6872

Tilling Various Soil Zones Affects Corn Yields

J. S. McKibben, F. D. Whitaker
ASSOC. MEMBER
ASAE

REDUCED tillage practices are gaining widespread popularity among corngrowers of the nation. These practices vary widely in the depth, width, and intensity of soil tillage at planting. Tillage after planting varies with mechanical weed control practices used to supplement herbicides.

Throughout the Corn Belt, sod-based rotations have generally been replaced with intensive row-crop farming. As a result, sloping areas that were not considered erosive are now producing high runoff and soil loss. To reduce the erosion potential, tillage practices that leave crop residue on or near the soil surface are needed. Acceptance of planting practices without prior tillage and with minimal disturbance of the previous crop's residue is largely based on reduced production cost, reduced runoff and soil loss, and a favorable crop yield response.

In Missouri, grain yields from corn grown with reduced tillage were comparable with those from corn grown in seedbeds prepared in the conventional manner of plowing and disking (Jamison et al 1968; Whitaker et al 1966). In these earlier studies (Jamison et al 1968), the seedbeds on the reduced tillage plots were prepared with a field cultivator. On others, the corn was wheel-track planted on plowed plots or plots on which the row zone was strip plowed (Whitaker et al 1966). The favorable corn yield response from the earlier reduced tillage studies indicated a need for additional investigations of tillage methods that further reduce the amount of tillage. Additional data were needed to determine whether satisfactory corn yields could be maintained over a period of years from the reduced tillage practices.

The objectives of this study were to determine the effect that tillage of various soil zones has on corn yields and plant population. The soil zones tilled are shown in Fig. 1. This study showed that the depth and degree of root zone tillage do affect corn yield.

SOIL AND LOCATION

Similar experiments were conducted on Mexico silt loam at the University of Missouri South Farms near Columbia, Missouri, and on Sharon silt loam, a soil formed by outwash from the river hills in the Mississippi River Bottom near Elsberry, Missouri. Mexico soil is representative of the claypan soils of the Midwest, characterized by gently rolling topography; a gray, leached surface; low fertility; and a clay subsoil layer of low permeability. Optimum soil moisture is necessary at planting time for good tilth. Sharon silt loam in the research area has a plastic, "gumbo" layer that is near the surface in about one-third of the area but is well below plow depth in the remaining area. The tilth of the gumbo layer is poor, especially if it is slightly wet. Detailed profile descriptions of

