Do Spray Adjuvants Increase Herbicide Effectiveness on Leafy Spurge?

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Leafy spurge is a serious weed problem in range and pastures of the Northern Great Plains. It displaces nearly all other species and thereby decreases both plant and animal biodiversity (Belcher and Wilson, 1989). Leafy spurge currently infests over 3.5 million acres in the Northern Great Plains and Intermountain West and costs an estimated $195 million annually in decreased forage and livestock production, decreased wildland and wildlife associated recreation, and increased soil and water conservation and control costs (Leitch et al, 1994).

Picloram is the most effective herbicide for leafy spurge control and when applied at 0.5 lb/A or less with 2,4-D provides better control than picloram applied alone (Lym and Messersmith, 1990a). Previous research at North Dakota State University has shown that less than 40% of the picloram applied to leafy spurge is absorbed and approximately 5% reaches the roots (Lym and Messersmith, 1990b; Lym and Moxness, 1989). A likely approach for increased picloram efficacy for leafy spurge control is to increase absorption with an adjuvant and thereby increase the amount of picloram translocated to the roots.

This study evaluated various adjuvants applied with picloram and picloram plus 2,4-D for increased leafy spurge control compared to the herbicides applied alone. More than 130 adjuvants were screened for potential use to increase picloram and 2,4-D phytotoxicity to leafy spurge in greenhouse studies. Adjuvants with the most potential in the greenhouse were further evaluated in a series of field trials.

Greenhouse:

Spray adjuvants were evaluated for their enhancement of picloram and picloram plus 2,4-D for leafy spurge control. Adjuvants (>130) were evaluated from many classes of additives. Spray adjuvants alone and with herbicides were applied to leafy spurge 4 to 8 inches tall in the vegetative growth stage. Oils and solvents which are not water soluble were mixed with 10% Atplus 300F emulsifier and were applied at 1 quart/acre while surfactants were applied at 0.5% of total spray volume. Picloram was applied at 1 oz (active ingredient)/acre and picloram plus 2,4-D applied at 0.5 plus 2 oz/acre, respectively. All treatments were applied in 17 gallons/acre spray volume. Foliar injury to leafy spurge topgrowth was evaluated visually 1, 7, and 14 days after treatment. Topgrowth was removed 14 days after treatment and the plants were allowed to regrow for four weeks. The number of plants that regrew was compared to the control. Spray adjuvants that caused foliar injury when applied without herbicide were not further evaluated.

Field:

Adjuvants that increased picloram or picloram plus 2,4-D efficacy on leafy spurge in the greenhouse were further evaluated in a series of field experiments. The first experiment evaluated picloram applied alone or with various spray adjuvants as spring- or fall-applied treatments. The experiment was established on June 7 and September 19, 1990 near Valley City, N.D., and June 24 and September 12, 1990 on the Sheyenne National Grasslands. A second experiment evaluated picloram plus 2,4-D applied alone or with various spray adjuvants and was established at the same locations and dates as the picloram experiment. All treatments were reapplied for both experiments on approximately the same dates in 1991 and 1992 for a total of three annual treatments.

The herbicides were applied using a tractor-mounted sprayer delivering 8.5 gallons/acre at 35 pounds per square inch. The plots were 10 by 30 feet in a randomized complete block design with four replications. Leafy spurge control evaluations were based on a visual estimate of percent stand reduction as compared to the untreated check.

The adjuvants evaluated in the field included the commercial surfactants, X-77, LI-700, Silwet L-77, Triton CS-7, Triton X-100, Triton N-57, and Surftac. Industrial surfactants evaluated were Gafac RA-600 (free acids of a complex organic phosphate ester), Emulphor ON-877 (polyoxyethylated fatty alcohol), Mapeg 400 MO (PEG 400 Monooleate), Pluronic L63 (block copolymers of propylene oxide and ethylene oxide), and Tetronic 1504 (block copolymers of ethylene oxide and propylene oxide). All adjuvants were applied at 0.5% of total spray volume except Silwet L-77 plus X-77 were applied at 0.25 plus 0.25% of total volume.

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Findings

Greenhouse:

Oil and surfactant spray adjuvants generally enhanced foliar injury from picloram or picloram plus 2,4-D compared to the herbicides applied without an adjuvant (Table 1). As commonly occurs with perennial weeds, the level of foliar injury did not always result in an equivalent reduction of leafy spurge regrowth. For example, picloram plus 2,4-D applied with SunSpray 11N resulted in 82% foliar injury but all plants regrew. Regrowth generally was reduced more by adjuvants applied with picloram plus 2,4-D than adjuvants applied with picloram alone. Adjuvant treatments that resulted in 50% or less regrowth included anionic and non-

Table 1. Spray adjuvants evaluated for their enhancement of picloram and picloram plus 2,4-D for leafy spurge control in the greenhouse. Only commonly available adjuvants and those that resulted in 50% or less regrowth (printed in bold) are listed[a].

