Profitability of Seven Nonirrigated Soybean Cropping Rotations on a Shallow Silt Loam Soil

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Introduction

Crop rotation has been recognized for quite some time as a good way to control soilborne diseases. With the removal of Dibromochloropropane, the most cost-effective nematacide for general use in soybean *(Glycine max* L.) production, about the only control left for the cyst nematode *(Heteroderu Glycine* Ichinohe) is selection of resistant soybean cultivars coupled with crop rotation. Previous work has indicated that nonhost crops for one year in rotation dramatically decreased the nematode population (Riggs, 1995, Personal Comm.). In the Mississippi Delta and loessial terraces regions of Arkansas, there are several million acres of loess-derived soils that are quite low in organic matter and very prone to having severe cyst nematode problems. Cropping patterns of the region on nonirrigated land not cropped to cotton are almost exclusively continuous soybeans or doublecropped wheat-soybeans. The wheat residue is burned on almost the entire acreage planted to wheat. This straw burning has been perceived by agronomists as a bad practice on soils with very low organic matter (< 0.8 %) for as long as it has been occurring. Agronomically feasible crop rotations that result in nematode suppression were studied. These crop rotations were compared to ones currently utilized in continuous soybeans and doublecropped wheat-soybeans. The practice of leaving the wheat residue and no-till crop production were investigated.

Materials and Methods

Agronomic

The study reported herein was conducted from 1980 to 1984 at the Arkansas Cotton Branch Experiment Station on a Loring-Calloway-Henry (Alfisol) silt loam. The soil test values were 6.2 for soil pH with 0.6% organic matter and 64 and 170 pounds per acre P and K, respectively. The study included seven rotational cropping systems composed of continuous soybeans (monocropped), wheat-soybeans doublecropped, and five biennial rotations of which two are single crops per year and the others doublecrop systems. The cropping sequences are shown in Table 1. Additional cultural practices were imposed on selected crop rotations. The continuous soybeans and wheat-soybean doublecrop systems were grown both conventionally and no-till. The wheat-soybean doublecrop also had residue management treatments; the wheat stover was either burned or left. This resulted in a total of four doublecropped wheat-soybean production systems and two continuous soybean systems.

A total of 11 crop production systems were arranged in a randomized complete block design with three replications. Individual production system plots were 13.7 feet x 100 feet. Grain sorghum and soybeans were planted on 38-inch rows with a conventional planter (John Deere 7100) equipped for no-till by using cutting coulters, double disk openers, cast iron press wheels, and heavy down pressure springs, while the wheat was sown in 7.5-inch rows with a Crust Buster@ no-till drill. Wheat residue was burned in all cases where the crop production system did not specify that it was to remain.

The study area was planted to soybeans in the summer of 1980. The study began with wheat planted that fall and summer crops in the spring of 1981. Yields were determined by harvesting the two center rows in each plot for grain sorghum and soybeans or a 60-inch wide swath in the center of the wheat plots. Grain yields were adjusted to 14.0, 13.0, and 13.0% moisture for grain sorghum, soybeans, and wheat, respectively.

Soybeans monocropped. Conventional 'Forrest' soybeans were planted at 180,000 seeds per acre between June 1 and June 15. Preemergence herbicides consisted of metribuzin at 0.375 lb ai/A and alachlor at 2.5 lb ai/A. Seedbed preparation consisted of disking once and going over with a do-all. Mechanical cultivations were done at V3 stage once each year. Harvest dates ranged from October 18 to October 28. No-till production consisted of a chemical burndown with paraquat at 0.468 lb ai/A per acre at planting. Preemergence herbicides consisted of metribuzin at 0.375 Ib ai/A and alachlor at 2.5 lb ai/A. Postemergence herbicides used were sethoxydin at 0.187 lb ai/A per acre and an oil-based surfactant. Otherwise, production practices were the same as conventional.

Soybeans doublecropped. Conventional 'Forrest' soybeans were planted at 180,000 seeds per acre between June 1 and June 15. Wheat residue was either burned or left according to the production system. The seedbed was prepared by disking once and going over with a do-all. The preemergence herbicides used were trifluralin at 0.75 lb ai/A and metribuzin at 0.375 lb ai/A. One or two mechanical cultivations were

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Table 1. Cropping sequences and seedbed preparation for 11 crop production systems from 1981 to 1984.

