A Comparative Study of the Influence of Two Tillage Systems on Soybean Production, Soil Properties and Nutrient Uptake

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ABSTRACT

Due to savings in fuel, labor and machinery, conservation tillage is generally more economical even with equal, or slightly reduced, yields relative to conventional tillage (CN). Because of its increased potential for double-cropping, for reduced soil erosion and for reduced environmental pollution and due to its various other advantages, conservation tillage is attractive to growers and is becoming increasingly popular. Tennessee State University has been involved in a study of no-till (NT) soybeans for the last several years. This study is being conducted on a Byler silt loam soil, which is moderately well-drained with about 5% land slope. Perennial weeds have not generally been a problem on this site.

In seven years of side-by-side comparison of NT and CN, soybean yields in NT were equal to those in CN. No significant bulk density difference in the two tillage systems was found after five years under our conditions on a medium-textured silt loam soil. However, research elsewhere in Tennessee has shown that silt loam soils are less likely to compact than sandy or heavy clay soils. Organic matter levels were also higher in NT.

Even though we did not use any nitrogen fertilizer, we found that NT surface soil had a tendency to be acidic at the end of five years. However, this condition was easily ameliorated by surface application of lime to the soil.

Some growers are skeptical of surface stratification of fertilizer elements with continued surface application of fertilizers in no-till. This research has shown that generally such surface accumulations of nutrients do not occur. Available phosphorus, potassium, calcium and magnesium content of soil was practically equal in the two tillage systems after five years of continuous experimentation. Similarly, with the exception of seed nitrogen, plant nutrient-uptake remained uninfluenced by tillage. Seed nitrogen tended to be higher in NT than in CN.

In conclusion, in five to eight years of experimentation with soybeans, NT has been equal or superior to CN in regard to yield, soil properties and nutrients. Potential savings in fuel, labor and soil should more than make up for the added possible seed, herbicide and lime costs in NT. However, these results may be different under other soil and growing conditions, especially if heavy soils, poorly drained soils or perennial weeds are a problem.

INTRODUCTION

Because of savings in fuel, labor and machinery, conservation tillage is generally more economical with equal, or even slightly reduced, crop yields in conservation tillage. Due to its potential for double-cropping, for reduced soil erosion and for reduced environmental pollution and due to its other advantages, conservation tillage is generally attractive to farmers and is becoming increasingly popular.

OBJECTIVES

This research, initiated in 1981, sought to study the influence of two tillage systems, conventional (CN) and no-till (NT), (1) on the performance and yield of soybean *(Glycine max* (L.) Merrill) (var. Forrest), (2) on soil pH and soil organic matter (OM) and (3) on the dynamics of soil-nutrients and plant-uptake of these nutrients.

METHODS

This research was conducted for eight years on a Byler silt loam soil (Typic Fragiudalf). An old sod-field, uncultivated for at least 15years, was utilized for the study. The two tillage systems, CN and NT, were main plots in a split-plot statistical design. The splits were comprised of three herbicides in the first four years. Five potassium (K) rates (0. 45, 90, 135 and 180 kg %O/ha) were superimposed on the main tillage plots during the last four years of the study. Conventional tillage consisted of plow/disc and plant; the NT consisted of either glyphosate or paraquat application and planting with a no-till planter. Main plots measured 29 x 4.6 m with 4.6 x 4.6 m. sub-plots. Soybean yields were determined, except in

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1989. Soil pH, OM and soil N, P, K, Ca and Mg were monitored, and seed and leaf nutrient-uptake by soybeans was measured at four- to five-year intervals. However, this paper reports, in addition to the soybean yields, the soil properties/plant nutrient uptake after the initial five years.

RESULTS

Growth/Yield

Seven-year data indicated that soybean general plot population and growth (vigor, height) in NT compared favorably with those of CN (data not shown). Grain yields in NT were equal to or better than those in CN (Table 1.

Table 1. Soybean **yields (kg/ha)** as Influenced by tillage.

