Pink Section **Perennial and Noxious Weed Control** **Page**

Effect of aminocyclopyrachlor applied with chlorsulfuron or 2,4-D on broadleaf and grass production in non-cropland. Rodney G. Lym (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Aminocyclopyrachlor (AMCP) has been used for 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 formulation on long-term broadleaf and grass production in non-cropland.

The experiment was established on May 31, 2012 in an ungrazed non-cropped area in north Fargo. The area had previously been heavily infested with leafy spurge, but the *Aphthona* spp. biological control agents had reduced the weed to a minor component of the vegetation. 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. The area contained a wide variety of broadleaf species, but the major grass species present was Kentucky bluegrass. AMCP efficacy was visually evaluated on native and weedy species that were commonly present in all plots using percent stand or height reduction compared to the untreated control. Biomass was harvested in mid-September of 2012 and 2013 by clipping three 0.25-m^2 quadrats per plot and separated into broadleaf or grass species content. Harvested plant material was dried at 120 F for at least 72 hr and weighed to estimate yield.

Leafy spurge control with AMCP only averaged 12 and 77% 3 months after treatment (MAT) when applied with chlorsulfuron and 2,4-D, respectively (Table 1). Leafy spurge control was much lower in this study than in any other study conducted at North Dakota State University. The reason for the poor control is unknown, but may be due to poor treatment coverage during application as leafy spurge was a minor component in the field with much denser stands of buckbrush or western snowberry (*Symphoricarpos occidentalis* Hook.) and Kentucky bluegrass present. Leafy spurge control declined to an average of 37% 14 MAT when averaged over all AMCP treatments. Canada thistle control averaged 91% 3 MAT regardless of AMCP application rate or formulation, but declined rapidly to an average of 47% by 14 MAT. Buckbrush was reduced when treated with AMCP plus chlorsulfuron with 74% control in September 2102, but gradually recovered with 33% injury observed 14 MAT on this native species. Wild licorice (*Glycyrrhiza lepidota* Pursh) was tolerant of all AMCP treatments. However, wild rose (*Rosa arkansana* Porter) was reduced by an average of 88% 3 MAT with AMCP plus chlorsulfuron but only 35% with AMCP plus 2,4-D. This result was surprising since 2,4-D alone will reduce wild rose nearly 100%.

AMCP applied with chlorsulfuron or 2,4-D did not reduce grass production compared to the control in either year of the study (Table 2). Grass biomass averaged 1410 lb/A in 2012 but only 990 lb/A in 2013. The 2013 growing season had below average precipitation which reduced grass production despite much less competition from broadleaf species. Broadleaf plant production following AMCP application averaged 680 lb/A in 2012 compared to 1640 lb/A in the untreated control. AMCP reduced broadleaf production less than the untreated control in 2013 only when applied a 1 oz/A, the maximum use rate in this study.

In summary, AMCP reduced many of the broadleaf species in this study, especially Canada thistle. Buckbrush growth was reduced the year of AMCP treatment, but the species recovered by the year after treatment and wild licorice was very tolerant. Grass production was not affected either year of the study. AMCP should maintain long-term control of many broadleaf species with limited effect on grass species.

Table 1. Control of various wildland grass, weed, and native species with aminocyclopyrachlor applied either with chlorsulfuron or 2,4-D near Fargo, ND.

		Evaluation date/plant species											
		4 September 2012						16 August 2013					
Treatment	Rate	Grass	Leafy spurge	Canada thistle	Buck brush	Wild licorice	Wild rose	Grass	Leafy spurge	Canada thistle	Buck brush	Wild licorice	Wild rose
	oz/A	% control											
AMCP + chlorsulfuron[a] + NIS[b]	0.9 + 0.3 + 0.25%	0	3	89	61	0	85	0	6	51	19	0	25
AMCP + chlorsulfuron + NIS	1 + 0.4 + 0.25%	0	21	95	86	0	90	0	33	58	46	35	38
AMCP + 2,4-D[c] + NIS	0.6 + 4.8 + 0.25%	0	76	86	11	0	21	0	53	49	3	0	0
AMCP + 2,4-D + NIS	1 + 7.6 + 0.25%	0	79	92	23	3	49	0	59	31	18	16	0
Untreated	• • •	0	0	0	0	0	0	0	0	0	0	0	0
LSD (0.05)		NS	30	10	21	NS	14	NS	17	29	19	20	18

[a]Dispersible granular formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.
[b]Surfactant Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[c]Soluble liquid formulation, by E.I. duPont de Nemours and Company.

Table 2. Effect of aminocyclopyrachlor applied either with chlorsulfuron or 2,4-D on grass and broadleaf species near Fargo, ND.

		Harvest date			
		20 September 2012		19 September 2013	
Treatment	Rate	Grass	Broadleaf	Grass	Broadleaf
	oz/A	lb/A			
AMCP + chlorsulfuron[a] + NIS[b]	0.9 + 0.3 + 0.25%	1225	885	1085	1020
AMCP + chlorsulfuron + NIS	1 + 0.4 + 0.25%	1535	565	970	670
AMCP + 2,4-D[c] + NIS	0.6 + 4.8 + 0.25%	1315	800	1050	1515
AMCP + 2,4-D + NIS	1 + 7.6 + 0.25%	1180	470	910	685
Untreated	• • •	1795	1640	940	1940
LSD (0.05)		NS	535	NS	517

[a]Dispersible granular formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.
[b]Surfactant Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[c]Soluble liquid formulation, by E.I. duPont de Nemours and Company.

Comparison of aminocyclopyrachlor applied with chlorsulfuron or 2,4-D for invasive weed control.
Rodney G. Lym (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050).
Aminocyclopyrachlor (AMCP) has generally been applied with chlorsulfuron for control of a variety of invasive weeds. AMCP plus chlorsulfuron is marketed as a dispersible granule (DG) formulation which may be more difficult to adapt to direct injection application often used in roadside weed control compared to soluble liquid (SL) formulations. The purpose of this research was to compare AMCP applied with chlorsulfuron as a DG or with 2,4-D as a SL formulation for long-term control of three invasive weed species.

Studies were established for leafy spurge, Canada thistle, or spotted knapweed control near Walcott, ND in an ungrazed area of pasture, on the campus of North Dakota State University, and on airport ground near Hawley, MN, respectively. 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 all locations. The leafy spurge study was established on June 6, 2011 when the plants were in the true-flower growth stage and 12 to 24 inches tall. Spotted knapweed was treated when in the rosette stage on June 9, 2011. The Canada thistle experiment was established on July 18, 2011 when the plants were 4 to 6 inches tall and beginning to bolt. A herbicide treatment considered the current standard for control of each weed species was included in each trial. Weed control was evaluated visually using percent stand reduction compared to the untreated control.

Long-term leafy spurge control was better when AMCP was applied as a liquid formulation with 2,4-D compared to application with chlorsulfuron as a DG or the standard treatment of picloram plus imazapic plus 2,4-D (Table 1). For instance, leafy spurge control averaged 82% with AMCP plus 2,4-D applied at 1 + 7.6 oz /A, respectively, 14 months after treatment (MAT) (August 28, 2012) compared to only 41% with AMCP plus chlorsulfuron at 1 + 0.4 oz/A, respectively. Control declined to an average of 40 and 76% with the liquid and DG formulations, respectively, 24 MAT.

In contrast to the leafy spurge study, spotted knapweed control from AMCP was excellent whether applied with chlorsulfuron or 2,4-D and averaged 94% 24 MAT which was similar to the standard treatment of aminopyralid at 1.25 oz/A which averaged 93% (Table 2). Similarly, Canada thistle control was excellent regardless of treatment or formulation and averaged 100% 13 MAT (Table 3). AMCP applied with chlorsulfuron suppressed annual foxtail species (*Setaria* spp.) nearly 90% averaged over application rate, compared to 66% when AMCP was applied with 2,4-D as an SL. All treatments provided excellent control of common ragweed (*Ambrosia artemisiifolia* L.) except AMCP + 2,4-D. As reported in previous studies, AMCP will suppress some annual grass species. The increased control when AMCP was applied as a DG compared to a SL was likely due to the chlorsulfuron in the DG mixture which is known to control many annual grass species. AMCP plus chlorsulfuron and aminopyralid provided nearly 100% ragweed control 11 MAT, compared to no control when AMCP was applied with 2,4-D.

In summary, leafy spurge control was better when AMCP was applied with 2,4-D compared to AMCP applied with chlorsulfuron, but control of Canada thistle and spotted knapweed was similar regardless of formulation. Long-term control of spotted knapweed and Canada thistle with AMCP treatments was much better than control of leafy spurge. Suppression of annual grass species is likely when AMCP plus chlorsulfuron is used to control various invasive weed species.

