United States Department of Agriculture

Agricultural Research Service

ARS–119

December 1994

Effects of Crop Rotation and Irrigation on Soybean and Wheat Doublecropping on Clay Soil

An Economic Analysis

Abstract

Wesley, R.A., L.G. Heatherly, C.D. Elmore, and S.R. Spurlock. 1994. Effects of Crop Rotation and Irrigation on Soybean and Wheat Doublecropping on Clay Soil: An Economic Analysis. U.S. Department of Agriculture, Agricultural Research Service, ARS–119, 20 pp.

Field experiments were conducted from 1984 to 1991 to determine and compare the yields and economic returns of soybean [*Glycine max* (L.)] monocrops, continuous wheat [*Triticum aestivum* (L.)]-soybean doublecrops, and 2-year rotations of corn [*Zea mays* (L.)]/wheat-soybean and sorghum [*Sorghum bicolor* (L.) Moench]/wheat-soybean in irrigated and nonirrigated environments on Tunica clay (clayey over loamy, montmorillonitic, nonacid, thermic Vertic Haplaquept). Yields, production records, and commodity prices were used to calculate annual net returns above specified costs for each cropping system. In the irrigated study, the highest overall net returns per acre were produced by the corn/wheat-soybean ($136.29) and the wheat-soybean doublecrop ($123.47) systems, whereas the lowest overall net returns per acre were from soybean monocrops ($52.85). In the nonirrigated study, the highest overall net returns per acre were from the sorghum/wheat-soybean rotation ($63.65) and the wheat-soybean doublecrops ($47.79). The lowest overall net returns per acre were from the nonirrigated corn/wheat-soybean rotation ($15.47). Supplemental irrigation of the summer crops increased the overall net returns per acre of soybean monocrops ($28.12), wheat-soybean doublecrops ($75.68), corn/wheat-soybean rotations ($120.82), and sorghum/wheat-soybean rotations ($31.67). The average net returns per acre of wheat were high for all cropping systems, whereas the average net returns per acre of nonirrigated soybean in all cropping systems were not sufficient to cover land rental charges.

Keywords: economic analysis, cropping system, yields, crop rotation, irrigation, corn, sorghum, soybean, wheat, monocrop, doublecrop.

Acknowledgments
The authors sincerely appreciate the assistance of Ray Adams and John Black in conducting the field experiments and preparing the data for economic analysis.

While supplies last, single copies of this publication may be obtained at no cost from USDA–ARS, Application and Production Technology Research Unit, P.O. Box 36, Stoneville, MS 38776.

Copies of this publication may be purchased from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

Issued December 1994.

Contents

Tables

Effects of Crop Rotation and Irrigation on Soybean and Wheat Doublecropping on Clay Soil

An Economic Analysis

R.A. Wesley, L.G. Heatherly, C.D. Elmore, and S.R. Spurlock

Crop rotation, the growing of different crops in a regular sequence, is a process that increases crop yields (Fahad et al. 1982, Baird and Benard 1984, Boquet et al. 1986, Young et al. 1986, and Dabney et al. 1988). Crop rotations of corn [*Zea mays* (L.)]-wheat [*Triticum aestivum* (L.)]-soybean [*Glycine max* (L.) Merr.], and sorghum [*Sorghum bicolor* (L.) Moench]-wheat-soybean not only enhance yields of rotational crops but also permit effective control of johnsongrass [Sorghum *halepense* (L.) Pers.] during the soybean sequence (Litsinger and Moody 1976). Likewise, irrigation has been shown to consistently and significantly increase soybean yields on clay soil regardless of planting date or row spacings (Heatherly 1984, Heatherly 1988). Recent research indicated that irrigation increased corn yields 63 percent, whereas sorghum yields were increased only 11 percent (Heatherly et al. 1990).

The adoption and continued use of rotational cropping systems and the decision of whether or not to irrigate are partially dependent on economic relationships. An economic analysis has shown that properly timed irrigation of a soybean monocrop system on Dubbs silt loam (Typic Hapludalf, fine-silty, mixed, thermic) in the Mississippi Valley can result in increased returns to help offset overhead from land rental, management, and general farm costs (Salassi et al. 1984). In an irrigated (I) study on Tunica clay (clayey over loamy, montmorillonitic, nonacid, thermic Vertic Haplaquept) in the Mississippi Valley, Wesley and Cooke (1988) showed that profits were greater from a soybean monocrop system than from wheat-soybean doublecrop systems in which soybean was planted as a no-till crop in standing wheat stubble. However, these same researchers showed that profits from the I wheat-soybean doublecrop systems were higher than profits from the soybean monocrop when the wheat straw was burned before the soybean was planted as a no-till crop. In a nonirrigated (NI) companion study, returns from wheat-soybean doublecrop systems in which the no-till soybeans were planted in standing or burned wheat stubble were higher than those from the soybean monocrop mainly because of the returns generated by the wheat. In fact, returns of the NI soybean monocrop were not sufficient to cover land rental charges.

