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Influence of RICE Production on Subsequent COTTON Growth and Yield

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Introduction

Since the 1700's, measuring the response of crops and soils to various cropping systems or sequences has been of interest to many researchers (32). The first consideration in crop rotation is yield maintenance (11). Secondary to this is pest control, prevention of soil erosion, and maintenance of soil nutrient status.

The benefits of crop rotation on cotton yields have varied. Sturkie (29) reported that average yields of cotton and corn were increased by rotating when compared to continuous cropping systems. In another study, continuous cotton yielded 17 pounds per acre (lb/A) less than the highest yielding rotation (3). In other rotational studies throughout the cotton belt, results have varied (2, 13, 14, 15, 27). Although yield is a primary consideration, crop rotation is usually practiced to prevent yield decline of the primary crop instead of to enhance yield.

While yield considerations are paramount to the utilization of crop rotations with cotton, rotations have been more successful in benefiting pest control. Crop rotations have been successful in reducing incidence of diseases, nematodes, and weeds (1, 7, 9, 17, 26). Dale and Chandler (8) effectively controlled johnsongrass by growing corn in rotation with cotton. In the southern United States, rice is commonly rotated with soybeans to reduce grass infestation in subsequent rice crops. Herbicide crop rotation studies have been conducted to maximize weed control while reducing or varying herbicide input (9, 24).

The influence of crop rotations on soil productivity has been reported by many researchers (10, 16, 21, 23, 30, 31). Brawand and Hossner (4) studied the nutrient status of sorghum leaves and grain as affected by rotations. Spurgeon and Grissom (28) reported that organic matter content of soils increased when a sod crop was used in different cropping systems. However, this was the only significant change for several rotation sequences. Crop rotation sequences have also been shown to alter enzymatic events in the soil, which may or may not be beneficial (25).

Recently, market instability of various commodities has precipitated the need for diversification of income, which can be considered an additional benefit of crop rotation. By increasing the number of commodities produced per farm unit, producers can offset some of the risk associated with producing one particular commodity. Also, different cultural practices needed at different times for various crops provide for a more even distribution of labor. Historically, in the Mississippi Delta, cotton has been grown continuously on soils with less than 1% organic matter. Soil organic matter plays a major role in the chemical, microbiological, and physical aspects of soil fertility. Continuous cotton produces little residue and as a result, depletion of soil organic matter is possible.

Soybean-cotton and soybean-rice rotations have been reported (2, 15, 19), but there have been only limited studies on rice-cotton cropping systems (18, 20) – and those were in India. The study summarized in this bulletin was conducted to examine the influence of rice on subsequent cotton yield, growth, and soil parameters.

Materials and Methods

This experiment was initiated in 1984 at the Mississippi Agricultural and Forestry Experiment Station Delta Branch Station at Stoneville on a mixed Bosket (Mollic hapludalf) and Beulah (Typic dystrochepts) very fine sandy loam that had been in cotton for approximately 10 years. The six rotations selected for evaluation were: (1) continuous cotton; (2) continuous rice; (3) 1 year rice:1 year cotton; (4) 1 year rice:2 years cotton; (5) 2 years rice:2 years cotton; and (6) 1 year rice:3 years cotton. Treatments were 60 feet wide by 130 feet long replicated four times.

General recommended crop production practices were utilized for each crop in an effort to obtain maximum yields. Plots planted to cotton were subsoiled to a depth of 14 to 16 inches in the late fall or winter each year. Cotton (cv. DES 422) was hill-drop planted to 40-inch rows during the last 2 weeks of April each year at a seeding rate of 19 lb/A. Anhydrous ammonia was applied prior to planting at the rate of 100 lb/A of nitrogen (N) and was the only fertilizer used in cotton. Weed control was maintained with applications of trifluralin applied preplant incorporated, followed by fluometuron or norflurazon applied preemergence at planting. Cultivation and post-directed applications of dinoseb or fluometuron + MSMA were used to control escaped weeds. Cotton was machine-harvested each year and seed cotton weight was recorded.

Rice (cv. 'Newbonnet') was drill-seeded in mid to late April each year at a seeding rate of 90 lb/A. When necessary, rice was flood-irrigated to obtain a stand.

A 2- to 4-inch permanent flood was established in late May or early June when rice was 6 to 8 inches tall. Nitrogen, at a rate of 135 lb/A, was applied as urea immediately prior to flooding. Weeds were controlled with tank-mix applications of propanil + thiobencarb or bifenox applied postemergence prior to flooding.

