INFLUENCE OF TILLAGE SYSTEMS ON CORN YIELDS AND SOIL TEST VALUES

D.D. Buchholz, N.C. Wollenhaupt and R.L. Smoot
Department of Agronomy and Agricultural Experiment Station
University of Missouri-Columbia

A long term tillage study was initiated at the Greenley Memorial Research Center (Novelty, MO) in 1976 to look at the effects of 4 tillage systems on corn production. The study was initiated and conducted by researchers in the Agricultural Engineering Department. Agronomy has become involved in the study beginning in 1985 to assess the effects of tillage systems on soil chemical and physical properties.

The upland soils at this site are poorly drained and are generally refered to as "claypan" soils. The climate tends to be hot and dry (droughty) during the summer.

Methods

The study consists of 4 tillage systems (treatments); 1) moldboard plow + 2 diskings, 2) chisel plow + 2 diskings, 3) 2 diskings and 4) no-till. The tillage treatments are approximately 60' x 600' and are replicated 3 times. All tillage operations were conducted in the spring and all plots were planted with the same no-till planter.

The experiment covers about 8 acres which consists of Putnam silt loam and Kilwinning silt loam soils. Both soils have a slowly permeable silty clay texture B horizon which results in poor internal drainage.

Soil tests in 1976 were: pH_s = 6.3, organic matter = 2.6% Bray 1-P = 65 lbs P/acre, exchangeable K = 230 lbs K/acre. These tests were taken from the 0 to 6 inch soil depth. The study has been continuous corn with approximately a 160-50-100 ($N-P_2O_5-K_2O$) applied per acre annually over the entire study. Three tons of agricultural limestone per acre was applied in 1980 and in 1985.

Detailed soil sampling of the study was conducted in March, 1986 after ten years of continuous treatments. Soil test data presented is the average of three replications divided into the depth shown with each table of data.

Corn Yield Results

The ten year average yields (Table 1) show only a 3.8 bu/acre difference between the highest and lowest yielding treatments. Each of the 4 tillage systems has provided the highest corn yield in at least one of the past 10 years of the experiment. The lower no-till yields in 1981 and 1983 are attributed to poor weed control.

<u>Summary</u>. No yield advantage can be attributed to any one of the 4 tillage systems compared in this study. In any given year, one system may show a slight yield advantage which can be attributed to weather, insects, weeds or plant stands.

At this location, no-till performed as well as the other tillage systems or poorly drained soils.

Other factors such as risk, timeliness, soil loss and equipment availability must be considered when evaluating tillage systems.

Table 1. Novelty long term tillage study corn yields (1976-1985)

Year	Plow + 2 disk	Chisel + 2 Disk	2 Disk	No-Till	Average
	-----bu/A-----				
1976	72.1	71.9	70.3	71.6	71.5
1977	73.7	73.8	75.2	87.5	77.6
1978	109.5	111.3	111.6	107.0	109.9
1979	164.3	163.5	175.1	170.1	168.3
1980	103.0	115.4	118.8	118.2	113.9
1981[P]	145.2	158.9	146.2	100.6[WCG]	137.7
1982[H]	67.7	58.9	65.5	80.0	63.2
1983[D]	14.3	19.3	18.7	11.2[W]	15.9
1984[D]	31.5	32.3	36.7	33.2	33.4
1985	157.1	158.7	151.9	152.9	155.2
10 year average	93.8	96.4	97.0	93.2	95.1

Yield Reducing Conditions
C = Cutworm, D = Dry Weather, G = Poor Germination, H = Hail Damage,
W = Weeds, P = No-till plots planted 15 days later (rainout).

Soil Sampling Results

To what depth should soil samples be taken if the ground has been plowed, chiseled, disked, no-tilled? Does depth of fertilizer incorporated affect the depth needed for soil fertility assessment? Data from this tillage study at Greenley Memorial Center sheds some interesting light on the subject.

