Soybean Production in the Midsouth

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chapter eleven

Crop rotation systems for soybeans

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Contents

Introduction

Crop rotation refers to the growing of different crops in sequence and has been shown to increase crop yields. The cause of the higher yields is related to increased soil fertility, to improved soil physical properties, to improved weed control, or to reduced incidences of diseases, nematodes, and insect pests.

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Fahad et al. (1982) attributed the increase in crop yields to the enhanced water infiltration rate of the soil caused by the rotation. Baird and Bernard (1984) and Young et al. (1986) claim crop rotations tend to control plant parasitic nematode populations, whereas Boquet et al. (1986) suggest that the reduction in disease incidence is a vital factor. Recent research in Louisiana indicated that soybeans grown after either sorghum or summer fallow consistently outyielded soybeans following soybeans. This favorable response was attributed to the reduction of soybean cyst nematode populations by rotation (Dabney et al., 1988). In corn–wheat–soybean and sorghum–wheat–soybean rotation sequences, crop yields were enhanced and johnsongrass was effectively controlled during the soybean sequence (Litsinger and Moody, 1976).

Organic matter content increased when a sod crop was used in different crop rotations (Spurgeon and Grissom, 1965). However, no other changes were reported for the rotations studied. In a 4-year rice–cotton rotation, rotations with rice did not result in an increase in subsequent seed cotton yield (Snipes et al., 1990). The appreciable amount of rice straw at the end of the growing season also failed to increase the soil organic matter content at either the 6-in. or 12-in. depth.

Doublecropping wheat and soybeans can be an effective way of increasing net farm income (Sanford, 1982; Sanford et al., 1986), especially with irrigation (Wesley and Cooke, 1988). Yield of doublecropped soybeans, however, is usually reduced below that of soybeans grown alone (Crabtree and Rupp, 1980; Sanford, 1982; Sanford et al., 1986; Dabney et al., 1988; Wesley and Cooke, 1988), probably because of the later planting and the considerable amount of moisture removed from the soil by the maturing wheat crop (Heatherly, 1988; Heatherly et al., 1990). However, doublecropping offers a number of potential advantages over monocropping. Among these are more extensive use of fixed resources, reduced soil erosion, improved cash flow, and increased net returns (Hairston et al., 1984; Sanford et al., 1986).

A feasible alternative to continuous doublecropping is rotational doublecropping, where a summer grain crop such as corn or grain sorghum is grown in rotation with the conventional wheat–soybean doublecrop sequence. In this system, wheat follows the summer grain crop, and winter fallow follows the soybean crop. This rotational system produces three cash crops every 2 years.

Biennial rotations of two summer crops is an attempt to improve the yield of one or both crops. Biennial rotations of soybeans and corn have produced significant increases in the yield of both soybeans (Crookston and Kurle, 1989; Peterson and Varvel, 1989a; Meese et al., 1991) and corn (Crookston et al., 1988; Crookston and Kurle, 1989; Meese et al., 1991). Similar results were obtained with biennial rotations of grain sorghum and soybeans (Clegg, 1982; Dabney et al., 1988; Peterson and Varvel, 1989a). The effects of corn and grain sorghum on the yield of the following crop are generally equal (Peterson and Varvel, 1989a). However, in some instances under nonirrigated conditions, the effect of soybeans on the succeeding corn grain yields has been varied over a period of years (Edwards et al., 1988; Peterson and Varvel, 1989b).

Cropping systems studies

General

Nonirrigated and irrigated field studies were conducted from 1984 through 1991 on a Tunica clay near Stoneville, MS to determine crop yields and to compare net returns from the selected cropping systems (Wesley et al., 1994a, b; 1996). Each study included eight cropping systems (treatments) composed of three monocrops, two biennial rotations, one

Table 11.1 Cropping System and Crop Production Sequences for Corn, Soybean, Sorghum, and Wheat Grown on Tunica Clay near Stoneville, MS (1984 through 1991)

		Crop year			
		1984, 1986, 1988, 1990		1985, 1987, 1989, 1991	
Cropping	Crop	Summer	Winter	Summer	Winter
1	Corn–corn	Corn	—	Corn	—
2	Soybean–soybean	Soybean	—	Soybean	—
3	Sorghum–sorghum	Sorghum	—	Sorghum	—
4	Corn–soybean	Corn	—	Soybean	—
5	Sorghum–soybean	Sorghum	—	Soybean	—
6	Wheat–soybean	Soybean	Wheat	Soybean	Wheat
7	Corn–wheat–soybean	Corn	Wheat	Soybean	—
8	Sorghum–wheat–soybean	Sorghum	Wheat	Soybean	—

