COTTON/CORN/SOYBEAN ROTATIONS - EFFECTS ON YIELD AND PROFITABILTY

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Abstract

Long-term crop rotation studies were established at the Delta Research and Extension Center near Stoneville, MS to evaluate the contributions of rotations involving cotton, corn, and soybean with respect to both yield and profitability. The most up-to-date technology has been used that incorporates the latest advances in biotechnology, herbicides, cultural practices, irrigation, and fertility. The five cropping sequences include 1) corn-cotton, 2) corn-cotton-cotton, 3) corn-soybean, 4) soybean-corn-cotton, and 5) soybean-corn-cotton-cotton with a continuous cotton system as the basis for comparison. Each crop has been grown each year giving a total of 15 'treatments' in the study with four replications. Crop yields, nutrient uptake, and nutrient removal are calculated annually based on harvests made with commercial harvesters adapted for plot harvest. The value of the crop being grown has been calculated based on loan rate (LR) or the average price received by producers (NASS), whichever is higher. The economic impact of crop rotations is evident in most years just from the yield standpoint. As the cost of inputs continues to increase the more important crop rotation becomes. In the first few years where cotton prices were low and producers sold into the loan, cotton's value was high relative to corn and soybean. However, in the last few years grain prices have increased dramatically while cotton prices have remained lower or constant. As the grain prices increased the crop value greatly increased. When taking into consideration the cost of production for each crop, cotton production costs greatly exceed corn or soybean production cost even with high fertilizer and seed costs.

Introduction

Crop rotation has been practiced for centuries with modern rotations begun as early as 1730 in England. The benefits of rotating crops in the South have been divided into three major areas and include: a) maintenance of crop yields; b) control of diseases, insects, and weeds; and c) prevention of soil erosion. The use of crop rotation also provides for some distribution of labor and diversification of income. Before the extensive use of chemical fertilizers, maintenance or improvement of crop yield was best achieved by improving the base fertility of the soil. This usually required growing a legume crop to promote nitrogen fixation or applying manure to provide additional organic nutrients. Corn was rotated with cotton through the first three to four decades of the 20th century as animal power on the farm was extremely important. Mechanization of production and inorganic fertilizer materials eliminated the need for some crops and rotations and mono-crop agriculture gained in popularity. Herbicides were introduced to control weeds in monocrop systems and the need for crop rotation waned. With today's farm policies and the freedom to choose different crop mixes, rotations have come back into prominence. Field research across the cotton producing states had always supported crop rotation. However, growers were reluctant to rotate cotton because of government payments and the rotations complicated production practices and presented extra challenges to overall farm management.

Initial research began in the Mississippi Delta in 1904 through an act of the Mississippi Legislature authorizing the establishment of a branch research station in the Yazoo and Mississippi Delta. This marked the beginning of the Delta Branch Experiment Station which has now been in existent for more than 100 years. The station continues to meet the original objective of the experiment station and land-grant institution - to make agriculture a profitable enterprise. Early research in Mississippi included simple rotations and the use of manure on fields that had been used for cotton production. In the following years, mechanization shifted the agricultural industry from hand labor to machines and chemicals while today that shift continues with the introduction and acceptance of biotechnology. The shift from rotation to mono-cultural and gradually back to rotation brings us to the 21st century. Cotton, corn, soybean, grain sorghum, and rice production saw record yields in recent years with the aid of new technology and advancements through research. Since 2001, cotton, corn, and soybean have seen those record yields and in 2007 and 2008 with record prices received for that crop. Corn yields in 2007 averaged 148 bu/ace on 910,000 harvested

acres while soybean in the same year had an average yield of 40.5 bu/acre on 1.44 million acres harvested. Cotton acreage has dropped significantly in the last three years to a low of 295,000 acres in 2009. Cotton reached 1.6 million acres in 2001. Record yields were achieved in 2004 (1,024 lb/acre). Higher grain prices and lower cotton prices have eroded the cotton base while corn production has increased in the last few years. Figure 1 shows the distribution of cotton, corn, and soybean and the shifts in production for the last 16 years. Corn and soybean production are increasing while cotton declines. The purpose of this research project was to establish long-term rotations involving cotton, corn, and soybean with the crops to be grown with the most up-to-date technology available. It was designed to examine the impact of rotations on the whole-farm enterprise while monitoring soil nutrients, nematodes, and other pests. Several cooperators were identified to assist in the overall management of the project to assure maximum utilization of the data collected.