Adjuvant or chemical class	Source	Leafy spurge: Picloram Injury	Picloram Regrowth	Pic + 2,4-D Injury	Pic + 2,4-D Regrowth
		%			
None		16	90	22	95
PETROLEUM OIL/SOLVENT					
Norpar 15	Exxon	60	87	82	**50**
SunSpray 11N	SUNOCO	57	100	82	100
VEGETABLE OIL					
Linseed	Cargill	67	62	79	75
Soybean	Cargill	78	62	81	82
MODIFIED VEGETABLE OIL					
Linseed fatty acids	NDSU	FI[b]			
Methylated canola	AGSCO	FI[b]			
Methylated sunflower	AGSCO	FI[b]			
COMMERCIAL SPRAY ADJUVANT					
Dash	BASF	FI[b]			
Surfactant WK	DuPont	84	62	75	**50**
Ortho X-77	Chevron	52	75	74	69
LI-700	Loveland	55	**50**	71	69
Triton CS-7	Rohm and Haas	60	100	74	55
Herbex	Unknown[c]	64	100	58	**50**
Surfel	Rhone-Poulenc	...	...	70	**50**
Inhance	MCA Labs	58	88	50	**0**
SCI-40 (acid buffer)	Unknown[c]	50	75	50	**31**
Silwet L77	**Loveland**	50	100	85	**50**
Activater 90	Loveland	45	100	60	100
Surphtac	Brea Ag Service	45	100	80	**50**
Triton AG-98	Rohm and Haas	71	60	60	**44**
SURFACTANT BLENDS					
Triton X207	Rohm and Haas	62	75	88	**50**
T-Mulz O	Harcros Chemical	53	75	60	**31**
Triton AG190	Rohm and Haas	...	...	85	**25**
Sponto N710	Witco	50	87	80	**50**
Sponto AK3158	Witco	82	62	69	58
Sponto AK3167	Witco	68	**50**	95	**0**
Sponto 140T	Witco	67	75	92	**50**
Sponto 150T	Witco	50	87	75	**50**
NONIONIC SURFACTANT (Polyethylene glycol based)					
Mapeg 400 MOT	Mazer Chemical	71	75	77	**42**
Mapeg 200 MOT	Mazer Chemical	...	...	72	**44**

Adjuvant or chemical class	Source	Leafy spurge: Picloram Injury	Picloram Regrowth	Pic + 2,4-D Injury	Pic + 2,4-D Regrowth
		%			
NONIONIC SURFACTANT					
Alcohol ethoxylate					
39% EO	Proctor/Gamble	52	88	78	**50**
Igepal CO530	Rhone-Poulenc	70	**38**	74	54
Triton AG190	Rohm and Haas	70	**50**	60	69
Triton N57	Rohm and Haas	80	100	73	**50**
Triton X100	Rohm and Haas	85	**25**	90	62
Triton X165	Rohm and Haas	70	**50**	72	75
Triton X405	Rohm and Haas	65	**50**	60	100
Triton X300	Rohm and Haas	40	**50**	78	**50**
Triton X363M	Rohm and Haas	50	88	68	**25**
ANIONIC SURFACTANTS					
Witconate P10-59	Witco	68	62	69	**42**
ORGANIC PHOSPHATE ESTER					
Gafac RS710	Rhone-Poulenc	85	**25**	76	62
Gafac RS610	Rhone-Poulenc	80	**25**	73	**44**
Gafac RS410	Rhone-Poulenc	70	100	73	**19**
Gafac RE610	Rhone-Poulenc	60	**50**	78	60
FERTILIZER					
NH_4SO_4		40	75	60	**50**
Urea		50	75	50	**50**
28-0-0		50	75	70	**38**
10-34-0		40	88	52	**25**
NH_4NO_3+X77		90	88	52	**12**
Urea + X77		90	75	55	**38**
28-0-0 + X77		80	62	60	**12**
10-34-0 + X77		80	75	50	**25**
BLOCK COPOLYMER ETHYLENE OXIDE/PROPYLENE OXIDE					
Pluronic 10R5	BASF	72	75	80	75
BLOCK COPOLYMER PROPYLENE OXIDE/ETHYLENE OXIDE					
Pluronic L62	BASF	70	75	80	88
MISCELLANEOUS					
Lauryl alcohol	Sigma	...	...	60	**50**
Surfadone LP100	Rhone-Poulenc	50	75	75	**50**

