EFFECTS OF SMALL AMOUNTS OF PENDIMETHALIN HERBICIDE ON SUGAR BEET PLANT DEVELOPMENT

Clint Shock and Erik Feibert
Malheur Experiment Station
Oregon State University
Ontario, Oregon

Introduction

We have observed phytotoxic damage to sugar beets following onions in Malheur County since 1991. In the spring and summer of 1994 the loss of sugar beet stands in commercial fields was particularly pronounced. Surviving plants in affected fields were stunted and roots became deformed.

The most recent change in cultural practices for onion production in Malheur County has been the use of pendimethalin for weed control, particularly effective for the control of dodder and many other weeds in onions. Four fields with deformed beets were sampled in August, 1994 for pendimethalin residues, following crops of onions that had pendimethalin application in 1993. Soil residual pendimethalin ranged from 0.03 to 0.08 ppm in the top foot of soil in August, 1994.

Trials were conducted to determine whether small amounts of residual pendimethalin herbicide could cause damage to sugar beets that follow onions or potatoes in the crop rotation and to identify damage symptoms (if any).

Procedures

Two trials, using the same procedures and the same soil, were conducted with different rates of pendimethalin. The first trial (Trial 1) using lower pendimethalin rates was conducted from November 4, 1994 to February 2, 1995 and the second trial (Trial 2) using higher pendimethalin rates was conducted from February 23, 1995 to May 24, 1995.

Approximately 1.5 tons of Owyhee silt loam 0 to 8-inch depth with no history of pendimethalin application was thoroughly mixed to fill forty 3-gallon pots. For each experiment eight pots were assigned to each of five treatments (Tables 1 and 3). The proper amount of soil to be treated for a given treatment was spread out in a thin layer and sprayed with a dilute rate of pendimethalin to achieve the desired treatments. The pendimethalin treatments were applied to the soil with a sprayer and then the soil was mixed in a concrete mixer and put in the eight pots in a greenhouse. The pendimethalin was applied either to all the soil in each pot or to only half the soil. Replicated soil samples were collected from each treatment and frozen for pendimethalin analysis.

Eighteen sugar beet seeds (cv. Hilleshog MonoHy HM WSPM9) were planted in each pot at one-inch depth on November 4, 1994 for Trial 1 and on February 23, 1995 for Trial 2. The plants were grown in a greenhouse and watered as necessary. The greenhouse lights and heaters were set to maintain 12 hr. day length at 70 °F and 12-hr nights at 40 °F. Grow lights were installed to ensure adequate daytime light intensity. The pots were randomly placed within the lighted area and were moved twice a week to avoid bias from unequal light distribution. The seedlings were thinned to 9 plants/pot, three weeks after planting. One month after planting, six plants/pot were carefully removed and checked for root deformities and root length was measured approximately. The soil was carefully replaced in each pot around the remaining three plants. The pots were fertilized with urea at 50 lb N/ac approximately 2 months after planting. Three months after planting the plants were removed, washed, weighed and the roots measured and checked for deformities. Soil at 6-inch depth in the center of each pot was sampled and frozen.

Results and Discussion

Sugar beet seedlings grown in pot tests were maintained at ideal temperature and nearly ideal soil moisture conditions without insect or disease pressure. These conditions were less stressful than the conditions that sugar beets would normally encounter in the field.

Seedlings emerged normally in all treatments in Trial 1. No root deformities were noted in any treatment on December 6 (Table 1). The pendimethalin treatments did not result in any significant difference in any of the measured parameters in the first trial. Root deformities consisting of forked roots were only found on 3 plants in the check treatment.

Pendimethalin content of the soil at planting was designed to be higher in Trial 2 than in the Trial 1 (Tables 2 and 4). Pendimethalin treatments in the second trial resulted in reduced plant height and reduced root length (Table 3). The treatments with only half the soil receiving pendimethalin resulted in reduced total plant fresh weight in late May. The plants in the untreated soil had the single, long tap root characteristic of sugar beets. There were high proportions of plants with short and deformed roots (roots with 2 or 3 forks) in the pendimethalin-treated soil compared with the check treatment.

The reported 90-day half-life for pendimethalin in the soil was substantiated by the pot tests. The average pendimethalin concentration on November 4, 1994 was 0.089 ppm and 90 days later on February 2, 1995 the concentration was about half at 0.041 ppm (Table 2). Trial 2 pendimethalin concentrations were 1 ppm at planting on February 23, 1995 and 0.46 ppm on May 24, 1995, 90 days later (Table 4).

