Chemical weed controls affect runoff, erosion, and corn yields

F. D. WHITAKER, H. G. HEINEMANN, and W. H. WISCHMEIER

ABSTRACT—Chemical treatment in lieu of cultivation for weed control in corn grown on conventionally tilled seedbeds may significantly increase runoff and erosion losses and decrease yields from claypan soils that are subject to surface crusting. Data from a Mexico silt loam (1966-1969) showed that, when rainfall was about normal, chemically treated plots lost two to four times as much water and four to eight times as much soil as comparable plots that were cultivated. The additional water loss reduced corn yields 27 bushels per acre during the driest year. Breaking the soil crust by cultivation was less effective in reducing runoff during wet years.

CHEMICALS are now widely used in lieu of cultivation for weed control in corn. This is a result of farmers' seeking ways to combat farm labor shortages, high operating costs, and crop damage by weeds and grass when wet weather prevents timely cultivations.

A 16-year study (1950-1965) of soil fertility's effect on runoff and soil loss on Midwest claypans showed that tillage generated a pronounced and immediate effect on runoff and soil loss. Data for a 3.75-inch rain occurring from May 4 to 8, 1961, exemplify this. Runoff from plots plowed on April 20 averaged 0.11 inch in contrast to 2.39 inches from a nearby plot that had been disked and seeded to oats on March 2. Corresponding soil losses were 0.06 and 2.23 tons per acre. Reduced soil density and surface roughness provided by plowing accounted for most runoff and soil loss differences.

Seedbed preparation for corn on claypan soils usually includes late fall or early spring plowing, followed by diskings as needed before planting. Herbicides are applied to the entire soil surface for weed and grass control throughout the growing season. Compaction by tractors and tillage equipment during seedbed preparation, planting, and spraying operations and by raindrop impact during intense storms may leave the soil with a density approaching that before plowing. Surface sealing by raindrop impact on the unprotected soil and subsequent crust formation substantially reduce infiltration rates. Consequently, more water from subsequent rains is lost as runoff from uncultivated corn than from fields where cultivation breaks the soil crust. The increased runoff is accompanied by greater soil losses.

Reported here are the results of a 4-year study begun in 1966 and designed to determine how much the use of chemicals in lieu of cultivation for weed control in corn affects runoff, soil loss, and crop yields. The study compared the two methods of weed control in (a) corn from which only the grain was removed and (b) corn from which the corn was removed for silage. In the latter treatment the soil was bare or without adequate cover for about three-fourths of the year.

F. D. Whitaker is a hydrologic technician and H. G. Heinemann is a research hydraulic engineer at the North Central Watershed Research Center, Agricultural Research Service, U. S. Department of Agriculture, Columbia, Missouri 65201. W. H. Wischmeier is a research statistician with ARS, USDA, in Lafayette, Indiana 47907. This article is a contribution from ARS in cooperation with the Agronomy Department of the Missouri Agricultural Experiment Station.

Experimental Site

The study was conducted on the Midwest Claypan Experiment Farm near Kingdom City (McCredie), Missouri. Eight plots used for the study were among 39 runoff plots established in 1940 on Mexico silt loam with a 3 percent slope. The soil is representative of 10 million acres of Midwest cropland that are characterized by a clay subsoil layer of low permeability, gently rolling topography, and a gray, leached surface.

The 10.5- by 90-foot plots, with 7-foot border areas between, were enclosed with sheet metal dividers driven 6 or 7 inches into the soil and extending 3 or 4 inches above the surface. The upper end of the plots was enclosed with small earthern dikes. A concentrating trough and pipe at the lower end of each plot conducted all runoff from the plot into a covered tank. If runoff exceeded the capacity of this tank, one-ninth of the excess was delivered to a second tank through a nine-slot divisor unit. The tanks were calibrated to facilitate measurement of runoff volume. After each runoff event, collected runoff was measured, sampled for soil-density determination, and drained. The two tanks in series could accommodate 6.5 to 7.0 inches of runoff.

Plots were farmed lengthwise with the slope, using farm equipment.

Experimental Procedure

The eight plots were cropped to adequately fertilized corn for 8 years immediately before the study and during the 4-year study. Fertilizer (based on soil tests to meet nutrient needs for near-maximum yields) was plowed down each year about April 1 or as soon as soil moisture permitted plowing. Seedbed preparation and planting operations were the same on all plots. After planting, weed control and crop management practices on replicated plots were as follows:

1. Conventional cultivation: (a) harvest corn for grain (about October 15) and shred stalks immediately after harvest, leaving crop residue on the soil surface; (b) remove corn for silage at the proper stage of maturity (about September 7-15), leaving the soil with a corn stubble cover.

