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COMPETITIVE GRANT REPORT
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Weed population dynamics in ridge-tilled soybeans with and without herbicides

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Budget
$29,356 for year one
$26,721 for year two

Background and goals

Iowans are growing increasingly concerned about potential water pollution in Iowa due to heavy fertilization and extensive use of herbicides. The long-term productivity of soils has also come under scrutiny as the cumulative effects of erosion become more apparent. As a result, researchers are emphasizing the importance of developing new farming practices. One such practice already in use is ridge tillage.

In this project, field tests on several Iowa farms showed that ridge-till cultivation of soybeans can be an effective way to maintain high yields while reducing herbicide application and soil erosion. Ridge tillage leaves substantial vegetative debris on the soil surf a ce during much of the year. Thus, it is an effecti ve means of reducing soil erosion. Trials by at least one farmer suggest that ridge tillage can be used without any herbicides.

In fact, weed densities with ridge tillage can be even lower than those achieved with conventional tillage or with minimal tillage plus herbicides. Thus, ridge tillage is potentially very useful as a technique for maintaining both short-term and long-term soil productivity.

Prior to this research, agronomists had little information on the relationship of ridge tillage to weed growth and crop yields. Researchers found in 1988 that weed seed production during a season usually replaces seed germinated during the season. They also found :hat when compared to conventional tillage with herbicides, ridge-tillage crop yields were reduced in continuous corn but not in corn-soybean rotations. Those findings suggested that crop rotation may play an important role in regulating seed densities and maximizing the effectiveness of ridge-tillage cultivation.

This two-year study built on the 1988 findings by assessing the interactions between ridge-till cultivation, pre-emergence herbicide application, weed populations, and soybean crop yield. In 1989, the objective was to contrast ridge-till cultivation with and without herbicide application at planting in order to determine the relationship of herbicide application to environmental conditions, weed population dynamics, and crop yield. In 1990, a similar objective evaluated whether rotary hoeing was an effective substitute for herbicide banded in the row at planting.

Approach and methods

Four farms operated by members of Practical Farmers of Iowa were used for field studies both years, although different fields were used each year. All were located in north-central Iowa on Clarion-Webster soils. (For discussion purposes, we refer to the farms here by the farmers' surnames: Graaf, Grau, Hartsock, and Thompson.) Each farm used its own equipment, seed, and fertilization and herbicide practices to establish and grow a soybean crop on the field sites. Because a severe wind and hail storm destroyed the experiment on the Graaf farm, 1990 data are available only for the other three farms.

While the herbicide and fertilization practices varied between sites, they were consistent among treatments on a site. Farmers banded herbicide in the row at planting in those treatments receiving herbicide. They replicated each treatment on each site at least six times, using a complete randomized block design with each of two (in 1989) or three (in 1990) treatments constituting a block. Each plot had six or eight rows, either 400 or 800 meters (440 or 880 yards) in length.

In 1989, farmers either banded herbicide in the row at plantir g or used no herbicide. All plots received two rotary hoeings and two ridge-building cultivations. All were cultivated twice. On the Thompson farm, heavy rains the day after planting caused extensive washing. Because the herbicide movement and loss was probably substantial, the trials at this location were converted to test the effect of rotary hoeing on weed populations. Those plots that originally received herbicide were rotary-hoed once; the others were rotary hoed four times. Both were cultivated twice.

In 1990, farm cooperators essentially used three experimental treatments: (1) no herbicide, two rotary hoeings, two cultivations; (2) herbicide banded in a row, one rotary hoeing, two cultivations; and (3) herbicide banded in a row, no rotary hoeing, two cultivations. (An extremely wet spring caused late planting and delays in other field operations, resulting in one rotary hoeing and three cultivations on the Grau and Hartsock farms.)

Weed population studies: Weed populations were usually sampled at irregular intervals, from late April to early August, a day or two before a field operation. Samples were taken nine times in 1989 and 12 times in 1990. Because cultivation made it impossible to relocate exactly the same position in the field each time, investigators targeted a sample area for each plot that was typically from four to twelve square meters (43 to 129 square feet) in size. In late summer, however, low weed densities allowed an increase in size of some sample areas to as large as 600 m^2 in each plot, or nearly 10% of the total plot area.

