THE CENTENNIAL ROTATION COTTON/CORN/SOYBEAN PRODUCTION IN THE MIDSOUTH (2004-2011)

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Abstract

In order to celebrate the centennial anniversary (1904-2004) of the Delta Branch Experiment Station, a long-term cotton-based rotation study was established at the Delta Research and Extension Center near Stoneville, MS. The study is planned for 100 years and has been designed to utilize the latest technology and biotechnology available to producers. The crops included in the study are cotton, corn, and soybean, with the only continuous crop as cotton. At the outset of the study, cotton was the dominant crop even though more soybeans were grown in the state. In the last several years, cotton acreage has declined and corn acreage has increased to more than 900,000 acres. The study has five rotation systems with each crop from each rotation grown each year and continuous cotton. The rotations include 1) continuous cotton, 2) cotton/corn [1:1], 3) cotton/cotton/corn [2:1], 4) corn/soybean [1:1], 5) soybean/corn/cotton [1:1:1], and 6) soybean/corn/cotton/cotton [1:1:2]. Each crop is grown each year in order for direct comparisons of the systems with respect to price. In many years, producers make their decision on crop mix in their operation based on commodity prices. After eight years, commodity prices have doubled or tripled for some crops. Grain prices are at all-time highs and this coupled with irrigation, early planting, and early harvest place the Mississippi producer with a distinct advantage. In the eight years of the study, the loan rate has been used to calculate cotton value in four of eight years while grain prices have been as much as two times the loan value. Cotton prices have been higher in the last two years. Rotations involving corn have resulted in higher yields for cotton compared to continuous cotton as expected and have resulted in the largest cash values. The lowest value rotation has been the corn/soybean rotation but has probably been the most profitable as the costs of production are substantially lower than cotton. After the 12th growing season all rotations will return to the beginning point. Some will have completed six cycles, others four cycles, and the last three cycles. At that time a complete economic evaluation will be completed.

Introduction

Crop rotation has been used in farming systems for hundreds of years with modern rotations (green manures) begun as early as 1730 in England. The benefits of crop rotation in the south can be divided into three major areas that include: a) maintenance of crop yields; b) control of diseases, insects, and weeds; and c) prevention of soil erosion. Before the extensive use of chemical fertilizers, maintenance and/or improvement of yields were best achieved by improving the base fertility of the soil in which the crop was grown. This usually required growing a legume crop to promote nitrogen fixation or applying manure to provide additional organic nutrients. Corn/cotton rotations were used through the first three to four decades of the 20th century as animal power on the farm was extremely important and corn was needed as feedstock for the animals. Mechanization and inorganic fertilizer materials reduced the need for some crops, crop rotation decreased, and mono-crop agriculture gained in popularity. With today's farm policies and programs, and the freedom to choose different crop mixes, rotations are coming back into prominence. Field research across the cotton producing states supported crop rotation. However, growers were reluctant to rotate cotton because of government payments and crop rotations complicated production practices and presented extra challenges for producers.

The Mississippi Legislature authorized the establishment of an experiment station in the Yazoo and Mississippi Delta. This marked the beginning of research in the region and 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 – that is 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. 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 recorded record

yields in recent years with the aid of new technology and advancements through research. Since 2001, cotton, corn, and soybean have had yields and record prices. Corn acreage has increased while cotton has decreased in response to profitability. Grain crops can be planted early. With irrigation, yield stability has led to shifts in the crop mix and some producers shifting from cotton altogether.

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 scientific cooperators were identified to assist in the overall management of the project in order to assure maximum utilization of the data collected. The objectives of this research program were: 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; and 4) demonstrate the long-term need for crop rotation for the next century and beyond.

Materials and Methods

The research study includes five crop rotation sequences along with 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.

Table 1. Cropping sequence for long term cotton-based rotation cropping system. All crops in each sequence to be grown each year. MAFES-DREC, Stoneville, MS.

