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Evaluation of aminocyclopyrachlor applied with various herbicides for leafy spurge control and grass tolerance. Rodney G. Lym (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Aminocyclopyrachlor (AMCP) applied with chlorsulfuron has provided very good long-term leafy spurge control when applied in the spring or fall. Research at North Dakota State University has shown that leafy spurge control is improved when AMCP is applied with 2,4-D rather than chlorsulfuron. AMCP will likely be marketed with various commercial formulations of other herbicides. The purpose of this research was to evaluate leafy spurge control and grass tolerance with AMCP applied with various other herbicides.

The experiment was established at the North Dakota State University main station on land that had become infested with leafy spurge. Treatments were applied June 12, 2013 when leafy spurge was in the true-flower growth stage using a hand-held boom sprayer delivering 17 gpa at 35 psi. Experimental plots were 10 by 30 feet and replicated four times in a randomized complete block design. The dominate grass species present were both cool season species and included Kentucky bluegrass and smooth bromegrass. The grasses ranged from 10 to 18 inches in height when herbicides were applied. Leafy spurge control and grass injury was evaluated visually using percent stand reduction compared to the untreated control.

Leafy spurge injury ranged from 30 to 88% 12 days after treatment, but little grass injury was observed regardless of treatment (Table). The highest grass injury (21%) was to smooth bromegrass following AMCP plus 2,4-D applied at 2.4 + 18.4 oz/A. AMCP plus 2,4-D at both application rates, and AMCP at 2.5 oz/A applied with thifensulfuron or tribenuron provided an average of 95% leafy spurge control which was similar to the standard treatment of picloram plus imazapic plus 2,4-D which averaged 96% 2 MAT (months after treatment). The greatest grass injury was 14% 2 MAT on smooth bromegrass from the picloram plus imazapic plus 2,4-D treatment.

The best long-term leafy spurge control occurred when AMCP was applied at >2 oz/A and with 2,4-D, thifensulfuron, or tribenuron which averaged 84% 13 MAT which was equal to picloram plus imazapic plus 2,4-D (Table). There was no injury observed on Kentucky bluegrass and only 5% or less on smooth bromegrass regardless of treatment the season after application. Based on these results and other studies at North Dakota State University, AMCP will provide long-term control of leafy spurge with little or no cool season grass injury expected.

Leafy spurge control and grass tolerance with aminocyclopyrachlor applied with various herbicides on June 12, 2013 at Fargo, North Dakota.

		Evaluation date/species								
		24 June 13			13 August 13			14 July 14		
Treatment[a]	Rate	Leafy spurge	Kentucky bluegrass	Smooth brome	Leafy spurge	Kentucky bluegrass	Smooth brome	Leafy spurge	Kentucky bluegrass	Smooth brome
	oz/A	% injury			% control	% injury		% control	% injury	
AMCP + 2,4-D[b]	1 + 7.6	79	0	2	96	0	8	74	0	4
AMCP + thifensulfuron	1 + 0.125	43	0	0	74	0	1	63	0	4
AMCP + thifensulfuron	1.2 + 0.23	28	0	0.5	84	0	0	81	0	0
AMCP + tribenuron	1 + 0.125	30	0	0.5	73	0	1	62	0	0
AMCP + chlorsulfuron[c]	1 + 0.4	41	0	0	84	0	3	71	0	4
AMCP + metsulfuron[d]	1.1 + 0.2	36	0	0	52	0	5	67	0	0
AMCP	1	36	0	0	78	0	0	62	0	0
AMCP + 2,4-D	2.4 + 18.4	86	3	21	98	0	9	91	0	1
AMCP + thifensulfuron	2.5 + 0.3	48	0	2	93	0	0	89	0	1
AMCP + thifensulfuron	2.5 + 0.5	50	0	1	82	0	3	81	0	0
AMCP + tribenuron	2.5 + 0.3	60	0	3	92	0	8	89	0	5
Picloram + imazapic + 2,4-D + MSO[e]	4 + 1 + 16 + 1 qt	88	1	10	96	0	14	84	0	4
Control	• • •	0	0	0	0	0	0	0	0	0
LSD (0.05)		12	NS	4.5	15	NS	7	27	NS	NS

[a]Commercial surfactant at 0.25% applied with all treatments except when MSO was used - Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[b]Commercial formulations - RRW97, [c]Persective, [d]Rejuvra - E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.
[e]Commercial MSO - Upland by West Central Inc., 2700 Trott Ave. S.W., Willmar, MN 56201.

Effect of aminocyclopyrachlor applied as a dry or liquid formulation on common milkweed and prairie dogbane. Rodney G. Lym (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Aminocyclopyrachlor (AMCP) will control several invasive weeds in pasture, rangeland, and wildlands. While control of leafy spurge, Canada thistle, and the knapweeds are desirable, the gain must be measured against the loss of desirable native forbs. The purpose of this research was to evaluate the effect of AMCP on the native forbs common milkweed (*Asclepias syriaca* L.) and prairie dogbane (*Apocynum cannabinum* L.). While these native forbs are considered desirable in native prairie, they sometimes can be troublesome in cropland.

The common milkweed and prairie dogbane studies were separate experiments and were both established on July 1, 2013 in an ungrazed non-cropped area in north Fargo. The area was undisturbed prairie that had been heavily infested with leafy spurge. However, the *Aphthona* spp. biological control agents had reduced the weed to a minor component of the vegetation and many native species had returned. Treatments were applied using a hand-held boom sprayer delivering 17 gpa at 35 psi. Experimental plots were 3 by 3 feet and replicated six times in a randomized complete block design. The number of common milkweed or prairie dogbane plants in each plot were counted prior to treatment. First injury and then control was evaluated visually using percent injury or stand reduction compared to the untreated control.

Common milkweed was greatly reduced by all treatments in this study but there was a lot of variation from plant to plant and plot to plot as reflected in LSD values of up to 40% (Table 1). AMCP plus metsulfuron reduced common milkweed by an average of 92% compared to an average of 68% with AMCP plus 2,4-D. There was a natural reduction of 35% in the untreated plots from 2013 to 2014.

Prairie dogbane was also severely reduced by all treatments evaluated (Table 2). In contrast to the milkweed study, AMCP plus 2,4-D reduced prairie dogbane more than AMCP plus metsulfuron and control averaged 100 and 73%, respectively. Prairie dogbane declined 37% in the untreated control plots from 2013 to 2014.

AMCP applied with metsulfuron or 2,4-D reduced both common milkweed and prairie dogbane in this study. These species would be adversely affected in an invasive weed control program that included AMCP.

Table 1. Common milkweed control with aminocyclopyrachlor applied on July 1, 2013 at Fargo, North Dakota.

Treatment[a]	Rate	Evaluation date		
		31 July 13	30 Aug 13	14 July 14
	—— oz/A ——	% injury	—— % control ——	
AMCP + metsulfuron[b]	1.1 + 0.18	30	67	88
AMCP + metsulfuron	1.8 + 0.3	37	83	100
AMCP + 2,4-D[c]	1 + 7.6	27	75	72
AMCP + 2,4-D	1.7 + 12.7	58	100	64
Tribenuron + 2,4-D + dicamba	1.65 + 5.7 + 1	32	88	92
Untreated	•••	0	0	35
LSD (0.05)		20	40	35

[a]Commercial surfactant Induce at 0.25% applied with all treatments - Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[b]Commercial formulations - Rejuvra and [c]RRW97 by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.

Table 2. Prairie dogbane control with aminocyclopyrachlor applied on July 1, 2013 at Fargo, North Dakota.

Treatment[a]	Rate	Evaluation date		
		31 July 13	30 Aug 13	14 July 14
	—— oz/A ——	% injury	—— % control ——	
AMCP + metsulfuron[b]	1.1 + 0.18	13	0	71
AMCP + metsulfuron	1.8 + 0.3	32	70	76
AMCP + 2,4-D[c]	1 + 7.6	74	100	100
AMCP + 2,4-D	1.7 + 12.7	99	100	100
Tribenuron + 2,4-D + dicamba	1.65 + 5.7 + 1	29	90	80
Untreated	•••	0	0	37
LSD (0.05)		40	28	28

[a]Commercial surfactant Induce at 0.25% applied with all treatments - Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[b]Commercial formulations - Rejuvra and [c]RRW97 by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.

