Bulletin 676
June 2011

Alabama Agricultural Experiment Station
William Batchelor, Director
Auburn University, Auburn, Alabama

Centennial of Alabama's Cullars Rotation, the South's Oldest, Continuous Soil Fertility Experiment

C. C Mitchell, D. P. Delaney, and K. S. Balkcom

INTRODUCTION

Alabama's Cullars Rotation experiment (circa 1911) was placed on the National Register of Historical Places as the oldest, continuous soil fertility experiment in the South in 2003. Along with its nearby predecessor on the National Register, the Old Rotation (circa 1896), these experiments contain the oldest cotton research plots in the world. Both experiments are located on the campus of Auburn University in east-central Alabama.

Treatments on the Cullars Rotation demonstrate dramatically the long-term effects of fertilization and the lack of specific nutrients on non-irrigated crop yields over a 100-year period. The Cullars Rotation is one of the few sites where controlled nutrient deficiencies can be observed on five different crops during the course of a year (cotton, crimson clover, corn, wheat, and soybean). The experiment preserves a site for monitoring nutrient accumulation and loss and soil quality changes and their effects on long-term sustainability of an intensive crop rotation system.

THE CULLARS ROTATION ON THE ALVIS FIELD

The Cullars Rotation was named for J. A. Cullars who owned and farmed this land in the late 19th and early 20th centuries along with his brother-in-law John P. Alvis. Early records suggest that Mr. Cullars and Mr. Alvis allowed Professor George F. Atkinson of the Agricultural and Mechanical College of Alabama (now Auburn University) and others to conduct numerous early cotton fertility experiments on this property. Professor Atkinson's research on this site led to the discovery that cotton rust was caused by a deficiency of potassium (Atkinson, 1891, 1892).

Mitchell is a professor, Delaney an extension specialist, and Balkcom an affiliate assistant professor in the Department of Agronomy and Soils, Auburn University; Balkcom is also an agronomist at the USDA-National Soil Dynamics Lab.

An appropriation by the Alabama Legislature in 1911 enabled the Alabama Agricultural Experiment Station to conduct on-farm research throughout the state. Williams and Funchess (1923) summarized 226 soil fertility experiments on farmers' fields throughout Alabama. Williams (1929) added to the data available from these tests. An extensive cotton, corn, and legume fertility test begun in 1911 on the Auburn farm of Mr. Cullars and Mr. Alvis is the only one of these experiments that has been continued. Unlike the nearby Old Rotation experiment which was begun by Professor J.F. Duggar, records do not credit any single researcher with designing the Cullars Rotation experiment. Names of professors and researchers that have been associated with the Cullars Rotation, chronologically, include J. F. Duggar, E. F. Cauthen, J. T. Williamson, M. J. Funchess, D. G. Sturkie, E. M. Evans, L. E. Ensminger, J. T. Touchton, C. C. Mitchell, and D. P. Delaney. The site of the Cullars Rotation became known as the Alvis Field.

In 1938, the Alvis Field was sold to Alabama Polytechnic Institute (now Auburn University) by Bessie Alvis Emerick and Lillian Alvis Miller, daughters and heirs of Mr. John P. Alvis. In 2000, construction of the Jule Collins Smith Museum of Art occupied most of the Alvis Field but the Cullars Rotation with a 40-foot border is preserved for on-going research and demonstration on sustainable crop production for soils of the southern U.S.

AGRONOMICS AND EXPERIMENTAL DESIGN

The Cullars Rotation was designed primarily to study the long-term effect of phosphorus, potassium, lime, and other nutrients on a three-year rotation which included cotton, corn, small grain, and summer legumes (cowpeas, crotalaria, or soybean). Today, the experiment is a three-year rotation of (1) cotton followed by crimson clover, (2) corn harvested for grain followed by winter wheat, and (3) soybean double cropped after wheat is harvested for grain. It is located on a Marvyn loamy sand (fine-loamy, siliceous, thermic Typic Kanhapludults), a soil associated with Alabama's Coastal Plain physiographic region.

Experimental design. Original design was 11 soil treatments replicated three times, one replicate for each of the three crops in the three-year rotation, in an ordered block design (Figure 1). In 1914, an additional three treatments (designated A, B, and C) were added to include the effect of winter legumes in the rotation. Plot size is 20 by 99 feet with a 2-foot border between each plot and 20 feet between each tier (block). Plots were originally 110 feet long but were shortened in the 1950s so mechanical equipment could maneuver between tiers.

Tillage and other cultural practices. Prior to 1997, all crops were conventionally tilled with moldboard plowing, disking, and regular cultivation. All green manure crops (winter legumes, cowpeas, and crotalaria) and crop residues

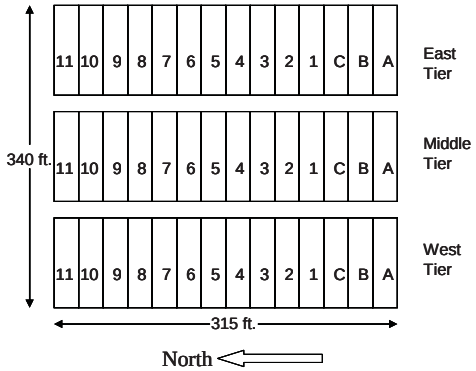


Figure 1. Schematic of Cullars Rotation (not drawn to scale) and view of experiment looking toward the east with plots A, B and C on the right as in the schematic. Each number indicates a fertility treatment. The plots designatied A, B, and C were added in 1914.

Jules Collins Smith Museum of Art

were turned under using a moldboard plow. Since 1997, all crops have been grown with minimum tillage and transgenic cultivars. Cotton and corn are planted directly into previous crop residue in 30-inch rows after paratilling or in-row subsoiling. Soybeans are drilled into wheat residue in June using a no-till drill. Since 1996, few insecticides have been applied for insect control. This has been possible because of the boll weevil eradication program in East Alabama and the advent of Bollgard® technology. All crops are machine harvested although cotton and corn yield estimates are made by hand-harvesting portions of each plot.

Fertilization. In the early years of the Cullars Rotation, sources of plant nutrients were blood meal (12-1-1) and cottonseed meal (6-1-1) for N, superphosphate (0-18-0) and rock phosphate for phosphorus, and kainit (0-0-12) for potassium. In recent decades, phosphorus as concentrated superphosphate (0-45-0), potassium as muriate of potash (0-0-60), sulfur as gypsum (18% S), and a micronutrient mix containing B, Zn, Mn, Cu, and Mo are applied to appropriate plots in split applications in the spring prior to planting cotton and in the fall just prior to planting small grain. Nitrogen as ammonium nitrate (34-0-0) is applied to appropriate plots just prior to planting cotton and corn with the remaining N applied as a sidedress application to these crops. Small grain is topdressed with 60 pounds N per acre in late February. Fertility treatments and recent soil test results are presented in Table 1. Historic treatments are listed in the Appendix tables.

Table 1. Treatments Since 1985, Mean Soil pH, Mehlich-1 Extractable Plant Nutrients, and Rating from 0- to 6-inch Soil Samples on the Cullars Rotation [1,2]

Plot	Description	Treatments [3] N	P	K	S	Other	Soil pH	Soil-test rating and Mehlich-1 extractable nutrients [4] P	K	Mg	Ca
								mg/kg			
A	No N/+legume	0	+	+	+		6.1	VH 63	M 46	H 28	423
B	No N/no legume	0	+	+	+	No legume	6.0	VH 57	M 44	H 23	330
C	***No soil amendments***	***0***	***0***	***0***	***0***		***5.2***	***L 5***	***L 21***	***L 6***	***73***
1	No winter legumes/ + N	+	+	+	+	No legume	6.2	H 46	M 52	H 33	371
2	***No P***	+	0	+	+		6.2	***VL 3***	M 34	H 31	285
3	Standard fertilization	+	+	+	+		6.1	VH 51	M 42	H 37	395
4	4/3 K	+	+	+	+	Extra K	6.2	VH 81	M 47	H 38	525
5	Rock phosphate	+	+	+	+	Rock P	6.0	***EH 200***	M 47	H 30	732
6	***No K***	+	+	0	+		6.3	EH 101	***VL 13***	H 43	541
7	2/3 K	+	+	+	+		6.2	VH56	M 37	H 34	826
8	***No lime***	+	+	+	+	No lime	4.7	VH 68	L 26	***L 3***	***200***
9	No S	+	+	+	0		6.2	VH 90	M 50	H 46	1100
10	Standard fertilization + micronutrients	+	+	+	+	+Zn,Cu, Mn, Fe, B & Mo	6.3	VH 85	M 66	H 36	953
11	1/3 K	+	+	+	+		6.1	VH 67	***L 28***	H 32	680
$LSD_{.05}$							0.3	11	16	8	376

[1] Samples taken in November 2004

[2] Particularly relevant values are in ***bold italics.***

[3] Standard lime and fertilizer treatments:
- Limed to pH 5.8 to 6.5
- 90 lb. P_2O_5 per acre per three-year rotation
- 240 lb. K_2O per acre per three-year rotation
- 90 lb. N per acre on cotton
- 120 lb. N per acre on corn
- 60 lb. N per acre topdress on small grain
- 40 lb. sulfate-S per acre applied as gypsum to cotton and small grain

[4] Rating based upon cotton on sandy soils (C.E.C. < 4.6 cmol/kg); VL=very low; L=low; M=medium, H=high (desirable range); VH=very high; EH=Extremely High (Adams et al., 1994).

THE YIELD RECORD

Few research areas exist in the U.S. where one can see such dramatic deficiencies of plant nutrients on one site. Historic yields, by year, are included in the Appendix tables. Particularly dramatic are plot C (the treatment where no soil amendment has been applied since 1911), plot 6 (the no K treatment), plot 8 (the no lime treatment), and plot 2 (the no P treatment). Deficiencies sometimes appear on other treatments but are less dramatic. In general, cotton is most sensitive to low soil K in this experiment while corn, soybean, and small grain are most sensitive to low soil P (Table 2). Cotton and soybean seem to be more sensitive to the acid soil (pH = 4.7 in 2004) in the no lime treatment than other crops in the rotation. Since 1955, all plots except treatment 8 (no lime) and treatment C (nothing) receive an application of ground, dolomitic limestone whenever the surface soil pH drops below 5.8. Although B fertilization of cotton and reseeding clover and Zn fertilization of corn are routinely recommended by Auburn University's Soil Testing Laboratory (Adams et al., 1994), no crop demonstrated a significant response to micronutrient fertilization in the period 1995-2004. Mean yields of cotton, corn, soybean, and small grain from 2001 through 2010 seem to reflect long-term trends (Table 2).

Long-term trends as demonstrated by the five-year running average yields in Figures 2 through 5 show periods of yield increases and dramatic decreases. Because this is a non-irrigated experiment, short-term droughts and other weather-related disasters during the growing season can have dramatic effects on yields. Year-to-year yield variability is high as reflected by the coefficient of variation in the 10-year average yields in Table 2. However, the downward yield trend in the late 1970s and early 1980s reflected management problems when the main research farm moved and no one was left to take care of the day-to-day management of these plots. Nevertheless, the relative yields of the different fertility treatments remained about the same.

Coincidentally, record crop yields have been recorded on the Cullars Rotation since 1996 when we switched to genetically modified varieties and in 1997 when we switched to conservation tillage (Table 3).

These yields are attributed to (1) favorable growing seasons; (2) adoption of deep tillage to disrupt traffic pans; (3) conservation tillage, which allows better moisture infiltration, higher water holding capacity, and cooler soils; (4) higher plant populations; (5) timely planting; (6) better weed control especially through the new genetically modified varieties; and (7) less insect problems as a result of the boll weevil eradication program and the new Bollgard® cotton varieties.