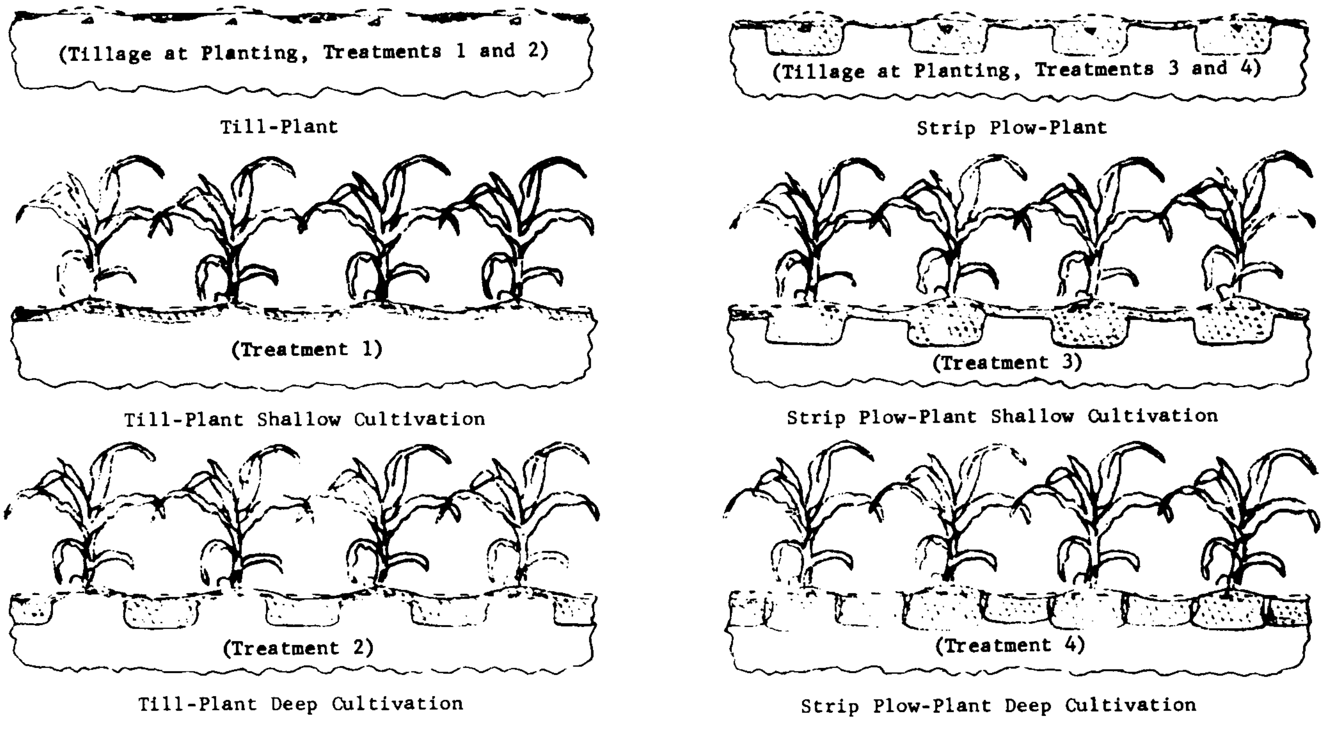

FIG. 1 Tilled soil zones indicated by shaded area; soil surface before tillage indicated by dotted line.

This article is reprinted from the TRANSACTIONS of the ASAE (Vol. 16, No. 3, pp. 404, 405, 406, 1973)
Published by the American Society of Agricultural Engineers, St. Joseph, Michigan

---

Article was submitted for publication on March 3, 1972; reviewed and approved for publication by the Power and Machinery Division of ASAE on November 16, 1972. Presented as ASAE Paper No. Mc-71-603.

The Authors are: J. S. McKIBBEN, Professor, Agricultural Engineering Dept., University of Missouri, and F. D. WHITAKER, Hydrologic Technician, North Central Region, ARS, USDA, Columbia, Missouri.

Contribution from the Agricultural Engineering Dept. of the Missouri Agricultural Experiment Station, in cooperation with the North Central Watershed Research Center, North Central Region, ARS, USDA, Columbia, Missouri.

FIG. 2 A slightly modified lister planter similar to Nebraska till planter.

FIG. 3 The strip plow and planter.

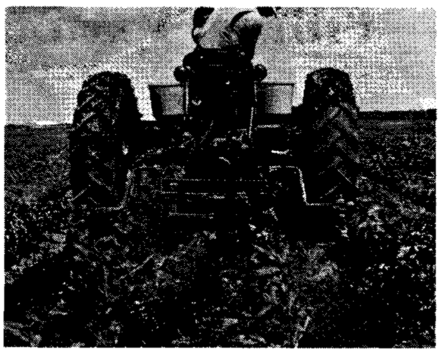

FIG. 4 Normal cultivation was with two-row mid-mounted tractor cultivator.

Mexico silt loam and Sharon silt loam are given by Kroth et al (1960).

EXPERIMENTAL DESIGN AND DATA ANALYSIS

Four treatments consisting of combinations of two planting and two cultivation methods were used in this study (described in the next section). All treatments were replicated three times.

The plots used for the study near Columbia were 20 by 100 ft and those near Elsberry were 20 by 400 ft. The treatments at both locations were in a random design. Each plot consisted of six rows of corn with six adjacent rows of check treatment which received uniform tillage and planting.

Four samples were taken from each plot for yield determinations. Each treatment sample was compared with an adjacent check sample. The treatment yield was adjusted by the difference between the check yield and the average check yields for the four plots within the replication. The adjusted treatment yields from the three replications were averaged to give yields for comparisons.

TILLING, PLANTING AND FERTILIZING

The soil zones tilled in each of the four treatments are shown in Fig. 1. A planter similar to those used in the "Nebraska Till-Plant System" (Lane and Wittmuss 1961; Wittmuss 1959) was used to till and plant corn on treatments 1 and 2. A slightly modified lister (Fig. 2) was mounted on each of the planting units and operated at a depth so that only the tops of the previous crop's row ridges were removed. Therefore, little soil was disturbed below the seed planting zone. Treatments 3 and 4 were initially tilled and planted with a strip plow and planter developed at the Missouri Agricultural Experiment Station (Whitaker et al 1966; McKibben 1966). A band 22 in. wide and 8 to 10 in. deep was strip plowed, and the transport wheels of the plow compacted a zone for seed placement by rear-mounted unit planters (Fig. 3).