			Year							
		Wheat	1980	1981	1981	1982	1982	1983	1983	1984
Crop Rotation	Tillage	Stubble	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
GS , S	Conv.	—	—	GS	—	S	—	GS	—	S
S , S	Conv.	—	—	S	—	S	—	S	—	S
	No-till	—	—	S	—	S	—	S	—	S
W - F , S	Conv.	Bum	W	—	—	S	W	—	—	S
W - G S , S	Conv.	Bum	W	GS	—	S	W	GS	—	S
W - GS, W - S	No-till	Burn	W	GS	W	S	W	GS	W	S
W - S , S	Conv.	Bum	W	S	—	S	W	S	—	S
W - S , W - S	Conv.	Bum	W	S	W	S	W	S	W	S
	No-Till	Burn	W	S	W	S	W	S	W	S
	Conv.	Leave	W	S	W	S	W	S	W	S
	No-till	Leave	W	S	W	S	W	S	W	S

[1] Yearly cropping rotations are divided by comma (,) and individual crops harvested same year are divided by hyphen (-).
[2] Crops are shown as 'GS' for grain sorghum, 'S' for soybean, 'W' for wheat, and 'F' for fallow.

done between June 8 and June 18. Harvest dates ranged from October 18 to October 28. No-till production began with burning or leaving the wheat residue as the production system required. Those with wheat residue remaining received a burndown of paraquat at 0.468 lb ai/A just prior to planting. Post-plant weed control was accomplished by sethoxydim at 0.187 lb ai/A and an oil-based surfactant. Other cultural practices were the same as the conventional production system.

Grain sorghum monocropped. Conventional 'Funk's G522DR' grain sorghum was planted at a seeding rate of 90,000 seeds per acre between June 8 and June 15 Seedbed preparation consisted of disking, bedding, and going over with a do-all. The post-emergence herbicide applied was atrazine at 2 lb ai/A. Mechanical cultivations were done at the six-leaf growth stage (Vanderlip and Reeves, 1972). Urea was applied broadcast over the area at the rate of 100 lb N/A to supply nitrogen requirements. Harvest ranged from October 20 to October 29.

Grain sorghum doublecropped. The agronomic inputs that changed from monocropped conventionally grown grain sorghum follow. Grain sorghum was planted between June 18 and June 20. Urea was applied broadcast in early spring at the rate of 60 lb N/A. No-till production differed from conventional in that a chemical burndown of atrazine at 2 lb ai/A was used instead of mechanical seedbed preparation.

Wheat. 'Oasis' soft red winter wheat was drilled at a seeding rate of 1,350,000 seeds per acre between October 29 and November 5. Seedbed preparation for conventional plots consisted of disking and going over with a do-all. Both conventional and no-till plots were planted using a Crust Buster no-till drill. Harvest dates ranged from June 1 and June 14.

Economic Analysis

Budgets were compiled on each cropping system annually by using the Mississippi State Budget Generator computer program (Spurlock, 1992). Crop prices were based on 6-year averages (1986-1993) for each crop. Total income was calculated by multiplying yield and average crop price. Direct expenses were calculated by using average costs paid for seed, chemicals, and fuel. Fixed expenses were calculated based on prices paid for using equipment such as tractors, combines, and other field equipment. Total expenses included both direct and fixed expenses combined. Net returns are considered the difference between total income and total expenses. Average net returns are calculated based on all 4 years' data combined. Gross income, total expenses, and net returns for the doublecrop rotations include the total income, expenses, and returns for both crops produced in each system. No charge was issued for land, overhead labor, other overhead, crop insurance, real estate taxes, and management.