2. Chemical weed control, entire area treated, no tillage after corn planting: (a) harvest corn for grain (about October 15) and shred stalks immediately after harvest, leaving crop residue on the soil surface; (b) remove corn for silage at the proper stage of maturity (about September 7-15), leaving the soil with a corn stubble cover.

Results and Conclusions

Precipitation

Annual precipitation was well below normal the first year, near normal

Reprinted from the Journal of Soil and Water Conservation
July-August 1973, Volume 28, Number 4

the second, and very high the last 2 years (Table 1). The erosion-potential index of the rain, EI (*1*), ranged from about one-third its normal value for the location in 1966 to more than twice its normal value in 1968. The extremely high EI associated with a 43.3-inch rainfall in 1968 shows that rainfall intensities and durations that year were more above normal than total precipitation. One-third of the EI value (458) was due to a 5.9-inch storm on October 13. The almost continuously wet soil profile in 1969 caused a higher rate of soil loss per EI unit on all plots than is normal for this soil. The fact that the 4-year study included a wide range in annual precipitation and in the relation of EI to rainfall added to the study's value.

Runoff and Soil Loss

Runoff and soil loss as influenced by cultivation and chemical treatment are summarized in table 1 for corn harvested as grain and silage. The data are replication averages, but differences in favor of cultivation were consistent.

Where only corn ears were harvested, chemically treated plots with no tillage after planting averaged 10 percent more runoff and 56 percent more soil loss than cultivated plots. Quantitatively, this amounted to 1 inch more water and 7.5 tons more soil per acre per year. Where corn was harvested for silage, leaving the soil without adequate cover for about 9 months, plots with chemical weed control lost 2.3 inches (22 percent) more water and 14.6 tons (63 percent) more soil per acre per year than comparable cultivated plots.

During the dry (1966) and near-normal (1967) years, runoff from uncultivated plots was two to four times that from cultivated plots, and soil losses were four to eight times those from cultivated plots. During the wet years (1968 and 1969), when the soil profile above the "pan" remained saturated much of the time, cultivation reduced runoff less effectively. In those years, water losses from cultivated plots were 85 to 96 percent of those from uncultivated plots. However, differences in soil loss were much greater, relatively speaking, than differences in runoff.

Table 1. Precipitation, runoff, and soil losses on continuous-corn plots cultivated for weed control and on others where weeds were chemically controlled without cultivation.

Treatment and Year	Annual Precipitation[a]		Runoff		Soil Loss	
	in	*EI*	*Cult. (in)*	*Chem. (in)*	*Cult. (t/a)*	*Chem. (t/a)*
Grain harvest[b]						
1966	24.6	68	0.6	1.1	0.3	1.2
1967	33.6	102	.4	1.5	.5	3.7
1968	43.3	458	11.4	12.3	10.2	15.7
1969	58.6	417	22.3	23.2	43.0	63.6
Average	40.0	261	8.7	9.5	13.5	21.0
Silage harvest[c]						
1966	24.6	68	0.3	1.0	0.3	1.3
1967	33.6	102	1.6	4.6	2.9	10.5
1968	43.3	458	14.0	16.5	31.1	50.1
1969	58.6	417	25.3	28.1	59.1	90.1
Average	40.0	261	10.3	12.6	23.4	38.0

[a]Average precipitation, 1939-1969, 35.5 inches; 50 percent probability EI 190.
[b]Grain harvested and residue left on surface until spring plowing.
[c]Corn harvested for silage, leaving soil surface without adequate cover for about 9 months of the year.

Table 2. Effect of cultivation and chemical weed control on corn yields.

Year	Grain (bu/a)		Silage[a] Grain (bu/a)		Silage[a] Grain and Forage (t/a)	
	Cult.	*Chem.*	*Cult.*	*Chem.*	*Cult.*	*Chem.*
1966	99	72	84	68	18	17
1967	136	132	116	103	23	22
1968	119	123	111	114	21	22
1969	96	92	91	92	18	19
Average	113	105	101	94	20	20

[a]Corn grain was harvested separately and yields were determined (15.5 percent moisture in the grain). Grain and forage at 70.0 percent moisture.