Effect of aminocyclopyrachlor on established grasses. Rodney G. Lym. (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Aminocyclopyrachlor (AMCP) has been used to control a variety of invasive weed species in pasture and rangeland. AMCP is usually applied with chlorsulfuron for broad spectrum weed control, but will also be available as a commercial mixture with 2,4-D. The purpose of this research was to compare AMCP applied with chlorsulfuron formulated as a DG or with 2,4-D as a SL on cool- and warm-season grass species production.

The studies were conducted on North Dakota State University research land near Fargo, North Dakota. The grasses evaluated were the cool season species green needlegrass [*Nassella viridula* (Trin.) Barkworth] var. 'Lodorm' and intermediate wheatgrass [*Thinopyrum intermedium* (Host) Barkworth & D.R. Dewey] var. 'Manifest' and the warm season grass big bluestem (*Andropogon gerardii* Vitman) var. 'Bison'. The AMCP treatments were compared to a standard leafy spurge control herbicide mixture of picloram plus imazapic plus 2,4-D.

Grasses were seeded at Natural Resource Conservation Service recommended rates of 8 to 10 lb/A pure live seed using a 6-row grain drill with 12-inch spacing on May 26, 2011. The plots were 10 by 14 feet and replicated four times in a randomized complete block. Weed competition consisted primarily of Canada thistle (*Cirsium arvense* L.), common ragweed (*Ambrosia artemisiifolia* L), and perennial sowthistle (*Sonchus arvensis* L.). Treatments were applied using a hand-held boom sprayer delivering 17 gpa at 35 psi on June 7, 2013. Herbicide efficacy was estimated by visual assessment of grass response approximately 30 days after treatment and were made on a scale of 0 to 100, with 0 equal to no injury and 100 equal to complete above-ground grass control. Above-ground biomass was harvested in one 0.25-m^2 quadrats from the fourth and eighth rows, respectively, in each plot in mid-July 2013. Plants were separated into desired grass species, grass weeds, and broadleaf weeds. Harvested plant material was dried at 50 C for at least 72 hr and weighed to estimate yield.

Intermediate wheatgrass production tended to be greater than the untreated control when AMCP was applied at 0.6 to 0.7 oz/A with chlorsulfuron or 2,4-D, respectively (Table 1). Production tended to decrease as the AMCP rate increased. Intermediate wheatgrass production was 2075 lb/A when the standard treatment of picloram plus imazapic plus 2,4-D was applied compared to 3030 lb/A in the untreated control.

Green needlegrass production averaged 2510 lb/A when AMCP plus chlorsulfuron at 0.6 + 0.2 oz/A was used to control weeds compared to 2085 lb/A in the untreated control (Table 2). As in the intermediate wheatgrass study, production tended to decline when picloram plus imazapic plus 2,4-D was applied and only averaged 1690 lb/A. Big bluestem production was similar regardless of the treatment and averaged 3910 lb/A (Table 3)

In summary, treatments that included AMCP generally had greater grass production than the standard treatment of picloram plus imazapic plus 2,4-D. There was very little grass injury from any treatment except when 60% injury was observed when the standard was applied to green needlegrass. Based on this and other studies conducted at North Dakota State University, the use of AMCP for invasive weed control should not reduce desirable grass species production.

Table 1. Effect of aminocyclopyrachlor applied with chlorsulfuron or 2,4-D on established intermediate wheatgrass, at Fargo, North Dakota.

		Evaluation date/species				
		2 July 13	8 July 13			8 July 14
Treatment[a]	Rate	Intermediate — wheatgrass —		Weedy broad-leaves	Weedy grasses	Interm. wheat grass
	—— oz/A ——	% inj	—— lb/A dry weight ——			% inj
AMCP + chlorsulfuron[b,c]	0.6 + 0.2	1	3835	0	4	0
AMCP + chlorsulfuron[b]	1 + 0.4	3	3255	0	0	0
AMCP + 2,4-D[b,d]	0.7 + 5.1	3	3375	0	0	1
AMCP + 2,4-D[b]	1 + 7.6	3	3025	0	0	0
Picloram + imazapic + 2,4-D + MSO	4 + 1 +16 + 1 qt	8	2075	0	0	1
Untreated	• • •	2	3030	0	0	0
LSD (0.10)		3	538	NS	NS	NS

[a]Treatments were applied on June 7, 2013 to intermediate wheatgrass seeded on May 26, 2011.
[b]Surfactant - Induce included at 0.25% - Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[c]Formulations - Perspective and [d]RRW97 - E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.

Table 2. Effect of aminocyclopyrachlor applied with chlorsulfuron or 2,4-D on established green needlegrass at Fargo, North Dakota.

		Evaluation date/species				
		2 July 13	10 July 13			8 July 14
Treatment[a]	Rate	Green needlegrass		Weedy broad-leaves	Weedy grasses	Green needle grass
	—— oz/A ——	% inj	—— lb/A dry weight ——			% inj
AMCP + chlorsulfuron[b,c]	0.6 + 0.2	0.5	2510	3	115	0
AMCP + chlorsulfuron[b]	1 + 0.4	0	2180	1	60	0
AMCP + 2,4-D[b,d]	0.7 + 5.1	1	1965	8	110	1
AMCP + 2,4-D[b]	1 + 7.6	0.5	2371	3	65	0
Picloram + imazapic + 2,4-D + MSO	4 + 1 +16 + 1 qt	60	1690	2	70	0
Untreated	• • •	0	2085	130	145	0
LSD (0.05)		20	671	32	NS	NS

[a]Treatments were applied on June 7, 2013 to green needlegrass seeded on May 26, 2011.
[b]Surfactant - Induce included at 0.25% - Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[c]Formulations - Perspective and [d]RRW97 - E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898. Surfactant Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.

Table 3. Effect of aminocyclopyrachlor applied with chlorsulfuron or 2,4-D on established big bluestem at Fargo, North Dakota.

		Evaluation date/specoes				
		2 July 13	22 July 13			8 July 14
Treatment[a]	Rate	Big bluestem		Weedy broad-leaves	Weedy grasses	Big bluestem
	—— oz/A ——	% inj	— lb/A dry weight —			% inj
AMCP + chlorsulfuron[b,c]	0.6 + 0.2	4	3980	0	65	1
AMCP + chlorsulfuron[b]	1 + 0.4	8	3930	0	0	1
AMCP + 2,4-D[b,d]	0.7 + 5.1	2	4620	0	0	0
AMCP + 2,4-D[b]	1 + 7.6	2	3440	0	15	1
Picloram + imazapic + 2,4-D + MSO	4 + 1 +16 + 1 qt	7	3575	0	0	1
Untreated	• • •	2	3465	6	0	0
LSD (0.05)		0.5	NS	NS	NS	NS

[a]Treatments were applied on June 7, 2013 to big bluestem seeded on May 26, 2011.
[b]Surfactant - Induce included at 0.25% - Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[c]Formulations - Perspective and [d]RRW97 - E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898. Surfactant Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.

Herbicide mixtures applied in the spring or fall for absinth wormwood control. Rodney G. Lym. (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Aminopyralid and clopyralid are commonly used to control absinth wormwood in a variety of environments. Aminocyclopyrachlor (AMCP) has also been used to control absinth wormwood in non-grazed or hayed areas. Often combinations of herbicides have provided better long-term control of invasive species than a single herbicide used alone. The purpose of this research was to evaluate aminopyralid or AMCP applied at reduced rates with other herbicides for long-term absinth wormwood control.

The aminopyralid study was established on an active gravel quarry near Valley City, ND that was heavily infested with absinth wormwood. The treatments were applied on May 26 or September 15, 2011. Absinth wormwood was in the vegetative growth stage and 11 to 18 inches tall when treatments were applied in May. Because absinth wormwood grows 4 to 6 feet tall, the plot area was mowed in late-July 2011. The plants had regrown and were 6 to 8 inches tall when the fall treatments were applied.

