SUGAR BEET TOLERANCE TO SOIL CARRY-OVER RESIDUES OF PROWL HERBICIDE

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Introduction

Depending on the crop, pendimethalin (Prowl) is a selective herbicide applied preplant, preemergence, or early postemergence for the control of annual broadleaf and grassy weeds. Prowl has low solubility in water (0.5 ppm) and can persist in the soil up to eighteen months when applied at the upper limit use rates. Pendimethalin inhibits plant growth and development by stopping cell division (mitosis) in roots and shoots. The herbicide is used extensively for weed control in onions, potatoes, corn, beans, and mint crops. Sugar beets, in some cases, follow these crops in rotation. The objective of this study was to measure the effects of pendimethalin on root yield, root quality, and root morphology and development when the herbicide was applied at four rates in the fall and compared for sugar beet injury when diluted in the soil by mold-board plowing and surface tillage (6 inches) by a Triple-k field cultivator. Variations of individual treatments were evaluated by determining plant populations, root yield, beet shape and quality, and yield of recoverable sugar per acre.

Procedures

Soil at the experimental site was a silt loam texture with 1.3 percent organic matter, 18.5 cation exchange capacity, and a pH reading of 7.1. The field was summer fallowed previous to applying herbicide treatments in October 1994. Individual plots were 30 feet by 18 feet and each treatment was replicated 4 times. Ten foot wide untreated buffer strips were adjacent (sides, top, and bottom) to each treated plot. Herbicide rates in the mold-board plowed treatments were Prowl applied at 0.25, 0.50, 1.0, and 2.0 lb ai per acre. Prowl rates in the non-plowed, cultivated treatments were 0.1, 0.25, 0.50, and 1.0 lb ai per acre. Following application of the herbicide, the trial area was disked twice before plowing or cultivating. Plowing depth was 12 inches. Tillage teeth on the cultivator were set to operate to a depth of 8 inches. After plowing and cultivating the trial site was worked with a Ground-hog and the field bedded on 22 inch row spacings and left until spring.

Spray equipment included a single wheel bicycle plot sprayer with an 8.5 foot boom. Spraying pattern was double-overlap with 8002 teejet fan nozzles spaced 10 inches apart on the boom. Spray pressure was 42 psi, and the spray volume of water was 29 gallons per acre.

On April 8 the seed-bed of the bedded land was prepared by harrowing the bed tops with a spike-tooth harrow, and sugar beet seed, variety WS-PM9, was planted to stand at a 5-inch drop between seeds using a Beck planter. Soil active herbicides were not applied in 1995, and the trial site was not hand-thinned. On May 4 a tank-mix combination of Betamix-Progress and Poast herbicides were applied to sugar beets in the cotyledon to 2 true leaf seedling stage. Betamix-Progress and Poast herbicide rates were 0.25 and 0.10 lb ai per acre, respectively. The few weeds emerging after the postemergence herbicide applications were removed by hand-weeding. The trial was irrigated in furrows. Total amount of fertilizer applied was 210 lb of nitrogen and 100 lb of phosphate. Sixty pounds of nitrogen and 100 pounds of phosphate were applied in the fall before plowing and cultivating, and 150 pounds of nitrogen were sidedressed on June 13.

Plant populations were determined by counting the number of plants in 120 feet of row on May 10 when the sugar beets had 6 true leaves. Plants emerged in all treated plots but showed injury and began dying between cotyledon and 4 true leaf stage of growth.

Harvesting began on October 12. Sugar beet roots from 4 rows, 28 feet long, were harvested from each plot. Eight samples were collected and sent to the Amalgamated tare laboratory at Nyssa, Oregon, for analysis to determine percent sucrose, conductivity, and pulp nitrate-N. Each sample contained eight sugar beet roots. All roots in the 28 foot length were weighed to determine root yield per acre. Percent extraction and estimated recoverable sugar per acre were calculated. Roots were observed at harvest time for any abnormal root or crown growth. Roots from the check treatments were compared to roots growing in treated plots.

