B-1568
April 1987

Controlling Weeds & Volunteer Crops During Fallow Periods

THE TEXAS AGRICULTURAL EXPERIMENT STATION/Neville P. Clarke, Director/The Texas A&M University System/College Station, Texas

Contents

Cover Photo: Kill of fully tillered wheat when sprayed with 0.25 pounds per acre of glyphosate in 7 gallons per acre of spray carrier.

Keywords: Pigweed/barnyardgrass/witchgrass/stinkgrass/wheat/barley/corn/sorghum/glyphosate/paraquat/controlled droplet applicator.

Controlling Weeds and Volunteer Crops During Fallow Periods

A. F. Wiese and E. W. Chenault
Professor and Research Associate
The Texas Agricultural Experiment Station
Bushland, Texas

Summary

Because postemergence herbicides are the heart of most no-tillage systems, research has been conducted since 1978 to determine the lowest rates of paraquat (1,1′-dimethyl-4,4′-bipyridinium ion), glyphosate [N-(phosphonomethyl)glysine], and other herbicides to kill common annual weeds and volunteer crops during fallow periods between crops. Using carrier volumes of 7 gallons per acre (gpa) with fan tip nozzles and 3 gpa or less with a controlled droplet applicator (CDA) increased weed control compared to using 26 gpa of carrier. The best control with the two herbicides occurred when small weeds growing in wet soil were sprayed. Pigweed (*Amaranthus palmeri* S. Wats.) that were 1.5 inches tall or less were controlled with 0.12 pounds per acre (lb/A) paraquat or glyphosate. With 2-inch pigweed, paraquat at 0.25 lb/A and glyphosate at 0.19 lb/A were required to give 90 percent or more control when applied with a CDA. By comparison, the minimum effective rate for the two herbicides was 0.5 lb/A when 26 gpa of carrier volume was used.

Barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.] that was 3 to 6 inches tall and under stress for moisture was not controlled with paraquat at 0.25 lb/A with any amount of carrier. Glyphosate at 0.19 lb/A applied with fan nozzles at 7 gpa or a CDA at 1.2 or 0.55 gpa carrier volume gave over 90 percent control of the barnyardgrass.

With carrier volumes of either 3 or 26 gpa, control of witchgrass (*Panicum capillare* L.) or stinkgrass [*Eragrostis cilianensis* (All.) E. Mosher] was accomplished with 0.25 lb/A glyphosate. Paraquat at 0.25 lb/A only controlled witchgrass when applied at 3 gpa of carrier through a CDA. Small volunteer wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.) were controlled with paraquat and glyphosate each at 0.25 lb/A. Glyphosate at 0.25 lb/A controlled small volunteer sorghum [*Sorghum bicolor* (L.) Moench] and corn (*Zea mays* L.).

Introduction

No-tillage leaves crop residues on the soil surface, thus offering the greatest potential for reducing soil erosion and conserving soil water of any innovation in the 20th century. In order for no-tillage systems to be successful, herbicides must control weeds in both crops and fallow periods (Wiese and Staniforth 1973). Control of weeds and volunteer crops with herbicides must be at the lowest possible rates of herbicide to compete with conventional tillage before no-tillage can be adopted. The purpose of these studies was to evaluate several herbicides, volumes of herbicide spray carrier, and additives to find the lowest possible rate for controlling with postemergence herbicides the annual weeds that grow during fallow periods in no-tillage systems in the Southern Great Plains.

