Screening New Herbicides for Weed Control in Head and Leaf Lettuces and Broccoli

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Abstract

In preemergence (PREE) herbicide testing, all three lettuces, head, romaine, and red leaf, exhibited some tolerance to carfentrazone, sulfentrazone, flumetsulam, rimsulfuron, and thifensulfuron while giving effective weed control. In postemergence (POST) testing, cloransulam and flumetsulam controlled weeds at the lowest applied rates while lettuces were safe to cloransulam at 0.01 lb AI/A and flumetsulam at 0.03 lb AI/A. Imazamox was safe on lettuces at 0.01 lb AI/A and controlled weeds at 0.007 lb AI/A. For broccoli, sulfentrazone, fluroxypyr, and thifensulfuron applied PREE demonstrated reasonable safety and weed control. Cloransulam, flumetsulam, and fluroxypyr applied POST on broccoli exhibited adequate crop safety and good weed control.

Introduction

Weeds compete with all crops and can significantly reduce crop stands and quality. In lettuce, three herbicides, pronamide (Kerb®), benefin (Balan®), and bensulide (Prefar®) are commonly used at planting time for general weed control. Kerb®, Balan®, and Prefar® are primarily grass herbicides, however, for general weed control, many of the broadleaved weeds are not effectively controlled. Supplemental cultivations and hand-hoeing are often necessary to eliminate escape weeds such as *Malva sp*. (cheeseweed), *Cruciferae sp*. (mustards, London rocket, shepherd's purse), *Chenopodium sp*. (lambsquarters and goosefoot), *Amaranthus sp*.(pigweeds), *Melilotus sp*.(clovers), and *Compositae sp*. (sowthistle). The lack of complete weed control by a herbicide program is evidenced by the continued reliance upon hand-hoeing to ultimately remove difficult to control weeds in lettuce crops.

The implementation of the Food Quality Protection Act of 1996 has enhanced the importance of the minor crops commodity groups to impress upon the IR-4 registrations process to facilitate expeditious crop protection chemicals new registrations. Many of the "new and safe", low dosage crop chemicals will continue to be targeted at only the major crops of corn, soybeans, small grains, and cotton. Major manufacturers and inventors of herbicides express very little interest in targeting discovery efforts toward minor crops such as lettuce and broccoli. Evaluations of the "new and safe" chemicals will need to be conducted for the minor crops at the local or regional levels.

The objectives of this project are to screen new herbicides for potential use in head, leaf lettuces, and broccoli by evaluating and determining crop safety and weed control efficacy.

Materials and Methods

Two small plot field tests were conducted at the University of Arizona, Maricopa Agricultural Center, Maricopa, AZ. Each treatment replicate consisted of two conventional 40-inch raised beds with one bed planted to one seedline of head lettuce cv. Del Oro and another seedline of romaine lettuce cv. Parris Island Cos spaced 12 inches apart. The second

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bed was planted to one seedline of red leaf lettuce cv. Red Line and the other seedline planted to broccoli cv. Liberty. Crops were planted on 13 October 1999. The crops were furrow irrigated during the season. Herbicide treatments were applied as a single replicate on two beds with the four crops measuring 180 ft in length. On 14 October, preemergence (PREE) herbicide treatments were applied on the dry soil surface. Herbicides were applied using a hand-held boom equipped with four flat fan 8002 nozzle tips spaced 20 inches apart. The treatments were sprayed using a CO_2 backpack sprayer set up to deliver a constant dilution of the spray solution from a 0.5 L plastic bottle supplied with 2L of water. The sprays were applied in 24 gpa water pressurized to 30 psi. At the time of PREE applications, the weather was clear with air temperature at 97°F and no wind. The soil was dry and 74°F. The field was irrigated soon after herbicide applications on the same day and the beds were wetted completely across to activate the herbicides and germinate the crops. Postemergence (POST) herbicide applications were made on 12 November with the same equipment and delivery system and an adjuvant, Latron CS-7 at 0.25% v/v was added to all treatments. The lettuces were at the 4-leaf stage of growth, broccoli was at the 2-leaf stage and the predominant weed present was black mustard at the 4 to 5-leaf stage. The air temperature was 84°F, clear, and there was only a slight breeze during applications. Crop safety and weed control were evaluated visually at 14, 32, and 50 days after treatment (DAT) for the PREE treatments and at 3 and 21 DAT for the POST treatments. Acceptable weed control was measured as better than 80% control and acceptable crop safety was measured as less than 30% injury. The rate of the herbicide demonstrating crop safety and effective weed control was calculated by measuring the distance between the application of the starting rate and the observed effective rate.