In March 1984, 1986, and 1987, and in April 1985, soil samples to depths of 0 to 6 inches and 6 to 12 inches were taken from each plot and analyses conducted by the Mississippi Cooperative Extension Service Soil Testing Laboratory at Mississippi State University. Results were tabulated and analyzed to examine the influence of each rotation on soil test values.

During the third and fourth years of the study, soil compaction, and heights and populations of cotton were measured in each cotton plot approximately 6 weeks after planting. Data for plant populations were taken within each plot from four random locations 10 row-feet in length. Main stem height of 10 plants was measured within each of these 10-foot sections for plant height determination. Soil compaction or cone index was determined from 10 penetrometer readings taken within each plot.

Net returns were calculated for each treatment to determine profitability. Calculations were derived from actual yields from each plot. Cotton revenue was based on $0.57/lb of lint, which was the 5-year average reported in 1988 (6). Lint percentage was assumed to be 38%. Seed and trash percentages were 50% and 12%, respectively. A price of $0.04/lb was added to revenue for cottonseed. Total specified expenses for cotton were $405.73/A. Rice revenue was based on a price of $3.42/bushel. Total specified expenses for rice were $370.47/A. In 1986 and 1987, total specified expenses were $388.97/A for the continuous rice plots due to the necessity of an additional propanil application for weed control.

All data were subjected to analysis of variance for an RCB and differences were significant at the 5% probability level according to Fisher's Protected Least Significant Difference (LSD) Test. Where appropriate, sub-sample error was included in the analysis.

Results and Discussion

Cotton establishment and growth

Cotton populations in 1986 were similar for all production systems evaluated (Table 1). However, in 1987 cotton populations were significantly higher in the 1:1 system than in continuous cotton. This suggests a possible reduction in disease incidence for this system. However, disease incidence was not reported and did not appear prevalent during the 1987 season. In a 1:1 system, adjustment in plant populations may need to be considered.

Table 1. Influence of a rice-cotton rotation on various cotton or soil parameters after 4 years. Delta Branch Experiment Station, Stoneville, MS.

Treatment description	Cotton data					
	Stand counts		Crop height		Cone index	
	1986	1987	1986	1987	1986	1987
	(plants/acre)		--------(in)--------		------(psi)------	
Continuous cotton	65,350	57,500	11	14	720	950
1:1 Rice-cotton	–	64,040	–	12	–	940
1:2 Rice-cotton	66,660	–	11	–	940	
2:2 Rice-cotton	70,580	62,740	9	15	1,050	920
1:3 Rice-cotton	69,270	58,820	11	13	770	930
LSD (5%)[1]	6,540	5,230	1	1	220	70
C.V. (%)	11.5	12.7	13.6	12.9	25.5	17.0

[1]For comparison of any two means within a column.

Cotton height was reduced in 1986 following 2 years of rice compared to continuous cotton (Table 1). In 1987, cotton height was reduced following 1 year of rice as compared to the continuous cotton treatment. Control of crop height is desirable throughout much of the irrigated cotton belt. However, implementation of a rotation system involving rice to control crop height seems less reliable t han conventional methods, such as applications of growth regulators.

Reductions in crop height in 1986 can be explained in part by soil compaction, which was greater following 2 years of rice than in any other system evaluated in 1986 (Table 1). This increase in compaction could conceivably adjust crop growth and establishment. In 1987, soil compaction did not seem to be influenced by any rotation system. Soil compaction following 2 years of rice may have increased due to the cementing action of water.

Table 2. Influence of a rice-cotton rotation on crop yield for 4 years at the Delta Branch Experiment Station, Stoneville, MS.

Treatment description	Crop yields[1]		
	1985	1986	1987
	--------(lb/A)--------		
Continuous cotton	2,376	1,556	2,351
Continuous rice	(6,963)	(5,972)	(5,254)
1:1 Rice-cotton	2,480	(5,672)	2,007
1:2 Rice-cotton	2,565	1,507	(5,928)
2:2 Rice-cotton	(7,111)	1,961	2,242
1:3 Rice-cotton	2,499	1,307	2,084
LSD (5%)[2]			
cotton	491	714	274
rice	1,912	1,609	886
C.V. (%)			
cotton	12.4	28.2	12.2
rice	12.1	12.3	7.1

[1]Rice yields are shown in parentheses. Cotton yields are for seed cotton.

