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Adjuvants with Laudis and Impact. Zollinger, Richard K., Jerry L. Ries, and Angela J. Kazmierczak. An experiment was conducted near Lynchberg, ND, to evaluate weed efficacy from tank-mixes of Laudis and Impact with adjuvants. 'Plainsman' amaranth, quinoa (*Chenopodium quinoa*), 'Sheyenne' conventional soybean, and 'Mancan' tame buckwheat were planted perpendicular to each plot length on June 2, 2010. POST treatments were applied on July 9, at 9:20 am with 80 F air, 84 F soil surface, 51% relative humidity, 0% cloud cover, 1 to 3 mph NW wind, dry soil surface, moist subsoil, excellent crop vigor, and no dew present. Species stages at time of application were: 20 to 28 inch (20 to 25/ft^2) amaranth; 20 to 26 inch (15 to 20/ft^2, 90% budding) quinoa; 10 to 14 inch (5 to 10/ft^2) soybean; and 24 to 28 inch (20 to 30/ft^2) tame buckwheat. Treatments were applied to the center 6.7 feet of the 10 by 40 foot plots with a backpack-type plot sprayer delivering 8.5 gpa at 40 psi through 11001 Turbo TeeJet nozzles. The experiment had a randomized complete design with three replicates per treatment.

Weed control varied by tank-mix partner, adjuvant, adjuvant rate, and species. (Department of Plant Sciences, North Dakota State University, Fargo).

Table. Adjuvants with Laudis and Impact (Zollinger, Ries, Kazmierczak).

		14 DAT				28 DAT			
Treatment	Rate	Amar	Quin	Soyb	Tabw	Amar	Quin	Soyb	Tabw
	(product/A)	------- % control -------				------- % control -------			
Buccaneer Plus+Laudis+	12fl oz+1fl oz+								
Savvy+AMS	0.5% v/v+8.5lb/100 gal	68	65	47	37	78	68	72	63
Savvy+N-Tense	0.5% v/v+0.5% v/v	72	72	52	35	78	68	62	58
Soy-Stik+AMS	1% v/v+8.5lb/100 gal	86	68	73	42	82	70	72	52
Savvy+N-Tense	1% v/v+0.5% v/v	62	70	50	33	63	75	62	52
Stake+AMS	0.5% v/v+8.5lb/100 gal	72	50	43	32	63	60	58	62
Premium COC+N-Tense	1% v/v+0.5% v/v	78	73	68	42	63	68	80	72
Buccaneer Plus+Impact+	12fl oz+0.25fl oz+								
Savvy+AMS	0.5% v/v+8.5lb/100 gal	82	72	70	40	78	73	62	74
Savvy+N-Tense	0.5% v/v+0.5% v/v	70	60	60	35	85	72	60	72
Soy-Stik+AMS	1% v/v+8.5lb/100 gal	63	63	47	37	67	73	57	68
Savvy+N-Tense	1% v/v+0.5% v/v	67	63	50	37	73	73	60	68
LSD (0.05)		4	9	8	6	4	5	5	5

Glyphosate with acidic AMS replacement adjuvants. Zollinger, Richard K., Jerry L. Ries, and Angela J. Kazmierczak. An experiment was conducted near Lynchberg, ND, to evaluate weed efficacy from glyphosate and acidic AMS replacement adjuvants. 'York' flax, 'Plainsman' amaranth, quinoa (*Chenopodium quinoa*), and 'Mancan' tame buckwheat were planted perpendicular to each plot length on June 2, 2010. POST treatments were applied on July 8, at 8:50 am with 80 F air, 89 F soil surface, 51% relative humidity, 0% cloud cover, 2 to 6 mph W wind, dry soil surface, moist subsoil, good crop vigor, and no dew present. Species stages at time of application were: 8 to 12 inch (12 to 15/ft^2) flax; 6 to 20 inch (10 to 25/ft^2) amaranth; 6 to 20 inch (2 to 15/ft^2, 80% budding) quinoa; and 15 to 25 inch (15 to 25/ft^2, 90% flowering) tame buckwheat. Treatments were applied to the center 6.7 feet of the 10 by 40 foot plots with a backpack-type sprayer delivering 8.5 gpa at 40 psi through 11001 Turbo TeeJet nozzles. The experiment had a randomized complete design with three replicates per treatment.

Acidic AMS replacement (AAR) adjuvants are relatively new class of adjuvants. Most commercial AAR adjuvants used in this study contain AMADS or monocarbamide dihydrogen sulfate which is equivalent to urea + sulfuric acid. Manufacturers of AAR adjuvants claim water conditioning properties with AAR adjuvants but they do not contain AMS. The mechanism of AAR adjuvants is to lower the spray solution pH below 2. This is below the pKa of the 3 binding sites of glyphosate causing glyphosate molecules to remain in the acid form and not bind with antagonistic ions naturally in water. AAR adjuvants do not contain ammonia which has been shown to enhance absorption and resulting weed control. This is the first study where any non-AMS containing adjuvant has given weed control greater than AMS + NIS. Previous research has shown similar weed control of pure AMADS to AMS + NIS. However, many commercial products do not show the enhancement. Rate of products containing AMADS is very important as shown in this research. The rate 4 pt/100 gal most often gives greater weed control but growers usually use only 2 and rarely 3 pt/100. Hazards of very low pH spray solution to the applicator and equipment may limit use of this type of adjuvant, but research shows good herbicide enhancment. (Department of Plant Sciences, North Dakota State University, Fargo).

Table. Glyphosate with acidic AMS replacement adjuvants (Zollinger, Ries, Kazmierczak).

		14 DAT				28 DAT			
Treatment	Rate	Flax	Amar	Quin	Tabw	Flax	Amar	Quin	Tabw
	(product/A)	------- % control -------				------- % control -------			
Touchdown Hi-Tech +	7.2 fl oz +	10	42	12	20	10	32	10	37
R-11	0.25% v/v	42	57	27	25	72	43	27	45
AMS	8.5lb/100 gal	28	68	12	33	38	52	13	55
R-11+AMS	0.25% v/v+8.5lb/100 gal	73	82	58	47	77	72	53	63
N-Tense	3pt/100 gal	45	52	28	28	65	52	28	47
ET-4000	4pt/100 gal	20	43	13	20	20	53	13	40
N-Tense	4pt/100 gal	60	60	52	27	70	60	52	47
ET-4000+R-11	4pt/100gal+0.25% v/v	38	53	35	32	62	52	52	52
Import	3pt/100 gal	60	52	30	30	71	63	43	53
Import	4pt/100 gal	65	70	30	33	87	90	45	65
Brimstone	3pt/100 gal	62	62	30	30	82	82	60	48
Brimstone	4pt/100 gal	73	72	27	33	73	68	83	53
Gun Smoke	3pt/100 gal	55	62	22	25	62	62	28	52
Gun Smoke	4pt/100 gal	83	62	60	40	93	72	63	53
Hel-Fire	3pt/100 gal	53	57	32	30	67	57	42	37
Hel-Fire	4pt/100 gal	60	60	30	35	60	80	55	43
Quest	2pt/100 gal	32	50	25	25	22	52	12	28
Quest	4pt/100 gal	17	43	18	23	17	63	12	23
Request	2pt/100 gal	22	40	13	20	22	50	12	30
Request	4pt/100 gal	18	47	10	20	17	45	10	25
LSD (0.05)		11	7	9	6	8	6	5	5

Glyphosate with HSOC adjuvants. Zollinger, Richard K., Jerry L. Ries, and Angela J. Kazmierczak. An experiment was conducted near Lynchberg, ND, to evaluate species efficacy to glyphosate and Laudis tank-mixes with different HSOC adjuvants. 'York' flax, 'Plainsman' amaranth, quinoa (*Chenopodium quinoa*), and 'Mancan' tame buckwheat were planted perpendicular to each plot length on June 2, 2010. POST treatments were applied on July 8, at 10:15 am with 76 F air, 80 F soil surface, 70% relative humidity, 0% cloud cover, 3 to 6 mph SW wind, dry soil surface, moist subsoil, excellent crop vigor, and no dew present. Species stages at time of application were: 12 to 18 inch (25 to 35/ft^2) flax; 16 to 22 inch (15 to 25/ft^2) amaranth; 18 to 24 inch (10 to 15/ft^2, 90% budding) quinoa; and 24 to 28 inch (15 to 25/ft^2, 90% flowering) tame buckwheat. Treatments were applied to the center 6.7 feet of the 10 by 40 foot plots with a backpack-type plot sprayer delivering 8.5 gpa at 40 psi through 11001 Turbo TeeJet nozzles. The experiment had a randomized complete design with three replicates per treatment.

Glyphosate is applied with tank-mix herbicides for full spectrum weed control. Glyphosate is very water soluble, is enhanced by surfactants, and is antagonized by oil adjuvants. Most herbicides applied with glyphosate (Select/clethodim, Status, Sharpen, Laudis/Impact/Callisto, and Flexstar) are highly lipophilic and are greatly enhanced by oil adjuvants. This creates a conundrum of which adjuvants to use with glyphosate tank-mixes. High surfactant oil concentrate (HSOC) adjuvants were developed to enhance oil-loving herbicides without antagonizing glyphosate. The adjuvant type is listed below next to the brand name: PO - petroleum oil or COC, MSO = methylated seed oil, OS = organosilicone surfactant.

