Alternatives for Control of Atrazine Tolerant Weeds in Sweet Corn Production

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Introduction

Continued use of atrazine for weed control in sweet corn has led to the evolution of atrazine tolerant weeds. The objective of the research was to evaluate efficacy and crop tolerance of several new herbicides and several herbicide combinations at sites with atrazine tolerant pigweed.

Methodology

Trials were located at three grower operated sites in the Willamette valley where atrazine tolerant seed banks were suspected: Stayton, Banks, and St.Paul. Treatments were evaluated though the 5-6 leaf stage of corn for corn tolerance and weed control. A fourth trial was established at the Vegetable Research Farm near Corvallis where corn tolerance was further evaluated for yield comparisons between treatments. The soil types at Banks, St.Paul, and Corvallis were silt loams while Stayton was a silty clay loam.

Herbicides were applied pre-plant incorporated (PPI), preemergence (PRE), or postemergence (POST) with several treatments that included a combination of applications. All treatments were applied with a CO_2 unicycle plot sprayer at 30 PSI in 29 gal H_20/acre. Golden Jubilee sweet corn was planted at all four sites.

All plots were hoed and cultivated twice at the Corvallis site after the weed evaluation at 35 days after planting. The 'weeded' treatment was hoed prior to the weed evalaution and the cultivated plot was hand-cultivated once prior to the weed evaluation. Treatments at Corvallis also included a preliminary investigation on propane flaming for in-row weed control.

Results and Discussion

Site specifics

Atrazine was effective on pigweed at sites in Banks, St. Paul, and Corvallis (Tables 1-4, Figure 2). Pigweed was not controlled by atrazine at the Stayton site, indicating atrazine tolerance at this site. Soils conditions were poor (cloddy) prior to PPI applications at Stayton and Banks. Rain delayed planting nearly two weeks after the PPI application at Banks. Heavy rain followed PRE application at Stayton. The total plot at Stayton was oversprayed with metolachlor, trifluralin, and EPTC two days prior to PRE application. No effect was noted because trifluralin and EPTC were not incorporated and metolachlor was apparently leached by the heavy rain after the PRE application (note lack of control in metolachlor treatments at Stayton, Table 2).

Herbicide Performance

Acetochlor. Excellent pigweed and barnyardgrass control; effective on atrazine tolerant pigweed. Best control when applied PRE. Slight corn injury was noted except at St. Paul. Heavy rain immediately after PRE application did not diminish control compared to metolachlor (Stayton).

Acetochlor plus atrazine. No increase in weed control for species evaluated compared to acetochlor alone.

Acetochlor plus dimethenamid. Excellent weed control and low injury PPI.

Dimethenamid. Excellent control of atrazine tolerant pigweed. Injury potential equal for PPI and PRE applications. Weed control best with PRE application at Stayton, which was followed by heavy rain.

Dimethenamid plus atrazine. No advantage over dimethenamid alone.

Niclosulfuron. Good weed control but not tested on atrazine tolerant pigweed.

Halosulfuron. Good control of atrazine tolerant pigweed in PPI treatments (Not tested as PRE or POST on atrazine tolerant pigweed). Moderate to high injury with PPI application. Less corn injury with PRE or POST application.

Halosulfuron plus niclosulfuron (POST). Moderate injury to corn with good weed control.

Thiazopyr (Mon 13200). Poor weed control with moderate injury.

CGA 152005. Moderate to high injury to corn, good broadleaf control.

Imazethapyr. Although anticipated injury, good control of resistant pigweed.

Propane flaming.

Preliminary work indicates potential of propane flaming to control weeds in the row. Final yield was not affected by flaming when treated at 6 to 10 inches tall, even though leaf burn was obvious after treatment.

Table 1. Stayton site: weed control and crop injury 35 days after corn planting.

