Injection of Preemergence Herbicides

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Certain preemergence herbicides have proved more effective when incorporated into the soil at the time of application (1,5,6).[2] Surface application followed by furrow irrigation frequently effects little or no weed control. Volatilization or photodecomposition may reduce the apparent rates of surface applied materials before rainfall or overhead irrigation moves them into the soil.

Many methods of mechanical incorporation have been evaluated by researchers. These methods can be grouped as: a) rotary tillers (power driven), b) rotary hoes (ground driven), c) harrows, d) subsurface applicators, and e) miscellaneous devices or procedures such as chain drags and listing-shaping operations.

A general criterion for an optimum method of incorporation is acceptable weed control and crop response with minimum overhead, operating costs, and power consumption. Because of the many influencing factors such as herbicide, soil type and moisture content, climate, irrigation practice, crop, and weed species, little progress has been made in establishing the optimum method for various field conditions.

Rotary tillers have produced the most consistent results, apparently owing to good mixing of herbicide and soil under a variety of soil conditions. In addition the rotary tiller aids in seedbed preparation and destroys weed seedlings if present. However, costs and power consumption of these units are high compared to harrows and rotary hoes. Under some soil conditions excessive pulverization has occurred, leading to crusts which impede crop emergence.

Investigations of high-pressure injection of soil fumigants (4) and anhydrous ammonia (2) suggested this technique for incorporating herbicides into the soil. Since the necessary penetration depths for herbicides are less than those sought for fumigants or anhydrous ammonia, lower application pressures were anticipated. Reduced overall power requirements as compared to rotary tillers were foreseen. Furthermore, such a nontillage method would be practical as a post-seeding operation. The common problem of contaminating the treated zone with untreated soil during seeding would be eliminated. While rotary

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[2] Numbers in parentheses refer to literature cited.

tillers have followed seeding operations experimentally for cotton (3), none of the mechanical methods are practical for extensive post-seeding incorporation.

Preliminary calculations indicated application rates in gallons per acre (gpa) may be excessive with direct injection. On the premise that a fluid soil mass could be penetrated more readily than a static mass, injection over a subsurface blade at reduced pressures was investigated as a compromise.

A description and discussion of the two methods follow.

Direct Injection

Commercially available nozzle tips[3] producing a relatively compact jet were selected for the tests. Trials with a single jet at pressures up to 400 pounds per square inch (psi) indicated a maximum effective width of treatment to be ½ to 1 inch, depending upon the soil structure and degree of compaction. The 1-inch spacing was chosen initially to minimize application rates.

A manifold with nozzles 1 inch apart was constructed. The manifold was bracketed to a vertical standard with an angled deflector and skid to protect the nozzles. The orifices were adjusted to ⅛ inch above the bottom of the skid. The unit was clamped to a tool bar supported with a three-point hitch and gage wheels. (Figure 1).

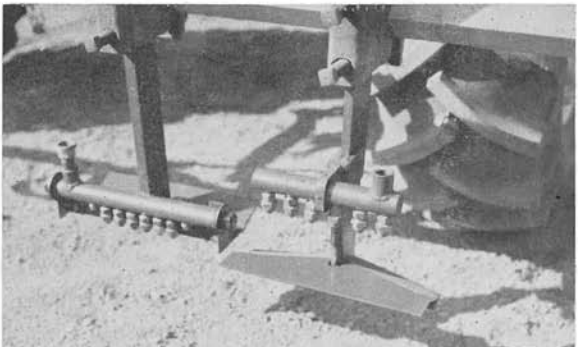

Figure 1.—Assemblies for direct injection (left) and injection over a subsurface blade.

Orifice sizes of 0.023 and 0.039 inches were used to determine the variation of penetration depth with flow rate, pressure, and ground speed. Orifice data and application rates are given in Table 1.

[3] Manufactured by Spraying Systems Co., Bellwood, Illinois.

Table 1.—Orifice data and application rates.

Orifice diam., inches	Pressure, psi	Flow rate,[1] gpm	Application rate,[2] gpa		
			1 mph	2 mph	3 mph
0.023	150	0.140	831	415	277
	250	0.184	1.090	545	363
	400	0.234	1.390	695	463
0.039	150	0.448	2,660	1,330	887
	250	0.567	3,370	1,680	1.120
	400	0.705	4,190	2.100	1.400

[1] Average of 4 orifices.
[2] Based on overall coverage and 1 inch effective width per orifice.

Air-dried Yolo sandy loam passing a No. 4 Tyler mesh was compacted at 1/2 psi to a depth of approximately 4-7/8 inches and loose soil added to fill a 5-inch-deep pan. The pan was placed on a floor and the skid height adjusted to 1/4 inch above the soil surface. Pressures of 150, 250, and 400 psi and tractor speeds of 1, 2, and 3 miles per hour (mph) were used. Depth of penetration was determined by immediately cutting three vertical profiles and taking the average wetted depth to the nearest 1/8 inch. Effective width of treatment varied from 1/4 inch for the 0.023-inch orifices at 150 psi and 3 mph to 3/4 inch for the 0.039-inch orifice at 400 psi and 1 mph. Considerable heaving of the soil surface occurred under the latter condition, indicating increased hydraulic pressure in the soil (2). The test results are shown in Figure 2.

