CROP SEQUENCE EFFECTS ON THE PRODUCTIVITY AND ORGANIC MATTER CONTENT OF MISSISSIPPI RIVER ALLUVIAL SOILS

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INTRODUCTION

Continuous monocropping has been, and still remains, the primary cropping system used by cotton and soybean farmers in the Mississippi River Valley during most of this century. Long-time continuous monocropping of cotton has had adverse effects on soil and crop productivity. According to Waddle (1984). crop rotation is a beneficial cost-effective soil management practice that has not been used extensively by cotton growers because it complicates production and is an extra challenge to management. This is true, but reluctance to implement alternative cropping systems is also related to the difficulty of demonstrating to producers that continuous monocropping does, in fact, result in decreased productivity over the long term.

The influence of crop sequences grown for two or more years can have positive, neutral or negative influences on crop yields. Increased yield of cotton grown in two- and three-year cropping sequences with corn and grain sorghum compared with continuous cotton has been attributed to nematode suppression and beneficial changes in some soil properties [Barnett et al., 1961; Brage et al., 1950; Kirkpatrick and Sasser, 1984; Page and Willard, 1947; Sturkie, 1966; Vhland, 19491. A soybean crop preoeding cotton can increase yield and also reduce the fertilizer N required by cotton [Boquet et al., 1987; Gordon et al., 1986; Melville, 1961-72; Waddle, 1984). Not all studies have demonstrated beneficial effects from crop rotation. Spurgeon and Grisson (1965) reported yield decreases for cotton following other crops because the rotations improved conditions for cotton growth to the extent that lodging and insect infestation became more of a problem. Hinkle and Fulton (1963) found that crop rotations had no beneficial effect on cotton yield unless soils were infested with Verticillium wilt.

The use of soybean in multi-crop systems has largely been done to provide benefits of residual fertility to non-leguminous crops such as corn, cotton, and grain sorghum. In many instances the response of these crops to a preceding soybean crop has been immediate and obvious (Dabney et al., 1986; Kinlock and Hewitt, 1984). On the other hand, the benefits of alternate crops on soybean yield have been less obvious, and in some cases, lacking entirely (Boquet et al., 1987, 1993; Dick and Van Doren, 1985; Griffin et al., 1985; Hutchinson, et al., 1990; Rabb et al., 1985). Exceptions occur where diseases and nematodes are present, in which case, benefits to soybean productivity are likely.

The objectives of these studies were to: i) determine the effects of selected crop sequences on soybean, cotton and wheat yields and, ii) determine the effects of these crop sequences on soil organic matter content.

MATERIALS AND METHODS

In 1982, two cropping systems studies were initiated at the Northeast Research Station near St. Joseph, Louisiana. One of the studies, with 13 different cropping sequences, was on Commerce silt loam [fine-silty, mixed, nonacid, thermic Aeric Fluvaquentl. In this study, cotton was included in most crop sequences except the continuous corn, soybean and grain sorghum treatments [Table 11. A second cropping system study with eight crop sequences was located on Sharkey clay (very fine montmorillonitic, thermic, nonacid, vertic Haplaqueptl [Table 2). Both studies were conducted in a randomized complete block design with four blocks. Plots in the silt loam study were 16 rows 140-inch spacing) wide and 50 feet in length. Plots in the clay study were 16 rows (20-inch spacing) wide and 120 feet in length. Each year, each crop except for doublecrop soybean was planted at optimal dates and was grown using labeled pesticides for control of weeds and insects. Optimal management and fertilization practices were used for each crop to maximize yields. In

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Table 1. Cropping sequences under evaluation on Commerce silt loam soil at the Northeast Research Station, St. Joseph, Louisiana.

Treatment number	Year 1982 1988	1983 1989	1984 1990	1985 1991	1986 1992	1987 1993
1	C	C	C	C	C	C
2	S	S	S	S	S	S
3	CRN	CRN	CRN	CRN	CRN	CRN
4	GS	GS	GS	GS	GS	GS
5	CRN	C	CRN	C	CRN	C
6	CRN	S	CRN	S	CRN	S
7	C	S	C	S	C	S
8	GS	C	GS	C	GS	C
9	GS	S	GS	S	GS	S
10	C	CRN	S	C	CRN	S
11	C	GS	S	C	GS	S
12	C	C	S	C	C	S
13	C	C	CRN	C	C	CRN

C, cotton; S, soybean; CRN, corn; GS, grain sorghum.

spring 1990, soil samples were taken from the 0- to 6-inch depth from each plot to determine, after nine years, the effect of each crop sequence on soil organic matter content. Analyses for soil organic matter were done at the Louisiana Agricultural Center Agronomy Department Soils Lab using the Walkley-Black procedure (Nelson and Sommers, 1982).

