The Control of Annual Grasses in Sugar Beets With Dalapon

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Weed control usually accounts for a large proportion of the expense incurred by the grower in raising a crop of sugar beets. Annual grasses, because of the nature and vigor of growth, present the most difficult problem. Hand-blocking and thinning costs are increased considerably; indeed, thinning crews have refused to work in some fields because of the dense stand of grass. Even after the grass has been cleaned up at thinning time a new crop often comes back following irrigations, necessitating continued hoeing costs through the season. Mechanical blocking, of course, will reduce the grass population depending on the method used but many small grass seedlings still remain in the block of beets.

Recently chemicals have been used to alleviate this burden of weed control. Pre-emergence sprays which kill by contact have been applied a few days ahead of emergence of the beets; ideally, this kills all weed foliage above ground. Chemical residues which injure the beet seedlings emerging later have been a problem with this treatment.

Sodium TCA is another chemical being used successfully in some areas to control annual grasses. Since TCA acts through the soil, the success of this treatment depends on the proper amount of rainfall or sprinkling following application to carry the toxicant into the soil.

In searching for new selective chemicals it has been recognized that a treatment applied after emergence of the weeds and crop is more desirable than pre-emergence type sprays. Some of the advantages to be realized with this type of control are: 1. The grower can evaluate the weed population before treating. 2. He can wait for emergence of the beets. 3. If weeds are not general, "spot spraying" is possible.

Toxic materials, to be active on the growing plants, could be absorbed through the roots as with TCA, or through the leaves or through both, as occurs with 2,4-D on broadleaved plants. Of course, translocation of the compound must carry it to a point within the plant where the biological processes will be disturbed sufficiently to cause death or severe inhibition. TCA, which is absorbed through the roots, can be effective against young grasses after emergence if proper rainfall occurs to carry it to the root zone of the grasses in lethal quantities. However, there is a risk, except with artificial rainfall, that the material will not be leached into the soil until too late to control the grass, or that it will be leached too deep to be effective.

Recently a chemical that is absorbed and translocated downward through the blades of grasses was discovered (1) [2] It has been given the name "dalapon." The compound is 2,2-dichloropropionic acid. It may be interesting to note the structure of the sodium salt of dalapon (furnished to

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[2] Numbers in parentheses refer to literature cited.

experiment stations in 1953) compared to the sodium salt of TCA. Sodium TCA is $Cl_3CCOONa$. Sodium dalapon is $CH_3Cl_2CCOONa$. Except for the substitution of a methyl group for a chlorine atom on the No. 2 carbon, these compounds are the same. Yet TCA can be absorbed through the roots only whereas dalapon is absorbed through both leaves and roots. Dalapon has been found by results of single oral acute experiments to be less toxic to warm-blooded animals than table salt. The sodium salt, which will be the first formulation to be marketed, is readily soluble in water.

At the rates required for annual grass control, contact burn usually does not occur; however, it may develop on the margins of both broadleaves and grasses under conditions of high temperature. The killing action on grasses is first manifested 2 to 3 weeks after spraying as necrosis of blade margins, which gradually progresses downward to the crown of the plant in 7 weeks. This is the time usually required for ultimate kill, although young seedling grasses may succumb in 3 to 4 weeks.

One of the first crops considered for selective treatments with this chemical was sugar beets. The first applications were made in the summer of 1952 to beets in various growth stages where watergrass was a problem. Observations of these plots indicated the following: 1. The dosage for control of grasses was in the range of 3 to 6 pounds per acre. 2. Although the beet top growth was suppressed for a few weeks, at harvest time there were no observable differences between the treated and untreated plots.

With this encouragement, plans for the 1953 season were made to confirm the findings of our 1952 work and in addition to determine: 1. Effect of dalapon on the yield of beets. 2. Optimum volume rate. 3. Relationship of growth stage of grasses to dosage. 4. Effect of environmental conditions such as temperature and soil moisture.

The yield plots were uniform beets which received normal culture including good non-chemical weed control. Applications were made at two growth stages—just after thinning and about 5 weeks later—both as separate and repeat sprays. One experiment was applied to beets in the 2-leaf stage with the second and repeat sprays after thinning. Two or three samples per plot were collected for sucrose analysis and processed by the appropriate company laboratories.

The dosage required for control of watergrass under conditions favorable to the action of dalapon is in the range of 3 to 5 pounds sodium salt per acre, as shown in Table 1.

The dosage rates specified are based on excellent wetting (film type) of grass blades. It has been found that dalapon is much more efficient with

Table 1.—Control of Watergrass in Sugar Beets with Dalapon.

