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Tillage and Residue Management Practices for Soybean Production in a Soybean-Small Grain Rotation[1]

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ABSTRACT

Management of oat straw residues and tillage practices for soybean production in an oat-soybean rotation were studied. The effects of tillage practices on soybean yields were not significant. Burning the oat straw before planting soybeans had no significant effect on yields. Fertilization of soybeans after growing the oats did not increase bean yields. Tillage and residue management had no marked influence on soil temperatures and available moisture. Soybean stands were somewhat larger if the oat straw was burned or moved from the seed zone. Properties of the lister-plant-tilled and disk-harrow-tilled soils were more favorable for soybean growth than those of the turnplow-tilled soils, although this was not reflected in soybean yields.

A ONE-YEAR ROTATION of soybeans-small grain is a common cropping system used in the Southeastern Coastal Plains in the production of soybeans, a major crop of the area. The customary practice of burning the grain straw to facilitate the operation of conventional tillage equipment for planting soybeans may adversely affect the production potential of the soils.

Cultural procedures and residue management practices that will conserve soil organic matter and more efficiently utilize plant residues to improve soil tilth are immediate needs (3). Studies of minimal tillage methods, residue management, and fertilization practices have been conducted and the effects of these treatments on soybean yields and on soil moisture, temperature, and properties are reported in this paper.

McAlister (5) tested a minimum tillage lister planter that prepared the seedbed, distributed fertilizer, and planted soybeans in one operation after the small grain had been harvested in mid-June. He suggested that soil moisture conservation, improved soil tilth, and lower production cost were factors that would favor lister planting soybeans without burning, instead of burning the straw and using conventional turnplow tillage.

Types of minimum tillage for corn have been described by several investigators (2, 4, 5, 6). Rao et al. (7) reported that infiltration rates of minimally tilled soils were higher, bulk densities were lower, and resistances to penetration (hammer-type penetrometer) were less than those of the conventionally tilled soils. Moisture contents of the minimally and the conventionally tilled soils were not substantially different.

Mulch tillage, a type of minimum tillage, caused significant increases in total nitrogen, irganic matter, and aggregation of Cecil sandy loam (1). Yields of mulch and turnplow-tilled corn were not significantly different.

PROCEDURES AND METHODS

The study was conducted at the Pee Dee Experiment Station, Florence, South Carolina. The soil was Norfolk fine sandy loam and slopes were less than 0.5%. The experiment was a split plot, randomized block design. Main plot treatments were tillage and residue management practices and subplot treatments were soybean fertilization rates. Each treatment was in quadruplicate each year and was repeated each of the 4 years on the same plot. Main plots were 40 ft long and 28 ft wide (8 rows).

The rotation was a 1-year cycle of soybeans ('Jackson') and oats ('Moregrain'). The oat crop was planted between October 15 and November 1 and harvested about June 15 the following year. The early soybeans, without oats, were planted about May 1 and the late soybeans, with and without oats, were planted after the oats were harvested.

Oat fertilization was 20 pounds of N, 26 pounds of P, and 50 pounds of K (500 pounds 4–12–12) per acre, broadcast on the plots before land preparation by disk harrowing. Oats were planted with a disk drill and were topdressed with 50 pounds of N per acre in early spring. The early and late soybean plots without oats were fallow during the winter months, but were fertilized the same as those with oats.

The soybeans on one subplot were fertilized with 16 pounds of N, 21 pounds of P, and 40 pounds of K (400 pounds 4–12–12) per acre at planting; those on the second subplot were not fertilized. The fertilizations of the early and late soybeans without oats were the same as those following oats.

Tillage for soybeans and oat straw residue management treatments were: *(1)* turnplow—burned; *(2)* turnplow—not burned; *(3)* disk harrow—burned; *(4)* disk harrow—not burned; *(5)* lister plant—burned; *(6)* lister plant—not burned; *(7)* turnplow—no oats (late planting); and *(8)* turnplow—no oats (early planting). Turnplow tillage was turnplowing, disk harrowing one or two times, and planting with conventional equipment in three or four operations. Disk harrow tillage was disk harrowing one or two times and planting with conventional equipment. The turnplow-tilled and disk-harrow-tilled soybeans were planted within 4 days after oat harvest. Lister plant tillage was accomplished with equipment that opened the seed furrow, planted the beans, and distributed the fertilizer in one operation immediately after oat harvest. The straw was spread on each plot after combining the oats and burned *in situ* before the soybean seedbed was prepared.

Physical and chemical properties were measured in the 0- to 8-inch soil layer. Total carbon contents of the soils were determined by the dry combustion method and organic matter was calculated by multiplying the organic carbon content by the conventional factor, 1.72. Permeability and percentage of pores drained were determined according to Uhland's procedure (8). The undisturbed soil cores were evacuated at 50 cm of mercury suction during saturation. Permeability and pore space were measured at a tension of 60 cm of water. Soil moisture was determined in the 0- to 8-, 18- to 24-, 35- to 42-inch layers and soil temperatures were measured about 4 inches deep, below the zone of residue concentration, at intervals during the soybean-growing season.