A study conducted on two Blackland Prairie soils in Mississippi indicated that a wheat-soybean doublecrop system was more profitable and also more soil conserving than soybean monocrop systems (Hairston et al. 1984). Sanford et al. (1986) conducted a NI study to evaluate monocrop systems of corn, soybean, sorghum, wheat, and sunflower [*Helianthus annuus* (L.)] and doublecrop systems of wheat rotated with corn, soybean, sorghum, and sunflower. The two cropping systems with the highest net return were the corn monocrop followed by the wheat-soybean doublecrop. Crabtree et al. (1986) compared yields and net returns of monocrops and doublecrops of wheat and sorghum in which the wheat was not irrigated and the sorghum was either not irrigated or irrigated (sprinkler). NI monocrops of wheat produced the highest net return, but returns of NI monocrops of sorghum were nearly equal to those of wheat. In another study that involved monocrops and doublecrops of wheat and soybean, Crabtree et al. (1987) indicated that highest net returns were produced by NI doublecrops of wheat and NI doublecrops of no-till soybean. Sprinkler irrigation increased the yield of soybean monocrops and doublecrops 9.5 and 7.8 bushels/acre, respectively. However, given these yields, irrigation of soybean was not economically feasible.

In the lower Mississippi River Valley, clay soils occupy almost half (9.6 million acres) of the land area. Most of this acreage is planted to NI soybean monocrops. Soybean yields from this system of production

Wesley is an agricultural engineer and Elmore is a plant physiologist, U.S. Department of Agriculture, Agricultural Research Service, Application and Production Technology Research Unit, P.O. Box 36, Stoneville, MS 38776. Heatherly is an agronomist, U.S. Department of Agriculture, Agricultural Research Service, Soybean Production Research Unit, P.O. Box 343, Stoneville, MS 38776. Spurlock is an agricultural economist, Agricultural Economics Department, Mississippi State University, Mississippi State, MS 39762.

have been consistently low and only marginally profitable. The objective of this study was to determine the feasibility of using irrigation and crop rotations to enhance yields and economic returns on these clay soils. In this study, yields and economic returns of four cropping systems grown in I and NI environments were compared for this purpose. The cropping systems included a soybean monocrop, wheat-soybean doublecrop, and two-year rotations of corn/wheat-soybean and sorghum/wheat-soybean.

Materials and Methods

Agronomic Materials and Procedures

The study was conducted for 8 years (1984–1991) on a Tunica clay near Stoneville, MS. The soil has a high percentage of clay (50–60 percent), poor internal drainage, and high water-holding capacity. Soil pH ranged from 6.0 to 6.5, percentage organic matter ranged from 0.89 to 2.41, and P and K levels were within ranges recommended by the Mississippi Cooperative Extension Service. Two adjacent areas were designated for the experiment—one for irrigated production and one for nonirrigated production. Plots of each crop were 60 feet wide by 100 feet long.

The study included four cropping systems (treatments). Treatments were continuous soybean monocrop, continuous wheat-soybean doublecrop, and 2-year rotations of corn/wheat-soybean and sorghum/wheat-soybean. Treatments were arranged in a randomized complete block design with four replicates in both I and NI experiments. Data obtained included eight cycles of the soybean monocrop and wheat-soybean doublecrop and four cycles of the corn/wheat-soybean rotation and sorghum/wheat-soybean rotation. Crop sequences for each cropping system are presented in table 1.

The soybean monocrops were planted in a prepared seedbed, whereas soybeans in the wheat-soybean doublecrop and in the corn/wheat-soybean and sorghum/wheat-soybean rotations were planted as no-till crops in burned wheat stubble. All wheat was drill-seeded in 7-inch rows, whereas corn, sorghum, and soybean were planted in 40-inch rows near the optimum planting dates. Corn and sorghum were planted on beds that had been formed the previous fall.

Recommended management practices were used to schedule cultural, weed control, and irrigation inputs to each cropping system. All plots were mechanically cultivated for weed control as needed during the early part of the growing season. Fertilizers and pesticides were applied as needed for prevailing conditions. All N applications to corn and sorghum were applied beside each row as urea-NH_4NO_3 solution. N applications to wheat consisted of granular urea-[$CO(NH_2)_2$] broadcast in the spring. Each crop in each replicate was irrigated separately by controlling gates and nozzles. Irrigation of corn began at tassel emergence and ended at near-dent stage. Irrigation of sorghum began at the boot stage and ended at the hard-dough stage. Soybean irrigation started when the first bloom appeared and ended at the full-seed stage. Irrigation water was applied only during each crop's reproductive period and only when the soil water potential (as determined by tensiometers located at the 12-inch soil depth in three replicates) averaged between –50 and –70 centibars. Previous research with soybean on clay soil showed that a greater yield response was obtained when the need for irrigation was measured at this tensiometer depth rather than at a deeper depth (Heatherly 1984). All plots were machine-harvested at crop maturity. Yields of corn and sorghum were adjusted to 15.5 and 14.0 percent seed moisture (dry basis), respectively, whereas yields of soybean and wheat were adjusted to 13.0 percent seed moisture (dry basis).

The power equipment included one 90- to 100-drawbar-horsepower (DBHP) tractor, one 100- to 115-DBHP tractor, one 115- to 150-DBHP tractor, and one self-propelled combine having a 20-foot header width, an auxiliary header, and reel equipment for harvesting corn. The other equipment included a heavy disk, disk harrow, field cultivator, no-till planter, cultipacker, grain drill, cultivator, liquid-fertilizer applicator, stalk shredder, spin spreader, and tractor-mounted sprayer.

