Movement and Persistence of Endothal (3,6-Endoxo-hexahydrophthalic Acid) as Influenced by Soil Texture, Temperature, and Moisture Levels[1]

R. D. Comes, D. W. Bohmont, and H. P. Alley[2]

Received for publication March 7, 1960

Introduction

Many chemicals have been screened for selective weed control in sugar beets with varying degrees of success. The herbicide 3,6-endoxohexahydrophthalic acid, hereafter referred to as endothal, has given excellent results in some trials as a pre-emergent treatment, while other trials have been highly disappointing. Success or failure appears to depend largely upon the method in which moisture is received after application of the herbicide. It is generally accepted that, to obtain satisfactory results, moisture in the form of rainfall or sprinkler irrigation is necessary within a short period of time after application of the chemical.

Since endothal is known to be more effectively absorbed by roots than by foliage, this study was conducted with the following purposes: 1—to study the movement pattern of endothal in soil, 2—to determine the breakdown rate of endothal, and 3—to investigate some of the possible factors causing variation in endothal movement and persistence in soil.

Procedure

Movement of Endothal

Preliminary experiments were conducted to study the vertical movement of endothal in three different soil textures without regard to soil temperature or moisture. Three Wyoming soils with the following characteristics were used in these studies:

Characteristics of Soils[1]

Soil Type	% Sand	% Silt	% Clay	Organic Matter Percent	pH
Hill sandy clay loam	62.4	14.8	22.8	1.89	7.50
Greeley fine sandy loam	68.4	19.8	11.8	1.26	7.35
Billings clay loam	36.0	35.2	28.8	2.24	7.50

[1] Analyses were made by the University of Wyoming Soil Testing Laboratory, Plant Science Division, Laramie, Wyoming.

[1] Published with approval of the Director, Wyoming Agricultural Experiment Station, as Journal Paper No. 147.

[2] Graduate Research Assistant, Head of Plant Science Division, and Assistant Professor, respectively, College of Agriculture, University of Wyoming.

All soils were dried and screened through a 2-millimeter screen. Each of the three soils was placed in separate 6-inch pots and treated with endothal at the rate of 4 lbs. (acid equivalent) per acre on an area basis. The material was applied at the following depths: surface, ½ inch to 1½ inches and 1½ inches to 3 inches. Hereafter, all rates refer to acid equivalent per acre.

The vertical movement of the herbicide in the soil was determined by biological assay. Norland flax was employed as the test plant since in the germinating stage it is very susceptible to injury by endothal.

Ten flax seeds were planted at a depth of ½ inch in all treated soils. Untreated pots of each soil texture were planted in the same manner. After planting, three pots of each soil treatment were subirrigated and three were sprinkle irrigated. These methods of irrigation were continued throughout the course of the experiment.

Thirty days after the planting date, all plants were counted and harvested. Reduction in total green weight of the flax plants was used as a measure of the presence, and therefore the movement, of endothal.

Subsequent movement studies were made with the same three soils. The air-dry soils were placed in 3-inch galvanized metal tubes and packed to simulate the soil conditions of a well-prepared seedbed. Packed height of the soil columns was 8 inches. Half of the soil columns were then wetted to field capacity. The air-dry and the field-capacity soil columns were placed in temperature-control chambers at 10, 15, 20, 25, and 30° C. ± 1°. Twenty-four hours were allowed for the soil temperatures to reach an equilibrium with the control chambers before endothal was applied to the surface of each column at the rate of 4 lbs. per acre. Eight hours after chemical treatment, all soil columns were leached with 2 surface inches of water. Twenty-four hours after leaching, the soil columns were sliced into five layers.

Each section in reference to the soil surface was as follows: 0 to 1 inch, 1 inch to 2 inches, 2 inches to 3 inches, 3 inches to 4 inches, 4 inches to 6 inches, and 6 inches to 8 inches. Each soil section was placed in a 3-inch waxed-paper container which allowed for subirrigation so that further leaching of the chemical would not be a factor.

Ten flax seeds were planted in each soil section and subirrigated in the greenhouse, periodically as needed. Untreated soil of each type was planted with flax at the same time and used for comparison with the various treatments. Thirty days after planting, green weight of flax plants was measured as before.

Persistence of Endothal

Studies were conducted to determine the effect of temperature and moisture levels on the rate of disappearance of endothal in different soil textures.