Table 2. Mean Crop Yields on the Cullars Rotation, 2001-2010

Plot	Treatment [1]	Cotton lint *lb/A*	Corn grain *bu/A*	Soybean grain *bu/A*	Wheat grain *bu/A*	Clover dry matter *lb/A*
A	No N/+legume	990	56	39.1	24.5	3080
B	No N/no legume	930	36	38.8	18.9	–
C	No soil amendments	20	0	0	0.4	0
1	No winter legumes/ + N	1190	94	41.1	46.3	–
2	No P	520	35	9.3	21.3	1620
3	No micronutrients	1220	98	41.0	47.3	3600
4	4/3 K	1020	89	39.7	44.6	3100
5	Rock phosphate	1080	94	41.6	47.7	2630
6	No K	0	36	21.9	39.6	1810
7	2/3 K	1030	101	40.0	51.3	3140
8	No lime, pH=4.9	220	32	2.7	9.0	870
9	No S	1030	90	41.4	45.9	2820
10	Complete fertilization + micronutrients	1150	102	42.8	50.3	3970
11	1/3 K	720	95	37.0	49.4	2840
C.V.		***33.1***	***31.3***	***28.0***	***20.5***	***50.7***
L.S.D. (P<0.05)		***233***	***19***	***7.7***	***6.4***	***1060***

[1] Standard lime and fertilizer treatments:
- Limed to pH 5.8 to 6.5 (except plots C and 8)
- 200 lb. P_2O_5 per acre per three-year rotation (except plots C and 2)
- 270 lb. K_2O per acre per three-year rotation (except plots 4,6,7 and11)
- 90 lb. N per acre on cotton in split applications (except plots A, B, C)
- 120 lb. N per acre on corn in split applications (except plots A, B, C)
- 60 lb. N per acre topdress on small grain (except C)

Table 3. Record Crop Yields on the Cullars Rotation Since 1996

Plot	Treatment [1]	Crop	Yield	Year
A	No N/+legume	Corn	161.0 bu/A	1999
1	No winter legumes/ + N	Cotton lint	1930.0 lb/A (~4 bales)	2004
5	Rock phosphate	Wheat	64.7 bu/A	2000
7	2/3 K	Cotton lint	1580.0 lb/A (3+ bales)	1996
9	No S	Wheat	63.5 bu/A	1999
10	Complete fertilization + micronutrients	Soybean	75.1 bu/A	1996
11	1/3 K	Wheat	70.0 bu/A	2001

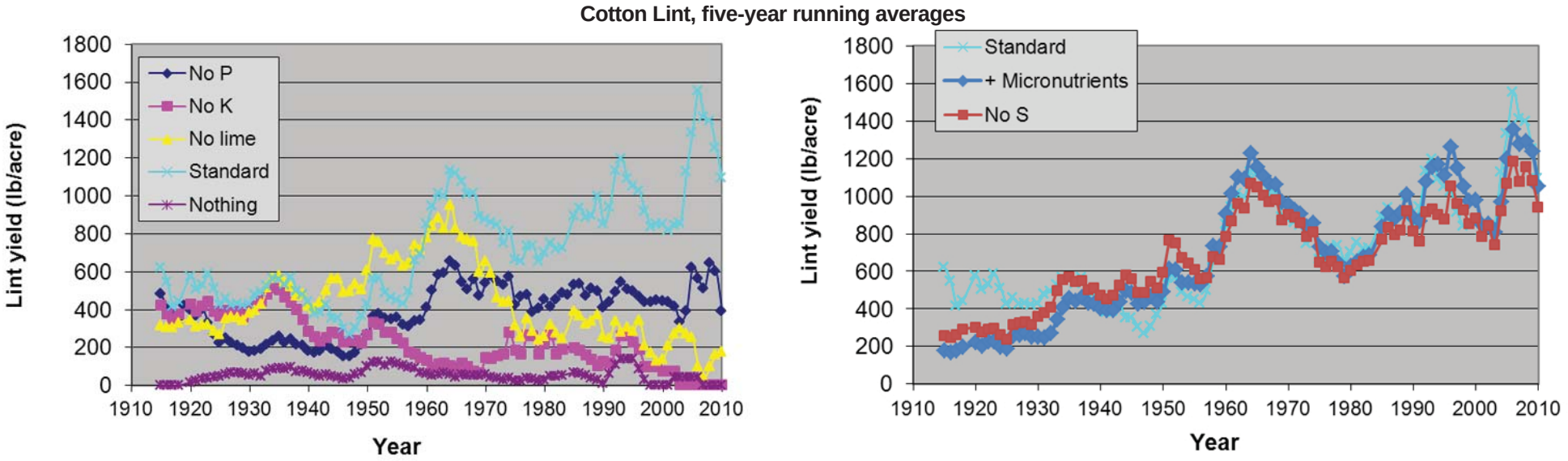


Figure 2. Long-term cotton yield trends on selected treatments on the Cullars Rotation, 1911-2010. Each point is a five-year running average.

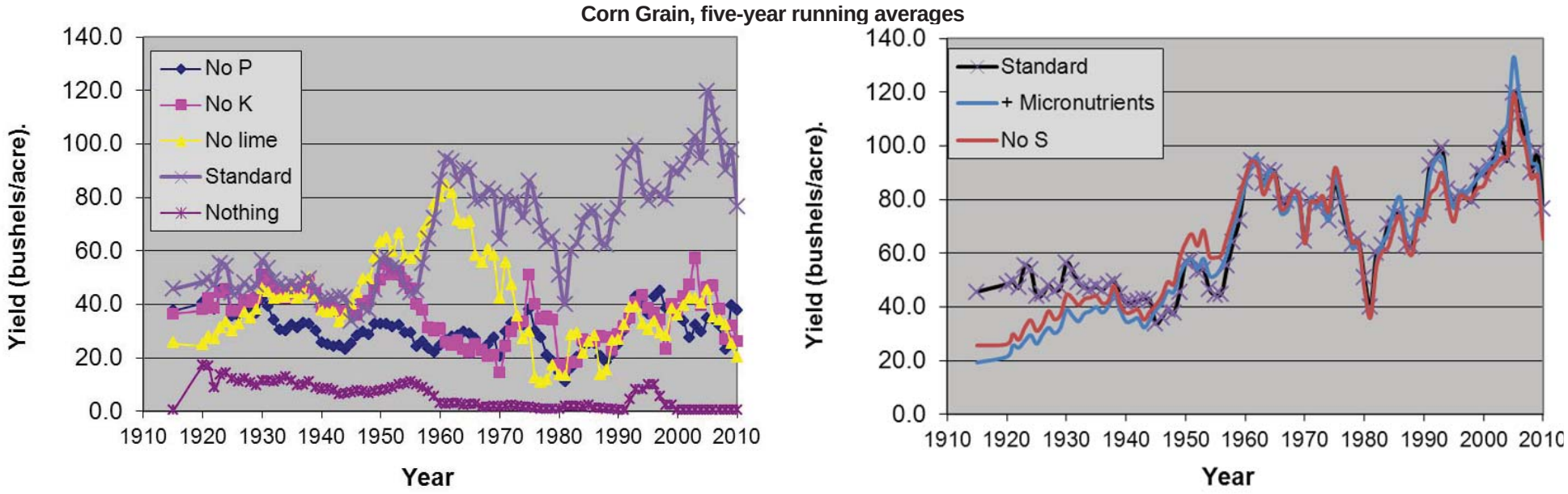


Figure 3. Long-term corn yield trends on selected treatments on the Cullars Rotation, 1911-2010. Each point is a five-year running average.

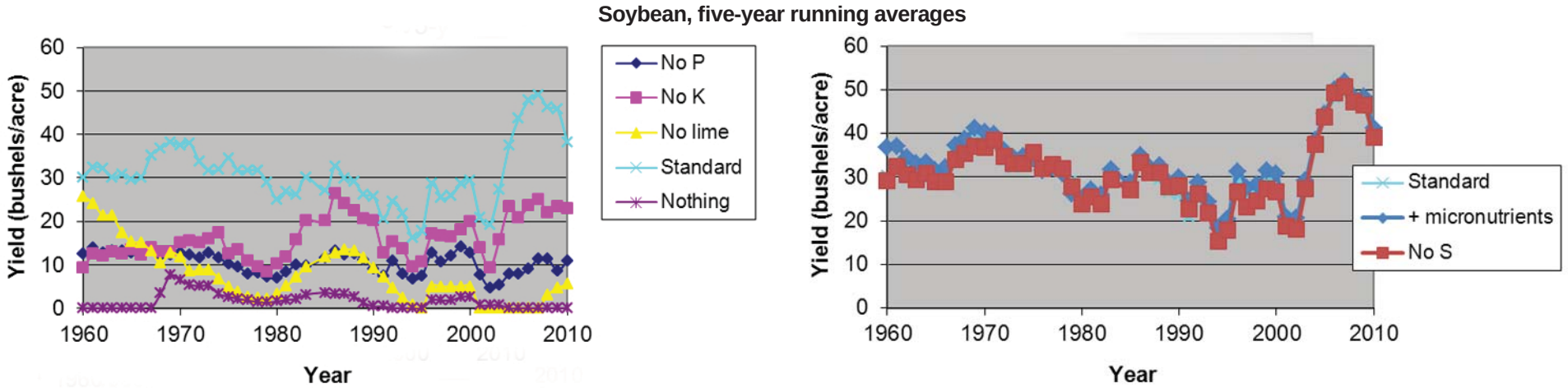


Figure 4. Long-term soybean yield trends on selected treatments on the Cullars Rotation, 1960-2010. Each point is a five-year running average.

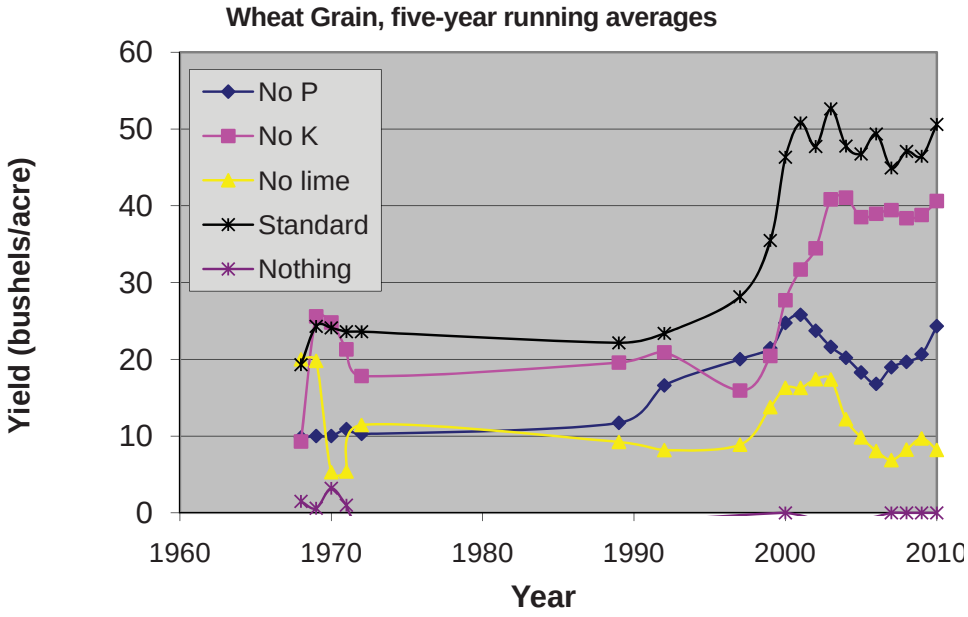


Figure 5. Long-term wheat yield trends on selected treatments on the Cullars Rotation, 1968-2010. Each point is a five-year running average. Rye instead of wheat was grown from 1972-1988.

THE SOIL TEST RECORD

The soil test record goes back to 1955, a year after the Auburn University Soil Testing Laboratory began full operation. We can find no record of soil tests prior to that time. Initially, only soil water pH (pHw) and Mehlich-1 extractable P and K were run. Magnesium was added to the record in 1965 and calcium in 1981. Trends in pHw and in Mehlich-1 extractable P, K, Mg, and Ca on selected treatments are presented in Figures 6 through 9. Mean soil test values across all three tiers by year and plot are presented in the Appendix tables.

Periodic soil organic matter (SOM) analyses on plow layer samples indicate that SOM averages about 1.2 percent (0.63 percent C) across all treatments. There is not much difference between treatments except for plot C (SOM = 0.8 percent), which has not received any fertilizer and is unproductive. Estimated cation exchange capacity of these soils based on cation summation is 3.8 cmol+/kg.