Determination of Costs and Returns

Crop enterprise budgets were developed annually for each cycle of each cropping system in the I and NI environments. The costs of specific inputs, such as fertilizers, pesticides, and water were accounted for in each experiment. Crop prices used in the budgets were the seasonal average prices received for the year as reported by the Mississippi Agricultural Statistics Service (1984–91) and adjusted for deficiency payments per unit of corn, sorghum, and wheat. Variable costs were the actual prices paid by farmers each year to produce a crop and included the cost of herbicides, seed, labor, fuel, equipment repairs and maintenance, and interest on operating capital. Fixed costs included costs of tractors, self-propelled equipment, implements, and the irrigation system. Total specified costs included both variable and fixed costs. Net returns per acre were calculated annually as the difference between gross income and total specified costs. Average net returns were calculated for each crop as the mean of the annual net returns over the study period. Overall net returns reflected the average net returns to each cropping system over the 8-year period. In the budgets no charges were included for land, management, or overhead. Performance rates on all field operations were based on using eight-row equipment with associated power units.

Irrigation costs were based on a quarter-mile center pivot system capable of irrigating 130 acres from 1 pivot point. Investment costs included the cost of an engine, well, pump, gearhead, generator, fuel tank and fuel lines, and the pivot system. Total fixed costs consisted of annual depreciation, interest on investment, and insurance. Annual depreciation was calculated using the straight-line method with zero salvage value. Annual interest charges were based on one-half of the original investment times a nominal interest rate for each year of the study. Insurance was estimated at 1 percent of the original investment. Operating or direct costs included fuel, oil, labor, and engine repair. Fuel requirements were determined from engineering formulas (Spurlock et al. 1987).

Results and Discussion

Yields, commodity prices, gross returns, total specified costs, and net returns above total specified costs for each cropping system in the I and NI environments are presented in tables 2–6. Variable and fixed costs associated with each cropping system are shown in table 7.

Effect of Irrigation on Crop Yield

Wheat yields from all cropping systems in the I and NI environments were similar each year (table 2). Over the test period, the average yields of wheat from all cropping systems ranged from 38.2 to 48.8 bushels/acre.

Irrigation increased the average yield of soybean in all cropping systems. In the soybean monocrop, wheat-soybean doublecrop, corn/wheat-soybean rotation, and sorghum/wheat-soybean rotation, irrigation increased soybean yields 91 percent (41.1 vs. 21.5 bushels/acre), 202 percent (32.6 vs. 10.8 bushels/acre), 92 percent (38.2 vs. 19.9 bushels/acre), and 69 percent (37.3 vs. 22.1 bushels/acre), respectively. All wheat and soybean yields for crop years 1984–89 are discussed in detail in an earlier report (Wesley et al. 1991).

Yields of corn from the I environment ranged from 100.0 to 156.2 bushels/acre (table 2). However, yields of corn from the NI environment were highly variable because of the occurrence of severe moisture stress in some years. In 1986 yields of NI corn averaged 89.2 bushels/acre because of near-adequate soil moisture, but in 1988 the NI corn emerged after planting but died before harvest due to severe moisture stress.

Sorghum yields from the I experiments of 1984, 1988, and 1990 averaged 116.4 bushels/acre; however, because of low yields in 1986 caused by severe infestations of sorghum midge [*Contarinia sorghicola* (Coquillett)] the average yield of I sorghum for the 4 years was only 103.3 bushels/acre. Yields of sorghum from the NI experiment were variable. In 1984 and 1990, yields averaged 84.0 and 86.1 bushels/acre, respectively, and were typical of sorghum yields in the area. However, because of severe midge infestation in 1986 and insufficient soil moisture for planting in 1988, yield from the NI experiment averaged only 58.2 bushels/acre.

Economic Returns in Response to Irrigation

Gross returns per acre (table 4) were calculated as the product of each respective crop yield (table 2) and commodity price (table 3). In 1988, when severe drought prevented the planting and development of all summer crops in the NI environment, gross returns for the NI crops were zero and therefore decreased the average gross returns per acre over the 8-year period.

The average specified costs per acre (table 5) for wheat grown in the continuous wheat-soybean doublecrop system in I and NI environments were virtually identical ($85.27/acre and $84.10/acre, respectively) and averaged $18.00/acre lower than those for wheat grown in corn and sorghum rotations. The higher average specified costs for wheat in the corn and sorghum rotations were a direct result of the additional tillage required to prepare a seedbed in the corn and sorghum residue and the additional N application needed in the fall to wheat following the corn and sorghum crops.

In the I cropping systems, the average specified cost of soybean was highest for the monocrop system ($192.85/acre), whereas the average specified costs of soybean in the doublecrop system and in the rotations ranged from $165.59/acre to $170.89/acre. The higher specified costs for soybean in the monocrop system were due to the tillage required to prepare the seedbed, whereas in all other cropping systems soybeans were planted as no-till crops in burned wheat stubble. In the NI cropping systems, the average specified costs for soybean were highest in the corn and sorghum rotation systems ($105.93/acre and $105.47/acre, respectively). The lower specified costs for NI soybean in the monocrop ($99.05/acre) and doublecrop ($87.86/acre) systems included the near-zero costs of production for those systems in 1988.

The average specified costs for I and NI corn were $245.91/acre and $159.62/acre, respectively.

The difference between the specified costs of I sorghum ($222.53/acre) and NI sorghum ($120.67/acre) is not typical; minimum production inputs were used in the NI study in 1988 because the extreme drought prevented planting of the crop. However, in 1984, 1986, and 1990, the average specified costs of I sorghum still averaged $64.65/acre higher than NI sorghum.