Materials and Methods

Studies to control annual weeds and volunteer crops during noncrop periods were conducted at the U.S. Department of Agriculture Conservation and Production Research Laboratory, Bushland, Texas from 1978 through 1983. The soil was Pullman clay loam (fine, mixed, thermic family of Torrertic Paleustolls, order Mollisols), with equal parts of sand, silt, and clay; 1.5 percent organic matter; and a pH of 6.5 at the soil surface (Mathers, et al. 1963). Since 1979, pigweed [primarily *Amaranthus palmeri* S. Wats. and *A. hybridus* (L.)], barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.], witchgrass (*Panicum capillare* L.), and stinkgrass [*Eragrostis cilianensis* (All.) E. Mosher] have been sprayed at various stages of growth. Visual plant vigor ratings at treatment which reflected soil water conditions were excellent, good, fair, or poor. Volunteer stands of winter wheat (*Triticum aestivum* L.), winter barley (*Hordeum vulgare* L.), sorghum [*Sorghum bicolor* (L.) Moench], and corn (*Zea mays* L.) also were sprayed. Herbicides used and rates applied are shown in subsequent tables. Additional information including trade name and manufacturer is in the Appendix. In some studies, herbicides were sprayed at 26, 7, 3, 1.2, or 0.55 gallons per acre (gpa) of spray carrier. The 26 and 7 gpa volumes were obtained with tapered fan nozzles operated at 30 pounds per square inch (psi) and at a speed of 3 miles per hour. The three lowest volumes were applied through controlled droplet applicators (CDA). From 1978 through 1980, a hand held "Herbi" was used for CDA application, and after that, a "Micro Max" was used.[1] Both CDA's generated droplets 250 microns in diameter. All applications except with the "Herbi" were made with applicators mounted on a small tractor. Spray additives were used with most treatments, and amounts are shown in the tables. Additives used were X-77 (alkylaryl polyoxyethylene glycols free fatty acids and isoproponal), Ag 98 (alkylaryl polyoxyethylene glycols), WK (trimethylnonyl polyethoxyethanol), 411F type crop oil concentrate (COC), and a cotton oil based product with 7 percent emulsifier. Plot size varied from 5 to 15 feet wide and 25 to 75 feet long. In all studies, treatments were replicated three times in a randomized block design. Mean significance was tested with a combination of analysis of variance and the least significance difference at $P = 0.05$.

[1]"Herbi" and "Micro Max" are products of the Micron Corporation, P.O. Box 19698, Houston, Texas 77024.

Results

Pigweed

Results from seven studies conducted on pigweed since 1978 are given in Tables 1 through 5. Three studies were conducted comparing carrier volumes of 26 and 3 gpa with several rates of paraquat and glyphosate (Table 1). Pigweed size varied from 6 to 30 inches and the weeds were growing vigorously with good soil moisture. Control was markedly better with 3 gpa of carrier than with 26 gpa. Six-inch weeds were a little easier to control than larger weeds, especially with 26 gpa of carrier. Two-inch pigweed were easy to control with paraquat or glyphosate (Table 2). Percent control exceeded 92 percent with 0.25 lb/A of either paraquat or glyphosate sprayed with either 3 or 7 gpa carrier.

In another study, paraquat and glyphosate each at 0.18 and 0.25 lb/A were applied in late June to pigweed that were 2 to 4 inches tall with poor growth because the soil moisture level was approaching the wilting point. Carrier volume varied from 0.55 to 26 gpa (Table 3). A cotton-based oil additive containing 7 percent emulsifier was compared to Ag 98 surfactant. There was not a consistent difference among the additives. As carrier volume was reduced, control of pigweed increased. Paraquat gave some initial burn of pigweed leaves 6 days after treatment, but this result did not persist. About 5 weeks after application, effects of paraquat on the pigweed had disappeared from all carrier volumes except 0.55 gpa (Table 3). Control with glyphosate was better with 7, 1.2, and 0.55 gpa of carrier than with 26 gpa carrier.

In a fourth study, several different herbicides were applied with 26 gpa carrier to pigweed at three stages of growth (Table 4). Pigweed were germinated with an irrigation about September 1. By September 7, they had two true leaves, and 5 days later were 1.5 inches tall with excellent or good vigor. A week later, pigweed were 6 inches tall and had dried out the soil and were in poor growing condition. Timing of application was critical. Control of small pigweed that had two true leaves or were 1.5 inches tall was excellent with bromoxynil (3,5-dibromo-4-hydroxybenzonitrile). It took 0.25 lb/A to eliminate the pigweed with two true leaves, but 0.38 lb/A was required to eliminate 1.5-inch pigweed. Only bromoxynil at 0.5 lb/A gave 80 percent control of 6-inch pigweed under dry conditions. The

Table 1. Effect of carrier volume on control of pigweed with paraquat and glyphosate

Herbicide plus additive	Herbicide rate	Carrier volume	Percent pigweed control by year		
			1978	1980	1982
	(lb/A)	(gpa)			
Paraquat + 0.5% S[a]	0.25	3	100	83	86
	0.5		100	97	95
	1.0		100	100	99
Glyphosate + 0.5% S	0.25		100	99	95
	0.5		100	99	99
	1.0		100	99	—
Paraquat + 0.5% S	0.25	26	23	20	37
	0.5		80	68	72
	1.0		91	95	92
Glyphosate + 0.5% S	0.25		65	17	34
	0.5		100	58	83
	1.0		100	99	100
LSD 0.05			20	13	9
Pigweed height, inches			6	10	30
Plant vigor			good	good	excellent
Application date			8-31-78	8-12-80	7-9-81
Evaluation date			9-12-78	9-8-80	8-6-81