[2]For comparison of any two means within a column or crop.

Seed cotton yield

In 1985 and 1986, seed cotton yields (Table 2) were not influenced by any rotation system evaluated when compared to continuous cotton. However, there was a trend for higher yields following 2 years of rice. This numerical increase may be largely attributed to the fact that subsoil moisture was more adequate in plots that had 2 previous years of flooded rice. In 1987, second and third year cotton crops following rice were similar. In the 1:1 system, seed cotton yields were lower than in the continuous cotton plots. This may be due to the higher plant population (approximately 64,000/A) in these plots. Bridge et al. (5) reported gradual yield declines from plant populations greater than 48,000 plants/A. However, this may not apply to the earlier, faster fruiting varieties such as the one used in this study. They also reported that hill-drop planted cotton was more sensitive to higher populations than drill-planted cotton.

Soil nutrient status

Percent organic matter at either depth sampled was not affected by any system evaluated (Table 3). Soil pH at the 6- to 12-inch depth was not affected by any system evaluated. In 1987, soil pH for the continuous cotton system was statistically higher than any system except the 1:3 rice-cotton rotation. Earlier reports have indicated that the rotation receiving the greatest amount of nitrogen fertilizer had lower pH values (14). In this study, rice received 35 pounds per year more nitrogen than cotton. Phosphorus and potassium remained relatively unchanged at either depth for all systems evaluated (Table 4). By 1987, calcium levels at 0-6 inches were lower in continuous rice plots and plots with the 1:1 system.

Differences in magnesium, zinc, and sulphur did not appear to be due to the rotational scheme (Table 5). For example, in 1987, the 1:1 system seemed to deplete magnesium more than other systems. However, the magnesium level was found to be lower in these plots at the beginning of the study. When comparisons were made to continuous cotton, differences in these elements were not apparent.

Changes in soil nutrient status for this study were minor and support earlier findings (15, 22, 28). These types of changes usually require longer periods than reported here and usually involve those crops which provide residual nitrogen such as legumes (12). Both cotton and rice require additional inputs of nitrogen to achieve maximum yield. The soil type used in this study tested high or very high for all available nutrients other than nitrogen. Thus, it appears that any change in the soil nutrient status would be in addition to that already present and of no benefit to the crop. Changes in soil nutrient status, if definable for these systems, would be more important on soil

Table 3. Influence of a 4-year rice-cotton rotation on percent organic matter and soil pH. Delta Branch Experiment Station, Stoneville, MS.

Treatment description	Soil test analysis at 0 t o 6 inches[1]							
	% Organic matter				Soil pH			
	1984	1985	1986	1987	1984	1985	1986	1987
	(%)							
Continuous cotton	0.78	0.93	0.86	0.65	6.7	6.2	6.1	7.0
Continuous rice	0.73	0.90	0.84	0.68	6.5	6.3	6.2	6.7
1:1 Rice-cotton	0.71	0.96	0.86	0.70	6.6	6.1	6.2	6.7
1:2 Rice-cotton	0.76	1.01	0.85	0.74	6.6	6.3	6.2	6.7
2:2 Rice-cotton	0.86	0.99	0.90	0.78	6.7	6.4	6.2	6.6
1:3 Rice-cotton	0.76	1.00	0.93	0.81	6.6	6.1	6.3	6.8
LSD (5%)[2]	0.13	0.12	0.1	0.1	0.2	0.5	0.3	0.3
C.V. (%)	11.5	8.1	7.4	12.5	2.9	5.0	3.5	2.5
	Soil test analysis at 6 to 12 inches							
Continuous cotton	0.69	0.79	0.66	0.52	6.6	6.2	6.5	6.7
Continuous rice	0.68	0.73	0.67	0.60	6.5	6.7	6.6	7.1
1:1 Rice-cotton	0.67	0.77	0.52	0.54	6.5	6.3	6.4	7.0
1:2 Rice-cotton	0.66	0.87	0.59	0.63	6.4	6.4	6.4	6.9
2:2 Rice-cotton	0.76	0.83	0.65	0.62	6.8	6.7	6.6	7.0
1:3 Rice-cotton	0.62	0.80	0.49	0.60	6.5	6.3	6.4	6.7
LSD (5%)	0.17	0.13	0.2	0.2	0.4	0.5	0.4	0.4
C.V. (%)	17.0	11.2	20.4	20.0	3.8	5.1	2.8	3.5

[1]As determined by the MCES Soil Testing Laboratory.
[2]For comparison of any two means within a column or sample depth.

