The Effects of Dalapon on Pectic Substances and on Root Growth of Sugar Beets[1]

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Introduction

The herbicide, alpha, alpha, dichloropropionic acid, hereafter referred to as dalapon, is a selective chemical used for control of grasses. It has been used successfully as a post-emergent treatment for control of weeds in sugar beets. Although outstanding control has been obtained, the chemical has not been received with much favor. Considerable stunting of the sugar-beet seedling is prevalent, especially when treatments are made after the cotyledon to the 4-leaf stage of growth. Timely application is very important. Research data show no reduction in sugar-beet yield over a five-year period when timing was proper. This paper reports the results of a study conducted to: 1) determine the effect of post-emergent application of two rates of dalapon on the root growth of sugar beets; 2) determine by chemical analysis the effects of the dalapon upon the amounts of pectin and of pectic substances contained in sugar beets; 3) determine the longevity of inhibiting effects of chemical treatment upon sugar-beet roots.

Greenhouse Studies

As dalapon was known temporarily to delay sugar beet growth, a greenhouse study was undertaken to determine the reaction of the roots to post-emergent applications of the chemical at rates of 0, 6, and 10 pounds of acid per acre (hereafter referred to as pounds per acre). Galvanized metal flats were used which had been constructed so that a plate of glass served as one side to allow for observation of the root developments.

The flats were filled with sterilized, homogeneous, greenhouse soil and watered to field capacity and planted with sugar beet seed approximately 3/4 inch deep. Shortly after emergence, the sugar beets were thinned to 6 plants per flat. The roots were marked and measured when the beets had reached the 2- to 4-leaf stage of growth. Dalapon was applied to 4 flats of plants each at 0, 6, and 10 pounds per acre.

Observations were made frequently and photographs were made weekly. Beet roots were measured in centimeters.

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Seventeen days after the chemical treatment, all of the plants receiving the 10-pound-per-acre rate were dead. At this point all plant roots were carefully washed from the soil for observation, photographing, and chemical analysis. One group of plants from the untreated and one from the 6-pound treatment were also washed for comparison.

Since all plants receiving 10 pounds of dalapon died, it was decided to repeat the experiment and treat the plants at an earlier stage of growth. In the next trial, the plants were treated shortly after the appearance of the first 2 true leaves 17 days after planting.

Fifty days after chemical application, the plants from one flat of the 6-pound treatment and one untreated flat were removed and the soil washed from them leaving the roots for comparison and chemical analysis of pectic substances. Since beets treated at the 10-pound rate had again died shortly after chemical application, no attempt was made to analyze these roots chemically.

Results of Greenhouse Study

Dalapon at 10 pounds per acre proved to be lethal to all treated sugar beets in the greenhouse trial. Within 3 days after treatment, all plants wilted. Foliage of beets treated with 6 pounds per acre displayed lack of vigor 3 days after treatment when compared to the check.

Root growth was retarded in the 6-pound-per-acre treatment compared to the untreated plants. Figure 1 illustrates the condition of the beets at time of treatment. Figure 2 compares the amount of root growth which had taken place during the week

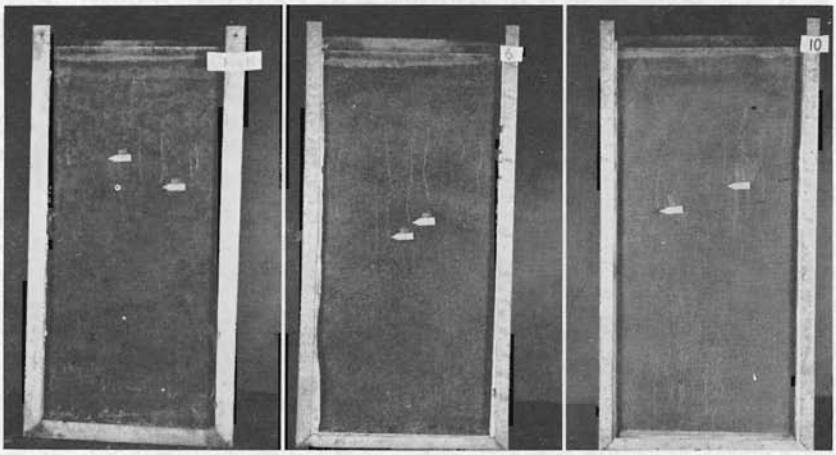

Figure 1.—Root development of sugar beets at time of treatment. Note root length compared with top growth, 17 days after planting.