Results and Discussion

Grain yields for the study are shown in Table 2. These particular crop rotations were selected for the alternation of host crop for soilborne plant pathogens, weed spectrum easily controlled by available herbicides, and economic potential. Other production practices were included to reduce mechanical inputs (no-till) or to retain crop residue. Wheat yields in the study were significantly lower in those cropping systems where wheat followed grain sorghum or in those systems where the wheat residue was left on the surface. The grain sorghum yields were significantly different in each production system employed. Grain sorghum yields were highest in the monocrop grain sorghum-monocrop soybean rotation. Grain sorghum yields were the lowest under the total doublecropped wheat-grain sorghum-monocrop soybean rotation. The difference in the monocropped grain sorghum versus doublecropped grain sorghum was expected. However, the different grain sorghum yield for the two doublecropped systems was not expected. The no-till doublecropped grain sorghum yielded measurably less than the conventional doublecropped grain sorghum.

The soybean yields showed more complex results than did

Table 2. Grain yield for the 11 cropping systems.

Crop Rotation[1,2]	Tillage	Wheat Stubble	Crop	Year 1981	1982	1983	1984	Avg.
				bu/acre				
GS , S	Conv.	—	GS	86.0[3]	—	107.1	—	96.6
	Conv.	—	S	—	40.8	—	36.8	38.8
S , S	Conv.	—	S	28.7	31.2	17.1	35.4	28.1
	No-Till	—	S	34.6	20.2	10.7	31.2	24.2
W - F , S	Conv.	Burn	W	34.0	—	38.6	—	36.3
	Conv.	Bum	S	—	34.7	—	34.6	34.6
W - G S , S	Conv.	Bum	W	34.0	—	40.6	—	37.3
	Conv.	Burn	GS	62.3	—	62.3	—	62.3
	Conv.	Burn	S	—	36.7	—	36.9	36.8
W - GS , W - S	No-Till	Bum	W	34.0	28.0	40.1	32.3	33.6
	No-Till	Burn	GS	36.0	—	35.5	—	35.8
	No-Till	Burn	S	—	28.7	—	33.9	31.3
W - S , S	Conv.	Burn	W	34.0	—	40.1	—	37.1
	Conv.	Bum	S	27.1	32.7	16.4	39.0	28.8
w - s , w - s	Conv.	Bum	W	34.0	34.7	37.6	42.1	37.1
	Conv.	Bum	S	34.6	30.3	19.4	33.9	29.5
	No-Till	Burn	W	34.0	32.0	38.6	43.9	37.1
	No-Till	Burn	S	35.3	31.2	19.0	35.4	30.2
	Conv.	Leave	W	34.0	31.4	35.7	34.1	33.8
	Conv.	Leave	S	33.1	31.0	16.8	36.5	29.4
	No-Till	Leave	W	34.0	34.0	37.1	23.7	32.2
	No-Till	Leave	S	39.5	29.4	19.0	26.6	28.6

[1] Yearly cropping rotations are divided by comma (,) and individual crops harvested same year are divided by hayphen (-).
[2] Crops are shown as 'GS' for grain sorghum, 'S' for soybean, 'W' for wheat, and 'F' for fallow.
[3] Measured plots yields of 16 bu/acre were adjusted to 86 bu/acre based on experiment station average on 300 acres. Small plots of early grain sorghum were heavily damaged by birds.

Table 3. Total income (TINC), total expenses (TEXP), and total returns above expenses (TRET) for the 11 crop systems.

Crop Rotation	Tillage	Wheat Stubble	1981 TINC	1981 TEXP	1981 TRET	1982 TINC	1982 TEXP	1982 TRET	1983 TINC	1983 TEXP	1983 TRET	1984 TINC	1984 TEXP	1984 TRET
			$/acre											
GS , S	Conv.	—	175.44	120.32	55.123	245.82	134.70	111.12	218.55	123.56	94.99	221.55	134.08	87.46
S , S	Conv.	—	172.98	75.00	97.98	188.03	133.23	54.80	102.94	73.21	29.73	213.11	134.87	78.24
	No-till	—	208.29	76.85	131.44	121.61	116.61	5.00	64.41	76.42	(12.00)	187.53	118.28	69.25
W - F , S	Conv.	Burn	108.46	70.78	37.68	208.69	133.75	74.94	123.13	71.50	51.63	208.29	133.74	74.55
W - G S , S	Conv.	Bum	235.62	170.51	65.11	221.13	134.06	87.07	256.67	171.54	85.13	222.14	134.10	88.04
W - GS , W - S	No-till	Bum	181.83	141.15	40.68	262.29	158.92	103.37	200.41	142.04	58.37	307.01	154.11	152.90
w - s , s	Conv.	Bum	271.80	139.31	132.49	196.86	133.46	63.40	226.65	138.64	88.01	234.58	134.41	100.17
W - S , W - S	Conv.	Bum	316.55	140.40	176.15	292.90	145.74	147.16	236.84	138.66	98.18	338.28	147.46	190.82
	No-till	Burn	320.76	147.28	173.48	289.70	157.86	131.84	237.72	145.53	92.19	353.35	160.38	192.97
	Conv.	Leave	307.72	139.78	167.94	287.09	148.98	138.11	214.92	137.55	77.37	328.61	150.24	178.37
	No-till	Leave	346.05	158.88	187.17	285.35	159.97	125.38	232.82	156.26	76.56	235.54	157.93	77.61