Sources: Wesley et al., 1994; 1996.

doublecrop, and two rotational doublecrop systems. Monocrop systems were corn, soybeans, and sorghum. Biennial rotations were corn–soybeans and sorghum–soybeans. The doublecrop system included soft red winter wheat and soybeans, whereas the rotational doublecrop systems included summer crops of corn and sorghum one year, followed by a wheat–soybean doublecrop sequence the next year. Crop production sequences for the eight treatments or cropping systems are presented in Table 11.1. Land area available for these studies was limited; thus, it was not possible to evaluate all components of a rotation each year.

Corn and sorghum in the monocrop, biennial rotation and rotational doublecrop systems were planted on undisturbed beds that had been formed the previous fall. Corn and sorghum were planted in 40-in.-wide rows with a conventional planter with double-disk openers. Soybeans were planted in 40-in. rows in a flat, undisturbed seedbed with the same planter; however, doublecrop soybeans were planted no-till after burning the wheat straw. Summer crops were mechanically cultivated for weed control as needed during the early part of each growing season. Wheat was planted in prepared seedbeds (disked and harrowed) with a conventional grain drill with double-disk openers spaced 8 in. apart.

All crops in the nonirrigated study were totally dependent on rainfall. An overhead lateral-move sprinkler irrigation system was used to irrigate all crops in the irrigated study. Each crop was irrigated only during its reproductive period. Irrigation of corn began at tassel emergence and ended at near dent stage. Irrigation of soybeans started at beginning bloom and ended at full-seed stage, whereas irrigation of sorghum began at boot stage and ended at hard-dough stage. Water deficits that occurred during the reproductive stage of each crop were monitored by tensiometers positioned 12 in. beneath the planted row. The amount of water applied and the number of irrigations each crop received were recorded each year of the study.

Economic analysis

Incomes and expenses on a per-acre basis were estimated annually for each cycle of each cropping system. Application rates for all the variable inputs were those recommended and used for crop production in these studies. Crop prices used were the seasonal average prices as reported by the Mississippi Agricultural Statistics Service (1984–1991). The estimated net returns did not include charges for land, management, and general farm

Table 11.2 Average Crop Yield (bu/acre) and Net Returns (NETRET — $/acre) from Eight Nonirrigated and Irrigated Cropping Systems on Tunica Clay near Stoneville, MS (1984 through 1991)

Cropping system[a]	Crop	Nonirrigated Yield	NETRET[b]	Irrigated Yield	NETRET[b]
1	Corn	60.8	–9e	116.8	79c
2	Soybean	21.5	25cd	41.1	53d
3	Sorghum	79.9	60ab	93.8	19e
4	Corn	53.8	42bc	126.8	110ab
	Soybean	40.3		49.8	
5	Sorghum	59.8	76a	105.7	84c
	Soybean	44.0		51.6	
6	Wheat	38.2	48abc	43.9	123a
	Soybean	10.8		32.6	
7	Corn	40.3	16de	125.1	136a
	Wheat	43.1		48.8	
	Soybean	19.9		38.2	
8	Sorghum	58.2	64ab	103.3	95bc
	Wheat	45.1		44.2	
	Soybean	22.0		37.3	

[a] Cropping systems are as follows: 1 = monocrop corn; 2 = monocrop soybean; 3 = monocrop sorghum; 4 = biennial rotation of corn–soybean; 5 = biennial rotation of sorghum–soybean; 6 = continuous wheat–soybean doublecrop; 7 = biennial rotation of corn and wheat–soybean doublecrop; 8 = biennial rotation of sorghum and wheat–soybean doublecrop.

[b] Values in individual columns followed by the same letter are not significantly different at a probability level of 0.05.

Source: Wesley et al., 1994, 1996.

overhead. Net returns for the wheat–soybean doublecrop system, and for the wheat–soybean sequence in the rotational doublecrop systems represent the sum of net returns for both the wheat and soybean crops produced in each respective system.