Table 1. Evaluation of aminocyclopyrachlor applied with chlorsulfuron or 2,4-D for leafy spurge control, near Walcott, ND.

		Evaluation date			
		2011	2012		2013
Treatment	Rate	4 Aug	24 May	28 Aug	6 June
	oz/A	% control			
Aminocyclopyrachlor + chlorsulfuron[a] + NIS[b]	1 + 0.4 + 0.25%	89	55	41	20
Aminocyclopyrachlor + chlorsulfuron + NIS	1.8 + 0.7 + 0.25%	95	73	64	59
Aminocyclopyrachlor + 2,4-D[c] + NIS	1 + 7.6 + 0.25%	98	89	82	68
Aminocyclopyrachlor + 2,4-D + NIS	2 + 15.2 + 0.25%	99	95	90	83
Picloram + imazapic + 2,4-D + MSO	4 + 1 + 16 + 1 qt	99	76	61	52
Untreated	•••	0	0	0	0
LSD (0.05)		6	22	28	29

[a]Dispersible granule formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.
[b]Surfactant Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[c]Soluble liquid formulation, by E.I. duPont de Nemours and Company.

Table 2. Evaluation of aminocyclopyrachlor applied with chlorsulfuron or 2,4-D for spotted knapweed control near Hawley, MN.

		Evaluation date			
		2011	2012		2013
Treatment	Rate	2 Aug	24 May	17 Aug	17 June
	oz/A	% control			
Aminocyclpyrachlor + chlorsulfuron[a] + NIS[b]	1 + 0.4 + 0.25%	92	96	96	92
Aminocyclpyrachlor + chlorsulfuron + NIS	1.8 + 0.7 + 0.25%	100	100	100	94
Aminocyclpyrachlor + 2,4-D[c] + NIS	1 + 7.6 + 0.25%	96	97	98	92
Aminocyclpyrachlor + 2,4-D + NIS	2 + 15.2 + 0.25%	100	100	100	94
Aminopyralid[d] + NIS	1.25 + 0.25%	100	98	98	93
Untreated	•••	0	0	0	0
LSD (0.05)		3	5	3	5

[a]Dispersible granule formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.
[b]Surfactant Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[c]Soluble liquid formulation, by E.I. duPont de Nemours and Company.
[d]Commercial formulation - Milestone by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

Table 3. Evaluation of aminocyclopyrachlor applied with chlorsulfuron or 2,4-D for Canada thistle control, Fargo, ND.

		Evaluation date						
		13 Sept 2011			12 June 12		16 Aug 12	17 June 13
Treatment	Rate	Canada thistle	Rag-weed	Foxtail spp.	Canada thistle	Rag-weed	Canada thistle	Canada thistle
	oz/A	% control						
Aminocyclpyrachlor + chlorsulfuron[a]+ NIS[b]	0.987 + 0.394 + 0.25%	100	100	82	99	99	100	95
Aminocyclpyrachlor + chlorsulfuron+ NIS	1.777 + 0.709 + 0.25%	100	100	94	100	99	100	98
Aminocyclpyrachlor + 2,4-D[c] + NIS	1 + 7.6 + 0.25%	100	100	55	100	0	100	94
Aminocyclpyrachlor + 2,4-D + NIS	2 + 15.2 + 0.25%	100	100	76	100	0	100	99
Aminopyralid[d] + NIS	1.25 + 0.25%	100	99	0	100	97	100	99
Untreated	•••	0	0	0	38	20	0	0
LSD (0.05)		1	1	16	28	24	1	6

[a]Dispersible granule formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.
[b]Surfactant Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[c]Soluble liquid formulation, by E.I. duPont de Nemours and Company.
[d]Commercial formulation - Milestone by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

Evaluation of aminocyclopyrachlor applied with various herbicides for absinth wormwood control. Rodney G. Lym (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Aminocyclopyrachlor (AMCP) is generally applied with chlorsulfuron for control of a variety of invasive species. AMCP has provided excellent long-term control of leafy spurge, Canada thistle, and spotted knapweed but has been less effective when applied on woody species such as absinth wormwood. Previous research at North Dakota State University found AMCP plus chlorsulfuron applied in the fall provided much better long-term absinth wormwood control than the same treatment applied in early spring. The purpose of this research was to evaluate absinth wormwood control with AMCP plus chlorsulfuron applied with commonly used brush herbicides.

The experiment was established in Valley City, ND in an abandoned feed lot area. Treatments were applied May 23, 2012 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. A methylated seed oil adjuvant at 1 qt/A was applied with all treatments that contained AMCP while aminopyralid was applied with a non-ionic surfactant at 0.25%. 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. Control was evaluated visually using percent stand reduction compared to the untreated control.

Absinth wormwood control was 96% when averaged over all treatments 15 months after application (Table). Absinth wormwood control was similar when AMCP plus chlorsulfuron was applied with imazapyr, triclopyr ester, triclopyr amine, or metsulfuron. No antagonism was observed with any of the herbicide combinations. Thus, application of AMCP with commonly used brush herbicides likely would provide a wider spectrum of brush control than AMCP plus chlorsulfuron used alone.

Table. Evaluation of AMCP applied with a variety of herbicides for absinth wormwood control applied on May 23, 2012, near Valley City, ND.

Treatment[a]	Rate	Evaluation date			
		2012		2013	
		9 July	22 Aug	3 June	19 Aug
	oz/A	% control			
AMCP + chlorsulfuron[b] + imazapyr	2 + 2.8	97	98	100	89
AMCP + chlorsulfuron + imazapyr	4 + 5.6	100	99	100	91
AMCP + chlorsulfuron + triclopyr ester	2 + 2	92	96	99	97
AMCP + chlorsulfuron + triclopyr ester	4 + 4	98	99	100	100
AMCP + chlorsulfuron + triclopyr amine	2 + 2	95	97	100	100
AMCP + chlorsulfuron + triclopyr amine	4 + 4	98	99	100	98
AMCP + chlorsulfuron + triclopyr amine	2 + 4	96	99	99	100
AMCP + chlorsulfuron + triclopyr amine	4 + 8	97	100	100	99
AMCP + chlorsulfuron + imazapyr + triclopyr amine	2 + 2.8 + 2	97	99	100	89
AMCP + chlorsulfuron + imazapyr + triclopyr amine	4 + 5.6 + 4	100	100	100	90
AMCP + chlorsulfuron + metsulfuron	4 + 1.3	99	100	100	98
AMCP + chlorsulfuron + metsulfuron + imazapyr	4 + 1.3 + 5.6	100	100	100	94
AMCP + chlorsulfuron + metsulfuron	2 + 0.6	95	100	100	99
Aminopyralid[c] + NIS[d]	1.75 + 0.25%	94	99	100	100
LSD (0.05)		5	2	1	9

[a]MSO at 1 qt/A was applied with all treatments that contained AMCP. Dyne-Amic 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.
[d]NIS Activator 90 by United Agri Products 7251 W. 4th St. Greeley, CO 80634.

Leafy spurge and Canada thistle control with aminocyclopyrachlor applied with various herbicides. Rodney G. Lym (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Aminocyclopyrachlor (AMCP) provides good to excellent control of many invasive weeds and is generally applied with either metsulfuron or chlorsulfuron. These herbicide combinations may also be applied with other compounds to broaden the spectrum of weed control, or with insecticides to control pests with a single application. The purpose of this research was to evaluate the effect of AMCP plus chlorsulfuron or metsulfuron applied with other herbicides, malathion, or with nitrogen as a carrier for leafy spurge or Canada thistle control.

The leafy spurge experiment was established near Walcott, ND in an ungrazed area of pasture with a dense stand of leafy spurge. Treatments were applied June 24, 2011 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 Canada thistle experiment was established on unused cropland on the campus of North Dakota State University in Fargo. Treatments were applied as previously described on June 30, 2011 when Canada thistle was in the rosette to early bolt growth stage and 4 to 6 inches tall. Leafy spurge and Canada thistle control was evaluated visually using percent stand reduction compared to the untreated control.

Initial leafy spurge control averaged 99% 2 months after treatment (MAT) but most treatments resulted in smooth bromegrass injury (Table 1). The highest injury occurred (> 60%) when AMCP was applied with triclopyr plus fluroxypyr or AMCP plus metsulfuron was applied in a nitrogen carrier. Leafy spurge control averaged nearly 100% 11 and 14 MAT with all treatments except AMCP plus metsulfuron applied alone. Grass injury was not observed the year after treatment (data not shown). Leafy spurge control averaged 94% 24 MAT with all herbicide combinations except AMCP applied with metsulfuron which only averaged 79%. Long-term control was improved by the presence of *Aphthona* spp. biocontrol agents which reduced leafy spurge in the untreated control plots 20 and 16% 12 and 24 MAT, respectively.