Research Objectives

1. Determine the effects of long-term crop rotation with respect to yield and profitability while utilizing state-of-the-art technology.
2. Assess the impact of crop rotation on the whole-farm enterprise.
3. Monitor changes in soil nutrient status, nematode numbers and types, and weed species.
4. Demonstrate the long-term need for crop rotation for the next century

Materials and Methods

The study includes five crop rotation sequences and continuous cotton as the base systems All crops in a rotation sequence are grown each season thus establishing 15 distinct 'treatments' that are replicated four times. The five crop rotation sequences include 1) corn-cotton, 2) corn-cotton-cotton, 3) corn-soybean, 4) soybean-corn-cotton, and 5) soybean-corn-cotton-cotton and are summarize in Table 1. Each plot contains eight 40-in rows 200 ft in length with a minimum of four rows harvested for yield determinations. Fertility requirements are determined from soil tests each year. All cultural practices are maintained as uniformly as possible taking into consideration the technology that is available. Commercial equipment, adapted for plot harvests has been used for harvest. Each plot is sampled for nutrient status and soil acidity (liming). The nutrient management and pesticide regimen is selected based on the committee expertise and recommendations. Production inputs and returns are then analyzed to determine the overall effects of rotation on whole-farm economics. With the current systems, it will take 12 years for all rotation systems to cycle back to the same point and the sequences will repeat. The actual arrangement of the research field is shown in Figure 2 for the 2009 cropping year.

Results and Discussion

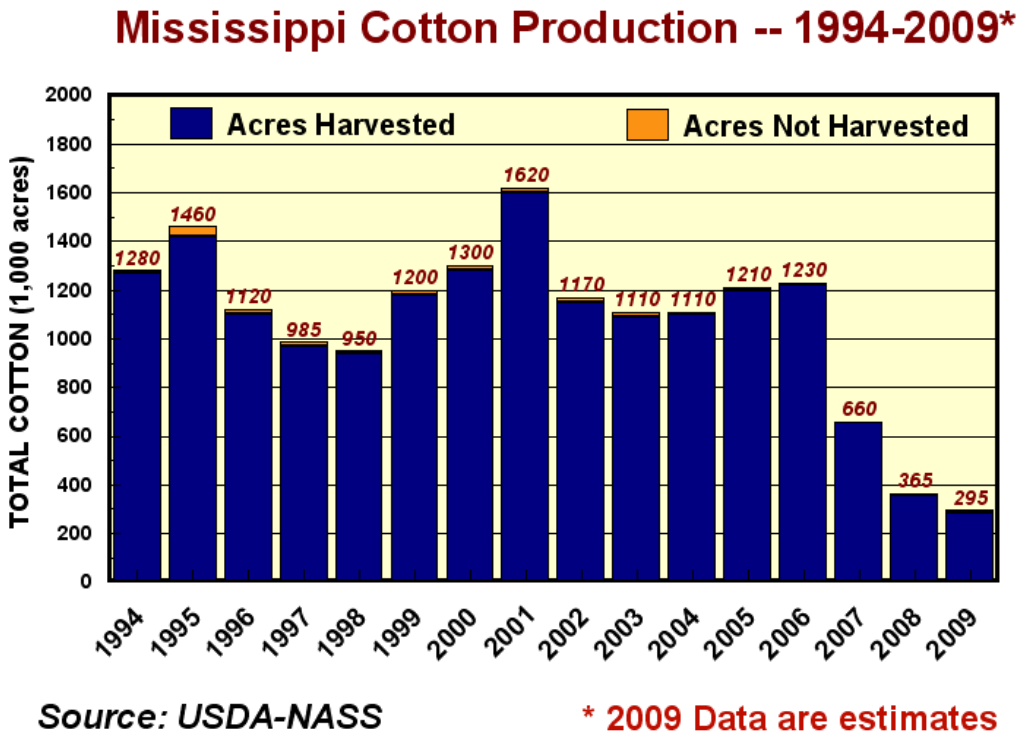
The first six years of a planned 100-year rotation program has been completed. Long-term rotations and long-term research are limited in their scope in many areas of the world or are no longer in existence. The Morrow plots at the University of Illinois and The Old Rotation at Auburn University are some of the oldest continuous plots in the United States. In an effort to celebrate the centennial anniversary of the Delta Branch Experiment Station and a new era in agricultural technology, the Centennial Rotation was initiated at the Delta Research and Extension Center at Stoneville, MS. The "treatments" as outlined in Table 1 show the first 12 years of the rotations and the crops being grown each year. The project was originally setup as a cotton-based system due the historic significance of cotton to this region of the United States. Only one system (treatments 7 and 8) does not contain cotton and is meant to document the long standing advantages of corn/soybean rotations. This rotation has become of more interest as both corn and soybean acreage has increased. The systems will not begin to repeat until the 13th season at which time some rotations will have completed six, four, or three cycles.