Flax is tolerant to Laudis at 1 fl oz/A and was chosen to show the affect of oil adjuvants on glyphosate. Data from amaranth, quinoa, and tame buckwheat was averaged to show the affect of oil adjuvants on the cumulative weed control from glyphosate and Laudis. Oil adjuvants were applied at an optimum rate which may be different than grower use rates. For example, PO adjuvants were applied at 2 pt/A, MSO at 1.25 pt/A, PO-HSOC at 1 pt/A, and MSO-HSOC at 0.5 to 1 pt/A. Where as growers may apply PO and MSO adjuvants at 1% v/v and PO-HSOC and MSO-HSOC adjuvants at 0.5% v/v which at 8.5 gpa is equivalent to 0.34 and 0.68 pt/A, respectively. Flax data shows the antagonism from PO type adjuvants and MSO adjuvants lacking glyphosate "friendly" emulsifiers. Adjuvant enhancement of glyphosate + Laudis was: MSO-HSOC > PO-HSOC = MSO > PO. Only some MSO and PO / MSO-HSOC adjuvants validate the definition of HSOC adjuvants to enhance the oil-loving herbicide without antagonizing glyphosate. (Department of Plant Sciences, North Dakota State University, Fargo).

Table. Glyphosate with HSOC adjuvants (Zollinger, Ries, Kazmierczak).

		14 DAT				28 DAT				Ave of Amar,
Treatment	Rate	Flax	Amar	Quin	Tabw	Flax	Amar	Quin	Tabw	Quin, and tabw
	(product/A)	------- % control -------				------- % control -------				-- % control --
Touchdown Hi-Tech+Laudis +	7.2fl oz+1fl oz +	12	50	12	25	12	50	12	40	34
Agri-Dex (PO)	1pt	27	52	52	30	27	53	22	45	40
Prime Oil (PO)	1qt	22	60	52	30	22	50	28	50	43
Superb HC (PO-HSOC)	1pt	42	65	60	38	42	63	50	58	57
Stake (PO-HSOC)	1pt	27	62	50	32	27	58	40	53	50
Soy-Stik (MSO)	1.25pt	32	50	67	37	45	50	57	60	56
Persist Ultra (MSO)	1.25pt	27	48	60	25	27	52	62	48	54
Dyne-Amic (MSO + OS)	0.5% v/v	32	50	63	23	32	45	48	37	43
Dyne-Amic (MSO + OS)	0.75% v/v	35	65	67	28	35	62	63	47	57
Kixyt (MSO-HSOC)	1pt	35	72	55	32	45	58	55	52	55
Savvy (MSO-HSOC)	1pt	58	62	68	32	59	60	68	60	63
Destiny HC (MSO-HSOC)	1pt	58	62	68	32	63	52	68	58	65
Cide Winder (MSO-HSOC)	0.75% v/v	55	75	68	40	62	65	65	65	65
LSD (0.05)		4	6	6	5	4	5	5	4	4

Sharpen + Glyphosate with water conditioners. Zollinger, Richard K., Jerry L. Ries, and Angela J. Kazmierczak. An experiment was conducted near Lynchberg, ND, to evaluate species efficacy from tank-mixtures of Sharpen, glyphosate, MSO and water conditioning agents. 'York' flax, 'Plainsman' amaranth, quinoa (*Chenopodium quinoa*), and 'Mancan' tame buckwheat were planted perpendicular to each plot length on June 2, 2010. POST treatments were applied on July 9, at 9:20 am with 78 F air, 82 F soil surface, 51% relative humidity, 0% cloud cover, 1 to 3 mph NW wind, dry soil surface, moist subsoil, excellent crop vigor, and no dew present. Species stages at time of application were: 16 to 24 inch (20 to 30/ft^2) flax; 20 to 26 inch (20 to 25/ft^2) amaranth; 16 to 20 inch (10 to 20/ft^2, 90% budding) quinoa; and 24 to 30 inch (20 to 30/ft^2, 90% flowering) tame buckwheat. Treatments were applied to the center 6.7 feet of the 10 by 40 foot plots with a backpack-type plot sprayer delivering 8.5 gpa at 40 psi through 11001 Turbo TeeJet nozzles. The experiment had a randomized complete design with three replicates per treatment.

This study shows how oil adjuvants antagonize glyphosate and the enhancement of Sharpen from an MSO type oil adjuvant does not compensate from the oil antagonism of glyphosate. Weed control was greatest from the non-oil adjuvant ClassAct NG (NIS + AMS) which optimized glyphosate but only partially enhanced the highly lipophilic Sharpen while MSO (Soy-Stik) + AMS (Soy-Stik + Bronc Max) which optimized Sharpen, but resulted in severe antagonism of glyphosate. AMS did not overcome the antagonism from the oil. Acidic AMS replacement adjuvants (Import, N-Tense, Choice WM, and Speedway) applied with MSO did not overcome the antagonism either. (Department of Plant Sciences, North Dakota State University, Fargo).

Table. Sharpen + Glyphosate with water conditioners (Zollinger, Ries, Kazmierczak).

		14 DAT				28 DAT			
Treatment	Rate	Flax	Amar	Quin	Tabw	Flax	Amar	Quin	Tabw
	(product/A)	------- % control -------				------- % control -------			
Sharpen+Buccaneer+	0.5fl oz+12fl oz+								
Soy-Stik	1% v/v	37	48	60	20	37	28	30	20
Soy-Stik+AMS	1% v/v+8.5lb/100gal	50	53	65	23	50	33	67	33
Class Act NG	2.5% v/v	96	87	73	10	98	73	73	70
Soy-Stik+Class Act NG	1% v/v+2.5% v/v	70	58	67	22	80	38	73	38
Soy-Stik+Import	1% v/v+0.5% v/v	75	62	73	23	85	48	73	27
Soy-Stik+N-Tense	1% v/v+0.5% v/v	60	45	65	22	70	25	75	22
Soy-Stik+Choice WeatherMaster	1% v/v+0.5% v/v	60	45	67	20	70	35	73	28
Soy-Stik+Speedway	1% v/v+0.25% v/v	50	48	65	22	60	42	75	33
Soy-Stik+Bronc Max	1% v/v+0.5% v/v	37	45	60	20	47	45	40	30
LSD (0.05)		3	4	4	3	3	4	4	5

Sharpen + Glyphosate with adjuvants. Zollinger, Richard K., Jerry L. Ries, and Angela J. Kazmierczak. An experiment was conducted near Lynchberg, ND, to evaluate species efficacy from Sharpen plus glyphosate and adjuvant tank-mixes. 'York' flax, 'Plainsman' amaranth, quinoa (*Chenopodium quinoa*), and 'Mancan' tame buckwheat were planted perpendicular to each plot length on June 2, 2010. POST treatments were applied on July 9, at 8:50 am with 77 F air, 80 F soil surface, 51% relative humidity, 0% cloud cover, 1 to 3 mph NW wind, dry soil surface, moist subsoil, excellent crop vigor, and no dew present. Species stages at time of application were: 12 to 18 inch (20 to 30/ft^2) flax; 20 to 26 inch (20 to 25/ft^2) amaranth; 16 to 20 inch (10 to 20/ft^2, 90% budding) quinoa; and 24 to 30 inch (20 to 30/ft^2, 90% flowering) tame buckwheat. Treatments were applied to the center 6.7 feet of the 10 by 40 foot plots with a backpack-type plot sprayer delivering 8.5 gpa at 40 psi through 11001 Turbo TeeJet nozzles. The experiment had a randomized complete design with three replicates per treatment.

MSO type adjuvants applied at 1% in 8.5 gpa is equivalent to 0.68 pt/A which is below the recommended rate of 1.25 to 1.5 pt/A. Herbicide enhancement was variable among MSO adjuvant and species. The rate of MSO-HSOC adjuvants were based on label recommendations and weed control increased as rate/A increased. The addition of Interlock with a reduced rate of MSO-HSOC did not improve weed control of all species tested. Weed control from MSO-organosilicone (OS) adjuvants was also variable but was equal or less effective than MSO-HSOC adjuvant (Kixyt) applied at 0.34 pt/A. (Department of Plant Sciences, North Dakota State Universtiy, Fargo).

Table 1. Sharpen + Glyphosate with adjuvants (Zollinger, Ries, and Kazmierczak).