Sodium dalapon lbs. per acre	Estimated % control Expt. 1	Expt. 2
3.5	96	
4.7	92	93
7.0	99	

a good surfactant. Curves (Figure 1) have been drawn for another experiment, which show the improvement in action of dalapon at a given dosage per acre with good wetting action after 27 days.

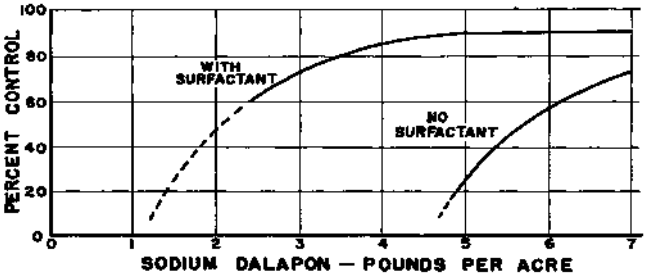

Figure 1.—Effect of surfactants on action of dalapon.

In Table 2 we can see that the controls at given dosages are essentially equal at three growth stages irom seedling to stooling. Experiments 1 and 2 were immediately adjacent; 3 was in another field but in all three the beets, and consequently the grasses, were maintained in good growth during the season. The information on temperatures shows that over this range there is no apparent difference in the control of grasses.

Table 2.—Effect of Temperature and Size of Grass on Control with Sodium Dalapon.

Grass growth Temperature[1] Lbs. per acre	1-3 leaves 65-87° F	Several leaves 69-84° F	Stooled 100° F
2.3	84	83	81
3.5	96		90
4.7	92	93	95
7.0	99		98

[1] Maximum temperature range during first week.

The influence of soil moisture on control was indicated *in* an experiment in which, at the time of the first application and for a few days afterwards, the grower withheld irrigation to retard the growth of the grass. This was effective in reducing the vigor of the grass. Very poor control with dalapon occurred, which may have been because the grasses were under moisture stress.

Results of tests to determine the optimum volume rate for dalapon sprays revealed no differences in the range of 100 to 12.5 gpa, as shown in Table 3. In selecting the rate of surfactant to be used in the volume rate tests, it was decided to use an intermediate scale between percent solution and constant amount per acre.

Table 3.—A Comparison of Volume Rates Using Dalapon in Grass Contol.

Sodium dalapon Lbs. per acre	Gallons per acre				
	100	75	50	25	12.5
3.5	87	96	79	83	70
4.7	96	92	88	91	93

The results of studies to determine whether dalapon influences the yield of sugar beets are summarized in Table 4. It is readily seen that sucrose percentage is not affected by any of these treatments. Neither does the wetting agent influence any of the results. Therefore, the only consideration is the effect of dalapon on the size of the beets. Analyses of variange of these data indicate that the following treatments may reduce sugar beet yields significantly; 1. Rates over 4 pounds sodium dalapon per acre. 2. Repeat applications of 4 pounds or more per acre each time.

Table 4.—Effect of Sodium Dalapon on Yield of Sugar Beets.

Time of application	Sodium dalapon Lbs. per acre	Results — plot means			
		Expt. 1		Expt. 2	
		Yield[1] pounds	Percent sucrose	Yield[2] pounds	Percent sucrose
2 wks. after thinning	2	637	14.4	404	13.5
2 wks. after thinning	4	605	14.3	373	13.1
2 wks. after thinning	6	556[a]	14.3	336[a]	12.7
7 wks. after thinning	4	584	14.4	390	14.0
7 wks. after thinning	6	568	14.2	341[a]	12.3
Both times	4 + 4.7	579	14.1	316[b]	12.7
Both times	6 + 7.0	491[b]	14.6	290[b]	12.6
Untreated		634	14.6	425	13.6

[1] 5 percent L.S.D. = 68; 1 percent L.S.D. = 91
[2] 5 percent L.S.D. = 55; 1 percent L.S.D. = 74
[a] = significant at 5 percent level
[b] = significant at 1 percent level.

The degree to which the beets will recover from dalapon treatments appears to be a function of time to harvest. Therefore, it may be advantageous to allow as much time as possible after treatment before digging the crop. Beets in seedling stage are not more sensitive than at later periods.

Although the work reported here in connection with sugar beets is concerned with only water grass *(Echinochloa crusgalli)* , research on other projects indicates that a wide variety of annual grasses, both winter and summer, can be controlled with the dosages of dalapon specified above. Factors relating to environment, surfactants, volume rates, etc., appear to apply as well to these other species.