[a]Contact the senior author for a complete list of adjuvants evaluated.
[b]Adjuvant resulted in foliar injury and was not further evaluated.
[c]Unknown indicates product is no longer manufactured or proprietary rights have been sold to private ownership.

ionic surfactants that represent a range of lipophilic and hydrophilic chemistries (Table 1). Fertilizers, 28-0-0 and 10-34-0, enhanced picloram plus 2,4-D phytotoxicity to leafy spurge and reduced regrowth.

Field:

Leafy spurge control with picloram or picloram plus 2,4-D was similar when annually applied alone or with an adjuvant for 3 years (Figures 1 and 2). There was some variation in control depending on the growing season and location. However, control was similar regardless of location 36 months after the first treatment so data have been combined by experiment over location and adjuvant.

Leafy spurge control was increased when an adjuvant was applied with picloram at 0.25 lb/acre applied in the spring 24 months after the first treatment (Figure 1A). The adjuvants X-77 plus Silwet L-77, Mapeg 400 MO, Gafac RA-600, and Emulphor ON-877 tended to increase leafy spurge control with picloram more than the other adjuvants evaluated (data not shown). However, control was similar regardless of adjuvant 36 months after the first treatment and averaged 87% control over both locations.

Control with picloram at 0.5 lb/acre applied in the fall was similar regardless whether applied alone or with a spray adjuvant at either location (Figure 1B). Leafy spurge control only averaged 70% with the fall-applied picloram treatments (Figure 1B) compared to 87%, when spring-applied (Figure 1A) even through twice as much herbicide had been applied in the fall.

In the second experiment, no adjuvant increased leafy spurge control when applied with picloram plus 2,4-D in the spring (Figure 2A). However, several adjuvants including

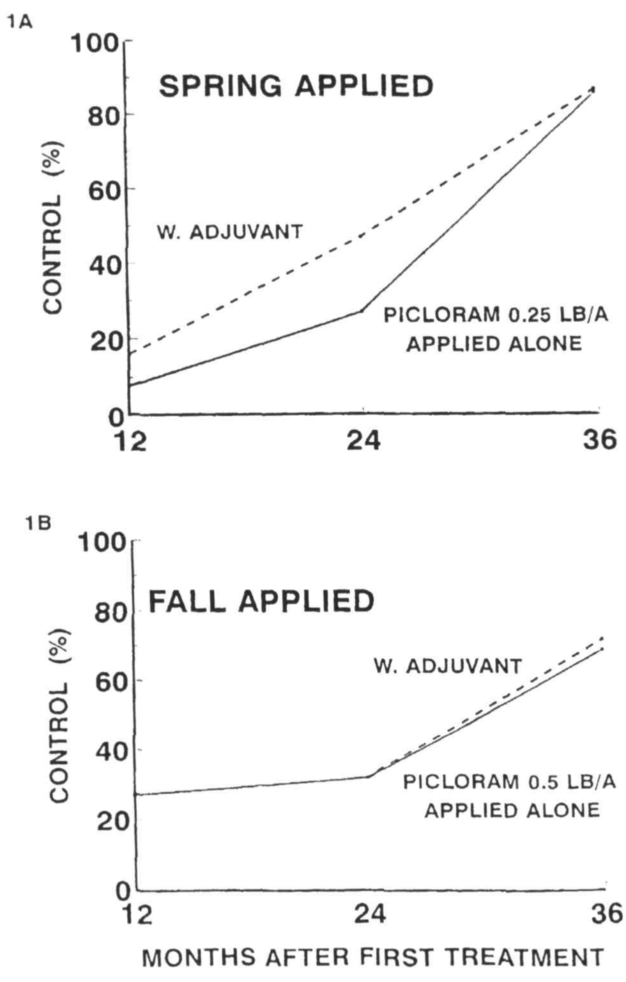

Fig 1. *Leafy spurge control in the field with picloram applied annually either alone or with various adjuvants for 3 years at two locations in North Dakota. Picloram was applied annually at 0.25 lb/A in the spring (A) or at 0.5 lb/A in the fall (B), and adjuvants were applied at 0.5% of total spray volume.*