RESULTS AND DISCUSSION

Yields of soybeans as affected by tillage, oat straw residue management, and fertilization treatments are shown in Table 1. Tillage, residue management, and fertilization had no significant effects on soybean yields. Average yields of soybeans that were fertilized (F-1) and not fertilized (F-0) at planting and those for the burned and not burned residue management practices were identical—28 bu per acre. Average bean yields of the turnplow, disk harrow, and lister plant tillage treatments were 1,800, 1,680, and 1,680 pounds, per acre, respectively.

Soil moisture variations from year to year affected soybean yields to some extent. During a considerable portion of the 1961 and 1962 maturation periods, soil moisture tensions were from 7 to 15 bars in the 0- to 8-inch depth. Yields ranging between 1,500 and 1,680 lb per acre for all treatments reflected the critical available moisture supply for plant growth. In 1959 and 1960, when rainfall was

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Table 1. The effects of tillage, oat straw residue management, and fertilization on soybean yields (4-year averages) and plant densities.

Tillage	Oat straw residue management	Soybean yields per acre, lb			Plants per acre	
		F-0*	F-1*	Avg	F-0*	F-1*
Turnplow	Burned	1740	1620	1680	230,000	296,000
Turnplow	Not burned	1860	1800	1860	224,000	262,000
Disk harrow	Burned	1680	1740	1740	257,000	289,000
Disk harrow	Not burned	1560	1680	1620	212,000	237,000
Lister plant	Burned	1680	1620	1680	217,000	236,000
Lister plant	Not burned	1620	1620	1620	235,000	224,000
Turnplow	No oats†	1680	1620	1680		
Turnplow	No oats‡	1800	1860	1860		
	Avg	1680	1680	LSD, .05§	27,000	27,000

* F-0 beans not fertilized. F-1, beans fertilized with 16 lb N; 21 lb P; and 40 lb K per acre annually. Oats of F-0 and F-1 treatments fertilized with 70 lb N; 26 lb P and 50 lb K annually. † Beans planted about June 15. ‡ Beans planted about May 15.
§ LSD, .05 for comparison of F means, same tillage-residue management = 8,000.

Table 2. Oat yields as affected by tillage for soybeans and oat straw residue management (4-year averages).

Tillage	Oat straw residue management	Yields of oats, lb/A, 4-yr avg		
		F-0*	F-1*	Avg
Turnplow	Burned	1700	1630	1665
Turnplow	Not burned	1890	1730	1810
Disk harrow	Burned	1570	1570	1570
Disk harrow	Not burned	1440	1440	1440
Lister plant	Burned	1540	1440	1490
Lister plant	Not burned	1470	1410	1440
	Avg	1600	1540	

* Refer to note 1, Table 1.

adequate and was distributed over the growing season, yields were 1,800 to 2,100 lb per acre. Yields for any 1 year were almost equal for all treatments, irrespective of amount of rainfall. Soil moisture contents throughout the soybean growing seasons were not materially affected by treatments. However, the average soil moisture level in the 0- to 8-inch depth of the not-burned treatment was 7.35%, and that of the burned was 7.02%, a difference of approximately 0.05 inch of available water.

Soil temperatures at the 4- to 5-inch depth during soybean growth were not substantially affected by treatments. Measurements in the row were from 81 to 83 F and those in the middles ranged from 85 to 89 F.

Soybean plant densities by tillage and residue management practices are shown in Table 1. Differences in stands due to treatments had no marked effects on yields. The stand of the F-1 treatment was about 12% greater than that of the F-0. Although the conventional and lister planters were calibrated to plant the same number of seed per foot, the plant stands of the turnplow-tilled and disk-harrow-tilled beans were about 10% greater than those of the lister-planted beans. The stands of the turnplow-burned and disk-harrow-burned treatments for the F-1 level were significantly larger than those of the not burned. Residues were plowed from the seedbed by lister planting for both the burned and the not burned treatments and plant densities for these management practices were almost equal. Burning the residues or removing them from the seedbed caused greater survival of soybean plants.

Average yields of oats as affected by the cultural practices for soybeans and oat straw management are presented in Table 2. Different tillage, residue management, and fertilization of soybean's had no significant effects on oat yields, but seasonal differences (years) were highly significant. Average yields of all treatments by years ranged from 704 to 2,176 lb per acre. Generally, the low yields were associated with exceptionally cold winters and/or inadequate rainfall during April and May. Yield trends of any one treatment were not consistent from year to year. Although yield differences among treatments were not significant in 1959, yield of the disk harrow, not burned treatment was highest. However, the yields of this treat-

Table 3. The effects of tillage for soybeans and oat straw residue management on some soil properties.