In the I study, the overall net returns (table 6) were highest from the corn/wheat-soybean system ($136.29/acre) followed by the wheat-soybean doublecrop system ($123.47/acre). The overall net returns from the sorghum/wheat-soybean system averaged $95.32/acre, whereas the lowest net returns were from the soybean monocrop ($52.85/acre).

In the NI study the highest overall net returns were from the sorghum/wheat-soybean system ($63.65/acre) followed by the wheat-soybean doublecrop system ($47.79/acre). The NI soybean monocrop system produced overall net returns of $24.73/acre, whereas the lowest overall net returns were produced by the NI corn/wheat-soybean system ($15.47/acre). These data indicate that overall net returns from the NI sorghum/wheat-soybean system and the NI wheat-soybean doublecrop system were moderately higher than those from the NI soybean monocrop and considerably higher than those from the NI corn/wheat-soybean system. Also, the overall net returns from the NI sorghum/wheat-soybean system and the NI wheat-soybean doublecrop system were comparable to the overall net returns from the I soybean monocrop.

Examination of the net returns by crop within each cropping system indicates that irrigation increased the annual net returns of the soybean monocrops in all years except 1985, 1989, and 1991. In 1985 irrigation increased seed yield 14.3 bushels/acre (table 2); however, the resulting increase in gross income ($74.36/acre, table 4) was not sufficient to cover the additional production inputs such as the cost of irrigation. Irrigation costs could have been reduced if a less expensive surface irrigation method was used (see Spurlock et al. 1987 for alternative irrigation methods). In 1989 rainfall was near adequate; however, apparent water deficits occurred on several occasions. The soybean monocrop was irrigated four times because of these deficits, but the I soybean produced 2.8 bushels/acre less than the NI soybean (table 2). The reduced yield may have been due to the fact that a significant amount of rain was received after each irrigation. The additional water apparently saturated the soil profile and adversely affected yields. The lower gross return plus the cost of overhead irrigation reduced the net return of the I soybean monocrop $88.33/acre below that of the NI soybean monocrop (table 6). In 1991 water deficits occurred during the June-August period. Because of these deficits, the soybean monocrop in the I study was irrigated eight times. However, significant rainfall was received after six of the irrigations. As in

1989, a yield decline (2.1 bushels/acre, table 2) was recorded, and this decline reduced the gross return and net return. In 1986 irrigation increased the yield of the soybean monocrop by 28.9 bushels/acre, yet net returns were negative (–$58.08/acre) because the yield of the irrigated soybean was somewhat low (30.5 bushels/acre).

Net returns of the NI soybean monocrop were near zero or negative in all years except 1989 and 1991. The high net returns in 1989 ($176.98/acre) and 1991 ($117.57/acre) were attributed to the exceptional yields in those years (49.8 and 40.8 bushels/acre, respectively).

In the wheat-soybean doublecrop system, net returns of wheat grown in the I and NI studies were positive in all years except 1991. The small negative returns in 1991 were attributed to the excessive amount of rainfall (42.0 inches) received during the period from January to May. However, the average net returns of wheat for the 8-year period were $99.42/acre in the I study and $74.30/acre in the NI study. This difference was almost totally due to the higher average yield from I wheat (table 2), which apparently benefitted from irrigation of the summer crops because it seldom needed irrigation. Net returns of soybean grown in the I doublecrop system were negative in 1986, 1987, and 1989. Over the 8-year study, soybean increased the overall net returns of the I doublecrop system only $24.05/acre. Net returns of soybean grown in the NI doublecrop system were negative or zero in all years except 1989 and 1991, when the net returns were only $21.67 and $20.55 per acre, respectively. Over the study period, the average net returns of soybean grown in the NI doublecrop system were negative (–$26.51/acre) and thereby reduced the overall net returns of the NI doublecrop system.

Net returns of wheat in the I and NI corn/wheat-soybean systems were positive in all years except 1991. However, over the 8-year study the average net returns of wheat in this crop system were $99.93/acre and $76.05/acre, respectively. In the I study, the average net returns of soybean and corn were $47.27/acre and $125.38/acre, respectively. The positive returns of wheat, soybean, and corn resulted in overall net returns of $136.29/acre for the I corn/wheat-soybean system.

In the NI study, the average net returns of soybean were near zero ($5.12/acre) and the average net returns of corn were highly negative (–$50.24/acre). The negative returns of corn virtually eliminated the positive returns contributed by wheat ($76.05/acre) and thus reduced the overall net returns of the NI corn/wheat-soybean system to only $15.47/acre.

In the I and NI sorghum/wheat-soybean systems, net returns of wheat were positive in all years except 1991. The average net returns of wheat in this crop system in the I and NI environments averaged $76.41/acre and $78.87/acre, respectively. In the I study, soybean contributed $44.20/acre to the average net returns of the cropping system. Net returns of I sorghum were negative in 1986 (–$43.99/acre) due to midge damage but positive in 1984, 1988, and 1990. The net return of irrigated sorghum in the sorghum/wheat-soybean system averaged $70.03/acre and increased the average net returns of the system. Overall net returns of the I sorghum/wheat-soybean system averaged $95.32/acre. In the NI study, the average net returns of soybean and sorghum were $17.80/acre and $30.62/acre, respectively. Average net returns of NI sorghum were reduced by the severe midge infestation in 1986 and inadequate soil moisture for planting in 1988. Overall net returns of the NI sorghum/wheat-soybean system averaged $63.65/acre.