[1] Yearly cropping rotations are divided by comma (,) and individual crops harvested same year are divided by hyphen (-).
[2] Crops are shown as 'GS' for grain sorghum, 'S' for soybean, 'W' for wheat, and 'F' for fallow.
[3] No charge was issued for land, overhead labor, other overhead, crop insurance, real estate taxes, and management.

Table 4. Total income (TINC), total expenses (TEXP), and total returns above expenses (TRET) for the 11 crop systems averaged over 4 years.

			Average of 1981 through 1984		
Crop Rotation	**Tillage**	**Wheat Stubble**	**TINC**	**TEXP**	**TRET**
				$/acre	
GS , **S**	Conv.		215.34	128.17	87.17[3]
S , S	Conv.		169.26	104.07	65.19
	No-till		145.46	97.04	48.42
w - F , S	Conv.	Burn	162.15	102.45	59.70
w - G S , S	Conv.	Bum	233.89	152.55	81.34
W - ***GS*** , W - S	No-till	Bum	237.89	149.06	88.83
W - S , S	Conv.	Burn	232.47	136.45	96.02
W - S , W - S	Conv.	Burn	296.14	143.06	153.08
	No-till	Burn	300.38	152.76	147.62
	Conv.	Leave	284.59	144.14	140.45
	No-till	Leave	274.94	158.26	116.68

[1] Yearly cropping rotations are divided by comma (,) and individual crops harvested same year are divided by hyphen (-).
[2] Crops are shown as 'GS' for grain sorghum, 'S' for soybean, 'W' for wheat, and 'F' for fallow.
[3] No charge was issued for land, overhead labor, other overhead, crop insurance, real estate taxes, and management.

the grain sorghum or wheat. The continuous monocropped soybeans yielded significantly less (approximately 10 bu/A) than any monocropped soybeans following a full year of a crop that is a nonhost for cyst nematode. In fact, the monocropped continuous soybeans had yields equivalent to doublecropped soybeans. The yield of doublecropped soybeans following a full year of nonhost was not any better than those where soybeans were included in the prior year. This indicates that the "rotational effect" of the year of nonhosts did not extend to doublecropped soybeans. Over the entire 4 years of the study, average net returns ranged from a high of $153.08 for conventionally produced doublecropped wheat-soybeans to a low of $57.64 (Table 3 and 4) for no-till continuous soybeans. Of the crop rotation systems, the wheat-soybeans continuous doublecropped systems, regardless of tillage practice and stubble management, produced the largest net returns. The least favorable of these four was for soybeans was no-tilled into wheat residue. At the time of this study, the technology was not available to make this treatment yield as it should (Keisling et al, 1994). Therefore, the net profits reported for continuous doublecropped wheat-soybeans with wheat residue left and soybeans no-tilled into the wheat straw will be lower than can be currently expected. The next most profitable systems were monocropped grain sorghum-soybeans, continuous doublecropped wheat-grain sorghum-wheat-soybeans and doublecropped wheat-soybeans-monocropped soybeans. These crops were about two-thirds as profitable as the profit maximizing system. The least profitable group was continuous soybeans regardless of tillage practice, wheat-summer fallow-monocropped soybeans, and doublecropped wheat-grain sorghum-monocropped soybeans. This least profitable group had about one-third the profits of the most profitable group.

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