	Herbicide	Timing	Rate (# ai/acre)	Corn injury[1]	Pigweed control[1]	Barnyardgrass control[1]
1	Untreated			7	0	0
2	Atrazine	PRE	1.00	12	10	10
3	Acetochlor	PPI	1.50	21	92	58
4	Acetochlor	PPI	1.75	32	95	65
5	Acetochlor	PPI	2.00	18	70	60
6	Acetochlor	PRE	1.50	16	100	90
7	Acetochlor	PRE	1.75	25	100	88
8	Acetochlor	PRE	2.00	35	100	88
9	Acetochlor Atrazine	PPI PRE	1.75 1.00	31	100	94
10	Acetochlor Atrazine	PRE PRE	1.75 1.00	13	100	81
12	Alachlor	PPI	2.75	18	58	43
13	Alachlor Atrazine	PPI PRE	2.75 1.00	17	80	50
15	Metolachlor	PRE	2.00	8	0	0
16	Metolachlor Atrazine	PRE PRE	2.00 1.00	8	6	6
18	Acetochlor Metolachlor	PPI PRE	1.50 1.25	18	97	60
19	Dimethenamid	PRE	1.25	22	100	90
20	Dimethenamid	PPI	1.25	30	75	49
21	Dimethenamid	PPI	1.50	18	87	53
24	Dimethenamid Acetochlor	PPI PPI	0.75 1.50	16	100	83
27	Halosulfuron	PPI	0.075	37	100	40
28	Halosulfuron	PPI	0.094	37	92	35
29	Halosulfuron Alachlor	PPI PPI	0.075 2.75	42	100	65
41	Imazethapyr	PPI	0.32	93	100	83
42	Imazethapyr	PPI	0.47	96	100	99
44	Imazethapyr	PPI	0.32	92	100	76
	LSD (p=0.05) CV			15 41	25 30	37 54

[1] Visual evaluations: 0=no effect on crop or weeds, 100=complete kill.

Table 1a. Herbicide application data: Stayton site.

Sweet corn planted May 21, 1993 'Golden Jubilee'	Application 1	Application 2
Application Date	May 18	May 24
Application Timing	PPI	PRE
Start/End Time	10-12	3:30-5:30 PM
Air Temp	81	85
Soil Temp (2 ")	90	NA
Rel Humidity	49	NA
Wind Direction	-	NE
Wind Velocity	0	5-10, gusty
Cloud Cover	clear	none
Soil Moisture	surface dry	dry surface
Plant Moisture	-	
Sprayer/PSI	CO_2 plot sprayer, 30 PSI	CO_2 plot sprayer, 30 PSI
Mix Size	2 liters	2 liters
Gallons H20/Acre	29	29
Nozzle Type	SS8003	SS8003
Nozzle Spacing and Height	22/20	26/22
Soil Inc Depth (PPI/PRE)	1"	
Soil Inc Method/Implement	Vibrashank	
Rainfall/Irrigation Events Heavy thunderstorm immediately after PRE application		
Notes PPI: soil very cloddy and in poor condition Accidently sprayed with Dual, Eptam and Treflan on 5/23 Pre treatments up to dimethenamid were applied		

Table 2. Banks site: weed control and crop injury 40 days after corn planting.

	Herbicide	Timing	Rate	Corn injury[1]	Pigweed control[1]	Barnyardgrass control[1]
1	Untreated			10	75	37
2	Atrazine	PRE	1.00	23	92	47
3	Acetochlor	PPI	1.50	28	71	52
4	Acetochlor	PPI	1.75	10	60	42
5	Acetochlor	PPI	2.00	26	70	75
6	Acetochlor	PRE	1.50	17	95	87
7	Acetochlor	PRE	1.75	15	100	97
8	Acetochlor	PRE	2.00	21	100	97
9	Acetochlor Atrazine	PPI PRE	1.75 1.00	56	100	88
10	Acetochlor Atrazine	PRE PRE	1.75 1.00	18	100	95
11	Acetochlor 2,4-D[2]	PRE POST	1.75	43	100	92
12	Alachlor	PPI	2.75	11	72	52
13	Alachlor Atrazine	PPI PRE	2.75 1.00	32	100	55
14	Alachlor 2,4-D[2]	PPI POST	2.75 1.00	40	100	71
15	Metolachlor	PRE	2.00	18	96	100
16	Metolachlor Atrazine	PRE PRE	2.00 1.00	16	100	60
17	Metolachlor 2,4-D[2]	PRE POST	2.00 1.00	32	98	96
18	Acetochlor Metolachlor	PPI PRE	1.50 1.25	16	95	87
19	Dimethenamid	PRE	1.25	27	88	92
20	Dimethenamid	PPI	1.25	30	90	93
21	Dimethenamid	PPI	1.50	26	47	92
22	Dimethenamid Atrazine	PPI PRE	1.25 1.00	17	97	57
23	Dimethenamid 2,4-D[2]	PPI POST	1.25 1.00	35	100	87
24	Dimethenamid Acetochlor	PPI PPI	0.75 1.50	13	80	96
25	Halosulfuron	PRE	0.075	21	73	6
26	Halosulfuron	PRE	0.094	15	81	30
27	Halosulfuron	PPI	0.074	41	97	55
28	Halosulfuron	PPI	0.094	62	97	55
29	Halosulfuron Alachlor	PPI PPI	0.075 2.75	62	97	70
30	Halosulfuron	POST	0.032	38	83	46
31	Halosulfuron 2,4-D[2]	POST POST	0.032 1.00	36	100	30
32	Halosulfuron Niclosulfuron[2,3]	POST POST	0.032 0.029	22	96	95
33	Mon 13200	PRE	0.15	11	45	30
34	Mon 13200	PRE	0.25	18	45	50