[a]S = Surfactant and was either X-77 or WK.

pigweed, 1.5 inches or less, also were controlled at 94 percent or more with paraquat, sulfosate (trimethylsulfonium carboxy methylamino methylphosphonate), and glyphosate each at 0.12 lb/A. Fomesafen (5-[2-chloro-4-(trifluoro-methyl)phenoxy]-N-(methylsulfonyl)-2-nitrobenzamide) gave 90 percent or more control of small pigweed at 0.12 lb/A. Fenoxaprop (±)-2-[4[(6-chloro-2-benzoxazolyl)oxy]phenoxy]propanoic acid) and dimethylamine salt of dicamba (3,6-dichloro-2-methoxybenzoic acid) gave 76 percent or less control at 0.12 lb/A.

Another study compared several herbicides for control of 4-inch pigweed and 5-inch barnyardgrass with poor vigor (Table 5). The following herbicides were applied in 26 gpa of spray carrier: fluazifop ((±)-2-[4-[[5-trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoic acid), sethoxydim (2-[1-(ethoxyimino)butyl]-5-[2(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one), haloxyfop (2-[4-[[3-chloro-5-(trifluoromethyl)-2-pyridinyl] oxy]phenoxy] propanoic acid), quizalofop (2-[4-[(6-chloro-2-quinoralinyl) oxy]phenoxy]-propionic acid, ethyl ester), glyphosate, paraquat, sulfosate, and fenoxaprop. Rates varied from 0.18 to 0.25 lb/A and each herbicide was applied alone or tank mixed with 1.0 lb/A 2,4-D ester. The 2,4-D with glyphosate, sulfosate, or fenoxaprop effectively controlled pigweed, but control of barnyardgrass was 80 percent or less with herbicides other than glyphosate. Adding 2,4-D to sulfosate and glyphosate did not enhance pigweed control. Adding 2,4-D to fenoxaprop did not improve pigweed control and control of barnyardgrass was unsatisfactory with or without 2,4-D. Adding 2,4-D to paraquat improved pigweed control, but control of drought stressed barnyardgrass was poor.

Table 2. Effect of carrier volume on control of small pigweed with paraquat and glyphosate

Herbicide plus additive	Herbicide rate	Percent pigweed control at two carrier volumes	
		3 gpa	7 gpa
	(lb/A)		
Paraquat + 0.5% X-77	0.19	93	—
	0.25	97	98
	0.38	100	100
	0.5	—	100
Glyphosate + 0.5% X-77	0.19	72	—
	0.25	92	99
	0.39	—	99
	0.5	100	100
LSD 0.05		8	
Pigweed height, inches		2	
Plant vigor		fair	
Evaluation date		8-13-82	
Scoring date		8-25-82	

Barnyardgrass

Control of 3- to 6-inch barnyardgrass growing in dry soil with poor vigor was attempted with paraquat and glyphosate at 0.18 and 0.25 lb/A applied in carrier volumes of 26, 7, 1.2, or 0.55 gpa (Table 6). The cotton oil additive was compared to Ag 98 surfactant at all levels of carrier volume. There were no consistent differences among additives. Control with the two herbicides applied in a carrier volume of 26 gpa was

not above 66 percent 5 weeks after treatment. With the exception of a carrier volume of 0.55 gpa, all leaf burn from paraquat had disappeared 5 weeks after application. Glyphosate at 0.25 lb/A, on the other hand, gave 95 percent or more control at carrier volumes of 7 gpa or less at the final evaluation date.

Witchgrass

Excellent control of large mature witchgrass was obtained with glyphosate at 0.12 lb/A applied in 3 gpa of carrier volume regardless of plant vigor. If plant vigor was fair, but not poor, 0.12 lb/A of glyphosate killed witchgrass when applied in 26 gpa of carrier volume (Table 7). At 26 gpa, 0.25 lb/A of glyphosate gave 95 percent or more control in each of 2 years. Paraquat at 0.25 lb/A gave excellent control the year when soil moisture and plant vigor were fair, but failed when the soil was dry. MSMA gave excellent control of witchgrass at 2.0 and 4.0 lb/A irrespective of carrier volume or soil moisture.

Stinkgrass

Glyphosate controlled stinkgrass at 0.25 lb/A (Table 7). Paraquat and MSMA failed regardless of application rate. Herbicides were applied in a carrier volume of 26 gpa.