Yields

In the nonirrigated study, yield of monocrop soybeans averaged 21.5 bu/acre over the 8-year study (Table 11.2). Yield of soybeans grown in the corn–soybean and sorghum–soybean rotations during the odd years of the study averaged 40.3 and 44.0 bu/acre, respectively, whereas yield of monocrop soybeans these years averaged 33.7 bu/acre. These higher yields are attributed to the benefits derived from rotations. Also, yields of soybeans from the corn–wheat–soybean and the sorghum–wheat–soybean systems during the odd years averaged 19.9 and 22.0 bu/acre, respectively, whereas yields of soybeans in the continuous wheat–soybean doublecrop system averaged 15.6 bu/acre these years and only 10.8 bu/acre over the 8-year study. Soybeans in these doublecrop systems were planted no-till as soon as feasible following wheat harvest and burning of wheat straw and residue. However, soybeans in these systems were always planted later than soybeans in the monocrop and biennial rotations.

In the irrigated study, yields of all crops were higher than those produced in the nonirrigated study. As in the nonirrigated study, soybean yields from the corn–soybean and sorghum–soybean rotation grown during the odd years were the highest and averaged 49.8 and 51.6 bu/acre, respectively. Yield of monocrop soybeans averaged 42.3 bu/acre during the odd years. Soybean yields from the monocrop soybean system and the

Table 11.3 Average Net Returns above Specified Expenses for Eight Nonirrigated Cropping Systems on Tunica Clay near Stoneville, MS (1984 through 1991)

Cropping system[a]	Net returns, $/acre		
	Even years[b]	Odd years[c]	All years
1	–39	20	–9
2	–26	76	25
3	30	90	60
4	–6	91	42
5	37	116	76
6	33	62	48
7	–50	81	16
8	31	97	64

[a] Cropping systems are as follows: 1 = monocrop corn; 2 = monocrop soybean; 3 = monocrop sorghum; 4 = biennial rotation of corn–soybean; 5 = biennial rotation of sorghum–soybean; 6 = continuous wheat–soybean doublecrop; 7 = biennial rotation of corn and wheat–soybean doublecrop; 8 = biennial rotation of sorghum and wheat–soybean doublecrop.

[b] Average net returns for crop years 1984, 1986, 1988, and 1990, when corn and sorghum were the component crop in the rotations.

[c] Average net returns for crop years 1985, 1987, 1989, 1991, when soybeans were the component crop in the rotations.

corn–wheat–soybean and the sorghum–wheat–soybean systems during the odd years were nearly identical and averaged 42.3, 38.2, and 37.3 bu/acre, respectively. As in the nonirrigated study, soybean yields from the continuous wheat–soybean doublecrop system were the lowest, but averaged 32.6 bu/acre.

Net returns

In the nonirrigated study, net returns from monocrop corn, soybeans, and sorghum averaged –$9, $25, and $60/acre, respectively (Table 11.2). Average net returns of $76/acre from the 2-year rotation of sorghum–soybean were greater than the $42/acre from the corn–soybean rotation. Average net returns from the sorghum–wheat–soybean system were $64/acre while the average from the corn–wheat–soybean system was $16/acre. The wheat–soybean doublecrop system provided average net returns of $48/acre, but average soybean yield in this system was only 10.8 bu/acre. Thus, grain sorghum was determined to be the more desirable component crop for rotation with soybean and the wheat–soybean doublecrop sequence under nonirrigated conditions in this study.

During the even years of the study when grain sorghum was grown in cropping systems 3, 5, and 8 and corn was grown in cropping systems 1, 4, and 7, the respective average net returns for the grain sorghum component ($30, $37, and $31) were among the highest and greater than respective returns (–$39, –$6, and –$50) for the comparable corn component (Table 11.3). During the odd years of the study, net returns from soybean rotated with corn ($91) and with grain sorghum ($116) were higher than net returns from monocrop soybeans ($76). Average net returns from the wheat–soybean doublecrop sequences rotated with corn ($81) and grain sorghum ($97) were higher than net returns from the continuous doublecrop sequence ($62). These established trends favor rotated crop sequences over continuous monocrop and wheat–soybean doublecrop culture.

Table 11.4 Average Net Returns above Specified Expenses for Eight Irrigated Cropping Systems on Tunica Clay near Stoneville, MS (1984 through 1991)

Cropping system[1]	Net returns, $/acre		
	Even years[b]	Odd years[c]	All years
1	97	61	79
2	55	51	53
3	22	16	19
4	136	84	110
5	74	94	84
6	184	62	123
7	126	146	136
8	70	120	95

[a] Cropping systems are as follows: 1 = monocrop corn; 2 = monocrop soybean; 3 = monocrop sorghum; 4 = biennial rotation of corn–soybean; 5 = biennial rotation of sorghum–soybean; 6 = continuous wheat–soybean doublecrop; 7 = biennial rotation of corn and wheat–soybean doublecrop; 8 = biennial rotation of sorghum and wheat–soybean doublecrop.