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

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. Plots are harvested with commercial equipment adapted for plot harvests. 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 prices used to calculate the value of a crop sequence are shown in Table 2 with the loan rate used if it exceeded the actual price. This was the case in 4 of 8 years for cotton. For grain crops, the loan rate was always lower than actual prices.

Table 2. Average price paid for commodities and loan rate for cotton, corn and soybean. (Source: National Agricultural Statistics Service). Cotton estimates are based on calendar year as reported.

MISSISSIPPI - 2004-2011

Cotton-Corn-Soybean Price Received

	Average Price Received and Loan Rate							
	2004	2005	2006	2007	2008	2009	2010	2011*
Cotton (US)	0.447	0.497	0.484	0.613	0.491	0.648	0.832	0.881
Cotton LR	0.525	0.525	0.525	0.525	0.525	0.520	0.520	0.520
Corn (MS)	2.43	2.22	2.84	3.68	4.63	3.72	4.60	6.40
Corn (US)	2.06	2.00	3.04	4.20	4.06	3.55	5.40	6.40
Corn LR	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95
Soybean (MS)	6.20	5.92	6.23	8.36	9.29	9.24	11.10	11.70
Soybean (US)	5.74	5.66	6.43	10.10	9.97	9.59	11.70	11.70
Soybean LR	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00

National Agricultural Statistics Service * Estimates

Results and Discussion

The first eight years of the Centennial Rotation program were completed in 2011 (100-yr rotation). Long-term cropping system rotations and long-term research are limited in their scope in many areas of the world or are no longer in existence. The Centennial Rotation was designed as a replicated field study with each component of a cropping sequence grown during the same year. This provides the opportunity to evaluate the economic implications of decision on crop mix and whole-farm enterprise. Even with long range planning, a producer cannot determine his potential production or the value of that production in a given year and weather pattern. Various scenarios can be evaluated in this study and should provide needed information on long-term rotation practice. 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. With recent shifts to grain production, this system has become quite important. Figure 1 shows Mississippi production for the last 20 year. In just the last few years cotton production has dropped and corn production greatly increased. Corn yields have also increased dramatically over the years as more irrigation has been installed. Irrigation and earlier planting systems have also allowed soybean production to double in the last 30 years with producer harvesting 75-80 bu/acre or more. Prices received for commodities have also increased and are summarized in Table 2. Mississippi grain prices do vary some from the US average price (NASS) due to the local markets and harvest timing. The cotton values are not broken out for the individual states and reflect a calendar year rather than a marketing year. Prices used to calculate crop value are Mississippi prices or loan rate (LR), whichever is higher. Therefore in 4 of the 8 years to date, LR has been used for cotton but no other crop.

The summary of the first eight 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 corn 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. Over the years the range has been 13.1 to 41.8% higher yields (115.0 to 387.3 lb lint/acre) where cotton was in some rotation with corn compared to continuous cotton. Average cotton yields have varied across years ranging from 891.1 lb lint/acre in 2007 to a high of 1461.8 lb/acre. Corn yields in the same time frame have ranged from 192.3 to 212.0 bu/acre excluding 2011. The 2011 yields (91.2 bu/acre) were way below average due to a lack of irrigation in a timely fashion. Soybean yields have ranged from 50.3 to 78.5 bu/acre with the lowest yields in 2011 (Table 2). 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 as evident in 2011. Timing of the first irrigation is critical.