Potassium movement and accumulation in soil profile is presented in Figure 10. Soil samples taken in incremental depths to 48 inches from the K-variable treatments reveal that large quantities of K accumulate in the upper soil profile in this loamy sand with a CEC of 3.8 cmol/kg. Potassium leaching below 48 inches does occur with the higher K rates as indicated by Mehlich-1 extractable K. Therefore, routine, plow-layer soil sampling appears to be adequate to predict responses to K fertilization. Note that the application of an anion in the form of sulfate-S (as gypsum) increases K leaching.

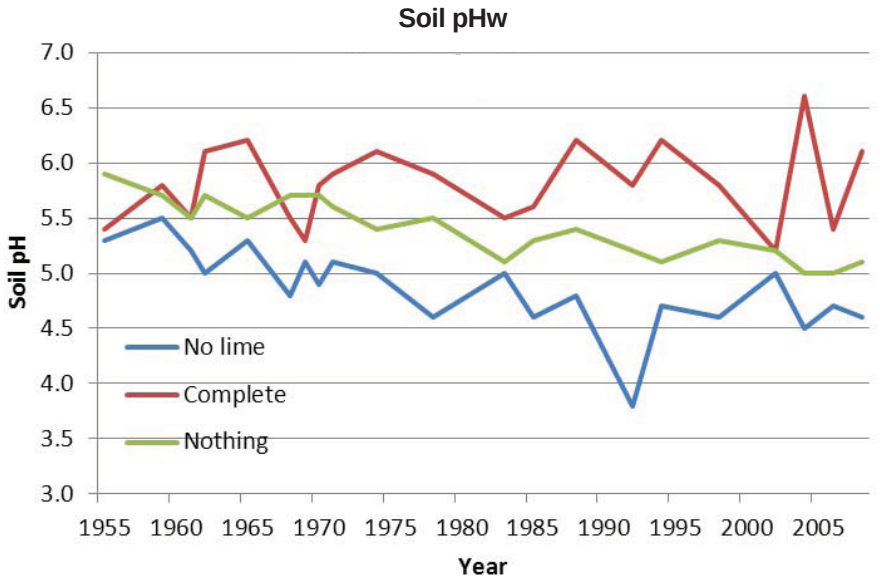


Figure 6. Trends in soil test pHw in selected treatments on the Cullars Rotation, 1955-2010.

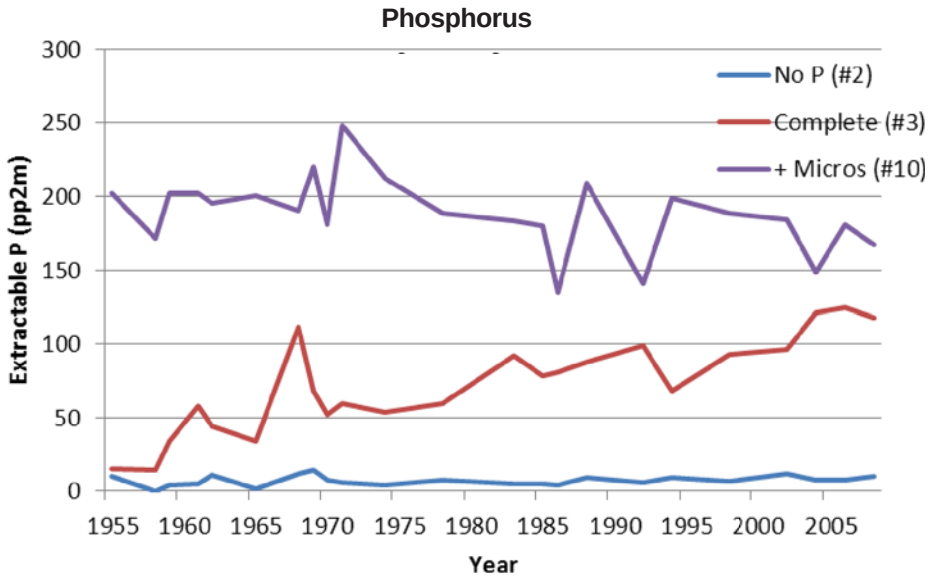


Figure 7. Trends in Mehlich-1 extractable P in selected treatments on the Cullars Rotation, 1955-2010.

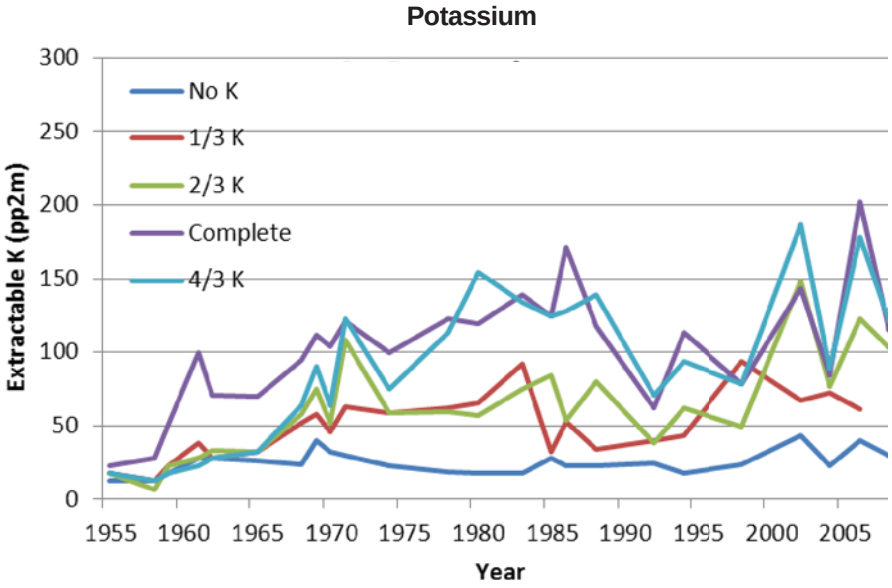


Figure 8. Long-term trends in Mehlich-1 extractable K on selected treatments on the Cullars Rotation, 1968-2010.

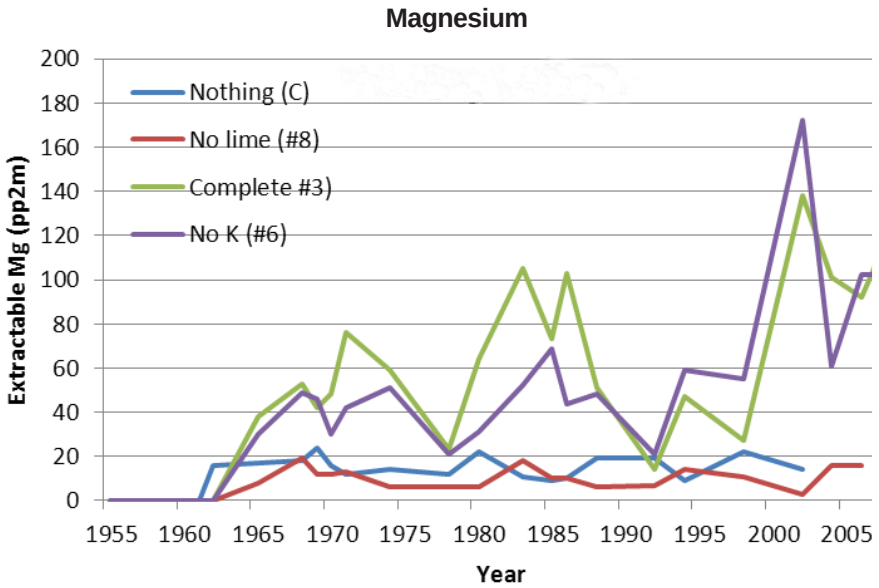


Figure 9. Long-term trends in Mehlich-1 extractable K on selected treatments on the Cullars Rotation, 1968-2010. Sharp increases in Mg are due to periodic applications of dolomitic limestone to maintain soil pH above 5.8.

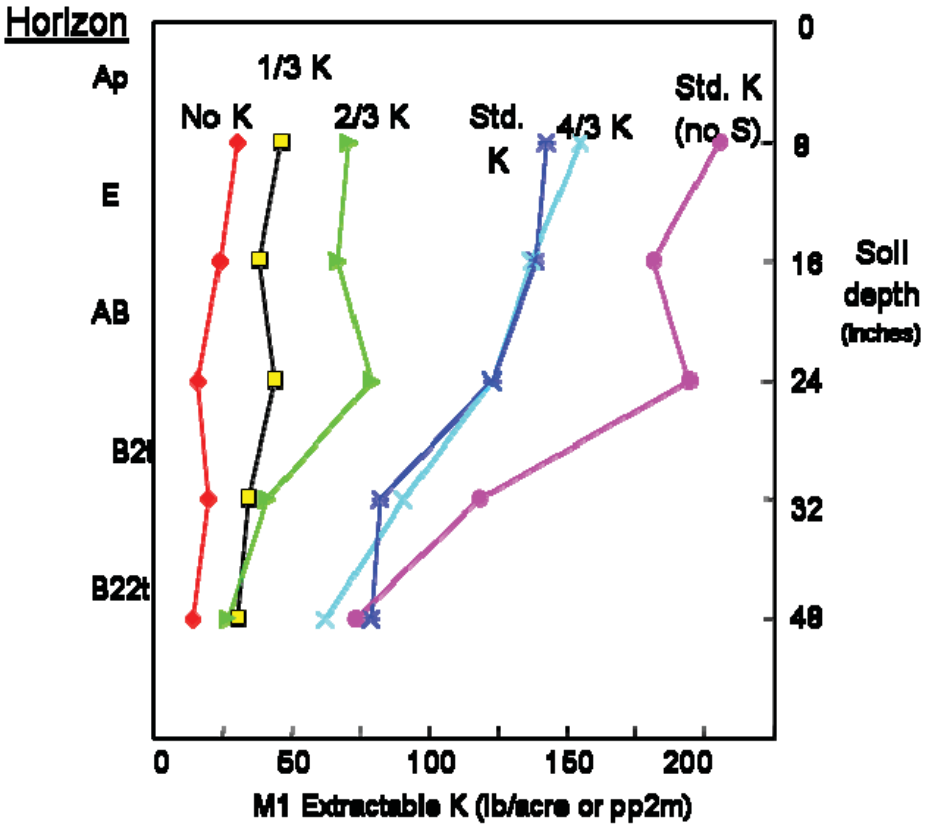


Figure 10. Soil profile K as affected by 90 years of K fertilization and cropping in the Cullars Rotation.

SUMMARY

The Cullars Rotation experiment continues to document long-term trends in non-irrigated crop yields and soil changes due to variable rates of P, K, S, micronutrients, and lime. It provides a valuable and accessible teaching tool for monitoring crop nutrient deficiencies. It also is a source of uniform soil with variable fertility conditions for allied studies. No other such resource exists in the Coastal Plain of the southern United States. For these and other reasons, the Cullars Rotation was placed on the National Register of Historical Places in 2003.

LITERATURE CITED

Adams, J.F., C.C. Mitchell, and H.H. Bryant. 1994. Soil test fertilizer recommendations for Alabama Crops. Ala. Agric. Exp. Stn. Dep. Ser. No. 178. Auburn University, Alabama.

Atkinson, G.F. 1891. Black rust of cotton. Agric. Exp. Stn. Bul. No. 27. Agricultural and Mechanical College of Alabama, Auburn, Alabama.

Atkinson, G.F. 1892. Some leaf blights of cotton. Agric. Exp. Stn. Bul. No.36. Agricultural and Mechanical College of Alabama, Auburn, Alabama.

Williamson, J.T., and M.J. Funchess. 1923. Fertilizer experiments with cotton. Agric. Exp. Stn. Bul. 219. Alabama Polytechnic Institute. Auburn, Alabama.

Williams, J.T. 1929. Fertilizer experiments with cotton. Agric. Exp. Stn. Bul. No. 228. Alabama Polytechnic Institaute, Auburn, Alabama.