		14 DAT				28 DAT			
Treatment	Rate	Flax	Amar	Quin	Tabw	Flax	Amar	Quin	Tabw
	(product/A)	% control				% control			
MSO-Type Adjuvants									
Sharpen+Buccaneer+AMS+	0.5fl oz+12fl oz+8.5lb/100 gal+								
Soy-Stik	1% v/v = 0.68 pt	40	53	63	30	50	43	43	30
MSO Leci-Tech	1% v/v = 0.68 pt	60	68	72	32	60	52	73	42
Succeed	1% v/v = 0.68 pt	50	65	65	33	50	52	63	43
Sundance	1% v/v = 0.68 pt	55	68	72	32	58	53	72	32
Super Spread MSO	1% v/v = 0.68 pt	43	57	67	27	43	37	57	27
Persist Ultra	1% v/v = 0.68 pt	47	65	70	28	57	65	70	32
MSO-HSOC Type Adjuvants									
Kixyt	0.5% v/v = 0.34 pt	63	62	72	28	63	48	65	38
Savvy	0.75% v/v = 0.5 pt	70	67	75	32	73	53	63	48
Destiny HC	0.75pt	73	75	80	43	73	57	72	60
Destiny HC+Interlock	0.5pt+4fl oz	53	57	65	32	53	38	65	38
MSO + OS Type Adjuvants									
Syl-Tac	0.5% v/v = 0.34 pt/A	57	55	60	25	57	47	57	43
Airforce	0.5% v/v = 0.34 pt/A	62	60	65	25	62	52	58	32
LSD (0.05)		5	6	5	5	5	6	5	7

Water conditioning adjuvants. Zollinger, Richard K., Jerry L. Ries, and Angela J. Kazmierczak. Two experiments were conducted near Lynchberg, ND, to evaluate several water conditioning agents to AMS in distilled water and 1000 ppm calcium and magnesium tank-mixes. 'York' flax, 'Plainsman' amaranth, 'Mancan' tame buckwheat, and Pioneer '39B22' conventional corn were planted perpendicular to each plot length on June 2, 2010. POST treatments were applied on July 8, at 9:20 am with 72 F air, 75 F soil surface, 70% relative humidity, 0% cloud cover, 3 to 6 mph SW wind, dry soil surface, moist subsoil, excellent crop vigor, and no dew present. Species stages at time of application were: 8 to 16 inch (20 to 30/ft^2) flax; 10 to 20 inch (15 to 25/ft^2) amaranth; 20 to 26 inch (15 to 25/ft^2, 90% flowering) tame buckwheat; and 24 to 30 inch (V5 to V6, 5 to 7/ft^2) corn. Treatments were applied to the center 6.7 feet of the 10 by 40 foot plots with a backpack-type plot sprayer delivering 8.5 gpa at 40 psi through 11001 Turbo TeeJet nozzles. The experiment had a randomized complete design with three replicates per treatment.

This study was conducted at ND, IL, KS, NE, and MN to help create an ASTM certified standard for "water conditioning adjuvants". Commercial water conditioning adjuvants used in this study may or may not contain AMS and or NIS. MON 0818 was the adjuvant package included in the first glyphosate formulation released in the mid 1970s. Glyphosate + or - MON 0818 + AMS is the standard to compare all other treatments. In general, those adjuvants used at use rates of 0.5% v/v were inferior in control to those used at higher use rates of 2.5% v/v or 9 and 10 lb/100 gal water. These higher use rate adjuvants contain the equivalent of AMS at 8.5 lb/100 gal water + NIS at 0.25% v/v. Adjuvants used at 0.5% v/v may not contain AMS or NIS, or contain only a small amount of either material. Differences in control exist among species. (Department of Plant Sciences, North Dakota State University, Fargo).

Table 1. Water conditioning agents, with MON 0818 (Zollinger, Ries, Kazmierczak).

Treatment[1]	Rate	Water Hardness	14 DAT				28 DAT			
			Flax	Amar	Quin	Corn	Flax	Amar	Quin	Corn
	(product/A)	(ppm)	% control				% control			
Touchdown HiTech +	7.2fl oz +									
MON 0818	0.25% v/v	Distilled	72	70	55	57	72	80	53	57
MON 0818	0.25% v/v	1000	68	52	42	50	66	52	43	50
AMS	8.5lb/100 gal	Distilled	83	78	60	65	95	83	72	75
MON 0818+AMS	0.25% v/v+8.5lb/100 gal	1000	82	75	63	65	92	78	63	78
MON 0818+Request	0.25% v/v+0.5% v/v	1000	50	70	50	50	70	60	45	67
MON 0818+Hel-Fire	0.25% v/v+0.5% v/v	1000	79	68	58	62	88	65	58	82
MON 0818+N-Tense	0.25% v/v+0.5% v/v	1000	70	75	53	63	78	70	53	72
MON 0818+Array	0.25% v/v+9lb/100gal	1000	70	65	62	67	83	60	72	85
MON 0818+Bronc Max	0.25% v/v+0.5% v/v	1000	63	62	48	55	72	62	48	72
MON 0818+Choice WM	0.25% v/v+0.5% v/v	1000	67	67	53	63	80	67	53	73
MON 0818+Class Act NG	2.5% v/v+2.5% v/v	1000	78	75	55	63	78	85	55	83
MON 0818+ Bronc Plus EDT Dry	0.25% v/v+ 10lb/100gal	1000	87	89	62	70	95	89	73	87
MON 0818+Flame	0.25% v/v+0.5% v/v	1000	72	60	48	43	82	60	50	48
MON 0818+Cayuse Plus	0.25% v/v+0.5% v/v	1000	65	58	42	50	75	58	48	50
MON 0818+Bronc Triple	0.25% v/v+0.5% v/v	1000	67	62	47	55	67	52	45	62
MON 0818+ Weathergard Complete	0.25% v/v+ 0.5% v/v	1000	73	60	50	48	77	62	60	58
LSD (0.05)			9	7	5	6	6	7	5	5

[1]MON 0818 = the adjuvant package in the first Roundup formulation (~1974); Choice WM = Choice WeatherMaster.

Table 2. Water conditioning agents (Zollinger, Ries, Kazmierczak).

Treatment	Rate	Water Hardness	14 DAT				28 DAT			
			Flax	Amar	Quin	Corn	Flax	Amar	Quin	Corn
	(product/A)	(ppm)	% control				% control			
Touchdown HiTech	7.2fl oz	Distilled	27	62	42	42	40	53	42	42
Touchdown HiTech +	7.2fl oz +	1000	0	0	0	0	0	0	0	0
AMS	8.5lb/100 gal	Distilled	43	74	60	72	45	85	70	72
AMS	8.5lb/100 gal	1000	35	68	55	67	42	78	65	70
Request	0.5% v/v	1000	17	42	38	40	13	42	42	40
Hel-Fire	0.5% v/v	1000	78	53	57	58	78	42	60	62
N-Tense	0.5% v/v	1000	73	53	57	63	73	53	63	62
Array	9lb/100 gal	1000	50	65	68	72	43	58	65	72
Bronc Max	0.5% v/v	1000	30	52	43	60	30	52	50	63
Choice WeatherMaster	0.5% v/v	1000	73	60	58	52	85	60	58	62
Class Act NG	2.5% v/v	1000	85	89	72	82	92	79	72	92
Bronc Max EDT Dry	10lb/100 gal	1000	88	75	69	75	82	70	69	87
Flame	0.5% v/v	1000	27	43	42	40	27	31	42	42
Cayuse Plus	0.5% v/v	1000	27	52	48	78	37	62	42	47
Bronc Triple	0.5% v/v	1000	45	68	45	50	58	58	45	53
Weathergard Complete	0.5% v/v	1000	60	52	50	42	60	32	43	42
LSD (0.05)			8	7	7	8	8	10	7	6

Broadleaf control at various spray quality. Howatt, Roach, and Harrington. 'Omega' flax, amaranth, tame buckwheat, and quinoa were seeded at Casselton on June 1. Treatments were applied to 4 to 6 inch flax, 4 inch amaranth, and 8 to 12 inch tame buckwheat on July 6 with 75°F, 40% relative humidity, 100% cloud cover, 5 mph wind at 225° and dry soil at 75°F. Applications were made with a backpack sprayer mounted on a 4-wheeler delivering 8.5 gpa at 35 psi through 11001 TT nozzles for medium; 20 psi through 110015 TT for coarse, and 40 psi through AI 110015 for very coarse 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	Quality	8/10 Flax	8/10 Amaranth	8/10 Tabw
			%	%	%
Pxdn+Brox&MCPA	0.86+8	medium	0	32	91
Pxdn+Brox&MCPA	0.86+8	coarse	0	30	87
Pxdn+Brox&MCPA	0.86+8	v coarse	0	32	87
Pxdn+Brox&MCPA+AG 02013	0.86+8+4	v coarse	0	32	90
Pxdn+Brox&MCPA+InPlace	0.86+8+4	v coarse	0	30	87
Pxdn+Brox&MCPA+Array	0.86+8+12	v coarse	0	30	80
Pxdn+Brox&MCPA+Vector	0.86+8+2.7	v coarse	0	30	47
Pxdn+Brox&MCPA+DVA 9466	0.86+8+1.25%	v coarse	0	30	74
Untreated			0	0	0
CV			0	10	10
LSD 5%			0	4	11

Control of flax and amaranth was consistent and very poor across all treatments. Control of tame buckwheat tended to be less with coarse and very coarse droplet sizes, but variance within treatment generally was greater than variance among treatments because of one treatment with substantially less control that had a very wide response range.

Broadleaf control with 2,4-D formulations at different spray qualities. Howatt, Roach, Harrington. 'Omega' flax, amaranth, tame buckwheat, and quinoa were seeded in bioassay strips at Fargo on May 28. Treatments were applied to 4 to 8 inch flax and amaranth, 6 to 10 inch tame buckwheat, and quinoa on July 6 with 75°F, 53% relative humidity, 15% cloud cover, and damp soil at 65°F. Applications were applied with a backpack sprayer mounted on a 4 wheeler delivering 8.5 gpa at 35 psi through 11001 TT nozzles to a 7-foot wide area the length of 10- by 30-foot plots. The experiment was a randomized complete block design with three replicates.

