nozzles at 20-inch spacing. Experimental design was a randomized complete block with four replicates. Glyphosate was applied at a reduced rate of 0.06 lb ae/A to better detect treatment effects on herbicide efficacy. As recommended on glyphosate labels, ammonium sulfate (AMS) was added either alone at 1% w/v or as a component of Class Act Next Generation (Class Act NG), which was added at 2.5% v/v. Insecticides and fungicides were applied at labeled rates. Weed control was evaluated visually where 0 equaled no visible injury and 100 equaled complete death of assay species.

Location	Fargo	Carrington	Minot
Planting date	May 22	May 21	May 15 – 28*
Treatment date	June 25	June 26	June 26
Air temperature (F)	75	76	83
Relative humidity (%)	75	45	55
Wind (mph)	5-8	3-5	5
Sky (% clouds)	75	0	10
Oat			
growth stage	tillering	tillering	tillering
height (inch)	8-12	8-10	6-8
Proso millet			
growth stage	tillering	tillering	3-6 leaf
height (inch)	6-8	8-10	2-6
Barley			
growth stage	tillering	tillering	tillering
height (inch)	8-12	8-10	8-10
Flax			
height (inch)	6-8	---	3-8
Wheat			
growth stage	---	tillering	---
height (inch)	---	8-10	---

* Flax – May 15, barley – May 21, proso millet – May 28, and oat – May 28.

Glyphosate as Roundup Custom plus Class Act NG was influenced less by insecticides and fungicides than Roundup UltraMax and Touchdown formulations. The surfactant in Class Act NG applied with Roundup Custom may have minimized the influence of the tank-mixed pesticides. Overall, pesticides formulated as emulsifiable concentrates, particularly dimethoate and chlorpyrifos, were occasionally synergistic to the reduced glyphosate rate. Flowable formulations of pesticides were occasionally antagonistic to glyphosate; most notable was the fungicide azoxystrobin.

Table 1. Glyphosate with insecticides and fungicides at Minot, ND.

		July 10				July 24		
Treatment[a]	Rate	Flax	Proso millet	Oat	Barley	Flax	Oat	Barley
	(lb/A)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Glyt-C + Class Act NG	0.06 + 2.5%							
alone	-	55	85	95	96	50	96	96
+ esfenvalerate (I)	0.05	48	75	96	89	43	98	92
+ carbaryl (I)	1.5	56	82	96	91	50	97	91
+ lambda-cyhalothrin (I)	0.03	50	77	96	95	50	96	96
+ zeta-cypermethrin (I)	0.05	65	87	98	96	63	99	95
+ chlorpyrifos (I)	1	52	83	98	94	47	96	95
+ dimethoate (I)	0.5	73	89	99	94	65	97	95
+ azoxystrobin (F)	0.25	52	80	97	92	48	96	87
+ pyraclostrobin (F)	0.15	59	82	98	95	55	98	94
+ propiconazole (F)	0.13	48	78	98	91	47	98	92
LSD (0.05)		8	6	NS	NS	12	NS	NS
Glyt-UM + AMS	0.06 + 1%							
alone	-	55	83	94	89	50	91	88
+ esfenvalerate (I)	0.05	43	77	89	82	38	89	82
+ carbaryl (I)	1.5	56	75	92	86	47	89	86
+ lambda-cyhalothrin (I)	0.03	50	78	90	83	42	86	82
+ zeta-cypermethrin (I)	0.05	57	78	92	85	57	92	86
+ chlorpyrifos (I)	1	50	70	88	84	43	86	89
+ dimethoate (I)	0.5	58	80	92	86	52	96	87
+ azoxystrobin (F)	0.25	37	68	78	75	28	72	72
+ pyraclostrobin (F)	0.15	58	78	90	86	55	89	83
+ propiconazole (F)	0.13	53	81	95	88	50	94	86
LSD (0.05)		9	7	7	7	10	9	10
Glyt-TD + AMS	0.06 + 1%							
alone	-	33	65	78	81	18	72	75
+ esfenvalerate (I)	0.05	47	67	96	92	37	86	91
+ carbaryl (I)	1.5	43	67	95	88	35	87	86
+ lambda-cyhalothrin (I)	0.03	30	60	89	91	18	77	88
+ zeta-cypermethrin (I)	0.05	45	75	96	96	37	91	95
+ chlorpyrifos (I)	1	58	81	99	94	43	99	97
+ dimethoate (I)	0.5	65	82	98	93	53	96	96
+ azoxystrobin (F)	0.25	37	62	76	77	17	68	72
+ pyraclostrobin (F)	0.15	52	75	97	93	43	93	95
+ propiconazole (F)	0.13	73	88	99	97	65	99	99
LSD (0.05)		12	7	7	7	14	9	11

