the Old Rotation 1995

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This Progress Report is the first in a planned annual update on the "Old Rotation." Crops yields and trends on the Old Rotation seem to reflect experiences that Alabama cotton producers also experience each year. The Old Rotation is an index of long-term sustainability of cotton production in Alabama.

Acknowledgments

The Old Rotation exists as the world's oldest, continuous cotton plots, and the third oldest continuous field crop experiment on the same site in the United States because of the dedication of cooperation of many individual researchers and administrators at Auburn University. Recently, the support of the Alabama Agricultural Experiment Station (AAES), under the leadership of AAES Director Dr. Lowell Frobish and AAES Associate Director Dr. David Teem, has been the primary reason the Old Rotation has continued to exist. The help of the staff at E.V. Smith Research Center (EVSRC), Dr. Jim Bannon, EVSRC Director, and the AAES's Research Operations on the A.U. campus have been necessary to plant, maintain, and harvest the plots. Most of the day-to-day work and maintenance is conducted by Mr. Charlie France, Research Technician, who has worked on these plots for more than 35 years.

The Old Rotation--1995

Charles C. Mitchell[1]

The "Old Rotation" experiment on the campus of Auburn University contains the oldest, continuous cotton plots in the world. The test was started in 1896 by Professor J.F. Duggar to test and demonstrate his theories that sustainable cotton production was possible on Alabama soils if growers used crop rotation and include winter legumes (clovers and/or vetch) to protect the soil from winter erosion and provide nitrogen (N) for the summer crop. The experiment has continued with only slight modifications in the treatments used on the 13 original plots. The Old Rotation was placed on the National Register of Historical Places in 1988. The year 1995 marks the 100th cropping year for the Old Rotation.

Objectives

The objectives today are very similar to Professor Duggar's original objective, i.e. to determine the effect of crop rotations and winter legumes on sustainable production of cotton in the southern U.S. In addition, fertilizer phosphorus (P) and potassium (K) treatments initiated in 1925 allowed early researchers to evaluate the timing of P and K applications to cotton rotation systems. Today, the site is also used as a field laboratory for researchers, students, and visitors interested in long-term, sustainable crop production systems in the southern U.S.

Methods

The site is at the junction of the Piedmont Plateau and Gulf Coastal Plain soil physiographic regions. The soil is generally identified as a Pacolet sandy loam (clayey, kaolinitic, thermic Typic Hapluduts). There are 13 plots on one acre of land. Each plot is 136 feet long by 21.5 feet wide with a three-foot alley between each plot. Originally, each plot was a separate treatment, but today, treatments may be described as the following cropping systems:

I. Continuous cotton
- A. No legume/no fertilizer N (plots 1 & 6)
- B. Winter legumes (crimson clover and/or vetch) (plots 2, 3, & 8)
- C. 120 pounds N per acre (as ammonium nitrate) (plot 13)

II. Cotton-corn rotation
- A. Winter legumes (plots 4 & 7)
- B. Winter legumes + 120 pounds N per acre (plots 5 & 9)

III. Three-year rotation
- (1) Cotton (winter legumes) - (2) corn (small grain for grain)
- (3) soybeans (plots 10, 11, & 12)

[1] Mitchell is Professor of Agronomy and Soils at Auburn University.

Of minor interest today is the timing of fertilizer P and K. Originally, the soil was low in both P and K and the winter legume produced more biomass (and more N) with direct P and K applications. This provided more N for the following cotton crop resulting in higher cotton yields. Today, all soils test high in P and K and there is no longer a differential response to the time of fertilizer application although the treatments continue. They are:

(1) P & K applied prior to planting cotton (plot 8)
(2) P & K applied to the winter legume in fall (plot 2)
(3) P & K split, i.e. 1/2 to cotton and 1/2 to legume (plot 3)
(4) P & K split between cotton and winter legumes in a cotton-corn rotation (plots 4 & 7)

All plots have received a total application of 80 pounds P_2O_5 and 60 pounds K_2O per acre per year since 1956. Fertilizer N or legume N is the only fertility variable. Lime is applied to each plot as determined by a soil test to maintain soil pH between 5.8 and 6.5. Soil samples are taken in even-numbered years.