Year	Tillage CT[1]	NT
1981	2138	2075
1982	2263	2201
1983	1446	1572
1984	2263	2452*
1985	—	—
1986	2452	2578
1987	1760	1949
1988	3049	3074
Average	2225	2194

* Statistically different at P = 0.05
[1]CT = conventional tillage; NT = no-till

Soil pH, Organic Matter and Soil Nutrients

Soil pH tended to be lower in NT than in CN (Table 2) as expected after five years of no-tillage. Soil organic matter levels were generally higher in NT than in CN. Available P, K, Ca and Mg content of the soil was not significantly different after five years of continuous experimentation.

Plant Nutrient Uptake

With the exception of seed N, plant nutrient uptake remained uninfluenced by tillage (Table **3).** Seed N tended to be higher in NT than in CN.

CONCLUSION

In five to eight years of experimentation with soybeans, NT has been equal or superior to CN in regard to yield, soil properties, soil nutrients and plant nutrient-uptake. Potential savings in fuel and labor costs should more than make up for the added possible seed, herbicide and lime costs in NT.

In the case of NT, the potential for reduced soil erosion and reduced pollution, with lower overall operating/capital costs, should make this method of cultivation an excellent choice under most soil/climatic conditions.

Table 2. Effect of tillage on **pH,** organic matter and roil nutrients.

Soil property/ Nutrient	Tillage	Soil depth (cm) 02.5	2.55	5-10	1015	15-30	Ave
pH	CT[1]	6.31	6.26A[2]	6.03A	6.08	6.34	6.16A
	NT	6.38	6.06B	5.888	6.10	6.32	6.058
	Ave.	6.34P[3]	6.06Q	5.91Q	6.09R	6.33P	
Organic matter (%)	CT	1.98A	1.92A	1.65	1.51	0.85	1.57A
	NT	2.728	1.868	1.70	1.49	0.88	1.81B
	Ave.	2.36P	1.89Q	1.68R	1.50s	0.87T	
P (ppm)	CT	111.2	128.4	135.2	139.2	72.4	119.6
	NT	124.8	140	146	151.2	80	130
	Ave.	118P	134.4Q	140.8QR	145.2R	76.4S	
K (ppm)	CT	74.4	48.8	36.4	32.8	25.2	44
	NT	70.4	53.6	37.2	30	25.6	43.2
	Ave.	72.4P	51.2Q	36.8RS	31.2ST	25.2T	
Ca (ppm)	CT	1508	1600	1576	1644	1416	1552
	NT	1760	1320	1448	1624	1392	1520
	Ave.	1640P	1456QR	1512PQR	1636P	1404R	
Mg (ppm)	CT	100	54	47.2	51.2	50.8	60.4
	NT	92	56.8	50	46.4	46	57.6
	Ave.	96P	55.4Q	48.8R	48.8R	48.4R	

[1]CT = conventional tillage: NT = no-till
[2]A,B = Statistically significant (P = .05) differences within each depth by F test.
[3]P,Q,R,S,T = Statistically significant (P = .05) differences between depths by Duncan Multiple Range Test.

Table 3. Effect of tillage on plant nutrient uptake.

Nutrient	Tillage		K rate (kg K_2O/ha)				
	CT[1]	NT	0	45	90	135	180
Leaf N	4.4	4.6	4.5	4.4	4.3	4.6	4.4
Leaf P	0.28	0.29	0.28AB[2]	0.29A	0.29AB	0.29AB	0.276
Leaf K	1.2	1.4	1.1A	1.2A	1.2A	1.46	1.5C
Leaf Ca	1.19	1.13	1.21	1.13	1.16	1.15	1.13
Leaf Mg	0.39	0.39	0.44A	0.396	0.36C	0.38BC	0.37BC
Seed N	6.3P[3]	6.5Q	6.3	6.5	6.5	6.3	6.3
Seed P	0.60	0.61	0.61	0.60	0.61	0.61	0.60
Seed K	1.8	1.9	1.78A	1.84AB	1.90BC	1.94BC	2.0C
Seed Ca	0.23	0.24	0.22A	0.23AB	0.256	0.23AB	0.24AB
Seed Mg	0.20	0.20	0.20	0.20A	0.20A	0.20A	0.216

[1]CT = conventional tillage; NT = no-till
[2]A,B,C = Statistically significant (P = .05) differences betwenn K rates by Duncan Multiple Range Test.
[3]P,Q = Statistically significant (P = .05) differences between two tillages by F test.