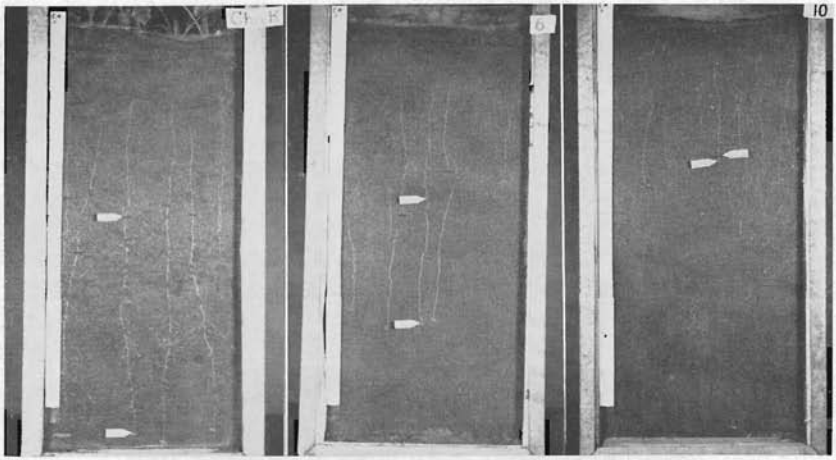

Figure 2.—Root growth of sugar beets during first week after post-emergent application of dalapon at 0, 6, and 10 pounds per acre. Distance between arrows indicates the amount of elongation occurring 7 days after treatment.

after treatment. Roots of the untreated plants had grown 25 centimeters or more and had numerous lateral roots and root hairs. Dalapon at 6 pounds per acre had retarded root growth to 12 to 15 centimeters in a week with practically no lateral roots apparent. Root growth on beets treated at 10 pounds per acre was nil.

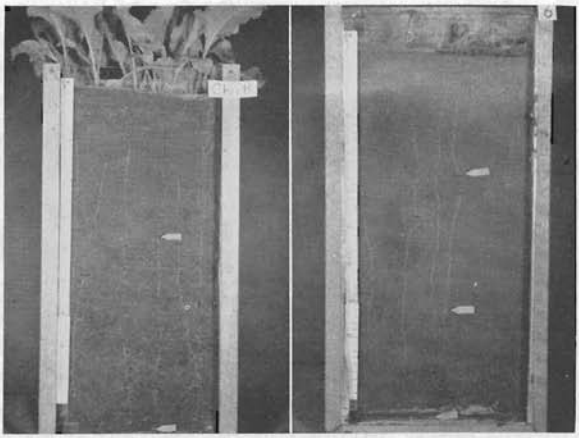

Figure 3.—Root growth 14 days after treatment with 6 pounds of dalapon per acre. Roots of treated plants have reached the bottom of the flats. Note the greater amount of lateral roots and root hairs on the untreated beets, left. Lack of top growth is apparent on the treated beets, right.

Fourteen days after treatment, roots of beets treated at 6 pounds per acre had reached maximum observable length. When compared with untreated plants, lack of development of both the roots and the tops was evident as seen in Figure 3.

The results of the chemical analysis for pectic substances are shown in Table 1. The percentage of pectic substances in alcohol-insoluble solids of untreated beets reached 13.52 compared with 9.82 and 2.73 for beets treated with 6 and 10 pounds of dalapon per acre. It appears that dalapon increases the percentage of alcohol-insoluble solids, but decreases the percentage of pectic substances in sugar beets for a time after treatment.