Results and Discussion

In PREE herbicide testing, all three lettuces, head, romaine, and red leaf, exhibited some tolerance to carfentrazone, sulfentrazone, flumetsulam, rimsulfuron, and thifensulfuron (Table 1 and 2) and gave effective weed control (Table 5). At 32 DAT, carfentrazone was safe on head lettuce at 0.015 lb AI/A (Table 1) and no injury could be observed on the leaf lettuces at 0.032 lb AI/A (Table 2) while controlling weeds at 0.008 lb AI/A. Sulfentrazone was safe on the leaf lettuces at 0.3 lb AI/A, head lettuce at 0.06 lb AI/A with effective weed control at 0.047 lb AI/A. Flumetsulam at 0.02 lb AI/A was safe on lettuces while weed control was observed at the lowest applied rate of 0.005 lb AI/A. Rimsulfuron was safer on leaf lettuces at 0.014 lb AI/A compared to 0.007 lb AI/A on head lettuce with weed control effective at the lowest rate at 0.003 lb AI/A. Thifensulfuron was safe on the lettuces at the highest rate tested at 0.004 lb AI/A with no weeds observed at 0.0004 lb AI/A. All of the PREE treatments were effective until ratings at 50 DAT showed that effective weed control declined and higher rates were necessary. The margin of crop safety decreased as higher rates of herbicides were needed to control weeds for a longer period of time. PREE treatments that were not safe at the lowest applied rates on lettuces were cloransulam, flumioxazin, fluthiamide/metribuzin, halosulfuron, *s*-metolachlor, and clomazone. Herbicides applied PREE that did not offer sufficient weed control at the applied rates were flumiclorac and flumioxazin. Herbicides applied PREE that did not exhibit an adequate margin of crop safety with unacceptable weed control were dimethenamid, imazamox, fluroxypyr, triflusulfuron, and primisulfuron/prosulfuron.

In POST herbicide testing, at 3 DAT, carfentrazone, sulfentrazone, flumiclorac, flumioxazin, fluthiamide/metribuzin, and fluroxypyr caused significant crop injury on all lettuces at the lowest applied rates (Table 3). At 21 DAT, cloransulam, flumetsulam, and imazamox exhibited adequate crop safety while giving adequate weed control. Cloransulam and flumetsulam controlled weeds at the lowest applied rates of 0.004 and 0.005 lb AI/A, respectively. Lettuces were safe to cloransulam at 0.01 lb AI/A and flumetsulam at 0.03 lb AI/A. Imazamox was safe on lettuces at 0.01 lb AI/A and controlled weeds at 0.007 lb AI/A.

POST herbicides that were not safe on lettuces at the lowest applied rates when rated at 21 DAT included halosulfuron, rimsulfuron, primisulfuron/prosulfuron, and clomazone. POST herbicides that did not provide an adequate differential between crop safety and weed control efficacy were dimethenamid, s-metolachlor, thifensulfuron, and triflusulfuron.

For broccoli, sulfentrazone, fluroxypyr, and thifensulfuron applied PREE offered a marginal differential between crop safety and weed control (Table 4 and 5). At 32 DAT, sulfentrazone was safe at 0.059 lb AI/A and controlled weeds at 0.047 lb AI/A. Fluroxypyr was safe at the highest rate tested at 0.11 lb AI/A and weed control was effective at 0.069 lb AI/A. Carfentrazone was extremely marginal with a very narrow differential of safety with acceptable weed control at 0.009 to 0.008 lb AI/A. Thifensulfuron provided good safety at the starting rate of 0.004 lb AI/A and controlled

weeds at the lowest rate. Herbicides that were not safe PREE on broccoli at the lowest rates tested included cloransulam, halosulfuron, and clomazone.

In POST herbicide testing, cloransulam and flumetsulam at 0.015 and 0.02 lb AI/A, respectively, exhibited safety on broccoli at 21 DAT and weed control was effective at less than the lowest rates applied at 0.005 lb AI/A. Fluroxypyr exhibited very marginal crop safety at 0.019 lb AI/A versus weed control at 0.012 lb AI/A. Herbicides that caused crop injury at 3 DAT with a narrow or no differential for weed control were carfentrazone, sulfentrazone, flumiclorac, flumioxazin, and fluthiamide/metribuzin. At 21 DAT, herbicides that did not exhibit a wide margin of safety on broccoli and effective weed control were dimethenamid, imazamox, *s*-metolachlor, rimsulfuron, thifensulfuron, and triflusulfuron. Halosulfuron, primisulfuron/prosulfuron, and clomazone were not safe POST on broccoli at the lowest rates tested and were effective for weed control.