Variable costs were divided into major categories of usual components of crop production schemes (table 7). Two items shown in this table are of special interest. One, the average costs for herbicides used for soybean production in the various cropping systems, ranged from $29.69/acre to $36.25/acre. This high weed-control cost reduced net returns of soybean in all systems and must be reduced to improve profits in soybean production. In these studies, all preemergence and most postemergence herbicide applications were broadcast, and cultivation was also used to control weeds. If the herbicides had been applied on 20-inch bands, then herbicide costs would have been reduced by 50 percent. Cultivation of the middle of the rows should have been sufficient for weed control in the nondrill area. The same would have been true for corn and sorghum weed control, but the reduction in herbicide costs would have been smaller for these two crops, since the total herbicide costs for the crops were much lower. Much of the total costs for I soybean production was attributable to the cost of the sprinkler irrigation system. The high cost of irrigation is reflected in the differences in the mean fixed expense for I and NI systems. For soybean, the cost of sprinkler irrigation was approximately $55.00/acre. Less expensive surface delivery systems (either furrow or flood) are available and, if used, would have reduced irrigation costs (Spurlock et al. 1987) while maintaining or improving yields (Heatherly et al. 1990, Heatherly and Pringle 1991). In fact, the overwhelming majority of soybean irrigation in the Mississippi Valley is conducted with flood or furrow systems (Pennington, personal communication 1992).

Conclusions

The following conclusions can be drawn from the results presented in this report:

1. The I corn/wheat-soybean cropping rotation produced the largest overall net returns followed closely by the I wheat-soybean doublecrop, and sorghum/wheat-soybean rotation. Overall net returns of the NI soybean monocrop and corn/wheat-soybean systems were not sufficient to cover land rental charges.

2. Irrigation of the summer crops in all cropping systems increased seed yields of all summer crops and the overall net returns to all I cropping systems.

3. Irrigation of corn resulted in the largest average net return of any crop, whereas the production of corn in NI environments resulted in the largest average net loss.

4. In all cropping systems the average net returns of wheat were virtually identical whether or not the crop was irrigated and were second only to the average net returns of I corn.

5. The average net returns of NI soybean in all cropping systems and of NI corn in the corn/wheat-soybean system were near zero or negative, and therefore these crops are not economically feasible in these NI cropping systems on the clayey soils in the southern United States.

References

Baird, S.M., and E.C. Benard. 1984. Nematode populations and community dynamics in soybean-wheat cropping and tillage regimes. Journal of Nematology 16:379–386.

Boquet, D.J., A.B. Coco, and D.E. Summers. 1986. Cropping systems for higher yields. Louisiana Agriculture 30:4–5,7.

Crabtree, R.J., R.G. Greenland, S.O. Mehdawi, and P.L. Claypool. 1986. Mono- and double-cropped wheat and grain sorghum under rainfed and irrigated conditions. Agronomy Journal 78:986–990.

Crabtree, R.J., R.G. Greenland, J.D. Prater, J.D. Adesina, and P.L. Claypool. 1987. Mono- and double-cropped wheat and soybeans under rainfed and irrigated conditions. Soil Science 144:53–60.

Dabney, S.M., E.C. McGawley, D.J. Boethel, and D.A. Berger. 1988. Short-term crop rotation systems for soybean production. Agronomy Journal 80:197–204.

Fahad, A.A., L.N. Mielke, A.D. Flowerday, and D. Swartzendruber. 1982. Soil physical properties as affected by soybean and other cropping sequences. Soil Science Society of America Journal 46:377–381.

Hairston, J.E., J.O. Sanford, J.C. Hayes, and L.L. Reinschmiedt. 1984. Crop yield, soil erosion, and net returns from five tillage systems in the Mississippi Blackland Prairie. Journal of Soil Water Conservation 39:391–395.

Heatherly, L.G. 1984. Soybean response to irrigation of Mississippi River Delta soils. U.S. Department of Agriculture, Agricultural Research Service, ARS–18.

Heatherly, L.G. 1988. Planting date, row spacing, and irrigation effects in soybean grown on clay soil. Agronomy Journal 80:227–231.

Heatherly, L.G., R.A. Wesley, and C.D. Elmore. 1990. Corn, sorghum, and soybean response to irrigation in the Mississippi River alluvial plain. Crop Science 30:665–672.

Heatherly, L.G., and H.C. Pringle III. 1991. Soybean cultivars' response to flood irrigation on clay. Agronomy Journal 83:231–236.

Litsinger, J.A., and K. Moody. 1976. Integrated pest management in multiple cropping systems. *In* R.I. Papendick, P.A. Sanchex, and G.B. Triplett, eds., American Society of Agronomy, Special Publication 27, pp. 293–316. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

Mississippi Agricultural Statistics Service. 1984–1991. Mississippi Agricultural Statistics. Supplement 24. U.S. Department of Agriculture and Mississippi Department of Agriculture and Commerce.

Salassi, M.E., J.A. Musick, L.G. Heatherly, and J.G. Hamill. 1984. An economic analysis of soybean yield response to irrigation of Mississippi River Delta soils. Mississippi Agriculture and Forestry Experiment Station Bulletin 928.

Sanford, J.O., B.R. Eddleman, S.R. Spurlock, and J.E. Hairston. 1986. Evaluating ten cropping alternatives in the Mid-south. Agronomy Journal 78:875–880.