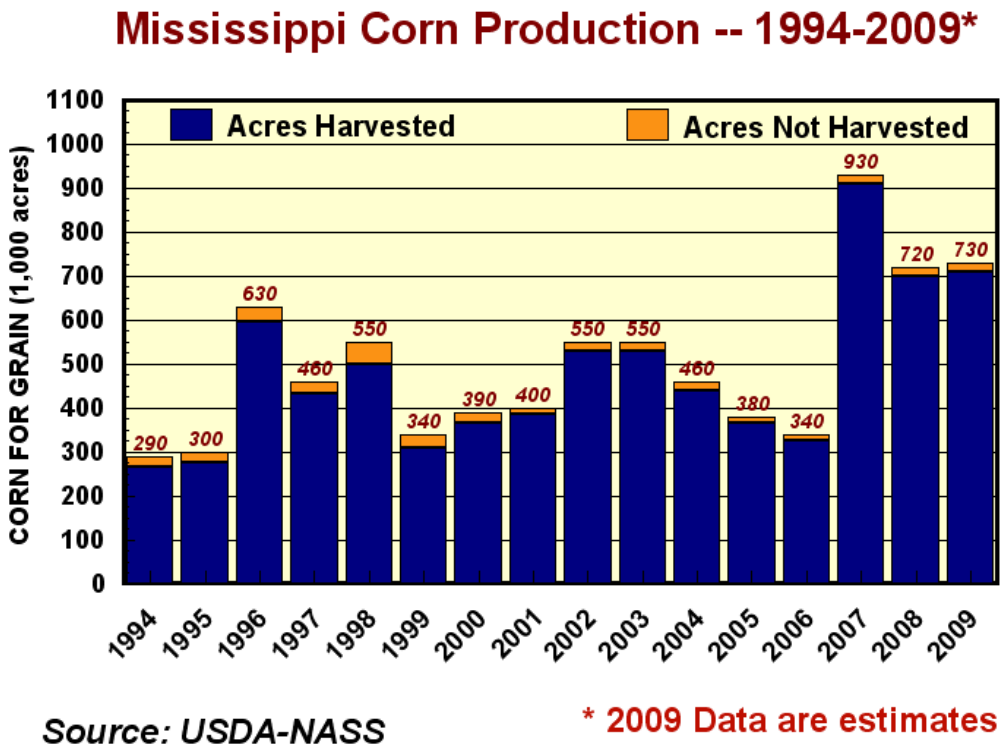
The summary of the first six years of crop yields are shown in Table 2. Cotton yields in the continuous cotton area have the overall lowest yields for cotton compared to the other systems. The greatest cotton yields, as expected, follow cotton production. Insect pressure and adverse weather conditions in 2007 resulted in the lowest cotton yields to date. In that year cotton yields were at least 18.6% higher where some other crop had been rotated compared to the continuous cotton system. Where cotton followed a year of soybean and a year of corn (Treatment 10), cotton yields were 41.8% (300 lb lint/acre) higher than the continuous cotton system. Soybean yields in 2007 ranged from 75.5 to 81.5 bu/acre for twin-row planted soybean grown in 40-in rows with irrigation. Corn yields throughout the history of the study have been at least 185 bu/acre and have reached 223 bu/acre in 2007. Adverse

weather problems such as hurricanes have caused some problems (lodging) but the yields have still been harvestable. Timely irrigation is a key to successful and consistent corn production. Soybean yields have exceeded 60 bu/acre in most years.