Volunteer Wheat

In 1978, 1982, and 1983, paraquat and glyphosate were applied to wheat in either 26 or 3 gpa of spray carrier (Table 8). In two of the five experiments, carrier volume of 7 gpa also was compared. In 1978 and October 1982, 3 gpa applied with a CDA and 26 gpa applied with fan nozzles were compared on small wheat that had not been tillered. In each case, the lower amount of carrier resulted in more kill of wheat at the same rates of paraquat or glyphosate. In August 1982 when 3 and 7 gpa were compared, the 7 gpa carrier volume was comparable or better than the lower carrier volume. Once wheat had tillered, there was not a marked difference in volume of carrier. If wheat had jointed, application at 3 gpa with a CDA was not effective. Control was much better with either paraquat or glyphosate applied in 7 or 26 gpa; however, control with the herbicides at this stage was not as good as when smaller wheat was sprayed. Herbicides

Table 3. Pigweed control with paraquat and glyphosate applied in several carrier volumes[a]

Herbicide	Herbicide rate	Additive and rate	Carrier volume (gpa)			
			26	7	1.2	0.55
	(lb/A)		Percent pigweed control 6 days after treatment			
Glyphosate	0.18	Oil 1 qt/A[b]	13	76	99	99
		Oil 2 qt/A	8	76	99	—
		Ag 98[c]	28	86	99	99
Glyphosate	0.25	Oil 1 qt/A	13	46	98	93
		Oil 2 qt/A	18	37	100	—
		Ag 98	27	67	91	99
Paraquat	0.18	Oil 1 qt/A	—	—	—	73
		Oil 2 qt/A	63	43	43	—
		Ag 98	—	—	—	53
Paraquat	0.25	Oil 1 qt/A	63	56	23	72
		Oil 2 qt/A	70	43	16	—
		Ag 98	73	80	33	88
LSD 0.05				8		
			Percent pigweed control 35 days after treatment			
Glyphosate	0.19	Oil 1 qt/A	0	95	99	91
		Oil 2 qt/A	0	96	96	—
		Ag 98	13	98	98	95
Glyphosate	0.25	Oil 1 qt/A	23	63	99	98
		Oil 2 qt/A	36	67	99	—
		Ag 98	36	85	99	85
Paraquat	0.18	Oil 1 qt/A	—	—	—	73
		Oil 2 qt/A	0	0	0	—
		Ag 98	—	—	—	0
Paraquat	0.25	Oil 1 qt/A	0	0	0	86
		Oil 2 qt/A	0	0	0	—
		Ag 98	0	0	0	43
LSD 0.05				6		

[a]Pigweed 2 to 4 inches at treatment on 6/22/83. Plant vigor was poor because the soil moisture level was approaching wilting point.

[b]Cotton oil 93 and 7 percent emulsifier.

[c]One percent by volume of carrier of Ag 98 used on 1.2 and 0.55 gpa, and 0.5 percent used with 26 and 7 gpa. Also, an extra 7 percent X-77 by volume of carrier was added to the oil to make a sprayable emulsion on the 1.2 and 0.55 gpa carrier rates of carrier.

in 7 gpa of carrier gave the highest control, and glyphosate at 0.5 lb/A gave 93 percent control of wheat that was jointed. When herbicides were applied with a CDA at 3 gpa, small droplets apparently did not penetrate the foliage and there was no control of the wheat in the jointing stage.

Volunteer Barley

Barley with good or excellent plant vigor was sprayed with paraquat and glyphosate in carrier volumes of 3 or 26 gpa (Table 9). This crop was easiest to kill if sprayed before tillering. Using 3 gpa of spray carrier, 0.25 lb/A of paraquat eliminated barley at the 4 to 5 leaf stage. It took 0.25 lb/A of glyphosate to kill barley with 4 to 5 leaves sprayed with either 26 or 3 gpa of carrier. Control was about the same or better after the barley had tillered and little control was achieved once barley had jointed. No control of jointing barley was obtained with either paraquat or glyphosate applied with a CDA at 3 gpa.

Volunteer Sorghum

Control of sorghum that was 4 inches tall with paraquat was better at 3 gpa carrier than with 26 gpa (Table 10). Glyphosate at 0.25 lb/A gave 95 percent or more control with either 3 or 26 gpa carrier.