The influence of environmental factors such as temperature, soil and air moisture and soil fertility appears to be important because they influence the growth conditions of the grasses. It seems reasonable that translocation and assimilation would be faster and more effective when the plant is growing vigorously, as is found with 2,4-D on broadleaved plants. There-

fore, it may be desirable to apply dalapon during periods of vigorous grass growth. If soil moisture is adequate and other environmental factors are favorable, growth is most rapid from seedling to early stooling of the grass. Practices which maintain the beets in good growing condition would favor the grass as well, so the cultural operations would not need to be changed to accommodate the dalapon application.

Undoubtedly applications should not be made a few days before or after blocking and thinning because of the stress this disturbance places on the young beets.

Although observations to date indicate that temperature does not influence action of dalapon except to cause marginal leaf burn in hot weather, it is quite possible that a temperature stress may reduce the control.

The yield data indicate that care will have to be exercised in applying dalapon to sugar beets. Since these were overall sprays, it is difficult to determine whether dalapon is absorbed by the beet more readily through the leaves or the roots. Surface irrigation following application would carry chemical on the soil surface into the root zone easily. However, in the first two experiments, the beet leaves at the second application formed a nearly complete canopy over the soil surface. Therefore, since most of the spray probably remained on the leaves, and the yields at this time were reduced as much as or more than earlier treatments, it can be assumed that dalapon is absorbed through beet foliage in sufficient amounts to affect growth.

Although dalapon is undoubtedly absorbed through the foliage of beets, it was evident that yields were equal whether or not a wetting agent was included in the sprays. Undoubtedly, this is because plain water carriers spread readily over the beet leaves and the wetting agent does not decidedly enhance either the spreading or penetrating qualities of the dalapon solution. Therefore, since it has been shown that good surface active agents improve the action of dalapon on grasses, it is desirable to use a good wetting spray for this application.

Because of the reduction in yield with over 4 pounds of dalapon per acre, it becomes desirable to consider the effect of treatments using 2 to 4 pounds. Figure 1 shows that good control is possible with dosages of 3 pounds per acre. Two pounds per acre could be quite effective in relieving the strain on the thinning crew. Where later germination of grasses is likely, a timely application of 3 pounds of dalapon to the later crop of grass may benefit the beets more than an earlier treatment. It is possible that treatment of seedling grass at sub-lethal but growth retarding rates followed by sprays of lethal dosages on regrowth of the grass would provide effective control and still not reduce the beet yield.

Other possibilities of reducing the effect dalapon might have on the crop include placed sprays. The beets are shielded and/or the spray directed to contact only as much of the beet plants as is necessary to cover the grasses adequately. Good application techniques are always important and here, in addition to the types of spraying mentioned above, it is desirable to attempt the best possible coverage of the weeds. Reasonably fine sprays usually accomplish this purpose best.

Conclusions reached from data available are as follows:

1. Dosage of 3 to 4 pounds sodium dalapon per acre was required for control of watergrass. (Research is necessary on other grasses.)

2. When grasses were growing well, dosage required was same from seedling to early stooling stage.

3. Above dosage rates assume excellent wetting of grasses.

4. Maximum effect of dalapon on grasses required 6 to 8 weeks.

5. Severe soil moisture stress reduced grass control.

6. Temperature in range of 55° F. to 100° F. had no effect on control.

7. Controls were same for volume rates from 100 to 12.5 gpa.

8. Addition of surfactant did not affect yield.

9. Sucrose percentage was not affected by dalapon at 2 to 7 pounds per acre.

10. Yields were reduced by sodium dalapon applied as follows:

a. More than 4 pounds per acre.

b. More than one application of 4 pounds or more per acre.

Much more research is necessary before dalapon can be recommended to control grasses in sugar beets. Some of these projects are as follows:

1. Effect of sodium dalapon at 2 to 4 pounds per acre on yield. (Higher rates may be desirable in some areas.)

2. Use of placed and shielded sprays.

3. Relationship of volume rate to control and yields.

4. Influence of various times between treatment and harvest.

5. More data on effects of environmental factors, particularly growth stresses on control and yield.

6. More data on value of repeat sprays to control:

a. The first crop of grass to be treated.

b. Succeeding germinations of grasses.

7. Effect of dalapon in the soil on germinating beet seedlings.

8. Presence or absence of dalapon residue in soil and crop at harvest.

9. Differences of beet varieties in response to dalapon.

10. Best types of surfactants.

Dalapon will be recommended in 1954 only for non-crop grass control. It will be marketed as the sodium salt with some wetting agent added. Under some circumstances this may be insufficient to provide the best wetting and additional surfactants will be desirable. Experimental formulations of sodium dalapon without wetting agent will be available for research purposes.

Literature Cited

(1) Dalapon Bulletins Nos. 1 and 22, The Dow Chemical Company.