Qualitative tests with a fluorescent tracer were made in the field by observation at night of profiles illuminated with ultraviolet light. Compacted areas severely reduced penetration. Large surface clods caused spattering while small clods were displaced or rotated, producing irregular distribution patterns.

Herbicide tests were made using 0.039-inch orifices at 400 psi and speeds of 1, 2, and 3 mph. Pre-irrigated beds in Yolo sandy loam were spike-tooth harrowed to a depth of about 2 inches and sledded to form a level bed top. Most of the loose soil was removed by the sledding operation. Proso millet *(Panicum miliaceum)* was sown by hand in an 8-inch band to insure the presence of a weed. The seed was covered by raking to a maximum depth of about 1 inch. Tomato variety FW36 was seeded 1 inch deep with a sled-mounted planter followed by the application of a commercial formulation of propyl ethyl n-butylthiolcarbamate (PEBC) at a constant rate of 4 pounds active per acre in a 6-inch band (6 nozzles). The plot was furrow irrigated the following day.

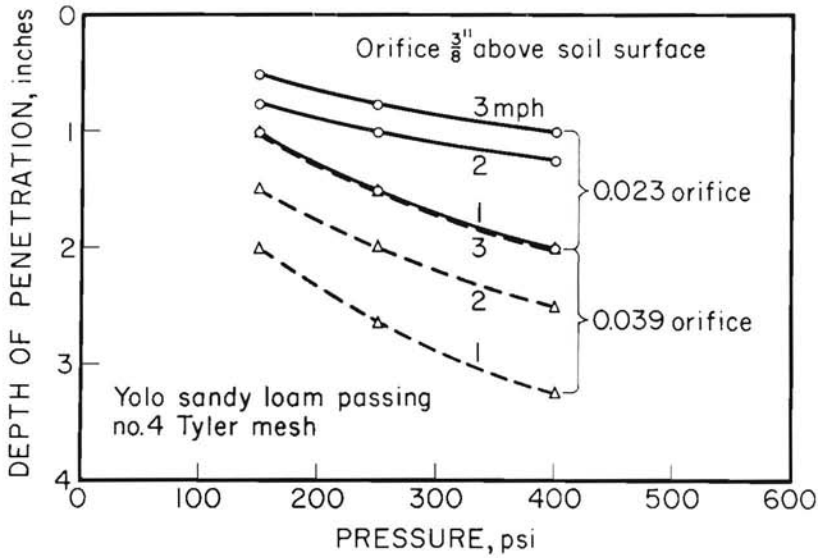

Figure 2.—Penetration into soil of a compact water jet.

Observation three weeks after treatment showed significant millet control at only the 1 mph speed. The natural weed population was insufficient to evaluate. Depths of penetration at the higher speeds were inadequate to produce consistent control. The application rate of 4,190 gpa at 1 mph (overall basis) and low field capacity (acres per hour) would be economically prohibitive for most operations. There was no evidence of herbicide injury to the tomato plants.

Injection Over a Subsurface Blade

A manifold similar to that described above was mounted above the deck of a subsurface blade (Figure 1). The deck provided a positive limit of penetration. The blade had an inclination of 26° and a lift of 1-½ inches. Manifold height was adjusted to provide smooth flow of soil between the nozzles and deck with minimum clearance.

Distribution as determined with a fluorescent tracer was uniform in the lower 2 inches of a 2-½-inch profile treated with the 0.023-inch orifice at 150 psi and 3 mph. The upper ½ inch contained little fluorescent material. Higher pressures tended to concentrate the material lower in the profile.

Herbicide tests were made under field conditions similar to those previously described. After sowing and raking in the millet PEBC was applied with 0.023-inch orifices at 4 pounds per acre with pressures of 150 and 400 psi and speeds of 1 and

3 mph. Blade operating depth was 2-½ inches. Tomato seeding was done after the herbicide treatment. All tests showed excellent control of millet and natural weeds. No herbicide symptoms were observed on the tomato plants.

Summary and Conclusions

Direct injection of herbicides appears feasible only under very favorable conditions of soil consistence, structure, and tilth. Compacted soil severely reduces penetration. Clods reduce penetration and cause irregular distribution patterns. Good control of proso millet with PEBC at 4 pounds per acre was achieved with a 0.039-inch orifice at 400 psi and a tractor speed of 1 mph. However, the corresponding application rate of 4,190 gpa and low field capacity cannot be justified by the advantages of post-seeding incorporation and reduced power consumption.

Injection over a subsurface blade produced a uniform tracer distribution in the lower 2 inches of a 2½-inch profile with a 0.023-inch orifice at 150 psi and 3 mph. The same conditions provided excellent control of proso millet with 4 pounds per acre of PEBC. The corresponding application rate of 277 gpa is 6 to 10 times higher than presently used in conjunction with rotary tillers, but is not impractical in view of reduced costs and power consumption.

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