APPENDIXES

1. Seed cotton yields on Cullars Rotation, 1911-2010
2. Corn grain yields on Cullars Rotation, 1911-2010
3. Soybean yields on Cullars Rotation, 1960-2010
4. Wheat grain yields on Cullars Rotation, 1968-2010
5. Winter legume (mostly crimson clover) dry matter yields on Cullars Rotation, 1986-2010
6. Mean soil pHw in Cullars Rotation since 1955
7. Mean Mehlich-1 extractable soil P in Cullars Rotation since 1955
8. Mean Mehlich-1 extractable soil K in Cullars Rotation since 1955
9. Mean Mehlich-1 extractable soil Mg in Cullars Rotation since 1965
10. Mean Mehlich-1 extractable soil Ca in Cullars Rotation since 1968
11. Mean soil organic matter and estimated CEC in Cullars Rotation
12. History of fertilizer applied to cotton on Cullars Rotation
13. History of fertilizer applied to corn on Cullars Rotation
14. History of fertilizer applied to oats, rye, or wheat on Cullars Rotation
15. Crop rotations used on the Cullars Rotation, 1911-2010

Appendix Table 1. Seed cotton yields on Cullars Rotation, 1911-2010

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Pounds seed cotton per acre†													
1911				326	1834	1922	284	1802	1434	300	800	768	556	120
1912				156	726	1922	88	930	592	78	538	114	70	44
1913				484	1600	1690	680	1634	1340	414	924	810	680	450
1914				380	360	372	106	530	494	190	870	786	466	180
1915				600	1384	1672	302	1612	1274	182	722	638	384	90
1916				328	834	1032	350	922	878	344	702	624	424	256
1917				180	274	308	180	420	290	168	530	318	188	162
1918				520	1320	2070	650	2060	1650	470	1240	1150	940	550
1920	702	422	210	400	1100	1940	502	1650	1114	282	1016	940	740	260
1921	242	66	84	102	486	828	160	840	810	152	302	300	190	100
1922	648	194	132	324	678	1352	330	1250	1206	406	852	820	710	292
1923	210	48	36	152	436	968	142	842	578	102	534	350	188	66
1924	406	72	52	120	602	1150	244	1070	1046	168	828	786	556	204
1925	719	375	300	282	529	885	469	789	783	421	751	637	607	378
1926	1042	166	184	654	800	1230	684	1224	1206	656	1388	1240	1056	756
1927	751	208	238	264	381	940	358	882	1069	332	965	942	751	433
1928	270	60	30	39	291	1053	60	873	624	60	438	408	294	51
1929	546	124	30	114	382	1030	162	886	712	172	666	592	318	126
1930	1236	108	150	181	315	1032	382	1040	1241	339	1235	1191	626	222
1931	1737	600	306	366	864	1797	597	1590	1446	507	1539	1482	1029	396
1932	955	173	102	124	496	1114	424	1553	1371	233	1384	1286	996	213
1933	1318	362	378	416	586	1454	465	1254	1057	486	1491	1489	1210	299
1934	959	287	136	242	602	1514	549	1637	1152	446	1265	1297	1122	448
1935	1152	210	192	351	618	960	543	1245	1107	363	1389	1359	1197	324
1936	1266	546	282	333	468	1440	465	1338	990	342	1107	1197	873	261
1937	1312	471	200	313	733	1571	548	1522	990	389	1140	1328	1183	394
1938	1023	279	81	150	231	621	405	783	636	327	867	933	891	264
1939	1491	591	210	276	507	1281	333	1212	480	279	1416	1380	1044	234

continued

Appendix Table 1, continued. Seed cotton yields on Cullars Rotation, 1911-2010

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Pounds seed cotton per acre†													
1940	693	312	69	195	297	459	258	480	336	231	615	915	921	294
1941	768	267	144	228	324	699	306	942	666	327	942	933	762	219
1942	1038	318	117	282	855	1656	603	1929	672	396	1545	1575	1146	330
1943	1035	291	189	420	585	1095	741	1554	894	639	1602	1563	1470	579
1944	1545	510	93	195	282	417	480	1284	807	378	2214	2070	1749	345
1945	576	48	24	51	132	456	225	846	300	126	576	669	762	153
1946	150	60	24	27	30	66	45	75	63	60	66	63	63	72
1947	1503	456	153	381	849	1233	573	1431	732	507	1629	1536	1284	522
1948	2277	840	405	402	825	1584	678	1857	981	489	2043	2295	1800	381
1949	1596	675	222	285	825	1176	594	1410	594	462	1869	1659	1389	333
1950	1128	810	432	495	765	1221	501	1308	852	639	1797	1686	1416	546
1951	2004	1626	249	429	1197	1695	666	1908	855	501	2091	2106	1590	372
1952	1200	1152	240	411	1017	1197	582	1203	642	471	1428	1392	1203	456
1953	1059	333	129	237	549	681	300	1059	435	249	1362	1305	948	282
1954	1470	1104	480	441	750	903	621	1074	612	552	1440	1356	1398	438
1955	1539	903	315	411	864	1008	582	918	465	570	2007	1251	1377	441
1956	1600	842	132	518	743	1475	314	1432	545	518	1498	1528	1502	350
1957	1564	686	129	228	878	2017	109	1888	46	66	1561	1439	1769	116
1958	2389	908	76	495	891	2676	472	2445	353	719	2548	2670	2897	568
1959	1119	409	178	614	842	1284	347	1205	347	716	1139	1172	1330	521
1960	2957	1511	261	756	1663	2954	624	3333	287	466	2789	2746	3551	462
1961	2340	637	30	221	1851	2600	66	2531	96	198	2234	2564	2818	274
1962	2897	795	158	528	1865	2874	92	2907	277	703	2102	2534	2845	445
1963	2571	1139	185	386	1043	2478	185	2567	432	366	1815	2353	2736	393
1964	2221	690	59	370	1551	2897	36	3092	145	165	2653	2795	3006	264
1965	2214	426	115	244	1402	2795	0	2789	158	195	1323	2518	2696	261
1966	2132	805	205	191	802	2079	0	1709	373	152	1683	2036	2204	267
1967	2158	409	89	353	1406	2069	33	2198	99	162	1944	2138	2356	162

continued

Appendix Table 1, continued. Seed cotton yields on Cullars Rotation, 1911-2010

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Pounds seed cotton per acre†													
1968	2468	1066	195	2907	1700	2508	1795	2666	86	2379	1683	2442	2703	1931
1969	1785	901	59	1647	459	1409	93	1581	46	1459	653	1472	1868	878
1970	2864	1894	152	2525	2237	2597	2096	2666	1175	2517	2036	2897	2528	1445
1971	1980	1548	66	2162	1251	1944	1736	1964	320	1907	947	1855	1848	1667
1972	1901	1261	13	2330	1089	1848	2033	1990	228	1927	370	1795	2079	1221
1973	2082	1597	92	1643	1424	1340	1673	1657	218	1782	1370	1511	1874	1495
1974	2472	1640	129	2264	1020	2221	2020	2224	1449	2132	736	1785	2119	1416
1975	1274	851	20	1205	446	776	990	548	33	1082	439	927	944	723
1976	1492	1214	30	1762	1723	1835	1640	1888	53	1789	257	1587	1538	1092
1977	2389	1808	221	3112	1214	2805	2534	2356	1485	2736	1551	2132	2099	2399
1978	1000	1105	16	1531	330	1353	1162	1333	122	1290	541	1155	1178	1181
1979	1343	1066	40	1340	1254	1257	1092	1356	287	773	129	1082	1218	1330
1980	1310	1191	73	1320	1026	1356	1327	1422	719	1419	703	1403	1594	1535
1981	2168	2376	257	2402	1260	2402	2435	2485	590	2409	1016	1920	1841	2056
1982	2353	2181	191	2640	1683	2409	2214	2528	287	2637	1030	2373	2379	2320
1983	772	924	99	1485	713	1432	1247	1497	383	1320	165	1201	1307	1300
1985	2632	2149	220	2713	1657	3329	3190	2985	440	2728	1899	2449	3080	2567
1986	2156	1577	0	2435	1313	1892	2149	2369	535	2156	374	2200	2464	2229
1987	1665	1371	139	1547	917	1723	1386	1555	278	1393	499	1430	1503	1034
1988	1960	1597	0	2468	1162	2614	2250	2323	0	2468	1234	2686	2759	1888
1989	1016	998	0	2686	1053	2650	2686	2650	0	2250	580	2468	2468	1851
1990	1343	1416	0	1234	580	1525	1198	1125	690	1561	472	1125	1633	1525
1991	2870	2900	653	2900	1670	3010	3010	2430	440	2580	250	1520	2210	1780
1992	3160	2830	690	4140	1560	4030	3880	3590	1120	3850	1630	3380	4070	3670
1993	2800	3160	360	3120	1780	3380	2830	2500	910	2500	510	2870	3670	2180
1994	1340	1810	0	1630	580	1340	1050	1450	0	1420	870	2110	2690	1380
1995	559	523	0	1234	512	1053	878	842	268	889	280	806	926	1201
1996	3270	3340	0	2180	1310	2720	3230	2870	0	3960	940	3670	4060	1710

continued

Appendix Table 1, continued. Seed cotton yields on Cullars Rotation, 1911-2010

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Pounds seed cotton per acre†													
1997	2430	1920	0	3270	1200	2690	2500	2790	0	3270	0	2210	2690	2650
1998	2660	2480	0	2260	1790	2440	3130	2030	910	2180	0	2460	2440	1920
1999	1000	1200	0	1520	700	1480	1480	1260	0	1590	350	1260	1740	1090
2000	1140	1310	0	1630	410	1060	900	820	0	820	410	1140	980	980
2001	2220	2530	0	2740	1260	2310	2440	2570	0	3090	1830	2480	2480	2570
2002	3220	2570	560	3010	910	3050	2790	3050	0	2960	740	2920	2740	2570
2003	870	1050	0	1440	830	2530	910	1180	0	960	350	1220	1920	740
2004	3590	2790	0	5070	1390	4810	3050	3660	0	3350	0	3480	3720	2660
2005	2302	1885	0	3275	3225	3600	2972	2722	0	2598	162	2932	3728	942
2006	2744	6049	0	4400	522	4966	4400	4356	0	4007	0	3877	4443	1742
2007	2290	1850	0	1220	260	1350	1220	1330	0	1240	0	1630	1760	1610
2008	1917	2265	0	2461	2483	2330	2265	2766	0	2374	1067	2134	2113	2004
2009	2770	2570	0	3240	890	3030	2850	2790	0	2610	780	2590	3050	1220
2010	1550	1550	0	1550	650	1680	1290	1420	0	1370	350	1200	1440	1089

† Before the 1990s, the percentage of lint in seed cotton was between 35 and 38 percent. Since the mid 1990s, it has risen to 40 to 45 percent.