The AMCP study was established within a fenced area of a horse pasture near Spiritwood, ND. Herbicides were applied on June 3, 2013 when absinth wormwood was 4 to 16 inches tall in the rosette growth stage. Fall treatments were applied on September 13, 2013 to plants that had 12 to 18 inches of regrowth after being mowed in August.

Herbicides were applied using a hand-held boom sprayer delivering 17 gpa at 35 psi. Experimental plots were 10 by 30 feet at Valley City and 10 by 25 feet at Spiritwood. Treatments were replicated four times in a randomized complete block design. Absinth wormwood control was evaluated visually using percent stand reduction compared to the untreated control.

All treatments that contained aminopyralid or clopyralid provided 90% or better absinth wormwood control 36 months after treatment (MAT) whether applied in June or September (Table 1). The most cost-effective treatment was clopyralid plus aminopyralid at 2.4 + 0.5 oz/A which provided 95% absinth wormwood control 36 MAT treatment. The least effective treatment was dicamba applied at 16 oz/A in the spring which provided 56% absinth wormwood control by the end of the study.

All treatments that contained AMCP or aminopyralid applied alone provided 90% or more absinth wormwood control the season after treatment in the pasture location (Table 2). Control was similar whether AMCP at 1.1 or 1.8 oz/A was applied with chlorsulfuron, metsulfuron, or 2,4-D.

In summary, absinth wormwood was easily controlled with aminopyralid or clopyralid applied alone or in combination and with any treatment that contained AMCP whether applied in the spring or fall. The choice of treatments should be based on both cost and other target weeds in the same area where absinth wormwood has established.

Table 1. Efficacy of aminopyralid and clopyralid for absinth wormwood control applied in the spring or fall near Valley City, ND.

		Evaluation date						
		2011		2012		2013		2014
Treatment[a]	Rate	13 July	5 Sept	17 May	22 Aug	3 June	14 Aug	20 May
	— oz/A —	— % control —						
Applied 26 May 2011								
Clopyralid + aminopyralid	2.4 +0.5	92	96	97	96	99	95	95
Clopyralid + aminopyralid	3.4 + 0.75	97	99	99	99	100	99	97
Clopyralid + aminopyralid	4.6 + 1	99	99	99	97	100	99	98
Clopyralid + aminopyralid	5.8 + 1.3	98	99	100	99	99	97	95
Clopyralid + aminopyralid	6.95 + 1.5	100	100	100	99	100	99	99
Aminopyralid	1.25	89	95	94	93	91	90	90
Aminopyralid	1.75	95	99	96	96	99	96	94
Clopyralid	6	95	99	97	99	99	97	96
Dicamba	16	93	80	65	75	73	71	56
Applied 15 Sept 2011								
Clopyralid + aminopyralid	3.4 + 0.75			99	100	100	99	98
Clopyralid + aminopyralid	4.6 + 1			99	99	100	98	97
Clopyralid + aminopyralid	5.8 + 1.3			99	100	100	96	97
Aminopyralid	1.25			99	99	100	96	96
Dicamba	16			91	96	79	84	86
LSD (0.05)		7	5	5	9	14	11	14

[a]Surfactant at 0.25% applied with all treatments -Activator 90 from United Agri Products 7251 W. 4th St. Greeley, CO 80634.

Table 2. Efficacy of aminocyclopyrachlor applied with various other herbicides on absinth wormwood applied in spring or fall at Spiritwood, ND.

		Evaluation date		
		2013	2014	
Treatment[a]	Rate	1 Aug	21 May	11 Sept
	— oz/A —		— % control —	
Applied 3 June 2013				
AMCP + metsulfuron[b]	1.1 + 0.2	94	94	95
AMCP + metsulfuron	1.8 + 0.3	98	98	95
AMCP + chlorsulfuron[c]	1 + 0.4	94	96	96
AMCP + chlorsulfuron	1.8 + 0.7	98	98	90
AMCP + 2,4-D[d]	1 + 7.6	95	97	96
AMCP + 2,4-D	1.7 + 12.7	98	99	98
Aminopyralid[e]	1.75	99	99	99
Applied 13 Sept 2013				
AMCP + metsulfuron[b]	1.1 + 0.2		93	94
AMCP + metsulfuron	1.8 + 0.3		97	95
AMCP + chlorsulfuron[c]	1 + 0.4		93	90
AMCP + chlorsulfuron	1.8 + 0.7		98	95
AMCP + 2,4-D[d]	1 + 7.6		95	95
AMCP + 2,4-D	1.7 + 12.7		98	95
Aminopyralid[e]	1.75		99	98
LSD (0.05)		NS	5	NS

[a]Surfactant at 0.25% applied with all treatments - Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[b]Formulations -Rejuvra, [c]Persective, [d]RRW97 by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.
[e]Commercial formulation - Milestone by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

Aminopyralid applied alone or in combination with clopyralid or chlorsulfuron in the spring for Canada thistle control. Rodney G. Lym. (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Aminopyralid is generally applied at 1.25 to 1.75 oz/A for Canada thistle control in North Dakota. Clopyralid was commonly used to control Canada thistle prior to the release of aminopyralid. Often combinations of herbicides have provided better long-term control of invasive species than a single herbicide used alone, even at maximum use rates. The purpose of this research was to evaluate aminopyralid applied alone or with clopyralid or chlorsulfuron for long-term Canada thistle control.

The experiment was established at two locations in North Dakota. The first site was located on a wildlife production area near Valley City. Treatments were applied June 12, 2012 when Canada thistle was 12 to 24 inches tall and beginning to bolt. The second site was established on an abandoned crop field that had become heavily infested with the weed on the North Dakota State University Agricultural Experiment Station in Fargo. The treatments were applied June 22, 2012 when Canada thistle was in the bolted to early bud growth stage and 8 to 24 inches tall. Herbicides were applied using a hand-held boom sprayer delivering 17 gpa at 35 psi. Experimental plots were 10 by 30 feet and replicated four times in a randomized complete block design. Canada thistle control was evaluated visually using percent stand reduction compared to the untreated control. Results were similar so data were combined over locations.

All treatments provided excellent long-term Canada thistle control except chlorsulfuron applied alone (Table). Also, Canada thistle control was similar whether the location was nearly bareground (Fargo) or had a dense grass cover (Valley City). Aminopyralid applied alone at 1.25, 1.75 and 2.5 oz/A provided an average of 94% Canada thistle control 25 MAT (months after treatment). Control declined to an average of 78% by September 2014 but tended to increase as the application rate increased. Aminocyclopyrachlor plus chlorsulfuron at 1.9 + 0.75 oz/A provided 90% Canada thistle control 27 MAT (September 2014). Canada thistle control was similar whether aminopyralid was applied alone or with clopyralid or chlorsulfuron. Aminopyralid at 1.25 oz/A would be the most cost-effective treatment in this study and is currently widely used to control Canada thistle in pasture, rangeland, and wild lands in the region.

Table. Aminopyralid applied alone or with clopyralid or chlorsulfuron at two locations for Canada thistle control in June 2012 at two locations in North Dakota.

		Evaluation date				
		2012	2013		2014	
Treatment[a]	Rate	Sept	July	Sept	July	Sept
	oz/A	% control				
Aminopyralid	1.25	84	97	97	93	68
Aminopyralid	1.75	89	99	98	92	81
Aminopyralid	2.5	92	99	99	98	86
Aminopyralid + clopyralid	0.75 + 3.4	86	98	96	91	75
Aminopyralid + clopyralid	1 + 4.6	88	99	99	90	89
Aminopyralid + clopyralid	1.25 + 5.75	91	99	98	95	86
Aminopyralid + chlorsulfuron	1.25 + 0.5	89	98	98	94	84
Aminopyralid + chlorsulfuron	1.75 + 0.75	93	98	98	95	88
Clopyralid	5.75	87	97	95	84	69
Chlorsulfuron	0.75	78	33	24	31	22
Aminocyclpyrachlor + chlorsulfuron[b]	1.9 + 0.75	85	99	99	96	90
AMCP + chlorsulfuron + aminopyralid	0.8 + 0.3 + 1.75	93	99	99	97	84
LSD (0.05)		11	6	24	14	18

[a]Surfactant at 0.25% was applied with all treatments - Activator 90 by United Agri Products 7251 W. 4th St. Greeley, CO 80634.