Soil, 1½ inches deep, was surface treated with endothal in an aqueous solution at a rate of 6 lbs. per acre. Application of the chemical was made under simulated field conditions with a knapsack and boom sprayer. The total volume of treated soil was then placed in a tumbler mixer and thoroughly mixed to obtain a uniform distribution of the chemical in the soil. Half of each soil treatment was wetted to 80 percent of field capacity and the remaining half left in an air-dry condition.

The soils were then placed in five-quart containers and covered with glass panes to allow aeration but to conserve moisture, and placed in the temperature-control chambers.

Triplicate 10.6-cubic-inch soil samples were removed from each chemical treatment and from the untreated control 7 days after the initiation of the experiment and every 7 days thereafter for 56 days. The soil samples were placed in waxed-paper containers, planted with 10 flax seeds, and subirrigated periodically.

Flax plants were harvested at the soil level 21 days after planting and the green weight taken as a criterion for the presence of endothal.

Experimental Results

Movement of Endothal

Endothal moved in the same general direction as the water in sandy loam and sandy clay loam soils. The chemical, applied on the surface of these soils at the rate of 4 lbs. per acre, and sprinkle irrigated, reduced green flax weight by 91 percent in the sandy clay loam soil, 93 percent in the sandy loam, and 77 percent in the clay loam, as compared with the untreated check. Movement of the chemical by subirrigation of this treatment reduced green flax weight by 31 percent on the sandy clay loam soil with no reduction occurring in green flax weight on the sandy loam soil. Endothal, when applied on the surface of clay loam soil and subirrigated, reduced the flax weight by 86 percent. Apparently, the chemical moved downward when the soil was saturated, which is a reverse from the observed movement in sandy-type soils.

Conversely, subirrigation moved the greatest amount of endothal when the chemical was incorporated into the soil at depths of ½ to 1½ and 1½ to 3 inches (Table 1). When the

Table 1.—Average Green Weight of Flax from 3 Soil Types, Treated with 4 Pounds of Endothal per Acre at 3 Soil Levels, Using Two Methods of Irrigation.

Method of Irrigation	Soil Type	Depth of Chemical from Surface in Inches	Grams Green Weight	Percent Reduction of Green Weight Based on Untreated Check
	SCL[1]	0	.10	90.6
		½-1½	.20	81.1
		1½-3	1.07	0.0
Sprinkle Irrigated	SL[2]	0	.07	92.8
		½-1½	.40	58.8
		1½-3	.67	30.0
	CL[3]	0	.13	77.2
		½-1½	.27	52.6
		1½-3	.60	0.0
	SCL	0	1.20	30.6
		½-1½	0	100.0
		1½-3	.23	86.7
Sub Irrigated	SL	0	1.73	0.0
		½-1½	.37	77.3
		1½-3	.43	73.6
	CL	0	.20	85.7
		½-1½	.13	90.7
		1½-3	.17	87.9

[1] Sandy Clay Loam Soil.
[2] Sandy Loam Soil.
[3] Clay Loam Soil.

chemical was placed at these 2 soil depths and subirrigated, chemical movement was similar for both depths in all soils observed.

Methods of irrigation were not as critical when the chemical was incorporated in the ½- to 1½-inch depth. However, subirrigation of the treated soils consistently resulted in the greater movement of endothal as compared with the sprinkler irrigation method.

Additional chemical-movement studies indicated that soil texture was very influential on the amount of endothal retained in the top 1 inch of soil when leached with 2 surface inches of water. The chemical was more resistant to leaching in clay loam and sandy clay loam than in sandy loam soil. The two finer textured soils retained a greater amount of the chemical in the surface two inches of soil than at any other depths tested (Figure 1).

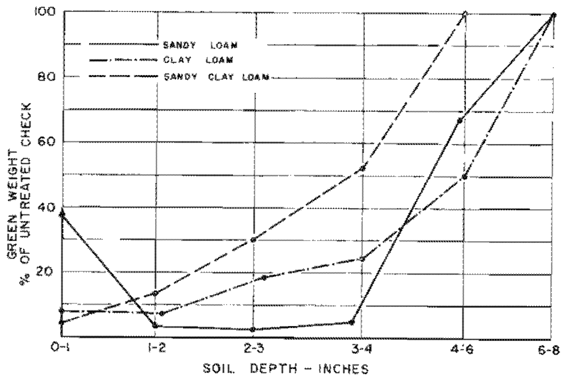

Figure 1.—Movement of endothal through three soil types after application of 2 surface inches of water, as measured by flax growth.

