

Timing of Glyphosate Application for Weed Control in Glyphosate Tolerant Lettuce

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Abstract

Studies were conducted to determine the optimum time to apply glyphosate to glyphosate-tolerant Lactuca sativa cv. Raider (head lettuce). The study was initiated near Yuma, Arizona in September 2000. Single applications of glyphosate at 1.0 lb AI/A were made to head lettuce at development stages of 2, 4, 6 and 8 leaves. Glyphosate treatments did not injure lettuce. A single application at the 2 or 4 leaf stage was optimal for near complete control of Portulaca oleracea (common purslane), Chenopodium murale (nettleleaf goosefoot), Malva parviflora (cheeseweed), and Leptochloa spp. (sprangletop). Later applications at the 6 or 8 leaf stages allowed weeds, especially, common purslane to compete with the crop. Treatments applied at the 2 or 4 leaf stages required the least amount of time to hand weed and resulted in highest fresh weight yields.

Introduction

There are only three commercially available herbicides that are utilized for desert lettuce production. They are effective primarily against grass weeds and few broadleaved weeds are consistently controlled by the use of any of the three preemergence (PREE) soil applied herbicides. There are currently no safe and effective postemergence (POST) herbicides available for use in lettuce or many other vegetables. Biotechnological advances have provided improvements in many vegetable crops. Among the first introduced developments for potential use in desert production systems are herbicide tolerant crops. A gene conferring glyphosate tolerance in lettuce has the potential to offer a selective POST herbicide that can control a broad spectrum of weeds ranging from annuals to perennials and grasses to broadleaved weeds. POST applications of glyphosate may be complimentary to many weed control strategies. It could be applied sequentially after PREE herbicides to control escaping weeds or it might be applied singly without the use of PREE herbicides to control all emerging weeds with either one or multiple well-timed applications. Also very critical to lettuce production is the timing of cultural operations such as application of water and fertilizers, cultivating, and thinning. The use of a POST herbicide should be complimentary to irrigation, fertilization, optimally reduce the need for excessive cultivations, and expedite the thinning practice. This field experiment was conducted to evaluate the efficacy and safety of glyphosate when applied as a single application on various growth stages of genetically modified head lettuce.

Materials and Methods

A small plot field experiment was conducted in Wellton, Yuma County, AZ under commercial growing conditions on a loamy soil. Glyphosate tolerant head lettuce cv. Raider seed was hand planted on conventional 40-in raised beds and

spaced 12-in apart in two seedlines per bed on 22 September 2000. The treatment plots consisted of two beds measuring 25-ft long and each treatment was replicated four times in a randomized complete block design. Sprinklers were started on 23 September to germinate and establish the crop stand. The sprinklers were removed after one week and then the crop was furrowed irrigated for the remainder of the growing season. Typical commercial applications of insecticides were used for pest control and nitrogen fertilizer was applied with the irrigations. Immediately after planting, the commercial standard herbicide treatments, bensulide and pronamide, were applied PREE on the soil surface before the sprinkler irrigation was initiated. All herbicide treatments were applied using a backpack CO₂ sprayer equipped with a hand-held boom consisting of four flat fan 8002 nozzle tips spaced 20-in apart. All treatments were applied in 25 gpa water pressurized to 30 psi. At the time of PREE herbicide applications, the weather was clear and 70EF with a very slight breeze. The soil was dry and the temperature below the surface was 80EF. The first postemergence (POE-1) application of glyphosate was on lettuce with 2 leaves fully developed on 05 October. The lettuce stand was thinned to one plant spaced every 12-in in each of the two seedlines prior to spraying. The weather was clear and 82EF with no wind. The predominant weed was common purslane that was at the 4 leaf stage with stems measuring 2-in long and other weeds present were nettleleaf goosefoot at the 2 leaf stage, sprangletop with 2 to 4 leaf, few cheeseweed at the cotyledon to 2 leaf stage, and very few *Trianthema portulacastrum* (horse purslane) at the 2 to 4 leaf stage. The handweeded check plots were hand hoed initially on 05 October and then weeds were removed regularly until hand hoeing was done for the entire experiment area. The second POST (POE-2) application was made on 09 October when the lettuce was fully developed at the 4 leaf stage of growth. The air temperature was 74EF, partly cloudy, and there were few gusts of wind at 5 to 10 mph. The purslane had 4 to 6 stems measuring 4 to 8-in long, goosefoot was at the 4 to 6 leaf stage, sprangletop had 3 tillers, cheeseweed was at the 4 leaf stage, and the few horse purslane had 3 stems measuring 2 to 3-in long. The third POST (POE-3) application was made on 13 October when the lettuce was at the very early 6 leaf stage. The weather was clear, with air temperature at 56EF, and with a very slight breeze. The purslane had multiple stems measuring greater than 4 to 5-in long, goosefoot was at the 6 leaf stage at 1 to 2-in height with lateral branches being initiated, sprangletop was tillering and measured 5 to 6-in high, cheeseweed was at the 8 to 12 leaf stage and measuring 4 to 6-in in diameter, and horse purslane had stems measuring 3-in long. The fourth POST (POE-4) application was made on 17 October when the lettuce was at the 8 leaf stage of growth. The air temperature was 74EF, skies clear, and wind was calm. The purslane was beginning to flower and stems measured 10-in long, goosefoot was flowering and 3 to 4-in high, cheeseweed was at the 12 leaf stage and measured 12-in in diameter, no grasses or horse purslane were present to count and measure. No water was applied to the crop during the period when POST treatments were applied. Visual observations for weed control and weed stand counts were conducted at several intervals before and after herbicide applications. The weed stand counts were collected from a randomly selected 3 ft by 20-in section of the tops of both raised beds within each treatment replicate. At 6 weeks after planting on 02 November, all weeds in all plots were removed by hand hoeing and hoeing times for two people per each treatment replicate were recorded. The mature lettuce was harvested on 01 December from a randomly selected area within each plot and from a 5-ft section of one seedline on each bed.