[a] Glyt-C = Roundup Custom; Glyt-UM = Roundup UltraMax; Glyt-TD = Touchdown; (I) = insecticide; (F) = fungicide; esfenvalerate = Asana XL; carbaryl = Sevin XLR Plus; lambda-cyhalothrin = Warrior; zeta-cypermethrin = Mustang; chlorpyrifos = Lorsban 4E; dimethoate = Dimethoate 400; azoxystrobin = Quadris; pyraclostrobin = Headline; propiconazole = Tilt.

Table 2. Glyphosate with insecticides and fungicides at Fargo, ND.

Treatment[a]	Rate	July 9				July 23			
		Flax	Barley	Oat	Proso millet	Flax	Barley	Oat	Proso millet
	(lb/A)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Glyt-C + Class Act NG	0.06 + 2.5%								
alone	-	49	91	96	98	40	95	96	93
+ esfenvalerate (I)	0.05	51	95	96	98	45	98	98	94
+ carbaryl (I)	1.5	51	96	98	99	40	97	98	93
+ lambda-cyhalothrin (I)	0.03	55	97	97	98	51	98	98	95
+ zeta-cypermethrin (I)	0.05	51	95	98	99	51	99	99	97
+ chlorpyrifos (I)	1	56	95	97	99	53	99	99	97
+ dimethoate (I)	0.5	54	99	99	99	50	98	99	96
+ azoxystrobin (F)	0.25	49	96	98	98	48	98	99	95
+ pyraclostrobin (F)	0.15	55	96	99	99	53	99	99	95
+ propiconazole (F)	0.13	58	96	99	99	59	99	99	97
LSD (0.05)		NS	3	NS	NS	11	NS	NS	NS
Glyt-UM + AMS	0.06 + 1%								
alone	-	41	87	88	95	30	84	86	83
+ esfenvalerate (I)	0.05	50	91	95	98	48	93	95	95
+ carbaryl (I)	1.5	46	91	92	96	39	89	95	89
+ lambda-cyhalothrin (I)	0.03	45	92	94	98	41	93	95	90
+ zeta-cypermethrin (I)	0.05	49	91	91	98	38	91	91	89
+ chlorpyrifos (I)	1	58	97	98	99	54	99	99	97
+ dimethoate (I)	0.5	56	97	97	99	54	99	98	96
+ azoxystrobin (F)	0.25	31	86	83	91	19	84	80	84
+ pyraclostrobin (F)	0.15	54	98	97	99	55	99	99	95
+ propiconazole (F)	0.13	54	96	95	98	51	97	98	97
LSD (0.05)		6	5	4	4	10	5	5	4
Glyt-TD + AMS	0.06 + 1%								
alone	-	40	90	83	93	24	91	79	84
+ esfenvalerate (I)	0.05	57	96	95	99	53	98	96	94
+ carbaryl (I)	1.5	48	90	90	97	33	91	94	91
+ lambda-cyhalothrin (I)	0.03	39	89	85	91	23	90	84	86
+ zeta-cypermethrin (I)	0.05	50	95	91	98	33	94	92	92
+ chlorpyrifos (I)	1	56	98	98	99	50	99	98	97
+ dimethoate (I)	0.5	55	96	97	99	46	97	97	96
+ azoxystrobin (F)	0.25	35	85	83	91	18	84	80	84
+ pyraclostrobin (F)	0.15	54	96	97	99	48	98	99	96
+ propiconazole (F)	0.13	56	97	95	99	53	98	96	97
LSD (0.05)		7	4	5	5	11	6	5	4

[a] Glyt-C = Roundup Custom; Glyt-UM = Roundup UltraMax; Glyt-TD = Touchdown; (I) = insecticide; (F) = fungicide; esfenvalerate = Asana XL; carbaryl = Sevin XLR Plus; lambda-cyhalothrin = Warrior; zeta-cypermethrin = Mustang; chlorpyrifos = Lorsban 4E; dimethoate = Dimethoate 400; azoxystrobin = Quadris; pyraclostrobin = Headline; propiconazole = Tilt.