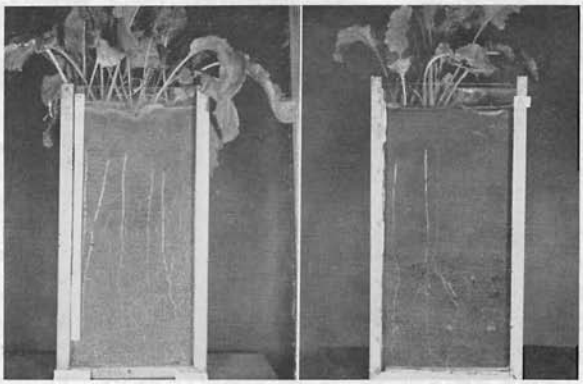

Figure 4.—Beets 40 days after treatment with dalapon at 6 pounds per acre. Lack of lateral roots and root hairs is still apparent in the treated beet, right. Foliar growth appears to be equal at this time.

In Figure 4 a flat of untreated plants is compared with a flat treated with 6 pounds per acre of dalapon 40 days after treatment. Apparently recovery had largely been completed by this time. Lateral roots and root hairs appear to be fewer on the treated plants. Washed roots from the flat in Figure 4 are compared in Figure 5. Results of chemical analysis for pectic substances in these beets, 50 days after treatment, are shown in Table 2. The amount of pectic substances in root tissues increased with maturity, as would be expected with sugar beets.

The amount of water-soluble pectic substances showed reversed trends in treated and untreated sugar beets. The percentage of water-soluble pectic substances in untreated beet foliage remained nearly equal during the 50-day period. The percentage of water-soluble pectic substances in the roots of untreated beets rose from 1.20 to 6.85 percent during the period. Dalapon-treated beets showed just the opposite condition with water-soluble pectic compounds rising from 1.00 to 5.59 percent in the

Figure 5.—Sample obtained for chemical analysis 50 days after treatment with 6 pounds of dalapon. Treated beets on the left appear to have recovered from effects of treatment at this date.

Table 1.—Chemical Analysis of Sugar Beets for Pectic Substances in Alcohol-Insoluble Solids.[1]

Sample	Rate of Dalapon Per Acre	Grams Fresh Weight	Percent AIS[2]	Percent Pectin in AIS				Percentage Pectin in Total AIS, Foliage, and Roots
				Water Soluble	Oxalate Soluble	Acid Soluble	Total	
Trial 1								
Foliage	0	46	3.36	0.06	0.96	5.15	6.17	5.71
Roots	0	9	5.10	0.15	2.81	1.24	4.20	
Foliage	6	5	4.70	0.00	6.43	0.00	6.43	4.80
Roots	6	1	8.00	0.00	0.38	0.00	0.38	
Foliage and roots[3]	10	10	10.60	0.00	2.45	0.28	2.73	2.73
Trial 2								
Foliage	0	190	2.46	2.70	9.30	2.90	14.90	13.52
Roots	0	20	5.20	1.20	3.80	2.20	7.30	
Foliage	6	41	3.47	1.00	7.40	2.90	11.30	9.82
Roots	6	3	32.80	2.40	2.60	2.70	7.70	

[1] Samples were analyzed 17 days after dalapon treatment.

[2] AIS refers to alcohol-insoluble solids; materials insoluble in 70 percent ethanol and water.

[3] Foliage and roots were combined because root sample alone was too small for analysis.

Table 2.—Chemical Analyses of Sugar Beets for Pectic Substances in Alcohol-Insoluble Solids.[1]

Sample	Rate of Dalapon Per Acre	Grams Fresh Weight	Percent AIS[2]	Percent Pectin in AIS				Percentage Pectin in Total AIS, Foliage and Roots
				Water Soluble	Oxalate Soluble	Acid Soluble	Total	
Foliage	0	73	9.99	2.47	3.61	10.84	16.92	16.39
Roots	0	56	5.40	6.85	2.66	5.77	15.28	
Foliage	6	82	9.92	5.59	2.14	9.10	16.83	15.89
Roots	6	25	5.71	2.97	2.12	6.13	11.22	

[1] Samples were analyzed 50 days after treatment with 6 pounds dalapon per acre.