Canada thistle control averaged 99% 14 MAT regardless of treatment (Table 2). All treatments provided excellent control of annual foxtail species. No chemical incompatibility was observed with any treatment in either experiment. Canada thistle control averaged 100% in September 2012 (13 MAT) and 91% 24 MAT.

AMCP applied with chlorsulfuron or metsulfuron has provided excellent leafy spurge and Canada thistle control in previous studies. Control was excellent in this study as well with nearly all herbicide mixtures except when AMCP was applied with metsulfuron on leafy spurge. Application of AMCP with other herbicides should broaden the weed control spectrum compared to AMCP applied alone.

Table 1. Aminocyclopyrachlor applied with various herbicides for leafy spurge control near Walcott, ND.

Treatment	Rate	Evaluation date/species				
		16 Aug 11		24 May 12	28 Aug 12	6 June 13
		Leafy spurge	Smooth brome	Leafy spurge		
	oz/A	%				
Aminocyclpyrachlor + chlorsulfuron[a] + NIS[b]	2 + 0.8 + 0.25%	100	15	99	96	96
Aminocyclpyrachlor + chlorsulfuron + 2,4-D + NIS	2 + 0.8 + 15.2 + 0.25%	96	20	97	92	88
Aminocyclpyrachlor + chlorsulfuron + picloram + NIS	2 + 0.8 + 8 + 0.25%	99	48	100	99	99
Aminocyclpyrachlor + chlorsulfuron + aminopyralid[c] + NIS	2 + 0.8 + 1.75 + 0.25%	100	24	99	97	96
Aminocyclpyrachlor + triclopyr + fluroxypyr[d] + NIS	2 + 0.8 + 12 + 4 + 0.25%	100	68	99	96	94
Aminocyclpyrachlor + metsulfuron + NIS	2 + 0.3 + 0.25%	99	10	88	82	79
Aminocyclpyrachlor + metsulfuron + 2,4-D + dicamba[e] + NIS	2 + 0.3 + 11.5 + 4.01 + 0.25%	100	20	96	90	91
Aminocyclpyrachlor + metsulfuron + picloram + 2,4-D[f] + NIS	2 + 0.3 + 2.1 + 8.1 + 0.25%	98	21	97	96	97
Aminocyclpyrachlor + metsulfuron + NIS in nitrogen carrier[g]	2 + 0.3 + 0.25%	100	63	97	96	96
Aminocyclpyrachlor + metsulfuron + malathion + NIS	2 + 0.3 + 16 + 0.25%	98	14	96	94	91
Untreated	•••	0	0	20[h]	0	16[h]
LSD (0.05)		3	19	11	9	16

[a]Commercial formulation Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.
[b]Surfactant Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
Commercial formulatons - [c]Milestone, [d]Pastureguard, [f]Grazon P+D by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.
[e]Commercial formulation - Weedmaster by Nufarm Inc., 150 Harvester Drive, Burr Ridge, IL 60527.
[g]Nitrogen fertilizer 28-0-0.
[h]Biological control agents (*Aphthona* spp.) reduced leafy spurge stand.

Table 2. Aminocyclopyrachlor applied with various herbicides for Canada thistle control Fargo, ND.

Treatment[a]	Rate	Evaluation date/species				
		16 Aug 11		1 June 12	16 Aug 12	17 June 13
		Canada thistle	Foxtail spp.	Canada thistle		
	oz/A	% control				
Aminocyclpyrachlor + chlorsulfuron[a] + NIS[b]	2 + 0.8 + 0.25%	99	98	100	99	90
Aminocyclpyrachlor + chlorsulfuron + 2,4-D + NIS	2 + 0.8 + 15.2 + 0.25%	89	97	100	99	90
Aminocyclpyrachlor + chlorsulfuron + picloram + NIS	2 + 0.8 + 8 + 0.25%	100	96	100	99	88
Aminocyclpyrachlor + chlorsulfuron + aminopyralid[c] + NIS	2 + 0.8 + 1.75 + 0.25%	100	100	100	99	94
Aminocyclpyrachlor + triclopyr + fluroxypyr[d] + NIS	2 + 0.8 + 12 + 4 + 0.25%	98	99	99	99	91
Aminocyclpyrachlor + metsulfuron + NIS	2 + 0.3 + 0.25%	99	100	99	99	93
Aminocyclpyrachlor + metsulfuron + 2,4-D + dicamba[e] + NIS	2 + 0.3 + 11.5 + 4.01 + 0.25%	98	86	99	98	88
Aminocyclpyrachlor + metsulfuron + picloram + 2,4-D[f] + NIS	2 + 0.3 + 2.1 + 8.1 + 0.25%	99	98	100	99	93
Aminocyclpyrachlor + metsulfuron + NIS in nitrogen carrier[g]	2 + 0.3 + 0.25 %	99	91	100	99	87
Aminocyclpyrachlor + metsulfuron + malathion + NIS	2 + 0.3 + 16 + 0.25 %	98	99	100	100	91
Untreated	•••	0	0	0	0	0
LSD (0.05)		3	5	1	4	14

[a]Dispersible granule formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.
[b]Surfactant Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
Commercial formulatons - [c]Milestone, [d]Pastureguard, [f]Grazon P+D by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.
[e]Commercial formulation - Weedmaster by Nufarm Inc., 150 Harvester Drive, Burr Ridge, IL 60527.
[g]Nitrogen fertilizer 28-0-0.

Aminocyclopyrachlor applied with various herbicides for leafy spurge and yellow toadflax control. 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 has generally provided inconsistent yellow toadflax control when applied with chlorsulfuron. The purpose of this research was to evaluate long-term control of leafy spurge or yellow toadflax with AMCP applied with various other herbicides.

The leafy spurge control experiment was established near Walcott, ND in an ungrazed area of pasture with a dense stand of leafy spurge. Treatments were applied May 30, 2012 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 yellow toadflax experiment was established on a wildlife production area near Valley City, ND. Treatments were applied as previously described on July 25, 2012 when yellow toadflax was beginning to flower and 8 to 24 inches tall. Leafy spurge and yellow toadflax control was evaluated visually using percent stand reduction compared to the untreated control.

Long-term leafy spurge control was similar when applied with chlorsulfuron or 2,4-D and tended to be higher when AMCP was applied at 1.8 or 2 oz/A compared to 1 oz/A (Table 1). For example, leafy spurge control in August 2013 averaged 80% 15 months after treatment (MAT) when applied at 1 oz/A with chlorsulfuron or 2,4-D but control increased to an average of 94% when the AMCP application rate increased to 2 oz/A. The current standard treatment of picloram plus imazapic plus 2,4-D at 4 + 1 + 16 oz/A only provided 63% leafy spurge control 15 MAT.

AMCP applied with chlorsulfuron, 2,4-D, or metsulfuron provided excellent long-term yellow toadflax control regardless of application rate (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.

AMCP provided excellent long-term leafy spurge and yellow toadflax control when applied with chlorsulfuron, 2,4-D, or metsulfuron (yellow toadflax only). Unlike previous studies, leafy spurge control was similar when AMCP was applied with chlorsulfuron or 2,4-D and control increased as AMCP application rate increased. In contrast, yellow toadflax control was similar regardless of AMCP application rate.

Table 1. Evaluation of aminocyclopyrachlor applied with chlorsulfuron or 2,4-D on May 30, 2012 for leafy spurge control near Walcott, ND.

		Evaluation date			
		2012		2013	
Treatment[a]	Rate	27 July	28 Aug	28 June	21 Aug
	oz/A	% control			
Aminocyclopyrachlor + chlorsulfuron[b]	1 + 0.4	97	94	92	83
Aminocyclopyrachlor + chlorsulfuron	1.8 + 0.7	100	99	97	94
Aminocyclopyrachlor + 2,4-D	1 + 7.6	97	93	92	77
Aminocyclopyrachlor+ 2,4-D	2 + 15.2	99	95	98	93
Picloram + imazapic + 2,4-D + MSO	4 + 1 + 16 + 1 qt	97	96	92	63
Untreated	•••	0	0	0	0
LSD (0.05)		3	5	5	13

[a]Surfactant applied at 0.25% with all AMCP treatments, Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[b]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	
Treatment[a]	Rate	13 Sept	11 June	13 Sept
	oz/A	% control		
Aminocyclopyrachlor + chlorsulfuron[b]	1.8 + 0.7	66	99	94
Aminocyclopyrachlor + chlorsulfuron	2.4 + 0.95	63	99	99
Aminocyclopyrachlor + 2,4-D	2 + 15.2	67	96	93
Aminocyclopyrachlor + 2,4-D	2.5 + 19	65	97	94
Aminocyclopyrachlor + metsulfuron[c]	1.8 + 0.3	62	94	81
Aminocyclopyrachlor + metsulfuron	2.4 + 0.4	65	99	94
Picloram + dicamba + diflufenzopyr[d]	16 + 4 + 1.6	71	100	99
Untreated	•••	0	0	0
LSD (0.05)		13	4	9

[a]All treatments applied with surfactant Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[b]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, 1007 Market Street, Wilmington, DE 19898.
[d]Commercial formulation - Overdrive by BASF, 100 Campus Drive, Florham Park, NC 07932.