Cotton yields were determined by mechanically picking four rows from each 16-row plot. Soybean yields were determined by combine harvesting four rows from each 16-row plot in both the Commerce silt loam and Sharkey clay experiments. Wheat yields were determined by harvesting a 6.5 by 50 foot strip from each plot. Cotton yields are reported as seedcotton yields per acre. Soybean, corn and wheat yields are reported as grain

Table 2. Cropping sequences under evaluation on Sharkey clay at the Northeast Research Station, St. Joseph, Louisiana.

Treatment number	Year 1982 1988	1983 1989	1984 1990	1985 1991	1986 1992	1987 1993
1	S	S	S	S	S	S
2	GS	GS	GS	GS	GS	GS
3	S	GS	S	GS	S	GS
4	GS	S	GS	S	GS	S
5	S-W	S-W	S-W	S-W	S-W	S-W
6	S-W	GS-W	S-W	GS-W	S-W	GS-W
7	GS-V	GS-V	GS-V	GS-V	GS-V	GS-V
8	SF	S-W	SF	S-W	SF	S-W

S, soybean; GS, grain sorghum; W, wheat; V, hairy vetch; SF, summer fallow.

Table 3. Crop yields and soil organic matter content in selected crop sequences of a long-term crop rotation experiment on Commerce silt loam, Northeast Research Station. St. Joseph, Louisiana.

Crop sequence	Seedcotton or grain yield						Soil organic mattert
	1988	1989	1990	1991	1992	1993	
	lb or bu per acre						-%-
Continuous cotton	2100	2512	3800	3092	2587	2633	0.84
Continuous soybean	47	36	51	49	---‡	50	0.84
Continuous corn	115	151	174	136	123	99	0.85
Continuous sorghum4	---	---	---	---	---	---	0.87
1 yr cotton - 1 yr corn	119	3100	175	3190	162	2910	0.74
1 yr cotton - 1 yr soybean	1845	55	4190	61	3080	61	0.77
1 yr sorghum§ - 1 yr cotton	---	3200	---	3330	---	3040	0.80
1 yr cotton-1 yr corn-1 yr soybean	2210	174	65	3170	159	65	0.70
lyr cotton-lyr sorghum-lyr soybean	2270	---	66	3370	62	61	0.70
2 yr cotton - 1 yr soybean	2285	2900	63	3610	2820	62	0.80
2 yr cotton - 1 yr corn	1780	3060	180	3320	2770	133	0.77
1 yr corn - 1 yr soybean	117	54	180	58	161	67	0.66
1 yr sorghum§ - 1 yr soybean	---	59	---	58	---	65	0.86
LSD(0.05) cotton	370	360	248	377	180	242	
LSD(0.05) soybean		10	9	6		6	0.18
LSD(0.05) corn	10	22	16		26	16	

t Soil organic matter after 9 years of each crop sequence.
‡ Soybean plot weight not recorded in 1992.
§ Sorghum yields not reported because bird depredation reduced yields 30 to 100%.

yield in bushels per acre. Grain moisture content was adjusted to 13% for soybean and wheat and to 15.5% for corn. Yield data were analyzed by analysis of variance and the LSD P=0.05 was calculated for mean separations.

RESULTS AND DISCUSSION

Yield

Silt loam. On Commerce silt loam, the 12th year of the study was completed in 1993. Continuous cotton yields have varied from a low of 1980 pounds of seedcotton per acre in 1985 to a high of 4048 pounds of seedcotton per acre in 1987. On a year to year basis there has been no consistent trend in the yield of the continuous cotton treatment as the lowest yield was produced in the 4th year of the study and the highest yield was produced in the 9th year of the study. When yields were grouped into 3-year intervals, however, a trend did emerge. The initial 3-yr yield average was 3360 pounds of seedcotton per acre, the second 3-yr interval yield average was 3020 pounds, the third 3-yr interval yield average was 2800 pounds, and the fourth 3-year interval yield average was 2770 pounds of seedcotton per acre. Thus, it appears that the yield trend for continuous cotton has been downward since the inception of the study in 1982.

Although year to year variations in the yield of continuous cotton have been large, rotations have increased yield in most years. Two-year rotations of cotton with corn, sorghum or soybean increased cotton yield compared with continuous cotton (Table 3). The only exception was 1988. In 1988, rainfall between planting (April 25) and maturity (August 101was only 2.5 inches, which limited the yield of cotton in all treatments. Cotton following two years of alternate crops, either soybean-corn or soybean-sorghum was also higher yielding than

Table 4. Yield of soybean and wheat and soil organic matter content in selected crop sequences of a long-term cropping system study on Sharkey clay.