[2] AIS refers to alcohol-insoluble solids, materials insoluble in 70 percent ethanol and water.

foliage, while the roots contained approximately the same amount on both dates (Tables 1 and 2). Indications are that dalapon interferes with the normal distribution of water-soluble pectic substances. The oxalate-soluble fraction of the pectic substances shows the same tendency to decrease in both treated and untreated sugar beets during the 50-day test period. The total amount of oxalate-soluble pectic substances is reduced by dalapon.

The percentage of acid-soluble pectic substances is smaller in beets treated with dalapon than in untreated beets. However, the decreased percentage of oxalate-soluble pectic substances is reversed and approximately equalled by the increase in percentage of acid-soluble pectic substances (Tables 1 and 2).

The percentage of alcohol-insoluble solids in root tissue is increased by dalapon treatments. This trend is consistent in all analyses (Tables 1 and 2). The effect of dalapon on the percentage of alcohol-insoluble solids in sugar beets is clearly noted. It is assumed that the percentage of alcohol-insolube solids rose from the time of treatment with dalapon to 32.8 percent at time of sampling. This assumption is based on the percentage of alcohol-insoluble solids in untreated plants the same age. Apparently as the effects of dalapon are overcome and root growth approaches normality, the percentage of alcohol-insoluble solids decreases to approximately that of untreated plants.

Field Study

Field studies were conducted at Wheatland and Torrington, Wyoming, in fields which had previously been treated with 6 and 10 pounds of dalapon per acre. The experimental plots were

selected at random from these larger fields. Twenty-one days, 28 days, 41 days, and 50 days after treatment, stand counts were made. Plants selected at random from each of the treated rows were given a figure rating from 1 to 10, with 10 indicating maximum plant size and vigor. The number of leaves on each of the 10 rated plants was counted and the length of the longest leaf on each rated plant recorded.

Excavation was made along the rows to expose the roots of the plants as they were growing in the soil. Length of roots was measured and photographs made.

Results of Field Study

Results of ratings and measurements made on plants in field plots at Wheatland 28 days after treatment are shown in Table 3. On a percentage basis the length of leaves on treated plants was reduced. The average height of beets in the plots treated at 10 pounds per acre was 80 percent of untreated plants. Six pounds of dalapon did not measurably reduce the vigor of the sugar beets, while 10 pounds reduced vigor by 41 percent. Analysis-of-variance treatment data show that leaf length is significantly reduced by 10 pounds of dalapon. Reduction in plant vigor resulting from treatment with 10 pounds of chemical per acre is significant at the 5 and the 1 percent levels.

Excavation of the root zone revealed little difference in the length of tap roots resulting from the various treatments after 28 days. Roots were measured to be 10.0 inches for untreated plants, 9.0 for the 6-pound dalapon treatment, and 8.5 for the 10-pounds-per-acre treatment. Closer examination revealed lack of lateral roots and root hairs as was observed in greenhouse trials. When removed from the soil for comparison, the roots on treated plants appeared definitely reduced in size and vigor, particularly the plants from the 10-pound treatments.

Table 3.—Effect of Two Rates of Dalapon Upon Sugar-Beet Vigor, Plant Heights, and Number of Leaves Compared with the Untreated Check at Wheatland.[1]

Treatment	Plant Height in Inches	Number of Leaves	Vigor[2]
Untreated	5.26	7.76	4.50
6 lbs. Dalapon	6.21	7.53	4.40
10 lbs. Dalapon	4.35	7.73	2.60
L.S.D. 5% Level	.70	NS	.87
L.S.D. 1% Level	NS	NS	1.16

[1] All figures are the means for 30 plants selected from each treatment.
[2] Vigor rating of 10 indicates maximum size and vigor.