The economic impact of crop rotation is a complicated issue as producers must make the decision on crop mix in a constantly changing market. In the last few years, fertilizer, planting seed, and fuel prices have reached levels never witnessed before. Commodity, especially for grains, also reached new levels. Table 3 gives the shift in planted acres for the last four years and the average price of commodities for a given year. Loan prices are also given as that is the price that producers receive in the market price falls below the loan price. In 2004, 2005, and 2006 the average market price was below loan for cotton while market price has been above loan for the grain crops. Corn and soybean prices have risen above long-term averages and represent the highest prices producers have experienced. While Corn prices have fallen off some in 2009, average soybean prices continue at all-time highs. Thus the shift to grain crops continues. If cotton prices rebound, then cotton production should increase.

The economic value of the rotated crops is shown in Table 4. The value is calculated based on yields and the average market value (LR if higher than market value). The value of each "treatment" has been summarized as Total Crop Value (TCV). This analysis will only consider the value of the crop and not the cost of production. Cotton remains the most expensive crop to produce followed by corn followed by soybean. Technology fees continue to play an important role in the cost of production. In 2004, the highest value crop was cotton even with lower cotton prices. However, as grain prices increased in 2006 and thereafter, the value of the corn and soybean crop both exceeded the value of the cotton crop. Coupled with higher costs of production, corn and soybean production increased and cotton decreased. After six years, the greatest value of crop has come from a 2/1 cotton/corn rotation, but this was only the case when corn was grown in certain years (Table 4). The value of the rotation system depends greatly on the year that the crop was grown and the price received that year. The lowest value so far has been with a soybean/corn/cotton/cotton (4-yr rotation) system in which corn and soybean were grown when commodity prices were lower. In comparing treatments 7 and 8 (Table 4), there was a difference of $455 even though both crops were grown for three years. Further economic analysis is forthcoming as we continue to take a closer look at the cost of production and how input costs greatly affect the profitability of a particular crop sequence.