Table 4. Effect of pigweed stage of development on herbicides activity when applied in a carrier volume of 26 gpa

Herbicide plus additive	Herbicide rate	Percent pigweed control at three growth stages		
		2-leaf	1.5 inches	6 inches
	(lb/A)			
Bromoxynil	0.25	99	87	23
	0.38	100	98	60
	0.50	100	99	80
Paraquat + 0.25% WK	0.12	99	96	23
Sulfosate + 0.25% WK	0.12	98	94	7
Glyphosate + 0.25% WK	0.12	97	96	7
Fenoxaprop + 0.25% WK	0.12	76	73	15
Fomesafen	0.12	92	90	20
	0.25	92	97	28
	0.38	98	91	35
Dicamba	0.06	58	26	0
	0.12	66	33	3
	0.25	75	46	3
LSD 0.05		12	12	15
Plant vigor		excellent	good	poor
Treatment date		9-7-83	9-12-83	9-19-83
Evaluation date		9-21-83	9-21-83	9-27-83

Table 5. Control of pigweed and barnyardgrass with herbicides applied in a carrier volume of 7 gpa

Herbicide plus additive	Herbicide rate	Percent control	
		Pigweed	Barnyardgrass
	(lb/A)		
Fluazifop + COC	0.18	0	0
Fluazifop + 2,4-D + COC[a]	0.18 + 1	98	23
Sethoxydim	0.18	13	32
Sethoxydim + 2,4-D + COC	0.18 + 1	91	80
Haloxyfop + COC	0.18	22	3
Haloxyfop + 2,4-D + COC	0.18 + 1	93	12
Quizalofop + COC	0.18	20	83
Quizalofop + 2,4-D + COC	0.18 + 1	67	58
Sulfosate + Ag 98 [b]	0.18	97	80
Sulfosate + 2,4-D + Ag 98	0.18 + 1	97	80
Glyphosate + Ag 98	0.18	94	88
Glyphosate + 2.4-D + Ag 98	0.18 + 1	97	85
Glyphosate + 2,4-D + Ag 98	0.25 + 1	90	91
Paraquat + Ag 98	0.18	78	38
Paraquat + 2,4-D + Ag 98	0.18 + 1	95	30
Paraquat + 2,4-D + Ag 98	0.25 + 1	93	40
Fenoxaprop + Ag 98	0.25	22	43
Fenoxaprop + 2,4-D + Ag 98	0.25 + 1	93	45
LSD 0.05		24	25
Weed height		4 inches	5 inches
Plant vigor		poor	poor
Treatment date		6-22-83	6-22-83
Evaluation date		8-2-83	8-2-83

[a]Agridex crop oil concentrate at 1 qt/A.

[b]Ag 98 surfactant at 0.5 percent of carrier volume.

Table 6. Barnyardgrass control with several carrier volumes and additives[a]

Herbicide	Herbicide rate	Additive and rate	Carrier volume (gpa) 26	7	1.2	0.55
	(lb/A)		Percent barnyardgrass control 6 days after treatment			
Glyphosate	0.19	Oil 1 qt/A[b]	11	67	92	99
		Oil 2 qt/A	0	67	93	—
		Ag 98[c]	23	76	97	94
Glyphosate	0.25	Oil 1 qt/A	6	26	76	93
		Oil 2 qt/A	9	43	83	—
		Ag 98	23	53	87	98
Paraquat	0.18	Oil 1 qt/A	—	—	—	53
		Oil 2 qt/A	37	33	33	—
		Ag 98	—	—	—	63
Paraquat	0.25	Oil 1 qt/A	57	47	36	67
		Oil 2 qt/A	53	23	30	—
		Ag 98	67	60	43	78
LSD 0.05				8		
			Percent barnyardgrass control 35 days after treatment			
Glyphosate	0.19	Oil 1 qt/A	0	67	99	95
		Oil 2 qt/A	0	77	96	—
		Ag 98	6	87	99	97
Glyphosate	0.25	Oil 1 qt/A	0	98	99	95
		Oil 2 qt/A	16	99	99	—
		Ag 98	66	98	99	93
Paraquat	0.18	Oil 1 qt/A	—	—	—	3
		Oil 2 qt/A	0	0	0	—
		Ag 98	—	—	—	0
Paraquat	0.25	Oil 1 qt/A	0	0	0	66
		Oil 2 qt/A	0	0	0	—
		Ag 98	0	0	0	36
LSD 0.05				6		

[a]Barnyardgrass 3 to 6 inches at treatment on 6/22/83. Plant vigor was poor because the soil moisture level was approaching wilting point.

[b]Cotton oil 93 and 7 percent emulsifier.

[c]One percent by volume of carrier of Ag 98 used on 1.2 and 0.55 gpa, and 0.5 percent used with 26 and 7 gpa. Also, an extra 1 percent X-77 by volume of carrier was added to the oil to make a sprayable emulsion on the 1.2 and 0.55 gpa carrier rates.