Soil pH_s - No significant differences in soil pH_s were found in the top 9 inches due to tillage (Table 2). Only at 9 to 12 inches did deep incorporation of lime in the plow system give a higher pH_s than for any other system. Fears of acid layers or disproportionately high pH in the surface of the no-till do not show up. With lime applications and near neutral soil pH_s, limestone solubility is likely low enough that no difference in pH_s due to tillage system exists. Looks like any depth increment from 0 to 6 inches would give a similar picture on any tillage system.

Phosphorus- Phosphorus is quite different. Though the soil has had the same rate of P_2O_5 applied across tillage systems, large differences in soil P levels exist (Table 3). Recall that yields have been very similar over the years and crop removal has nothing to do with the differences.

Table 2. Tillage influence on soil pH (in 0.01M $CaCl_2$) by sampling depth.

Sample Depth	Plow	Chisel	Disk	No-Till	$lsd_{.05}$
	Tillage System				
inches	pH_s				
0-1	6.5	6.8	6.7	6.7	NS
1-3	6.5	6.6	6.8	6.7	NS
3-6	6.7	6.8	6.7	6.5	NS
6-9	6.6	6.5	6.3	6.1	NS
9-12	6.3	5.4	5.1	5.1	0.8
12-24	4.7	4.7	4.6	4.7	NS
24-36	5.3	5.2	5.0	5.2	NS

Table 3. Tillage influence on Bray 1-phosphorus by sampling depth.

Sampling Depth	Plow	Chisel	Disk	No-till	$lsd_{.05}$
	Tillage System				
inches	lbs P/a				
0-1	49	121	157	168	37
1-3	45	113	123	69	30
3-6	49	65	34	19	16
6-9	50	20	16	12	6
9-12	40	13	12	11	7
12-24	21	11	13	14	NS
24-36	47	47	56	50	NS

The plow system has the lowest soil P level in the 0 to 6 inch sample (Table 4). No-till is intermediate and chisel and disk highest. There is no good explanation of why no-till is not higher in available soil P. Distribution can certainly explain why plow is the lowest. Mixing all the way to 12 inches in the plow system is obvious. Even a slight influence, though not significant, is apparent in the 12 to 24 inch depth under the plow (Table 3). Chisel and disk was only mixed to 6 inches with a little influence in the 6 to 9. Therefore, the surface 6 inch soil sample is picking up more of total fertilizer application in the chisel, disk, and no-till than with the plow. The result is higher soil P in conservation tillage systems, even when sampled to 6 inches.

It is interesting if you take a weighted average of the soil P tests across depths to a total depth of 12 inches. Tillage system differences cease to exist. Results of taking weighted averages for estimating 0 to 12 inch soil samples are given in Table 4.

Table 4. Weighted average soil test values for sampling to a depth of 0 to 6 or 0 to 12 inches.

	Tillage System			
	Plow	Chisel	Disk	No-till
Bray 1-P	lbs P/a			
0-6 inches	54	95	108	69
0-12 inches	47	53	49	36
Exchangeable K	lbs K/a			
0-6 inches	419	450	497	422
0-12 inches	343	304	303	273
Organic Matter	%			
0-6 inches	2.5	3.2	3.3	3.5
0-12 inches	2.4	2.6	2.5	2.6

No-till still seems lower than any other. Some surface movement of phosphorus may have occured down slope in the no-till though no work has been done to prove that.

Considering all treatments received about 500 pounds P_2O_5 per acre over 10 years, one would expect all soil tests to be about the same. When sampling to the full depth of incorporation for the plow and comparing that to the same depth in chisel and disk, the results are the same!

Potassium- Potassium is similar to phosphorus in its distribution in the soil with tillage (Table 5). Again in a 0 to 6 inch sample, chisel and disk systems have highest available K levels (Table 4). No-till and plow are not different. Weighted averages to 12 inches are given previously in Table 4, also. In this case, plow takes a slight advantage over other tillage systems in 12 inch sampling.