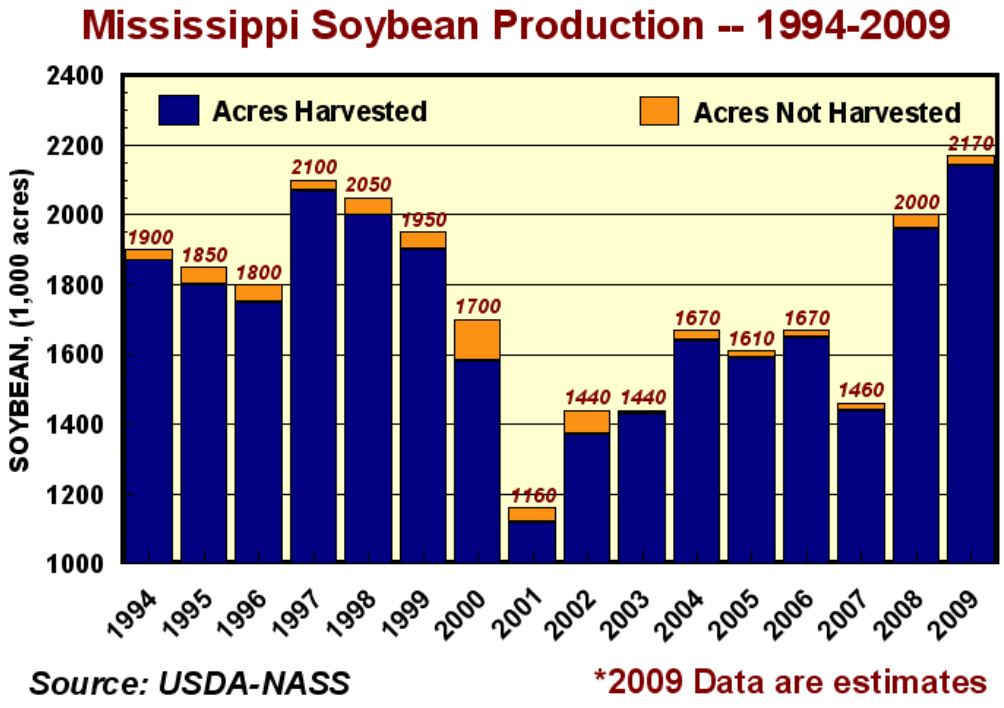


Figure 1. Cotton, corn, and soybean production for Mississippi

Table 1. Cropping sequence for long-term cotton based rotation cropping system. All crops in each sequence grown each year.

CENTENNIAL ROTATION STUDY

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
System	1	2	3	4	5	6	7	8	9	10	11	12
1	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT
2	CT	CR	CT	CR	CT	CR	CT	CR	CT	CR	CT	CR
3	CR	CT	CR	CT	CR	CT	CR	CT	CR	CT	CR	CT
4	CR	CT	CT	CR	CT	CT	CR	CT	CT	CR	CT	CT
5	CT	CR	CT	CT	CR	CT	CT	CR	CT	CT	CR	CT
6	CT	CT	CR	CT	CT	CR	CT	CT	CR	CT	CT	CR
7	CR	SB	CR	SB	CR	SB	CR	SB	CR	SB	CR	SB
8	SB	CR	SB	CR	SB	CR	SB	CR	SB	CR	SB	CR
9	SB	CR	CT	SB	CR	CT	SB	CR	CT	SB	CR	CT
10	CT	SB	CR	CT	SB	CR	CT	SB	CR	CT	SB	CR
11	CR	CT	SB	CR	CT	SB	CR	CT	SB	CR	CT	SB
12	SB	CR	CT	CT	SB	CR	CT	CT	SB	CR	CT	CT
13	CT	SB	CR	CT	CT	SB	CR	CT	CT	SB	CR	CT
14	CT	CT	SB	CR	CT	CT	SB	CR	CT	CT	SB	CR
15	CR	CT	CT	SB	CR	CT	CT	SB	CR	CT	CT	SB