Table 4. Influence of a 4-year rice-cotton rotation on phosphorous, potassium, and calcium. Delta Branch Experiment Station, Stoneville, MS.

Treatment description	Phosphorous 1984	Phosphorous 1984	Phosphorous 1986	Phosphorous 1987	Potassium 1984	Potassium 1985	Potassium 1986	Potassium 1987	Calcium 1984	Calcium 1985	Calcium 1986	Calcium 1987
	Soil test analysis at 0 to 6 inches[1] (lb/A)											
Continuous cotton	201	215	211	163	341	379	355	330	2,825	3,118	3,025	2,341
Continuous rice	188	190	196	143	331	372	334	238	2,930	2,825	2,686	1,800
1:1 Rice-cotton	189	188	210	155	345	409	366	288	2,695	2,699	2,739	1,808
1:2 Rice-cotton	232	236	226	191	340	436	339	291	3,237	3,466	2,803	2,247
2:2 Rice-cotton	226	222	238	176	392	409	387	298	2,845	3,091	3,057	2,287
1:3 Rice-cotton	212	202	232	175	359	396	343	312	3,026	2,962	3,101	2,421
LSD (5%)[2]	57	44	72	67	102	83	58	94	758	783	289	438
C.V. (%)	18.1	13.9	21.7	18.8	19.3	13.8	10.9	21.2	17.2	17.1	6.6	13.5
	Soil test analysis at 6 to 12 inches											
Continuous cotton	216	252	218	160	287	361	236	173	3,182	4,100	3,546	2,414
Continuous rice	199	227	211	188	289	355	250	201	3,219	3,692	3,618	2,468
1:1 Rice-cotton	206	232	215	192	302	382	256	215	3,221	3,610	3,360	2,365
1:2 Rice-cotton	240	270	280	234	290	392	243	178	3,120	4,329	3,335	2,751
2:2 Rice-cotton	237	285	231	202	334	408	274	214	3,605	4,272	3,495	2,742
1:3 Rice-cotton	226	257	233	181	282	360	212	198	3,507	3,760	3,140	2,560
LSD (5%)[2]	90	80	132	79	101	78	68	68	634	478	350	624
C.V. (%)	27.1	27.1	37.7	27.2	22.5	13.8	18.5	23.0	12.7	8.0	8.7	16.2

[1]As determined by the MCES Soil Testing Laboratory.
[2]For comparison of any two means within a column or sample depth.

Table 5. Influence of a 4-year rice-cotton rotation on magnesium, zinc, and sulphur. Delta Branch Experiment Station, Stoneville, MS.

Treatment description	Magnesium 1984	Magnesium 1984	Magnesium 1986	Magnesium 1987	Zinc 1984	Zinc 1985	Zinc 1986	Zinc 1987	Sulphur 1984	Sulphur 1985	Sulphur 1986	Sulphur 1987
	Soil test analysis at 0 to 6 inches[1] (lb/A)											
Continuous cotton	480	454	508	366	4.5	4.7	6.7	2.2	111	133	123	93
Continuous rice	429	436	496	356	3.3	4.9	6.1	2.1	116	128	121	97
1:1 Rice-cotton	429	438	488	272	5.2	4.4	4.5	1.6	102	128	123	100
1:2 Rice-cotton	437	626	536	412	4.2	6.2	6.6	2.1	109	142	122	107
2:2 Rice-cotton	425	486	567	365	3.7	5.4	5.6	2.1	124	145	130	112
1:3 Rice-cotton	528	550	574	395	3.1	4.3	5.0	1.9	109	144	133	116
LSD (5%)[2]	66	136	176	130	3.5	1.8	3.3	0.8	27	17	14	20
C.V. (%)	9.6	18.1	22.1	23.9	58.4	23.3	38.0	25.3	15.9	8.1	7.3	12.6
	Soil test analysis at 6 to 12 inches											
Continuous cotton	578	520	711	406	3.7	5.4	4.0	2.0	99	113	96	74
Continuous rice	569	529	698	571	3.7	4.9	4.9	1.7	98	105	90	85
1:1 Rice-cotton	542	514	862	417	2.5	5.9	3.2	1.5	96	110	74	78
1:2 Rice-cotton	537	563	715	452	3.6	5.6	4.2	2.2	95	125	84	91
2:2 Rice-cotton	531	605	709	492	4.0	6.4	3.9	2.4	109	119	93	87
1:3 Rice-cotton	650	642	908	511	2.1	4.4	2.9	1.5	89	114	71	91
LSD (5%)[2]	104	101	218	258	1.6	2.4	2.3	0.6	25	20	26	26
C.V. (%)	12.2	12.0	18.8	36.0	32.2	29.0	39.6	20.7	17.2	11.4	20.5	20.8

[1]As determined by the MCES Soil Testing Laboratory.
[2]For comparison of any two means within a column or sample depth.

types that require additional inputs of nutrients other than nitrogen.