[b]Commercial formulation aminocyclopyrachlor (AMCP) plus chlorsulfuron - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.

Yellow toadflax control with aminopyralid or aminocyclopyrachlor applied alone and with other herbicides. Rodney G. Lym (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Yellow toadflax has been much more difficult to control with herbicides than the related species dalmatian toadflax. The most commonly used treatment in North Dakota is picloram applied at 8 to 16 oz/A with dicamba plus diflufenzopyr at 3 to 4 + 1.2 to 1.6 oz/A, respectively. Control has been consistently high, but this treatment costs from $40 to $65/A for the chemical alone. Recently, aminocyclopyrachlor (AMCP) has been widely evaluated for yellow toadflax control, but results have been inconsistent. The purpose of this research was to evaluate picloram, aminopyralid, or aminocyclopyrachlor applied alone and with other herbicides for yellow toadflax control.

The experiments were established on a wildlife production area near Valley City, ND. The first study compared aminopyralid and picloram with various herbicide mixtures. Treatments were applied August 5, 2012 when yellow toadflax was 10 to 16 inches tall and beginning to flower. The AMCP experiment was established at the same site and treatments were applied on July 25, 2012 when yellow toadflax was beginning to flower and 8 to 24 inches tall. Herbicides were applied using a hand-held boom sprayer delivering 17 gpa at 35 psi. Experimental plots were 10 by 30 feet and replicated four times in a randomized complete block design. Yellow toadflax control was evaluated visually using percent stand reduction compared to the untreated control.

Picloram applied alone at 8 or 16 oz/A provided the most cost-effective short-term yellow toadflax control which averaged 83% 13 months after treatment (MAT) (Table 1). Control was similar when picloram was applied with chlorsulfuron and/or dicamba plus diflufenzopyr. Aminopyralid applied alone averaged 16% yellow toadflax control 13 MAT, but control increased to 76% when aminopyralid was applied with chlorsulfuron. Control was not improved when dicamba plus diflufenzopyr was applied with aminopyralid plus chlorsulfuron. AMCP plus chlorsulfuron at 1.9 + 0.73 oz/A provided 83% yellow toadflax control 13 MAT and control was unchanged when aminopyralid was added to the mixture. Control declined rapidly the second season after application regardless of treatment. Combination treatments that included aminocyclopyrachlor or picloram plus dicamba plus diflufenzopyr tended to provide better control 24 MAT than picloram alone.

AMCP applied with chlorsulfuron, 2,4-D, or metsulfuron provided excellent long-term yellow toadflax control regardless of application rate in the second study (Table 2). Yellow toadflax control averaged 93% 14 MAT the same as the standard treatment of picloram plus dicamba plus diflufenzopyr at 16 + 4 + 1.6 oz/A. Yellow toadflax was slowly controlled in this study. Average control in September 2012 was only 66% averaged over all treatments, but increased to 98% by June 2013. Aminocyclopyrachlor applied with chlorsulfuron or metsulfuron provided an average of 93% control by September 2014 (26 MAT) which was comparable to the standard treatment of picloram plus dicamba plus diflufenzopyr.

Long-term yellow toadflax control was higher when the same treatments were applied in July compared to August. This is in agreement with research at North Dakota State University which has shown treatments that include picloram or aminocyclopyrachlor provided better yellow toadflax control when applied in June and July compared to August and September. In summary, picloram alone at 8 oz/A provided the most cost-effective yellow toadflax control in this study. However, previous research has shown that dicamba plus diflufenzopyr should be added with picloram to obtain consistent long-term control. Aminocyclopyrachlor also provided excellent yellow toadflax control and will likely be used more widely once the herbicide is labeled for areas that are grazed and hayed.

Table 1. Evaluation of aminopyralid applied with various herbicides on August 5, 2012 for yellow toadflax control near Valley City, ND.

		Evaluation date				
		2012	2013		2014	
Treatment[a]	Rate	13 Sept	11 July	13 Sept	10 July	11 Sept
	oz/A	% control				
Aminopyralid	2.5	49	36	23	38	13
Aminopyralid	3.5	50	15	9	31	6
Chlorsulfuron	0.75	29	62	51	53	24
Aminopyralid + chlorsulfuron	1.75 + 0.75	39	92	89	75	44
Aminopyralid + chlorsulfuron + dicamba + diflu[b]	1.75 + 0.75 + 3 + 1.2	63	77	63	56	35
Aminopyralid + chlorsulfuron	2.5 + 0.75	43	53	63	72	58
Aminocyclopyrachlor + chlorsulfuron[c]	1.9 + 0.73	68	84	83	86	76
Aminocyclopyrachlor + chlorsulfuron + aminopyralid	0.8 + 0.3 + 1.75	64	67	71	60	39
Picloram	8	44	88	81	67	58
Picloram	16	51	62	84	69	51
Picloram + dicamba + diflufenzopyr	8 + 3 + 1.2	68	89	90	87	79
Picloram + chlorsulfuron	8 + 0.75	62	84	82	71	36
Picloram + chlorsulfuron + dicamba + diflufenzopyr	8 + 0.75 + 3 + 1.2	58	90	91	86	77
Picloram + dicamba + diflufenzopyr	16 + 4 + 1.6	73	86	84	80	70
LSD (0.05)		10	25	22	31	26

[a]All treatment applied with Activator 90 at 0.25%. Activator 90 by United Agri Products 7251 W. 4th St. Greeley, CO 80634.
[b]Commercial formulation - Overdrive by BASF Corporation, 100 Campus Drive, Florham Park, NC 07932.
[c]Commercial formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.

Table 2. Evaluation of aminocyclopyrachlor applied with various herbicides on July 25, 2012 for yellow toadflax control near Valley City, ND.

		Evaluation date				
		2012	2013		2014	
Treatment[a]	Rate	13 Sept	11 June	13 Sept	10 July	11 Sept
	—— oz/A ——	——————	——————	% control	——————	——————
Aminocyclpyrachlor + chlorsulfuron[b]	1.8 + 0.7	66	99	94	94	91
Aminocyclpyrachlor + chlorsulfuron	2.4 + 0.95	63	99	99	99	97
Aminocyclopyrachlor + 2,4-D	2 + 15.2	67	96	93	93	90
Aminocyclopyrachlor + 2,4-D	2.5 + 19	65	97	94	71	72
Aminocyclopyrachlor + metsulfuron[c]	1.8 + 0.3	62	94	81	76	75
Aminocyclopyrachlor + metsulfuron	2.4 + 0.4	65	99	94	95	93
Picloram + dicamba + diflufenzopyr[d]	16 + 4 + 1.6	71	100	99	92	90
Untreated	...	0	0	0	0	0
LSD (0.05)		13	4	9	18	16

[a]All treatments applied with surfactant Induce @ 0.25%. Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[b]Commercial formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.
[c]DPX-RDQ98 formulation - Rejuvra by E.I. duPont de Nemours and Company.
[d]Commercial formulation dicamba plus diflufenzopyr - Overdrive by BASF Corporation, 100 Campus Drive, Florham Park, NC 07932.

Aminocyclopyrachlor application proximity affects common cottonwood injury. Rodney G. Lym (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Aminocyclopyrachlor (AMCP) was sold in the turfgrass market starting in the fall of 2010 for broadleaf weed control. Previous research in the region found trees growing nearby but not within an AMCP treated area were not injured by the herbicide. However, DuPont voluntarily withdrew the product from the turf market in August 2011 because of widely reported tree damage following AMCP application. The purpose of this research was to estimate the distance from young cottonwood trees (*Populus deltoides* W. Bartram ex Marshal) AMCP could be applied to avoid injury.