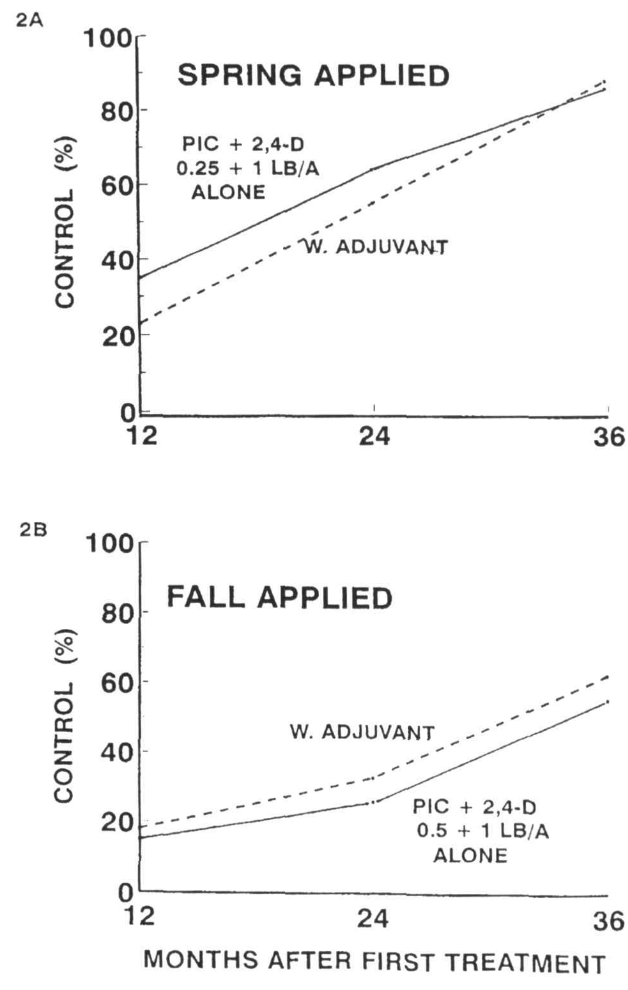

***Fig 2**. Leafy spurge control in the field with picloram plus 2,4-D applied annually either alone or with various adjuvants 3 years at two locations in North Dakota. Picloram plus 2,4-D were applied at 0.25 plus 1 lb/A in the spring (A) or 0.5 plus 1 lb/A in the fall (B), and adjuvants were applied at 0.5% of total spray volume.*

Triton CS7, LI-700, and Triton N57 tended to decrease control when applied with picloram plus 2,4-D compared to the herbicides applied alone (data not presented). The combination of 2,4-D plus these adjuvants may have resulted in rapid phytotoxicity and reduced picloram translocation to the roots and decreased control.

As with picloram alone, control with picloram plus 2,4-D applied in the fall was similar regardless of adjuvant (Figure 2B). Again leafy spurge control was higher when picloram plus 2,4-D were spring-applied compared to fall-applied (88 to 63%) even though the fall treatment contained twice as much picloram.

Summary

Leafy spurge control with annual picloram or picloram plus 2,4-D treatments was similar whether applied alone or with a variety of adjuvants in the field. The increase in control when picloram was applied with various adjuvants in the greenhouse may have been overcome by picloram residue in the soil. Occasionally, a particular adjuvant increased control with picloram at one location but the increase was not consistent from year to year or location to location. This occasional increase in control from the addition of an adjuvant may be useful when leafy spurge is growing under stress such as very dry or high temperature conditions. Under those conditions a commonly used inexpensive adjuvant such as X-77 increased leafy spurge control with picloram or picloram plus 2,4-D as much as the more specialized or expensive adjuvants.

References

Belcher, J. W. and S. D. Wilson. 1989. Leafy spurge and the species composition of a mixed-grass prairie. J. Range Manage. 42:172-175.

Leitch, J. A., F. L. Leistritz, and D. A. Bangsund. 1994. Economic effect of leafy spurge in the upper Great Plains: methods, models, and results. Agric. Econ. Rep. No. 316, North Dakota State Univ., Fargo, 58105. 8 p.

Lym, R. G. and C. G. Messersmith. 1990a. Cost-effective long-term leafy spurge (*Euphorbia esula*) control with herbicides. Weed Technol. 4:635-641.

Lym, R. G. and C. G. Messersmith. 1990b. Effect of temperature on picloram absorption and translocation in leafy spurge (*Euphorbia esula*). Weed Sci. 38:471-474.

Lym. R. G. and K. D. Moxness. 1989. Absorption, translocation, and metabolism of picloram and 2,4-D in leafy spurge (*Euphorbia esula*). Weed Sci. 37:498-502.