[b] Average net returns for crop years 1984, 1986, 1988, and 1990, when corn and sorghum were the component crop in the rotations.

[c] Average net returns for crop years 1985, 1987, 1989, and 1991, when soybeans were the component crop in the rotations.

In the irrigated study, average net returns from all cropping systems except monocrop sorghum were higher than those in the nonirrigated study (Table 11.2). Average net returns from the corn–wheat–soybean ($136/acre), wheat–soybean ($123/acre), corn–soybean ($110/acre), sorghum–wheat–soybean ($95/acre), and sorghum–soybean ($84/acre) systems in the irrigated study were greater than average returns from the monocrop systems of the component crops. Net returns to all cropping systems that included corn were greater than comparable cropping systems with sorghum as the component crop. Thus, under irrigated conditions, cropping systems that included corn provided maximum profit potential on this clayey soil.

During the even years of the irrigated study, net returns from the irrigated corn component of cropping systems 1, 4, and 7, respectively, averaged $97, $136, and $126/acre (Table 11.4), and greatly exceeded the respective net returns from the irrigated grain sorghum component of cropping systems 3, 5, and 8 ($22, $74, and $70). As in the nonirrigated study, net returns to soybeans grown in the odd years in rotated sequences with corn ($84) and with grain sorghum ($94) were higher than returns to monocrop soybean ($51). Average net returns from the wheat–soybean sequence rotated with corn ($146) and with grain sorghum ($120) were higher than from the continuous doublecrop sequence ($62). These trends also favor rotated sequences.

Summary

All rotational systems with irrigation provided greater net returns than corresponding monocrop systems. Without irrigation, biennial rotations resulted in improved soybean yields, but net returns were not always significantly improved. These results indicate that a doublecrop wheat–soybean system should be used only with irrigation, and that rotation of soybeans with sorghum produced the highest net returns in nonirrigated environments, whereas rotations with corn produced the highest net returns when irrigation was used.

Table 11.5 Influence of a Rice–Soybean Rotation on Yield of Soybean Grown on Sharkey Clay at the Delta Branch Experiment Station, Stoneville, MS (1983–1990)

Crop rotation	Soybean yield, bu/acre							
system	1983	1984	1985	1986	1987	1988	1989	1990
1 Rice: 1 Soybean		26.8		15.4		37.3		25.4
2 Rice: 1 Soybean			39.1			40.1		
3 Rice: 1 Soybean				16.7				33.1
1 Rice: 2 Soybean		24.8	35.4		11.2	32.7		20.8
2 Rice: 2 Soybean			40.5	12.1			27.0	29.4
Continuous soybean	14.0	19.1	29.4	8.1	4.3	30.1	24.4	17.7
LSD (0.05) = 9.0[a]								
LSD (0.05)[b]	NS	NS	8.5	4.7	NS	4.6	NS	9.8

[a] For comparison of any two means across years of continuous soybean.

[b] For comparison of any two means within a single year.

Source: Kurtz, M.E. et al., MAFES Bull. 994, 1993. With permission.

Table 11.6 Influence of a Rice–Soybean Rotation on Yield of Rice Grown on Sharkey Clay at the Delta Branch Experiment Station, Stoneville, MS (1983–1990)

Crop rotation	Rice yield, bu/acre							
system	1983	1984	1985	1986	1987	1988	1989	1990
1 Rice: 1 Soybean	126.4		160.2		141.2		124.6	
2 Rice: 1 Soybean	139.5	148.1		123.1	125.9		126.6	95.2
3 Rice: 1 Soybean	137.8	146.1	139.0		142.2	118.0	116.6	
1 Rice: 2 Soybean	134.0			139.6			134.6	
2 Rice: 2 Soybean	141.5	143.4			155.5	138.4		
Continuous Rice	138.1	150.9	139.8	93.5	98.8	92.1	113.0	89.9
LSD (0.05) = 22.9[a]								
LSD (0.05)[b]	NS	NS	19.2	12.5	29.7	39.4	NS	NS

[a] For comparison of any two means across years of continuous rice.

[b] For comparison of any two means within a single year.