Comparison of aminocyclopyrachlor applied with chlorsulfuron or 2,4-D for plumeless thistle and houndstongue control. Rodney G. Lym (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Previous research at North Dakota State University found aminocyclopyrachlor (AMCP) applied alone provided excellent plumeless thistle (*Carduus acanthoides* L.) control but might be best used in combination with an ALS herbicide for consistent houndstongue (*Cynoglossum officinale* L.) control. Leafy spurge control was improved when AMCP was applied with 2,4-D compared to application with chlorsulfuron but control of Canada thistle and yellow toadflax was similar regardless of AMCP treatment. The purpose of this research was to evaluate control of the invasive biennial species plumeless thistle and houndstongue with AMCP applied alone or with chlorsulfuron or other herbicides.

The plumeless thistle study was established on May 24, 2012 on unused pasture on the North Dakota State University campus. The plants were in the rosette to bolt growth stage and 2 to 12 inches tall. The plots were 10 by 30 ft and replicated four times. The houndstongue experiment was established on private pasture near McLeod, ND on May 30, 2012. The houndstongue plants were either in the rosette stage (first yr) or beginning to bolt (second yr) and 1 to 3 inches tall. The plots were 9 by 25 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.

AMCP applied with either chlorsulfuron or 2,4-D provided rapid and complete control of plumeless thistle and houndstongue, regardless of application rate (Tables 1 and 2). Plumeless thistle control averaged 99% the year of treatment and nearly 100% 13 MAT which was similar to the current standard treatment of aminopyralid alone at 0.75 oz/A. Houndstongue control averaged 99% 13 MAT regardless if AMCP was applied with 2,4-D, chlorsulfuron, or metsulfuron and was similar to metsulfuron at 1.2 oz/A, the current standard. Previous research had shown that AMCP applied alone did not provide consistent houndstongue control.

In summary, AMCP applied with chlorsulfuron or 2,4-D provided near complete control of plumeless thistle. AMCP applied with chlorsulfuron, metsulfuron, or 2,4-D also provided excellent houndstongue control. Since both weed species are biennial, control should be long-term if regeneration from seedlings is prevented.

Table 1. Efficacy of aminocyclopyrachlor applied with chlorsulfuron or 2,4-D for plumeless thistle control at Fargo, ND.

Treatment	Rate	Evaluation date	
		20 July 12	4 June 13
	oz/A	% control	
Aminocyclpyrachlor + chlorsulfuron[a]+ NIS[b]	0.6 + 0.24 + 0.25%	98	99
Aminocyclpyrachlor + chlorsulfuron + NIS	1 + 0.4 + 0.25%	99	100
Aminocyclpyrachlor + 2,4-D[c] + NIS	0.6 + 4.75 + 0.25%	93	99
Aminocyclpyrachlor + 2,4-D + NIS	1 + 7.6 + 0.25%	99	100
Aminopyralid[d] + NIS	0.75 + 0.25%	99	100
Untreated	• • •	0	0
LSD (0.05)		8	1

[a]Dispersible granule formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.
[b]Surfactant Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[c]Soluble liquid formulation - E.I. duPont de Nemours and Company.
[d]Commercial formulation - Milestone by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268.

Table 2. Efficacy of aminocyclopyrachlor herbicide for houndstongue control near McLeod, ND.

Treatment	Rate	Evaluation date		
		2012		2012
		27 July	28 Aug	20 June
	oz/A	% control		
Aminocyclpyrachlor + chlorsulfuron[a] + NIS[b]	1.8 + 0.7 + 0.25%	100	100	100
Aminocyclpyrachlor + 2,4-D[c] + NIS	2 + 15 + 0.25%	100	100	97
Aminocyclpyrachlor + metsulfuron[c] + NIS	1.1 + 0.17 + 0.25%	99	98	99
Aminocyclpyrachlor + metsulfruon + NIS	1.8 + 0.27v+ 0.25%	98	97	97
Metsulfuron + NIS	1.2 + 0.25%	100	99	99
Untreated	• • •			
LSD (0.05)		NS	2.5	5

[a]Dispersible granule formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.
[b]Surfactant Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[c]DPX-RDQ98 formulation Rejuvra 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). Previous research at North Dakota State University has shown that leafy spurge control is improved when aminocyclopyrachlor (AMCP) is applied as a liquid formulation with 2,4-D compared to a dry formulation with chlorsulfuron. The increase long-term control is generally about 20 to 30 percentage points. 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 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). No difference in weed control between AMCP formulations was observed at any evaluation date. AMCP plus chlorsulfuron or AMCP plus 2,4-D provided similar control of both weed species as the standard treatment of aminopyralid at 1.25 oz/A. Although long-term weed 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	
Treatment[a]	Rate	20 July	17 Aug	23 May	20 Aug
	oz/A	% control			
AMCP + chlorsulfuron[b] DF	1 + 0.4	96	96	98	96
AMCP + chlorsulfuron DF	1.8 + 0.7	97	99	98	91
AMCP SL + 2,4-D	1 + 7.6	98	99	96	95
AMCP SL + 2,4-D	2 + 15.2	99	99	98	96
Aminopyralid[c]	1.25	99	98	97	98
Untreated	•••	0	0	0	0
LSD (0.05)		3	2	2	5

[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. 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	
Treatment[a]	Rate	30 July	20 Aug	17 June	19 Aug
	oz/A	% control			
AMCP + chlorsulfuron[b] DF	1 + 0.4	99	99	99	92
AMCP + chlorsulfuron DF	1.8 + 0.7	99	99	98	93
AMCP SL + 2,4-D	1 + 7.6	94	95	96	87
AMCP SL + 2,4-D	2 + 15.2	95	96	97	96
Aminopyralid[c] + NIS	1.25	100	98	93	85
Untreated	•••	0	0	0	0
LSD (0.05)		6	6	3	11

[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. 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.

Aminopyralid applied alone or in combination with clopyralid in the spring or fall for Canada thistle and absinth wormwood 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 and absinth wormwood control in North Dakota. Prior to the release of aminopyralid, clopyralid was commonly used to control these weeds. Often combinations of herbicides have provided better long-term control of invasive species then a single herbicide used alone. The purpose of this research was to evaluate aminopyralid applied alone or at reduced rates with clopyralid for long-term Canada thistle and absinth wormwood control.

The Canada thistle study 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 30 or September 26, 2011. June treatments were applied to Canada thistle in the bolted to early bud growth stage and 30 to 48 inches tall while plants were post-flower with woody stems and 36 to 48 inches tall when herbicides were applied in the fall.

The absinth wormwood study was established on an active gravel quarry near Valley City, ND that was heavily infested. 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 were 6 to 8 inches tall when the fall treatments were applied.

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 with four replications. Canada thistle and absinth wormwood control was evaluated visually using percent stand reduction compared to the untreated control.

Canada thistle control was similar whether aminopyralid was applied alone or with clopyralid, (Table 1). For instance, aminopyralid applied at 1.25 oz/A in June, provided 99 and 77% control 12 and 24 months after treatment (MAT), respectively, while aminopyralid plus clopyralid at 1.25 + 5.8 oz/A averaged 99 and 85% control, respectively. In general, there was little difference in long-term Canada thistle control when the treatments were applied in June compared to September. The most cost-effective treatment was aminopyralid plus chlorsulfuron at 0.5 + 2.4 oz/A which provided 70% Canada thistle control 26 MAT and cost $11.05/A.

All treatments that contained aminopyralid or clopyralid provided 90% or better absinth wormwood control 26 MAT whether applied in June or September (Table 2). The most cost-effective treatment again was aminopyralid plus chlorsulfuron at 0.5 + 2.4 oz/A which provided 95% absinth wormwood control 26 MAT. The least effective treatment was dicamba applied at 16 oz/A in the spring which provided 71% absinth wormwood control by the end of the study. In summary, the combination of aminopyralid plus clopyralid at reduced rates generally provided similar weed control to aminopyralid applied alone with only a slight reduction in herbicide cost.

Table 1. Aminopyralid plus clopyralid for Canada thistle control applied on June 30 or September 26, 2011 at Fargo, ND.