Spurlock, S.R., E.M. Hood III, J.G. Hamill, and J.G. Thomas. 1987. Cost estimates for nine irrigation systems in the Mississippi Delta. Mississippi State University, Agricultural Economics Research Report No. 175.

Wesley, R.A., and F.T. Cooke. 1988. Wheat-soybean double-crop systems on clay soil in the Mississippi Valley Area. Journal Production Agriculture 1:166–177.

Wesley, R.A., L.G. Heatherly, and C.D. Elmore. 1991. Cropping systems for clay soils: Crop rotation and irrigation effects on soybean and wheat double-cropping. Journal Production Agriculture 4:345–352.

Young, L.D., E.E. Hartwig, S.C. Anand, and D. Widick. 1986. Response of soybeans and soybean cyst nematodes to cropping sequences. Plant Diseases 70:787–791.

Table 1. Crop sequences for corn, sorghum, soybean, and wheat grown near Stoneville, MS

Crop year	Season	Cropping system*			
		SB	WSB	CWSB	SGWSB
1983	Winter		Wheat		
1984, 86, 88, 90	Summer	Soybean	Soybean	Corn	Sorghum
	Winter		Wheat	Wheat	Wheat
1985, 87, 89, 91	Summer	Soybean	Soybean	Soybean	Soybean
	Winter		Wheat		

* *SB* = soybean monocrop, *WSB* = wheat-soybean doublecrop, *CWSB* = corn/wheat-soybean rotation, and *SGWSB* = sorghum/ wheat-soybean rotation.

Table 2. Yields of corn, sorghum, soybean, and wheat grown in monocrop, doublecrop, and rotational cropping systems over an 8-year period on Tunica clay near Stoneville, MS

Crop year	Crop	Grain yield by cropping system and irrigation level*							
		SB		WSB		CWSB		SGWSB	
		I	NI	I	NI	I	NI	I	NI
		bushels/acre							
1984	Wheat			48.0	47.5				
	Soybean	38.2	12.6	37.5	8.9				
	Corn					107.0	46.0		
	Sorghum							118.0	84.0
1985	Wheat			38.0	35.3	33.3	29.5	28.1	25.3
	Soybean	37.8	23.5	37.7	21.1	43.4	29.1	42.4	31.1
1986	Wheat			42.6	28.7				
	Soybean	30.5	1.6	31.0	0.8				
	Corn					137.0	89.2		
	Sorghum							64.0	62.7
1987	Wheat			42.7	37.6	66.7	53.8	60.3	52.0
	Soybean	45.6	20.8	20.9	2.0	37.2	7.5	35.9	7.5
1988	Wheat			63.8	45.0				
	Soybean	48.9	0.0†	45.3	0.0†				
	Corn					100.0	0.0†		
	Sorghum							117.7	0.0†
1989	Wheat			49.5	57.4	60.6	58.3	53.2	71.1
	Soybean	47.0	49.8	22.7	22.4	26.5	16.9	24.4	21.3
1990	Wheat			40.8	26.7				
	Soybean	42.3	22.9	37.7	13.9				
	Corn					156.2	25.7		
	Sorghum							113.6	86.1
1991	Wheat			25.5	27.7	34.7	30.8	35.0	32.0
	Soybean	38.7	40.8	27.8	17.0	45.8	26.2	46.5	28.4
Average	Wheat			43.9	38.2	48.8	43.1	44.2	45.1
	Soybean	41.1	21.5	32.6	10.8	38.2	19.9	37.3	22.1
	Corn					125.1	40.2		
	Sorghum							103.3	58.2

*_SB_ = soybean monocrop, _WSB_ = wheat-soybean doublecrop, _CWSB_ = corn/wheat-soybean rotation, and _SGWSB_ = sorghum/wheat-soybean rotation; _I_ = irrigated and _NI_ = nonirrigated.
†Crops not planted due to lack of moisture for germination.

Table 3. Seasonal average price plus deficiency payment received per bushel of corn, sorghum, soybean, and wheat in Mississippi

Crop year	Commodity price			
	Corn	Sorghum	Soybean	Wheat
	dollars/bushel			
1984	3.42	2.53	6.10	3.72
1985			5.20	4.44
1986	2.30	2.17	5.10	5.16
1987			5.84	4.82
1988	3.48	3.35	7.50	4.23
1989			5.90	3.97
1990	2.92	2.98	5.90	4.12
1991			5.70	2.75

Source: Mississippi Agricultural Statistics Service (1984–1991).

Table 4. Gross returns from corn, sorghum, soybean, and wheat grown in monocrop, doublecrop, and rotational cropping systems over an 8-year period on Tunica clay near Stoneville, MS