Further research is warranted to evaluate specific rates of carfentrazone, sulfentrazone, flumetsulam, rimsulfuron, and thifensulfuron applied PREE on lettuces. For POST applications, cloransulam, flumetsulam, and imazamox exhibited adequate crop safety on lettuces while giving adequate weed control to warrant further investigations. For broccoli, sulfentrazone, fluroxypyr, and thifensulfuron applied PREE demonstrated reasonable safety and weed control for further testing to be conducted. Cloransulam, flumetsulam, and fluroxypyr applied POST should be further evaluated to determine specific rates to ensure crop safety and effective weed control.

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Table 1. Preemergence herbicide screening test safety on head lettuce.

Herbicide Treatment	Start Rate (lb AI/A)	Safe Rate (<30% injury) 14 DAT	32 DAT	50 DAT
carfentrazone	0.032	0.025	0.015	0.01
sulfentrazone	0.375	0.094	0.06	0.055
cloransulam	0.039	0.025	<0.004	<0.004
flumetsulam	0.05	0.046	0.021	0.037
flumiclorac	0.05	0.044	0.05	0.009
flumioxazin	0.094	0.012	0.01	0.022
fluthiamide/metribuzin	0.94	<0.1	<0.10	0.12
dimethenamid	1.5	0.44	0.22	0.38
halosulfuron	0.1	0.1	<0.01	<0.01
imazamox	0.04	0.04	0.018	0.01
fluroxypyr	0.11	0.059	0.032	0.04
s-metolachlor	2.0	<0.21	<0.21	>2.0
rimsulfuron	0.031	0.013	0.007	0.008
thifensulfuron	0.004	0.004	0.004	0.004
triflusulfuron	0.031	0.017	0.01	0.017
primisulfuron/prosulfuron	0.036	0.011	0.007	0.014
clomazone	1.0	<0.11	<0.11	<0.11

Table 2. Preemergence herbicide screening test safety on leaf lettuces.

Herbicide Treatment	Start Rate (lb AI/A)	Safe rate (<30%) 14 DAT Romaine	14 DAT Red	32 DAT Romaine	32 DAT Red	50 DAT Romaine	50 DAT Red
carfentrazone	0.032	0.032	0.032	0.032	0.032	0.015	0.015
sulfentrazone	0.375	0.298	0.375	0.3	0.32	0.069	0.087
cloransulam	0.039	0.031	0.021	<0.004	<0.004	0.018	0.018
flumetsulam	0.05	0.05	0.05	0.022	0.022	0.05	0.034
flumiclorac	0.05	0.05	0.05	0.05	0.05	0.01	0.018
flumioxazin	0.094	0.012	<0.01	0.01	<0.01	0.03	0.022
fluthiamide/metribuzin	0.94	0.24	0.24	0.17	0.2	0.14	0.12
dimethenamid	1.5	0.44	0.44	0.38	0.38	0.75	0.88
halosulfuron	0.1	0.1	0.1	<0.01	<0.01	<0.01	<0.01
imazamox	0.04	0.04	0.04	0.03	0.03	0.014	0.013
fluroxypyr	0.11	0.094	0.075	0.081	0.035	0.11	0.044
s-metolachlor	2.0	0.27	0.27	0.23	0.23	>2.0	>2.0
rimsulfuron	0.031	0.031	0.027	0.014	0.014	0.014	0.014
thifensulfuron	0.004	0.004	0.004	0.004	0.004	0.004	0.004
triflusulfuron	0.031	0.031	0.031	0.017	0.031	0.017	0.017
primisulfuron/prosulfuron	0.036	0.018	0.018	0.015	0.011	0.014	0.014
clomazone	1.0	0.135	<0.11	<0.11	<0.11	<0.11	<0.11

