10-1968

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Published in *Journal of Economic Entomology* 61:5 (October 1968), pp. 1424–1427; doi: 10.1093/jee/61.5.1424.

Accepted June 10, 1968; published October 1, 1968.

Western Corn Rootworm Egg Distribution and Adult Emergence under Two Corn Tillage Systems[1]

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Abstract
Under a conventional plowing system, eggs of *Diabrotica virgifera* LeConte were more uniformly deposited in the top 6 inches of the soil profile than under a reduced strip-tillage system which resulted in heaviest egg deposition in the furrow or ridge. Equal numbers of eggs were deposited in both systems. After corn was planted, more eggs occurred in the seedling zone in conventionally planted corn; in till-plant corn, eggs were removed from the seed row, and eggs concentrated in the furrow were covered with additional soil. Adult emergence was 5–10 days later in till-plant corn than in the conventional tillage system.

The Nebraska till-plant system for corn production has gained wide farmer acceptance in many areas of the state. Under this reduced tillage system, corn is planted in the same rows as the preceding season. Except for cutting the old stalks, soil conditioning for planting is limited to strips in and adjacent to the seed row and is performed as part of the planting operation. There is less soil disturbance than in the conventional system of disking and plowing before surface planting. Larson (1962) summarized effects of different tillage systems on the physical environment of the corn plant, but little is known about effects on the soil biota. Since the till-plant method is most widely used in irrigated regions in Nebraska where the western corn rootworm, *Diabrotica virgifera* LeConte, has been a serious problem, it seemed desirable to determine effects of tillage systems on egg distribution and rootworm development.

Methods

Corn has been grown continuously since 1961 under both the till-plant and conventional systems in an agronomic experiment at the North Platte Experiment Station. Soil samples were taken in 1964 and 1966 to determine the distribution of rootworm eggs. Soil samples were frozen until they could be processed. Eggs were recovered by washing the samples through screens and examining the residue under a stereoscopic microscope as described by Lawson and Weekman (1966).

In 1964, cores (39 mm diam 3 in. deep) were taken 0, 10, 20, and 30 in. north of east-west rows which were 40 in. apart. Four depths relative to the soil surface, 0–3, 3–6, 6–9, and 9–12 in., were sampled at each position. Three subsamples, taken about 2 ft apart parallel to the row, were composited for each depth. This sampling plan was repeated at 6 locations in each of 4 replicates, resulting in 384 samples/tillage system. Samples were taken May 1–4 before any tillage operations except for the cutting of stalks in 2 replicates. The conventional plots were disked and harrowed May 11 and plowed May 14. All plots were planted May 14. A second set of samples, taken in the same manner, was obtained between May 25 and June 2 before the 1st cultivation.

In 1966, soil samples were taken only after corn was planted on June 14–18. Soil was successively removed from a 1 ft^2 area to 0–6 and 6–12 in. depths; each sample was mixed and 1 pint of soil retained for making egg counts. Samples were taken only from the row and furrow. Four locations were sampled in each plot for a total of 64 samples/treatment.

Cages 18×24 in. at the base, tapering to a 6×6-in. opening at a height of 20 in. were used to study adult emergence. They were constructed of screencloth soldered to a galvanized-metal frame. Each cage enclosed 2 plants; since plants were spaced about 8 in. apart and the cage was placed with its long dimension parallel to the row, the plant at each end outside the cage was removed. Tops were pulled from those plants within a cage; it is unlikely that this procedure influenced rootworm development, since the plants lived through July. Beetles were removed and counted at frequent intervals as they emerged during July and August.

In 1965 the entire experimental area was treated at the rate of 10 lb/acre of 10% diazinon granules applied at planting time in a 7-in. band over the row. Each tillage treatment received 16 cages and 6 additional cages were placed in an adjacent untreated plot.

In 1966, 1 untreated row was left in each plot, which provided an opportunity to compare emergence in insecticide-treated and untreated corn. Emergence was again determined with the use of 16 cages/tillage treatment (8 used in each subplot). Adult counts were not obtained in 1964, but some visual observations were recorded.

Results

Because eggs were clumped in an overdispersed distribution, all counts were transformed by log(x + l) prior to statistical analysis. Figure 1 shows egg distribution found in 1964; densities are expressed as geometric means equated to 1000 cc of soil. Table 1 gives results of the 1966 samples, expressed in the same manner.