Plots at Torrington 28 days after treatment were given vigor ratings of 10 for untreated beets, 7 for plots treated with 6 pounds per acre, and 4 plots receiving 10 pounds per acre. Stand counts were made on 25 feet of row replicated four times for each treatment. Average stand count for 25 feet of row was 20.8 plants for untreated rows, 23.8 beets in rows treated with 6 pounds of dalapon per acre, and 12.8 beets in the rows receiving 10 pounds of chemical. Analysis-of-variance treatment of the results shows that 10 pounds of dalapon reduced the stands significantly. An L.S.D. of 8.65 at the 5 percent level and 13.1 at the 1 percent level were required for significance.

Measurements of roots at Torrington 28 days after treatment failed to show any reduction in tap-root length of treated beets. However, the roots of beets treated with dalapon did not have the size or the profusion of lateral roots and root hairs exhibited by untreated beets. Only the beets treated at 10 pounds per acre showed a marked reduction in size when removed from the soil and compared with untreated beets. The effect of 6 pounds of dalapon appeared to be nearly outgrown at this stage. Comparisons of vigor, root weights, top weights, and root diameter at the crown are made in Figure 6.

Forty-one days after treatment, plots at Torrington were given vigor rating of 10 for untreated beets, 8 for 6 pounds dalapon, and 6 for 10-pound dalapon treatments. Forty-one

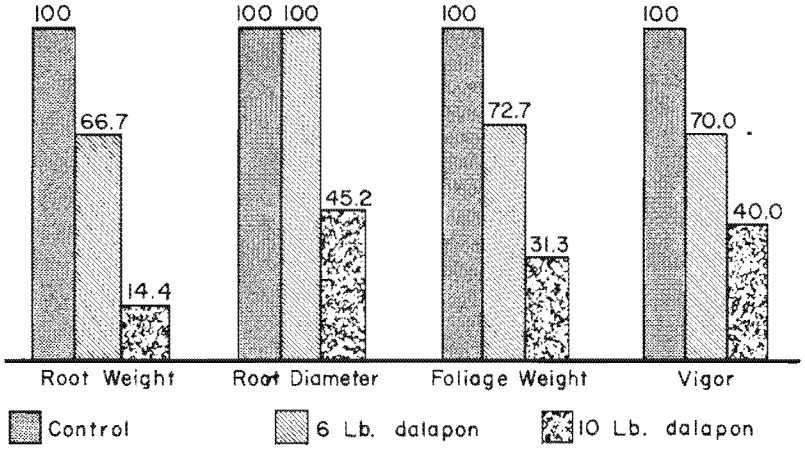

Figure 6.—Percentage comparison of root weight, root diameter at crown, foliage weight, and vigor of sugar beets from 3 treatments with dalapon. Observations made 41 days after chemical treatment. Untreated plants are considered as 100 percent.

days after treatment with 6 pounds of dalapon, beet roots would be about 60 percent as large as those not treated while beets given 10 pounds per acre are only one-third as well developed.

Samples taken at Wheatland 50 days after treatment showed the same pattern of growth. The foliage of the beets tends to return to normal before the root growth catches up. Size differences are apparent but length of roots appears equal. Pictures of 20 beets from each treatment are seen in Figure 7. As indicated by chemical analysis, it appears that by 50 days after treatment, the effects of dalapon applied at 6 pounds per acre have been overcome, but root growth of treated beets has not yet become equal to untreated beets.

Discussion and Summary

For at least 50 days after treatment with dalapon, sugar beets contain less pectic substances than untreated beets. The percentage of alcohol-insoluble solids in the roots of treated beets