		Gross returns by cropping system and irrigation level*							
		SB		WSB		CWSB		SGWB	
Crop year	Crop	I	NI	I	NI	I	NI	I	NI
		dollars/acre							
1984	Wheat			178.56	176.70				
	Soybean	233.02	76.86	228.75	54.29				
	Corn					365.94	157.32		
	Sorghum							298.54	212.52
1985	Wheat			168.72	156.73	147.85	130.98	124.76	112.33
	Soybean	196.56	122.20	196.04	109.72	225.68	151.32	220.48	161.72
1986	Wheat			219.82	148.09				
	Soybean	155.55	8.16	158.10	4.08				
	Corn					315.10	205.16		
	Sorghum							138.88	136.06
1987	Wheat			205.81	181.23	321.49	259.32	290.65	250.64
	Soybean	266.30	121.47	122.06	11.68	217.25	43.80	209.66	43.80
1988	Wheat			269.87	190.35				
	Soybean	366.75	0.0†	339.75	0.0†				
	Corn					348.00	0.0†		
	Sorghum							394.29	0.0†
1989	Wheat			196.51	227.88	240.58	231.45	211.20	282.27
	Soybean	277.30	293.82	133.93	132.16	156.35	99.71	143.96	125.67
1990	Wheat			168.10	110.00				
	Soybean	249.57	135.11	222.43	82.01				
	Corn					456.10	75.04		
	Sorghum							338.53	256.58
1991	Wheat			70.13	76.18	95.43	84.70	96.25	88.00
	Soybean	220.59	232.56	158.46	96.90	261.06	149.34	265.05	161.88
<u>Average (by crop)</u>									
	Wheat			184.67	158.40	201.34	176.61	180.72	183.31
	Soybean	245.71	123.77	194.94	61.36	215.09	111.04	209.79	123.27
	Corn					371.29	109.38		
	Sorghum							292.56	151.29
<u>Average (all years)</u>‡		245.71	123.77	379.61	219.76	393.86	198.52	341.54	228.94

*SB = soybean monocrop, WSB = wheat-soybean doublecrop, CWSB = corn/wheat-soybean rotation, and SGWSB = sorghum/wheat-soybean rotation; I = irrigated and NI = nonirrigated.

†Gross incomes were zero because crops were not harvested.

‡Represents average gross income from all crops in each cropping system.

Table 5. Total specified costs of production of corn, sorghum, soybean, and wheat grown in monocrop, doublecrop, and rotational cropping systems over an 8-year period on Tunica clay near Stoneville, MS

Crop Year	Crop	Production costs by cropping system and irrigation level*							
		SB		WSB		CWSB		SGWSB	
		I	NI	I	NI	I	NI	I	NI
		dollars/acre							
1984	Wheat			92.21	89.08				
	Soybean	186.64	111.69	175.42	109.59				
	Corn					225.19	150.52		
	Sorghum							241.89	170.94
1985	Wheat			72.64	72.26	87.93	87.24	101.47	101.08
	Soybean	193.04	116.55	167.12	119.46	164.51	118.47	164.35	113.56
1986	Wheat			77.88	75.93				
	Soybean	213.63	95.63	163.95	86.46				
	Corn					225.15	162.79		
	Sorghum							182.87	126.15
1987	Wheat			65.07	64.36	98.59	96.79	97.65	96.49
	Soybean	196.36	117.85	176.16	111.63	186.26	119.82	186.05	119.82
1988	Wheat			86.54	83.90				
	Soybean	205.43	14.77†	193.36	0.0†				
	Corn					270.67	151.56†		
	Sorghum							220.22	6.73†
1989	Wheat			99.64	100.75	113.88	113.56	112.85	115.35
	Soybean	188.65	116.84	193.85	110.49	178.69	107.58	178.35	110.31
1990	Wheat			100.32	98.35				
	Soybean	177.77	104.04	158.35	88.91				
	Corn					262.62	173.61		
	Sorghum							245.14	178.85
1991	Wheat			87.83	88.14	105.22	104.67	105.27	104.84
	Soybean	181.31	114.99	138.89	76.35	141.80	77.84	133.59	78.19
Average (by crop)									
	Wheat			85.27	84.10	101.41	100.57	104.31	104.44
	Soybean	192.85	99.05	170.89	87.86	167.82	105.93	165.59	105.47
	Corn					245.91	159.62		
	Sorghum							222.53	120.67
Average (all years)‡		192.85	99.05	256.16	171.96	257.57	183.06	246.22	165.29

*SB = soybean monocrop, WSB = wheat-soybean doublecrop, CWSB = corn/wheat-soybean rotation, and SGWSB = sorghum/wheat-soybean rotation; I = irrigated and NI = nonirrigated.

†Production costs for soybean and sorghum were minimal because crops were not planted. Production inputs and costs of corn were normal; however, corn yield was zero.

‡Represents overall production costs for all crops in each cropping system.

Table 6. Net returns above total specified costs for corn, sorghum, soybean, and wheat from monocrop, doublecrop, and rotational cropping systems over an 8-year period on Tunica clay near Stoneville, MS

Crop year	Crop	Net returns by cropping system and irrigation level*							
		SB		WSB		CWSB		SGWSB	
		I	NI	I	NI	I	NI	I	NI
		dollars/acre							
1984	Wheat			86.35	87.62				
	Soybean	46.38	–34.83	53.33	–55.30				
	Corn					140.75	6.80		
	Sorghum							56.65	41.58
1985	Wheat			96.08	84.47	59.92	43.74	23.29	11.25
	Soybean	3.52	5.65	28.92	–9.74	61.17	32.85	56.13	48.16
1986	Wheat			141.94	72.16				
	Soybean	–58.08	–87.47	–5.85	–82.38				
	Corn					89.95	42.37		
	Sorghum							–43.99	9.91
1987	Wheat			140.74	116.87	222.90	162.53	192.99	154.15
	Soybean	69.94	3.62	–54.10	–99.95	30.99	–76.02	23.60	–76.02
1988	Wheat			183.34	106.45				
	Soybean	161.32	–14.77†	146.39	0.0†				
	Corn					77.33	–151.56†		
	Sorghum							174.08	–6.73†
1989	Wheat			96.87	127.13	126.70	117.89	98.36	166.91
	Soybean	88.65	176.98	–59.92	21.67	–22.34	–7.87	–34.39	15.36
1990	Wheat			67.77	11.66				
	Soybean	71.80	31.07	64.08	–6.90				
	Corn					193.48	-98.56		
	Sorghum							93.39	77.72
1991	Wheat			–17.70	–11.96	–9.80	–19.97	–9.02	–16.84
	Soybean	39.28	117.57	19.57	20.55	119.26	71.50	131.46	83.69
<u>Average (by crop)</u>									
	Wheat			99.42	74.30	99.93	76.05	76.41	78.87
	Soybean	52.85	24.73	24.05	-26.51	47.27	5.12	44.20	17.80
	Corn					125.38	-50.24		
	Sorghum							70.03	30.62
<u>Average (all years)</u>‡		52.85	24.73	123.47	47.79	136.29	15.47	95.32	63.65