Tillage for soybeans	Oat straw residue management	Organic matter, %	Bulk density, g/cc	Permeability, cm/hr	Water drained at 60 cm. tension	
					15 min %	15 hours %
Turnplow	Burned	1,31	1,37	11,4	10,0	4,5
Turnplow	Not burned	1,25	1,36	11,2	9,8	5,2
Disk harrow	Burned	1,51	1,33	11,2	11,3	4,2
Disk harrow	Not burned	1,66	1,26	18,0	13,7	3,1
Lister plant	Burned	1,68	1,24	16,5	17,6	4,4
Lister plant	Not burned	1,50	1,29	18,3	12,7	2,5
Turnplow	No oats	1,22	1,40	14,2	13,3	3,8
LSD, .05		0,38	0,09	10,9	8,5	2,0

ment were significantly less than those of the turnplow, not burned treatment in 1961 and in 1962.

Oat yields following the minimally tilled soybeans (disk harrow and lister plant) were less than those following the turnplow-tilled soybeans when rainfall during the period of maturation was relatively low. However, yields for these tillage treatments were almost equal when average rainfall of 7 to 8 inches occurred during April and May.

Average oat yields following the turnplow, disk harrow, and lister-plant tilled soybeans were 3,300, 2,820, and 2,760 lb per acre, respectively. Average yields of the burned and not burned treatments were 2,940 lb per acre each.

The effects of tillage for soybeans and oat straw residue management on soil properties are shown in Table 3. The effects of minimum tillage substantiate the findings of Rao et al. (7). Oat straw management practices had no significant effects on soil properties. The organic matter contents, permeabilities, and pore volume percentages of the minimally tilled soils were somewhat greater and the bulk densities less than those of the turnplow-tilled soil.

The average organic matter content was 1.28% for the turnplow-tilled soil and 1.59% for the disk harrow and lister plant tilled soils. Average soil organic matter contents of the burned and not burned treatments were 1.50 and 1.47%, respectively. Organic matter contents were derived from total carbon, determined by the dry combustion method, which included elemental carbon and organic substances difficultly decomposed by microbiological organisms. Burning oat straw residues produced some of these substances and partially accounts for almost equal percentages in the soils of the burned and not burned treatments.

Comparisons of the average bulk density data indicate that the minimum tillages for beans caused less soil compaction than the conventional turnplow tillage. Bulk density of the lister plant-tilled soil, 1.27 g/cc, was significantly lower than that of the turnplowed soil, 1.37 g/cc. Bulk density of the disk harrow-tilled soils was 1.30 g/cc. The bulk density of both the burned and not burned treatment soils was 1.30 g/cc.

Permeability and pore measurements followed the same trends as organic matter and bulk density. Average permeabilities were 4.42 inches per hr for the turnplow, 5.76 for the disk harrow, and 6.82 for the lister plant tilled soils. Percentages of water drained from the soil volumes were in the same order.

The results of this investigation indicate that comparable yields of soybeans can be produced by using any of these tillage methods in combination with either the burning or not burning residue management practice. Differences among the soybean yields due to fertilization of the beans were not significant. Although differences between oat yields produced by the various systems were not significant, the high average yields of the turnplow tillage favored this practice over the disk harrow and lister plant tillages.

However, adequate and well distributed rainfall during the oat growing season minimized yield differences caused by tillage.

Desirable soil properties developed or improved by minimum tillages, which could influence production over a greater number of years, might be a prime consideration in selecting a tillage method.

Cost of production of soybeans is another equally important factor favoring minimum tillage. Buie (3) indicated that the lister-plant costs can be $4 to $8 per acre less than the conventional turnplow tillage. Disk harrow costs are probably comparable to those of the lister-plant tillage.

Burning oat residues had no marked effect on yields or soil properties during the course of the test, but the data do not constitute a recommendation for this practice. The effectiveness of plant residues and soil organic matter in reducing runoff, water, and wind erosion, and in improving soil tilth has been established. The use of equipment that precludes the necessity of burning residues to prevent raking of residues and clogging of cultural tools would be a more reasonable solution.

LITERATURE CITED

1. Beale, O. W., G. B. Nutt, and T. C. Peele. 1955. The effects of mulch tillage on runoff, erosion, soil properties, and crop yields. Soil Sci. Soc. Am. Proc. 19:244–247.
2. Bowers, Wendell, and H. P. Bateman. 1960. Research studies of minimum tillage. Trans. Am. Soc. Agr. Engr. 3:1–3.
3. Buie, T. S. 1960. Ashes or mulch. Better Crops With Plant Food. 44 (4):34–36.
4. McAdams, W. N., and O. W. Beale. 1959. Wheel-track planting in mulch and minimum tillage operations. Abstract, Proc. Assoc. So. Agr. Workers.
5. McAlister, J. T. 1962. Mulch tillage in the southeast. USDA Leaflet No. 512.
6. Poyner, R. R. 1950. An experimental mulch planter. Agr. Engr. 31:509–510.
7. Rao, A. A. S., R. C. Hay, and H. P. Bateman. 1960. Effect of minimum tillage on physical properties of soils and crop response. Trans. Am. Soc. Agr. Engr. 3:8–10.
8. Uhland, R. E., and Alfred M. O'Neal. 1951. Soil permeability determinations for use in soil and water conservation. SCS-TP-101.