Effects of Herbicides That Alter Plant Lipid Metabolism on Winter Survival of Sugarbeet Seedlings*

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Received for Publication June 1, 1984

INTRODUCTION

If increased winter survival of sugarbeets could be achieved in the cold temperate climates of the northern sugarbeet growing regions such as Michigan, improvement of this crop could be facilitated through less costly over-wintering methods of seed production. Currently, sugarbeet stecklings are removed from the field in the fall and their roots, with crown buds intact, are packed in crates and stored in a cold room (4 C). The following spring, these roots with their florally induced buds are replanted in soil to promote flowering, cross pollination, and seed production. Although this process is effective, it reduces the amount of sugarbeet breeding field research that can be accomplished in the northern temperate zones.

Cold hardy temperate zone crop plants are able to withstand winter temperatures of -30 C or less, but in the spring and summer months, they are susceptible to cold and can be easily killed at temperatures near 0 C (12). Cold hardiness of these species is dependent on their genetically controlled acclimation to survive freezing temperatures and their ability to express this trait.

Prevailing ambient temperature appears to be the most important environmental parameter for imparting cold hardiness to cereals (6,7). Low, above-freezing temperatures impart cold hardiness in the fall as most of these plants acclimate at temperatures gadually fall below 10 C

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(1), with optimal temperatures for cold acclimation near 3 C for cereals (6).

Stage of plant growth is important to acclimation and the maintenance of hardiness to cold temperature. Winter wheat (*Triticum aestivum* L.), growing 11 weeks or more in the fall, prior to cessation of growth, suffers more winter injury than younger plants (9). The four to six-leaf stage was the optimum stage for acquiring winter hardiness in this species.

There is considerable controversy on the biochemical and physiological processes involved in cold hardiness of higher plants (11). Much of this research has delt with lipids in relation to the cold hardening phenomenon. Cereals exposed to optimum temperatures for cold hardening showed an increase in linolenic acid in the fatty acid portion of cell membrane lipids (2). Membrane lipids that contain a high percentage of unsaturated fatty acids have been shown to be more fluid at low temperatures, which would aid in maintaining membrane integrity at lower temperatures (5). However, additional research has shown that this shift toward greater fatty acid unsaturation in cereals may only be a low-temperature response and not involved in cold acclimation, per se (3).

Chemical effects on membrane lipids and their relationship to cold hardening and chilling injury also have been investigated. Willemot (12) found that BASF 13-338 [4-chloro-5-(dimethylamino)-2- phenyl-3-(2H)-pyridazinone] inhibited linolenic acid accumulation and frost resistance in 12-day-old winter wheat plants. This chemical also affected cotton (*Gossypium hirsutum* L.) seedlings similarly, ultimately leaving the plants more susceptible to chilling injury (10). Other research demonstrated that the herbicides diethatyl [N-(chloroacetyl)-N-(2,6-diethylphenyl)-glycine] and vernolate increased cold hardiness in soybean (*Glycine max* (L.) Merr.) and this result corresponded to an increase in the unsaturated fatty acid content of plasmalemma in the root (8). Mahoney et al. (4) demonstrated that alachlor application to the foliage of 17-day-old sugarbeet increased the unsaturated fatty acid content of mitochondria membrane and plasmalemma similar to a cold temperature treatment.

Thus, the investigation was conducted to evaluate chemicals that increase the unsaturated faty acid content of plant cell membranes for their potential to increase winter survival of sugarbeet seedlings in the field.

MATERIALS AND METHODS

Two field experiments were conducted during the winter periods of 1980-81 and 1981-82, near East Lansing and Haslett, Michigan, respectively.

The first experiment was initiated on August 25, 1980 in a sand loam soil. 'US H20' sugarbeet seeds were planted 2.5 cm deep and 5 cm apart in rows 0.3 m apart in in plots 1.2 m wide by 1.2 m long. On October 27, 1980, sugarbeets in the 6-to-8-leaf stage of growth received foliar applications of solutions of alachlor (Lasso 4E) at 100 and 200 mg/l and vernolate (Vernam 7E) at 50 mg/l with 0.5% v/v Tween 20 surfactant. Applications were made with a hand-pump sprayer to the foliage until solution runoff occurred. All treatments were replicated three times. Two weeks following treatments, all plots were covered with 30 cm of wheat straw.