Source: Kurtz, M. E. et al., MAFES Bull. 994, 1993. With permission.

Rice–soybean rotation studies

1983–1990 study

A long-term rice–soybean rotation study was conducted on Sharkey clay near Stoneville, MS (Kurtz et al., 1993). The study included continuous rice, continuous soybeans, and five rotational sequences of rice and soybeans that were being utilized by producers in the region. Specifically, the treatments evaluated were (1) continuous rice, (2) continuous soybeans, (3) 1 year rice:1 year soybeans, (4) 2 years rice:1 year soybeans, (5) 3 years rice:1 year soybeans, (6) 1 year rice:2 years soybeans, and (7) 2 years rice:2 years soybeans. Rice was drill-seeded in mid-April to early May each year at a seeding rate of 90 lb/acre. Soybean (Centennial variety, MG VI) were planted in 40 in. rows in mid-May to early June each year at a seeding rate of 50 lb/acre. Soybean were not irrigated in any year.

Yields

Soybean and rice yields are presented in Tables 11.5 and 11.6, respectively. During the 8-year experiment, soybeans occurred 17 times in the various rotations following rice

Table 11.7 Net Returns above Specified Costs from an 8-year Rice–Soybean Rotation on Sharkey Clay at the Delta Branch Experiment Station, Stoneville, MS (1983–1990)

	Net returns above specified costs,[a] $/acre		
Crop rotation system	8-year avg	Last 4-year avg	Difference
1 Rice: 1 Soybean	66.75 a	74.15 ab	+7.40
2 Rice: 1 Soybean	63.75 a	38.69 cd	–25.06
3 Rice: 1 Soybean	58.25 a	51.96 bc	–6.29
1 Rice: 2 Soybean	56.87 b	37.16 cd	–19.71
2 Rice: 2 Soybean	83.50 a	93.11 a	+9.61
Continuous soybean	7.88 c	12.55 d	+4.67
Continuous rice	0.15 c	–52.59 e	–52.44

[a] Means followed by the same letter do not significantly differ (Duncan's MRT, $P = 0.05$).

Source: Kurtz, M. E. et al., MAFES Bull. 994, 1993. With permission.

(Table 11.5). Eight of these occurrences resulted in significant soybean yield increases over the continuous soybean system. When grown in the 1:1 system, soybean yields increased two out of the four times this rotation occurred (7.3 bu/acre in 1986 and 7.2 bu/acre in 1988). In the 2:1 (9.8 bu/acre average increase) and 3:1 (12.0 bu/acre average increase) systems, soybean yields when in rotation with rice were always significantly higher than continuous soybeans. No yield increase was measured for soybeans in the 1:2 rotation. Soybean yield increases occurred two out of four times in the 2:2 system (11.1 bu/acre in 1985 and 11.7 bu/acre in 1990).

Rice yields usually benefited from rotations with soybeans. After year one, rice occurred 18 times in various soybean rotations. Rotational rice yields were greater than yields from the continuous rice system in eight of those occurrences (Table 11.6). After year one, where rice was grown in all plots except the continuous soybeans, rice yields increased in the 1:1 rotation two out of three times this rotation occurred (20.4 bu/acre in 1985 and 42.4 bu/acre in 1987), one out of five times in the 2:1 system (29.6 bu/acre in 1986), one out of five times in the 3:1 system (43.4 bu/acre in 1987), one out of two times in the 1:2 rotation (46.1 bu/acre in 1986), and two out of three times in the 2:2 system (56.7 bu/acre in 1987 and 46.3 bu/acre in 1988). In the continuous rice system, yields decreased after the third year and never yielded as high as in the first year (Table 11.6).

Costs and Returns

The average net returns above specified costs for the 8-year experiment indicate all rotations out-performed continuous rice and continuous soybeans (Table 11.7). During the last 4 years of the experiment, all rotational sequences and continuous soybeans provided higher net returns than continuous rice; however, only the 2:2 (rice:soybean) and 1:1 rotations and continuous soybeans resulted in increased net returns compared to the 8-year average. The 2:2, 1:1, and 3:1 rotations provided significantly higher net returns than continuous soybeans. These rotational systems resulted in the highest net returns of $93, $74, and $52/acre/year, respectively, above specified costs during the last 4 years. Net returns from the 2:2 system were significantly greater than those from the 3:1 system. These values do not include management fees, land costs, or general farm overhead.