Results and Discussion

At 21 days after planting (DAP), the weed control given by a single application of glyphosate at POE-1 was superior to bensulide and pronamide applied PREE (Table 1). The single application of glyphosate was highly effective against the small weeds within just over 1 week. Bensulide offered acceptable control of purslane and nettleleaf goosefoot at 85% and near complete control of grass weeds at 98% for up to 21 (DAP). All other glyphosate treatments provided better weed control than the commercial standard practice of applying PREE herbicides, pronamide or bensulide (Table 2). The average density of the weeds present in most of the glyphosate treated lettuce plots was significantly reduced compared to the standard herbicides and the untreated check (Table 3). The density of purslane was not reduced for glyphosate applied at POE-4. Pronamide demonstrated little efficacy against any of the weeds and was almost similar to the untreated check. Pronamide applied on the soil surface near where the seed was planted was diluted out of the zone by the sprinkler irrigation.

Glyphosate applied on head lettuce at POE-1, POE-2, and POE-3 controlled purslane, nettleleaf goosefoot, and grass weeds at 90% or better at 33 and 42 DAP (Table 2). Glyphosate applied at POE-1 or POE-2 provided near complete control of purslane, nettleleaf goosefoot, cheeseweed, and sprangletop for 28 and 24 days after treatment, respectively. Almost no weeds were present in the plots except for few small cheeseweed that had stopped growing (Table 3). All applications of glyphosate gave near complete control of nettleleaf goosefoot and grass weeds. An application at POE-4

did not control the large purslane when evaluated at 42 DAP where the number of dying plants remaining in the plots was similar to the untreated check.

The least amount of time required to hand hoe and remove weeds were for plots with glyphosate treatments applied POE-1 and POE-2 which were better or similar to the handweeded check (Table 4). Times of 6.6 to 8.8 hr/A were significantly less than times required to hand hoe the untreated check plots, commercial standards treatment plots, and plots with later timed applications of glyphosate. The untreated check and commercial standard treatment plots required the use of hand-held knives to allow the weeds to be separated and removed more precisely from adjacent lettuce plants. Competition between lettuce and weeds in the untreated check, pronamide, and bensulide treated plots resulted in etiolated lettuce plants that recovered after hand hoeing.

At harvest, the head lettuce treated with glyphosate at POE-1 produced the greatest yields at 58,608 lb/A and exceeded the handweeded check at 54,912 lb/A (Table 4). A trend was observed for an increase in lettuce yields with earlier timed applications of glyphosate for effective weed control. The yields for lettuce treated with the commercial standards were suppressed compared to any of the glyphosate treatments. No lettuce injury was observed during the season for any of the herbicide treatments.

Early applications of glyphosate when the lettuce was at the 2 or 4 leaf stage of growth gave the best weed control for up to 42 DAP. Small weeds were controlled at about one week after applications. Purslane, nettleleaf goosefoot, cheeseweed, and sprangletop were completely removed. The time required to hand hoe the plots was the least and similar to the nearly weed-free handweeded check. Weeds continually emerged in the handweeded check plots due to the constant disturbance of the soil from hand hoeing. New weeds did not emerge after glyphosate applications at POE-1 or POE-2 compared to the handweeded check. Lettuce yields were highest for the nearly weed-free early glyphosate treated plots.

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Table 1. Comparison of POST and PREE herbicides for weed control at 21 days after planting (DAP).

