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Project Title: Agronomic and Economic Evaluation of Soybean/Corn Rotation with Twin-row Production and Increased Nutrient Management

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BACKGROUND AND OBJECTIVES

Corn and soybean rotations have been utilized throughout the US, with the most common rotation being one year soybean followed by one year of corn (1/1). The literature documents the "rotation effect" with many potential explanations for its occurrence. In the Mid-south and Southeast, less crop rotation was practiced because of cotton's presence on the farm landscape. Many fields were continuously cropped to cotton for decades. In recent times, corn has replaced cotton, irrigation has replaced dryland or rain-fed production, and soybean has moved from the last crop planted to the early soybean production system (ESPS), with planting in March and April rather than May and June.

Bedding remains the choice for most producers in the Delta on the lighter textured soils. Getting water off (drainage) and getting water on (irrigation) is of primary concern, especially with early planting of both corn and soybean. Twin-row (TR) planting systems (two rows planted on the same bed) have helped to combine wide-row and narrow-row technology into a viable alternative for Mid-south production systems. John Deere's introduction of a twin-row planter demonstrated the industry's vision for the future as well.

Twin-row production allows for more rapid ground cover and yet maintains adequate waterways for surface drainage and irrigation. On-farm research with corn in the Mississippi Delta has shown significant grain yield increases from increased seeding rates (up to 40,000 plants/acre). Soybean research has also shown advantages to TR production compared to single wide-row systems. Irrigation has led to a decrease in the fluctuation of grain yields in both corn and soybean and has led to increases in state average yields. Both crops achieved record yields across the state in 2014 (corn, 185 bu/acre on 485,000 acres harvested; and soybean, 52 bu/acre on 2.2 million acres as reported by NASS). However, both corn and soybean yields were lower in 2015 and 2016 compared to 2014, with corn averaging 166 bu/acre on 720,000 acres harvested and soybean averaging 48 bu/acre on 2.02 million acres harvested. Soybean yields in 2016 were second only to the 2014 yields while corn was near the bottom of the last five years. Average corn yields were lower in 2016 but acreage increased by 47% compared to 2015.

Yield stability and good prices are keys to successful and prolonged grain production in the Mid-south, and with recent declines in commodity prices, profitability has been challenged. Many producers have felt that fertility has not been an issue in the Mississippi Delta. Unfortunately, that perception has led to nutrient

deficiencies in some areas, and nutrient levels are expected to continue to decline.

The purpose of this research has been to combine the technologies coming forward into a management system that can optimize yields and increase profitability. The overall objectives are to 1) determine the agronomic implications of soybean/corn rotations in twin-row planting systems under standard and high management with irrigation on varying soil types, and 2) evaluate the economic impact of the above systems on whole-farm enterprise profitability. There is one year remaining on the project.

REPORT OF PROGRESS/ACTIVITY

Objective 1: Determine the agronomic implications of soybean/corn rotations in a twin-row planting system under standard and high management with irrigation.

Multiple-year field studies were initiated at two locations on the Delta Research and Extension Center near Stoneville, MS to evaluate the agronomic implications of soybean/corn rotations in twin-row planting systems. The first study (Exp. No.: SB31) was set up on a Commerce soil ranging in texture from very fine sandy loam to silt loam with a little silty clay loam. Prior to 2012, the area had been managed as a corn/cotton rotation field with the 2012 study following cotton. The rotation study has been continued in 2013, 2014, 2015, and 2016. Since soybean had not been grown in the field prior to 2012, soybean seed were inoculated each year prior to planting to insure nodulation; they were not inoculated in 2015 and 2016. Preplant N (120 lb N/acre) was applied 6 May, with planting on 8 April (Exp. 16-SB31, sandy field). Pioneer 2089 YHR was not available as in previous years so Mycogen 2C797 corn seed was planted at approximately 32,500 seed/acre in a twin-row planting pattern using a Monosem planter twin-row planter. Soybean was planted on 28 April (sandy field) with the same Monosem planter at 10-12 seed/ft (5-6 seed/ft in each row). This planting was more timely than in the pevious year. Soybean cultivar was HBK 4653 (LL). Phosphorus (P) and potassium (K) were applied at rates of 26.2 lb P/acre (60 lb P_2O_5/acre, 130 lb 0-46-0/acre) and 50 lb K/acre (60 lb K_2O/acre, 100 lb 0-0-60/acre), respectively. The materials were pre-weighed and then broadcast applied on 23 May (sandy field). Sideress N (100 or 140 lb N/acre) was applied on 24 May by injecting urea-ammonium nitrate solution (32% N) to both sides of the planted row. Above normal rainfall fell in March with below normal rainfall in April and May (Table 1). The rainfall for the past 12 months (January to December) was 7.45 in above normal for the whole year. July and August rainfall was more than 12 inches occurring in 31 measurable precipitation events, and was followed by 0.54 inches in September and October.