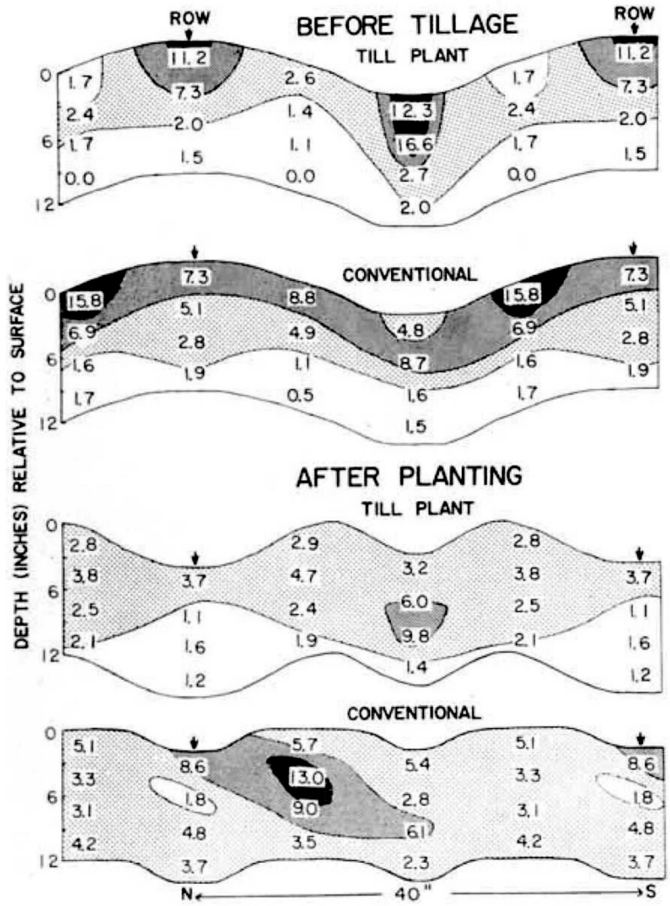

Figure 1. Profiles of upper 12 in. of soil (slightly diagrammatic) showing initial distribution of western corn rootworm eggs and subsequent displacement under 2 tillage systems. Shading from none to darkest represents, respectively, less than 2, 2–6, 6–10, and more than 10 eggs/1000 cc soil.

Table 1. Distribution of western corn rootworm eggs at hatching time under 2 corn tillage systems, North Platte, Nebraska, 1966

		Eggs/1000 cc soil	
Sample location	Depth (in.)	Till-plant	Conventional
Row	0–6	3.9	5.0
	6–12	1.3	3.7
Furrow	0–6	3.7	2.8
	6–12	7.8	2.6

Cultivation and opening of a furrow for gravity irrigation result in similar microreliefs in the 2 tillage systems at the time oviposition begins in August. This similarity. persists until spring tillage; samples taken before tillage in 1964 thus reflect oviposition sites. Total number of eggs deposited in the 2 tillage systems did not differ in 1964, but significant differences in egg. distribution did exist. Eggs were more uniformly distributed throughout the top 6 in. of soil in the conventional system. However, a major concentration was found at the 0–3 in. depth on the north side of the ridge. In the till-plant system, eggs were concentrated in the top 6 in. of soil in the ridge and. furrow with few eggs on the sides of the ridges.

Disking and plowing increased the thickness of the soil layer in the conventional system. Since all samples were taken at depths relative to the soil surface, deeper depths having fewer eggs were not sampled after planting in the conventional system. In the till-plant system, those samples taken in the row after corn was planted were from depths greater than those initially sampled and thus in a zone of lower egg density. While a statistical comparison of the 2 systems after planting was precluded by the aforementioned reason, it is apparent from figure 1 that the distribution of eggs was changed by tillage, though the distance and direction eggs were moved were quite different in the 2 systems. Conventional plots in 1964 were plowed in 1 direction to an average depth of 8–9 in. with a roll-over plow having two 16-in. bottoms. This method displaced the heaviest egg concentration, initially 0–3 in. deep on the north side of the ridge, to a position about 3 in. deeper on the south side of the new seed row. In these experimental plots, the new seed row coincided with placement of the row the preceding season. Under normal planting operations the new row might not have the same location relative to major egg concentrations in the conventional system; in the till-plant system the new row always coincides with the old row.

Planting in the till-plant system displaced sufficient soil to reduce the egg concentration in the row area. This soil movement resulted in increased egg concentrations on the sides of the ridges and covered the heavy concentration in the furrow with an additional 3 in. of soil.

The more limited sampling data obtained in 1966 indicated a similar trend. Cultivation after planting could result in further egg or larval displacement from the furrow to the ridge area in either system but was not investigated.

Figure 2 shows rate of adult emergence. During both years there was a delay of 5–10 days in beetle emergence in the till-plant system in insecticide-treated rows. In the untreated corn in 1966, adult emergence was only about 3 days later in till-plant corn. The emergence of adults and corn yields are given in Table 2.

