120 Years of Sustainable Crop Production

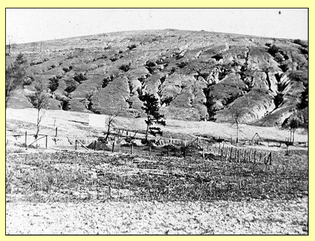
C.C. Mitchell*,and D.P. Delaney, Auburn University, AL
K.S. Balkcom, USDA-ARS Soil Dynamics Lab, Auburn, AL

The Old Rotation (circa 1896) experiment was placed on the National Register of Historical Places in 1988 as the oldest cotton study in the USA. Today, it is the oldest cotton study in the world and one of the world's oldest, continuous cover crop studies.

ABSTRACT

In the late 1800s, the Southern U.S. was producing most of the world's cotton on highly erodible soils with little or no lime or fertilizer inputs. Continuous cotton with no cover crops was taking a toll from the land and its farmers. Land Grant Universities and Experiment Stations were just getting started when Professor J.F. Duggar at Alabama Agricultural and Mechanical College (now Auburn University) established an experiment to test his theories that agriculture could thrive if farmers would ". . . keep their fields green in winter." Thus began Alabama's "Old Rotation" experiment (circa 1896) followed by the nearby "Cullars Rotation" experiment (circa 1911), two of the oldest, continuous experiments in the world involving cotton. They continue because of their contribution to our knowledge of sustainable crop production on the highly weathered soils of the Southeastern U.S. These experiments remain relevant because they have been modified for conservation tillage, irrigation, moisture monitoring and IPM and support relevant topics such as "sustainable agriculture", "soil health", and "nutrient use efficiency".

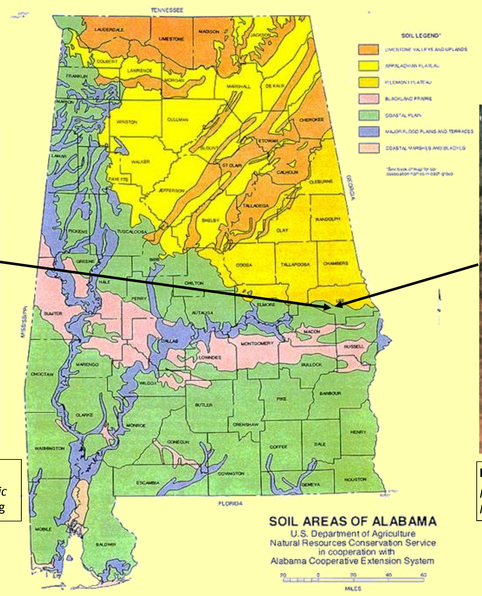
BACKGROUND



By the late 19th Century, continuous cotton production on highly erodible lands with no cover crops had taken a toll on most Southern cropland.

Professor J. F. Duggar at the Agricultural and Mechanical College of Alabama began an experiment in 1896 to test his theories that cover crops and crop rotations could sustain crop production on these soils. Today, Professor Duggar's experiment is known as the "Old Rotation". Photo shows Prof. Duggar standing in a mixture of crimson clover and hairy vetch in the Old Rotation around 1910. In 1911, the Alabama Agricultural. Experiment Station established over 200 on-farm experiments with lime and fertilizers. One of these experiments, the "Cullars Rotation" has been continued since then.

Cullars Rotation



Old Rotation

Marvyn loamy sand
Fine-loamy kaolinitic thermic Typic Kanhapludults CEC ~ 3.5 cmol+/kg

Pacolet f.s.l.
Fine kaolinitic thermic Typic Kanhapludults, CEC ~ 4.5 cmol+/kg

"Old Rotation" (circa 1896)

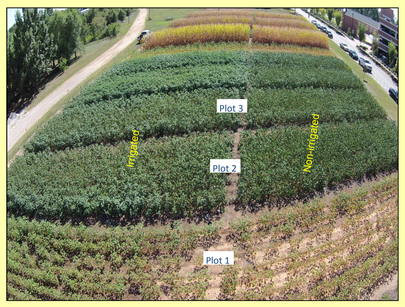
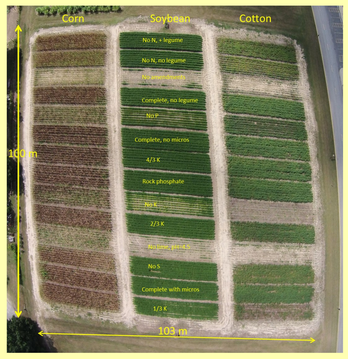


Image of "Old Rotation" (c. 1896) looking South from plot 1. Plots 1, 2 and 3 are exactly the same treatment except plots 2 and 3 are planted to a winter legume cover crop each fall. The left is irrigated and the right is not irrigated. The crop is cotton. Mature corn is on plots In the background.

"Cullars Rotation" (circa 1911)



Aerial image of "Cullars Rotation". (c. 1911), a 3-yr cotton-corn (wheat)-soybean rotation with 14 fertility treatments continuing across all tiers. Long-term fertility treatments can be dramatic. (image taken 9/04/2014)

The "Cullars Rotation" (circa 1911) was was placed on the National Register of Historical Places in 2003 as the oldest soil fertility experiment in the South. It was named for J.A. Cullars who originally farmed the land. The site is where K deficiency was first identified as the cause of cotton rust in the late 1880s.