Appendix Table 2. Corn grain yields on Cullars Rotation, 1911-2010

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Bushels grain per acre													
1911				18.8	36.5	44.9	21.4	39.2	35.2	20.8	28.7	25.7	13.4	17.5
1912				5.1	48.6	53.8	9.2	54.8	34.7	9.5	20.7	18.9	12.6	10.8
1913				23.5	43.9	46.9	28.8	43.0	45.7	29.1	28.0	33.4	27.7	21.3
1914				12.5	17.9	22.9	18.2	22.1	22.9	17.5	21.4	20.7	19.3	16.4
1915				20.0	40.7	59.9	20.0	52.0	43.5	20.2	27.6	29.6	23.6	20.9
1920	22.8	16.6	16.9	20.0	50.7	59.1	23.8	55.7	43.6	21.0	25.4	28.2	24.3	20.5
1921	30.7	13.2	16.4	24.8	51.4	58.8	27.9	59.6	55.5	30.7	35.2	37.7	33.0	22.5
1922	20.2	7.1	8.3	18.2	28.7	35.4	20.4	33.6	27.1	15.2	23.9	22.7	23.9	16.1
1923	24.4	7.7	13.3	24.4	53.6	63.1	27.8	61.1	52.0	23.4	41.7	43.2	31.8	23.2
1924	36.4	9.3	15.1	30.0	39.4	54.0	29.5	51.6	49.5	27.5	38.2	43.8	34.7	25.9
1925	8.6	6.2	5.7	12.9	2.6	9.5	11.8	4.5	2.2	9.7	10.2	8.0	8.1	12.2
1926	37.1	7.1	11.8	23.9	52.0	61.1	37.7	60.7	56.1	34.6	47.5	50.4	50.0	36.1
1927	42.0	9.0	12.9	20.9	41.2	52.2	25.7	48.5	47.6	23.6	46.2	47.1	36.8	24.0
1928	21.8	4.7	5.7	6.5	49.4	52.6	12.2	51.6	47.5	12.0	30.1	27.6	21.6	13.9
1929	43.4	4.5	10.7	18.3	36.8	60.6	29.2	55.0	58.0	30.4	54.6	52.3	44.8	29.6
1930	41.9	11.1	14.3	20.8	30.3	55.2	32.3	50.8	45.3	30.9	48.0	44.8	41.3	25.4
1931	41.0	7.0	11.9	24.8	36.6	47.1	33.3	39.1	47.2	29.0	42.4	44.5	39.1	26.5
1932	24.8	10.2	10.8	11.0	15.1	29.9	17.0	35.7	30.6	17.9	32.9	34.5	26.4	14.9
1933	22.7	4.6	8.9	15.9	31.1	44.2	25.3	45.9	37.5	16.8	34.3	38.7	36.3	20.3
1934	43.5	15.0	16.1	23.1	35.0	56.9	40.5	58.2	49.9	35.4	53.9	55.1	49.2	29.9
1935	32.9	10.6	8.4	18.1	42.5	59.7	26.6	72.9	61.3	32.2	55.6	48.1	49.1	28.8
1936	31.1	2.0	2.5	13.4	30.6	41.3	21.9	42.9	40.4	21.8	31.8	30.7	28.5	18.4
1937	44.8	16.9	12.6	19.6	24.3	39.9	32.4	40.3	41.0	33.1	42.2	38.2	37.4	25.7
1938	53.9	15.6	13.3	15.9	29.6	50.0	35.1	58.1	49.9	34.6	64.3	67.4	61.7	37.9
1939	23.4	5.7	5.4	13.2	22.3	33.2	16.4	36.5	27.9	13.9	21.1	20.5	18.1	12.4
1940	27.0	7.6	5.0	9.2	20.6	43.4	15.8	44.4	34.6	13.3	28.3	32.2	27.0	10.4
1941	25.0	7.9	5.1	7.6	25.4	42.1	20.0	51.5	41.8	19.0	28.0	32.8	30.3	19.1
1942	42.3	12.4	7.5	16.4	20.9	42.2	26.4	50.0	37.6	24.8	44.8	42.3	42.3	24.0

continued

Appendix Table 2, continued. Corn grain yields on Cullars Rotation, 1911-2010

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Bushels grain per acre													
1943	58.6	11.5	6.3	13.6	31.7	54.1	34.2	56.1	45.1	22.9	41.9	48.6	44.0	22.7
1944	32.0	7.5	6.9	11.9	15.0	31.1	24.9	37.8	25.8	21.4	36.8	35.6	32.3	21.9
1945	39.1	12.6	8.3	15.5	31.4	0.0	27.4	55.0	33.1	23.8	46.9	44.5	45.6	24.9
1946	47.7	19.3	7.1	14.2	39.6	52.6	32.7	62.3	38.6	27.3	50.1	49.2	42.6	21.5
1947	52.3	11.1	6.6	16.5	28.9	56.7	43.8	72.8	61.7	38.5	69.0	69.2	64.7	38.9
1948	42.9	5.7	2.1	15.4	25.8	47.8	30.7	59.3	45.8	27.4	42.2	43.9	42.2	24.5
1949	78.2	30.3	10.3	17.4	36.5	70.0	54.8	82.4	50.9	43.1	78.4	84.2	64.8	33.3
1950	63.0	19.4	9.9	20.0	30.4	56.2	42.7	59.4	48.3	41.2	74.4	72.8	66.7	39.7
1951	34.3	14.7	9.0	20.6	40.0	56.5	31.3	78.2	68.2	32.4	57.9	65.8	50.8	26.4
1952	42.7	21.6	10.2	13.7	22.8	36.1	36.2	45.9	41.5	34.7	43.9	47.4	46.1	29.7
1953	57.9	17.9	7.6	18.3	30.6	50.6	35.1	71.1	50.5	37.0	77.4	73.0	61.7	35.1
1954	34.9	14.6	13.0	14.7	20.5	32.9	30.0	40.6	34.1	26.5	33.8	35.1	33.0	22.7
1955	51.5	23.6	13.2	16.5	30.1	46.2	45.3	51.6	34.3	37.0	70.6	71.0	67.3	26.9
1956	51.0	6.2	3.0	8.5	15.3	58.8	33.7	59.5	38.8	30.2	65.7	70.2	66.3	28.2
1957	53.5	9.0	5.3	24.0	31.7	88.3	42.2	101.7	30.9	44.2	86.6	83.3	73.2	34.5
1958	92.0	13.6	1.3	8.6	17.4	95.4	28.0	102.7	17.7	18.1	94.8	108.5	108.9	20.6
1959	71.3	10.5	3.0	7.2	14.6	72.8	17.2	70.9	27.9	30.1	67.8	73.7	69.1	25.3
1960	114.7	2.5	1.4	17.7	41.2	117.3	20.4	119.3	39.4	42.0	84.6	106.8	111.6	29.8
1961	102.6	24.3	0.3	6.4	25.8	98.6	14.9	97.7	12.3	13.2	86.8	98.9	100.8	7.2
1962	71.6	9.2	6.3	12.3	38.6	82.0	26.9	80.6	25.8	25.2	73.1	78.5	87.9	30.0
1963	48.9	4.9	1.4	7.5	18.5	59.9	7.7	57.4	27.2	20.0	43.3	52.4	56.8	11.6
1964	100.7	17.9	0.9	4.5	21.8	96.6	8.4	96.5	11.4	9.3	62.3	96.0	96.4	8.6
1965	97.0	7.6	1.5	19.0	37.8	113.7	6.8	109.6	34.0	45.4	88.8	119.9	100.2	40.7
1966	25.1	5.6	1.9	8.0	16.5	42.0	1.0	45.1	26.2	22.8	21.8	35.5	33.7	19.6
1967	98.5	25.8	1.0	3.4	16.9	84.7	1.6	79.4	15.3	12.4	59.9	85.3	90.5	17.1
1968	80.0	6.9	1.3	74.0	30.8	79.1	51.1	81.0	16.1	65.1	67.2	79.2	83.4	70.9
1969	46.7	9.4	1.6	64.5	34.5	88.9	51.9	95.3	12.4	86.8	52.0	92.1	85.7	56.9
1970	23.4	3.6	0.0	23.4	2.3	27.2	9.8	23.2	1.3	14.5	7.5	25.9	27.7	6.7

continued

Appendix Table 2, continued. Corn grain yields on Cullars Rotation, 1911-2010

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Bushels grain per acre													
1971	104.5	13.8	3.7	103.4	62.8	120.2	108.9	113.9	76.8	95.6	90.4	114.3	116.1	103.8
1972	72.1	16.5	2.4	54.2	32.2	73.8	59.2	79.6	41.6	78.1	18.0	82.1	73.7	50.7
1973	85.7	20.6	0.0	79.8	36.9	83.0	87.8	84.5	31.9	90.8	7.7	92.8	89.2	57.3
1974	58.3	23.6	0.0	61.9	25.4	57.7	47.8	59.9	14.7	65.2	10.7	62.9	55.7	62.5
1975	106.0	12.0	0.3	92.0	32.0	95.0	95.0	101.0	90.0	96.0	20.0	106.3	110.0	135.0
1976	72.0	19.0	1.0	68.0	22.0	85.0	60.0	78.0	22.0	71.0	4.0	83.0	75.0	53.0
1977	36.0	14.0	1.0	29.0	19.0	26.0	27.0	29.0	14.0	29.0	9.0	26.0	29.0	30.0
1978	38.0	4.0	0.0	38.0	5.0	54.0	47.0	55.0	36.0	47.0	13.0	41.0	39.0	34.0
1979	54.5	11.3	0.5	64.8	13.6	65.5	65.1	62.5	7.7	61.9	38.3	65.0	67.9	60.1
1980	33.0	8.0	0.3	23.0	10.0	24.0	16.0	20.0	6.0	19.0	1.0	20.0	22.0	22.0
1981	33.0	6.0	5.0	34.0	6.0	31.0	26.0	30.0	18.0	15.0	3.0	28.0	25.0	28.0
1982	120.0	36.0	1.0	123.0	44.0	126.0	123.0	121.0	23.0	127.0	85.0	121.0	125.0	113.0
1983	82.0	20.0	0.3	71.0	25.0	68.0	74.0	73.0	37.0	75.0	18.0	69.0	79.0	83.0
1984	40.0	16.0	0.0	38.0	38.0	105.0	93.0	98.0	49.0	98.0	0.0	74.0	89.0	89.0
1985	43.0	28.0	3.0	54.0	11.0	43.0	44.0	58.0	4.0	55.0	22.0	58.0	67.0	26.0
1986	45.1	12.1	0.0	44.2	6.6	32.0	44.0	43.4	16.6	44.0	13.9	45.8	43.9	61.7
1987	73.3	19.0	0.0	48.4	20.8	67.2	62.4	69.9	33.3	68.2	11.4	64.2	59.4	50.1
1988	51.0	7.0	0.0	56.0	13.0	65.0	51.0	50.0	34.0	53.0	28.0	56.0	69.0	35.0
1989	132.0	23.0	0.0	135.0	54.0	156.0	126.0	155.0	25.0	155.0	54.0	138.0	142.0	114.0
1990	48.0	34.0	0.0	73.0	29.0	58.0	67.0	60.0	34.0	53.0	24.0	58.0	53.0	54.0
1991	112.0	46.0	0.0	121.0	31.0	118.0	105.0	109.0	31.0	99.0	43.0	93.0	124.0	105.0
1992	85.0	94.0	21.0	102.0	44.0	81.0	84.0	82.0	50.0	83.0	44.0	77.0	87.0	99.0
1993	88.0	62.0	17.0	84.0	54.0	83.0	89.0	79.0	63.0	79.0	30.0	84.0	73.0	64.0
1994	59.0	25.0	0.0	71.0	42.0	80.0	78.0	78.0	38.0	76.0	20.0	81.0	84.0	80.0
1995	44.0	35.0	9.0	36.0	9.0	32.0	40.0	30.0	10.0	40.0	13.0	24.0	16.0	32.0
1996	106.0	82.0	0.0	143.0	63.0	137.0	132.0	141.0	23.0	140.0	59.0	142.0	155.0	137.0
1997	54.0	30.0	0.0	101.0	55.0	73.0	75.0	72.0	36.0	89.0	23.0	71.0	87.0	94.0
1998	51.3	37.9	0.0	89.1	21.0	75.1	69.3	76.3	8.2	71.6	23.9	86.2	83.9	93.2

continued

Appendix Table 2, continued. Corn grain yields on Cullars Rotation, 1911-2010

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Bushels grain per acre													
1999	161.0	130.0	0.0	108.0	39.0	135.0	128.0	126.0	122.0	135.0	72.0	98.0	100.0	64.0
2000	30.8	14.7	0.0	24.1	0.0	26.1	26.8	34.1	0.0	32.8	0.0	28.8	30.1	26.8
2001	96.0	102.0	0.0	159.0	51.0	152.0	153.0	138.0	49.0	149.0	77.0	168.0	167.0	162.0
2002	88.0	31.0	0.0	79.0	25.0	98.0	90.0	106.0	58.0	109.0	37.0	83.0	94.0	102.0
2003	62.0	25.0	0.0	108.0	45.0	104.0	63.0	115.0	57.0	131.0	23.0	100.0	134.0	134.0
2004	64.0	40.0	0.0	106.0	25.0	94.0	102.0	104.0	33.0	108.0	63.0	102.0	116.0	107.0
2005	28.0	27.0	0.0	109.0	26.0	151.0	148.0	144.0	33.0	172.0	26.0	144.0	154.0	128.0
2006	43.0	11.0	0.0	94.0	50.0	110.0	85.0	96.0	54.0	93.0	25.0	102.0	96.0	96.0
2007	46.1	33.0	0.0	79.1	12.1	55.8	67.9	52.0	14.0	51.4	31.5	51.7	52.3	40.8
2008	35.8	42.3	0.0	39.8	0.0	39.8	45.4	41.4	0.0	42.6	13.4	39.5	50.7	33.0
2009	65.0	31.0	0.0	126.5	107.4	132.0	112.0	113.0	58.0	123.0	29.0	109.0	111.0	118.0
2010	36.6	18.0	0.0	37.6	17.7	45.5	24.4	34.2	4.3	32.7	0.0	24.1	42.1	33.0