Table 11.8 presents 8-year average yields, gross values, specified production costs, and net returns of continuous soybeans and soybeans produced in the 1:1 and 2:1 rotations with rice. Average yields of soybeans from the rotations exceeded those from the continuous soybean system by 9.3 bu/acre (27.7 vs. 18.4 bu/acre). Average net returns for soybeans

Table 11.8 Yield, Net Returns, and Costs for Continuous Soybeans Compared with Those from Soybeans Following 1 or 2 years of Rice, Delta Branch Experiment Station, Stoneville, MS (1983–1990)

Cropping system	Average[a] yield, bu/acre	Gross[b] value, $acre	Average production cost, $/acre	Net return, $/acre
Continuous soybeans	18.4	112.79	104.50	8.29
Soybeans following 1 or 2 years of rice	27.7	169.80	104.50	65.30

[a] Average yield represents the 8-year average for the specified crop sequence.

[b] Gross value determined as the product of yield and a seasonal average price of $6.13/bu.

Source: Kurtz, M. E. et al., MAFES Bull. 994, 1993. With permission.

following 1 or 2 years of rice were $65.30/acre, whereas average net returns to continuous soybeans were only $8.29/acre.

Summary

When soybeans were grown behind 1 or 2 years of rice, the average soybean yield increased 9.3 bu/acre compared with continuous soybeans (Table 11.8), resulting in $57.01/acre increased net returns. The rotations that resulted in the highest returns above specified costs during the last 4 years were the 2:2 and 1:1 rotations, with a 3:1 (rice:soybean) rotation being equal to the 1:1 rotation. Each of these rotational systems returned a higher dollar value than either continuous soybeans or continuous rice. These data clearly indicate that rice makes a valuable rotational crop with soybeans and the returns far exceed those for either crop grown in continuous monoculture.

1994–1995 study

Another rice–soybean rotation study was conducted at Stoneville, MS to determine the effect of irrigation on the yield of MG IV and V soybeans grown continuously and in a 1:1 rice:soybean rotation (Heatherly, 1995, personal communication). Soybeans in each production system were either grown in a nonirrigated or a furrow irrigated environment. All production inputs within a year were identical for all varieties and environments.

Yields

Soybeans in this study were planted on April 21, 1994 and April 18, 1995. The rotation had been in place for 4 years before the yield data were collected. In the nonirrigated environment, yields of MG IV and V soybeans following rice averaged 5.9 bu/acre higher than yields of soybean after soybean in 1994, and 5.1 bu/acre higher in 1995 (Table 11.9). In the irrigated environment, average yields of MG IV and V soybeans following rice and after soybean were nearly identical each year.

Furrow irrigation increased yields of continuous soybeans and soybean following rice both years. In 1994, irrigation increased the average yield of soybean 19.2 bu/acre in the continuous soybean system and 12.3 bu/acre in the rice:soybean rotation (Table 11.9). Furrow irrigation produced similar results in 1995 with increases of 26.0 and 19.3 bu/acre, respectively. In the irrigated environment, the average yield of soybeans in the continuous soybean system and in the rice rotation were nearly identical each year.

Summary

In a nonirrigated environment, the production of soybeans in a rice–soybean rotation produced yields that averaged 5 to 6 bu/acre more than those produced in a continuous

Table 11.9 Yield (bu/acre) of Nonirrigated and Furrow Irrigated Soybeans Following Rice (RICE) and Continuous Soybeans (SOY) on Sharkey Clay at Stoneville, MS (1994 and 1995)

	Nonirrigated		Irrigated	
Variety (MG)	RICE	SOY	RICE	SOY
April 21, 1994 planting date				
RA 452 (IV)	41.9	35.3	53.6	57.3
HBK 49 (IV)	38.0	33.9	52.7	55.5
DP 3499 (IV)	36.8	29.9	47.3	50.1
P 9592 (V)	43.6	39.5	56.2	55.4
A 5979 (V)	50.7	43.3	63.9	59.5
DP 3589 (V)	44.1	37.7	55.0	56.8
Average	42.5	36.6	54.8	55.8
April 18, 1995 planting date				
RA 452(IV)	37.5	32.6	57.1	59.6
DP 3478 (IV)	40.4	38.2	62.5	66.1
P 9501 (IV)	40.9	32.0	60.2	62.2
P 9592(V)	30.2	27.6	46.2	46.2
DP 3589(V)	32.3	26.1	52.2	52.2
Hutcheson(V)	39.6	33.9	58.2	60.1
Average	36.8	31.7	56.1	57.7

Source: Heatherly et al., 1995.

soybean system. Furrow irrigation of continuous soybeans and soybeans following rice increased the average yield of MG IV and V soybeans 19.2 bu/acre. However, with furrow irrigation the yield of continuous soybeans and soybeans following rice were nearly identical. Thus, the use of irrigation alleviated drought stress and masked the beneficial effects provided by the rotation.