Banks data cont'd

35	Acetochlor Mon 13200	PPI PRE	1.50 0.15	16	81	93
36	Alachlor Mon 13200	PPI PRE	2.75 0.15	40	62	76
37	Niclosulfuron[2,3]	POST	0.03	22	100	75
38	Niclosulfuron[2,3]	POST	0.05	36	100	93
39	CGA 152005[2]	POST	0.02	46	98	30
40	CGA 152005[2]	POST	0.02	31	75	20
41	Imazethapyr	PPI	0.32	76	100	90
42	Imazethapyr	PPI	0.47	92	100	97
43	Imazethapyr Atrazine	PPI PRE	0.32 1.00	83	100	10
44	Imazethapyr	PPI	0.32	85	100	90
45	Clopyralid	POST	0.13	30	20	12
	LSD (p=0.05) CV			23 50	28 24	30 31

[1] Visual evaluations: 0=no effect on crop or weeds, 100=complete kill.
[2] Plus COC (Morac 1% by volume).
[3] Plus liguid N (4% by volume).

Table 2a. Herbicide application data: Banks site

Corn planted June 4 'Golden Jubilee'	Application 1	Application 2	Application 3
Application Date	May 24	June 7	July 8
Application Timing	PPI	PRE	POST
Start/End Time	10-1 PM	9-10:45 AM	7-9 AM
Air Temp	72	65	70
Soil Temp (2 ")	NA	NA	63
Rel Humidity	NA	70	53%
Wind Direction	N	N	NW
Wind Velocity	5-12	2-10, gusty	2-5
Cloud Cover	none	overcast	cloudy
Soil Moisture	surface dry	dry surface	damp
Plant Moisture	-	light rain at times	dew
Sprayer/PSI	CO_2 plot sprayer, 30 PSI	CO_2 plot sprayer, 30 PSI	CO_2 plot sprayer, 30 PSI
Mix Size	2 liters	2 liters	2 liters
Gallons H20/Acre	29	29	29
Nozzle Type	SS8003	SS8003	SS8003
Nozzle Spacing and Height	22/20	22/20	22/20
Soil Inc Depth (PPI/PRE)	1"	-	-
Soil Inc Method/Implement	Vibrashank	-	-
Nearly two weeks from PPI to corn planting Soil very wet in blocks 2 and 3 when corn planted; uneven and poor soil conditions			

Table 3. St. Paul site: weed control and crop injury 30 days after corn planting.