Appendix Table 3. Soybean yields on Cullars Rotation, 1960-2010†

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Bushels grain per acre													
1960	27.5	missing	0.0	6.7	12.5	30.0	5.0	27.5	9.2	10.0	25.8	29.2	36.7	13.3
1961	36.7	missing	0.0	9.2	15.0	35.0	5.2	31.7	15.8	17.5	22.5	35.8	37.5	15.0
1962	36.1	missing	0.0	6.1	11.0	31.3	2.9	29.5	11.4	11.8	16.0	26.8	29.3	10.3
1963	29.2	missing	0.0	13.1	14.8	23.9	8.8	14.8	15.1	13.5	20.5	25.4	28.5	16.9
1964	39.4	missing	0.0	8.3	12.8	34.3	0.0	35.0	10.9	10.8	2.3	36.2	34.3	10.8
1965	30.3	missing	0.0	7.8	10.4	23.9	0.0	25.8	14.3	10.5	15.0	20.9	27.8	11.4
1966	35.8	missing	0.0	10.3	13.2	37.3	0.8	37.5	10.3	17.8	21.8	35.7	41.3	17.4
1967	47.3	missing	0.0	12.0	14.8	56.8	0.0	51.1	19.2	16.9	5.9	52.4	54.8	19.0
1968	33.0	29.6	3.4	23.4	9.3	32.1	15.0	29.0	10.3	28.6	6.7	31.7	34.7	21.3
1969	39.3	40.1	11.8	34.4	14.0	41.0	34.0	42.0	11.2	37.4	14.7	44.6	46.9	28.2
1970	24.0	27.7	3.9	24.9	12.5	20.8	24.7	19.0	24.9	16.8	9.8	20.2	23.6	27.5
1971	35.5	31.1	2.6	32.2	10.7	39.6	35.5	38.8	12.0	31.8	5.9	42.7	39.4	20.5
1972	30.9	29.1	3.9	26.8	12.0	35.1	29.0	30.6	16.5	30.1	7.0	34.9	35.6	42.5
1973	19.3	24.8	3.5	24.6	15.1	22.4	21.7	24.2	15.4	20.7	7.0	23.3	27.1	23.0
1974	36.3	36.3	2.4	38.5	7.7	41.8	42.9	40.7	17.6	36.3	4.4	44.0	48.4	29.7
1975	25.0	26.0	1.0	28.0	6.0	34.0	26.0	32.0	1.0	29.0	0.0	33.0	21.0	22.0
1976	24.0	16.0	0.0	19.0	7.0	25.0	20.0	22.0	17.0	18.0	0.0	25.0	25.0	12.0
1977	37.0	40.0	2.0	37.0	4.0	35.0	38.0	35.0	4.0	30.0	2.0	39.0	39.0	28.0
1978	27.0	25.0	2.0	17.0	16.0	23.0	20.0	24.0	8.0	25.0	5.0	19.0	21.0	8.0
1979	25.0	24.5	1.7	26.8	3.3	27.9	27.4	28.3	11.3	27.5	3.5	22.7	24.3	14.7
1980	14.0	11.0	2.0	11.0	4.0	14.0	15.0	11.0	11.0	13.0	6.0	13.0	16.0	11.0
1981	34.0	32.0	2.0	34.0	14.0	34.0	34.0	35.0	25.0	34.0	9.0	34.0	35.0	32.0
1982	28.0	29.0	3.0	31.0	13.0	32.0	30.0	32.0	23.0	32.0	12.0	30.0	33.0	32.0
1983	36.0	36.0	7.0	41.0	14.0	43.0	49.0	44.0	30.0	47.0	17.0	47.0	50.0	47.0
1985	9.0	18.0	4.0	13.0	13.0	13.0	11.0	16.0	12.0	14.0	15.0	12.0	10.0	14.0
1986	35.6	38.1	0.0	32.8	12.5	41.7	42.0	43.3	42.4	46.2	10.6	43.6	46.6	40.7
1987	18.3	23.0	2.1	18.8	8.5	20.0	19.2	20.0	12.9	20.6	12.8	23.0	21.8	22.8
1988	28.1	32.3	0.0	34.2	14.8	27.8	20.2	33.5	15.3	24.0	11.0	29.0	35.0	26.8

continued

Appendix Table 3, continued. Soybean yields on Cullars Rotation, 1960-2010†

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Bushels grain per acre													
1989	24.2	26.6	0.0	33.3	6.6	27.8	29.0	25.4	20.6	27.8	8.5	31.5	29.6	22.4
1990	15.3	0.0	0.0	11.9	3.0	11.7	11.1	13.8	10.1	13.2	3.3	13.4	16.6	12.2
1991	10.1	11.4	0.0	18.0	4.3	15.8	12.1	14.7	5.3	13.4	0.4	16.8	20.3	8.9
1992	43.0	33.0	0.0	42.0	26.0	40.0	44.0	45.0	25.0	48.0	0.0	40.0	42.0	35.0
1993	11.4	10.5	0.0	6.7	0.0	13.7	9.2	16.4	7.0	9.6	0.0	6.8	12.6	7.1
1994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	16.7	14.4	0.0	15.0	7.3	19.9	25.5	23.3	15.6	14.7	0.0	25.2	26.9	25.3
1996	63.8	68.0	9.2	68.7	30.2	70.0	67.2	68.5	37.6	66.8	24.9	61.7	75.1	62.5
1997	23.2	22.4	0.0	20.8	15.4	23.5	24.0	21.6	23.3	22.0	0.0	21.9	23.3	20.7
1998	14.1	6.3	0.0	15.2	7.6	16.0	12.6	16.0	5.3	12.8	0.0	13.6	15.8	10.0
1999	18.2	15.4	3.5	14.1	10.1	13.6	14.7	14.7	8.5	15.6	0.0	14.8	16.1	15.4
2000	0.0	0.0	0.0	22.7	0.0	24.0	28.2	27.0	24.9	28.3	0.0	21.3	23.5	24.8
2001	29.5	27.4	0.0	23.6	5.7	27.4	26.2	27.8	7.6	26.5	0.0	22.8	25.8	15.3
2002	24.3	28.4	0.0	25.8	0.0	15.1	14.4	17.2	0.0	14.0	0.0	17.9	21.7	22.5
2003	33.4	25.9	0.0	54.1	11.2	56.5	53.0	53.8	38.2	56.8	0.0	60.1	58.3	51.3
2004	63.8	63.3	0.0	61.8	22.0	64.2	54.9	61.6	46.1	57.6	0.0	65.1	62.6	57.7
2005	49.0	52.0	0.0	56.1	0.0	55.7	53.7	58.8	12.6	21.3	0.0	52.5	53.8	47.0
2006	51.2	53.8	0.0	48.5	11.6	47.5	49.9	48.2	21.3	50.3	0.0	50.6	54.0	50.8
2007	27.9	22.1	0.0	20.0	11.9	21.8	21.0	18.8	7.3	22.0	0.0	24.7	30.5	21.2
2008	43.1	41.3	0.0	40.9	10.9	41.8	43.9	45.2	22.8	42.4	15.5	42.7	41.0	41.7
2009	50.8	55.4	0.0	67.2	9.0	62.2	65.2	67.9	53.4	63.7	7.8	62.2	62.9	49.1
2010	18.2	18.0	0.0	18.2	10.7	17.9	15.1	17.1	10.1	15.9	4.1	15.1	17.8	13.8

† Prior to 1960, cowpea was the summer legume of choice on the Cullars Rotation; soybean always followed a grain harvest of wheat, oats, or rye.

Appendix Table 4. Wheat grain yields on Cullars Rotation, 1968-2010†

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Bushels grain per acre													
1968	19.4	4.9	1.5	28.2	9.8	19.3	24.3	19.8	9.3	18.9	20.0	22.4	17.7	19.6
1969	12.1	9.2	0.6	23.7	11.3	29.4	26.0	22.8	25.6	26.1	19.8	20.8	25.3	22.2
1970	6.3	6.4	3.2	25.3	9.0	23.6	26.4	15.6	24.8	22.7	5.3	14.3	14.8	20.9
1971	6.7	3.7	1.0	25.2	13.8	22.1	28.6	20.3	21.3	24.6	5.4	22.0	23.2	21.2
1972	4.3	0.8	0.4	12.7	7.5	13.5	13.8	10.3	8.1	11.9	6.7	11.3	11.5	10.5
1989	13.3	6.0	0.0	33.0	17.0	34.3	31.7	34.0	18.1	28.2	9.0	32.9	32.6	26.9
1992	24.4	19.0	0.0	55.8	35.7	42.7	35.4	46.1	32.2	41.5	14.5	42.7	41.9	55.8
1997	13.9	5.8	0.0	44.2	26.1	51.4	48.0	55.8	0.0	41.6	8.8	50.8	46.5	41.3
1999	17.5	15.8	0.0	50.5	20.9	56.9	54.6	55.0	43.8	61.7	29.9	63.5	60.9	57.6
2000	3.7	18.3	0.0	56.2	24.0	52.2	57.4	64.7	44.4	60.1	19.3	52.7	61.1	55.4
2001	18.9	11.8	1.6	49.1	22.3	30.4	49.2	66.9	38.1	50.5	8.9	49.6	51.2	70.0
2002	26.1	28.8	2.4	65.6	25.3	71.0	61.8	62.9	46.0	69.3	20.2	73.0	68.1	69.2
2003	18.5	17.4	0.0	42.5	15.6	37.5	35.0	34.2	31.9	41.9	8.6	38.6	37.5	42.6
2004	58.1	21.3	0.0	46.2	13.8	48.1	41.1	43.6	44.9	53.2	4.0	54.1	50.6	36.5
2005	9.9	10.9	0.0	33.4	14.4	40.8	36.7	41.1	31.7	45.8	7.5	39.1	40.6	37.0
2006	20.3	24.6	0.0	45.3	14.9	53.3	46.0	47.6	40.3	46.1	0.0	41.0	47.1	45.3
2007	21.5	11.7	0.0	44.7	36.1	46.1	46.8	55.1	48.4	53.0	14.3	43.9	53.0	50.9
2008	19.1	18.3	0.0	38.7	19.1	45.6	41.0	38.2	26.6	45.9	15.4	50.2	49.1	48.1
2009	34.5	28.8	0.0	57.6	18.8	57.4	47.7	45.8	47.0	57.0	11.3	54.8	51.2	47.8
2010	17.8	15.2	0.0	39.8	32.7	42.7	40.2	41.1	40.8	50.1	0.0	44.8	54.9	46.9

† Prior to 1968, oat and rye were the cool season grains of choice on the Cullars Rotation. Wheat has been planted periodically since then but always double-cropped with soybean.