Crop varieties planted have always been those common varieties recommended and used by area growers. In 1995, varieties planted and dates harvested were:

Crop	Variety/cultivar	Date planted	Date harvested
Winter legume	AU Robin	11/3/94	4/3/95
Cotton	DPL 5690	5/10/95	9/20/95
Corn	DK 689	4/13/95	8/30/95
Small grain	wheat	10/15/94	5/26/95
Soybean	Stonewall	6/20/95	11/15/95

Management involves conventional tillage and pest control. Subsoiling under the row just prior to planting was implemented about eight years ago. The following management sequence is generally used:

early April: clip winter legumes for dry matter yield; disk and turn under winter legume
mid April: subsoil cotton and corn plots; plant corn using conventional tillage
late April: plant cotton using conventional tillage
late May/early June: harvest small grain for grain
mid June: plant soybean following small grain
summer: scout cotton and apply appropriate insecticides
late August: harvest corn for grain
September: plant small grain following corn
early October: harvest cotton; overseed with winter legumes and incorporate with cultivator;
late October: chop cotton stalks when winter legumes are established
early November: harvest soybean

1995 RESULTS

<u>CROP YIELDS.</u> This year marked the 100th cropping year for the Old Rotation. It also produced one of the worst cotton crops in the history of the experiment. Long-term yields on plot #3 (cotton with winter legumes) gives an indication of the variation in yields from year to year and the five-year running average (Fig. 1). Estimated lint yields (assuming 38% lint in seed cotton) was 310 pounds per acre compared to the

1985-1994 10-year average of 920 pounds lint per acre (Table 1). Generally, yields from plot 3 are about 20% higher than the state average cotton yields. Cotton was initially planted on April 21. A 1.5-inch rain severely crusted the soil in all plots resulting in a very weak stand. The test was disked and cotton was replanted on May 10. A very dry May, June, and July devastated the cotton crop in central Alabama. Fortunately, the Old Rotation escaped some of the insect pressure commercial fields experienced. This may be related to the relative small size of the test and the large buffer areas which support beneficial insects.

The corn grain crop was also devastated by the drought. Grain yields on the three corn plots averaged 35 bushels per acre compared to a 10-year average of 90 bushels per acre.

Surprisingly, soybean following small grain did much better in 1995 than in 1994. The 1994 crop was not harvested due to extremely low yields. Rains in August, September, and especially Hurricane Opal on October 5, resulted in enough moisture to produce 27 bushels soybean per acre on plot #10.

SOIL ORGANIC MATTER. Interest in sustainable agricultural systems and soil quality dominates agronomic research today. Surprisingly, little effort has been directed over the past 100 years toward documenting the effects of the cropping systems in the Old Rotation on soil organic matter and its effect on yields. Soil organic matter was first measured on plots of the Old Rotation in 1988. Since then, measurements have been repeated in 1992 and 1994. As expected, the long-term treatments have had a dramatic effect on the buildup or depletion of soil organic matter. This is reflected in the yields. Yields in 1988, 1992, and 1994 are closely correlated with soil organic matter measurements (Fig. 2).

CONCLUSIONS

In its 100th cropping year, the Old Rotation continues to document the long-term effects of crop rotation and winter legumes on sustainable cotton production in the Deep South. 1995 was a disaster year for Alabama's cotton crop and especially for cotton and corn on the Old Rotation. Yields were approximately one-third of the 10-year average. Nevertheless, the long-term yields suggest that winter legumes are as effective as fertilizer N in producing optimum cotton yields. Yields are also highly correlated with soil organic matter which reflects the long-term treatments. While crop rotations benefit long-term cotton yields, the effect is small and probably not economical considering the crop value.

During fall of 1996, the Centennial of the Old Rotation will be celebrated on the campus of Auburn University.

TABLE 1. YIELDS OF WINTER LEGUMES AND COTTON LINT FROM THE OLD ROTATION, 1995					
		Winter legumes		Cotton lint	
Plot	Treatment	1995	10-yr. ave.	1995	10-yr. ave.
		*Lb. dry matter/acre**		*Lb. lint/acre*	
1	no legume	--	--	270	340
2	+ legume	3,040	3,350	250	850
3	+ legume	1,910	3,340	310	920
4	cotton-corn + legume	1,880	3,260	corn	820
5	cotton-corn + legume + 120 N	1,880	3,260	corn	850
6	same as #1	--	--	0	370
7	same as #4	1,520	3,400	350	980
8	+ legume	3,520	3,700	280	920
9	same as #5	1,790	3,490	330	1,190
10, 11 & 12	3-yr. rotation	4,460	3,240	470	840
13	no legume/+120 N	--	--	210	770

*There were no long-term, significant differences in winter legume dry matter yield.