The experiment was established May 2, 2012 in a row of volunteer cottonwood trees about 4 years old at the Maple River Dam in Cass County, ND. AMCP plus chlorsulfuron at 2.4 + 0.95 oz/A, respectively, or picloram at 16 oz/A were applied around a single tree or group of trees at the base, dripline, or 2X the dripline in a 15 foot wide band. Treatments were applied using a hand-held boom sprayer delivering 17 gpa at 35 psi. Care was take to avoid direct application of the herbicides to the tree bark when the base treatments were applied. Each tree (plot) was separated by at least 50 feet and there were two replications in a randomized complete block design. Tree injury was evaluated visually compared to the untreated control with 0 equal to no injury and 100% complete defoliation.

Leaf cupping on cottonwood trees was first noted 42 days after treatment (DAT) when AMCP plus chlorsulfuron was applied at either the base or dripline and averaged 48% (Table 1). Injury increased throughout the growing season and averaged 95 and 67% by 113 DAT for the base and dripline applied treatments, respectively. In comparison, injury only averaged 6% 113 DAT when AMCP + chlorsulfuron was applied at 2X the dripline. Injury symptoms (15%) appeared within 15 DAT when picloram was applied to the base of cottonwood trees and increased to 100% by 70 DAT. Picloram caused 18 and 50% tree injury 113 DAT when applied at the dripline and 2X the dripline, respectively. In general, normal rainfall occurred during the growing season with a total of 4.05 inches received by 113 DAT.

AMCP plus chlorsulfuron applied at the base and dripline resulted in severe cottonwood tree injury the season after treatment and averaged 100% 386 DAT (Table 2). Some leaf regrowth occurred during the second season, but the leaves were disfigured and brittle. AMCP plus chlorsulfuron applied at 2X the dripline resulted in only slight leaf cupping and averaged 18% injury 476 DAT. Cottonwood tree injury was higher with picloram than AMCP plus chlorsulfuron and averaged 100, 43, and 70% injury when applied at the base, dripline, and 2X the dripline, respectively, 476 DAT. A total of 22.84 inches of precipitation (including snow melt) was received during the study.

In summary, cottonwood tree injury from AMCP plus chlorsulfuron was generally less than injury from picloram. However, some injury from the AMCP treatments was observed even when applied at 2X the dripline. Treatments that contain AMCP should be applied greater than 2X the dripline from susceptible tree species.

Table 1. Cottonwood tree sensitivity to aminocyclopyrachlor and picloram the year of treatment at the Maple River Dam, near Embden, ND.

			2012 evaluation date/DAT[a]						
			15 May	30 May	13 June	28 June	11 July	26 July	23 Aug
Treatment[b]	Application	Rate	13	28	42	57	70	85	113
		— oz/A —	% injury						
AMCP[a] + chlorsulfuron[c]	Base	2.4 + 0.95	0	0	50	70	90	95	95
AMCP + chlorsulfuron	Dripline	2.4 + 0.95	0	0	45	52	62	68	67
AMCP + chlorsulfuron	2X dripline	2.4 + 0.95	0	0	0	0	0	8	6
Picloram + NIS	Base	16	15	60	68	70	100	100	100
Picloram + NIS	Dripline	16	0	3	15	15	12	13	18
Picloram + NIS	2X dripline	16	0	15	43	49	48	51	50
Untreated		•••							
Accumulated precipitation since establishment (inches)			0.11	1.48	1.8	1.8	2.1	3.67	4.05

[a]Abbreviations: DAT = days after treatment; AMCP = aminocyclopyrachlor.
[b]Surfactant at 0.25% added to all treatments - Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[c]Commercial formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.

Table 2. Cottonwood tree sensitivity to aminocyclopyrachlor and picloram 1 and 2 years after treatment at the Maple River Dam, near Embden, ND.

			2013 evaluation date/DAT[a]			
			23 May	11 June	13 July	7 Aug
Treatment[b]	Application	Rate	386	405	451	476
		—— oz/A ——	—— % injury ——			
AMCP[a] + chlorsulfuron[c]	Base	2.4 + 0.95	100	99	88	70
AMCP + chlorsulfuron	Dripline	2.4 + 0.95	100	98	60	64
AMCP + chlorsulfuron	2X dripline	2.4 + 0.95	25	55	20	18
Picloram	Base	16	100	100	100	100
Picloram	Dripline	16	50	65	35	43
Picloram	2X dripline	16	85	35	70	70
Untreated		•••				
Accumulated precipitation since establishment			14.95	16.61	21.72	22.84

[a]Abbreviations: DAT = days after treatment; AMCP = aminocyclopyrachlor.
[b]Surfactant at 0.25% added to all treatments - Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[c]Commercial formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.

Comparison of aminocyclopyrachlor applied as a dry or liquid formulation for spotted knapweed and Canada thistle control. Rodney G. Lym (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Aminocyclopyrachlor (AMCP) plus chlorsulfuron is a dry flowable herbicide formulation that has been marketed in non-grazed or hayed areas for invasive weed control. A liquid formulation of AMCP plus 2,4-D may be used for specific invasive weed species control in the future. The purpose of this research was to evaluate AMCP plus chlorsulfuron applied as a dry formulation compared to the liquid formulation of AMCP plus 2,4-D for spotted knapweed and Canada thistle control.

The spotted knapweed study was established on unused land at the Hawley, MN airport on May 25, 2012 when the weed was in the rosette growth stage and 3 inches tall. The Canada thistle study was established May 31, 2012 on the campus of North Dakota State University on unused land that had previously been cropped. Canada thistle was in the rosette to early bolt growth stage and 1 to 18 inches tall. Treatments were applied using a hand-held boom sprayer delivering 17 gpa at 35 psi. Experimental plots were 10 by 30 feet and replicated four times in a randomized complete block design at both locations. Aminopyralid was included in both studies as the current standard treatment. Weed control was evaluated visually using percent stand reduction compared to the untreated control.

Spotted knapweed and Canada thistle control was 95 and 91%, respectively, averaged over all treatments in August 2013, 15 months after treatment (MAT) (Tables 1 and 2). However, control declined rapidly by 24 MAT with all treatments evaluated. Spotted knapweed control averaged 79% with aminopyralid at 1.25 oz/A 24 MAT but control was only 18% or less with any treatment that contained AMCP (Table 1). In contrast, long-term Canada thistle control with treatments that contained AMCP was better than control from aminopyralid (Table 2). Canada thistle control averaged over all AMCP treatments was 74% 26 MAT compared to only 31% with aminopyralid.

No difference in weed control between AMCP formulations was observed at any evaluation date. Although long-term leafy spurge control has been better with the liquid formulation of AMCP plus 2,4-D compared to the dry formulation of AMCP plus chlorsulfuron, control of spotted knapweed and Canada thistle should be similar regardless of which AMCP formulation is used.

Table 1. Comparison of aminocyclopyrachlor dry and liquid formulations for spotted knapweed control applied on May 25, 2012 near Hawley, MN.

		Evaluation date				
		2012		2013		2014
Treatment[a]	Rate	20 July	17 Aug	23 May	20 Aug	23 May
	— oz/A —	% control				
AMCP + chlorsulfuron[b] DF	1 + 0.4	96	96	98	96	15
AMCP + chlorsulfuron DF	1.8 + 0.7	97	99	98	91	10
AMCP SL + 2,4-D	1 + 7.6	98	99	96	95	18
AMCP SL + 2,4-D	2 + 15.2	99	99	98	96	5
Aminopyralid[c]	1.25	99	98	97	98	79
Untreated	...	0	0	0	0	0
LSD (0.05)		3	2	2	5	19

[a]A non-ionic surfactant at 0.25% was added to all treatments. Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[b]AMCP=aminocyclopyrachlor. Commercial formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.
[c]Commercial formulation - Milestone by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

Table 2. Comparison of aminocyclopyrachlor dry and liquid formulations for Canada thistle control applied on May 31, 2012 at Fargo, ND.