Appendix Table 5. Winter legume (mostly crimson clover) dry matter yields on Cullars Rotation, 1986-2010†

Year	Plot/treatment number													
	A	B‡	C	1‡	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Pounds dry matter per acre													
1986	1849	0	0	0	777	1318	1953	2178	1652	2192	796	2187	1964	2067
1987	3080	0	0	0	234	3650	3720	3460	1860	3610	0	3760	3640	3260
1988	3510	0	0	3062	1100	3140	2890	2980	2310	3110	620	2800	3712	2970
1990	2670	0	0	0	630	2290	2440	2620	1220	3093	0	2336	2320	1800
1991	4020	0	0	0	1300	2770	2970	3880	2470	3020	0	3230	3630	2650
1992	3560	4970	0	3280	810	4170	3760	3960	1120	2810	0	3780	2720	2090
1993	2590	0	0	0	620	2720	2550	2440	1840	2660	0	2440	3010	2400
1994	3684	0	0	0	1429	3426	3241	3968	1750	4036	0	3083	3109	2847
1995	1920	0	0	0	50	2340	2550	2600	1130	2260	0	2120	3270	1480
1996	890	0	0	0	0	900	1460	1060	780	1440	0	970	1430	1290
1997	3570	0	0	0	1750	2700	3880	3870	3250	3370	0	3100	3750	3440
2001	3400	4080	0	3690	1030	3140	3340	3220	1710	3350	0	3520	3310	2650
2002	3280	0	0	0	600	3150	2090	3120	1530	2790	1600	1390	2430	2740
2003	4170	0	0	0	2020	5380	3750	4630	4130	6390	1780	3790	5800	4580
2005	2540	0	0	0	1230	3990	4210	5710	2370	5640	3560	5620	4870	4270
2006	5560	0	0	0	4740	5580	5060	6230	3130	510	0	4580	6780	2490
2008	1320	0	0	0	282	2090	1321	1221	0	1038	0	425	1545	1164
2009	1490	0	0	0	1440	2660	2240	1720	750	2240	0	1150	2620	1610
2010	3000	0	0	0	1580	2800	2820	3160	890	3200	0	2820	4400	3240

† Prior to 1986, winter legume yields were recorded as pounds green weight per acre.
‡ Winter legumes were planted on these plots by mistake in some years.

Appendix Table 6. Mean soil pHw in Cullars Rotation since 1955†

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Soil pH													
1955	5.3	5.4	5.9	5.4	5.8	5.5	5.4	5.5	5.5	5.3	5.4	5.3	5.3	5.4
1958	5.7	5.7	.	5.8	5.7	5.8	5.2	5.8	5.9	5.7	5.5	5.7	5.7	5.7
1959	5.6	5.7	5.6	5.7	5.7	5.6	5.0	5.8	5.6	5.6	5.4	5.6	5.6	5.7
1961	5.7	5.9	5.5	6.0	6.0	5.8	4.8	5.9	5.8	5.8	5.0	5.8	5.7	5.9
1962	6.1	6.2	5.5	6.1	6.1	5.9	5.1	6.1	5.9	5.9	5.2	6.0	6.1	6.2
1965	5.5	5.5	5.4	5.7	5.5	5.6	4.7	5.7	5.5	5.6	4.8	5.5	5.5	5.5
1968	6.0	6.1	6.1	6.0	6.1	5.8	6.2	6.2	6.1	5.8	5.2	6.0	6.0	6.1
1969	5.9	5.9	5.6	6.0	5.9	6.0	5.8	6.0	5.8	5.9	4.9	6.0	5.9	5.9
1970	5.8	5.7	5.8	5.7	5.8	5.8	6.0	5.9	5.6	5.8	5.0	5.7	5.8	5.7
1971	6.1	6.2	5.5	6.1	6.1	6.2	6.3	6.1	5.8	6.1	4.9	6.1	6.1	6.2
1974	5.9	6.0	5.4	6.1	5.9	6.0	6.1	5.9	5.8	5.8	4.8	5.9	5.9	6.0
1978	5.7	5.6	5.3	5.6	5.7	5.7	5.9	5.8	5.6	5.6	5.0	5.6	5.7	5.6
1980	•	•	•	•	•	5.6	5.5	•	5.7	5.6	•	•	•	•
1981	5.0	5.1	5.1	5.4	5.3	6.0	5.5	5.6	5.1	5.4	4.1	5.1	5.0	5.1
1983	5.9	5.9	5.1	6.1	5.9	6.1	6.0	6.2	5.7	6.0	4.8	6.1	5.9	5.9
1985	5.9	5.7	5.2	5.8	5.7	5.8	5.8	5.7	5.7	5.7	4.8	5.6	5.9	5.7
1986	6.1	5.7	5.2	.	6.5	6.2	6.4	6.3	6.0	6.2	4.1	6.3	6.1	5.7
1988	5.6	5.7	5.4	6.0	6.0	5.9	5.9	6.0	5.7	5.7	4.9	5.8	5.6	5.7
1992	5.5	5.2	5.1	5.6	5.6	5.5	5.4	5.6	5.3	5.4	4.5	5.4	5.5	5.2
1994	6.1	6.3	5.1	6.1	6.3	6.2	6.3	6.4	6.2	6.1	5.0	6.2	6.1	6.3
1998	5.9	5.9	5.3	5.7	5.8	5.9	6.0	6.2	6.0	6.0	4.9	5.7	5.9	5.9
2002	5.7	5.8	5.1	5.6	5.8	5.9	5.9	6.1	5.8	5.8	4.8	5.7	5.7	5.8
2004	6.3	6.1	5.2	6.2	6.2	6.2	6.2	6.0	6.3	6.2	4.7	6.2	6.3	6.1
2006	6.1	6.1	5.1	6.1	5.8	6.1	5.9	5.9	6.1	6.1	4.5	6.1	6.1	6.1
2008	6.3	6.0	5.0	6.5	6.3	6.2	6.0	6.2	6.2	6.4	4.4	6.2	6.3	6.0

† No data are available on soil tests prior to 1955. The A.U. Soil Testing Lab began routine operations in 1954. Values are the mean of soil samples taken from plots in the three tiers of the Cullars Rotation.

Appendix Table 7. Mean Mehlich-1 extractable soil P in Cullars Rotation since 1955†

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Pounds per acre or parts per 2 million													
1955	63	69	12	10	10	15	46	192	155	18	110	182	202	22
1958	118	81	•	1	0	14	16	202	114	11	78	171	171	14
1959	88	86	8	4	5	30	33	202	148	20	92	183	189	24
1961	102	110	7	3	4	35	26	202	1582	40	74	185	189	26
1962	90	109	9	6	7	37	34	327	163	25	96	212	194	30
1965	86	108	6	3	3	45	17	380	144	13	79	217	131	78
1968	108	126	9	15	8	72	35	445	168	24	96	208	190	33
1969	100	120	8	28	8	57	53	430	166	40	91	224	195	39
1970	99	105	12	27	9	46	46	454	149	46	79	157	167	65
1971	118	124	9	28	6	60	59	352	218	57	106	213	224	58
1974	115	124	7	35	6	71	75	690	208	57	121	219	209	69
1978	87	90	11	33	8	50	52	208	157	48	94	171	169	59
1980	•	•	•	•	•	64	53	•	180	44	•	•	•	•
1981	97	88	5	34	4	52	68	333	113	48	98	129	131	45
1983	118	110	6	57	6	77	89	222	154	72	109	164	167	80
1985	124	129	6	54	5	79	106	349	179	73	116	176	176	93
1986	•	132	6	•	4	83	81	870	219	73	109	155	144	67
1988	124	113	10	58	9	84	140	223	193	86	130	194	177	89
1992	114	108	16	57	20	76	136	282	173	101	125	143	145	94
1994	119	117	11	48	7	92	140	205	193	101	132	168	179	110
1998	121	108	19	51	7	78	133	400	188	114	121	162	149	99
2002	146	131	18	99	13	110	174	352	203	137	158	189	166	132
2004	127	115	11	93	7	102	164	3574	202	113	137	180	172	134
2006	142	150	13	83	11	116	155	1665	223	134	149	178	168	145
2008	146	154	10	72	16	107	133	605	229	124	161	174	173	125

† No data are available on soil tests prior to 1955. The A.U. Soil Testing Lab began routine operations in 1954. Values are the mean of soil samples taken from plots in the three tiers of the Cullars Rotation.

Appendix Table 8. Mean Mehlich-1 extractable soil K in Cullars Rotation since 1955†

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Pounds per acre or parts per 2 million													
1955	30	30	21	21	36	26	21	20	15	16	26	25	28	14
1958	28	23	.	18	28	28	13	28	13	7	33	28	23	13
1959	109	64	25	38	71	71	31	83	25	35	92	87	81	28
1961	94	72	33	37	77	69	28	77	31	30	60	93	83	33
1962	80	48	21	25	59	62	28	62	25	25	68	93	77	31
1965	89	62	27	32	43	71	27	76	3354	29	68	92	62	51
1968	93	78	32	63	73	78	51	69	25	49	71	81	83	44
1969	118	100	39	83	95	97	80	99	37	68	70	105	102	52
1970	101	91	29	73	85	93	76	85	29	54	66	92	92	50
1971	123	100	21	73	95	96	98	101	27	69	67	120	120	48
1974	86	94	29	80	79	93	83	75	24	58	57	103	91	50
1978	117	89	25	97	93	118	115	117	23	70	60	142	114	52
1980	•	•	•	•	•	98	111	•	20	53	•	•	•	•
1981	96	64	20	69	60	41	101	50	18	79	39	96	50	44
1983	129	112	27	121	96	126	124	136	30	85	64	156	118	59
1985	150	117	30	109	98	119	119	104	30	75	73	123	120	66
1986	•	118	22	•	100	155	143	158	30	71	60	205	126	46
1988	110	87	21	95	82	111	111	102	24	58	66	139	106	42
1992	106	111	29	96	105	105	113	91	31	74	81	109	102	53
1994	106	101	27	91	92	99	97	95	28	71	60	113	99	54
1998	139	106	34	79	93	80	78	95	29	62	77	107	81	48
2002	169	143	44	120	121	139	166	152	36	113	90	164	133	73
2004	93	88	44	105	68	86	94	94	27	74	53	101	112	58
2006	151	123	43	134	130	181	144	151	42	116	76	150	141	85
2008	142	99	35	107	86	118	141	115	34	105	65	116	131	63

† No data are available on soil tests prior to 1955. The A.U. Soil Testing Lab began routine operations in 1954. Values are the mean of soil samples taken from plots in the three tiers of the Cullars Rotation.

Appendix Table 9. Mean Mehlich-1 extractable soil Mg in Cullars Rotation since 1965†

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Pounds per acre or parts per 2 million													
1965	53	66	15	41	37	45	4	54	44	52	8	45	37	44
1968	126	81	16	58	58	68	157	91	105	86	15	107	84	72
1969	72	52	18	34	42	78	62	58	61	56	12	74	62	44
1970	72	64	20	26	38	54	76	52	44	50	12	56	54	42
1971	119	49	15	59	74	108	92	73	78	79	11	98	97	99
1974	80	37	13	55	50	70	80	68	65	72	7	68	77	62
1978	51	26	12	28	26	34	34	38	38	28	6	27	30	28
1980	•	•	•	•	•	49	•	•	56	57	•	•	•	•
1981	53	42	8	24	33	54	27	30	41	42	5	47	39	30
1983	110	105	15	89	73	107	93	130	91	114	9	137	89	92
1985	88	88	20	48	60	75	63	86	90	74	16	77	84	74
1986	•	•	16	•	164	110	148	83	93	129	12	116	79	52
1988	48	44	13	58	49	59	50	71	59	54	11	61	38	41
1992	36	22	10	29	27	29	27	34	36	32	9	35	37	24
1994	53	64	10	50	40	50	50	50	66	47	8	78	58	76
1998	68	46	20	36	33	49	52	64	73	58	19	50	55	55
2002	49	34	18	49	46	77	90	77	91	82	14	77	58	80
2004	53	66	15	67	64	74	77	60	87	73	6	92	73	64
2006	126	81	16	83	64	98	87	80	161	122	16	115	103	137
2008	72	52	18	95	77	85	63	74	90	85	12	96	90	63

† Extractable Mg was not determined on routine soil samples prior to 1965. Values are the mean of soil samples taken from plots in the three tiers of the Cullars Rotation.