		Evaluation date					
		2011	2012		2013		
Treatment[a]	Rate	13 Sept	1 June	17 Aug	17 June	21 Aug	Cost[b]
	— oz/A —			% control			$/A
June application							
Aminopyralid[c]	1.25	100	99	94	77	69	15.65
Aminopyralid	1.75	100	100	97	84	80	21.90
Clopyralid[d]	6	100	96	94	78	75	23.70
Dicamba	16	99	100	98	73	81	14.50
Aminopyralid + clopyralid	0.5 + 2.4	100	100	90	69	70	11.05
Aminopyralid + clopyralid	0.75 + 3.4	100	99	95	75	66	15.75
Aminopyralid + clopyralid	1 + 4.6	100	100	99	97	95	21.30
Aminopyralid + clopyralid	1.25 + 5.8	100	99	99	85	82	26.95
Aminopyralid + clopyralid	1.5 + 7	100	99	94	84	86	32.35
September application							
Aminopyralid	1.25		91	91	90	81	15.65
Dicamba	16		91	84	68	60	14.50
Aminopyralid + clopyralid	0.75 + 3.4		100	99	86	84	15.75
Aminopyralid + clopyralid	1 + 4.6		100	99	85	86	21.30
Aminopyralid + clopyralid	1.25 + 5.8		100	100	91	81	26.95
LSD (0.05)		NS	6	10	20	20	

[a]All treatments applied with NIS Activator 90 at 0.25%. Activator 90 from United Agri Products, 7251 W. 4th St. Greeley, CO 80634.
[b]Based on Milestone at $400/gal and Transline at $190/gal and does not include surfactant or application costs.
[c]Commercial formulation - Milestone and [d]Transline, from Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

Table 2. Aminopyralid plus clopyralid for absinth wormwood control applied May 26 or September 15, 2011, near Valley City, ND.

		Evaluation date					
		2011	2012		2013		
Treatment[a]	Rate	15 Sept	17 May	22 Aug	3 June	14 Aug	Cost[b]
	— oz/A —			% control			$/A
June application							
Aminopyralid[c]	1.25	95	94	93	91	90	15.65
Aminopyralid	1.75	99	96	96	99	96	21.90
Clopyralid[d]	6	99	97	99	99	97	23.70
Dicamba	16	80	65	75	73	71	14.50
Aminopyralid + clopyralid	0.5 + 2.4	96	97	96	99	95	11.05
Aminopyralid + clopyralid	0.75 + 3.4	99	99	99	100	99	15.75
Aminopyralid + clopyralid	1 + 4.6	99	99	97	100	99	21.30
Aminopyralid + clopyralid	1.3 + 5.8	99	100	99	99	97	26.95
Aminopyralid + clopyralid	1.5 + 7	100	100	99	100	99	32.35
September application							
Aminopyralid	1.25		99	99	100	96	15.65
Dicamba	16		91	96	79	84	14.50
Aminopyralid + clopyralid	0.75 + 3.4		99	100	100	99	15.75
Aminopyralid + clopyralid	1 + 4.6		99	99	100	98	21.30
Aminopyralid + clopyralid	1.3 + 5.8		99	100	100	96	26.95
LSD (0.05)		5	5	9	14	11	

[a]All treatments applied with NIS Activator 90 at 0.25%. Activator 90 from United Agri Products, 7251 W. 4th St. Greeley, CO 80634.
[b]Based on Milestone at $400/gal and Transline at $190/gal and does not include surfactant or application costs.
[c]Commercial formulation - Milestone and [d]Transline, from Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

Yellow toadflax control with aminopyralid and picloram 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. The purpose of this research was to compare picloram and aminopyralid applied alone and with other herbicides for cost-effective yellow toadflax control.

The experiment was established on a wildlife production area near Valley City, ND. Treatments were applied August 5, 2012 when yellow toadflax was 10 to 16 inches tall and beginning to flower. 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 yellow toadflax control which averaged 83% 13 months after treatment (MAT) (Table). Control was similar when picloram was applied with chlorsulfuron and/or dicamba plus diflufenzopyr. This is in contrast to previous research conducted at North Dakota State University when the combination treatment of picloram plus dicamba plus diflufenzopyr provided much better long-term yellow toadflax control than picloram alone. Aminopyralid alone averaged 16% 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. Aminocyclopyrachlor 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.

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. Yellow toadflax control with aminopyralid and picloram applied with various herbicides on August 5, 2012 near Valley City, ND.

		Evaluation date		
		2012	2013	
Treatment[a]	Rate	13 Sept	11 July	13 Sept
	oz/A	% control		
Aminopyralid	2.5	49	36	23
Aminopyralid	3.5	50	15	9
Chlorsulfuron	0.75	29	62	51
Aminopyralid + chlorsulfuron	1.75 + 0.75	39	92	89
Aminopyralid + chlorsulfuron	2.5 + 0.75	43	53	63
Aminopyralid + chlorsulfuron + dicamba + diflufenzopyr[b]	1.75 + 0.75 + 3 + 1.2	63	77	63
Picloram	8	44	88	81
Picloram	16	51	62	84
Picloram + chlorsulfturon	8 + 0.75	62	84	82
Picloram + chlorsulfuron + dicamba + diflufenzopyr	8 + 0.75 + 3 + 1.2	58	90	91
Aminocylopyrachlor + chlorsulfuron[c]	1.9 + 0.73	68	84	83
Aminocylopyrachlor + chlorsulfuron + aminopyralid	0.8 + 0.3 + 1.75	64	67	71
Picloram + dicamba + difulfenzopyr	8 + 3 + 1.2	68	89	90
Picloram + dicamba + diflufenzopyr	16 + 4 + 1.6	73	86	84
LSD (0.05)		10	25	22

[a]All treatment applied with surfactant 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]Formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.

Comparison of aminopyralid applied alone at high rates or in combination with clopyralid 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. Prior to the release of aminopyralid, clopyralid was commonly used to control Canada thistle, especially in cropland. The purpose of this research was to evaluate aminopyralid applied alone at rates up to 2.5 oz/A or at reduced rates with clopyralid for long-term Canada thistle control.

The study was established at two locations, the North Dakota State University Agricultural Experiment Station in Fargo and on a wildlife production area (WPA) near Valley City, ND. The Fargo location was unused cropland with little grass cover while the WPA location had a dense bromegrass and bluegrass cover. Treatments were applied on June 12, 2012 at the WPA and on June 22, 2012 at Fargo. Canada thistle was in the rosette to bolted growth stages at both locations and was 8 to 24 inches tall when herbicides were applied.

All 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. 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 (WPA). Control averaged 98% 15 months after treatment (MAT) when aminopyralid was applied alone at application rates from 1.25 to 2.5 oz/A. Aminopyralid applied with clopyralid at 0.75 + 3.4 oz/A provided 97% Canada thistle control but would cost approximately $23/A which is comparable to aminopyralid alone at 1.75 oz/A at $22/A. Aminocyclopyrachlor plus chlorsulfuron at 1.9 + 0.75 oz/A provided 99% Canada thistle control and would cost about $26/A. 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. Canada thistle control with aminopyralid applied alone or with clopyralid at averaged over two locations in North Dakota.

Treatment[a]	Rate	Evaluation/MAT 2	13	15
	oz/A	% control		
Aminopyralid	1.25	83	97	98
Aminopyralid	1.75	88	99	98
Aminopyralid	2.5	93	99	99
Aminopyralid + chlorsulfuron	1.25 + 0.5	84	98	99
Aminopyralid + chlorsulfuron	1.75 + 0.75	91	98	99
Aminopyralid + clopyralid	0.75 + 3.4	92	98	97
Aminopyralid + clopyralid	1 + 4.6	94	99	99
Aminopyralid + clopyralid	1.25 + 5.75	94	99	98
Aminopyralid + AMCP[b] + chlorsulfuron	1.75 + 0.8 + 0.3	92	99	99
Aminocyclopyrachlor + chlorsulfuron[c]	1.9 + 0.75	88	99	99
Clopyralid	5.75	88	97	95
Chlorsulfuron	0.75	72	33	24
LSD (0.05)		8	7	6

[a]All treatments were applied with Activator 90 at 0.25%. Activator 90 by United Agri Products 7251 W. 4th St. Greeley, CO 80634.
[b]AMCP = aminocyclopyrachlor.
[c]Formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.

Evaluation of herbicide mixtures for leafy spurge control under trees or in an open field. Rodney G. Lym. (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Leafy spurge generally is well controlled with herbicide mixtures such as picloram plus 2,4-D, picloram plus imazapic, or quinclorac plus dicamba plus diflufenzopyr. These treatments are labeled for use in pasture and rangeland but not near trees or wooded areas. The biological control agents such as *Aphthona* spp. also control leafy spurge in open areas unless the soil is extremely sandy, but will not reduce the weed in shaded areas. The purpose of this research was to evaluate leafy spurge control under trees and open areas with various herbicide mixtures.