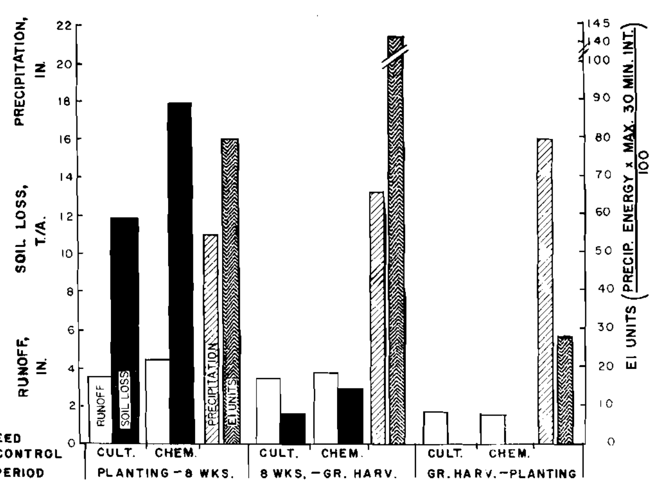

Figure 1. Effect of cultivation and chemical weed control on runoff and soil loss (by crop periods) from continuous corn grown for grain, 1966-1969.

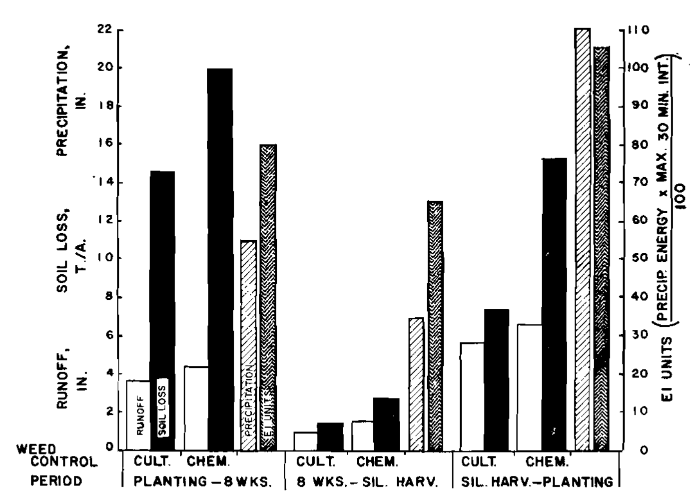

Figure 2. Effect of cultivation and chemical weed control on runoff and soil loss (by crop periods) from continuous corn harvested for silage, 1966-1969.

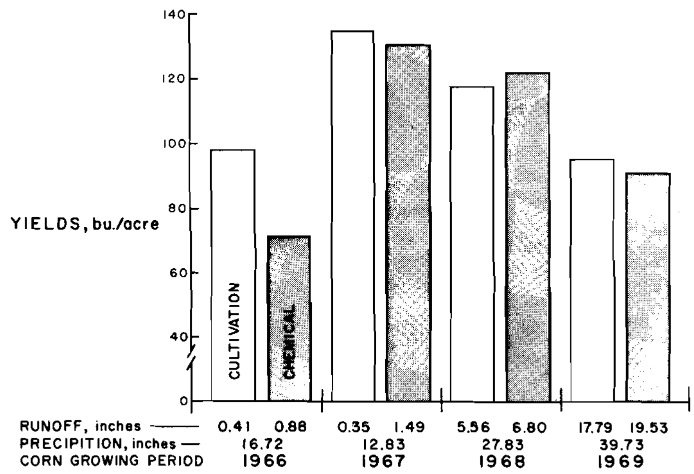

Figure 3. Effect of cultivation and chemical weed control on yields of corn grown for grain, 1966-1969.

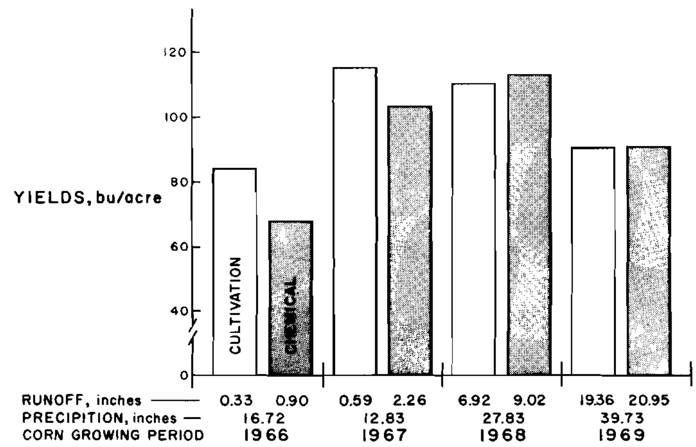

Figure 4. Effect of cultivation and chemical weed control on yields (grain portion) of corn grown for silage, 1966-1969.