The total value of a rotation system (yield X price summed across years) ranges from $4667.86 (treatment 8) to a high of $5602.90 (treatment 4) with continuous cotton falling in between ($4947.14). These calculations are not taking into consideration the cost of production that varies from year to year. The highest cost of production is associated with cotton and the lowest with soybean. In the last year (2011) overall value was lower where corn was grown due to a partial crop failure. Yields were 50% lower than any other year of the study. This again points to the critical need for yield stability in any of the systems. In the first three years (2004-2006) corn prices were $2 and 3$ compared to $6 or more for 2011. Soybean prices have almost doubled since the project was begun with 2011 estimated between $11 and $12. With the lower cost of production associated with soybean, the potential profitability is high. Price is the leading factor in soybean acreage decline in the early 2000's. The economic impact of crop rotations is evident in most years just from the yield standpoint. However, as the costs of inputs continue to escalate, particularly with respect to technology fees, the more important rotation becomes. The increase in herbicide-resistant weed species across the country could lead to even more emphasis on crop rotation and herbicide rotation. As grain crops remain profitable due to high prices and high yields, a continued shift to these crops will be evident. In the last two years cotton prices have improved and production has returned, but still remains 50% of what it was 6 years ago. A detailed economic analysis will be used to evaluate the profitability of the rotation systems once the cycles have returned to the same point (after 12 years). As long as grain prices remain high and water is available, grain production will continue in the Mid-South. Infrastructure is changing the landscape and grain bins are replacing cotton gins.

After eight years, commodity prices have doubled or tripled for some crops. Grain prices are at all-time highs and this coupled with irrigation, early planting, and early harvest place the Mississippi producer with a distinct advantage. In the eight years of the study, the loan rate has been used to calculate cotton value in four of eight years while grain prices have been as much as two times the loan value. Cotton prices have been higher in the last two years. Rotations involving corn have resulted in higher yields for cotton compared to continuous cotton as expected and have resulted in the largest cash values. The lowest value rotation has been the corn/soybean rotation but has probably been the most profitable as the costs of production are substantially lower than cotton. After the 12th growing season all rotations will return to the beginning point. Some will have completed six cycles, others four cycles, and the last three cycles. At that time a complete economic evaluation will be completed. A second poster presentation has been included to assess the impact of rotation on nutrient uptake and removal.