	Herbicide	Timing	Rate	Corn injury[1]	Shepherds purse control[1]
1	Untreated			5	27
2	Atrazine	PRE	1.00	2	96
6	Acetochlor	PRE	1.50	2	100
7	Acetochlor	PRE	1.75	0	100
5	Acetochlor	PRE	2.00	13	100
10	Acetochlor Atrazine	PRE PRE	1.75 1.00	10	100
11	Acetochlor 2,4-D[2]	PRE POST	1.75 1.00	35	100
12	Alachlor	PRE	2.75	0	97
15	Metolachlor	PRE	2.00	6	95
16	Metolachlor Atrazine	PRE PRE	2.00 1.00	0	97
17	Metolachlor 2,4-D[2]	PRE POST	2.00 1.00	47	100
19	Dimethenamid	PRE	1.25	10	100
21	Dimethenamid	PRE	1.50	2	100
22	Dimethenamid Atrazine	PRE PRE	1.25 1.00	0	100
23	Dimethanimid 2,4-D[2]	PRE POST	1.25 1.00	35	100
24	Dimethanimid Acetochlor	PRE PRE	0.75 1.50	0	100
25	Halosulfuron	PRE	0.075	0	100
26	Halosulfuron	PRE	0.094	2	100
29	Halosulfuron Alachlor	PRE PRE	0.075 2.75	20	100
30	Halosulfuron	POST	0.032	8	80
31	Halosulfuron 2,4-D[2]	POST POST	0.032 1.00	42	96
32	Halosulfuron Niclosulfuron[2,3]	POST POST	0.032 0.029	11	90
33	Mon 13200	PRE	0.15	13	81
34	Mon 13200	PRE	0.25	2	76
35	Mon 13200 Acetochlor	PRE PRE	0.15 1.50	0	90
36	Mon 13200 Alachlor	PRE PRE	0.15 2.75	5	100
37	Niclosulfuron[2,3]	POST	0.03	6	82
38	Niclosulfuron[2,3]	POST	0.05	15	85
39	CGA 152005[2]	POST	0.02	32	92
40	CGA 152005[2]	POST	0.02	35	92
	LSD CV			18 108	18 14

[1] Visual evaluations: 0=no effect on crop or weeds, 100=complete kill.
[2] Plus COC (Morac 1% by volume).
[3] Plus liguid N (4% by volume).

Table 3a. Herbicide application data: St. Paul site

Corn planted June 28 'Golden Jubilee'	Application 1	Application 2
Application Date	June 28	July
Application Timing	PRE	POST: 6-leaf corn, 12", 1st tiller
Start/End Time	4:30-7:00 PM	9:30-10:15 AM
Air Temp	70	61
Soil Temp (2 ")	NA	68
Rel Humidity	45	60
Wind Direction	W	N
Wind Velocity	2-10	0-2
Cloud Cover	partly cloudy	cloudy
Soil Moisture	very dry	very dry
Plant Moisture	dry	dew
Sprayer/PSI	CO_2 plot sprayer, 30 PSI	CO_2 plot sprayer, 30 PSI
Mix Size	2 liters	2 liters
Gallons H20/Acre	29	29
Nozzle Type	SS8003	SS8003
Nozzle Spacing and Height	22/20	22/20
Soil Inc Method/Implement	-	
Soil Inc Depth (PPI/PRE)	-	
Notes Lorsban insecticide soil applied		

Table 4. Vegetable Research Farm, Corvallis: weed control and crop injury 35 days after planting; crop yield at normal maturity.

	Herbicide	Timing	Rate	Pigweed control[1]	Nightshade control[1]	Corn injury[1]	Gross wt (t/ac)	Husked wt (t/ac)	# Ears /plot
1	Untreated, unweeded			20	27	23	13.6	8.0	53
2	Atrazine	PRE	1.00	87	92	15	13.5	6.7	42
3	Acetochlor	PPI	1.50	100	90	11	10.9	6.7	41
4	Acetochlor	PPI	1.75	100	90	21	16.0	7.0	66
7	Acetochlor	PRE	1.75	100	95	18	11.7	7.2	46
12	Alachlor	PPI	2.75	95	78	7	14.5	8.8	55
15	Metolachlor	PRE	2.00	37	22	20	11.6	7.9	54
17	Metolachlor 2,4-D[2]	PRE POST	2.00 1.00	78	88	32	13.3	7.8	57
20	Dimethenamid	PPI	1.25	96	73	5	14.3	8.2	55
21	Dimethenamid	PPI	1.50	97	78	10	14.8	8.9	57
24	Dimethenamid Acetochlor	PPI PPI	0.75 1.5	100	86	15	13.6	8.1	53
27	Halosulfuron	PPI	0.075	100	26	65	9.7	5.5	43
28	Halosulfuron	PPI	0.094	100	22	57	7.4	4.0	26
30	Halosulfuron	POST	0.032	72	22	25	10.3	6.5	39
33	Mon 13200	PRE	0.15	30	5	8	11.0	6.7	47
34	Mon 13200	PRE	0.25	62	33	10	10.0	7.7	39
37	Niclosulfuron[2,3]	POST	0.03	91	81	7	15.1	8.5	58
38	Niclosulfuron[2,3]	POST	0.05	86	78	15	15.4	8.5	58
39	CGA 152005[2]	POST	0.02	90	43	25	12.1	7.2	49
40	CGA 152005[2]	POST	0.05	92	47	18	10.7	6.6	50
46	Dimethenamid	PRE	1.50	100	80	11	13.0	8.3	46
48	4243	PRE	0.02	32	33	16	12.0	8.1	50
49	Untreated, weeded			97	78	16	14.1	8.3	54
50	One cultivation (see methodology section)			72	66	2	12.5	7.9	48
	LSD (P=0.05) CV			30 26	26 31	24 81	4.0 22	1.6 15	16 23