TABLE 2. YIELDS OF CORN GRAIN, SMALL GRAIN, AND SOYBEAN FROM THE OLD ROTATION, 1995							
		Corn grain		Small grain*		Soybean	
Plot	Treatment	1995	10-yr. ave.	1995	10-yr. ave.	1995	10-yr. ave.
		(Bu./acre)		*(Bu./acre)*		*(Bu./acre)*	
4	cotton-corn + legume	33	70	--	--	--	--
5	cotton-corn +legume/+120N	27	97	--	--	--	--
7	same as #4	cotton	58**	--	--	--	--
9	same as #5	cotton	75**	--	--	--	--
10,11 &12	3-yr. rotation	45	104	38	27	27	31

*Small grain is rye or wheat.
**A drought in 1986 devastated corn on these plots reducing the 10-year average yield compared to plots 4 and 5 which were planted in cotton that year.

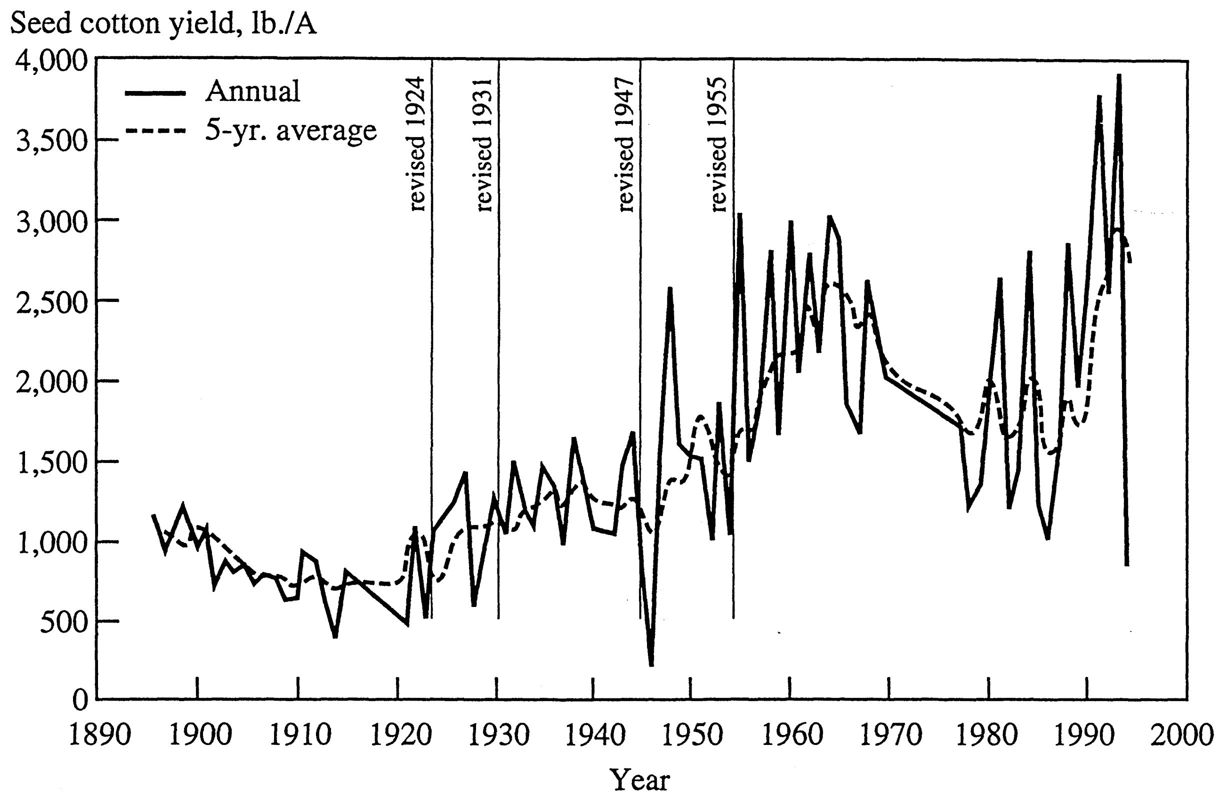

Fig. 1. Yield Trends Over 100 Years.
Seed cotton yields from plot #3 (continuous cotton with winter legumes) are examples of the yield trends over the 100 years of the Old Rotation. Year-to-year yields vary tremendously; however, rarely does an exceptionally high yielding year follow another high yielding year. The same is true for low yielding years. While 1994 was one of the highest