Net returns

The 4-year average net return per acre was calculated for each rotational scheme. Continuous cotton resulted in $143/A net return (Table 6). Two years of rice followed by 2 years of cotton resulted in net returns of $131/A. The 1:1 system had a 4-year average net return of $114/A. There were no statistical differences in net returns for any system evaluated. However, numerical differences, such as those discussed earlier, favor continuous cotton over a rotational system. This, coupled with the lack of short-term soil benefit, makes it difficult to consider rice as a rotational crop with cotton.

Table 6. Net returns (above specified expenses) to land and management for six rice-cotton rotation systems. Delta Branch Experiment Station, Stoneville, MS.

	Net returns[1]				
Treatment	**1984**	**1985**	**1986**	**1987**	**4 yr-avg.**
	($/A)				
Continuous cotton	301	156	−36	150	143
Continuous rice	(116)	(158)	(65)	(10)	88
1:1 Rice-cotton	(145)	181	(61)	69	114
1:2 Rice-cotton	(160)	201	−49	(80)	98
2:2 Rice-cotton	(170)	(170)	58	125	131
1:3 Rice-cotton	(154)	186	−96	87	83
LSD (5%)[2]	84	NS	NS	NS	NS

[1]Returns for rice are shown in parentheses.
[2]For comparison of any two means.

Conclusion

On a short-term basis, rice did not influence seed cotton yields appreciably, nor did it offer any advantages in terms of net profit. In fact, a slight reduction in yield occurred following 1 year of rice in 1987, due apparently to increased plant populations and reduction in height. The appreciable amount of rice straw at the end of the growing season did not improve organic matter as expected. For this soil type, continuous rice seemed to reduce available calcium significantly.

Problems associated with production of rice on the soil type used in this study make it economically infeasible to produce at present. These problems include:

(1) Instability of levee construction due to high sand content.
(2) The need for increased flushings early in the spring to maintain crop uniformity and stand. Flushing was necessary in some cases to alleviate constriction of young plants at the soil line.
(3) Nitrogen rates for rice on this soil type have not been established and will be necessary to more closely optimize yield.
(4) Disease incidence was higher on this soil type than when similar rice varieties were grown on other soil types in adjacent areas.
(5) An increased level of management was required due to fertilization, weed control, and disease problems associated with the soil type used in this study.

References

1. Allison, F. E. 1973. A factor in plant disease control. p. 378-396. *In* Soil Organic Matter and Its Role in Crop Production. Elsevier Scientif ic Publ. Co.
2. Barker, G. L., J. O. Sanford, and L. L. Reinschmiedt. 1984. Crop-rotations versus monocrop systems for the hill areas of Mississippi. MAFES Res. Rep. 9:7, 4 p.
3. Beatty, K. D., and I. L. Eldridge. 1980. 1979 results from crop rotation study. Keiser. Ark. Farm Res. 2:6.
4. Brawand, H., and L. R. Hossner. 1976. Nutrient content of leaves and grain as influenced by long-term crop rotation and fertilizer treatment. Agron. J. 68:277-280.
5. Bridge, R. R., W. R. Meredith, Jr., and J. F. Chism. 1973. Influence of planting method and plant population on cotton (*Gossypium hirsutum* L.). Agron. J. 65:104-109.
6. Cleveland, O. A., and J. G. Hamill. 1988. Cotton – 1988 cost and returns. MAFES Agric. Econ. Report 25.
7. Curl, E. A. 1963. Control of plant diseases by crop rotation. Bot. Rev. 29:413-479.
8. Dale, J. E., and J. M. Chandler. 1979. Herbicide-crop rotation for johnsongrass (*Sorghum halepense*) control. Weed Sci. 27:479-485.
9. Dowler, C. C., E. W. Hauser, and A. W. Johnson. 1974. Crop herbicide sequences on a southe astern coastal plains soil. Weed Sci. 22:500-505.
10. Flocker, W. J., J. A. Vomocil, M. T. Vittum, and L. D. Doneen. 1958. Affect of rotation with green manure and irrigation on physical characteristics of Hesperia sandy loam. Agron. J. 50:251-254.