Results and Discussion

Sugar beets germinated and emerged uniformly in all treated plots regardless of Prowl herbicide rates in both non-plowed and plowed areas. Prowl injury became evident in the non-plowed treatments at rates of 0.25, 0.50, and 1.0 lb ai per acre rates when the sugar beet seedlings were in the full cotyledon to 2 true leaf growth stage. Many sugar beet plants in the non-plowed plots with Prowl applied at rates of 0.25, 0.5, and 1.0 lb ai per acre had died. Plants in plowed plots at all rates appeared healthy without stand losses. The higher the rate the more severe were the first injury symptoms. Injured sugar beet seedlings became stunted in growth; the cotyledon leaves were darker green, and the hypocotyl dark red. Later symptoms demonstrated by the plants were that the leaves became necrotic, the roots desiccated, and plants with severe symptoms eventually died leaving carcasses of seedling plants. Plant counts (Table 1) show that plant populations were significantly reduced at all rates of Prowl not-plowed and at the 2.0 lb rate of Prowl mold-board plowed. Prowl at the 0.25, 0.50, and 1.0 lb ai per ac rates did not affect plant populations when these herbicide rates were diluted in the top 12 inches of the soil by mold-board plowing. When the soil was not plowed, Prowl rates of 0.25 lb ai per acre reduced plant populations by 12 percent. Rates of 0.50 and 1.0 lb ai per ac rates were eventually lethal to all sugar beet plants.

Prowl herbicide did not lower percent sucrose or reduce root quality by increasing conductivity or nitrate-N readings when sugar beet populations were not reduced. When sugar beet populations were reduced from Prowl injury (0.25 lb non-plowed), root pulp quality was lowered as a result of higher conductivity and nitrate-N readings (Table 2). The lower root quality resulted in 1.76 percent reduction in extractable sugar when sugar beet populations were 12 percent less than in the untreated checks and sugar beets were spaced farther apart. Root yields (t/ac) were not affected when Prowl was plowed under at rates of 0.25, 0.50, and 1.0 lb ai per ac and non-plowed Prowl at 0.1 lbs ai per ac. All other treatments resulted in significant reduction in root yield . Estimated recoverable sugar yields were less in non-plowed Prowl treatments at rates of 0.25, 0.50, and 1.0 lb ai per ac rates. Roots and crown development, shape and growth where not different than those in the untreated checks except in the non-plowed treatments. Crowns of sugar beets in the non-plowed plots treated with Prowl at 0.25 lb grew above the ground. Prowl did not appear to cause stubby or sprangled root growth.

Conclusions

Sugar beets are sensitive to low concentrations of pendimethalin which can cause injury to seedling sugar beets if residues of the herbicide remain in the soil where sugar beet seed germinates and roots of seedling sugar beet plants forage. In this trial, sugar beet injury occurred from Prowl in the non-plowed treatments between 0.1 to 0.25 lb ai/ac. Soil containing Prowl concentrations of more than 0.1 ppm could result in a significant reduction in sugar yield because of sugar beet stand losses.

Table 1. Number of growing sugar beet plants from plots treated with Prowl herbicide turned-under with mold-board plow and non-plowed but tilled into upper 6 inches of soil with triple-k and roller seed-bed tiller. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1995.

Number of plants per 120 feet of row (4-30 foot rows)							
Plowed or non-plowed	Prowl rate	Rep 1	Rep 2	Rep 3	Rep 4	Average	% Check
	lb ai/ac	%					
Plowed	0.25	267	261	255	252	259	100.3
Plowed	0.5	261	257	253	256	257	99.6
Plowed	1.0	249	254	259	255	254	98.4
Plowed	2.0	243	248	253	249	248	96.1
Non-plowed	0.1	240	249	251	247	247	95.7
Non-plowed	0.25	215	225	237	231	227	87.9
Non-plowed	0.5	5	0	5	0	3	0.01
Non-plowed	1.0	0	0	0	0	0	0
Untreated check	0	262	250	256	264	258	100
LSD (0.05)						8	
CV (%)						2.8	

Table 2. Root yields, sugar yield, and root quality data of sugar beets planted following applications of Prowl when Prowl was applied the previous fall or plowed under and non-plowed treatments. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1995.

Herbicides	Rate	Plowed or non-plowed	Root yield	Sugar	Conductivity	Root nitrate-N	Extraction	Estimated recoverable sugar
	lb ai/ac		t/ac	%	µmho	ppm	%	lb /ac
Prowl	0.25	plowed	49.04	15.72	842	343	83.51	12,880
Prowl	0.5	plowed	49.36	15.65	882	382	82.94	12810
Prowl	1	plowed	49.04	15.94	834	330	83.65	13060
Prowl	2	plowed	47.91	15.74	832	331	83.62	12620
Prowl	0.1	non-plowed	49.15	15.51	868	388	83.09	12650
Prowl	0.25	non-plowed	35.64	15.58	1,010	421	81.19	8997
Prowl	0.5	non-plowed	0	0	0	0	0	0
Prowl	1	non-plowed	0	0	0	0	0	0
Untreated check	0	plowed	50.8	15.55	880	381	82.95	13,105
LSD (0.05)			2.75	0.32	71	69	0.96	737
CV (%)			7.1	3.2	12.5	29	1.8	7.3