Table 3. Postemergence herbicide screening test safety on lettuces

Herbicide Treatment	Rate (lb AI/A)	Safe Rate (<30% injury) 3 DAT Head	3 DAT Romaine	3 DAT Red	21 DAT Head	21 DAT Romaine	21 DAT Red
carfentrazone	0.032	<0.003	<0.003	<0.003	0.01	0.015	0.015
sulfentrazone	0.375	<0.04	<0.04	<0.04	0.055	0.069	0.087
cloransulam	0.039	0.021	0.025	0.025	0.014	0.014	0.011
flumetsulam	0.05	0.05	0.05	0.05	0.037	0.05	0.034
flumiclorac	0.05	<0.005	<0.005	<0.005	0.009	0.01	0.018
flumioxazin	0.094	<0.01	<0.01	<0.01	0.022	0.03	0.022
fluthiamide/metribuzin	0.94	<0.10	<0.10	<0.10	0.12	0.14	0.12
dimethenamid	1.5	0.81	0.81	0.81	0.38	0.75	0.88
halosulfuron	0.1	0.1	0.1	0.1	<0.01	<0.01	<0.01
imazamox	0.04	0.04	0.04	0.04	0.01	0.014	0.013
fluroxypyr	0.11	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012
s-metolachlor	2.0	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0
rimsulfuron	0.031	0.031	0.031	0.031	<0.003	<0.003	<0.003
thifensulfuron	0.004	0.004	0.004	0.004	0.0005	0.0006	<0.0004
triflusulfuron	0.031	0.031	0.031	0.031	0.005	0.008	0.005
primisulfuron/prosulfuron	0.036	0.036	0.036	0.036	<0.004	<0.004	<0.004
clomazone	1.0	1.0	1.0	1.0	<0.11	<0.11	<0.11

Table 4. Herbicide screening test safety on broccoli.

Herbicide Treatment	Start Rate (lb AI/A)	Safe Rate (<30% injury)				
		Preemergence			Postemergence	
		14 DAT	32 DAT	50 DAT	3 DAT	21 DAT
carfentrazone	0.032	0.01	0.009	0.014	0.013	0.011
sulfentrazone	0.375	0.055	0.059	0.094	0.08	0.16
cloransulam	0.039	0.008	<0.004	<0.004	0.016	0.015
flumetsulam	0.05	0.017	0.005	0.017	0.05	0.021
flumiclorac	0.05	0.05	0.05	0.05	0.018	0.037
flumioxazin	0.094	0.016	0.012	0.032	0.023	0.035
fluthiamide/metribuzin	0.94	0.22	0.11	0.13	0.23	0.14
dimethenamid	1.5	0.47	0.3	0.37	0.87	0.88
halosulfuron	0.1	0.1	<0.01	<0.01	0.1	<0.01
imazamox	0.04	0.04	0.01	0.01	0.04	0.008
fluroxypyr	0.11	0.11	0.11	0.11	0.019	0.032
s-metolachlor	2.0	0.5	0.37	-	1.1	>2.0
rimsulfuron	0.031	0.031	0.021	0.021	0.031	0.004
thifensulfuron	0.004	0.004	0.004	0.004	0.001	0.001
triflusulfuron	0.031	0.018	0.017	0.006	0.031	0.011
primisulfuron/prosulfuron	0.036	0.013	0.011	0.011	0.036	<0.004
clomazone	1.0	0.21	<0.11	0.16	1.0	<0.11

Table 5. Herbicide screening test weed control efficacy

Herbicide Treatment	Start Rate (lb AI/A)	Weed Control Rate (>80%)			
		Preemergence		Postemergence	
		32 DAT	50 DAT	3 DAT	21 DAT
carfentrazone	0.032	0.008	0.02	0.017	0.017
sulfentrazone	0.375	0.047	0.118	0.174	0.17
cloransulam	0.039	<0.004	0.006	-	<0.004
flumetsulam	0.05	<0.005	0.021	-	<0.005
flumiclorac	0.05	0.05	0.027	0.016	0.05
flumioxazin	0.094	0.094	0.04	0.02	0.03
fluthiamide/metribuzin	0.94	0.37	0.37	0.64	0.13
dimethenamid	1.5	0.81	0.81	-	0.88
halosulfuron	0.1	<0.01	0.031	-	<0.01
imazamox	0.04	0.025	0.017	-	0.007
fluroxypyr	0.11	0.069	0.081	<0.012	0.03
s-metolachlor	2.0	0.79	-	-	>2.0
rimsulfuron	0.031	<0.003	0.031	-	<0.003
thifensulfuron	0.004	<0.0004	0.004	-	<0.0004
triflusulfuron	0.031	0.021	0.018	-	0.018
primisulfuron/prosulfuron	0.036	0.031	0.011	-	<0.004
clomazone	1.0	<0.11	<0.11	-	<0.11