Treatment	Rate	Spray quality	8/10 Amaranth	8/10 Tame buckwheat
	oz ai/A		%	%
2,4-D amine	8	medium	83	55
2,4-D acid	8	medium	92	82
2,4-D ester	8	medium	94	67
Thif-sg+NIS	0.3+0.25%	medium	89	68
Thif-sg+2,4-Dester+NIS	0.3+8+0.25%	medium	97	83
2,4-D amine	8	coarse	80	40
2,4-D acid	8	coarse	83	47
2,4-D ester	8	coarse	85	33
Thif-sg+NIS	0.3+0.25%	coarse	90	57
Thif-sg+2,4-D ester +NIS	0.3+8+0.25%	coarse	90	50
2,4-D amine	8	v coarse	83	47
2,4-D acid	8	v coarse	77	33
2,4-D ester	8	v coarse	83	55
Thif-sg+NIS	0.3+0.25%	v coarse	78	57
Thif-sg+2,4-D ester +NIS	0.3+8+0.25%	v coarse	94	78
Untreated	0		0	0
CV			6	14
LSD 5%			8	12

Individual herbicide treatments were not discernible 2 WAT: flax 40%, amaranth 70%, tame buckwheat 60%, and Venice mallow 70%. For each 2,4-D formulation, medium spray quality gave the best control of amaranth and buckwheat. At times the difference was more than 35 percentage points between medium and coarse or very coarse spray quality. Thifensulfuron showed the same trend, although amaranth control did not drop off until very coarse spray quality was used. The combined active ingredients were more stable for amaranth control but tame buckwheat again had variation.

Broadleaf control with 2,4-D formulations at different spray qualities. Howatt, Roach, and Harrington. 'Omega' flax, quinoa, amaranth and tame buckwheat were seeded at Casselton on June 2. Treatments were applied to 4 to 8 inch flax and amaranth, 6 to 10 inch tame buckwheat, 2 to 6 inch redroot pigweed and 1 to 6 leaf Venice mallow on July 6 with 72°F, 53% relative humidity, 0 % cloud cover, 2 mph wind at 225°, and damp soil at 62°F. Treatments were applied with a backpack sprayer mounted on a 4 wheeler delivering 8.5 gpa at 35 psi through 11001 TT nozzles, for medium; 20 psi through 1100015 TT nozzles, for coarse; and 40 psi through 1100015 TT nozzles for very coarse quality to a 7-foot wide area the length of 10- by 30-ft plots. The experiment was a randomized complete block design with three replicates.

Treatment	Rate	Quality	8/10 Flax	8/10 Amaranth	8/10 Rrpw	8/10 Vema	8/10 Tabw
	oz ai/A		%	%	%	%	%
2,4-D amine	8	medium	30	73	68	30	40
2,4-D acid	8	medium	57	78	80	10	37
2,4-D ester	8	medium	33	96	95	53	47
Thif-sg+NIS	0.3+0.25%	medium	17	97	94	30	30
Thif-sg+2,4-De+NIS	0.3+8+0.25%	medium	40	94	98	27	40
2,4-D amine	8	coarse	27	47	57	17	33
2,4-D acid	8	coarse	56	88	67	27	30
2,4-D ester	8	coarse	40	93	88	65	62
Thif-sg+NIS	0.3+0.25%	coarse	23	98	98	33	43
Thif-sg+2,4-De+NIS	0.3+8+0.25%	coarse	33	98	99	58	57
2,4-D amine	8	v coarse	20	47	43	37	37
2,4-D acid	8	v coarse	37	88	92	27	43
2,4-D ester	8	v coarse	43	94	87	60	47
Thif-sg+NIS	0.3+0.25%	v coarse	13	98	96	33	37
Thif-sg+2,4-De+NIS	0.3+8+0.25%	v coarse	27	98	98	70	47
Untreated	0		0	0	0	0	0
CV			36	7	13	34	23
LSD 5%			19	9	17	20	15

Substantial variation was recorded across the study within treatments resulting in very large LSDs. Spray quality effect in this study was not consistent across herbicide treatments and species. Control of flax, Venice mallow, and tame buckwheat were very poor across treatments. For amaranth spp., 2,4-D amine gave the least control but the greatest separation between control at medium spray quality compared with coarse or very coarse quality. Other 2,4-D formulations or thifensulfuron did not always demonstrate reduced control with larger droplet sizes.

Broadleaf efficacy at different spray quality. Howatt, Roach, and Harrington. Omega flax, amaranth, tame buckwheat, and quinoa were seeded near Fargo on May 28. Treatments were applied to 4 to 8 inch flax, 4 to 8 inch amaranth, 6 to 10 inch tame buckwheat, 1 to 4 inch Venice mallow, and 4 to 6 leaf yellow foxtail. Applications were made with a backpack sprayer mounted on a 4-wheeler delivering 8.5 gpa at 35 psi through 11001 TT nozzles for medium; 20 psi through 110015 TT for coarse; and 40 psi through AI 110015 for very coarse to a 7-ft wide area the length of 10- by 30-ft plots. The experiment was a randomized complete block design with three replicates.

Treatment	Rate	Quality	7/19 Flax	7/19 Amaranth	7/19 Tabw	7/19 Vema	7/19 Yeft
	ai/A		%	%	%	%	%
Pxdn+Brox&Pyst	0.86+2.83	medium	57	69	73	82	68
Pxdn+Brox&MCPA5	0.86+8	medium	20	47	80	65	72
Pxdn+Carf&2,4-D+NIS	0.86+4.13+0.25%	medium	78	91	89	92	73
Pxdn+Dica&Flox	0.86+1.75	medium	75	50	58	40	73
Pxdn+2,4-D Amine	0.86+8	medium	63	75	62	40	68
Pxdn+Brox&Pyst	0.86+2.83	coarse	47	47	75	75	62
Pxdn+Brox&MCPA5	0.86+8	coarse	13	37	67	47	70
Pxdn+Carf&2,4-D+NIS	0.86+4.13+0.25%	coarse	73	85	78	85	62
Pxdn+Dica&Flox	0.86+1.75	coarse	78	68	60	43	53
Pxdn+2,4-D Amine	0.86+8	coarse	37	62	47	20	60
Pxdn+Brox&Pyst	0.86+2.83	v coarse	37	43	78	78	67
Pxdn+Brox&MCPA5	0.86+8	v coarse	0	37	70	37	70
Pxdn+Carf&2,4-D+NIS	0.86+4.13+0.25%	v coarse	75	78	80	87	65
Pxdn+Dica&Flox	0.86+1.75	v coarse	75	43	47	30	73
Pxdn+2,4-D Amine	0.86+8	v coarse	33	58	47	20	75
Untreated	0		0	0	0	0	0
CV			18	22	10	20	14
LSD 5%			14	20	11	18	15

For many herbicide by species combinations, control decreased as spray quality changed from medium droplets to very coarse droplets. At times the largest difference was between medium and coarse, while other times the difference occurred between coarse and very coarse. In a few combinations, control declined substantially with each quality difference. For yellow foxtail control with pinoxaden, response to quality depended in part on the tank-mix partner.

Spray quality with Buccaneer. Zollinger, Richard K., Jerry L. Ries, and Angela J. Kazmierczak. An experiment was conducted near Lynchberg, ND, to evaluate weed species efficacy from Buccaneer and spray quality differences. 'York' flax, 'Plainsman' amaranth, quinoa (*Chenopodium quinoa*), and 'Mancan' tame buckwheat were planted perpendicular to each plot length on June 2, 2010. POST treatments were applied on July 7, at 10:30 am with 77 F air, 81 F soil surface, 32% relative humidity, 100% cloud cover, 1 to 3 mph SE wind, dry soil surface, moist subsoil, excellent crop vigor, and no dew present. Species stages at time of application were: 10 to 14 inch (20 to 30/ft^2) flax; 18 to 22 inch (15 to 20/ft^2) amaranth; 10 to 16 inch (10 to 15/ft^2, 75% budding) quinoa; and 14 to 22 inch (15 to 25/ft^2, 90% flowering) tame buckwheat. Treatments were applied to the center 6.7 feet of the 10 by 40 foot plots with an ATV-type plot sprayer. Nozzles, pressure, and speed were adjusted to obtain correct spray applications. The experiment had a randomized complete design with four replicates per treatment.

Droplet and Nozzle Information:

Fine Droplet - XR TeeJet 11002 - (F)
Medium Droplet: - Turbo TeeJet 11002 - (M)
Course Droplet - AIXR 11002 - (C)
Very Course Droplet - AI 11002 - (VC)

Gallonage and Speed Information:

5 GPA - 12 mph
10 GPA - 6 mph
15 GPA - 4 mph

This data support previous research from several weed scientists that droplets with high herbicide concentration (Pile Theory) enhanced weed control from glyphosate. Growers have reduced spray volumes to increase activity of glyphosate. Reducing water volume produces droplets with higher herbicide concentration but may also result in smaller droplets which may drift. To reduce drift, growers may use drift reduction nozzles which may produce larger droplets = C and VC droplet size. This and previous research shows that weed control is not penalized by using larger droplets, IF droplets are retained by adding appropriate adjuvants that aid in droplet retention. These results may or may not apply to other systemic herbicides. (Department of Plant Sciences, North Dakota State University, Fargo).

Table. Spray quality with Buccaneer (Zollinger, Ries, Kazmierczak).