Investigators recorded the number of weed seedlings, non-fruiting adults, and fruiting adults of all weed species present. Plants were further subdivided according to position in the ridge-furrow topography (see Fig. 1). The row area was defined as a 20-cm-wide strip (about 8 inches) with the soybean plants in the center. The row shoulder was a 15-cm-wide strip; the furrow width varied from 26 to 50 cm on the various farms. Weed counts on the two row shoulders in each sample were combined.

Environmental measurements: Cooperators determined the amount of plant residue aboveground in late April 1989 by collecting

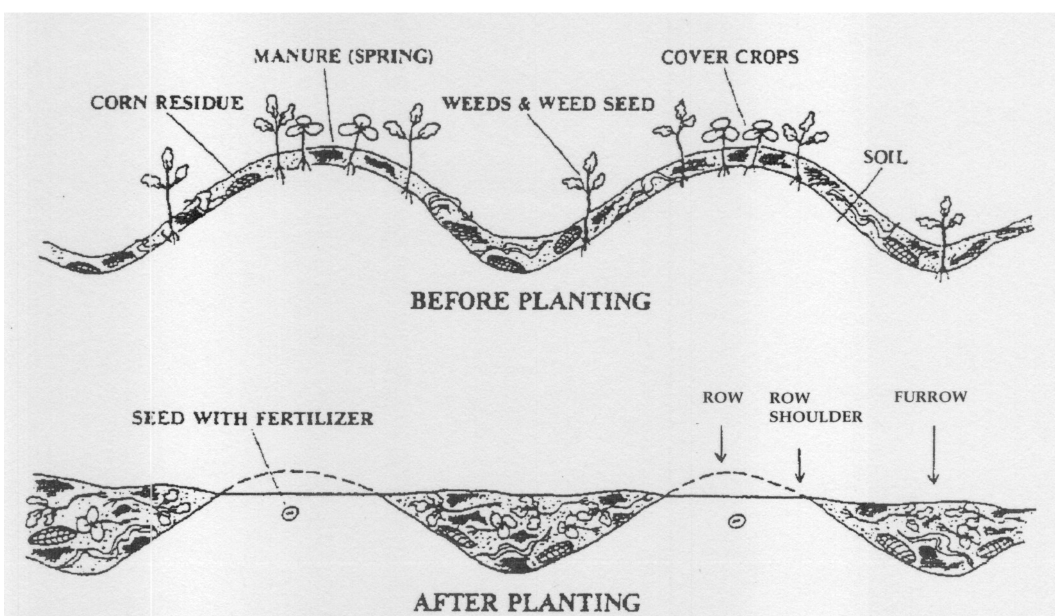

Fig. 1. Row, row shoulder, and furrow positions studied in the ridge-till system.

the biomass from quadrats (sample areas) in each plot. One quadrat was centered on the row; the other was centered on the furrow. (Shoulders, which had very little plant cover, were not sampled.) Soil was sampled for nutrient content. Soil temperature and moisture content were monitored continuously in the field. Farm cooperators also recorded rainfall data. Monitoring of soil moisture content, soil temperature, and rainfall continued in 1990.

Microenvironmental study: In ridge tillage, three "microsites" experience different environmental conditions and degrees of disturbance by cultivation (Fig. 1). The planter removes the top 5 cm from the ridge and transfers the soil to the furrow. Later ridging operations move the soil from the furrow back to the row, creating the ridge. The row shoulder is little affected by either the planting or ridging operations. Thus, weeds are not easily removed from this area by mechanical means.

On the Thompson farm, microenv uronmental conditions and their relation to residue cover were studied intensively. In April 1989, the investigator used three treatments: normal amount of residue, residue removed, and twice the normal amount of residues (created by placing all residues removed from a 10-m by 10-m plot onto an adjacent one of identical size). This test was replicated once: in each of three plots with herbicide and three without. Heavy rains in late May caused ponding and subsequent movement of the residue in two sets of the treatments, but measurements were taken in the remaining set until late July.

Temperature and light were recorded at 5- or 10-minute intervals; soil temperature was measured for two row, shoulder, and furrow positions in each plot. Instrumentation also measured light level above the plant canopy and at the soil surface in two row, shoulder, and furrow positions (under the litter).

In addition, weed photosynthesis was measured in the field, although small weed size delayed these measurements until late July.