The second experiment was initiated on August 21, 1981 in a loamy sand soil. All plots contained one row each of three sugarbeet lines [G-0 (seed mixture produced at Sorenson in 1980), J-0 (81B1-1) and I-0 (50% each 81B2-00 and 81B5-00) types] planted 2.5 cm deep and 5 cm apart in rows 0.6 m apart and 4.3 m long. On October 28, 1981, sugarbeets in the 6-to-8-leaf stage of growth received foliar applications of alachlor at 100 and 200 mg/l and vernolate at 25, 50 and 100 mg/l in 73 l/ha H_2O with 0.5% (v/v) X-77 surfactant. Treatments were made with a knap-sack sprayer, under 2.1 kg/cm^2 pressure supplied by a cartridge of compressed CO_2. Treatments were replicated four times and all sugarbeet lines were randomized within each plot. There were two sets of treatments for this experiment. One set received a cover of 30 cm of wheat straw three weeks after application, and the other set received no straw cover.

Each spring (March 30 and April 16 for experiments one and two, respectively) the straw was removed from the plots, stand counts taken, and flowering observed. The data were analyzed by analysis of variance and treatment means compared by Duncan's multiple range test.

RESULTS AND DISCUSSION

In the first experiment, alachlor at 100 mg/l and vernolate at 50 mg/l applied to runoff, increased the number of sugarbeets that survived during the winter compared to the untreated control (Table 1). This indicates that a relationship may exist between herbicides that increase the fatty acid unsaturation and their ability to impart cold tolerance to plants as reported by Rivera (8). The percentage of plants that survived during the winter was not calculated because stand counts were not taken in the fall. Of those plants that survived, approximately 80 percent of them flowered, indicating that the chemicals had no adverse effect on flowering.

Table 1. Effect of foliar applications of alachlor and vernolate on the survival of 'US H2O' sugarbeets in the field during the winter (1980-1981)[a].

Treatment	Rate	Number of Surviving Plants[b]
	(mg/l)	
Check	0	17 a
Alachlor	100	43 b
Alachlor	200	31 ab
Vernolate	50	44 b

[a]Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Average number of plants per plot for each treatment.

In the second experiment, the chemical treatments had no effect on winter survival of sugarbeets (Table 2). In this study 100 percent of the plants without cover and 80 percent of the plants with straw-cover survived the winter. Snowfall during the winters of 1980-81 and 1981-82 was 88.1 and 133.6 cm, respectively (Table 3). The

Table 2. Effect of foliar applications of alachlor and vernolate on the survival of 'US H20' sugarbeets in the field during the winter (1981-1982)[a].

Treatment	Rate	Number of Plants Surviving[b] G-O Type	J-O Type	I-O Type
	(mg/l)			
Check	0	24 a	19 a	25 a
Alachlor	100	25 a	25 a	28 a
Alachlor	200	24 a	29 a	25 a
Vernolate	25	24 a	26 a	28 a
Vernolate	50	31 a	21 a	23 a
Vernolate	100	25 a	24 a	23 a

[a]Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.
[b]Average number of plants per plot for each treatment.

Table 3. Total monthly snowfall and average monthly temperature for 1980-1981 and 1981-1982[1].

Month	1980-1981 Snowfall[2]	Temperature[3]	1981-1982 Snowfall	Temperature
	(cm)	(C)	(cm)	(C)
December	36.1	-4.6	40.4	-2.7
January	15.0	-8.0	39.6	-9.4
February	31.0	-2.1	20.8	-6.8
March	6.0	1.9	32.8	-0.5
TOTAL	88.1	--	133.6	--

[1]Climatic data was obtained from the National Weather Service Office at Lansing, Michigan.
[2]Total monthly snowfall.
[3]Average ambient temperature.

larger amount of snow-cover during the second winter might explain the increased sugarbeet survival in this experiment despite the lower temperatures. Snowfall during January, 1981 was considerably less than in January, 1982 with similar temperatures. Because of the unexpectedly high survival rate of plants without cover, chemical effects on winter survival could not be adequately assessed in experiment two. The lower survival rate of plants under the straw-cover than those with no cover was probably the result of rodent damage. As in experiment one, over 80 percent of the plants flowered in all treatments.

CONCLUSION

Treatments of alachlor at 100 mg/l and vernolate at 50 mg/l increased the number of 'US H20' sugarbeets that survived in the field during the winter of 1980-1981. The survival rate of the untreated controls of covered and uncovered sugarbeets was too high to assess herbicide effects on survival during the winter of 1981-82. Approximately 80 percent of the sugarbeets flowered the following spring irrespective of chemical treatment or year.

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