*SB = soybean monocrop, *WSB* = wheat-soybean doublecrop, *CWSB* = corn/wheat-soybean rotation, and *SGWSB* = sorghum/wheat-soybean rotation; *I* = irrigated and *NI* = nonirrigated.
†Crops were not harvested.
‡Represents overall net returns above total specified costs for each cropping system.

Table 7. Average variable costs and fixed expenses for monocrop, doublecrop, and rotational cropping systems over an 8-year period on Tunica clay near Stoneville, MS

Cropping system*	Variable costs										Fixed expense†		Total Cost
	Fuel		Labor		Herbicides		Fertilizer		All other				
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	
	dollars/acre												
Soybean													
SB–I‡	20.52	13.99–24.51	15.53	14.30–16.95	34.78	26.22–46.45			44.00	35.84–59.55	78.02	71.16–88.08	192.85
SB–NI‡	5.25	0.41–7.79	11.89	1.37–15.30	29.69	10.95–42.39			27.20	1.14–36.11	25.03	0.90–31.97	99.06
WSB–I‡	15.98	6.76–23.08	11.50	9.11–14.32	36.02	22.14–52.69			35.86	24.01–37.71	71.53	62.57–82.70	170.89
WSB–NI‡	3.98	0.00–7.11	8.92	0.00–12.70	31.49	0.00–42.98			23.80	0.00–36.91	19.68	0.00–28.19	87.87
CWSB–I	12.78	6.76–19.67	10.75	9.11–12.31	36.25	29.49–41.95			35.76	26.92–43.05	72.29	62.57–81.82	167.82
CWSB–NI	4.43	3.02–6.67	10.33	7.96–12.04	35.94	27.25–41.95			32.54	21.98–37.84	22.69	14.72–27.37	105.93
SGWSB–I	12.72	6.52–19.67	10.56	8.38–12.31	34.68	27.25–41.95			35.48	26.51–42.84	72.15	62.02–81.82	165.59
SGWSB–NI	4.27	3.02–5.97	10.14	7.96–11.19	35.94	27.25–41.95			32.75	22.33–37.28	22.37	14.72–26.48	105.47
Wheat													
WSB–I‡	2.72	1.41–3.95	7.02	3.60–10.15	0.69	0.00–5.50	19.99	14.56–29.66	34.62	27.03–32.25	20.23	16.11–25.78	85.27
WSB–NI‡	2.72	1.41–3.95	7.02	3.60–10.15	0.69	0.00–5.50	19.62	14.56–26.69	33.82	27.34–31.83	20.23	16.11–25.78	84.10
CWSB–I	4.09	3.75–4.39	10.69	7.29–12.15			21.97	16.18–26.08	37.86	32.33–37.06	26.81	23.14–29.33	101.42
CWSB–NI	4.09	3.75–4.39	10.69	7.29–12.15			21.97	16.18–26.08	37.02	31.78–35.26	26.81	23.14–29.33	100.58
SGWSB–I	4.36	3.91–4.85	11.23	9.46–12.15			23.28	16.18–26.35	37.70	32.38–36.12	27.74	25.53–29.33	104.31
SGWSB–NI	4.36	3.91–4.85	11.23	9.46–12.15			23.28	16.18–26.35	37.83	31.95–34.96	27.74	25.53–29.33	104.44
Corn													
CWSB–I	17.14	8.80–22.35	18.14	15.08–21.18	22.36	17.42–26.80	36.64	35.81–37.65	68.58	54.65–82.22	83.05	79.92–88.53	245.91
CWSB–NI	6.26	4.62–7.84	16.02	13.95–18.49	22.36	17.42–28.60	35.00	29.53–37.65	49.34	41.50–54.33	30.65	16.48–41.23	159.63
Sorghum													
SGWSB–I	17.84	9.54–22.34	19.21	15.20–24.06	27.42	21.65–33.00	31.36	29.53–37.65	47.05	31.84–50.59	79.65	73.29–87.79	222.53
SGWSB–NI	6.15	0.83–9.83	14.62	2.35–22.90	19.17	0.00–30.20	24.20	0.00–37.65	30.79	1.22–41.69	25.75	2.33–40.49	120.68

* *SB* = soybean monocrop, *WSB* = wheat-soybean doublecrop, *CWSB* = corn/wheat-soybean rotation, and *SGWSB* = sorghum/wheat-soybean rotation; *I* = irrigated and *NI* = nonirrigated.

†Fixed expense includes costs of tractors, self-propelled equipment, implements, and the irrigation system.

‡Means represent the average for 8 years; all other means represent the average for 4 years.