yielding years on record, 1995 was one of the worst. The five-year running average gives an indication of yield trends. Note that the relative decline in years following the arrival of the boll weevil in Alabma (1915) was not as dramatic as is commonly thought. Missing data from the 1970's, poor management of the plots that faced an uncertain future following relocation of the main station research farm, and the loss of the effective yet controversial insecticide DDT may all have contributed to the yield decline during this era.

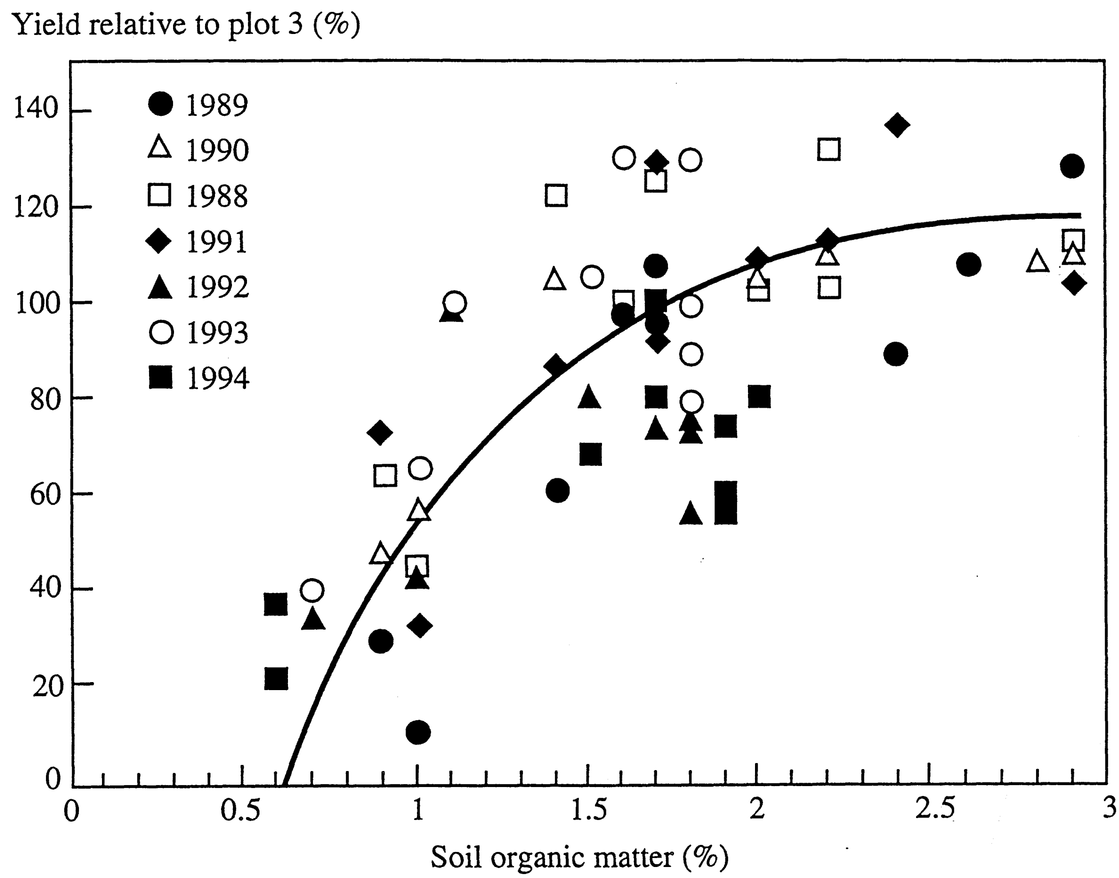

Fig. 2. Soil Organic Matter and Yield.
Long-term treatments have resulted in significant differences in soil organic matter. These differences are reflected in soil structure, water holding capacity of the plow layer, increased soil buffering capacity (e.g. increased cation exchange capacity), total mineralizable nitrogen, etc. Soil organic matter was measured in 1988, 1992, and 1994 and regressed against plot yield relative to plot #3 (continuous cotton and winter legumes).