The first experiment to evaluate leafy spurge control under trees was established in a pasture at the NDSU Albert Ekre Grassland Preserve near Walcott, ND. The site was a natural wooded area of bur oak (*Quercus macrocarpa* Michx.) on the perimeter of a grazed pasture. Treatments were applied on May 30, 2012 when leafy spurge was in the vegetative to flowering stage and 18 to 30 inches tall. Herbicides were applied using a hand-held boom sprayer delivering 17 gpa at 35 psi. Experimental plots were 10 by 25 feet and replicated three times in a randomized complete block design with care taken to ensure the plots were generally shaded. The second experiment was established in an open pasture immediately across a county road from the wooded area. Treatment date and application methods were the same but the plot size was 10 by 30 feet with four replications. Leafy spurge control was evaluated visually using percent stand reduction compared to the untreated control.

The herbicides evaluated for leafy spurge control in the shaded area are generally considered safe to apply under most tree species (Table 1). Quinclorac applied at 12 oz/A provided 78 and 81% leafy spurge control 3 and 12 months after treatment (MAT), respectively. However, aminopyralid, fluroxypyr, and 2,4-D applied alone only provided an average of 64% control 3 MAT. Leafy spurge control averaged 73% 13 MAT with 2,4-D applied at 30 oz/A. Aminopyralid or fluroxypyr applied alone did not control leafy spurge. Aminopyralid applied with dicamba plus diflufenzopyr averaged 60% control 13 MAT which was similar to quinclorac applied alone (62%). Dicamba plus diflufenzopyr appeared to provide the most consistent increase in leafy spurge control when that combination was added to other herbicide mixtures, but was not applied alone in this study for direct comparison.

All herbicide treatments applied alone or in combination in the open pasture area provided excellent long-term leafy spurge control (93%) regardless of application rate (Table 2). During the study, *Aphthona* spp. flea beetles became widely established in the study area and aided in the long-term reduction of leafy spurge.

In summary, quinclorac applied alone or herbicide combinations that contained dicamba plus diflufenzopyr provided good leafy spurge control in shaded area under trees. These treatments could safely be used under many tree species to reduce leafy spurge. Unfortunately, *Aphthona* spp. flea beetles greatly reduced leafy spurge in the open pasture study site so no treatment differences were observed.

Table 1. Leafy spurge control under trees with aminopyralid applied alone or various herbicide mixtures on May 30, 2012 near Walcott, ND.

		Evaluation date		
		2012	2013	
Treatment[a]	Rate	28 Aug	28 June	21 Aug
	oz/A	% control		
Aminopyralid	1.75	60	10	0
Fluroxypyr	8	74	12	0
Quinclorac[b]	12	78	81	62
2,4-D	30	58	73	32
Aminopyralid + 2,4-D[c]	1.7 + 14	76	25	10
Aminopyralid + 2,4-D + dicamba + diflufenzopyr[d]	1.7 + 14 + 2 + 0.8	89	78	62
Aminopyralid+ 2,4-D + fluroxypyr[e]	1.7 + 14 + 8	92	9	7
Aminopyralid + 2,4-D + fluroxypyr + dicamba + diflufenzopyr	1.7 + 14 + 8 + 2 + 0.8	97	85	80
Aminopyralid + fluroxypr	1.75 + 8	80	25	5
Aminopyralid + fluroxypr	2.5 + 8	83	67	22
Aminopyralid + dicamba + diflufenzopyr	1.75 + 2 + 0.8	90	82	71
Aminopyralid + fluroxypyr + dicamba + diflufenzopyr	1.75 + 8 + 2 + 0.8	93	52	28
LSD (0.05)		9	33	23

[a]NIS at 0.25% was added to all treatments and was Activator 90 by United Agri Products 7251 W. 4th St. Greeley, CO 80634.
[b]Commercial formulation - Paramount and [d]Overdrive by BASF Corporation, 100 Campus Drive, Florham Park, NC 07932.
[c]Commercial formulation - ForeFront HL and [e]Vista XRT by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

Table 2. Leafy spurge control with picloram mixtures applied on May 30, 2012, in an open field near Walcott, ND.

		Evaluation date		
		2012	2013	
Treatment[a]	Rate	28 Aug	28 June	21 Aug
	oz/A	% control		
Picloram	8	92	96	86
Picloram	12	98	98	95
Picloram	16	97	96	96
Picloram + MSO	8 + 1 qt	97	96	95
Picloram + dicamba + diflufenzopyr[b]	8 + 2 + 0.8	94	97	95
Picloram + dicamba + diflufenzopyr	8 + 1 + 0.4 + 0.25	96	98	92
Picloram + 2,4-D[c]	8.7 + 32	95	94	93
Picloram + 2,4-D + dicamba + diflufenzopyr	8.7 + 32 + 2 + 0.8	95	98	92
Picloram + fluroxypyr[d]	8 + 8 + 7.2	95	96	95
Picloram + fluroxypyr + dicamba + diflufenzopyr	8 + 8 + 2 + 0.8	95	99	95
AMCP + chlorsulfuron[e]	0.8 + 0.3	94	93	91
AMCP + chlorsulfuron	1.9 + 0.75	96	98	94
AMCP + chlorsulfuron + picloram	0.8 + 0.3 + 4	94	99	93
AMCP + chlorsulfuron + aminopyralid	0.8 + 0.3 + 1.75	89	92	87
LSD (0.05)		4	7	8

[a]NIS at 0.25% was added to all treatments (except when MSO was used) and was 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 formulations - Grazon P+D and [d]Surmount by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.
[e]AMCP=aminocyclopyrachlor, commercial formulation - Perspective by E.I. duPont de Nemours and Company, 1007 Market Street, Wilmington, DE 19898.

Evaluation of experimental 2,4-D formulations for control of plumeless thistle, absinth wormwood, and spotted knapweed. Rodney G. Lym. (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). The herbicide 2,4-D is often used by land managers to provide short-term control of invasive weed species because of the low chemical cost compared to other herbicides. 2,4-D has a wide weed control spectrum, does not injure desirable grass species, and would be more widely used if weed control had a greater longevity. The purpose of this research was to compare 2,4-D formulations from Winfield Solutions to commonly used 2,4-D compounds for control of plumeless thistle, absinth wormwood, and spotted knapweed.

The 2,4-D formulations evaluated included AGH2007 an ester and AGH9008, an acid formulation which included sulfuric acid. The plumeless thistle study was established on May 26, 2011 on unused pasture near the North Dakota State Univeristy campus. The plants were in the rosette to early bolt growth stage and 6 to 14 inches tall. The absinth wormwood study was established in Valley City, ND on a county gravel pit site. Treatments were applied May 26, 2011 when absinth wormwood was in the early bolt growth stage and was 16 to 18 inches tall. There were two spotted knapweed studies which were established on unused land at the Hawley, MN airport on June 9, 2011 when the weed was in the rosette growth stage and 6 to 8 inches tall.

Plumeless thistle control averaged over all herbicides was 99% 2 months after treatment (MAT) (Table 1). Control remained at 95% or better for all treatments in August 2011. However, plumeless thistle control only averaged 75 and 50% with AGH02007 and AGH09008, respectively, 12 MAT compared to 95% with the standard treatment of aminopyralid at 0.75 oz/A. The 2,4-D LV6 commercial formulation provided 90% control 12 MAT.

The 2,4-D ester formulations AGH02007 and 2,4-D LV6 provided an average of 92% absinth wormwood control 2 MAT which was similar to aminopyralid at 0.75 oz/A at 82% (Table 2). In comparison, AGH09008 only provided 64% control 2 MAT. 2,4-D LV6 and aminopyralid provided 90 and 95% absinth wormwood control, respectively, 12 MAT compared to 90% with AGH02007 and 50% with AGH09008.

Picloram or aminopyralid was added as a tank mix with the AGH09008 2,4-D formulation for the first spotted knapweed study (Table 3). Spotted knapweed control averaged 98% up to 15 MAT regardless of treatment. No treatment controlled spotted knapweed by 24 MAT. AGH09008 did not control spotted knapweed when applied alone regardless of adjuvant (Table 4). Control was 21% or less 2 MAT and the study was terminated.

In summary, the 2,4-D ester formulation AGH02007 provided better plumeless thistle and absinth wormwood control than the 2,4-D sulfuric acid AGH09008 and was comparable to control from the standard aminopyralid treatment. AGH09008 did not control spotted knapweed.

Table 1. Evaluation of 2,4-D formulations for plumeless thistle control applied on May 26, 2011 at Fargo, ND.

		2011		2012
Treatment	Rate	20 July	16 Aug	17 May
	— oz/A —	— % control —		
AGH02007[a]	16.1	99	99	75
2,4-D LV6	15	100	100	90
2,4-D amine	15.2	97	96	46
AGH09008[b]	14	98	95	50
Aminopyralid[c] + Activator 90[d]	0.75 + 0.25 %	100	100	95
LSD (0.05)		NS	NS	20

[a]Commercial formulation - E-99 2,4-D ester and [b]2,4-D acid and sulfuric acid formulation from Winfield Solutions, LLC, P.O. Box 64589, St. Paul, MN 55164-0089.
[c]Commercial formulation - Milestone by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.
[d]Activator 90 from United Agri Products 7251 W. 4th St. Greeley, CO 80634.