			14 DAT				28 DAT			
Treatment	Rate	Nozzle	Flax	Amar	Quin	Tabw	Flax	Amar	Quin	Tabw
	(product/A)	- type -	------ % control ------				------ % control ------			
5 GPA										
Buccaneer+R-11+AMS	32fl oz+0.25% v/v+8.5lb/100 gal	F	30	50	40	20	50	50	50	50
Buccaneer+R-11+AMS	32fl oz+0.25% v/v+8.5lb/100 gal	M	30	60	50	20	60	60	60	60
Buccaneer+R-11+AMS	32fl oz+0.25% v/v+8.5lb/100 gal	C	60	70	60	40	70	60	60	60
Buccaneer+R-11+AMS	32fl oz+0.25% v/v+8.5lb/100 gal	VC	80	80	70	50	95	70	70	70
10 GPA										
Buccaneer+R-11+AMS	32fl oz+0.25% v/v+8.5lb/100 gal	F	95	80	64	60	99	80	80	70
Buccaneer+R-11+AMS	32fl oz+0.25% v/v+8.5lb/100 gal	M	95	90	60	60	99	80	80	75
Buccaneer+R-11+AMS	32fl oz+0.25% v/v+8.5lb/100 gal	C	95	90	80	65	99	80	80	80
Buccaneer+R-11+AMS	32fl oz+0.25% v/v+8.5lb/100 gal	VC	95	90	90	75	99	90	90	85
15 GPA										
Buccaneer+R-11+AMS	32fl oz+0.25% v/v+8.5lb/100 gal	F	95	60	60	60	99	60	80	70
Buccaneer+R-11+AMS	32fl oz+0.25% v/v+8.5lb/100 gal	M	95	75	70	70	99	60	80	70
Buccaneer+R-11+AMS	32fl oz+0.25% v/v+8.5lb/100 gal	C	95	85	80	80	99	70	80	80
Buccaneer+R-11+AMS	32fl oz+0.25% v/v+8.5lb/100 gal	VC	95	70	70	90	99	55	70	90

Spray quality with Buccaneer Plus. Zollinger, Richard K., Jerry L. Ries, and Angela J. Kazmierczak. An experiment was conducted near Lynchberg, ND, to evaluate weed species efficacy from Buccaneer Plus and spray quality differences. 'York' flax, 'Plainsman' amaranth, quinoa (*Chenopodium quinoa*), and 'Mancan' tame buckwheat were planted perpendicular to each plot length on June 2, 2010. POST treatments were applied on July 7, at 11:00 am with 78 F air, 81 F soil surface, 32% relative humidity, 100% cloud cover, 1 to 3 mph SE wind, dry soil surface, moist subsoil, excellent crop vigor, and no dew present. Species stages at time of application were: 10 to 14 inch (20 to 30/ft^2) flax; 18 to 22 inch (15 to 20/ft^2) amaranth; 10 to 16 inch (10 to 15/ft^2, 75% budding) quinoa; 14 to 22 inch (15 to 25/ft^2, 90% flowering) tame buckwheat; and 24 to 36 inch (5 to 15/yd^2) giant ragweed. Treatments were applied to the center 6.7 feet of the 10 by 40 foot plots with an ATV-type plot sprayer. Nozzles, pressure, and speed were adjusted to obtain correct spray applications.The experiment had a randomized complete design with four replicates per treatment.

Droplet and Nozzle Information:

Fine Droplet - XR TeeJet 11002 - (F)
Medium Droplet: - Turbo TeeJet 11002 - (M)
Course Droplet - AIXR 11002 - (C)
Very Course Droplet - AI 11002 - (VC)

Gallonage and Speed Information:

5 GPA - 12 mph
10 GPA - 6 mph
15 GPA - 4 mph

This data support previous research from several weed scientists that droplets with high herbicide concentration (Pile Theory) enhanced weed control from glyphosate. Growers have reduced spray volumes to increase activity of glyphosate. Reducing water volume produces droplets with higher herbicide concentration but may also result in smaller droplets which may drift. To reduce drift, growers may use drift reduction nozzles which may produce larger droplets = C and VC droplet size. This and previous research shows that weed control is not penalized by using larger droplets, IF droplets are retained by adding appropriate adjuvants that aid in droplet retention. These results may or may not apply to other systemic herbicides. (Department of Plant Sciences, North Dakota State University, Fargo).

Table. Spray quality with Buccaneer Plus (Zollinger, Ries, Kazmierczak).

			14 DAT				28 DAT			
Treatment	Rate	Nozzle	Flax	Amar	Quin	Tabw	Flax	Amar	Quin	Tabw
	(product/A)	- type -	- - - - % control - - - -				- - - - % control - - - -			
5 GPA										
Buccaneer Plus+AMS	32fl oz+8.5lb/100 gal	F	30	50	40	20	50	30	40	60
Buccaneer Plus+AMS	32fl oz+8.5lb/100 gal	M	50	60	50	20	70	40	50	60
Buccaneer Plus+AMS	32fl oz+8.5lb/100 gal	C	60	70	60	40	90	60	60	65
Buccaneer Plus+AMS	32fl oz+8.5lb/100 gal	VC	95	80	70	50	99	85	95	75
10 GPA										
Buccaneer Plus+AMS	32fl oz+8.5lb/100 gal	F	95	90	75	60	99	90	80	85
Buccaneer Plus+AMS	32fl oz+8.5lb/100 gal	M	95	95	80	60	99	95	86	95
Buccaneer Plus+AMS	32fl oz+8.5lb/100 gal	C	95	95	85	65	99	85	90	90
Buccaneer Plus+AMS	32fl oz+8.5lb/100 gal	VC	95	95	85	70	99	90	99	90
15 GPA										
Buccaneer Plus+AMS	32fl oz+8.5lb/100 gal	F	95	95	60	75	85	80	70	70
Buccaneer Plus+AMS	32fl oz+8.5lb/100 gal	M	95	95	70	75	90	80	70	70
Buccaneer Plus+AMS	32fl oz+8.5lb/100 gal	C	95	95	80	75	90	80	80	75
Buccaneer Plus+AMS	32fl oz+8.5lb/100 gal	VC	95	80	90	80	90	80	70	80

Spray quality with clethodim. Zollinger, Richard K., Jerry L. Ries, and Angela J. Kazmierczak. An experiment was conducted near Lynchberg, ND, to evaluate weed species efficacy from Select and spray quality differences. 'Stockford' foxtail barley, 'Glenn' hard red spring wheat, 'Siberian' foxtail millet, and Pioneer '39B22' conventional corn were planted perpendicular to each plot length on June 2, 2010. POST treatments were applied on July 7, at 10:00 am with 76 F air, 81 F soil surface, 35% relative humidity, 100% cloud cover, 1 to 3 mph SE wind, dry soil surface, moist subsoil, excellent crop vigor, and no dew present. Species stages at time of application were: 12 to 14 inch (15 to 20/ft^2, tillering) foxtail barley; 12 to 14 inch (15 to 20/ft^2, tillering) hard red spring wheat; 12 to 14 inch (10 to 15/ft^2) foxtail millet; and 20 to 28 inch (V5 to V6, 5 to 7/ft^2) corn. Treatments were applied to the center 6.7 feet of the 10 by 40 foot plots with an ATV-type plot sprayer. Nozzles, pressure, and speed were adjusted to obtain correct spray applications. The experiment had a randomized complete design with three replicates per treatment.

Droplet and Nozzle Information:

Fine Droplet - XR TeeJet 11002 - (F)
Medium Droplet: - Turbo TeeJet 11002 - (M)
Course Droplet - AIXR 11002 - (C)
Very Course Droplet - AI 11002 - (VC)

Gallonage and Speed Information:

5 GPA - 12 mph
10 GPA - 6 mph
15 GPA - 4 mph

Results were variable and difference in control exist among species. Some species show improved weed control as droplet size increases as some show improved weed control as herbicide concentration in the droplet increases and some do not show a clear relationship with droplet size and herbicide concentration. (Department of Plant Sciences, North Dakota State University, Fargo).

Table. Spray quality with Select (Zollinger, Ries, Kazmierczak).

			14 DAT			28 DAT			
Treatment	Rate	Nozzle	Foba[1]	Wheat	Corn	Foba	Wheat	Fomi[2]	Corn
	(product/A)	- type -	- - - - % control - - - -			- - - - - - % control - - - - - -			
5 GPA									
Select+Herbimax	4fl oz+1.25pt	F	40	40	70	40	40	40	80
Select+Herbimax	4fl oz+1.25pt	M	20	20	60	30	40	40	80
Select+Herbimax	4fl oz+1.25pt	C	20	20	50	40	45	60	80
Select+Herbimax	4fl oz+1.25pt	VC	20	20	40	50	50	60	80
10 GPA									
Select+Herbimax	4fl oz+1.25pt	F	40	30	70	30	30	50	85
Select+Herbimax	4fl oz+1.25pt	M	40	30	65	30	40	50	85
Select+Herbimax	4fl oz+1.25pt	C	40	30	60	40	50	45	85
Select+Herbimax	4fl oz+1.25pt	VC	40	30	55	50	50	50	80
15 GPA									
Select+Herbimax	4fl oz+1.25pt	F	20	20	60	20	20	23	65
Select+Herbimax	4fl oz+1.25pt	M	20	20	50	20	20	20	50
Select+Herbimax	4fl oz+1.25pt	C	20	20	50	30	30	40	65
Select+Herbimax	4fl oz+1.25pt	VC	20	20	40	20	20	30	60

[1]Foba = forage barley.
[2]Fomi - foxtail millet.