Short-term crop rotation systems

General

In Louisiana, monocropped soybean is the most popular cropping system and has been continually grown on some land since the mid-1960s. During the late 1970s, Louisiana soybean farmers noted that soybean yields were declining with time, whereas soybean farmers in Arkansas were reporting yield increases where soybeans were rotated with grain sorghum (Beatty and Eldridge, 1980). Field studies were initiated in 1982 in Tangipahoa Parish, LA to identify short-term rotations that would increase soybean yields above those from monocropped soybeans and to determine the cause of the yield decline in monocropped soybeans (Dabney et al., 1988).

The experiment included eight 2-year crop rotations on a Providence silt loam that had been planted to soybeans during each of the previous 15 years. Only three of the rotations had soybeans planted on the same plots every year. These were (1) continuous soybeans (S–S); (2) continuous soybeans with a winter ryegrass cover crop (S,R–S,R); and (3) doublecropped soybeans and wheat (S,W–S,W). The other five rotations had a soybean crop only in alternate years. These were (4) soybeans alternated with wheat interseeded with alfalfa (S–W,A); (5) soybeans alternated with grain sorghum (S–GS); (6) soybeans alternated with grain sorghum, with each crop followed by a ryegrass winter cover crop (S,R–GS,R); (7) soybeans alternated with fallow (S–F); and (8) soybeans alternated with fallow with a ryegrass cover crop seeded each winter (S,R–F,R). In this study, fallow refers

Table 11.10 Mean Yields of Centennial and Davis Soybeans Grown in Several Crop Rotation Systems on a Providence Silt Loam in Southeast Louisiana (1983 to 1986)

Crop rotation system[a]	Crop sequence	Centennial, bu/acre	Davis, bu/acre
1	S–S	30.2	21.3
2	S,R–S,R	32.4	23.0
3	S–W	22.2	15.4
4	S–W,A	31.6	20.5
5	S–GS	35.0	26.8
6	S,R–GS,R	34.0	28.4
7	S–F	34.2	26.0
8	S,R–F,R	34.4	27.8

[a] Cropping systems are as follows: 1 = monocrop soybeans; 2 = monocrop soybean with a winter ryegrass cover crop; 3 = doublecrop soybeans and wheat. Crop rotation systems 4 to 8 had a soybean crop only in alternate years as follows: 4 = soybeans alternated with wheat interseeded with alfalfa; 5 = soybeans alternated with grain sorghum; 6 = soybeans alternated with grain sorghum with each crop followed by a ryegrass winter cover crop; 7 = soybeans alternated with fallow; and 8 = soybeans alternated with fallow with a ryegrass cover crop seeded each winter.

Source: Dabney, S. M. et al., *Agron. J.*, 80, 197–204, 1988. With permission.

to volunteer vegetation that occupied the land in the absence of tillage. It should be noted that rotation 3, the wheat–soybean doublecrop, produced two cash crops each year, whereas rotations 1, 2, 4, 5, and 6 produced one cash crop each year. Rotations 7 and 8 produced only one cash crop every 2 years. Centennial and Davis soybeans (MG VI varieties) were used in each of the rotations. Nematode populations were determined three times during each growing season: at planting, midseason, and harvest. Insect populations were monitored on a weekly basis from June to October of 1982 to 1985.

Yields

Over the 4 years, yields of Centennial and Davis soybeans were increased by rotation (Table 11.10). Centennial yielded significantly more than Davis all years of the study. Soybeans rotated with grain sorghum or alternated with fallow produced the greatest increase in yield above that produced by continuous soybeans. Doublecropped soybeans yielded significantly less than full-season soybeans all years except 1985. This exception is attributed to the relatively early planting date of doublecropped soybeans in 1985. There were no positive effects attributed to the presence of ryegrass. However, yields were reduced when rotations involved wheat or alfalfa.