[1] Visual evaluations: 0=no effect on crop or weeds, 100=complete kill.
[2] Plus COC (Morac 1% by volume).
[3] Plus liguid N (4% by volume).

Table 4a. Herbicide application data: Vegetable Research Farm

Sweet corn planted June 15, 1993 'Golden Jubilee'	Application 1	Application 2	Application 3
Application Date	June 15	June 16	July 8
Application Timing	PPI	PRE	POST
Start/End Time	8-10 AM	7:30-10:00 AM	8-9 AM
Air Temp	72	64	70
Soil Temp (2 ")	66	70	
Rel Humidity			70%
Wind Direction	N	NE	
Wind Velocity	0-5	5-10, gusty	0-2
Cloud Cover	clear	none	clear
Soil Moisture	surface dry	dry surface	dry
Plant Moisture			
Sprayer/PSI	CO_2 plot sprayer, 30 PSI	CO_2 plot sprayer, 30 PSI	CO_2 plot sprayer, 30 PSI
Mix Size	2 liters	2 liters	2 liters
Gallons H20/Acre	29	29	29
Nozzle Type	SS8003	SS8003	SS8003
Nozzle Spacing and Height	26/22	26/22	26/22
Soil Inc Depth (PPI/PRE)	1"		
Soil Inc Method/Implement	Rotara		

Rainfall/Irrigation Events

I	June 16	0.3"
R	June 22	0.1"
I	July 8	1.0"

