Distribution Patterns of Soil-Applied Herbicides Using Fluorescent Tracers

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DISTRIBUTION PATTERNS OF SOIL-APPLIED HERBICIDES
USING FLUORESCENT TRACERS

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Introduction

Research in recent years has shown that certain herbicides are more effective if they are incorporated in the soil profile than when they are applied to the surface. Results from surface application of volatile materials are frequently erratic. If it rains shortly after application, weed control is usually good; but if there is no precipitation for several days or if temperatures are high, weed control is poor. The extent to which the herbicide is incorporated through the seed-germinating zone of the soil is important.

A study to determine the distribution of a fluorescent chemical in the soil profile accomplished by specific application equipment and tillage methods was started in the fall of 1961. The method used to determine the distribution of the chemical was based on the method reported in WEEDS (January 1961) by C. G. McWhorter and O. B. Wooten. The use of a fluorescent indicator replaced the herbicide in these tests. The examination of the deposit was accomplished with the aid of a short-wave ultraviolet light with a principal radiation of 2537 angstroms under dark conditions.

The application equipment and tillage tools used for incorporating the fluorescent chemical, zinc silicate, into the soil were the Russ-Ken applicator, the Mulch Treader, an experimental spring-tine tiller, a double disk harrow, a special sweep applicator, a chisel injector, a Bolens rotary tiller, high pressure jets, and Mix-A-Product.

Methods and Results

The Russ-Ken applicator (Figure 1) consists of a furrow opener of 1/4 x 3 inch flat steel to scrape the top inch of soil to the side exposing a strip seven inches wide to be sprayed with a herbicide. Flat curved steel weeder blades cover the herbicide with soil, leaving the surface level. The chemical is laid down as a distinct band 7 inches wide, approximately 1 inch below the soil surface with the Russ-Ken applicator.

The Mulch Treader (Figure 2) is similar to the rotary hoe except that the spiders are heavier and run at an angle similar to the disk harrow. The term tilling will be used when the rotating fingers on the spider dig into the ground and treading when they drag into the ground. The axle of the Mulch Treader was set at an angle of 76° with the direction of travel for the tests. Zinc silicate sprayed on the soil surface was incorporated into the soil with one and two passes, both tilling and treading. The two passes approximated the action of a two-section tandem treader.

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The experimental spring-tine tiller (Figure 3) has eight tines, similar to the teeth on a side delivery rake, staggered on one and a half inch spacings, which give a light surface tillage action.

A double disk harrow was used for the disking tests. The ground was worked into seed bed condition by disking prior to spraying the fluorescent chemical on the soil surface. The chemical was incorporated into the soil by one pass of the disk made crosswise to the previous disking.

The sweep applicator (Figure 4) is a 14-inch, high-lift tillage sweep modified to allow for mounting a Spraying Systems 1/8K3 nozzle below a steel plate welded between the top edges of the wing blades of the sweep. This sweep applicator operates satisfactorily at depths of 1½ inches or greater in a firmed seed bed.

Soil fumigation chisels were used for applying the fluorescent tracers. Chisel spacing was 8 inches apart and injection depths were 2 inches and 4 inches. The chemical flowed by gravity from the metering orifice through a 1/8-inch pipe located on the back of the chisel and discharging at the heel of the chisel. The chisel injector laid down fluorescent tracer bands a little larger than the cross section of a writing pencil. The band was about 5/16 of an inch thick by 1/2 inch wide. Figure 17 shows the deposit as two very distinct bands.

The Bolens rotary tiller (Figure 5) mounted on the 7 hp Ride-A-Matic Bolens tractor, was used to incorporate the chemical into the soil to depths of 1½ inches, 2½ inches, and 3½ inches at a ground speed of approximately 1 mph and to a depth of 5 inches at approximately .6 mph. The spray nozzles were mounted on the tractor immediately ahead of the tilling reel.

A boom, with eight solid-stream nozzles (Figure 6) spaced 1 inch apart and 3/4 of an inch above the soil surface, was used with a .026-inch diameter orifice at 400 psi and a ground speed of 1 mph and with .043-inch diameter jets at 400 psi of pressure and 3 mph ground speed. The jets were operated perpendicular to the ground surface.

The Mix-A-Product (Figure 7) is similar to the rotary hoe, except that the spiders have straight spade-like teeth. The two rows of spiders do not rotate freely. The sprockets and connecting chain cause the front set of spiders to rotate at twice the speed of the rear set. The front spiders have a digging action and the rear spiders a dragging action. Depth of penetration is controlled by two steel shoes.

A short-wave ultraviolet light, model S68 mineral light, manufactured by Ultraviolet Products, with a principal radiation of 2537 angstroms, was used to examine the fluorescent deposits. The fluorescent deposits were examined visually and were recorded photographically. A portable dark room was set up in the field directly over the area to be photographed.
The tracer distribution was determined by cutting a trench across the treated area about 2 inches deeper than the maximum penetration of the tracer. One side of the trench was carefully cut away with a sharp-edged implement. Care was taken to keep from disturbing the distribution pattern. During preparation and photographing the profile, the ultraviolet light source was placed in the bottom of the trench. Replicates were taken by cutting back the side of the trench approximately 4 inches. A cord dipped in the fluorescent chemical calcium silicate was stretched across the soil surface at the top of the profile. Figures 8 through 13 were taken with the camera mounted 36 inches from the soil profile. The camera contained black and white film with an ASA rating of 400. Time exposures were taken at 7.5, 15, 30, and 120 seconds at F3.8. The third part of the code number indicates the exposure selected.