The second study (Exp. No.: SB32) was established in 2012 on a Sharkey clay soil previously cropped to soybean. The same cultivars of corn and soybean used in the sandy land study were planted on 28 April for both crops at the rates already mentioned. Preplant N for corn was applied on 5 May with sidedress N applied on 10 June. The pre-weighed P and K were applied at the same rates as mentioned above on 24 May 2016. Irrigation was applied on the clay soil site, but one irrigation was applied on on the sand field. Rainfall does vary across the location; therefore, it wasonly recorded at the weather station on the

experiment station.

Each study has been designed with four replications with each strip divided in four sections. Spatial variability with respect to soil test levels is evident and this technique will allow more observations across an array of soil test levels. Soil samples were taken after harvest to assess the nutrient status and plan for the following year P and K application rates. The samples were dried, ground, mixed and shipped to the Soil Testing and Plant Analysis Laboratory at Mississippi State University. Unfortunately, the analysis has yet to be completed and the lab offers no time line for completion. Dr. Keith Crouse, Lab Director, has retired along with the office manager and at least one other full-time employee. A complete analysis will be forthcoming as soon as the samples are processed and results become available.

Table 1: Summary of rainfall for Stoneville, Mississippi (January 1, 2016 through December 31, 2016), Delta Research and Extension Center.

Day of Mon	Sep 2016 (in)	Oct 2016 (in)	Nov 2016 (in)	Dec 2016 (in)	Jan 2016 (in)	Feb 2016 (in)	Mar 2016 (in)	Apr 2016 (in)	May 2016 (in)	Jun 2016 (in)	Jul 2016 (in)	Aug 2016 (in)	TOTAL RAIN (in)
1	0.00	0.00	0.00	0.00	0.01	0.05	0.00	0.41	0.66	0.00	0.00	0.00	
2	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.01	0.05	0.31	0.00	0.00	
3	0.00	0.00	0.00	1.44	0.00	1.08	0.71	0.00	0.05	0.12	0.00	0.01	
4	0.00	0.00	0.00	0.04	0.00	0.01	0.02	0.00	0.00	2.98	0.00	0.00	
5	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	1.11	0.00	
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	
7	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	
9	0.00	0.00	0.00	0.00	0.76	0.00	3.15	0.00	0.00	0.00	0.00	0.00	
10	0.00	0.00	0.00	0.00	0.20	0.00	4.69	0.00	0.00	0.00	0.57	0.00	
11	0.00	0.00	0.00	0.00	0.00	0.00	2.19	0.22	0.00	0.00	0.47	0.39	
12	0.00	0.00	0.00	0.09	0.01	0.00	0.37	1.62	0.00	0.00	0.12	0.00	
13	0.00	0.00	0.00	0.00	0.00	0.00	1.53	0.00	0.00	0.01	0.00	0.17	
14	0.00	0.00	0.00	0.00	0.00	0.00	1.28	0.01	0.00	0.38	0.00	0.23	
15	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.61	0.00	1.06	0.25	0.16	
16	0.00	0.00	0.00	0.00	0.00	1.49	0.04	0.04	0.01	0.01	0.00	1.22	
17	0.02	0.00	0.00	0.44	0.00	0.01	0.00	0.00	0.19	0.00	0.00	0.62	
18	0.01	0.00	0.77	0.38	0.00	0.00	0.37	0.00	0.01	0.15	0.00	0.25	
19	0.01	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0.01	0.00	0.00	0.51	
20	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.38	0.00	0.01	0.01	0.11	
21	0.00	0.17	0.00	0.00	0.03	0.02	0.00	0.18	0.00	0.00	0.00	0.00	
22	0.00	0.01	0.00	0.00	1.65	0.63	0.00	0.02	0.00	0.00	0.00	0.60	
23	0.00	0.00	0.53	0.00	0.04	0.20	0.00	0.00	0.00	0.00	0.00	0.03	
24	0.00	0.00	0.00	0.00	0.00	1.03	0.37	0.00	0.00	0.00	0.00	0.00	
25	0.00	0.00	0.00	0.00	0.01	0.02	0.22	0.00	0.00	0.00	1.41	0.00	
26	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.01	0.01	
27	0.00	0.00	0.00	0.37	0.01	0.00	0.00	0.03	0.00	0.00	0.01	0.80	
28	0.00	0.00	2.58	0.60	0.00	0.00	0.00	0.32	1.10	0.00	1.97	0.00	
29	0.00	0.00	1.33	0.07	0.00		0.00	0.00	0.01	0.00	0.35	0.00	
30	0.00	0.00	0.03	0.00	0.00		0.00	0.44	0.02	0.00	0.01	0.03	
31		0.00		0.47	0.00		3.23		1.16		0.23	0.00	
TOT	0.34	0.20	5.30	3.90	3.39	4.50	18.47	4.31	3.26	5.06	6.53	5.48	60.74
Norm	3.19	3.32	5.20	5.45	5.42	4.46	5.63	5.44	5.25	4.02	3.86	2.05	53.29
Diff	-2.85	-3.12	0.10	-1.55	-2.03	0.04	12.84	-1.13	-1.99	1.04	1.67	3.43	7.45
Event	4	3	6	9	10	10	14	14	10	11	14	17	