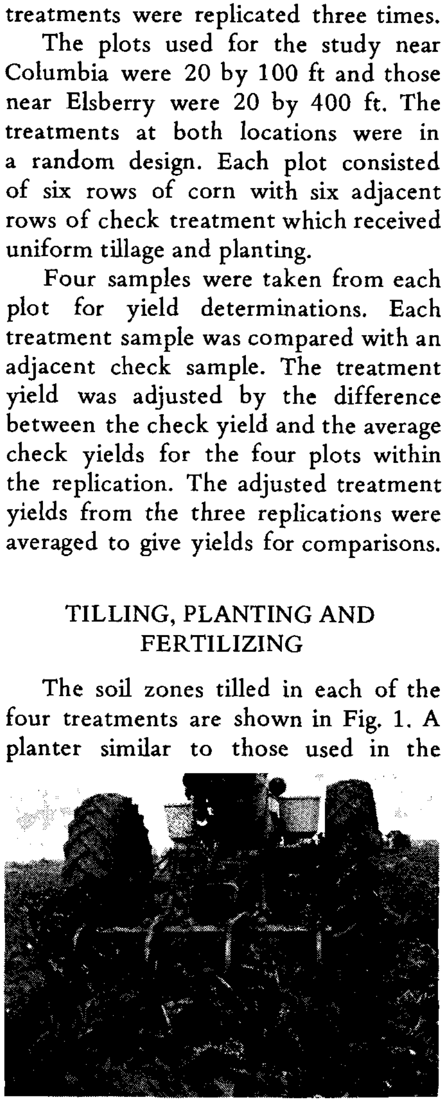

FIG. 5 Deep cultivation was with tool bar-mounted, strip-plow half units.

Fertilizer application rates were as uniform as possible on all of the treatments and check areas. The adequacy of the basic treatment was determined by soil tests. Fertilizer applied at planting was 5-20-20 at 200 lb per acre. The fertilizer was placed in bands along the rows, about 1.5 in. below the seed level on shallow-tilled treatments 1 and 2. It was banded at the bottom of the plowed strip on deep-tilled treatments 3 and 4.

Commercial hybrid seed corn adapted to this area was drilled with 9-in. spacing in 40-in. rows on all treatments for an anticipated stand of about 16,500 plants per acre.

About a month after planting, the corn was cultivated. A conventional, mid-mounted cultivator was used for treatments 1 and 3 (Fig. 4); treatments 2 and 4 were cultivated with special strip-plow half units that tilled the area between the rows to a depth of 6 to 8 in. (Fig. 5). The corn was sidedressed with 133 lb of nitrogen per acre at the time of cultivation.

DATA AND OBSERVATIONS

Climatic Conditions

Climatic conditions at both the Columbia and Elsberry experimental areas were generally unfavorable for corn production during most of the 6-year study (1963-68). Rainfall during June through August was about 3 in. below normal in 3 of the 6 years. Rainfall distribution was such that the corn plants were moisture stressed at some time during the critical moisture period for corn (July-August) in 5 of the 6 years. Other adverse conditions included cool, wet weather which retarded early growth, insect damage (wireworms and common stalk borers), and high air temperatures at the silking stage. As a result, corn yields were well below the potential for these areas.

Corn Yields and Plant Populations

The 1963-68 average adjusted corn yields and plant populations for the four treatments at both locations are shown in the following table. The corn yields were adjusted as described earlier

THE EFFECT OF TILLAGE ON CORN YIELDS AND PLANT POPULATIONS AT COLUMBIA AND ELSBERRY, MISSOURI, 1963-68

Surface tillage				Strip plow			
Conv. cult.		Deep cult.		Conv. cult.		Deep cult.	
Bu per acre	Stalks per acre	Bu per acre	Stalks per acre	Bu per acre	Stalks per acre	Bu per acre	Stalks per acre
			Columbia, Missouri				
101	14,200	106	14,600	106	15,100	104	15,300
			Elsberry, Missouri				
101	13,400	97	13,300	106	12,800	114	13,700