METHODS

The Old Rotation consists of 13 plots on 1-acre of land (photo above). Changes over time have now resulted in some treatment replications. Each plot is 6.5 m wide by 41.5 m long. In 2003, irrigation was installed on half of each plot. For the first 100 yr the experiment was managed using conventional tillage. Since 1997, it has been managed using conservation tillage using in-row subsoiling and planting into strips but no inversion or surface soil disturbance. Crop rotation, cover crops and N fertilization are the only variables. **The Cullars Rotation** was started in 1911 on the farm of J.A. Cullars near Auburn. It consists of 14 soil fertility variables (pH, P, K, S, micronutrients) replicated 3 times within a 3-yr rotation of cotton (legume cover crop) - corn (wheat) - soybean. In 1997, it was also converted from conventional tillage to conservation tillage.

Crimson clover (left in early April) and/or hairy vetch has always been planted as a winter legume cover crop on both experiments. Measured N fixation in the residue at full bloom ranges from 90 to 170 kg N ha^{-1} adequate for a cotton crop but not enough for high-yielding, irrigated corn.

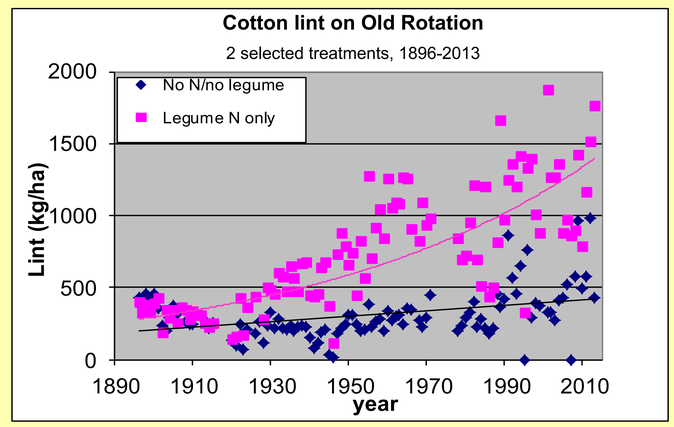
RESULTS

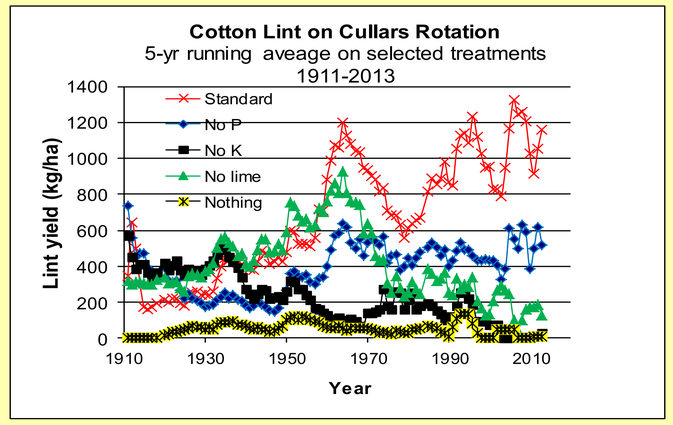
Mean crop yields and Soil Organic C on Old Rotation, 2004-2014

Treatment	Yield* Irrigated		Yield* Non-irrigated		Soil Organic C (0-10 cm)
Cotton lint (kg/ha)					---g C/kg---
No N/no cover crop	650	e	470	e	8.7
No N/+ cover crop	1220	d	1110	c	16.2
+ N/no cover crop	1530	b	1060	c	13.7
Rotation/no N + cover	1440	bc	1270	b	15.5
Rotation +N + cover	1750	a	1370	a	17.7
3-yr Rotation	1350	cd	850	d	17.0
11-YR MEAN	1260		1040		
Corn grain (kg/ha)					
Rotation no N +cover	5370	b	4270	b	15.5
Rotation +N +cover	11790	a	7120	a	17.7
3-yr Rotation	10540	a	6340	a	17.0
11-YR MEAN	9230		5230		
Wheat grain (kg/ha)					
3-yr Rotation	n/a		3510		17.0
Soybean following wheat (kg/ha)					
3-yr Rotation	3600		2510		17.0

*Values followed by the same letter or not significantly different at P<0.05.

Cover crops alone have almost doubled soil organic C; N from the legume accounts for cotton yields equivalent to about 134 kg N ha^{-1}.





Plots 6 and 7 on the Old Rotation are identical except plot 7 is a 2-yr rotation with only legume N. Neither has ever received any direct N fertilization. In 2015, plot 7 produced more than 4 times the cotton (over 4 bales per acre) as plot 6. Differences are attributed to the cover crop, soil organic matter and improved soil quality, factors that have taken many years to develop.

SUMMARY

Renewed interest in cover crops, irrigation, sustainability and soil quality/soil health in the humid Southeast make the Old Rotation and Cullars Rotation as relevant to modern crop production as they were 120 years ago. These experiments have been using conservation tillage with increasing crop yields for 19 years making them especially relevant to today's farmers and has proven a valuable resource for soil scientists and Extension specialists. Auburn University campus planners have protected both experiments from campus development.

These long-term experiments are maintained through a joint effort of the Auburn University Department of Crop, Soil and Environmental Sciences, the Alabama Agricultural Experiment Station and USDA Soil Dynamics Laboratory. They are supported by the Alabama Wheat and Feed Grains Committee, the Alabama Soybean Producers, and the Alabama Cotton Commission.