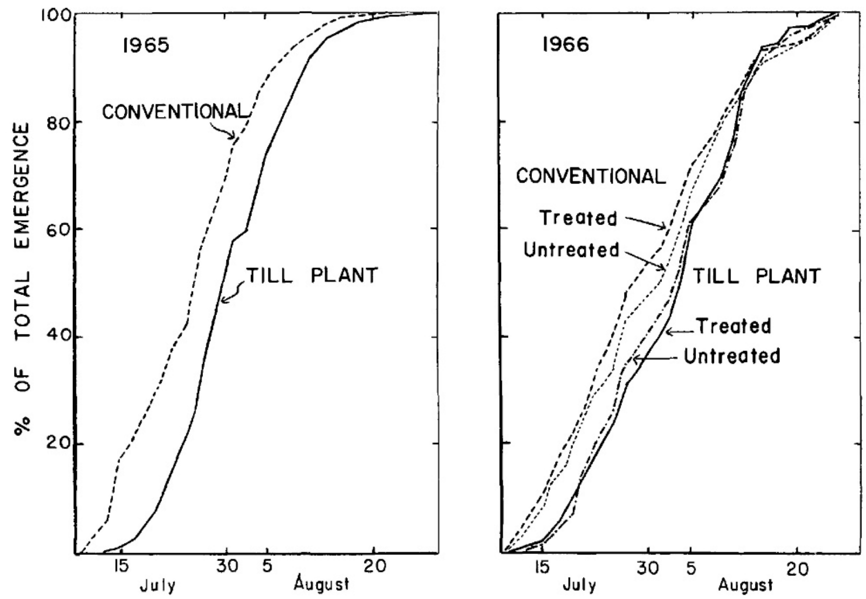

Figure 2. Cumulative emergence of western com rootworm adults in 2 corn tillage systems.

Table 2. Western corn rootworm adult emergence and corn yields in 2 tillage systems, North Platte, Nebraska

		No. beetles emerged/plant		
Year	Tillage system	Insecticide-treated	Untreated	Yield (bu/acre)
1965	Till-plant	31		125
	Conventional	30	55[a]	137
1966	Till-plant	115	170	156
	Conventional	73	96	157

a. Based on emergence in adjacent area.

Discussion

While the reasons for transposition of corn rootworm eggs during tillage are rather obvious, the causes of initial differences caused by oviposition are unknown. In the till-plant system, organic matter is left on or near the surface and tends to be deposited on the sides of the ridges during cultivation and opening of the furrow for irrigation during the summer; this mulch may reduce soil cracking on the sides of the ridges. It is commonly thought that beetles enter cracks for oviposition. In the conventional plowing system much of the old debris is buried and decomposes more rapidly; very little accumulates on the surface during the summer. Under either system wind action may loosen the soil in the ridge about the bases of plants, permitting access into the soil by beetles. Whatever the causes, differences in initial egg distribution coupled with subsequent soil movement resulted in more eggs in the seedling zone under the conventional system.

Root damage was not noted at any time in insecticide-treated plots, although large numbers of beetles emerged from those plots. In 1966, insecticides provided only 24–45% control based on adult emergence. A high percentage of rootworm larvae apparently completed their development on other than the chemically protected crown roots. In the till-plant system, a higher percentage of eggs lie outside this protected zone and thus could account for the greater adult emergence noted in 1966. These eggs also occurred at a greater depth, in soil with greater compaction, and under an area insulated by more surface debris; consequently soil temperature was lower and egg hatch or larval development probably delayed. This temperature effect also retards the early development of the corn plant in the till-plant system.

By silking time, there is no constant difference in the development of the corn plant in the 2 systems. In 1964 peak populations of beetles coincided with pollination in the conventional system while the later emergence in till-plant plots occurred after the corn was pollinated. The yield differential, 111 vs. 82 bu/acre for conventional and till-plant, respectively, was attributed to the higher percentage (39 vs. 19) of poorly filled ears in the conventional system. In 1965 peak adult populations occurred at pollination time in till-plant plots which were 2–3 days later in silking and had 6% poorly filled ears vs. 4% in the conventional system. Excellent yields were obtained under both systems in 1966 when adult populations were high.

Both larval and adult feeding of the rootworm in relation to development of the corn plant may be important in efficacy of control, reduction of injury by larvae, and prevention of pollination losses resulting from adult feeding on silks. But since 2 organisms, the rootworm and the corn plant, are involved and their development is not fully synchronized or amenable to regulation, it is unlikely that rootworm-related losses can be consistently reduced through choice of tillage system.

Notes

1. Published with the approval of the Director as Paper no. 2313, Journal Series, Nebraska Agricultural Experiment Station, and Contribution no. 301 of the Department of Entomology, University of Nebraska, Lincoln. Accepted for publication June 10, 1968.
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