Considering a half-life of 90 days, the range of concentrations of pendimethalin in March, 1994 in the fields that had sugar beet damage could be estimated. The soil in these fields had 0.03 and 0.08 ppm pendimethalin in the top foot of soil in August of

1994, so it is very likely that the soil had 0.8 to 0.24 ppm pendimethalin at March planting dates. The pot tests found that a pendimethalin concentration in the soil at planting of 0.25 ppm resulted in considerable damage to sugar beet seedlings, especially their roots (Table 5).

Where pendimethalin was present at 0.25 ppm or above at planting, differences in or effects on plant height, root length, and deformed beet roots were evident (Table 5). The plants were very sensitive to damage in spite of little additional plant stress from other environmental factors. Beet seedling tolerance to pendimethalin could be less in the field where seedlings are subject to other sources of stress.

Conclusions

Pendimethalin at 0.25 ppm and higher in the soil at planting reduced sugar beet plant height and root length development in pot tests. These low rates were within the range of pendimethalin concentrations estimated to be present in the soil at planting in fields showing sugar beet damage in the summer of 1994. These fields had pendimethalin applied for weed control in onion crops in 1993. The results of this trial suggest that pendimethalin residues in growers fields may be associated with damage observed to sugar beets. Caution should be exercised when planting sugar beets following crops of onions and potatoes where pendimethalin has been applied.

Table 1. Effect of pendimethalin herbicide on performance of potted sugar beets in Trial 1. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1996.

Rate	Treatment	Tap root length (12-6-94)	Beets with deformed roots	Plant height (2-2-95)	Beets with deformed roots	Plant fresh weight (tops and roots, 2-2-95)
lb ai/ac	(depth) of treated soil in pot	inches	%	inches	%	ounces
none	Check	3	0	6	13	7
1/8	0-12 inches	3	0	7	0	7
1/16	3-9 inches	3	0	6	0	6
1/4	0-12 inches	3	0	7	0	7
1/8	3-9 inches	3	0	7	0	7
LSD (0.05)		ns	ns	ns	ns	ns

Table 2. Pendimethalin content in potting soil in Trial 1. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1995.

Rate	Treatment	Replicates	Measured concentration	
			November 4, 1994	February 2, 1995
lb ai/ac	depth of treated soil		ppm	
none	0 - 12 inches		0. 000	0. 000
0.25	3-9 inches	1	0.085	0.039
0.25	3-9 inches	2	0.095	0.038
0.25	3-9 inches	3	0.086	0.046

Table 3. Effect of pendimethalin on performance of potted sugar beets in Trial 2. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1995.

Rate	Treatment	Plant height (3-15-95)	Root length (3-28-95)	Root length	Beets with deformed roots	Plant fresh weight (tops and roots)
				—— 5-24-95 ——		
lb ai/ac	Depth of treated soil in pot	inches			%	ounces
none	Check	3.5	3.2	6.2	8.3	5.9
0.75	0-12 inches	2.3	2.3	3.0	45.8	5.4
0.75	3-9 inches	2.8	2.6	3.7	45.8	4.6
1.50	0-12 inches	2.0	2.0	2.7	54.2	5.9
1.50	3-9 inches	3.0	2.6	2.7	83.3	4.2
LSD (0.05)		0.4	0.5	1.1	38.8	0.8

Table 4. Pendimethalin content in potting soil in Trial 2. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1995.

Rate	Treatment	Replicate	Measured concentration	
			February 23, 1995	May 24, 1995
lb ai/ac	Depth of treated soil in pot		——— ppm ———	
none	0 - 12 inches		0.00	0.00
1.5	3-9 inches	1	0.84	0.34
1.5	3-9 inches	2	0.89	0.44
1.5	3-9 inches	3	1.26	0.61

Table 5. Synthesis of the data from Trials 1 and 2 examining the effects of small amounts of pendimethalin on sugar beet development. Only significant differences from the check in Tables 1 and 3 are reported. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1995.

Distribution in soil	Residual pendimethalin at planting		Percent reduction			
			Plant height	Final root length	Beets with deformed roots	Plant fresh weight
	lb ai/ac	ppm	——— % ———			
Uniform 0-12 inches	0.125	0.04	ns	ns	ns	ns
	0.25	0.08	ns	ns	ns	ns
	0.75	0.25	34	55	38	ns
	1.50	0.50	43	56	46	ns
Non-uniform 3-9 inches	0.063	0.04	ns	ns	ns	ns
	0.125	0.08	ns	ns	ns	ns
	0.75	0.50	20	40	38	22
	1.50	1.00	14	56	75	29