Findings

In 1989, mid-July soybean plant densities were about 80% of the seeding density on all but the Graaf farm, where plant density was 53% of seeding density. In 1990, soybean plant densities in early August were 45 to 74% of the seeding densities. Rainfall in 1989 was lower than normal on all farms, though the Thompson farm had nearly twice that of the Hartsock farm. Although low, the rainfall was distributed fairly evenly over the growing season on all farms. Thus, soybeans exhibited few symptoms of moisture stress. In 1990, total rainfall was above normal for the season but was unevenly distributed, with higher amounts earlier in the season.

Weed population dynamics: Thirteen major weeds were found over the growing season. Redroot pigweed, lambsquarters, foxtail species, and Pennsylvania smartweed were most common. In general, the same species were found on a given farm in both years, although some variation occurred because different fields were used each year. Patterns were similar across all farms. In 1989, almost no seedlings were found in any plot in late April; in 1990, very few seedlings had appeared even by late May. In 1989, the total number of weed stems was highest in May and declined over the summer. There was relatively little difference in weed numbers between plots with and without herbicide, particularly later in the season. Weed seedlings appeared in greatest numbers in May and early June; practically no seedlings appeared after the last cultivation in late June or early July. Adults present late in the season arose almost entirely from seedlings appearing before the last cultivation. *The data clearly showed that rotary hoeing and cultivation were highly effective in reducing weed numbers.*

In the 1989 trial of one rotary hoeing versus four on the Thompson farm, total weed numbers were far higher in the former. There were more than ten times as many weeds in the one rotary hoeing plot, primarily because large numbers of seedlings established themselves in June and were not removed by later cultivation. Proportional differences in numbers of adult plants between the treatments generally increased over June. In the plots that had been rotary hoed four times, total weed numbers in late July were similar to weed numbers in the with/without herbicide treatments on the other farms.

Positions in the ridge-furrow topography differed in number of seedlings and adults present. Results for the herbicide trials resembled those for the rotary hoeing trials. The shoulder generally had the greatest number of seedlings, while the furrow had the fewest during May and June. The same was true for adult plants. Yet by late July, numbers of adults were highest in the row and lowest in the furrow. Most late-summer weeds grew in the row area, where they were less likely to be destroyed by cultivation.

Maximum weed populations in June were about the same in the plots with and without herbicide on the Graaf, Grau, and Hartsock farms. On the Thompson farm, weed populations in the plots hoed four times were similar to those in the herbicide trials on the other farms. Weed numbers in the treatment hoed once were much higher. Cultivation reduced weed numbers in late July to less than 0.5% of those in early June in all but the treatment hoed once. In that one, cultivation still greatly reduced weed numbers.

Soybean yield in 1989 did not differ significantly between plots with or without herbicide on the Graaf and Grau farms. The Hartsock farm plots showed small yield increases without herbicide. On the Thompson farm, the plots hoed four times had significantly higher yields than those hoed once.

Redroot pigweeds on the Thompson farm produced between 150,000 and 270,000 seeds per plant. (A rough estimate suggests these weeds produced between 40 million and 400 million total seeds per acre!)

Weed population dynamics in 1990 resembled those of 1989. Maximum weed populations in June varied widely among farms. The Grau farm had unusually low numbers in all treatments; cultivation resulted in reasonably low numbers on all farms. Soybean yield did not differ significantly among treatments on any of the farms.

Environmental conditions: Soil moisture in 1989 greatly declined over the season on all but the Thompson farm. By June, moisture level differed little by row position. Soil temperature was largely a function of sampling time. After planting, temperature differed little by row position. The resulting data also include local weather conditions, month, soybean canopy, cultivation, and residue.

Redroot pigweed's photosynthetic rate was among the highest reported for any species. This may explain pigweed's fast growth and ability to overtop soybean. This weed played a major role in reducing yields on the Thompson farm plots.

Implications

The results of this study indicate that careful management can replace herbicides for weed control in ridge-tillage soybean production. A large part of the efficiency of ridge tillage in controlling weeds appears to come from use of the rotary hoe. In fact, rotary hoeing followed by cultivation achieved weed control comparable to that of herbicides in this same system. Thus, ridge tillage can help protect long-term productivity and avoid further environmental degradation by reducing the amount of herbicide used to control weeds.

The optimal amount, timing, direction, and other aspects of rotary hoeing still need to be determined. Future research could help to optimize this technique for controlling weeds, reducing the use of fossil fuels and management inputs, and maximizing crop yields. The participation of Practical Farmers of Iowa was critical to the success of this project. It also provided opportunities to disseminate the results of this study via field days and newsletters.

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