		Evaluation date					
		2012		2013		2014	
Treatment[a]	Rate	30 July	20 Aug	17 June	19 Aug	9 June	20 Aug
	— oz/A —	% control					
AMCP + chlorsulfuron[b] DF	1 + 0.4	99	99	99	92	70	58
AMCP + chlorsulfuron DF	1.8 + 0.7	99	99	98	93	73	81
AMCP SL + 2,4-D	1 + 7.6	94	95	96	87	76	79
AMCP SL + 2,4-D	2 + 15.2	95	96	97	96	77	73
Aminopyralid[c] + NIS	1.25	100	98	93	85	25	31
Untreated	...	0	0	0	0	0	0
LSD (0.05)		6	6	3	11	20	27

[a]A non-ionic surfactant at 0.25% was added to all treatments. Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[b]AMCP=aminocyclopyrachlor. Commercial formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.
[c]Commercial formulation - Milestone by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

Kochia control and bareground maintenance for industrial sites. Rodney G. Lym. (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Total vegetation control is often need in a variety of industrial sites such as utility substations, tank farm fuel storage facilities, industrial storage and parking areas, flood control dams, airport runways, and along highways. Often the vegetation must be maintained for many months for regulatory and safety reasons including visibility, site security, fire prevention, and structural integrity. The purpose of this research was to evaluate a variety of herbicide combinations for long-term bareground management.

The experiment was established at two locations in North Dakota. The first site was located on an abandoned livestock sale barn and feedlot area near Valley City. Treatments were applied June 6, 2013. The area contained a dense stand of kochia that had emerged and was up to 2 inches in height. The second site was established on an gravel equipment parking site that had become heavily infested with the weed on the North Dakota State University Agricultural Experiment Station in Fargo. The treatments were applied June 10, 2013 following kochia emergence. Herbicides were applied using a hand-held boom sprayer delivering 17 gpa at 35 psi. Experimental plots were 10 by 25 feet and replicated four times in a randomized complete block design at both locations. Kochia control and percent bareground was evaluated visually using percent change compared to the untreated control.

All treatments evaluated at Valley City provided excellent season-long kochia control and maintained bare ground except glyphosate alone (Table 1). Nearly all industrial site weed control treatments contain glyphosate because of the wide spectrum of species the herbicide will kill. However, other compounds with long soil residuals must also be included to maintain vegetation free areas. Unfortunately, the land changed ownership during the study and evaluations could not be made the season following treatment at this location.

All treatments at Fargo also maintained excellent season-long kochia control and bareground at the Fargo site except glyphosate (Table 2). Any treatment that contained indaziflam and the tebuthiuron plus sulfometuron plus glyphosate treatment maintained >90% kochia control and nearly complete bareground up to 14 months after treatment (MAT) (August 2014). However, kochia control and percent bareground declined in all other treatments. For instance aminopyralid plus tebuthiuron plus sulfometuron plus glyphosate only provided 54 and 64% kochia control and bareground, respectively, 14 MAT.

In summary, season long kochia control and bareground was maintained at two sites in North Dakota with all treatments evaluated. However, the best long-term control was best maintained if indaziflam was included in the herbicide mixture.

Table 1. Kochia control and bareground percentage from treatments for industrial sites established on June 6, 2013 at Valley City, North Dakota.

		2013 evaluation date					
		20 June	28 June	3 Aug		19 Aug	
Treatment	Rate	Kochia	Kochia	Kochia	Bare ground	Kochia	Bare ground
	—— oz/A ——	——————— % ———————					
Aminopyralid + metsulfuron[a] + indaziflam[b] + glyphosate[c]	2 + 0.4 +1+32	96	99	97	97	96	96
Aminopyralid[d] + indaziflam + glyphosate	1.75 + 1 + 32	94	99	97	96	96	95
Aminocyclopyrachlor + chlorsulfuron[e] + sulfometuron[f] + glyphosate	4.4 + 2.3 + 32	99	100	99	99	99	99
Aminopyralid + flumioxazin[g] + sulfometuron + glyphosate	1.75 + 5 + 2.3 + 32	99	99	99	99	99	99
Aminopyralid + tebuthiuron[h] + sulfometuron + glyphosate	1.75 + 19 + 2.3 + 32	98	99	99	99	98	97
Tebuthiuron + sulfometuron + glyphosate	19 + 2.3 + 32	97	99	99	98	99	97
Glyphosate	32	93	96	73	63	68	49
Aminopyralid + metsulfuron + indaziflam + glyphosate	2 + 0.4 + 1.5 + 32	96	99	98	97	97	97
Aminopyralid + metsulfuron + indaziflam + glyphosate	1.75 + 1.5 + 32	93	99	96	95	98	97
Untreated	• • •	3	3	0	15	0	15
LSD (0.05)		4	1	9	13	12	16

[a]Commercial formulation - Opensight, [c]Accord XRT II, [d]Milestone, [h]Spike 80DF, by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

[b]Commercial formulation - Esplanade by Bayer CropScience LP, P.O.Box 12014, 2 T.W. Alexander Drive, Research Triangle Park, North Carolina 27709

[e]Commercial formulation - Perspective, [f]Oust XP by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.

[g]Commercial formulation - Payload by Valent USA Corp. P.O. Box 8025, 1600 Riviera Ave. Suite 200, Walnut Creek, CA 94596-8025.

Table 2. Kochia control and bareground percentage from treatments for industrial sites established on June 10, 2013 at Fargo, North Dakota.

		Evaluation date						
		24 June	9 Sept 13		4 June 14		20 Aug 14	
Treatment	Rate	Kochia	Kochia	Bare ground	Kochia	Bare ground	Kochia	Bare ground
	—oz/A—	—	—	—	%	—	—	—
Aminopyralid + metsulfuron[a] + indaziflam[b] + glyphosate[c]	2 + 0.4 + 1 + 32	99	99	99	99	98	91	90
Aminopyralid[d] + indaziflam + glyphosate	1.75 + 1 + 32	96	99	99	99	99	93	89
Aminocyclopyrachlor + chlorsulfuron[e] + sulfometuron[f] + glyphosate	4.4 + 2.3 + 32	98	97	96	20	68	0	26
Aminopyralid + flumioxazin[g] + sulfometuron + glyphosate	1.75 + 5 + 2.3 + 32	96	99	99	65	87	42	68
Aminopyralid + tebuthiuron[h] + sulfometuron + glyphosate	1.75 + 19 + 2.3 + 32	98	99	99	80	94	54	64
Tebuthiuron + sulfometuron + glyphosate	19 + 2.3 + 32	98	100	99	99	99	92	92
Glyphosate	32	99	70	78	29	73	11	40
Aminopyralid + metsulfuron + indaziflam + glyphosate	2 + 0.4 + 1.5 + 32	97	100	99	99	99	95	95
Aminopyralid + indaziflam + glyphosate	1.75 + 1.5 + 32	98	99	99	99	99	95	93
Untreated	• • •	0	0	19	0	0	0	0
LSD (0.05)		4	17	2	27	14	26	18

[a]Commercial formulation - Opensight, [c]Accord XRT II, [d]Milestone, [h]Spike 80DF, by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.
[b]Commercial formulation - Esplanade by Bayer CropScience LP, P.O.Box 12014, 2 T.W. Alexander Drive, Research Triangle Park, North Carolina 27709
[e]Commercial formulation - Perspective, [f]Oust XP by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.
[g]Commercial formulation - Payload by Valent USA Corp. P.O. Box 8025, 1600 Riviera Ave. Suite 200, Walnut Creek, CA 94596-8025.

Evaluation of AGH11201 for general weed control in pasture. Rodney G. Lym. (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Although herbicides such as aminopyralid and picloram control a variety of common pasture weeds very well, land managers seek the same control levels with less costly herbicides. 2,4-D is one of the least expensive herbicides available for use in pasture and rangeland, but does not control most perennial weed species for more than a month or two. Application of 2,4-D with dicamba may increase long-term weed control with only a slight increase in cost. The purpose of this research was to evaluate an AGH11021 for weed control in pasture. AGH11021is an experimental formulation of 2,4-D plus dicamba (3:1 v/v) and was compared picloram plus 2,4-D, a widely used standard for pasture and wildland weed control.

The study was established on unused pastureland near the campus of North Dakota State University. Treatments were applied on June 7, 2013 using a hand-held boom sprayer delivering 17 gpa at 35 psi. The plots were 10 by 30 feet and replicated four times. Species present included Canada thistle, leafy spurge, buckbrush (western snowberry), wild rose, and wild licorice. Injury and weed control was evaluated visually using percent stand reduction compared to the untreated control.