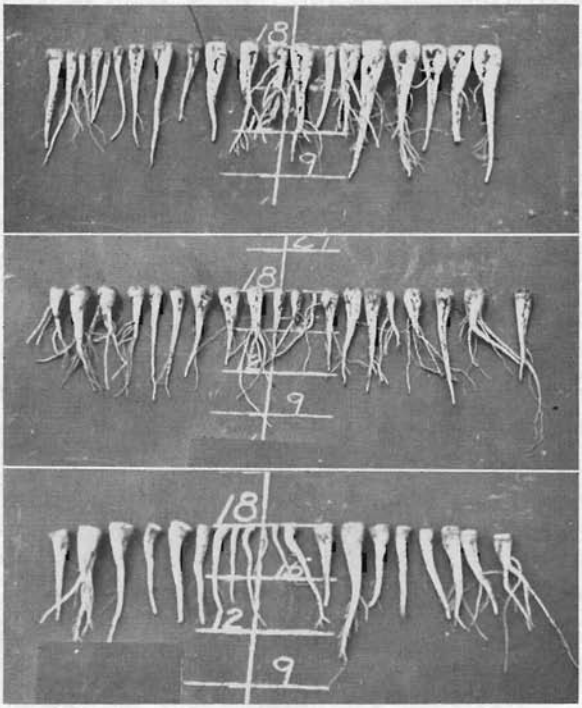

Figure 7.—Twenty beet roots from each of 3 dalapon treatments compared. Root length appears about equal in all samples. A reduction in size is apparent in the roots from the 10-pound treatment. Samples were taken 50 days after chemical application.

is much higher than in untreated beets. The cause for this is unknown, although one might postulate that, the pectic substance are believed to function in the transportation of water in the plants; therefore, if dalapon decreased the water-holding ability of the roots resulting in dehydration, then the percentage of alcohol-insoluble solids would be high.

Or, if the tops continue food manufacturing and translocation to root cells which are damaged by dalapon, there would again be an increase in the percentage of insoluble-alcohol solids. Perhaps cell walls are thicker, or the cell sap is more concentrated because of the upset in the balance of water-soluble pectic substances. As the effects of dalapon are outgrown by the plants and the root growth approaches normality, the percentages of alcohol-insoluble solids in the roots decrease to near that of untreated plants. Six pounds of dalapon per acre retarded the rate of root growth both in the greenhouse and in the field trials.

Field measurements indicate that 50 days after treatment with dalapon at 6 pounds per acre, foliar growth of beets was approximately equal to untreated beets. Root development was 60 percent as great in treated beets as in untreated beets. Since it has been found that the harvest yields are not reduced by 6 pounds of dalapon, it must be assumed that recovery is completed. Therefore, since good control of grassy weeds and some control of broadleaved weeds can be obtained with 6 pounds of dalapon, it would appear logical to use this rate as a post-emergent application.

Conclusions

1. Sugar-beet stands are significantly reduced with 10 pounds of dalapon per acre applied as a post-emergent spray.

2. Sugar beets that survive application of 10 pounds of dalapon are greatly retarded in root and foliar growth.

3. The percentage of alcohol-insoluble solids in sugar-beet roots increases rapidly for a time after treatment with dalapon. As the effects of dalapon are overcome by the growing plant, the percentage of alcohol-insoluble solids decreases to approximately that of untreated beets.

4. The amount of pectic substances in sugar beets is reduced for at least 50 days by treating with dalapon at 6 pounds per acre.

5. The amount of water-soluble pectic substances in alcohol-insoluble solids of sugar beets is affected by dalapon at 6 pounds per acre. The distribution of water-soluble pectic substances is

highest in the foliage of treated beets and in the roots of untreated beets. The oxalate-soluble fraction of pectic substances in alcohol-insoluble solids is smaller in dalapon-treated beets than in untreated beets. The percentage of oxalate-soluble pectic substances in alcohol-soluble solids decreases as the beets mature.

6. The acid-soluble fraction of pectic substances in alcohol-insoluble solids increases as the beets mature. Dalapon at 6 pounds per acre reduces the amount of acid-soluble pectic substances in treated beets compared with untreated beets

7. It may be expected that sugar beets treated with 6 pounds of dalapon as a post-emergent spray will be retarded in plant vigor, root, and foliar growth. However, one may expect treated plants to be equal in foliage to untreated plants after 50 days. Root growth of treated plants may be retarded somewhat longer.