Spray quality with Ignite. Zollinger, Richard K., Jerry L. Ries, and Angela J. Kazmierczak. An experiment was conducted near Lynchberg, ND, to evaluate weed species efficacy from Ignite and spray quality differences. 'York' flax, 'Plainsman' amaranth, quinoa (*Chenopodium quinoa*), and 'Mancan' tame buckwheat were planted perpendicular to each plot length on June 2, 2010. POST treatments were applied on July 7, at 11:30 am with 79 F air, 82 F soil surface, 33% relative humidity, 100% cloud cover, 1 to 3 mph SE wind, dry soil surface, moist subsoil, excellent crop vigor, and no dew present. Species stages at time of application were: 10 to 14 inch (20 to 30/ft^2) flax; 18 to 22 inch (15 to 20/ft^2) amaranth; 10 to 16 inch (10 to 15/ft^2, 75% budding) quinoa; and 14 to 22 inch (15 to 25/ft^2, 90% flowering) tame buckwheat. Treatments were applied to the center 6.7 feet of the 10 by 40 foot plots with an ATV-type plot sprayer. Nozzles, pressure, and speed were adjusted to obtain correct spray applications.The experiment had a randomized complete design with four replicates per treatment.

Droplet and Nozzle Information:

Fine Droplet - XR TeeJet 11002 - (F)
Medium Droplet: - Turbo TeeJet 11002 - (M)
Course Droplet - AIXR 11002 - (C)
Very Course Droplet - AI 11002 - (VC)

Gallonage and Speed Information:

5 GPA - 12 mph
10 GPA - 6 mph
15 GPA - 4 mph

This data support previous research that some contact herbicides (Flexstar/Reflex) require high spray volumes to produce adequate droplet patterns and coverage. This data also shows that high herbicide concentration in the droplet is of minimal importance which is opposite than glyphosate. This and previous research shows that weed control is not penalized by using larger droplets, IF droplets are retained by adding appropriate adjuvants that aid in droplet retention. These results may or may not apply to other contact herbicides (except Flexstar/Reflex). (Department of Plant Sciences, North Dakota State University, Fargo).

Table. Spray quality with Ignite (Zollinger, Ries, Kazmierczak).

			14 DAT			28 DAT			
Treatment	Rate	Nozzle	Flax	Amar	Tabw	Flax	Amar	Quin	Tabw
	(product/A)	- type -	- - - - % control - - - -			- - - - - - % control - - - - - -			
5 GPA									
Ignite+AMS	22fl oz+3lb	F	20	20	50	20	20	30	20
Ignite+AMS	22fl oz+3lb	M	20	20	50	20	20	40	20
Ignite+AMS	22fl oz+3lb	C	28	30	60	30	30	50	20
Ignite+AMS	22fl oz+3lb	VC	80	70	80	50	40	60	40
10 GPA									
Ignite+AMS	22fl oz+3lb	F	80	70	80	40	30	80	40
Ignite+AMS	22fl oz+3lb	M	80	70	80	45	40	80	50
Ignite+AMS	22fl oz+3lb	C	80	70	80	55	40	85	60
Ignite+AMS	22fl oz+3lb	VC	80	70	80	60	50	85	60
15 GPA									
Ignite+AMS	22fl oz+3lb	F	80	70	80	60	45	75	65
Ignite+AMS	22fl oz+3lb	M	80	70	80	60	20	80	60
Ignite+AMS	22fl oz+3lb	C	80	70	80	60	50	85	60
Ignite+AMS	22fl oz+3lb	VC	81	70	80	60	50	90	60

Spray quality with Laudis. Zollinger, Richard K., Jerry L. Ries, and Angela J. Kazmierczak. An experiment was conducted near Lynchberg, ND, to evaluate weed species efficacy from Laudis and spray quality differences. 'Sheyenne' soybean, 'Plainsman' amaranth, quinoa (*Chenopodium quinoa*), and 'Mancan' tame buckwheat were planted perpendicular to each plot length on June 2, 2010. POST treatments were applied on July 7, at 9:30 am with 74 F air, 78 F soil surface, 36% relative humidity, 100% cloud cover, 1 to 3 mph SE wind, dry soil surface, moist subsoil, excellent crop vigor, and no dew present. Species stages at time of application were: 10 to 12 inch (V4, 5 to 10/ft^2) soybean; 16 to 22 inch (15 to 20/ft^2) amaranth; 8 to 16 inch (10 to 15/ft^2, 75% budding) quinoa; and 14 to 20 inch (15 to 25/ft^2, 90% flowering) tame buckwheat. Treatments were applied to the center 6.7 feet of the 10 by 40 foot plots with an ATV-type plot sprayer. Nozzles, pressure, and speed were adjusted to obtain correct spray applications. The experiment had a randomized complete design with three replicates per treatment.

There are many factors involved in resulting weed control from herbicides applied through different nozzles, at different travel speeds, giving different spray quality. At least three parameters should be considered affecting efficacy including droplet size and droplet number (= pattern), and herbicide concentration in droplets. Weed control was greater as herbicide concentration in spray droplets increased (lower gpa). In general, weed control from spray quality was C > VC = M > F. MSO adjuvant was applied on an area basis, was at a common rate in all treatments which should not confound weed control. (Department of Plant Sciences, North Dakota State University, Fargo).

Droplet and Nozzle Information:

Fine Droplet - XR TeeJet 11002 - (F)
Medium Droplet: - Turbo TeeJet 11002 - (M)
Course Droplet - AIXR 11002 - (C)
Very Course Droplet - AI 11002 - (VC)

Gallonage and Speed Information:

5 GPA - 12 mph
10 GPA - 6 mph
15 GPA - 4 mph

Table. Spray quality with Laudis (Zollinger, Ries, Kazmierczak).

Treatment	Rate	Nozzle	28 DAT				Ave.
			Amar	Quin	Soyb	Tabw	
	(product/A)	- type -	- - - - - % control - - - - -				% control
5 GPA							
Laudis+Soy-Stik	2fl oz+1.25pt	F	40	40	40	35	39
Laudis+Soy-Stik	2fl oz+1.25pt	M	50	50	50	45	49
Laudis+Soy-Stik	2fl oz+1.25pt	C	60	60	60	60	60
Laudis+Soy-Stik	2fl oz+1.25pt	VC	50	50	50	50	50
10 GPA							
Laudis+Soy-Stik	2fl oz+1.25pt	F	30	30	30	25	29
Laudis+Soy-Stik	2fl oz+1.25pt	M	40	40	40	35	39
Laudis+Soy-Stik	2fl oz+1.25pt	C	50	50	50	50	50
Laudis+Soy-Stik	2fl oz+1.25pt	VC	40	40	40	40	40
15 GPA							
Laudis+Soy-Stik	2fl oz+1.25pt	F	20	20	20	10	18
Laudis+Soy-Stik	2fl oz+1.25pt	M	30	30	30	20	28
Laudis+Soy-Stik	2fl oz+1.25pt	C	50	50	50	40	48
Laudis+Soy-Stik	2fl oz+1.25pt	VC	20	20	20	10	18

Spray quality with Status. Zollinger, Richard K., Jerry L. Ries, and Angela J. Kazmierczak. An experiment was conducted near Lynchberg, ND, to evaluate weed species efficacy from Status and spray quality differences. 'York' flax, 'Plainsman' amaranth, quinoa (*Chenopodium quinoa*), and 'Mancan' tame buckwheat were planted perpendicular to each plot length on June 2, 2010. POST treatments were applied on July 7, at 9:00 am with 72 F air, 76 F soil surface, 35% relative humidity, 100% cloud cover, 1 to 3 mph SE wind, dry soil surface, moist subsoil, excellent crop vigor, and no dew present. Species stages at time of application were: 8 to 14 inch (20 to 30/ft^2) flax; 14 to 20 inch (15 to 20/ft^2) amaranth; 8 to 16 inch (10 to 15/ft^2, 75% budding) quinoa; and 14 to 20 inch (15 to 25/ft^2, 90% flowering) tame buckwheat. Treatments were applied to the center 6.7 feet of the 10 by 40 foot plots with an ATV-type plot sprayer. Nozzles, pressure, and speed were adjusted to obtain correct spray applications. The experiment had a randomized complete design with three replicates per treatment.

There are many factors involved in resulting weed control from herbicides applied through different nozzles, at different travel speeds, giving different spray quality. At least three parameters should be considered affecting efficacy including droplet size and droplet number (= pattern), and herbicide concentration in droplets. Weed control was greater as herbicide concentration in spray droplets increased (lower gpa). In general, weed control from spray quality was F = M > C = VC. MSO adjuvant was applied on an area basis, was at a common rate in all treatments which should not confound weed control. (Department of Plant Sciences, North Dakota State University, Fargo).

Droplet and Nozzle Information:

Fine Droplet - XR TeeJet 11002 - (F)
Medium Droplet: - Turbo TeeJet 11002 - (M)
Course Droplet - AIXR TeeJet 11002 - (C)
Very Course Droplet - AI TeeJet 11002 - (VC)

Gallonage and Speed Information:

5 GPA - 12 mph
10 GPA - 6 mph
15 GPA - 4 mph

Table. Spray quality with Status (Zollinger, Ries, Kazmierczak).