CT = Cotton CR = Corn SB = Soybean

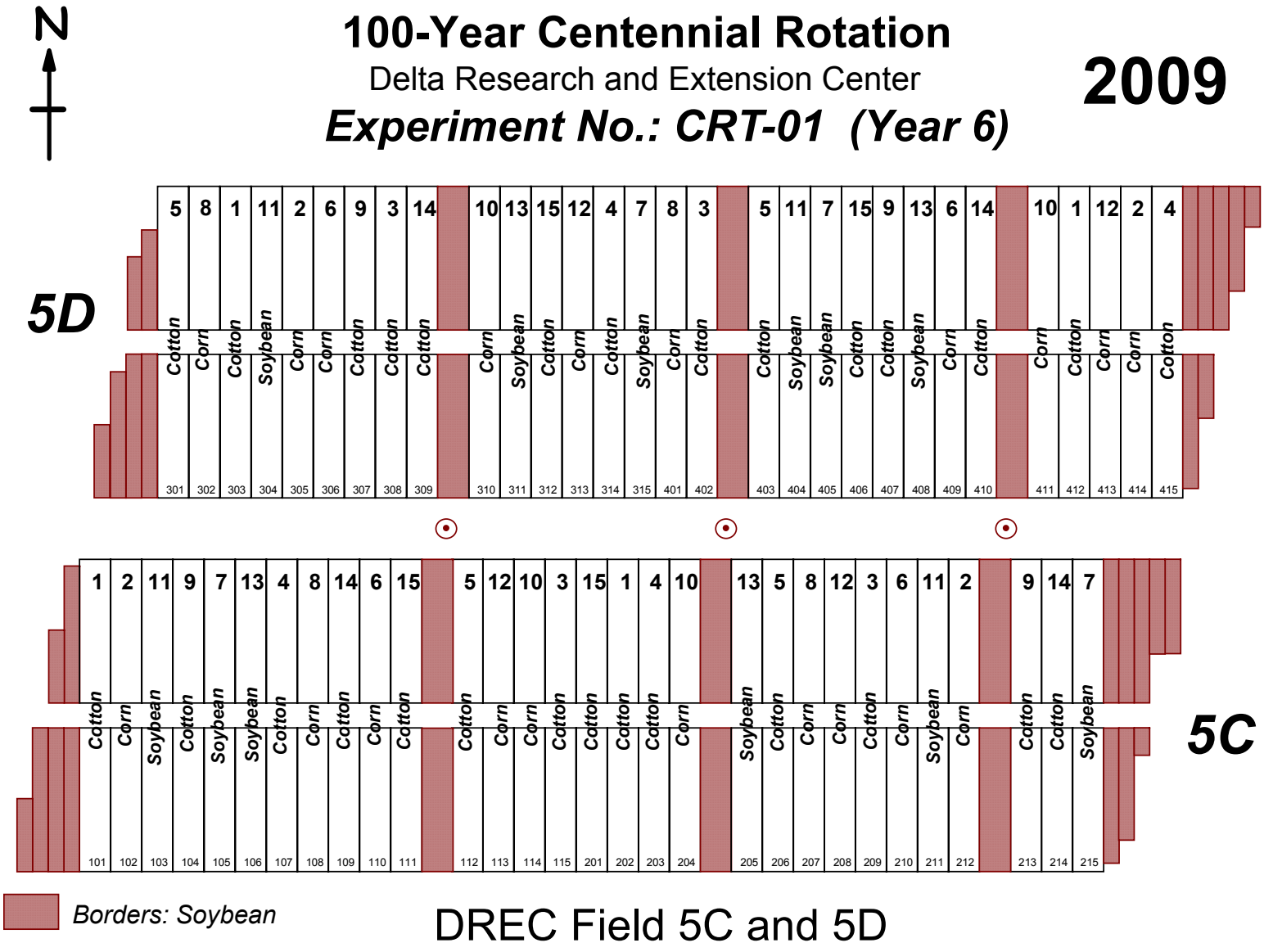


Figure 2: Field layout for long-term rotation. Crops listed for 2009 growing season.

Table 2: Summary of crop yields from long-term rotation cropping systems. 2004-2009 MAFES-DREC, Stoneville, MS

CENTENNIAL ROTATION STUDY - SUMMARY OF CROP YIELDS (2004-2009)

Rotation	---------- Crop Year ----------						2004	2005	2006	2007	2008	2009.0
System	2004	2005	2006	2007	2008	2009	Crop	Crop	Crop	Crop	Crop	Crop
	1	2	3	4	5	6	Yield	Yield	Yield	Yield	Yield	Yield
1	CT	CT	CT	CT	CT	CT	1430.5	1101.8	978.9	718.5	927.6	877.6
2	CT	CR	CT	CR	CT	CR	1470.9	204.6	1185.4	200.8	1218.9	182.4
3	CR	CT	CR	CT	CR	CT	201.2	1334.3	185.1	942.2	194.9	961.3
4	CR	CT	CT	CR	CT	CT	197.2	1298.4	988.0	219.4	1314.9	975.3
5	CT	CR	CT	CT	CR	CT	1509.4	213.3	1202.1	866.7	206.8	984.7
6	CT	CT	CR	CT	CT	CR	1525.1	1148.8	191.1	909.3	982.5	194.8
7	CR	SB	CR	SB	CR	SB	193.9	57.8	199.3	78.4	205.8	73.3
8	SB	CR	SB	CR	SB	CR	60.3	212.3	62.5	208.8	56.1	205.1
9	SB	CR	CT	SB	CR	CT	61.4	212.6	1206.2	75.5	197.6	994.5
10	CT	SB	CR	CT	SB	CR	1447.5	61.5	194.6	1019.2	60.4	209.4
11	CR	CT	SB	CR	CT	SB	195.9	1268.2	64.4	207.6	1222.3	66.3
12	SB	CR	CT	CT	SB	CR	60.4	199.0	1152.6	852.2	57.5	195.9
13	CT	SB	CR	CT	CT	SB	1402.7	52.3	191.2	929.5	978.7	69.8
14	CT	CT	SB	CR	CT	CT	1446.6	1148.2	58.1	223.4	1240.5	929.3
15	CR	CT	CT	SB	CR	CT	200.5	1359.4	947.2	81.5	199.9	992.6