The dicamba plus 2,4-D experimental herbicide was most effective for controlling buck brush and least active on wild licorice (Table). AGH11021 provided an average of 74 and 79% control 2 and 13 MAT (months after treatment), respectively, regardless of adjuvant. The standard treatment of picloram plus 2,4-D provided an average of 66 and 80% control 2 and 13 MAT, respectively. Wild licorice control with AGH11021 averaged less than 10% 2 MAT, compared to 83% with picloram plus 2,4-D. Initial control of wild rose with AGH11021 averaged 53% 1 MAT, but declined to 17% by 13 MAT. In general, the standard treatment of picloram plus 2,4-D provided better long-term control than AGH11021 of all species evaluated in this study except buck brush. Control of the various species was similar regardless of any adjuvant evaluated applied with AGH11021.

Table. Evaluation of AGH11021 (dicamba plus 2,4-D) for general weed control in pasture, applied June 7, 2013 at Fargo, North Dakota.

		Evaluation date									
		8 Aug 2013					10 July 2013				
Treatment	Rate	Canada thistle	Leafy spurge	Buck brush	Wild rose	Wild licorice	Canada thistle	Leafy spurge	Buck brush	Wild rose	Wild licorice
	— oz/A —	— % control —									
AGH11021[a]	38	28	23	68	49	10	11	11	86	25	0
AGH11021 + Prime Oil[b]	38 + 1%	14	16	81	42	4	9	11	74	0	0
AGH11021 + Superb HC[c]	38 + 16	32	27	77	69	11	5	13	75	29	0
AGH11021 + Superb HC + Interlock[d]	38 + 16 + 4	22	22	75	68	8	3	18	70	23	0
AGH11021 + Superb HC + Masterlock[e]	38 + 16 + 6.4	28	18	68	42	9	16	16	81	15	13
AGH11021 + Noble[f]	38 + 1%	21	25	79	49	5	18	14	84	20	0
AGH11021 + Destiny HC[g]	38 + 16	75	40	77	39	5	41	40	80	13	3
AGH11021 + Rivet[h] + Interlock	38 + 8 + 4	32	24	66	34	3	15	14	81	11	0
Picloram[i] + 2,4-D	4 + 16	80	60	66	73	83	49	60	80	49	31
LSD (0.05)		15	15	NS	NS	9	24	19	NS	29[j]	NS

[a]Experimental formulation - dicamba and 2,4-D (3:1),[b]petroleum oil concentrate, [c]surfactant petroleum oil concentrate, [d,e]deposition/retention/drift retardant, [f]methylated seed oil,[g]surfactant plus MSO concentrate, [h]MSO and organosilicone surfactant by Winfield Solutions, LLC, P.O. Box 64589, St. Paul, MN 55164-0089.

[i]Commercial formulation - Tordon 22K by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

Evaluation of various dicamba plus 2,4-D formulations for absinth wormwood and spotted knapweed control. Rodney G. Lym. (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Although herbicides such as aminopyralid and picloram control absinth wormwood and spotted knapweed very well, land managers seek the same control levels with less costly herbicides. 2,4-D is one of the least expensive herbicides available for use in pasture and rangeland, but does not control most perennial weed species for more than a month or two. Application of 2,4-D with dicamba may increase long-term weed control with only a slight increase in cost. The purpose of this research was to evaluate various 2,4-D formulations applied with dicamba for control of three weed species. The herbicide AGH11021, an experimental formulation of 2,4-D plus dicamba (3:1 v/v) was compared to a current commercial formulation alone.

The absinth wormwood study was established in Valley City, ND in an abandoned feed lot area. Treatments were applied May 23, 2012. The site had an extremely dense stand of absinth wormwood with many seedlings and rosettes that were beginning to bolt and averaged 18 inches tall. There were two spotted knapweed studies. They were established on unused land at the Hawley, MN airport on May 25, 2012 and May 29, 2013 when the weed was in the rosette growth stage and 3 to 4 inches tall.

The plots at all study sites were 10 by 30 ft and replicated four times. Treatments at all sites were applied using a hand-held boom sprayer delivering 17 gpa at 35 psi. Weed control was evaluated visually using percent stand reduction compared to the untreated control. Aminopyralid was included in all studies as the current standard treatment.

Absinth wormwood was well controlled the season after treatment regardless of herbicide or application rate (Table 1). Control averaged over all treatments was 70% in July 2012 but increased to 96% control 3 months after treatment (MAT) and 92% 15 MAT. Absinth wormwood control averaged 92% 24 MAT (May 2014) with all treatments except AGH11021 applied with Preference and Interlock which only provided 56% control. It is unclear why the addition fo the surfactant and drift retardant would reduce absinth wormwood control compared to AGH11021 used alone.

In contrast, the only treatment that provided acceptable control of spotted knapweed was aminopyralid at 1.25 oz/A which averaged 97 and 91% control 2 and 12 MAT, respectively (Table 2). Spotted knapweed control was generally 60% or less with all treatments that contained 2,4-D plus dicamba.

The third study compared the commercial and experimental dicamba plus 2,4-D formulations, Brash and AGH11021, repsectively, applied with various adjuvants and drift retardants for long-term spotted knapweed control (Table 3). Spotted knapweed control averaged greater than 90% 3 MAT regardless of treatment, but no treatment provided acceptable control 12 MAT, including the standard aminopyralid

In summary, the 2,4-D and dicamba combination treatments controlled absinth wormwood as well as the standard treatment of aminopyralid. However, only aminopyralid controlled spotted knapweed in the second study, while no treatments were satisfactory in adjuvant study. Land managers could use the less expensive option of 2,4-D plus dicamba to control some invasive species, but not the more long-lived weeds such as spotted knapweed.

Table 1. Evaluation of dicamba and 2,4-D herbicide formulations for absinth wormwood control applied on May 23, 2012 at Valley City, ND.

		Evaluation date				
		2012		2013		2014
Treatment	Rate	9 July	22 Aug	3 June	19 Aug	20 May
	oz/A	% control				
Dicamba + 2,4-D[a]	3 + 8.6	59	92	82	88	86
Dicamba + 2,4-D + Preference[b] + InterLock[c]	3 + 8.6 + 0.25% + 4	61	97	98	97	92
AGH11021[d]	28	68	96	96	95	93
AGH11021 + Preference + Interlock	28 + 0.25% + 4	57	94	76	85	56
Dicamba + 2,4-D	4 + 11.5	85	98	99	99	98
AGH11021	38	75	98	97	93	92
Aminopyralid[e]	1.25	84	99	90	87	89
LSD (0.05)		NS	NS	NS	NS	26

[a]Commercial formulation - Brash, [b]surfactant, [c]deposition/retention agent, and [d]2,4-D plus dicamba (3:1 v/v) from Winfield Solutions, LLC, P.O. Box 64589, St. Paul, MN 55164-0089.
[e]Commercial formulation - Milestone by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

Table 2. Evaluation of dicamba and 2,4-D formulations for spotted knapweed control, applied on May 24, 2012, near Hawley, MN.

		Evaluation date			
		2012			2013
Treatment	Rate	18 June	20 July	17 Aug	23 May
	oz/A	% injury	% control		
Dicamba + 2,4-D[a]	3 + 8.6	43	43	35	52
Dicamba + 2,4-D + Preference[b] + InterLock[c]	3 + 8.6 + 0.25% + 4	43	46	37	38
AGH11021[d]	28	38	46	37	55
AGH11021 + Preference + Interlock	28 + 0.25% + 4	38	49	51	56
Dicamba + 2,4-D	4 + 11.5	61	63	52	48
AGH11021	38	60	55	48	62
Aminopyralid[e]	1.25	74	97	95	91
LSD (0.05)		16	17	17	22

[a]Commercial formulation - Brash, [b]surfactant, [c]deposition/retention agent, and [d]2,4-D plus dicamba (3:1 v/v) from Winfield Solutions, LLC, P.O. Box 64589, St. Paul, MN 55164-0089.
[e]Commercial formulation - Milestone by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

Table 3. Evaluation of dicamba and 2,4-D formulations for spotted knapweed control applied on May 29, 2013, near Hawley, MN.