Rainfall in July and August resulted in little need for irrigation at either site but did lead to heavy weed pressure in the alleys and in the corn fields as leaf senescence occurred after physiological maturity. Corn harvest was completed at the sand site on 7 September, and on 9 September on the Sharkey clay site. Vine pressure was greater on the clay site due to the shorter stature of the corn plants on the poorly drained soil, howeved, this did not influence yield as the vines did not expand until the corn plants began to dry down. The two center rows of each plot were harvested with a commercial combine modified for plot harvest. Samples were collected at the time of harvest to determine harvest moisture, bushel test weight, and seed index (100-seed weight). Moisture determinations have been completed but seed index remains to be completed. Every effort is made to complete field work while weather permits. Soybean harvest was completed on 21 September (16-SB31, sand site) and 23 September (16-SB32, clay site). The center two rows of each plot was harvested with a Kincaid plot combine with samples collected for laboratory determination of harvest moisture, bushel test weight, and seed index.

Corn and Soybean Yields

Experiment No. 16-SB31-CR. Corn yields from the sandy land study in 2016 are summarized in Table 2. Overall corn grain yields ranged from 173.0 to 214.3 bu/acre (adjusted to 15.5% moisture) within the field, averaged across replications. The overall field average was 174.8 bu/acre (low based on yield potential with adequate irrigation and timely planting). The means across replications and determinations are shown in the table. Grain yields and bushel test weight differences were significant at the 5% level while seed index was not significant by Fisher's Protected Least Significant Difference. Bushel test weight ranged from 53.8 to 56.2 lb/bu and seed index ranged from 29.98 to 32.55 grams/100 seed (mean of three 100-seed lots). The CV for the study yields in 2016 was 6.4%, down from the previous year.

Table 2: Summary of corn grain yields averaged across replications (4) and sub-samples (4) for corn following one year of soybean or two year of soybean. Delta Research and Extension Center, 2016. Sandy loam research site (Experiment No. 16-SB31-CR).

Rotation System	Fertility	Grain Yield @ 15.5% (bu/acre)	Adjusted Bushel Weight (lb/bu)	Seed Index (grams/100seed)
SB-CR	Standard	187.6 a	54.2	30.95
SB-SB-CR	Standard	189.4 a	54.6	30.59
SB-CR	High	206.2 b	55.5	31.76
SB-SB-CR	High	210.5 b	55.4	31.59

Experiment No. 16-SB31-SB. Soybean yields from the sandy land study are briefly summarized in Table 3. The field average was 58.6 bu/acre for the HBK 4653 soybeans, which was about 10 bu/acre greater than the previous year where soybean was planted late. The moisture-corrected grain yields ranged form 52.6 to 62.5 bu/acre, with no significant difference between any rotation system. Soybean yields were not impacted by the rotation systems nor were they affected by the additional phosphorus and potassium. Bushel test weight and seed index were also not significantly different. When analyzed for main effects (no significant interaction), additional P and K increased grain yields by 5.6% (57.0 vs. 60.2 bu/acre) .

Table 3: Summary of soybean grain yields averaged across replications (4) and sub-samples (4) for soybean following corn and soybean following soybean. Delta Research and Extension Center, 2016. Sandy loam research site (Experiment No. 16-SB31-SB).