Treatment	Rate	Nozzle	28 DAT				Ave.
			Flax	Amar	Quin	Tabw	
	(product/A)	- type -	- - - - - - % control - - - - - -				% control
5 GPA							
Status+Soy-Stik	4oz+1.25pt	F	60	60	60	60	60
Status+Soy-Stik	4oz+1.25pt	M	60	60	60	60	60
Status+Soy-Stik	4oz+1.25pt	C	60	60	50	50	55
Status+Soy-Stik	4oz+1.25pt	VC	55	55	60	50	55
10 GPA							
Status+Soy-Stik	4oz+1.25pt	F	50	50	50	50	50
Status+Soy-Stik	4oz+1.25pt	M	50	50	60	50	55
Status+Soy-Stik	4oz+1.25pt	C	50	50	55	45	50
Status+Soy-Stik	4oz+1.25pt	VC	50	50	50	50	50
15 GPA							
Status+Soy-Stik	4oz+1.25pt	F	40	40	50	40	45
Status+Soy-Stik	4oz+1.25pt	M	45	45	50	40	45
Status+Soy-Stik	4oz+1.25pt	C	40	40	40	40	40
Status+Soy-Stik	4oz+1.25pt	VC	40	40	40	40	40

Wild oat control at various spray quality. Lukach, Howatt, and Harrington. Hard red spring wheat was seeded at Langdon. Treatments were applied to 3 leaf wheat and wild oat and 2 to 4 leaf wild mustard. Treatments were applied with a tractor sprayer delivering 10 gpa at 35 psi 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.

Treatment	Rate	Quality	7/22 Wioa	7/22 Wimu
	oz ai/A		%	%
Fenx+Clpy&Flox	1+3	medium	95	98
Fenx+Clpy&Flox	1+3	coarse	86	45
Fenx+Clpy&Flox	1+3	v coarse	87	50
Fenx+Clpy&Flox	1.32+3	medium	97	97
Fenx+Clpy&Flox	1.32+3	coarse	89	40
Fenx+Clpy&Flox	1.32+3	v coarse	87	42
Fenx+Clpy&Flox+AG 02013	1+3+4	v coarse	84	42
Fenx+Clpy&Flox+InPlace	1+3+4	v coarse	89	42
Fenx+Clpy&Flox+Array	1+3+12	v coarse	70	37
Fenx+Clpy&Flox+Vector	1+3+2.7	v coarse	74	42
Fenx+Clpy&Flox+DVA 9466	1+3+1.25	v coarse	65	40
Untreated	0		0	0
CV			6	10
LSD 5%			7	7

Fenoxaprop control of wild oat decreased with droplet ranges larger than medium. The drop in control rating was not corrected with adjuvants. The effect was more dramatic for clopyralid and fluroxypyr control of wild mustard. Herbicide control of wild mustard was 98% with medium spray quality compared with 40 to 50% control with coarse or very coarse spray quality. Again, adjuvant did not overcome the drop in control.

Adjuvant rate for saflufenacil. Howatt, Roach, Harrington. 'Omega' flax, Quinoa, Amaranth and Tame buckwheat were seeded at Fargo on May 28. Treatments were applied to 4 to 8 inch flax and amaranth, 6 to 10 in tame buckwheat, and 1 to 6 leaves Venice mallow on July 6 with 72°F, 53% relative humidity, 0% cloud cover, 2 mph wind at 225°, and damp soil at 62°F. Treatments were applied with a backpack sprayer mounted on a 4 wheeler delivering 17 or 8.5 gpa at 30 psi through 11001 TT 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.

			7/19	7/19	7/19	7/19	7/19
Treatment	Rate	Volume	Flax	Amaranth	Tame buckwheat	Common purslane	Venice mallow
	oz ai/A	gpa	%	%	%	%	%
Saflufenacil+MSO	0.36+1%	17	72	93	85	93	92
Saflufenacil+MSO	0.36+1%	8.5	75	93	85	93	91
Saflufenacil+MSO	0.36+1%	4	55	86	70	85	82
Saflufenacil+MSO	0.36+16	17	75	94	83	92	91
Saflufenacil+MSO	0.36+16	8.5	73	96	88	93	91
Saflufenacil+MSO	0.36+16	4	78	97	92	96	94
Saflufenacil+MSO	0.36+21	8.5	72	94	88	96	94
Saflufenacil+MSO	0.36+10	8.5	73	96	86	93	93
Saflufenacil+MSO	0.36+8	8.5	67	95	78	90	89
Saflufenacil+MSO	0.36+5	8.5	57	80	63	82	80
Untreated	0		0	0	0	0	0
CV			8	3	6	4	6
LSD 5%			9	5	8	6	8

Saflufenacil with MSO adjuvant at 1% vol/vol with less than 8.5 gpa water applied resulted in substantially less control than with 1% MSO in more water or a set 16 fl oz MSO per acre regardless of spray volume. Saflufenacil with MSO adjuvant at 16 fl oz/A in 4 gpa tended to result in best control and most rapid desiccation of plant tissue. In this study, MSO at 10 fl oz/A with saflufenacil was the minimum adjuvant load necessary to reach near optimum activity of saflufenacil.

Adjuvant rate for saflufenacil. Howatt, Roach, and Harrington. 'Omega' flax, quinoa, amaranth and tame buckwheat were seeded at Casselton on June 2. Treatments were applied to 4 to 8 inch flax and amaranth, 6 to 10 inch tame buckwheat, and 1 to 6 leaf Venice mallow on July 6 with 72°F, 53% relative humidity, 0 % cloud cover, 2 mph wind at 225°, and damp soil at 62°F. Treatments were applied with a backpack sprayer mounted on a 4 wheeler delivering 17 or 8.5 gpa at 30 psi through 11001 TT 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.

Treatment	Rate	Volume	8/10 Flax	8/10 Amaranth	8/10 Rrpw	8/10 Vema	8/10 Tabw
	oz ai/A	gpa	%	%	%	%	%
Saflufenacil+MSO	0.36+1%	17	90	94	90	89	67
Saflufenacil+MSO	0.36+1%	8.5	90	86	72	78	47
Saflufenacil+MSO	0.36+1%	4.2	80	80	72	72	37
Saflufenacil+MSO	0.36+16	17	88	88	83	83	50
Saflufenacil+MSO	0.36+16	8.5	83	85	72	80	40
Saflufenacil+MSO	0.36+16	4.2	87	90	82	88	50
Saflufenacil+MSO	0.36+21	8.5	88	83	82	85	53
Saflufenacil+MSO	0.36+10	8.5	87	87	77	82	33
Saflufenacil+MSO	0.36+8	8.5	85	78	63	62	37
Saflufenacil+MSO	0.36+5	8.5	82	72	60	63	37
Untreated	0		0	0	0	0	0
CV			6	7	12	11	22
LSD 5%			8	10	14	14	15

At this location, saflufenacil seemed to respond better with increased water volume as well as MSO application per acre rather than on % of volume. Optimum control with saflufenacil was not reached with all species until MSO rate was 21 fl oz/A, or 1% oil if volume is 17 gpa. There was a trend of steady increase in control of most species as MSO rate increased from 5 through 21 fl oz/A. Increased MSO rate beyond those included in this study may have given better activity with saflufenacil. For typical application volumes in North Dakota, 1% MSO by volume does not provide adequate adjuvant properties for saflufenacil.

Application volume of oil adjuvants. Zollinger, Richard K., Jerry L. Ries, and Angela J. Kazmierczak. An experiment was conducted near Lynchberg, ND, to evaluate application volumes of 8.5 and 17 gpa with oil adjuvants applied at a % v/v and at an area per acre basis. 'York' flax, 'Plainsman' amaranth, quinoa (*Chenopodium quinoa*), and 'Mancan' tame buckwheat were planted perpendicular to each plot length on June 2, 2010. POST treatments were applied on July 5, at 9:20 am with 72 F air, 81 F soil surface, 42% relative humidity, 100% cloud cover, 1 to 3 mph SE wind, dry soil surface, moist subsoil, excellent crop vigor, and no dew present. Species stages at time of application were: 8 to 14 inch (20 to 30/ft^2) flax; 10 to 16 inch (15 to 25/ft^2) amaranth; 12 to 16 inch (10 to 20/ft^2, 50% budding) quinoa; and 12 to 16 inch (20 to 30/ft^2, 75% flowering) tame buckwheat. Treatments were applied to the center 6.7 feet of the 10 by 40 foot plots with a backpack-type plot sprayer delivering 8.5 gpa through 11001 Turbo TeeJet nozzles at 40 psi and 17 gpa through 11002 Turbo TeeJet nozzles at 40 psi. The experiment had a randomized complete design with three replicates per treatment.

COC or petroleum oil adjuvants (PO) were used at 2 pt/A while MSO type adjuvant were used at 1.5 pt/A. Many herbicide labels recommend oil rates on a spray volume basis (% v/v). Oil adjuvant at 1% v/v in a spray volume of 17 gpa is equivalent to 1.4 pt/A which is near the optimum rate recommended by NDSU of 1.5 pt/A for MSO but less than the COC/PO rate of 2 pt/A. Growers in ND and the mid west have reduced spray volume because glyphosate is the principle herbicide applied and glyphosate activity increases as spray volume decreases (higher herbicide concentration in the spray droplet). As spray volume decreases so will the amount per acre of oil adjuvant if applied on a volume basis. Oil adjuvant applied at 1% v/v at 8.5 gpa is equivalent to 0.7 pt/A and will result in less weed control. This study shows the penalty for applying oil adjuvants on a volume basis in a low spray volume.

The following chart may help compare herbicide enhancement from oil adjuvants applied at 17 and 8.5 gpa on a volume and area basis:

pt/A		8.5 gpa		17 gpa
0.34	=	0.5%	=	0.25%
0.7	=	1%	=	0.5%
1.4	=	2%	=	1%
2	=	3%	=	1.5%

Sharpen enhancement from oil type is MSO-HSOC = or > MSO > PO-HSOC > PO.
Weed control from Sharpen was greater at 17 gpa than 8.5 gpa.
Weed control was reduced as oil adjuvant rates were reduced on % volume basis.
The higher the oil concentration the greater the weed control.
Oil adjuvants applied on an area basis is more consistent across spray volumes than applied on a volume basis. (Department of Plant Sciences, North Dakota State University, Fargo).