Soybean cyst nematode numbers

Soybean cyst nematode (SCN) populations were relatively low for both soybean varieties in 1982. However, at that time SCN populations under the Davis variety were significantly higher than under the Centennial variety. Over the study period, a tremendous increase in SCN occurred in continuous soybean culture, especially under the Davis variety. A steady but less dramatic increase occurred under continuous Centennial culture. Continuous production of a specific soybean variety year after year, even a resistant variety, is an important factor in the development of SCN populations. Data in Table 11.11 indicate continuous soybean culture resulted in higher SCN populations than those resulting when soybeans were rotated with either grain sorghum or fallow.

Table 11.11 Number of Soybean Cyst Nematodes per Liter at Harvest of Centennial and Davis Soybeans Grown in Several Crop Rotation Systems on a Providence Silt Loam in Southeast Louisiana (1984 to 1986)

Crop rotation system[a]	Crop sequence	Centennial, no. L^{-1}	Davis, no. L^{-1}
1	S–S	768	2427
2	S,R–S,R	389	3950
3	S–W	69	154
4	S–W,A	392	732
5	S–GS	155	922
6	S,R–GS,R	207	854
7	S–F	0	364
8	S,R–F,R	69	233

[a] Cropping systems are as follows: 1 = monocrop soybeans; 2 = monocrop soybean with a winter ryegrass cover crop; 3 = doublecrop soybeans and wheat. Crop rotation systems 4 to 8 had a soybean crop only in alternate years as follows: 4 = soybeans alternated with wheat interseeded with alfalfa; 5 = soybeans alternated with grain sorghum; 6 = soybeans alternated with grain sorghum with each crop followed by a ryegrass winter cover crop; 7 = soybeans alternated with fallow; and 8 = soybeans alternated with fallow with a ryegrass cover crop seeded each winter.

Source: Dabney, S. M. et al., *Agron. J.*, 80, 197–204, 1988. With permission.

Insect populations

Insect pressure at the test site was low. Economic thresholds for any species were reached only twice in 1982, and not at all in 1983, 1984, and 1985. Treatment with insecticides in 1982 rapidly reduced populations below threshold levels. Thus, it is unlikely that insect damage limited yields in any rotation except possibly the doublecrop rotation.

Summary

Soybeans in the rotated systems responded positively to crop rotations. Centennial produced higher yields each year than Davis; however, Davis showed a greater response to rotation. Doublecropped soybeans yielded less than full season soybeans all years except 1985. Ryegrass in the rotations failed to affect yields, SCN, or insect populations. High SCN populations in continuous soybean culture tended to reduce soybean yields, whereas rotations reduced SCN populations and enhanced soybean yields. Continuous production of a single variety, even a resistant variety, on the same land area over time is not recommended.

Conclusions

Biennial rotations of corn–soybean and sorghum–soybean produced soybean yields that were significantly higher than yields from monocropped soybeans in both nonirrigated and irrigated environments on Tunica clay. These high yields are attributed to the timely planting of soybeans each year and the positive benefits derived from rotations. In nonirrigated environments, net returns to cropping systems that included sorghum as a component crop were higher than net returns from cropping systems that included corn. Thus, sorghum is the more desirable rotation crop with soybeans in nonirrigated cropping systems on clayey soils. Continuous wheat–soybean doublecrop systems produced extremely low soybean yields without irrigation, and thus are not recommended for nonirrigated clay soils. In the irrigated environment, net returns to all cropping systems with corn as the component crop were higher than returns to cropping systems with sorghum as the component crop. Therefore, cropping systems that include corn provide the maximum profit potential in irrigated environments. Soybean–sorghum rotations reduced soybean cyst nematode populations and thereby enhanced soybean yields on a Providence silt loam.

Rotations of soybeans and rice on a Sharkey clay increased the yield of each crop above that produced by continuous monocropping of each crop. This was true when Centennial soybeans were grown following 1 or 2 years of rice. In these rotations, nonirrigated soybean yields averaged 9.3 bu/acre greater than yields from continuous monocropped soybeans; net returns averaged $57.01/acre higher.

In a rice–soybean rotation study on Sharkey clay, yields of nonirrigated MG IV and V soybeans rotated with rice averaged 5 to 6 bu/acre higher than the yield of continuous soybeans. Furrow irrigation significantly increased the yields of soybeans in the continuous soybean culture and in the rice rotation. However, with irrigation the yield of soybeans from the monocrop soybean treatments and from the rice–soybean rotation were nearly identical. Thus, furrow irrigation alleviated drought stress and masked the beneficial effects of rotation.

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