Notes:
Dyfonate insecticide soil applied

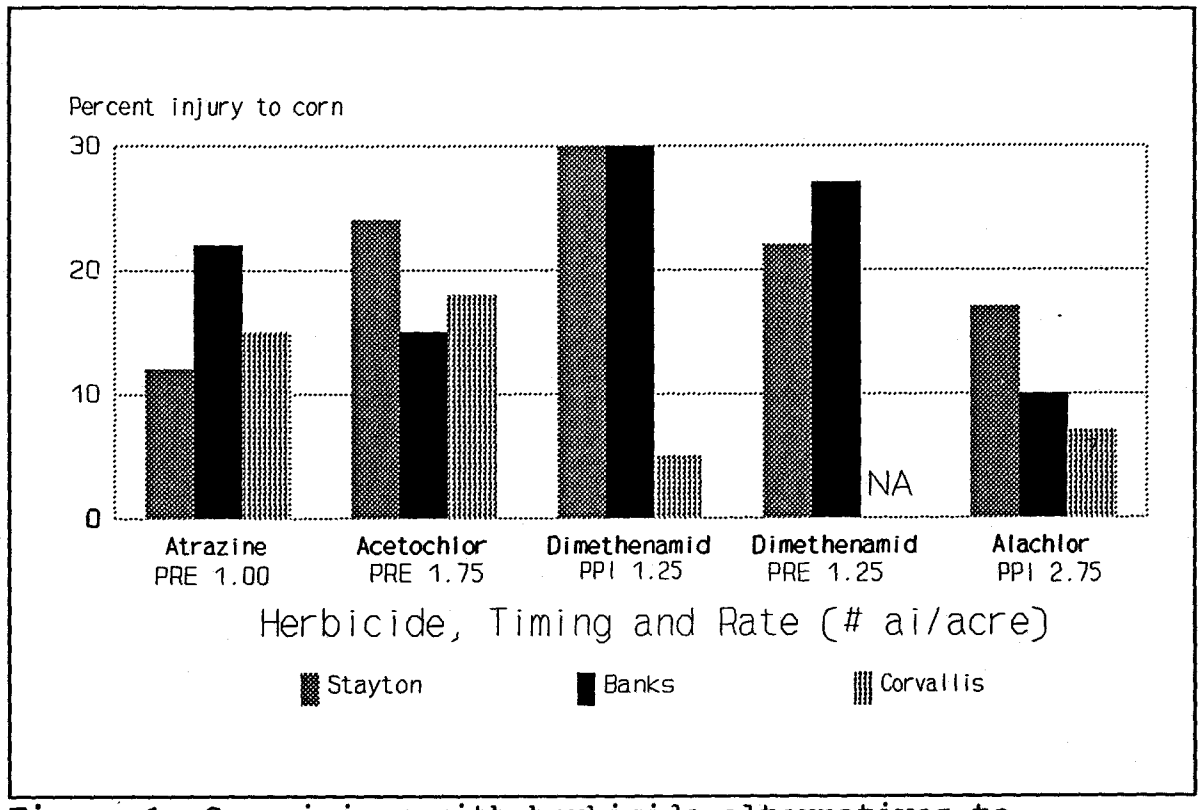

Figure 1. Corn injury with herbicide alternatives to atrazine.

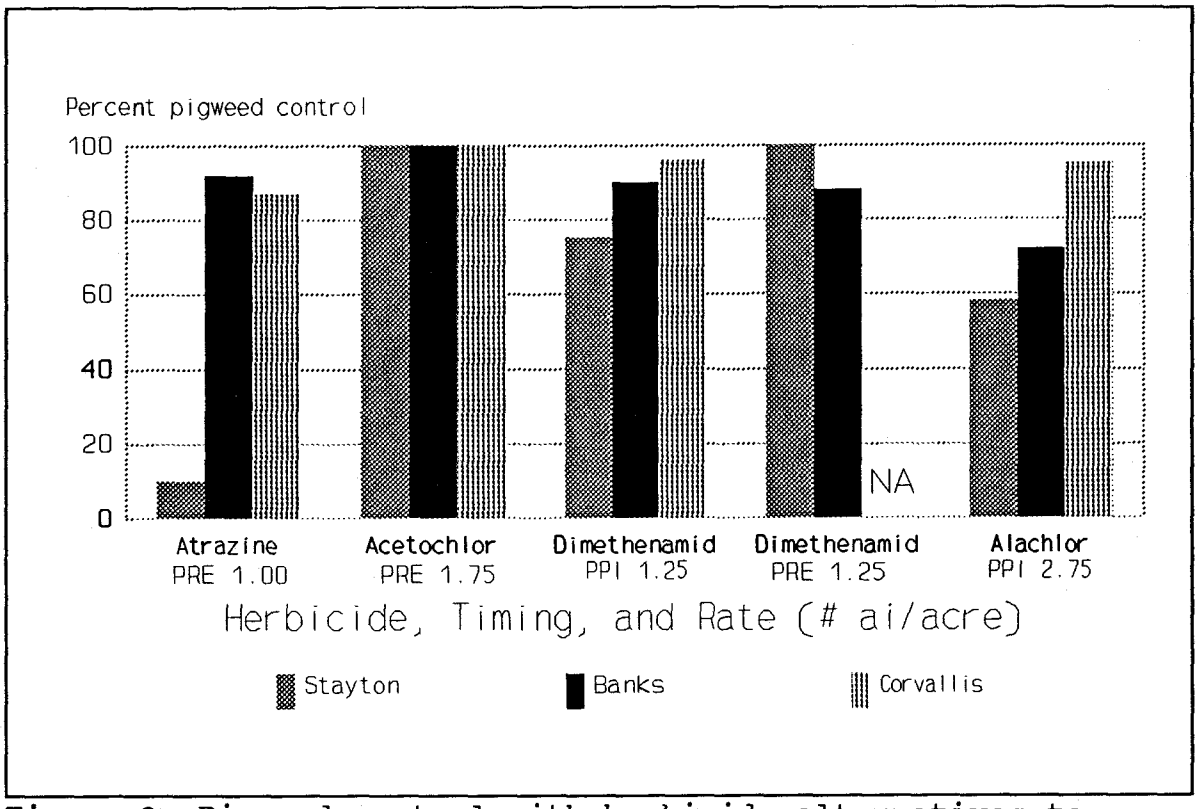

Figure 2. Pigweed control with herbicide alternatives to atrazine.