Volunteer Corn

Two studies were conducted. In each case, corn was 10 inches tall and plant vigor was either fair or good. In one study, carrier volumes of 7 and 26 gpa were compared (Table 11) and in the other, 7 gpa of carrier was used exclusively (Table 12). Where two carrier volumes were compared, best control was from glyphosate at 0.25 lb/A in 7 gpa of spray carrier. Paraquat at 0.25 lb/A did not control the corn. Fluazifop gave 93 percent or more control of corn regardless of carrier volume.

In the second study, the same trend continued (Table 12). Glyphosate and sulfosate gave 93 percent control of the corn at 0.25 lb/A and paraquat failed. Fluazifop and sethoxydim at 0.25 lb/A gave less control than glyphosate or sulfosate.

Discussion

The minimum practical amounts of paraquat and glyphosate that controlled different sized plants of pigweed, wheat, and barley are given in Table 13. Two-inch pigweed growing with adequate soil water were killed with 0.20 lb/A of paraquat or glyphosate applied with a CDA at 3 gpa. More herbicide was required if the carrier volume was increased to 26 gpa.

Small volunteer winter wheat was killed with 0.18 lb/A of paraquat or glyphosate when applied in a carrier volume of 3 gpa. Winter barley was harder to kill, requiring 0.38 lb/A of paraquat. Glyphosate gave 95 percent or better kill of winter barley.

Drought stressed barnyardgrass that was 4 inches tall could not be killed with paraquat (Table 14). Glyphosate killed barnyardgrass at 0.25 lb/A when applied in 7 gpa of spray carrier. Witchgrass was killed when paraquat at 0.25 lb/A was applied in 3 gpa of carrier. Glyphosate at 0.12 lb/A killed witchgrass in the same carrier volume. Stinkgrass was killed only with 0.25 lb/A glyphosate.

Corn and sorghum were both difficult to kill with paraquat, requiring 0.5 lb/A or more to give 93 percent control of 4-inch sorghum. Small corn plants were not killed with paraquat. Glyphosate on the other hand, killed both volunteer crops at 0.25 lb/A in 3 to 7 gpa of spray carrier.

Table 7. Effect of herbicide and carrier volume on control of witchgrass and stinkgrass

Herbicide	Herbicide rate	Carrier volume (gpa)			
		Witchgrass control			Stinkgrass control
		3	26	26	26
	(lb/A)	(percent)			
Paraquat + 0.5% WK	0.12	—	—	36	20
	0.25	100	80	0	45
	0.38	100	90	33	48
	0.50	—	—	53	78
Glyphosate + 0.5% WK	0.12	99	95	23	50
	0.25	98	98	95	98
	0.38	—	—	95	100
	0.50	—	—	100	100
MSMA	2.0	95	95	95	0
	4.0	100	99	98	13
LSD 0.05		7	7	21	21
Stage of grass		12 inch (mature)		12 inch (mature)	10 inch (mature)
Plant vigor		fair		poor	poor
Application date		7-20-81		7-25-82	7-25-82
Evaluation date		8-6-81		8-25-82	8-25-82

Table 8. Effect of carrier volume and date of herbicide application on control of volunteer wheat

Herbicide	Herbicide rate	Carrier volume	Percent wheat control for herbicide application				
			8-31-78	8-13-82	10-4-82	11-22-82	4-27-83
	(lb/A)	(gpa)					
Paraquat + 0.5% X-77	0.19	3	—	95	95	—	—
	0.25		100	90	99	77	0
	0.38		—	98	99	53	0
	0.50		100	—	—	95	0
Glyphosate + 0.5% X-77	0.19		—	82	99	—	—
	0.25		100	98	—	99	0
	0.38		—	—	100	99	—
	0.50		100	100	—	100	0
Paraquat + 0.5% X-77	0.12	7	—	—	—	—	13
	0.19		—	—	—	—	37
	0.25		—	100	—	—	57
	0.38		—	100	—	—	53
	0.50		—	100	—	—	77
Glyphosate + 0.5% X-77	0.12		—	—	—	—	47
	0.19		—	—	—	—	—
	0.25		—	100	—	—	67
	0.38		100	—	—	83	
	0.50			100	—	—	93
Paraquat + 0.5% X-77	0.12	26	—	—	30	0	0
	0.25		52	—	87	85	0
	0.38		—	—	98	99	28
	0.50		93	—	99	100	32
Glyphosate + 0.5% X-77	0.12		—	—	43	95	25
	0.25		69	—	93	98	53
	0.38		—	—	98	99	67
	0.50		100	—	100	100	83
LSD 0.05			21	5	11	12	6
Wheat state			4 inch	2 inch	5 leaves	full tiller	jointing
Plant vigor			good	fair	good	good	excellent
Evaluation date			9-12-78	8-25-82	5-16-83	5-16-83	6-13-83