		Evaluation date			
		2013			2014
Treatment	Rate	27 June	25 July	20 Aug	29 May
	— oz/A —	% injury	— % control —		
Dicamba + 2,4-D[a]	3 + 8.6	86	98	97	19
Dicamba + 2,4-D[a] + Preference[b] + InterLock[c]	3 + 8.6 + 0.25% + 4	88	95	96	15
AGH11021[d]	28	89	99	97	45
AGH11021 + Preference + InterLock	28 + 0.25% + 4	95	97	98	38
AGH11021 + Masterlock[e]	28 + 6.4	90	91	91	16
AGH11021 + Innergy[f] + Interlock	28 + 4 + 4	94	87	92	21
AGH11021 + Class Act Flex[g] + Interlock	28 + 1% + 4	89	90	94	16
AGH11021 + AG11011[h]	4 + 11.5	91	97	99	30
Aminopyralid[i]	1.25	94	98	100	58
LSD (0.05)		NS	NS	4	20

[a]Commercial formulation - Brash, [b]surfactant, [c,e]deposition/retention agent, and [d]2,4-D plus dicamba (3:1 v/v), [f]methylated seed oil and organosilicone surfactant, [h] experimental surfactant; all from Winfield Solutions, LLC, P.O. Box 64589, St. Paul, MN 55164-0089.
[i]Commercial formulation - Milestone by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

Evaluation of various 2,4-D formulations for absinth wormwood, spotted knapweed, and Canada thistle control. Rodney G. Lym. (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). The perennial invasive weed species absinth wormwood, spotted knapweed, and Canada thistle are well controlled with herbicides such as picloram and aminopyralid. However, some land managers prefer to control these species with 2,4-D because of the lower herbicide cost compared to picloram and aminopyralid. 2,4-D generally will control perennial weeds for a short-time, but regrowth occurs rapidly from the roots. The purpose of this research was to compare several formulations of 2,4-D for long-term control of absinth wormwood, spotted knapweed, and Canada thistle. The 2,4-D formulations were manufactured by Winfield Solutions and included AGH02007 an ester, AGH09008 an acid plus sulfuric acid formulation, and AGH11021 an experimental combination of 2,4-D and dicamba (3:1).

The absinth wormwood study was established in Valley City, ND in an abandoned feed lot area. Treatments were applied May 23, 2012. The site had an extremely dense stand of absinth wormwood with many seedlings and rosettes that were beginning to bolt and averaged 18 inches tall. The spotted knapweed study was established on unused land at the Hawley, MN airport on May 29, 2013 when the weed was in the rosette growth stage and up to 7 inches tall. The Canada thistle study was established on June 18, 2013 on former cropland at the North Dakota State University Experiment Station in Fargo. The plants were in the rosette to bolt growth stage and 12 to 22 inches tall. The plots at all study sites were 10 by 30 ft and replicated four times. Treatments were applied using a hand-held boom sprayer delivering 17 gpa at 35 psi. Weed control was evaluated visually using percent stand reduction compared to the untreated control. Aminopyralid was included in all studies as the current standard treatment for these weeds.

All treatments provided excellent long-term absinth wormwood control regardless of 2,4-D formulation or application rate (Table 1). Control was 72% 1 month after treatment (1 MAT) averaged across all treatments that included 2,4-D compared to 89% with aminopyralid at 0.75 oz/A. Control increased by 3 MAT (August 22), and averaged 98% over all treatments. Absinth wormwood control with 2,4-D LVE was generally less than the average control the season of treatment, but was similar by the second year of the study (2013) at 93%. The 2,4-D acid formulation AGH09008 and the 2,4-D plus dicamba mixture, AGH11021, tended to provide better absinth wormwood control 24 MAT (97%) compared to the 2,4-D ester and amine formulations (86%).

Aminopyralid was the only treatment to control spotted knapweed which averaged 97%, 3 MAT (Table 2). 2,4-D LVE at 16 oz/A provided 71% spotted knapweed control 1 MAT, but control with all other treatments that contained 2,4-D only averaged 28%. Aminopyralid was the only treatment to control spotted knapweed 12 MAT and averaged 84%.

The 2,4-D amine and AGH09008 plus Preference plus Interlock treatments provided an average of 90% Canada thistle control 2 MAT which was similar to aminopyralid at 97% (Table 3). However, only aminopyralid at 81% provided acceptable control the year after treatment.

In summary, the experimental 2,4-D formulations AGH02007, AGH09008, and AGH11021 provided long-term absinth wormwood control similar to commercially available 2,4-D formulations and aminopyralid. However, the same experimental 2,4-D treatments did not control spotted knapweed or Canada thistle for more than 1 or 2 MAT. Generally, 2,4-D ester and amine formulations provided similar weed control in these studies.

Table 1. Evaluation of various 2,4-D formulations applied on May 23, 2012 for absinth wormwood control at Valley City, ND.

		Evaluation date				
		2012		2013		2014
Treatment	Rate	9 July	22 Aug	3 June	19 Aug	20 May
	oz/A	% control				
AGH02007[a]	16	75	92	100	90	85
2,4-D LVE	15	38	85	92	93	89
2,4-D amine	15	63	96	91	86	84
AGH09008[b]	14	80	96	98	96	94
AGH09008 + Preference[c] + InterLock[d]	14 + 0.25% + 4	78	97	99	98	95
AGH11021[e]	28	82	97	100	100	99
AGH11021 + Preference + InterLock	28 + 0.25% + 4	89	99	99	99	99
Aminopyralid[f]	0.75	89	99	99	99	95
LSD (0.05)		19	10	NS	NS	NS

[a]Commercial formulation - E-99 2,4-D; [b]2,4-D acid and sulfuric acid formulation; [c]an NIS surfactant, [d]deposition/retention agent, and [e]an experimental formulation of 2,4-D plus dicamba. All by Winfield Solutions, LLC, P.O. Box 64589, St. Paul, MN 55164-0089.
[f]Commercial formulation - Milestone by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

Table 2. Evaluation of various 2,4-D formulations for spotted knapweed control applied on May 29, 2013 near Hawley, MN.

		Evaluation date		
		2013		2014
Treatment	Rate	25 July	20 Aug	29 May
	—— oz/A ——		% control	
AGH02007[a]	16	57	39	4
2,4-D LVE	15	71	67	40
2,4-D amine	15	39	12	0
AGH09008[b]	14	41	29	5
AGH09008 + Preference[c] + InterLock[d]	14 + 0.25% + 4	44	31	3
AGH09008 + Masterlock[e]	28	33	31	4
Aminopyralid[f]	0.75	88	97	84
LSD (0.05)		24	24	20

[a]Commercial formulation - E-99 2,4-D; [b]2,4-D acid and sulfuric acid formulation: [c]NIS surfactant: [d]deposition/retention agent, and [e]deposition/retention/drift retardant: all by Winfield Solutions, LLC, P.O. Box 64589, St. Paul, MN 55164-0089.
[f]Commercial formulation - Milestone by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

Table 3. Evaluation of various 2,4-D formulations for Canada thistle control applied June 18, 2013 at Fargo, ND.

		Evaluation date		
		2013		2014
Treatment	Rate	18 July	16 Aug	9 June
	—— oz/A ——		% control	
AGH02007[a]	16	70	75	0
2,4-D LVE6	15	78	81	10
2,4-D amine	15	81	92	58
AGH09008[b]	14	78	81	9
AGH09008 + Preference[c] + Interlock[d]	14 + 0.25 % + 4	68	88	13
AGH09008 + Masterlock[e]	28	76	83	4
Aminopyralid[f]	0.75	88	97	81
LSD (0.05)		8	12	25

[a]Commercial formulation - E-99 2,4-D; [b]2,4-D acid and sulfuric acid formulation; [c]an NIS surfactant, [d]deposition/retention agent, and [e]deposition/retention/drift retardant: all from Winfield Solutions, LLC, P.O. Box 64589, St. Paul, MN 55164-0089.
[f]Commercial formulation - Milestone by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.