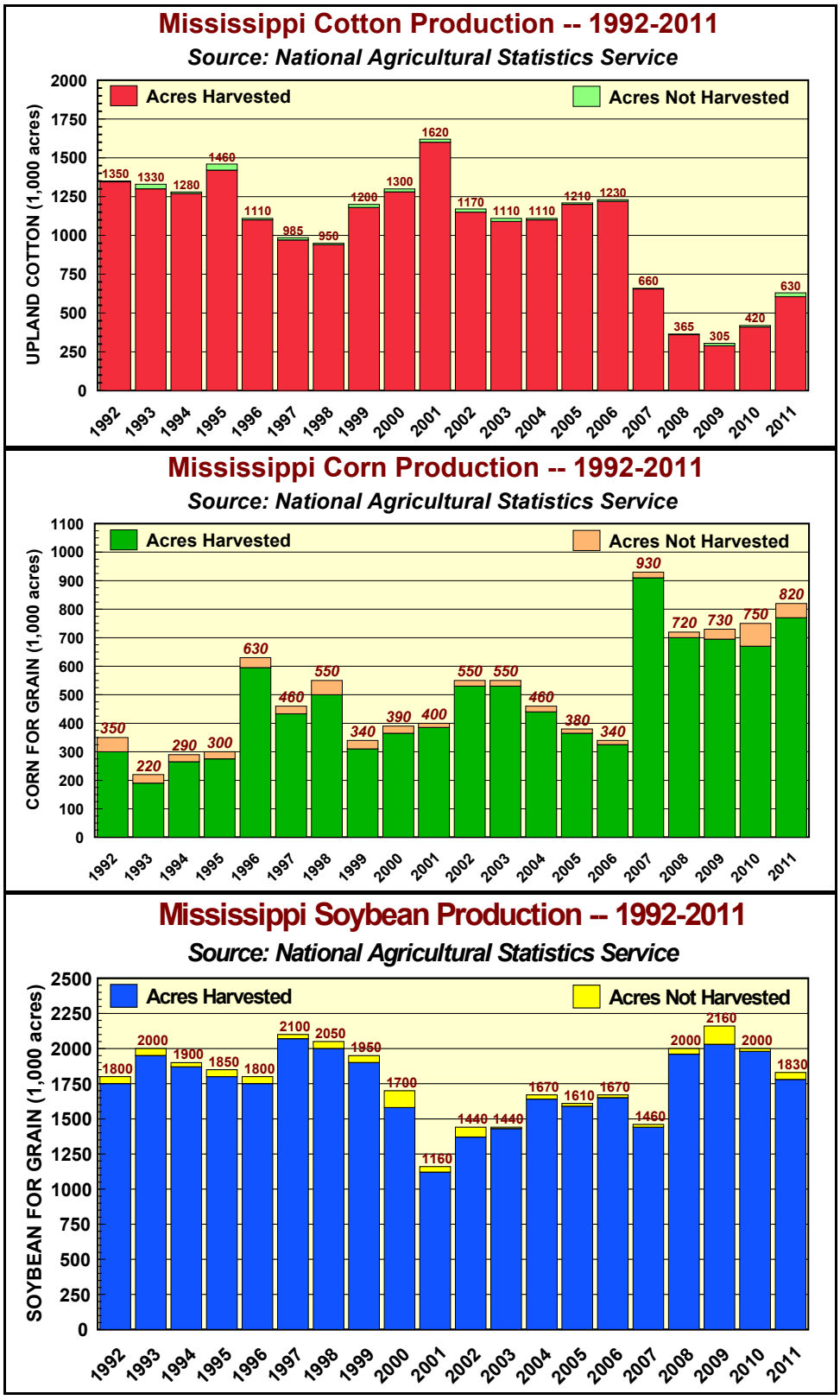

Figure 1. Shifts in cotton, corn, and soybean production (planted, harvested, and non-harvested acres). 1992-2011 (NASS)

Table 3. Summary of crop yields from the Centennial Rotation Study (2004-2011) Delta Research and Extension Center, Stoneville, MS

CENTENNIAL ROTATION STUDY - SUMMARY OF CROP YIELDS/ACRE (2004-2011)

Rotation	Crop Year								2004	2005	2006	2007	2008	2009	2010	2011
System	2004	2005	2006	2007	2008	2009	2010	2011	Crop Yield	Crop Yield	Crop Yield	Crop Yield	Crop Yield	Crop Yield	Crop Yield	Crop Yield
	1	2	3	4	5	6	7	8								
1	CT	CT	CT	CT	CT	CT	CT	CT	1430.5	1101.8	978.9	718.5	927.6	877.6	1039.4	843.2
2	CT	CR	CT	CR	CT	CR	CT	CR	1470.9	204.6	1185.4	200.8	1218.9	182.4	1185.6	61.6
3	CR	CT	CR	CT	CR	CT	CR	CT	201.2	1334.3	185.1	942.2	194.9	961.3	194.7	965.4
4	CR	CT	CT	CR	CT	CT	CR	CT	197.2	1298.4	988.0	219.4	1314.9	975.3	201.8	982.2
5	CT	CR	CT	CT	CR	CT	CT	CR	1509.4	213.3	1202.1	866.7	206.8	984.7	1148.2	73.8
6	CT	CT	CR	CT	CT	CR	CT	CT	1525.1	1148.8	191.1	909.3	982.5	194.8	1234.7	841.9
7	CR	SB	CR	SB	CR	SB	CR	SB	193.9	57.8	199.3	78.4	205.8	73.3	207.2	52.6
8	SB	CR	SB	CR	SB	CR	SB	CR	60.3	212.3	62.5	208.8	56.1	205.1	65.7	101.8
9	SB	CR	CT	SB	CR	CT	SB	CR	61.4	212.6	1206.2	75.5	197.6	994.5	70.6	113.7
10	CT	SB	CR	CT	SB	CR	CT	SB	1447.5	61.5	194.6	1019.2	60.4	209.4	1199.0	47.9
11	CR	CT	SB	CR	CT	SB	CR	CT	195.9	1268.2	64.4	207.6	1222.3	66.3	209.0	963.0
12	SB	CR	CT	CT	SB	CR	CT	CT	60.4	199.0	1152.6	852.2	57.5	195.9	1239.2	849.3
13	CT	SB	CR	CT	CT	SB	CR	CT	1402.7	52.3	191.2	929.5	978.7	69.8	208.0	1059.2
14	CT	CT	SB	CR	CT	CT	SB	CR	1446.6	1148.2	58.1	223.4	1240.5	929.3	66.8	105.0
15	CR	CT	CT	SB	CR	CT	CT	SB	200.5	1359.4	947.2	81.5	199.9	992.6	1026.1	50.4