The 4-year data and observations showed that cultivation's effectiveness in reducing runoff and soil loss is a function of timing with reference to rains that form soil crusts. In 1966, rains between planting and first cultivation totaled 2.9 inches, between first and second cultivations, 2.5 inches. During the corresponding periods in 1967, rains totaled 3.6 and 1.9 inches. Only one corn cultivation was possible in each of the wet years (1968 and 1969). Intensive rains reconsolidated the soil surface soon after cultivation, thereby reducing the time during which infiltration capacity was high. Individual storm data for these seasons showed that, soon after cultivation, runoff from cultivated and uncultivated corn was nearly equal and continued so for the remainder of the year. However, soil losses from cultivated plots in the wet years were about one-third less than from plots with chemical weed control. The soil-loss reduction was distributed over most of the growing season.

The lower soil loss from corn cultivated for weed control was attributed mainly to increased infiltration and reduced runoff velocity effected by tillage. Cultivation breaks up the direct runoff flow paths that develop on uncultivated soil. This reduces soil losses even though runoff from cultivated and uncultivated areas may be nearly equal when rain occurs on wet soil.

Not all the soil-loss reduction on cultivated plots could be attributed to cultivation, however. During the wet seasons, a light to moderate growth of annual grasses occurred in scattered portions of the row middles during late summer and fall. Soil deposition in these grassed areas occurred during runoff periods. Volunteer grasses on chemically treated plots were insufficient to retard soil loss.

Average annual runoff and soil losses are shown by crop periods in figures 1 and 2. High total erosion losses reflected in the figures were largely a result of the two abnormally wet years (Table 1). Nevertheless, the data show that, where corn residues were left on the surface until plowed under in the spring, erosion was excessive only during the first 8 weeks after planting (Figure 1). On the other hand, soil losses from corn chemically treated for weed control and harvested for silage was extremely high also after removal of the corn (Figure 2). Planting methods that keep corn residue on the surface after the new crop is planted, together with high soil fertility, should thus hold long-term average soil losses from continuous corn within the accepted limit of 3 tons per acre on moderate slope lengths.

Corn Yields

Effects of cultivation and chemical weed control on corn yields are shown in table 2 and figures 3 and 4. Most rains during the drier growing seasons occurred as intense storms. Runoff data show that cultivation between these storms reduced the time during which the soil surface is crusted, thereby increasing infiltration rates. Retention of relatively small amounts of additional water during the growing season in dry years may provide enough additional soil water during the critical period (of silking and ear development) to increase corn yields significantly. During the 1966 growing season, cultivation reduced runoff 0.47 inch, and corn yields were 27 bushels per acre higher. A similar runoff reduction from corn grown for silage was accompanied by an increase of 16 bushels of corn per acre (grain portion of the silage crop).

Differences in runoff between cultivated and chemically treated plots were greater in 1967 than in 1966 (Figures 3 and 4). However, yield increases from the additional water retained on the cultivated plots were greater in 1966. The limited yield response to increased moisture retention on cultivated plots in 1967 resulted from severe drought that prevented normal maturity of corn in both treatments. Planting was delayed by wet and cold weather until May 25. The drought began in late July and continued until mid-September. Three small showers produced 0.26 inch of precipitation in August. As a result, when corn needed adequate soil moisture, the supply was low on both cultivated and chemically treated plots. However, corn on chemically treated plots was under moisture stress a week before that on cultivated plots. Even with the drought, yields ranged from 103 to 136 bushels per acre. Adjacent plots that were irrigated during the drought yielded 180 to 185 bushels.

Cultivation did not significantly affect corn yields in 1968 and 1969. During these wet years, soil moisture was too high for optimum plant growth in the first half of the growing season.

REFERENCE CITED

1. Wischmeier, W. H. 1959. *A rainfall erosion index for a universal soil-loss equation.* Soil Sci. Soc. Am. Proc. 23: 246-249. □