*Rotation System	Fertility	Grain Yield @ 13.0% (bu/acre)	Adjusted Bushel Weight (lb/bu)	Seed Index (grams/100seed)
SB-CR-SB-CR-	Standard	56.2	59.7	12.64
SB-SB-CR-SB-	Standard	58.7	59.6	12.82
CR-SB-SB-CR-	Standard	56.1	59.9	12.64
SB-CR-SB-CR-	High	60.6	59.9	12.69
SB-SB-CR-SB-	High	60.4	60.0	12.85
CR-SB-SB-CR-	High	59.7	60.0	12.76

*Rotation systems are in Year 5 with the 2-yr rotation completing the 1st year of the 3rd cycle and the 3-yr rotations completing the 2nd year of the 2nd cycle. Italics indicates the cycles as initiated.

Experiment No. 16-SB32-CR. Corn yields from the clay study in 2016 are summarized in Table 4. Overall corn grain yields ranged from 149.4 to 168.8 bu/acre (adjusted to 15.5% moisture) within the field, averaged across replications. The means across replications and determinations are shown in the table. The overall field average was 158.9 bu/acre, 50 bu/acre less than the sandy loam site. The clay area was adversely affected by the early growing season rainfall that limited root development. In previous years, corn yields have been higher and in some years nearly equal to those from the sand site. In general, Sharkey clay is less suitable for corn production and can easily be influenced by weather issues such as too much rainfall. Corn yields were numerically higher with the added NPK fertilizer, but with wet soil conditions more denitrification losses are possible and probable. Increasing the available N can actually increase denitrification losses. Bushel test weight and seed index were not significantly impacted by rotation or fertility. Year-to-year differences between bushel test weight and seed index are more closely related to the different cultivars that have been used. At the rate cultivars arrive and disappear, it is difficult to maintain the same cultivar throughout the study.

Table 4: Summary of corn grain yields averaged across replications (4) and sub-samples (4) for corn following one year of soybean or two year of soybean. Delta Research and Extension Center, 2016. Sharkey Clay research site (Experiment No. 16-SB32-CR).

Rotation System	Fertility	Grain Yield @ 15.5% (bu/acre)	Adjusted Bushel Weight (lb/bu)	Seed Index (grams/100seed)
SB-CR	Standard	155.1	56.2	28.71
SB-SB-CR	Standard	156.3	56.0	28.24
SB-CR	High	163.1	56.2	29.57
SB-SB-CR	High	161.2	56.6	29.06

Experiment No. 16-SB32-SB. Soybean yields from the clay study are briefly summarized in Table 5. The field average was 55.8 bu/acre and ranged from 48.2 to 59.8 bu/acre, with no difference between any rotation system. Soybean yields were not impacted by the rotation systems nor were they affected by the additional phosphorus and potassium. The P and K levels on this site are high and above soil test levels that would lead to a significant response. Bushel test weight and seed index were also not significantly different. Compared to the sand site, bushel test weights were lower and seed index was higher, with the same cultivar planted on both soils but on different dates.

Table 5: Summary of soybean grain yields averaged across replications (4) and sub-samples (4) for soybean following corn and soybean following soybean. Delta Research and Extension Center, 2016. Sharkey Clay research site (Experiment No. 16-SB32-SB).

*Rotation System	Fertility	Grain Yield @ 13.0% (bu/acre)	Adjusted Bushel Weight (lb/bu)	Seed Index (grams/100seed)
SB-CR-SB-CR-	Standard	55.7	56.7	13.83
SB-SB-CR-SB-	Standard	56.4	56.6	14.04
CR-SB-SB-CR-	Standard	56.1	56.6	13.76
SB-CR-SB-CR-	High	56.0	56.6	13.78
SB-SB-CR-SB-	High	53.2	56.7	13.80
CR-SB-SB-CR-	High	57.2	56.6	13.95

*Rotation systems are in Year 5 with the 2-yr rotation completing the 1st year of the 3rd cycle and the 3-yr rotations completing the 2nd year of the 2nd cycle. Italics indicates the cycles as initiated.

Objective 2: Evaluate the economic impact of the rotation systems and fertilizer management on whole-farm enterprise profitability.

The economic evaluation will follow harvest and yield determinations at the end of the season. Fertilizer costs remain steady with nitrogen running 45 to 60 cents/lb depending on the N source. Recent price quotes showed potassium (0-0-60) and phosphorus (0-46-0) at around $500/ton and phosphorus.