11. Funchess, M. J. 1927. Crop rotation in relation to southern agriculture. Agron. J. 19:555-566.

12. Funchess, M. J. 1925. The utilization of legumes in rotation. Agronomy Journal 17:398-403.

13. Harvey, C., D. L. Jones, and C. E. Fisher. 1961. Dryland crop rotations on the southern high plains of Texas. Texas Agric. Exp. Stn. MP-544. 11 p.

14. Harvey, C., H. J. Walker, E. L. Whitely, and B. W. Hipp. 1964. Irrigated rotations on the south plains of Texas. Texas Agric. Exp. Stn. MP-711. 10 p.

15. Hinkle, D. A. 1969. Crop rotation studies on Sharkey clay soil. Arkansas Agric. Exp. Stn. Rep. Ser. 176. 11 p.

16. Hunisgai, G., and B. N. Patil. 1972. Effect of crop rotation on physical and chemical properties of soil and their effects on yield of Jowar and cotton. Indian J. of Agron. 17:182-187.

17. Johnson, W. M., and L. A. Brinkerhoff. 1977. Systems and formation of microsclerotia in weeds inoculated with the verticillium wilt pathogen. Abst. Proc. Beltwide Cotton Prod. Res. Conf. First Cotton Weed Science Research Conf. p. 183.

18. Krishnaiah, V. V., M. Dharma Raod, N. Ranganadhacharyulu, V. David, and G. R. Padaki. 1969. Sowing in prepared lands increases bottom yields in rice fallows. Indian Farm. 19:14-16.

19. Kurtz, M. E., C. E. Snipes, M. W. Ebelhar, and F. T. Cooke. 1987. Preliminary investigation of a soybean-rice rotation. MAFES Res. Rep. 12:17, 4 p.

20. Mandal, B. K., and M. V. Fao. 1979. Studies on multiple cropping involving cotton and rice on medium land of coastal Orissa. Oryza 16:8590.

21. Page, J. B., and C. J. Willard. 1947. Cropping systems and soil properties. Soil Sci. Soc. Amer. Proc. 11:81-88.

22. Peevy, W. J., F. V. Smith, and P. E. Brown. 1940. Effects of rotations and manure treatment for 20 years on the organic matter, nitrogen, and phosphorous, contents of Clarion and Webster soils. J. of Am. Soc. of Agron. 32:739-753.

23. Raney, W. A., and A. W. Cooper. 1968. Soil adaptation and tillage. p 75-115. *In* F. C. Elliot, M. Hoover, and W. K. Porter, Jr. (ed.) Cotton: Principles and Practices. Iowa State University Press, Ames, IA.

24. Robinson, E. L., J. E. Dale, and W. C. Shaw. 1967. Herbicide-crop rotation for weed control. Weed Sci. 15:243-245.

25. Rodriguez-Kabana, R. 1982. The effects of crop rotation on soil xylanase activity in a soil of the Southwestern United States. Plant and Soil. 64:237-247.

26. Rogers, C. H. 1937. The effect of three and four-year rotation on cotton root rot in the central Texas blacklands. Agron. J. 29:668-680.

27. Spurgeon, W. I., and P. H. Grissom. 1965. No advantages seen for crop rotation in the Delta cotton study. Mississippi Farm Res., 28:VI, June.

28. Spurgeon, W. I., and P. H. Grissom. 1965. The influence of cropping systems on soil properties and crop production. MAFES Bull. 710. p. 1-20.

29. Sturkie, D. G. 1966. Rotations increase yield of cotton, corn, and oats. MAFES Highlights of Agr. Res., Nov.

30. Uhland, R. E. 1949. Physical properties of soils as modified by crops and management. Soil Sci. Soc. Amer. Proc. 14:361-366.

31. Van Bavel, C. G. M., and F. W. Schaller. 1950. Soil agg regation, organic matter, and yields in long-time experiments as affected by crop management. Soil Sci. Soc. Amer. Proc. 15:399-404.

32. Weir, W. W. 1927. Crop rotation. Symposium on Crop Rotation. Agron. J. 19:517-568.

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