Crop sequence	Grain yield 1989	1990	1991	1992	1993	Soil organic matter†
	---------- bu per acre				----------	-%-
Continuous soybean	**29**	**21**	**43**	**42**	**25**	1.82
Continuous sorghum‡	---	---	---	---	---	2.03
1 yr soybean - 1 yr sorghum‡§	**32**	**28**	**49**	**42**	**34**	1.92
Continuous doublecrop	18	25	44	27	19	2.16
soybean/(wheat)	(22)	(0)	(33)	(60)	(10)	
1 yr doublecrop soybean/(wheat)	**14**	---	**41**	---	**20**	
1 yr doublecrop sorghum‡/(wheat)	**(21)**	**(0)**	**(34)**	**(56)**	**(14)**	1.97
1 yr soybean/wheat - 1 yr	20	SF	50	SF	16	
summer fallow	(37)	--	(42)	--	(37)	1.89
Continuous sorghum/vetch‡	---	---	---	---	---	2.40
LSD(0.05) soybean	4	5	6	7	5	
LSD(0.05) wheat	4		6	6	6	0.14

† Soil organic matter content after 9 years of each crop sequence.
‡ Sorghum yield not reported because of bird depredation.
§ Includes Treatments 3 and 4 for soybean yield, which alternate crop years.

continuous cotton. Planting two years of an alternate crop was not better than one year of alternate crop in increasing cotton yield. Second-year cotton following one year of soybean or corn experienced increased yields but the yields tended to be lower than first-year cotton following an alternate crop.

As with cotton, there has been large year to year variation in the yield of the continuous soybean treatment. The lowest yield of 36 bushels per acre was produced in 1989 and the highest yield of 51 bushels per acre was produced in 1991. Rotation of soybean with corn, cotton, or sorghum increased soybean yield each year compared with continuous monocrop yields (Table 3). The response of soybean to crop rotation was generally greater than the response of cotton. Whereas cotton yields were increased an average of 15% by rotation, soybean yield was increased by an much as 60%. Cotton, corn and grain sorghum increased soybean yield about the same amount with two and three-year crop sequences being equally effective.

Yields of continuous corn initially increased for several years, but were reduced in the latter stages of the study, especially in 1993. The lowest corn yield was produced in 1993 and the highest was produced in 1990 (Table 3). Corn has shown a less consistent response to rotation than cotton or soybean. Corn yields were increased by rotation in 1989, 1992 and 1993 but not in 1988 or 1990. Corn yields in 1988 were limited by dry weather, as were the yields in 1993. In 1988, corn following cotton produced yield similar to 7th year continuous corn, whereas, in 1993, corn yield following cotton was higher than yield of 12th year continuous corn.

Sharkey clay. The yield of both continuous monocrop and rotational soybean varied substantially from year to year in response to growing conditions. When a poor growing season occurred, such as the drier-than-normal summers in 1990 and 1993, continuous soybean yields were low and were impacted more than rotational soybean (Table 4). In three of the last four years, a 2-yr rotation of soybean and sorghum has increased soybean yield an average of 7 bushels per acre. In 1991, soybean following wheat/summer fallow produced yields equivalent to the soybean-sorghum rotations. Thus, both of these alternatives to continuous monocropping of soybean increased soil productivity. Crop rotations are preferable over fallow in most farm enterprises, however, because economic returns are needed each year and the cost of maintaining fallowed land can be high.

Soybean in the continuous soybean/wheat doublecrop system has yielded, on average, 4 bushels less than continuous monocrop soybean and 8 bushels per acre less than soybean rotated with sorghum. This crop sequence consistently produced excellent wheat yields in the early years of the study, but the yields of continuous doublecrop wheat have declined in recent years, probably because of disease buildup in the plots. The crop sequence in which wheat has been planted every other year (1989, 1991, 1993) has yielded an average of 18 bushels per acre higher than plots in which continuous wheat has been planted since 1983 (Table 4).

Soil organic matter

Silt loam. The organic matter content of the silt loam soil in this study is very low but is representative of this soil type after many years of continuous row cropping. After nine years, soil organic matter content among the 13 crop sequences did not differ significantly (Table 3). It appears that, on silt loam soil in the lower Mississippi River Valley, crop rotations alone cannot increase organic matter content of row-cropped land.

Sharkey clay. The organic matter of clay soil was much higher than silt loam and was affected by the different crop sequences. After nine years, the lowest soil organic matter was in the plots with continuous monocrop soybean (Table 4). Continuous monocrop sorghum increased organic matter 12% compared with continuous soybean. The doublecrop soybean/wheat treatment had organic matter levels 19% higher than continuous soybean plots. The highest organic matter was in plots continuously cropped to sorghum/vetch, which had soil organic matter content 32% higher than continuous soybean plots. These data contrast with the silt loam results in that some row crop sequences did increase organic matter content. However, the best crop sequences for improving soil organic matter were those that also included a winter crop of wheat or vetch and thus sustained a crop on the soil year round.

SUMMARY

Compared with continuous monocrop cotton, rotations of cotton on silt loam soil in 2- and 3-year cycles with soybean, corn or sorghum increased cotton yield by an average 15%. Rotation of soybean with corn, cotton or sorghum increased soybean yields by as much as 60%. On Sharkey clay, soybean yields increased an average of 16% when grown in rotation with sorghum. Soil organic matter content of silt loam was not affected by various crop sequences that included cotton, soybean, corn and grain sorghum. On Sharkey clay, soil organic matter was increased 12 to 32% by rotational crop sequences compared with monocrop soybean.

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