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

Table 4. Summary of crop values from the Centennial Rotation Study (2004-2011) based on yields and price. Delta Research and Extension Center, Stoneville, MS.

CENTENNIAL ROTATION STUDY - SUMMARY OF CROP VALUE (2004-2011)

Rot.	---------- Crop Year ----------								2004	2005	2006	2007	2008	2009	2010	2011	TOTAL
Sys.	2004	2005	2006	2007	2008	2009	2010	2011	Crop	Crop	Crop	Crop	Crop	Crop	Crop	Crop	Crop
	1	2	3	4	5	6	7	8	($)	($)	($)	($)	($)	($)	($)	($)	Value
1	CT	CT	CT	CT	CT	CT	CT	CT	751.03	578.46	513.92	440.44	487.01	568.70	864.76	742.82	**4947.14**
2	CT	CR	CT	CR	CT	CR	CT	CR	772.20	454.21	622.35	738.94	639.91	678.53	986.43	394.24	**5286.81**
3	CR	CT	CR	CT	CR	CT	CR	CT	488.92	700.51	525.68	577.57	902.39	622.92	895.62	850.49	**5564.10**
4	CR	CT	CT	CR	CT	CT	CR	CT	479.20	681.68	518.72	807.39	690.30	632.01	928.28	865.33	**5602.90**
5	CT	CR	CT	CT	CR	CT	CT	CR	792.45	473.53	631.08	531.26	957.48	638.10	955.34	472.32	**5451.56**
6	CT	CT	CR	CT	CT	CR	CT	CT	800.69	603.14	542.72	557.38	515.81	724.66	1027.25	741.75	**5513.41**
7	CR	SB	CR	SB	CR	SB	CR	SB	471.18	342.18	566.01	655.42	952.85	677.29	953.12	615.42	**5233.47**
8	SB	CR	SB	CR	SB	CR	SB	CR	373.86	471.31	389.38	768.38	521.17	762.97	729.27	651.52	**4667.86**
9	SB	CR	CT	SB	CR	CT	SB	CR	380.68	471.97	633.23	631.18	914.89	644.43	783.66	727.68	**5187.72**
10	CT	SB	CR	CT	SB	CR	CT	SB	759.94	364.08	552.66	624.79	561.12	778.97	997.53	560.43	**5199.52**
11	CR	CT	SB	CR	CT	SB	CR	CT	476.04	665.78	401.21	763.97	641.70	612.61	961.40	848.44	**5371.15**
12	SB	CR	CT	CT	SB	CR	CT	CT	374.48	441.78	605.14	522.39	534.18	728.75	1030.98	748.26	**4985.95**
13	CT	SB	CR	CT	CT	SB	CR	CT	736.41	309.62	543.01	569.76	513.83	644.95	956.80	933.20	**5207.58**
14	CT	CT	SB	CR	CT	CT	SB	CR	759.44	602.78	361.96	822.11	651.28	602.17	741.48	672.00	**5213.23**
15	CR	CT	CT	SB	CR	CT	CT	SB	487.22	713.66	497.27	681.34	925.54	643.22	853.69	589.68	**5391.62**