Table 9. Effect of carrier volume and date of herbicide application on control of volunteer barley

Herbicide	Herbicide rate	Carrier rate	Percent barley control for herbicide application on		
			10-4-82	11-22-82	4-27-83
	(lb/A)	(gpa)			
Paraquat + 1% X-77	0.25	3	99	27	0
	0.38		99	80	0
	0.50		100	95	0
Glyphosate + 1% X-77	0.25		53	92	0
	0.38		99	93	0
	0.50		98	99	0
Paraquat + 0.5% X-77	0.12	26	27	63	7
	0.25		80	97	7
	0.38		98	99	33
	0.50		99	100	30
Glyphosate + 0.5% X-77	0.12		53	67	13
	0.25		83	98	43
	0.38		100	98	57
	0.50		100	99	77
LSD 0.05			13	9	7
Barley stage			4-5 leaves	full tiller	jointing
Plant vigor			good	good	excellent
Evaluation date			11-18-82	5-16-82	6-13-83

Table 10. Effect of carrier volume on control of volunteer sorghum

Herbicide	Herbicide rate	Percent sorghum control at two carrier volumes	
		3	26
	(lb/A)		
Paraquat + 0.5% X-77	0.25	80	33
	0.50	93	73
	1.0	98	90
Glyphosate + 0.5% X-77	0.25	100	95
	0.50	100	98
	1.0	100	98
LSD 0.05		8	
Stage of growth		4 inches	
Plant vigor		good	
Application date		8-31-78	
Evaluation date		9-12-78	

Table 11. Effect of carrier volume on control of volunteer corn

Herbicide plus additive	Herbicide rate	Percent corn control at two carrier volumes	
		7 gpa	26 gpa
	(lb/A)		
Glyphosate + 0.5% X-77	0.06	37	0
	0.12	73	27
	0.25	97	87
Paraquat + 0.5% X-77	0.06	12	18
	0.12	33	12
	0.25	28	38
Fluazifop + 0.5% COC	0.2	93	97
LSD 0.05		16	
Corn stage		10 inches	
Plant vigor		fair	
Treatment date		6-3-82	
Evaluation date		6-18-82	

The studies indicate a decided advantage of using low carrier volumes with many postemergence herbicides. There is a big advantage to reducing carrier from 26 to 7 gpa with fan tip spray nozzles. Using CDA applications of 3 gpa or less was very effective against small weeds and volunteer crops. This is in keeping with results of previous researchers who found that reducing the amount of carrier increased phytotoxicity of glyphosate to annual and perennial weeds (Butler and Burnside 1983; Green et al. 1982; Jordan 1977; Stahlman and Phillips 1979). Once target plants were large, such as wheat that was jointing, poor control was obtained with a CDA. This is similar to results obtained by Reichard and Triplett (1983) who had better kill of established forages with fan tips than with CDA at 6 gpa carrier volume.

Table 12. Control of volunteer corn with herbicides applied in carrier volume of 7 gpa

Herbicide	Herbicide rate	Corn control
	(lb/A)	(percent)
Glyphosate + 0.5% X-77	0.14	32
	0.19	62
	0.25	93
	0.38	68
	0.50	87
Paraquat + 0.5% X-77	0.12	25
	0.25	23
	0.38	27
	0.50	32
Sulfosate + 0.25% X-77	0.25	93
	0.50	94
	1.0	93
Fluazifop	0.25	65
Sethoxydim	0.25	47
	0.50	72
LSD 0.05		31
Growth stage		10 inch
Plant vigor		good
Application date		6-2-82
Evaluation date		6-16-82

Literature Cited

Buhler, D. G. and O. C. Burnside. 1983. Effect of spray components on glyphosate toxicity to annual grass. Weed Sci. 31:124-130.

Green, J. J., E. W. Chenault, D. E. Lavake, and A. F. Wiese. 1982. Weed control with a controlled droplet applicator. Texas Agri. Exp. Sta. PR-4025. 8 pp.

Jordan, T. N. 1977. Effects of diluent volumes and surfactant on phytotoxicity of glyphosate to bermuda grass. Weed Sci. 29:79-83.