Table 1. Application volume of oil adjuvants, **8.5 gpa** (Zollinger, Ries, Kazmierczak).

Treatment	Rate	14 DAT				28 DAT			
		Flax	Amar	Quin	Tabw	Flax	Amar	Quin	Tabw
	(product/A)	- - - - - - - - % control - - - - - - - -				- - - - - - - - % control - - - - - - - -			
Sharpen +	1fl oz +								
Premium COC	0.5% v/v	37	52	30	38	17	23	30	12
Premium COC	1% v/v	27	50	30	30	23	20	20	10
Premium COC	2% v/v	40	55	35	37	33	32	35	8
Premium COC	3% v/v	52	63	48	43	42	42	48	10
Superb HC	0.5% v/v	55	63	40	40	55	50	40	10
Superb HC	1% v/v	62	72	53	48	62	62	60	13
Superb HC	2% v/v	55	77	58	58	55	72	75	33
Superb HC	3% v/v	63	77	60	62	63	57	70	38
Soy-Stik	0.5% v/v	53	83	45	47	33	53	55	12
Soy-Stik	1% v/v	58	88	50	52	42	65	68	22
Soy-Stik	2% v/v	62	92	58	57	42	62	85	33
Soy-Stik	3% v/v	68	87	63	52	48	57	87	22
Destiny HC	0.5% v/v	45	67	49	43	25	37	58	15
Destiny HC	1% v/v	47	75	50	50	47	60	73	20
Destiny HC	2% v/v	55	82	58	55	47	55	78	25
Destiny HC	3% v/v	72	85	67	58	72	65	86	33
LSD (0.05)		7	5	7	6	6	4	7	4

Table 2. Application volume of oil adjuvants, **17 gpa** (Zollinger, Ries, Kazmierczak).

Treatment	Rate	14 DAT				28 DAT			
		Flax	Amar	Quin	Tabw	Flax	Amar	Quin	Tabw
	(product/A)	- - - - - - - - % control - - - - - - - -				- - - - - - - - % control - - - - - - - -			
Sharpen +	1fl oz +								
Premium COC	0.25% v/v	22	77	23	33	22	37	27	5
Premium COC	0.5% v/v	42	82	33	42	18	38	47	5
Premium COC	1% v/v	45	85	30	45	45	48	73	15
Premium COC	2% v/v	72	92	65	75	72	62	82	32
Superb HC	0.25% v/v	53	72	53	48	12	40	43	13
Superb HC	0.5% v/v	52	73	55	55	20	53	60	22
Superb HC	1% v/v	53	88	65	68	30	58	85	40
Superb HC	2% v/v	62	92	80	82	50	65	95	67
Soy-Stik	0.25% v/v	32	53	30	30	15	23	20	20
Soy-Stik	0.5% v/v	52	85	47	48	52	45	73	68
Soy-Stik	1% v/v	53	97	58	73	53	60	78	63
Soy-Stik	2% v/v	75	93	75	83	65	73	92	74
Destiny HC	0.25% v/v	58	85	53	55	18	45	57	33
Destiny HC	0.5% v/v	73	96	50	57	43	63	62	37
Destiny HC	1% v/v	72	98	75	83	52	65	87	63
Destiny HC	2% v/v	77	95	85	92	67	93	92	87
LSD (0.05)		6	7	10	7	5	6	4	5

Herbicides by oil adjuvant volume. Zollinger, Richard K., Jerry L. Ries, and Angela J. Kazmierczak. An experiment was conducted near Lynchberg, ND, to evaluate weed efficacy from oil adjuvants and their application rate. 'York' flax, 'Plainsman' amaranth, quinoa (*Chenopodium quinoa*), and 'Mancan' tame buckwheat were planted perpendicular to each plot length on June 2, 2010. POST treatments were applied on July 5 at 9:05 am with 73 F air, 81 F soil surface, 42% relative humidity, 75% cloud cover, 1 to 3 mph SE wind, dry soil surface, moist subsoil, excellent crop vigor, and no dew present. Species stages at time of application were: 6 to 12 inch (20 to 30/ft^2) flax; 6 to 14 inch (15 to 25/ft^2) amaranth; 8 to 14 inch (10 to 20/ft^2) quinoa; and 12 to 16 inch (20 to 30/ft^2, 75% flowering) tame buckwheat. Treatments were applied to the center 6.7 feet of the 10 by 40 foot plots with a backpack-type plot sprayer delivering 17 gpa at 40 psi through 11002 Turbo TeeJet nozzles. The experiment had a randomized complete design with three replicates per treatment.

COC or petroleum oil adjuvants (PO) were used at 2 pt/A while MSO type adjuvant were used at 1.5 pt/A. Many herbicide labels recommend oil rates on a spray volume basis (% v/v). Oil adjuvant at 1% v/v in a spray volume of 17 gpa is equivalent to 1.4 pt/A which is near the optimum rate recommended by NDSU of 1.5 pt/A for MSO but less than the COC/PO rate of 2 pt/A. Growers in ND and the mid west have reduced spray volume because glyphosate is the principle herbicide applied and glyphosate activity increases as spray volume decreases (higher herbicide concentration in the spray droplet). As spray volume decreases so will the amount per acre of oil adjuvant if applied on a volume basis. Oil adjuvant applied at 1% v/v at 8.5 gpa is equivalent to 0.7 pt/A and will result in less weed control. This study shows the penalty for applying oil adjuvants on a volume basis in a low spray volume.

The following chart may help compare herbicide enhancement from oil adjuvants applied at 17 and 8.5 gpa on a volume and area basis:

pt/A		8.5 gpa		17 gpa
0.34	=	0.5%	=	-
0.7	=	1%	=	0.5%
1.4	=	-	=	1%

Soy-Stik is a commercial MSO type oil adjuvant and Dyne-Amic isn MSO + organosilicone type adjuvant.
Verdict is a premix of Sharpen and Outlook. Op-Till is a pemix of Sharpen + Pursuit.
Some weeds were controlled greater at 8.5 gpa than 17 gpa and the opposite also was true.
Weed control was reduced as oil adjuvant rates were reduced on % volume basis.
The higher the oil concentration the greater the weed control.
Oil adjuvants applied on an area basis is more consistent across spray volumes than applied on a volume basis. (Department of Plant Sciences, North Dakota State University, Fargo).

Table 1. Herbicides by oil adjuvant volume, **8.5 gpa** (Zollinger, Ries, Kazmierczak).

Treatment	Rate	14 DAT				28 DAT			
		Flax	Amar	Quin	Tabw	Flax	Amar	Quin	Tabw
	(product/A)	- - - - - - - - % control - - - - - - - -				- - - - - - - - % control - - - - - - - -			
Sharpen +	1fl oz +								
Soy-Stik	1% v/v	50	85	55	50	50	65	85	50
Soy-Stik	1.5pt	58	97	68	60	62	84	93	60
Dyne-Amic	0.5% v/v	40	67	40	42	40	52	80	12
Dyne-Amic	0.75pt	63	87	53	50	63	65	92	30
Verdict +	5.05fl oz +								
Soy-Stik	1% v/v	52	83	53	48	52	53	82	10
Soy-Stik	1.5pt	62	92	72	63	62	62	97	23
Dyne-Amic	0.5% v/v	53	80	57	52	53	50	77	12
Dyne-Amic	0.75pt	72	94	70	62	72	75	88	32
Op-Till +	1oz +								
Soy-Stik	1% v/v	47	65	48	42	47	68	68	12
Soy-Stik	1.5pt	62	96	60	57	62	95	77	27
Dyne-Amic	0.5% v/v	73	75	42	30	40	75	65	10
Dyne-Amic	0.75pt	62	93	53	43	62	83	77	27
LSD (0.05)		9	6	9	7	9	5	7	5

Table 2. Herbicides by oil adjuvant volume, **17 gpa** (Zollinger, Ries, Kazmierczak).

Treatment	Rate	14 DAT				28 DAT			
		Flax	Amar	Quin	Tabw	Flax	Amar	Quin	Tabw
	(product/A)	- - - - - - - - % control - - - - - - - -				- - - - - - - - % control - - - - - - - -			
Sharpen +	1fl oz +								
Soy-Stik	1% v/v	50	89	82	53	10	65	92	13
Soy-Stik	1.5pt	63	97	90	70	33	78	93	18
Dyne-Amic	0.5% v/v	30	62	65	37	5	32	48	5
Dyne-Amic	0.75pt	63	97	89	68	43	75	79	32
Verdict +	5.05fl oz +								
Soy-Stik	1% v/v	43	88	82	75	13	57	88	38
Soy-Stik	1.5pt	62	97	87	73	42	77	96	50
Dyne-Amic	0.5% v/v	47	87	82	65	17	62	87	35
Dyne-Amic	0.75pt	72	97	92	72	62	80	95	43
Op-Till +	1oz +								
Soy-Stik	1% v/v	42	77	75	55	13	70	82	25
Soy-Stik	1.5pt	57	96	90	65	37	85	95	35
Dyne-Amic	0.5% v/v	37	83	70	40	37	80	80	10
Dyne-Amic	0.75pt	82	95	90	70	52	93	93	43
LSD (0.05)		5	5	8	9	5	4	5	5