Table 5. Tillage influence on exchangeable potassium by sampling depth.

Sampling	Tillage System				
Depth	Plow	Chisel	Disk	No-till	$lsd_{.05}$
inches	lbs K/a				
0-1	541	716	815	716	NS
1-3	387	498	555	446	NS
3-6	335	322	260	241	NS
6-9	317	182	163	166	85
9-12	280	142	149	149	54
12-24	348	334	311	331	NS
24-36	286	264	266	270	NS

<u>Organic Matter</u>- Organic matter is also affected by tillage system. Significant differences favoring less tillage show up in the top 3 inches, while the plow is significantly higher in organic matter in the 9 to 12 inch depth (Table 6).

Has organic matter accumulated in the soil with less tillage? To a depth of 12 inches, weighted averages are similar suggesting very little if any accumulation (Table 4).

Table 6. Tillage influence on soil organic matter by sampling depth.

Sampling	Tillage System				
Depth	Plow	Chisel	Disk	No-till	lsd_{05}
inches	-------------% Organic Matter-------------				
0-1	2.5	3.3	3.5	4.1	0.8
1-3	2.3	3.0	3.1	3.2	0.4
3-6	2.5	3.0	2.7	2.7	NS
6-9	2.5	2.6	2.3	2.4	NS
9-12	2.4	1.7	1.6	1.7	0.3
12-24	1.2	1.5	1.5	1.5	NS
24-36	0.5	0.5	0.6	0.5	NS

More important is the influence organic matter plays when accumulated near the soil surface. Herbicide activity, nitrogen availability, moisture conservation and numerous other factors are affected by higher organic matter at the soil surface. Therefore, depth of sampling for assessment of organic matter may be more shallow in conservation tillage systems.

<u>Summary</u>. Now comes the question of how deep to sample these tillage systems for estimating fertilizer and limestone requirements. Considering that all treatments had the same fertilizer applied and lacked any significant differences in corn yields, one would expect that all treatments should have the same fertility status. With that argument, sampling to 12 inches would be the choice. Plow, chisel, and disk all have esentially the same phosphorus and potassium tests and pH_s is within 0.3 units. Organic matter is also the same for a 12 inch sample though that is not likely to be very important.

There is also the argument of where is high nutrient availability most important. If the 0 to 6 inch depth is most important, then the chisel and disk are currently able to supply more nutrients to the growing corn. The 0 to 6 inch sampling depth would be most appropriate. No plant analyses are available on this study, but with soil tests high it is not likely to show differences in nutrient uptake anyway.

Sampling 0 to 3 inches in conservation tillage has been promoted by some agronomists. These data would suggest a great favoring of nutrient status in the 0 to 3 inch depth for conservation tillage compared with a conventional plow system. Is this an appropriate assessment if no knowledge of what is below the 3 inch depth is known? Certainly a high phosphorus test in 0 to 3 inch depth of the no-till would be quite different from an equally high phosphorus test in a plow system.

If no prior knowledge of the fertility status of the zone below the depth of sampling is known (as is usually the case for farmers), then taking samples to a previous plow depth of 6 to 7 inches seem necessary to adequately utilize the majority of the soil test correlation work that has accumulated over the years. Shallower samples can be valuable for assessing organic matter and pH conditions near the surface. Some work to better assess the influence of fertility below 7 inches must be done if we are to gain more confidence in our fertilizer requirement judgements made every day.

Acknowledgement: This work is funded by the Missouri Soil and Water Conservation District Amendment #2 Funds directed toward soil and water conservation efforts.

PROCEEDINGS

OF THE SIXTEENTH NORTH CENTRAL EXTENSION-INDUSTRY SOIL FERTILITY WORKSHOP

OCTOBER 29-30, 1986

HENRY VIII HOTEL

BRIDGETON, MISSOURI