Mathers, A. C., H. R. Gardner, F. B. Lotspeich, H. M. Taylor, G. R. Loose, and R. E. Daniell. 1963. Some morphological, physical, chemical, and minerological properties of seven Southern Great Plains soils. U.S. Dept. Agr. ARS 41-85. pp. 7 and 10.

Reichard, D. L. and G. B. Triplett. 1983. Paraquat efficacy as influenced by atomizer type. Weed Sci. 31:779-782.

Stahlman, P. W. and W. M. Phillips. 1979. Effects of water quality and spray volume on glyphosate phytotoxicity. Weed Sci. 27:38-41.

Wiese, A. F. and D. W. Staniforth. 1973. Weed control in conservation tillage pp. 108-113 *in* Conservation Tillage the Proceedings of a National Conference. Soil Conservation Society of America, Ankeny, Iowa.

Table 13. Lowest practical rates of herbicides to give 95 percent control of pigweed, volunteer wheat, and volunteer barley

Plant species	Herbicide	Carrier volume	Plant size (inches) and plant vigor[a] 2 good	6 good	10 good	4 poor
		(gpa)	Active ingredient (lb/A)			
Pigweed	2,4-D	26	0.50	0.75	1.00	1.00
	Paraquat	26	0.25	0.50	1.00	none[b]
		3	0.20	0.38	0.50	none
	Glyphosate	26	0.25	0.50	1.00	none
		7	—[c]	—	0.25	
		3	0.20	0.38	1.00	0.25
		1	—	—	—	0.20
	Bromoxynil	26	0.38	none	—	—
Volunteer wheat	Paraquat	26	0.38	0.38	none	—
		7	0.25	—	none	—
		3	0.20	0.25	none	—
	Glysophosate	26	0.25	0.12	none	—
		7	0.25	—	0.50	—
		3	0.20	0.25	none	—
Volunteer barley	Paraquat	26	0.38	0.25	none	—
		3	0.25	0.50	none	—
	Glysophosate	26	0.38	0.25	none	—
		3	0.38	0.38	none	—

[a]Vigor ratings were: poor, fair, good, and excellent.

[b]None indicated that no herbicide rates evaluated gave 95 percent control of pigweed or volunteer crop.

[c]No tests were conducted on the indicated plant species.

Table 14. Lowest practical rates of paraquat or glyphosate to give 95 percent control of several weeds and volunteer

		Plant size (inches) and plant vigor[a]				
	Spray carrier	Barnyardgrass 4 poor	Witchgrass 4 poor	Stinkgrass 4 poor	Sorghum 6 poor	Corn 10 good
	(gpa)	Active ingredient (lb/A)				
Paraquat	26	none[b]	none	none	none	none
	7	—[c]	—	—	—	none
	3	none	0.25	—	0.5	none
Glyphosate	26	none	0.25	0.25	0.25	none
	7	0.25	—	—	—	0.25
	3	—	0.12	—	0.25	0.25

[a]Vigor ratings were: poor, fair, good, and excellent.

[b]None idicates that no herbicide rates evaluated gave 95 percent control of the weeds or volunteer crop.

[c]No tests were conducted on the indicated sized weed or volunteer crop.

Appendix. Description of herbicides used in this text

Common or chemical name	Manufacturer	Trade name	Formulation
Alkylaryl polyoxyethylene 100% glycols free fatty acids and isopropanol	Chevron Chemical Co.	X-77	90%
Alkylaryl polyethlene glycols	Rohm & Haas Co.	Ag 98	80%
Bromoxynil	Rhone-Poulenc, Inc.	Buctril	2 lb/gal
Fenoxaprop	American Hoechst	Whip	1.67 lb/gal
Fluazifop	ICI Americas, Inc.	Fusilade	4 lb/gal
Fomesafen	ICI Americas, Inc.	Reflex	2 lb/gal
Glyphosate	Monsanto	Roundup	3 lb/gal
MSMA	Diamond Shamrock Corp.	Bueno	6 lb/gal
Paraquat	Chevron Chemical Co.	Paraquat	2 lb/gal
Paraquat	ICI Americas, Inc.	Gramoxone	2 lb/gal
Quizalofop	DuPont Co.	Assure	0.8 lb/gal
Sethoxydim	BASF	Poast	1.5 lb/gal
Haloxyfop	Dow Chemical Co.	Verdict	4 lb/gal
Sulfosate	Stauffer Chemical Co.	Touchdown	2.8 lb/gal
Trimethylnonyl polyethoxyethanol	DuPont Co.	WK Surfactant	90%
2,4-D	Several	2,4-D	4 lb/gal

2M—5-87