NOTE: Cotton Yield reported in lb lint/acre, Corn Yield reported in bu/acre @15.5%, Soybean Yield reported in bu/acre @ 13%

Table 3. Commodity prices and loan values for rotation crops. Also Mississippi Crop Distribution Estimates for 2006 through 2009. MAFES-DREC. Stoneville, MS

MISSISSIPPI - 2004-2009
Cotton-Corn-Soybean Price Received

	Average Price Received and Loan Rate					
	2004	2005	2006	2007	2008	2009
Cotton	0.447	0.497	0.484	0.613	0.566	0.600
Cotton LR	0.525	0.525	0.525	0.525	0.525	0.525
Corn	2.43	2.22	2.84	3.68	4.60	3.55
Corn LR	1.95	1.95	1.95	1.95	1.95	1.95
Soybean	6.20	5.92	6.23	8.36	8.75	9.50
Soybean LR	5.00	5.00	5.00	5.00	5.00	5.00

MISSISSIPPI - 2006-2009
CROP DISTRIBUTION ESTIMATES

	Planted Acres (NASS)				Percent Change
	2006	2007	2008	2009	
	---------- 1,000 acres ----------				
Cotton	1,230	660	365	295	- 76.0
Soybean	1,670	1,460	2,000	2,170	29.9
Rice	190	190	230	240	26.3
Corn	340	930	720	730	114.7
Wheat	85	370	520	520	111.8
Grain Sorghum	15	145	85	13	- 13.3
TOTAL ACRES	3,530	3,775	4,155	3,628	2.8

Table 4. Summary of crop values from long-term rotation cropping systems. 2004-2009 MAFES-DREC. Stoneville, MS

CENTENNIAL ROTATION STUDY - SUMMARY OF CROP VALUE (2004-2009)

Rotation	---------- Crop Year ----------						2004	2005	2006	2007	2008	2009	TOTAL
System	2004	2005	2006	2007	2008	2009	Crop	Crop	Crop	Crop	Crop	Crop	Crop
	1	2	3	4	5	6	($)	($)	($)	($)	($)	($)	Value
1	CT	CT	CT	CT	CT	CT	751.03	578.46	513.92	440.44	525.04	526.57	3335.46
2	CT	CR	CT	CR	CT	CR	772.20	454.21	622.35	738.94	689.88	647.52	3925.10
3	CR	CT	CR	CT	CR	CT	488.92	700.51	525.68	577.57	896.54	576.77	3766.00
4	CR	CT	CT	CR	CT	CT	479.20	681.68	518.72	807.39	744.21	585.20	3816.39
5	CT	CR	CT	CT	CR	CT	792.45	473.53	631.08	531.26	951.28	590.83	3970.43
6	CT	CT	CR	CT	CT	CR	800.69	603.14	542.72	557.38	556.10	691.54	3751.57
7	CR	SB	CR	SB	CR	SB	471.18	342.18	566.01	655.42	946.68	696.35	3677.82
8	SB	CR	SB	CR	SB	CR	373.86	471.31	389.38	768.38	490.88	728.11	3221.91
9	SB	CR	CT	SB	CR	CT	380.68	471.97	633.23	631.18	908.96	596.69	3622.71
10	CT	SB	CR	CT	SB	CR	759.94	364.08	552.66	624.79	528.50	743.37	3573.34
11	CR	CT	SB	CR	CT	SB	476.04	665.78	401.21	763.97	691.82	629.85	3628.66
12	SB	CR	CT	CT	SB	CR	374.48	441.78	605.14	522.39	503.13	695.45	3142.35
13	CT	SB	CR	CT	CT	SB	736.41	309.62	543.01	569.76	553.96	663.10	3375.85
14	CT	CT	SB	CR	CT	CT	759.44	602.78	361.96	822.11	702.15	557.56	3806.01
15	CR	CT	CT	SB	CR	CT	487.22	713.66	497.27	681.34	919.54	595.57	3894.61