Table 2. Evaluation of various 2,4-D formulations for absinth wormwood control applied on May 26, 2011 at Valley City, ND.

		2011		2012
Treatment	Rate	13 July	15 Sept	17 May
	— oz/A —	— % control —		
AGH02007[a]	16.1	87	80	75
2,4-D LV6	15	97	95	90
2,4-D amine	15.2	11	21	46
AGH09008[b]	14	64	65	50
Aminopyralid[c] + Activator 90[d]	0.75	82	97	95
LSD (0.05)		22	21	29

[a]Commercial formulation - E-99 2,4-D ester and [b]2,4-D acid and sulfuric acid formulation from Winfield Solutions, LLC, P.O. Box 64589, St. Paul, MN 55164-0089.
[c]Commercial formulation - Milestone by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.
[d]Activator 90 from United Agri Products 7251 W. 4th St. Greeley, CO 80634.

Table 3. Evaluation of various 2,4-D formulations for spotted knapweed control applied June 9, 2011, near Hawley, MN.

Treatment	Rate	2011		2012		2013
		2 Aug	7 Sept.	24 May	17 Aug	23 May
	— oz/A —	% control				
AGH09008[a] + picloram[b]	14 + 4	100	98	99	99	34
AGH09008 + picloram + InterLock[c]	14 + 4 + 4	99	100	100	100	38
Picloram	4	90	93	96	94	41
Aminopyralid[d]	0.75	89	95	97	96	26
AGH09008 + aminopyralid	14 + 0.75	99	100	100	99	29
AGH09008 + aminopyralid + InterLock	14 + 0.75 + 4	100	100	100	98	25
LSD (0.05)		2	4	3	4	NS

[a]2,4-D acid and sulfuric acid formulation and [c]depositon/retention agent from Winfield Solutions, LLC, P.O. Box 64589, St. Paul, MN 55164-0089.
[b]Commercial formulation - Tordon 22K and [d]Milestone by Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268-1189.

Table 4. Evaluation of AGH09008 applied with various adjuvants on June 9, 2011 for spotted knapweed control near Hawley, MN.

Treatment	Rate	2011 evaluation	
		6 July	2 Aug
	— oz/A —	% inj	% control
AGH09008[a]	14	3	10
AGH09008 + Prime Oil	14 + 1%	4.8	9
AGH09008 + SuperbHC	14 + 16	4.6	21
AGH09008 + SuperbHC + InterLock[b]	14 + 16 + 4	4	12
AGH09008 + DestinyHC + InterLock[b]	14 + 16 + 4	4.6	6
AGH09008 + AG08001	14 + 16	4.5	20
LSD (0.05)		NS	8

[a]2,4-D acid and sulfuric acid formulation and [b]depositon/retention agent from Winfield Solutions, LLC, P.O. Box 64589, St. Paul, MN 55164-0089.

Evaluation of various dicamba + 2,4-D formulations for absinth wormwood, spotted knapweed, and plumeless thistle 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, spotted knapweed, and plumeless thistle 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 or 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 24, 2012 when the weed was in the rosette growth stage and 3 inches tall.

The plumeless thistle study was established on May 24, 2012 on unused pasture near the NDSU campus. The plants were in the rosette to bolt growth stage and 6 to 12 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 regardless of herbicide treatment 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. 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.

Plumeless thistle control was 93% averaged across all treatments 2 MAT (Table 3). Plumeless thistle is a biennial species so no regrowth was expected. However, this weed spreads and often reinfests areas by seed. All herbicides reduced seedling establishment with an average of 94% control 12 MAT.

In summary, the 2,4-D and dicamba combination treatments controlled absinth wormwood and plumeless thistle as well as the standard treatment of aminopyralid. However, only aminopyralid controlled spotted knapweed. 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	
Treatment	Rate	13 June	9 July	22 Aug	3 June	19 Aug
	oz/A	% injury	% control			
Dicamba + 2,4-D[a]	3 + 8.6	4.1	59	92	82	88
Dicamba + 2,4-D + Preference + InterLock[b]	3 + 8.6 + 0.25% + 4	4.6	61	97	98	97
AGH11021[c]	28.32	4.8	68	96	96	95
AGH11021 + Preference + Interlock	28 + 0.25% + 4	4.3	57	94	76	85
Dicamba + 2,4-D	4 + 11.5	5.8	85	98	99	99
AGH11021	38	6.1	75	98	97	93
Aminopyralid[d]	1.25	4.4	84	99	90	87
LSD (0.05)		1.2	NS	NS	NS	NS

[a]Commercial formulation - Brash, [b]deposition/retention agent, and [c]2,4-D plus dicamba (3:1 v/v) from Winfield Solutions, LLC, P.O. Box 64589, St. Paul, MN 55164-0089.
[d]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	4.3	43	35	52
Dicamba + 2,4-D + Preference + InterLock[b]	3 + 8.6 + 0.25% + 4	4.3	46	37	38
AGH11021[c]	28	3.8	46	37	55
AGH11021 + Preference + Interlock	28 + 0.25% + 4	3.8	49	51	56
Dicamba + 2,4-D	4 + 11.5	6.1	63	52	48
AGH11021	38	6	55	48	62
Aminopyralid[d]	1.25	7.4	97	95	91
LSD (0.05)		1.6	17	17	22

[a]Commercial formulation - Brash, [b]deposition/retention agent, and [c]2,4-D plus dicamba (3:1 v/v) from Winfield Solutions, LLC, P.O. Box 64589, St. Paul, MN 55164-0089.
[d]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 plumeless thistle control applied on May 24, 2012, at Fargo, ND.

		Evaluation date			
		2012			2013
Treatment	Rate	18 June	20 July	16 Aug	4 June
	— oz/A —	% injury	—— % control ——		
Dicamba + 2,4-D[a]	3 + 8.6	3.9	96	95	96
Dicamba + 2,4-D + Preference + InterLock[b]	3 + 8.6 + 0.25% + 4	4.1	99	98	96
AGH11021[c]	28	4.0	98	99	95
AGH11021 + Preference + InterLock	28 + 0.25% + 4	4.5	85	91	88
Dicamba + 2,4-D	4 + 11.5	4.8	86	91	92
AGH11021	38	4.4	90	94	95
Aminopyralid[d]	1.25	5.1	97	98	96
LSD (0.05)		NS	NS	NS	NS

[a]Commercial formulation - Brash, [b]deposition/retention agent, and [c]2,4-D plus dicamba (3:1 v/v) from Winfield Solutions, LLC, P.O. Box 64589, St. Paul, MN 55164-0089.
[d]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 plumeless thistle control. Rodney G. Lym. (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). The perennial invasive weed species absinth wormwood and spotted knapweed 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 absinth wormwood and spotted knapweed 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 and spotted knapweed. 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 25, 2012 when the weed was in the rosette growth stage and 3 inches tall. The plumeless thistle study was established on May 24, 2012 on unused pasture near the NDSU campus. The plants were in the rosette to bolt growth stage and 6 to 12 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%.

Aminopyralid was the only treatment to control spotted knapweed which averaged 93%, 3 MAT (Table 2). AGH02007 at 16 oz/A provided 63% spotted knapweed control 1 MAT, but control with all other treatments that contained 2,4D only averaged 41%. Aminopyralid was the only treatment to control spotted knapweed 12 MAT and the study was discontinued (data not shown).

Plumeless thistle was well controlled by some but not all 2,4-D formulations (Table 3). For instance, AGH02007 a 2,4-D ester formulation applied at 16 oz/A provided 91% plumeless thistle control 2 MAT, but 2,4-D LVE applied at 15 oz/A averaged only 10% control. AGH09008 averaged 84% control 2 MAT compared to 68% with AGH11201, the 2,4-D plus dicamba premix. The addition of Preference plus Interlock increased plumeless thistle control with AGH11021 to 81% 2 MAT. Aminopyralid provided 99% plumeless thistle control 1 MAT. AGH02007 and AGH09008 or AGH11021 applied with Preference or Interlock provided similar plumeless thistle control to aminopyralid and averaged 97% 12 MAT.

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. AGH02007 alone and AGH 09008 or AGH11021 applied with Preference and InterLock provided similar plumeless thistle control to the standard aminopyralid treatment.