Table 3. Glyphosate with insecticides and fungicides at Carrington, ND.

Treatment[a]	Rate	July 10				July 24			
		Wheat	Barley	Proso millet	Oat	Wheat	Barley	Proso millet	Oat
	(lb/A)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Glyt-C + Class Act NG	0.06 + 2.5%								
alone	-	90	95	85	89	95	99	90	94
+ esfenvalerate (I)	0.05	91	93	84	88	96	99	87	90
+ carbaryl (I)	1.5	87	89	80	86	87	95	81	87
+ lambda-cyhalothrin (I)	0.03	93	95	88	93	97	98	93	97
+ zeta-cypermethrin (I)	0.05	93	94	91	92	99	99	94	97
+ chlorpyrifos (I)	1	89	92	84	90	91	96	88	93
+ dimethoate (I)	0.5	93	94	91	92	98	99	95	96
+ azoxystrobin (F)	0.25	90	93	88	90	96	99	94	97
+ pyraclostrobin (F)	0.15	93	96	90	90	98	99	93	97
+ propiconazole (F)	0.13	91	93	86	88	97	98	88	92
LSD (0.05)		4	3	NS	NS	4	3	6	5
Glyt-UM + AMS	0.06 + 1%								
alone	-	91	91	87	88	92	98	92	93
+ esfenvalerate (I)	0.05	91	88	76	76	94	95	78	80
+ carbaryl (I)	1.5	89	87	80	80	83	91	82	82
+ lambda-cyhalothrin (I)	0.03	89	91	82	83	92	96	84	86
+ zeta-cypermethrin (I)	0.05	88	91	87	88	93	98	91	93
+ chlorpyrifos (I)	1	92	94	84	90	97	98	89	90
+ dimethoate (I)	0.5	92	92	86	88	96	99	91	88
+ azoxystrobin (F)	0.25	78	81	68	71	76	85	66	66
+ pyraclostrobin (F)	0.15	92	94	86	91	92	98	89	92
+ propiconazole (F)	0.13	87	89	86	89	93	97	89	92
LSD (0.05)		3	4	5	7	9	4	7	7
Glyt-TD + AMS	0.06 + 1%								
alone	-	90	91	86	87	92	98	90	87
+ esfenvalerate (I)	0.05	92	91	88	92	95	99	90	94
+ carbaryl (I)	1.5	88	89	79	83	91	96	77	83
+ lambda-cyhalothrin (I)	0.03	90	92	89	92	91	94	91	95
+ zeta-cypermethrin (I)	0.05	93	94	92	94	94	98	94	98
+ chlorpyrifos (I)	1	93	94	91	94	93	99	93	97
+ dimethoate (I)	0.5	94	95	92	94	96	99	93	97
+ azoxystrobin (F)	0.25	86	89	85	91	87	95	92	96
+ pyraclostrobin (F)	0.15	94	95	88	90	99	99	91	94
+ propiconazole (F)	0.13	91	93	88	90	97	99	89	94
LSD (0.05)		5	NS	NS	NS	NS	NS	NS	9

[a] Glyt-C = Roundup Custom; Glyt-UM = Roundup UltraMax; Glyt-TD = Touchdown; (I) = insecticide; (F) = fungicide; esfenvalerate = Asana XL; carbaryl = Sevin XLR Plus; lambda-cyhalothrin = Warrior; zeta-cypermethrin = Mustang; chlorpyrifos = Lorsban 4E; dimethoate = Dimethoate 400; azoxystrobin = Quadris; pyraclostrobin = Headline; propiconazole = Tilt.

C