Treatment	Rate (lb. AI/A)	Timing	Weed control and average weed density							
			<u>POROL</u>		<u>CHEMU</u>		<u>MALPA</u>		<u>LEPSP</u>	
			%	plants ¹	%	plants ¹	%	plants ¹	%	plants ¹
Untreated Check			0	30.6	0	16.9	0	0.3	0	4.3
Handweeded Check			100	0	100	0	100	0	100	0
Pronamide	1.0	PREE	24	22	16	12.9	7	0.3	30	2
Bensulide	6.0	PREE	85	8.4	85	6.5	0	1.3	98	0
Glyphosate	1.0	POE-1	99	0	99	0	95	0.8	99	0

¹Average weed density determined as number of plants / 5 sq ft.

POROL = *Portulaca oleracea* (purslane), CHEMU = *Chenopodium murale* (goosefoot),

MALPA = *Malva parviflora* (cheeseweed), LEPSP = *Leptochloa* spp. (sprangletop)

Table 2. Average weed control in glyphosate tolerant lettuce with POST applications of glyphosate

Treatment	Rate (lb. AI/A)	Timing	Weed control							
			<u>POROL</u>		<u>CHEMU</u>		<u>MALPA</u>		<u>LEPSP</u>	
			33DAP	42 DAP						
			%							
Untreated Check			0	0	0	0	0	0	0	0
Handweeded Check			100	100	100	100	100	100	100	100
Pronamide	1.0	PREE	0	3	13	0	0	0	13	0
Bensulide	6.0	PREE	76	50	68	23	0	0	97	91
Glyphosate	1.0	POE-1	99	99	99	99	95	97	99	99
Glyphosate	1.0	POE-2	96	99	99	99	91	99	99	99
Glyphosate	1.0	POE-3	90	90	96	99	88	98	99	99
Glyphosate	1.0	POE-4	81	73	89	99	80	92	91	99
LSD (p=0.05)			3.0	6.2	14.6	14.9	3.6	3.9	13.3	3.0

POROL = *Portulaca oleracea* (purslane), CHEMU = *Chenopodium murale* (goosefoot),

MALPA = *Malva parviflora* (cheeseweed), LEPSP = *Leptochloa* spp. (sprangletop)

Table 3. Weed density in glyphosate tolerant lettuce with POST applications of glyphosate

Treatment	Rate (lb. AI/A)	Timing	Average Weed Density							
			<u>POROL</u>		<u>CHEMU</u>		<u>MALPA</u>		<u>LEPSP</u>	
			33DAP	42 DAP	33DAP	42 DAP	33DAP	42 DAP	33DAP	42 DAP
			number of plants / 5 sq ft							
Untreated Check			18.8	14.4	14.5	15.3	0.6	0.5	1.5	1.9
Handweeded Check			0.0	0.0	0.0	0.0	0	0	0	0
Pronamide	1.0	PREE	17.8	15.3	15.8	14.9	0.8	0.6	2.1	1.5
Bensulide	6.0	PREE	6.8	6.8	8.5	8.4	0.6	0.6	0	0
Glyphosate	1.0	POE-1	0.0	0.0	0.0	0.0	0.5	0	0	0
Glyphosate	1.0	POE-2	0.4	0.0	0.1	0.0	0.9	0	0	0
Glyphosate	1.0	POE-3	11.0	6.9	0.5	0.0	0.5	0.6	0	0
Glyphosate	1.0	POE-4	17.0	13.4	7.0	0.0	0.6	0	2	0
<u>LSD (p=0.05)</u>			<u>3.68</u>	<u>3.05</u>	<u>3.29</u>	<u>2.68</u>	<u>0.61</u>	<u>0.74</u>	<u>0.71</u>	<u>0.56</u>

POROL = *Portulaca oleracea* (purslane), CHEMU = *Chenopodium murale* (goosefoot),
MALPA = *Malva parviflora* (cheeseweed), LEPSP = *Leptochloa* spp. (sprangletop)

Table 4. Hoeing times for weed removal and lettuce harvest

Treatment	Rate (lb. AI/A)	Timing	Hoe Time	Fresh wt
			hr/A	lb / A
Untreated Check			73.7	14784
Handweeded Check			8.8	54912
Pronamide	1.0	PREE	64.9	15576
Bensulide	6.0	PREE	35.1	35904
Glyphosate	1.0	POE-1	6.6	58608
Glyphosate	1.0	POE-2	8.8	53328
Glyphosate	1.0	POE-3	24.6	49896
Glyphosate	1.0	POE-4	35.1	42768
<u>LSD (p=0.05)</u>			<u>9.47</u>	<u>8448</u>