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	
Treatment	Rate	13 June	9 July	22 Aug	3 June	19 Aug
	oz/A	% injury	% control			
AGH02007[a]	16	6	75	92	100	90
2,4-D LVE	15	32	38	85	92	93
2,4-D amine	15	47	63	96	91	86
AGH09008[b]	14	56	80	96	98	96
AGH09008 + Preference[c] + InterLock[d]	14 + 0.25% + 4	55	78	97	99	98
AGH11021[e]	28	59	82	97	100	100
AGH11021 + Preference + InterLock	28. + 0.25% + 4	5	89	99	99	99
Aminopyralid[f]	0.75	64	89	99	99	99
LSD (0.05)		37	19	10	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 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.

Table 2. Evaluation of various 2,4-D formulations for spotted knapweed control applied on May 25, 2012 near Hawley, MN.

Treatment	Rate	2012 evaluation date		
		18 June	20 July	17 Aug
	oz/A	% injury	% control	
AGH02007[a]	16	63	68	61
2,4-D LVE	15	33	27	32
2,4-D amine	15	38	29	27
AGH09008[b]	14	34	34	27
AGH09008 + Preference[c] + InterLock[d]	14 + 0.25 % + 4	54	37	37
AGH11021[e]	28	43	34	29
AGH11021 + Preference + InterLock	28 + 0.25 % + 4	43	29	19
Aminopyralid[f]	0.75	79	90	93
LSD (0.05)		15	18	23

[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 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.

Table 3. Evaluation of various 2,4-D formulations for plumeless thistle control applied May 24, 2012 at Fargo, ND.

Treatment	Rate	Evaluation date			
		2012			2013
		18 June	20 July	16 Aug	4 June
	oz/A	% injury	% control		
AGH02007[a]	16	38	91	93	99
2,4-D LVE	15	10	10	11	0
2,4-D amine	15	25	48	69	73
AGH09008[b]	14	39	84	85	85
AGH09008 + Preference[c] + InterLock[d]	14 + 0.25 % + 4	40	88	92	95
AGH11021[e]	28	45	68	74	69
AGH11021 + Preference + InterLock	28 + 0.25 % + 4	48	81	82	96
Aminopyralid[f]	0.75	73	99	99	96
LSD (0.05)		11	22	21	31

[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 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.

Canada thistle control with aminopyralid plus clopyralid, Ellendale. Greg Endres and Kacey Holm. A field study was conducted in cooperation with Dow AgroSciences in CRP near Ellendale (Dickey County), ND to examine control of Canada thistle with early summer and fall application of an experimental mixture of aminopyralid and clopyralid [AMCLO (GF-2791): 2.8 lb ae/gal (0.5 lb aminopyralid + 2.3 lb clopyralid)]. Experimental design was a randomized complete block with three replications. Treatments were applied with a CO_2-pressurized backpack sprayer delivering 12 gal/A at 35 psi through 8001 flat fan nozzles to the center 6.7 ft of 10- by 30-ft plots. Summer treatments were applied July 22, 2011 to bolted to early bloom Canada thistle and fall treatments were applied September 28, 2011 to bolted to mature plants.

Canada thistle control was visually evaluated with excellent (97 to 99%) control with AMCLO at 20 and 24 fl oz/A applied during summer 11 months after treatment (MAT) on June 25, 2012 (Table). Summer-applied AMCLO at 12 and 16 fl oz/A, and Milestone at 5 and 7 fl oz/A provided good (80 to 88%) control 11 MAT. At 25 MAT (August 27, 2013), weed control was 77% with AMCLO at 24 fl oz/A. Fall-applied AMCLO at 16 and 20 fl oz/A generally provided good (78 to 90%) control 12 MAT (September 21, 2012) but at 23 MAT (August 27, 2013) the plants were only suppressed (71 to 73% control) with these treatments.

Table.

Herbicide		Canada thistle control		
Treatment[1]	Product rate	25-Jun-12	21-Sep-12	27-Aug-13
	fl oz/A		%	
Summer:				
AMCLO	8	72	53	33
AMCLO	12	80	70	37
AMCLO	16	82	79	27
AMCLO	20	97	87	53
AMCLO	25	99	94	77
Milestone	5	82	82	63
Milestone	7	88	87	43
Transline	16	38	53	20
Fall:				
AMCLO	12	98	69	47
AMCLO	16	99	90	73
AMCLO	20	89	78	71
Milestone	5	99	82	60
untreated check	x	0	0	0
CV (%)		10.8	22.8	52.1
LSD (0.05)		14	27	41

[1]AMCLO (GR-2971)=2.8 lb ae/gal (2.3 lb clopyralid + 0.5 lb aminpyralid); All treatments include NIS (Preference) at 0.25% v/v.

Canada thistle control with aminopyralid and aminocyclopyrachlor, Ellendale. Greg Endres and Kacey Holm. A field study was conducted in CRP near Ellendale (Dickey County), ND to examine long-term control of Canada thistle with aminopyralid and aminocyclopyrachlor. Experimental design was a randomized complete block with three replications. Treatments were applied October 1, 2010 at 46 F and 3 mph wind to 1- to 3-ft tall Canada thistle as mature plants with green to brown foliage with a CO_2-pressurized backpack sprayer delivering 12 gal/A at 35 psi through 8001 flat fan nozzles to the center 6.7 ft of 10- by 30-ft plots.

Canada thistle control visually evaluated 1 year after treatment (YAT) on September 28, 2011 was good (82 to 86%) with aminopyralid (Milestone) but was poor on August 27, 2013, which was near 3 YAT (Table). Aminocyclopyrachlor (MAT28) generally provided excellent (88 to 94%) Canada thistle control. At about 2 YAT, aminocyclopyrachlor provided good (85 to 87%) control but at the last date of evaluation control was poor.

Table.

Herbicide		Canada thistle control			
Treatment[1]	Product rate	22-Jul-11	28-Sep-11	21-Sep-12	27-Aug-13
	fl oz/A		%		
untreated check	x	0	0	0	0
2,4-D	32	32	0	0	0
dicamba + NIS	64	55	13	0	0
Stinger + 2,4-D	8.44 + 32	60	28	0	0
Milestone + NIS	5	96	86	73	45
Milestone + NIS	7	95	82	62	50
Overdrive + UAN + NIS	6 oz wt + 40	48	20	0	7
MAT28 + NIS	2 oz wt	99	94	85	48
MAT28 + Telar + NIS	2 oz wt + 0.167 oz wt	99	88	85	57
MAT28 + 2,4-D + NIS	2 oz wt + 32	99	90	87	52
CV (%)		11.2	19.0	17.8	72.3
LSD (0.05)		13	16	12	32

[1]Dicamba=Banvel (Arysta); NIS=Preference (Winfield) at 0.25% v/v; Milestone (Dow) contains aminopyralid; MAT28=aminocyclopyrachlor SG 50 (DuPont).

Canada thistle control with aminopyralid and aminocyclopyrachlor, New Rockford. Greg Endres and Tim Becker. A field study was conducted in a riparian area near New Rockford (Eddy County), ND to examine long-term control of Canada thistle with aminopyralid and aminocyclopyrachlor. Experimental design was a randomized complete block with three replications. Treatments were applied October 7, 2010 at 50 F and 3 mph wind to rosette- to mature-stage (≤36-inch tall) Canada thistle with a CO_2-pressurized backpack sprayer delivering 12 gal/A at 35 psi through 8001 flat fan nozzles to the center 6.7 ft of 10- by 30-ft plots.

Canada thistle control visually evaluated about 2 years after treatment (YAT) on September 26, 2012 was excellent (92 to 97%) with Milestone at 7 fl oz/A and all MAT28 treatments while good control (81%) was present with Milestone at 5 fl oz/A and Chaparral (Table). At 3 YAT, MAT28 and MAT28 plus Telar provided good control (80 to 83%) while Milestone, Chaparral, and MAT28 plus 2,4-D generally suppressed (60 to 73% control) Canada thistle.

Table.

Herbicide		Canada thistle control		
Treatment[1]	Product rate	29-Sep-11	26-Sep-12	3-Oct-13
	fl oz/A		%	
untreated check	x	0	0	0
2,4-D	32	0	13	0
dicamba + NIS	64	17	13	0
Stinger + 2,4-D	8.44 + 32	33	0	0
Milestone + NIS	5	77	81	60
Milestone + NIS	7	94	93	68
Chaparral + NIS	3 oz wt	85	81	68
MAT28 + NIS	2 oz wt	98	93	83
MAT28 + Telar + NIS	2 oz wt + 0.17 oz wt	99	97	80
MAT28 + 2,4-D + NIS	2 oz wt + 32	86	92	73
CV (%)		20.9	25.3	41.2
LSD (0.05)		21	24	31

[1]Dicamba=Banvel (Arysta); NIS=Preference (Winfield) at 0.25% v/v; Milestone and Chaparral (Dow) contain aminopyralid; MAT28=aminocyclopyrachlor SG 50 (DuPont).