Color slides of the distribution patterns for the Russ-Ken, Mulch Treader, spring-tine, and sweep applications were also taken using film with an ASA rating of 160, at exposures of 30, 90, and 180 seconds at F2.8. The pictures of distributions with a disk (Figures 14 and 15) and with the rotary tiller (Figures 18 to 20) were made from color slides with an ASA rating of 25 at an exposure of 300 seconds at F2.8. Filters used to exclude the ultraviolet were Tiffen 2A and Wratten K2. While working with ultraviolet light, it is necessary to protect the eyes with goggles that will filter out the ultraviolet. The soft glass usually used in corrective lenses does not remove this radiation.

The Russ-Ken applicator laid down a distinct band (Figure 8) 7 inches wide approximately 1 inch below the soil surface. The Mulch Treader had better distribution (Figures 9 to 12) with two passes than with a single pass. Distribution was better when tilling than when treading. The spring-tine tiller incorporated chemical lightly into the surface 1 to 1¼ inches of soil (Figure 13). The Mulch Treader, spring-tine tiller, and disk (Figure 14) left a large amount of chemical on the soil surface. Disking (Figure 15) placed the chemical in the soil profile as diagonal streaks 6 inches apart. The sweep applicator (Figure 16) deposited an uniform band of chemical 12 inches wide at injection depths of 1½ to 7 inches.

A chisel applicator deposited two distinct bands of chemical (Figure 17) about 5/16 inch thick and ½ inch wide. The Bolens rotary tiller operating at a 1½-inch depth (Figure 18) gave extremely uniform incorporation through the soil. Operating to a depth of 2½ inches (Figure 19), the distribution was reasonably good, but at the 5-inch depth (Figure 20), there was quite a variation in the depth of penetration. Hulbutt and Menzel, Agricultural Engineering, October 1953, indicate two passes of rotary tillers are required for good soil mixing to 6-inch depths.

Using vertical high-pressure jets a short distance above the soil surface, at the rate of 1,650 gallons of water per acre, the smaller jets with 1 mph forward travel (Figure 21) gave better penetration than did the larger nozzles at the same pressure but at a 3 mph forward travel (Figure 22).

The Mix-A-Product (Figure 23) at 2 mph, produced a reasonably uniform amount of mixing in the surface 1½ inches of soil.
Figure 1. Russ-Ken applicator; for deposit pattern see Figure 8.

Figure 2. The front view of a short section of the Mulch Treader set for treading; for deposit pattern see Figures 11 and 12.
Figure 3. Experimental spring-tine tiller; for deposit pattern see Figure 13.

Figure 4. Sweep applicator; for deposit pattern see Figure 15.
Figure 5. Bolens rotary tiller with spray nozzles mounted immediately behind the rear wheels; for deposit patterns see Figures 18 through 20.

Figure 6. Eight high-pressure jets spaced one inch on center and three fourths of an inch above the soil surface; for deposit penetration, see Figures 21 and 22.
Figure 7. Mix-A-Product. The chain drive causes the front set of spiders to rotate at twice the speed of the rear set; for deposit pattern, see Figure 23.

Figure 8. The distribution of a fluorescent tracer that was applied with the Russ-Ken applicator. The white line across the photograph represents the soil surface.
Figure 9. The distribution of a fluorescent tracer in the soil following one pass of the Mulch Treader tilling. The white line represents the soil surface.

Figure 10. The distribution of a fluorescent tracer in the soil following two passes of the Mulch Treader tilling.
Figure 11. The distribution of a fluorescent tracer in the soil following one pass of Mulch Treader treading.

Figure 12. The distribution of a fluorescent tracer in the soil following two passes of Mulch Treader treading.
Figure 13. The distribution of a fluorescent tracer in the soil following one pass of the tine tiller.

Figure 14. The distribution of a fluorescent tracer on the soil surface following one pass of the disk harrow. The Mulch Treader, tine tiller and Mix-A-Product have similar soil surface distribution patterns.
Figure 15. The distribution of a fluorescent tracer in the soil following one pass of the double disk harrow. The pencils are one foot apart.

Figure 16. The distribution of a fluorescent tracer in the soil following application with a sweep applicator equipped with a 1/8K3 nozzle.
Figure 17. The distribution of a fluorescent tracer that was applied with two chisels 8 inches apart with an injection depth of 2 inches.

Figure 18. Distribution patterns of a fluorescent tracer in the soil profile following one pass of the rototiller set at 1 1/2 inches. The white line marks the junction of the soil surface with the vertical profile.
Figure 19. Distribution patterns of a fluorescent tracer in the soil profile following one pass of the rototiller set at 2 1/2 inches. The white line marks the junction of the soil surface with the vertical profile.

Figure 20. Distribution pattern of a fluorescent tracer in the soil profile following one pass of the Bolens rototiller set 5 inches deep.
Figure 21. The penetration of a fluorescent tracer into the soil profile by .026 inch jets at 400 psi at one mile per hour.

Figure 22. The penetration of a fluorescent tracer into soil profile by .043 inch jets at 400 psi at 3 miles per hour.
Figure 23. The distribution of a fluorescent tracer in the soil profile accomplished by Mix-A-Product traveling at two miles per hour.