These results show that 87 percent more endothal was present 1 to 4 inches below the soil surface than on the soil surface of the sandy loam soil. There were no significant differences between the amount of chemical retained in the three soil layers within the 1- to 4-inch increment in the sandy loam soil.

Initial soil moisture did not have a significant effect on the mobility of endothal when leached with two surface inches of water.

Persistence of Endothal

The moisture content of the soil proved to be a very critical factor in the disappearance of endothal. Air-dry soils, which had been treated with 6 lbs. of endothal per acre and held in an air-dry condition for 8 weeks before the planting of flax, yielded no flax when irrigated. Results were the same for all temperatures employed.

Temperature also was very influential on the inactivation rate of endothal in soils that had been wetted to 80 percent of field capacity. There is a highly significant difference between the amount of chemical that remained in soils held at the 15° and 20° C. temperatures within 14 days after treatment. Inactivation, as measured by flax weight, was 12 times more rapid at 20° C. than 15° C. one week after treatment. There was no significant difference in the persistence of endothal among temperatures of 20, 25, and 30° C. nor between the two lower temperatures, 10 and 15° C.

The chemical disappeared more slowly in clay loam soil than in the sandy loam and the sandy clay loam soils which had been wetted. Sufficient breakdown had occurred within 14 days after treatment in sandy-type soils, held at 20° C. and higher, to allow weed seeds to germinate and grow. Endothal in clay loam soil did not exhibit any measurable degree of inactivation until 28 days after treatment. Inactivation of the herbicide was completed 42 days after treatment in all soils and at all temperatures employed.

Discussion and Summary

Endothal is very mobile in the three soil textures studied. The chemical was transported by water movement, either in an upward or downward direction, depending upon the type of irrigation. In the field application of endothal it may be possible to side-dress sugar beets 1½ to 2 inches deep with the chemical and expect the inward and upward movement of water from furrow irrigation to carry the herbicide into the weed-germinating zone.

The amount of chemical retained in the top 1 inch of soil after leaching with 2 surface inches of water depended primarily upon soil texture. The chemical was leached more readily in sandy loam soil than in clay loam or sandy clay loam soil. These greenhouse trials suggest that excessive sprinkler irrigation or precipitation on sandy soil may leach the bulk of the chemical below the germinating zone of most annual weeds.

Dry soils apparently do not hold endothal with any greater force than soils which have been wetted to field capacity, once precipitation is received. The depth to which the herbicide will leach undoubtedly depends on the amount of precipitation received and the moisture content of the soil at that time.

Endothal became quite inactive seven days after treatment in the moist sandy-type soils which had been held at temperatures of 20° C. and higher. Endothal in clay loam soil did not show any degree of chemical inactivity until 28 days after treatment. It would seem that clay loam soil, having a larger surface area and containing a higher percentage of organic matter than either of the sandy soils, would inactivate endothal more readily.

Biological activity may play an important role in the inactivation of endothal for the following reasons: 1—no flax seed germinated in any soil type at any temperature, when the soil was in an air-dry condition. This was true even eight weeks after treatment. 2—Temperatures of 20° C. and higher increased the rate of inactivation in moist soils. Volatilization of the herbicide is apparently not a critical factor in dissipation, as the dry soils were free to aeration within the temperature chambers, and the chamber doors were opened every seven days for sampling.

Conclusions

1. It is possible to move endothal down or up in soil by using surface or subirrigation, respectively.

2. Endothal in sandy loam soils is more susceptible to leaching than in clay soils.

3. Endothal is leached to a depth of at least 3 inches in the 3 soil types studied, with 2 surface inches of water.

4. An application of 2 surface inches of water leached endothal as readily in an air-dry soil as in a soil wetted to field capacity.

5. The persistence of endothal was influenced by soil texture. The chemical was inactivated more rapidly in sandy loam and sandy clay loam than in clay loam soil.

6. Soil moisture plays a very important role in the dissipation of endothal. No inactivation of the chemical was measurable 8 weeks after treatment in air-dry soil.

7. The rate of inactivation of endothal was significantly less at temperatures below 20° C. than at temperatures of 20, 25, and 30° C.