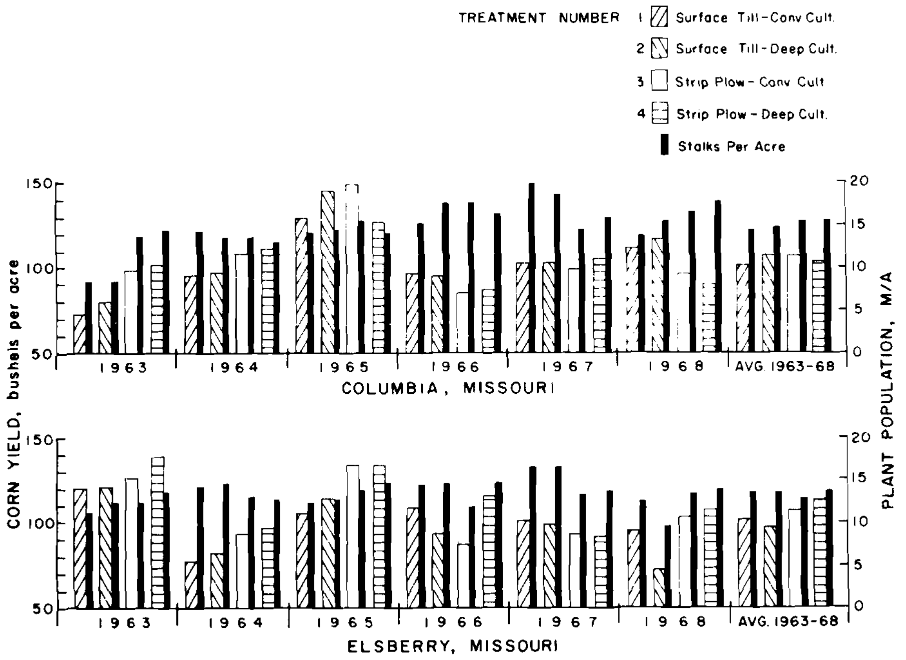

FIG. 6 Corn yields and plant populations at Columbia and Elsberry, Missouri, 1963-68.

in the data analysis section. Plant populations were based on actual stalk counts. The average check treatment yields were 107 bu per acre at Columbia and 111 bu per acre at Elsberry.

Data for each treatment are shown by years in Fig. 6. The 6-year average plant populations for all treatments and checks were about 14,800 stalks per acre at Columbia and 13,300 stalks per acre at Elsberry. The plant populations during most years were lower than the 16,500 to 17,000 stalks per acre considered optimum for maximum yields. However, when individual treatment yields for each of the years were plotted with the plant population levels, yields were highest from plant populations ranging from 13,000 to 15,500 stalks per acre.

DISCUSSION

During this study a favorable crop response to shallow or deep tillage usually depended on the amount of precipitation received from planting to about 4 weeks after planting and, to a lesser degree, after deep tillage at the time of cultivation. The timing of field operations and rainfall events therefore became the major factor influencing yields from a given tillage practice in a given year. For example, dry weather immediately following planting usually resulted in slow and uneven plant emergence on treatments 1 and 2. Wet periods following planting tended to impair the performance and populations of treatments 3 and 4. The deep-tilled furrows tended to retain the excess water, whereas more of the excess water ran off of the shallow-tilled areas.

Low plant populations were frequently associated with low yields. However, this trend was inconsistent. In 1963 and 1965, 2 of the 3 years in which growing conditions were considered near normal at Elsberry, yields were highest from the treatments with the highest plant populations (Fig. 6). However, in 1968, the other year with about normal annual rainfall, early growth of the corn was retarded by too much water retained in the root zone on the deep-tilled areas. This resulted in lower yields from these areas, although plant populations were as high as or higher than in 1963 and 1965. In 1964, a year with a severe summer drought, yields were higher from the strip-plow treatments at Columbia and Elsberry (Fig. 6), although plant populations were lower.

Data for 1964 and 1966 also show the effect of precipitation following deep tillage at the time of cultivation. Rainfall during 1964 was adequate to fill the soil profile to field capacity after deep tillage was completed at the time of cultivation. The rough soil surface left by the deep tillage allowed greater infiltration on these areas than on the shallow-tilled areas. However, the opposite effect was observed during a summer drought at Columbia in 1966. Precipitation was insufficient to reconsolidate the soil loosened by deep tillage, and the drought damaged the corn more on the deep-tilled areas than on the shallow-tilled areas.

CONCLUSIONS

The effect of shallow or deep tillage combined with the effect of weather caused annual corn yield differences among the four tillage treatments of 5 to 29 bu per acre. Yield response to a tillage treatment depended on precipitation following planting and tillage operations. For example, the yield response to shallow tillage during years with wet periods following corn planting was greater than that from deep tillage. Yield response during years with droughty periods following planting was greater from deep tillage than that from shallow tillage. During the period of study, 1963 to 1968, precipitation following planting was below the long-term normal during 3 years and above normal during the other 3 years. The 6-year average treatment yields do not show an important advantage for any of the treatments.

References

1 Jamison, V. C., D. D. Smith and J. F. Thornton. 1968. Soil and water research on a claypan soil. Tech. Bull. No. 1379. p. 37.

2 Kroth, E. M., V. C. Jamison and H. E. Grogger. 1960. Soil moisture survey of some representative Missouri soil types. ARS 41-34.

3 Lane, Delbert E. and Howard Wittmuss. 1961. Nebraska till-plant system. University of Nebraska Extension Service Publication E. C. 61-714.

4 McKibben, J. S. 1966. A tool for strip tilling and planting row crops. TRANSACTIONS of the ASAE 9(2):151, 152, 154.

5 Whitaker, F. D., J. S. McKibben and M. M. Jones. 1966. Reduced tillage in crop production. Missouri Agricultural Experiment Station Bull. 852.

6 Wittmuss, H. D. 1959. Minimum tillage method can cut costs. Nebraska Experiment Station Quarterly, Spring.