Appendix Table 10. Mean Mehlich-1 extractable soil Ca in Cullars Rotation since 1968†

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Pounds per acre or parts per 2 million													
1968	491	523	166	257	241	387	190	437	328	313	110	385	360	263
1978	700	517	153	330	240	390	397	1650	547	333	147	540	600	297
1980	•	•	•	•	•	513	420	•	560	410	•	•	•	•
1981	530	430	90	260	230	340	270	1700	490	250	170	460	470	220
1983	1057	873	147	637	410	790	653	2707	707	713	177	1060	873	573
1985	903	893	163	433	393	643	637	2147	787	557	220	813	883	570
1986	•	690	100	•	637	717	673	1795	740	750	143	727	790	360
1988	600	540	77	450	313	487	573	1963	577	440	143	650	573	350
1992	477	427	103	300	230	343	503	1657	583	350	137	470	493	257
1994	810	1050	90	617	523	810	1043	2150	1273	707	147	1443	927	880
1998	900	597	147	373	330	693	917	2497	953	730	227	660	857	543
2002	813	527	163	487	353	707	1027	2217	893	803	255	810	700	660
2004	847	660	147	743	570	790	1050	1873	1083	827	200	1100	953	680
2006	1322	1331	152	847	480	1047	1086	2362	1695	1294	214	1241	1233	1185
2008	845	1176	83	914	865	1045	920	2330	1049	963	163	1035	1153	663

† Extractable Ca was not determined on routine soil samples prior to 1968. Values are the mean of soil samples taken from plots in the three tiers of the Cullars Rotation.

Appendix Table 11. Mean soil organic matter and estimated CEC in Cullars Rotation†

Year	Plot/treatment number													
	A	B	C	1	2	3	4	5	6	7	8	9	10	11
	No N; + legume.	No N; no leg.	Nothing	No leg.; + N	No P	Complete fertilization	4/3 K rate	Rock P	No K	2/3 K	No lime	No S	+ micros	1/3 K
	Soil organic matter (%)													
1992	1.2	1.0	0.7	0.9	1.0	1.1	1.2	1.0	1.0	1.2	1.2	1.2	1.2	1.1
1994	1.3	1.0	0.8	1.1	1.0	1.2	1.2	1.3	1.2	1.2	1.3	1.3	1.2	1.2
2008‡	2.3	1.7	0.9	–	1.4	1.6	–	–	1.5	–	–	–	1.7	–
2009‡	2.1	2.1	1.1	–	1.4	1.9	–	–	1.8	–	–	–	1.7	–
	Estimated soil cation exchange capacity (cmol/kg)													
2002	4.57	3.48	2.38	3.36	2.85	4.21	5.02	7.71	4.50	4.49	3.50	4.68	4.11	3.94
2008	3.98	4.50	1.40	3.32	2.99	4.72	3.56	7.50	4.29	3.74	2.52	3.72	4.57	3.49

† These values have only been run periodically because of the added cost. Soil organic C x 1.9 = soil organic matter. ECEC is calculated based on Mehlich-1 extractable cations plus exchange acidity.
‡ Data from Kumi (2011) dissertation; higher values are the result of converting from conventional tillage in 1997 to strip tillage and sampling 0 to 10 cm.

Appendix Table 12. History of fertilizer applied to cotton on Cullars Rotation†

Plot/Treatment	Years and fertilizer added (pounds per acre N-P_2O_5-$K_2$0)					
	1911-1923	1924-1932	1933-1955	1956-1966	1967-1984‡	1985-2010§
A	0-42-24, SP & kainite	0-42-30, SP & muriate	0	120-200-200	0-100-135 + legume, no N	0-100-135 + legume, no N
B	0-42-24, SP & kainit, no legume	0-42-30, SP & muriate	0-68-30, SP & muraite	120-200-200	0-100-135 No legume, no N	0-100-135
C	0	0	0	0	0	0
1	0	0	0	120-0-0	120-100-135 No legume	90-100-135 No legume
2	108-0-74, DB & kainite	128-0-169 soda & muriate	38-0-0, soda	120-0-200	120-0-135 No P	90-0-135 No P
3	108-64-74, DB, SP, kainite	128-32-169, soda, SP, muriate	38-0-0, soda	120-200-200	120-100-135 Complete	90-100-135
4	0	0	0	120-0-0	120-100-180 4/3 K	90-100-180 4/3 K
5	108-42-74, DB, RP, kainite	128-65-169, soda, RP, muriate	38-0-0, soda	120-400-200 Rock P-	120-200-135 Rock P	90-200-135 Rock P
6	54-42-37, DB, RP, kainite	128-0-0, soda	38-0-0, soda	120-200-0 No K	120-100-0 No K	90-100-0 No K
7	0	0	0	120-0-0	120-100-90 2/3 K	90-100-90 2/3 K
8	12-42-24, CSM, SP, kainite	12-43-30, CSM, SP, muriate	0-68-30	120-200-200 No lime	120-100-135 No lime	90-100-135 No lime
9	12-29-24, CSM, RP, kainite	12-29-30, CSM, RP, muriate	0-68-30	120-200-200 No S (TSP)	120-100-135 No S (TSP)	90-100-135 No S/ no gypsum
10	9-29-12, CSM, RP, kainite	6-29-15, CSM, RP, muriate	0-68-30	120-200-200 + micros	120-100-135 + micros	90-100-135 + micros
11	0	0	0	120-0-0	120-100-45 1/3 K	90-100-45 1/3 K

†The early records indicate pounds per acre of material, not nutrients applied. We have estimated the nutrient concentrations (percentage N-P_2O_5-K_2O in the materials as follows: superphosphate (SP) 0-18-0; rock phosphate (RP) 0-6-0; kainit 0-0-12; muriate 0-0-60; cottonseed meal (CSM) 6-1-1; sodium nitrate (soda) 16-0-0; dried blood (DB) 12-1-1; triple superphosphate (TSP) 0-46-0;
‡ In 1967, the sources of all nutrients were ammonium nitrate (34-0-0), superphosphate (0-20-0), triple superphosphate (0-45-0) on plot 9, and muriate of potash (0-0-60),. The micronutrient mix used on plot/treatment 10 applies approximately 1 lb. B, 1.25 lb. Cu, 2.4 lb. Mn, 3 lb. Zn, and 0.2 lb. Mo per acre per three-year rotation.
§ Triple superphosphate (0-46-0) became the source of P for all plot in 1985 and gypsum was added as a source of S for all plots except for plot C and plot 9 (no S). Nitrogen rates for cotton were increased to 120 lb. N per acre in 2004. Rock phosphate applications to plot 5 ceased in 2002.

Appendix Table 13. History of fertilizer applied to corn on Cullars Rotation†

Plot/Treatment	Years and fertilizer added (pounds per acre N-P_2O_5-K_20)					
	1911-1923	1924-1932	1933-1955	1956-1966	1967-1984	1985-2010‡
A	0-42-24, SP & kainite	0-42-30, SP & muriate	0-68-30, SP & muriate	0-0-0 + legume	0-0-0 + legume	0-0-0 + gypsum + legume
B	0-42-24, SP & kainite	0-42-30, SP & muriate	0-68-30, SP & muriate	0-0-0 No legume	0-0-0 No legume	0-0-0 + gypsum No legume
C	0	0	0	0	0	0
1	0	0	0	120-0-0	120-0-0 No legume	120-0-0 + gypsum No legume
2	95-0-64, DB & kainite	112-0-79, soda & muriate	38-0-0, soda	120-0-0	60-0-0	60-0-0 + gypsum No P
3	95-49-64, DB, SP, kainite	112-49-79, soda, SP, muriate	38-0-0, soda	120-0-0	60-0-0	60-0-0 + gypsum
4	0	0	0	120-0-0	60-0-0 4 /3 K	60-0-0 + gypsum 4/3 J
5	95-33-64, DB, RP, kainite	112-32-79, soda, RP, muriate	38-0-0, soda	120-0-0 Rock P	60-0-0 Rock P	60-0-0 + gypsum Rock P
6	47-33-32, DB, RP, kainite	112-0-0, soda	38-0-0, soda	120-0-0	60-0-0 No K	60-0-0 + gypsum No K
7	0	0	0	120-0-0	60-0-0	60-0-0 + gypsum 2/3 K
8	18-42-24, CSM, SP, kainite	18-29-30, CSM, SP, muriate	0	120-0-0	60-0-0 No lime	60-0-0 + gypsum No lime
9	18-29-24, CSM, RP, kainite	18-29-30, CSM, RP, muriate	0	120-0-0	60-0-0 TSP No S	60-0-0 TSP No S
10	9-29-12, CSM, SP, kainite	9-14-15, CSM, RP, muriate	0	120-0-0	60-0-0 + micros	60-0-0 + gypsum + micros
11	0	0	0	120-0-0	60-0-0 1/3 K	60-0-0 + gypsum 1/3 K

†The early records indicate pounds per acre of material, not nutrients applied. We have estimated the nutrient concentrations (percentage N-P_2O_5-K_2O in the materials as follows: Superphosphate (SP) 0-18-0;Rock phosphate (RP) 0-6-0; kainit 0-0-12l; muriate 0-0-60; cottonseed meal (CSM) 6-1-1; sodium nitrate (soda) 16-0-0; dried blood (DB) 12-1-1.
‡ N rates for corn were increased to 120 lb. N per acre in 2004.

Appendix Table 14. History of fertilizer applied to oats, rye, or wheat on Cullars Rotation†

Plot/Treatment	Years and fertilizer added (pounds per acre N-P_2O_5-K_20)					
	1911-1923	1924-1932	1933-1955	1956-1966	1967-1984	1985-2011‡
A	0	0	0	0	0-100-135	0-100-135
B	0	0	0	0	0-100-135	0-100-135
C	0	0	0	0	0	0
1	0	0	0	60-0-0	60-100-135	60-100-135
2	75-0-61, soda & kainite	75-0-0, soda	38-0-0, soda	60-0-0	60-0-135 No P	60-0-135 No P
3	75-34-61, soda, SP, kainite	75-0-0, soda	38-0-0, soda	60-0-0	60-100-135 Complete	60-100-135 Complete
4	0	0	0	60-0-0	60-100-180 4/3 K	60-100-180 4/3 K
5	75-23-61, soda, RP, kainite	75-0-0, soda	38-0-0, soda	60-0-0	60-200-135 Rock P	60-200-135 Rock P
6	37-23-30, soda, RP, kainite	37-0-0, soda	38-0-0, soda	60-0-0	60-100-0 No K	60-100-0 No K
7	0	0	0	60-0-0	60-100-90 2/3 K	60-100-90 2/3 K
8	16-0-0, soda	16-0-0, soda	38-0-0, soda	60-0-0	60-100-135 No lime	60-100-135 No lime
9	16-0-0, soda	16-0-0, soda	38-0-0, soda	60-0-0	60-100-135 No S (TSP)	60-100-135 No S/ no gypsum
10	16-0-0, soda	16-0-0, soda	0	60-0-0	60-100-135 + micros	60-100-135 + micros
11	0	0	0	60-0-0	60-100-45 1/3 K	60-100-45 1/3 K

†The early records indicate pounds per acre of material, not nutrients applied. We have estimated the nutrient concentrations (percentage N-P_2O_5-K_2O in the materials as follows: Superphosphate (SP) 0-18-0;Rock phosphate (RP) 0-6-0; kainit 0-0-12; muriate 0-0-60; cottonseed meal (CSM) 6-1-1; sodium nitrate (soda) 16-0-0; dried blood (DB) 12-1-1.
‡ All N is applied as a topdressing in February. Rock phosphate applications ceased in 2002.

Appendix Table 15. Crop rotations used on the Cullars Rotation, 1911-2010

Years	Year 1 crops	Year 2 crops	Year 3 crops
1911-1931	Cotton – oats in fall	Oats harvested for grain – cowpeas turned under – winter legume†	Corn – cowpeas planted between rows
1932-1955	Cotton – winter legume†	Corn – cowpeas planted in middles – oats in fall	Oats harvested for grain – cowpeas turned under – winter legume
1955-1966	Cotton – winter legume	Corn – oats	Oats harvested for grain – crotalaria
1967-2010	Cotton – winter legume	Corn – rye or wheat	Rye or wheat harvested for grain – soybean

†Winter legume species varied and included crimson clover, hairy vetch, Austrian winter peas, and annual yellow malilotus.

Acknowledgement

The Cullars Rotation is one of several long-term, soil fertility experiments maintained by the Auburn University Department of Agronomy and Soils and the Alabama Agricultural Experiment Station in cooperation with the USDA-ARS National Soil Dynamics Laboratory. This experiment has received periodic support through the commodity checkoff programs of the Alabama Wheat and Grain Crops Committee, the Alabama Soybean Committee and the Alabama Cotton Commission.

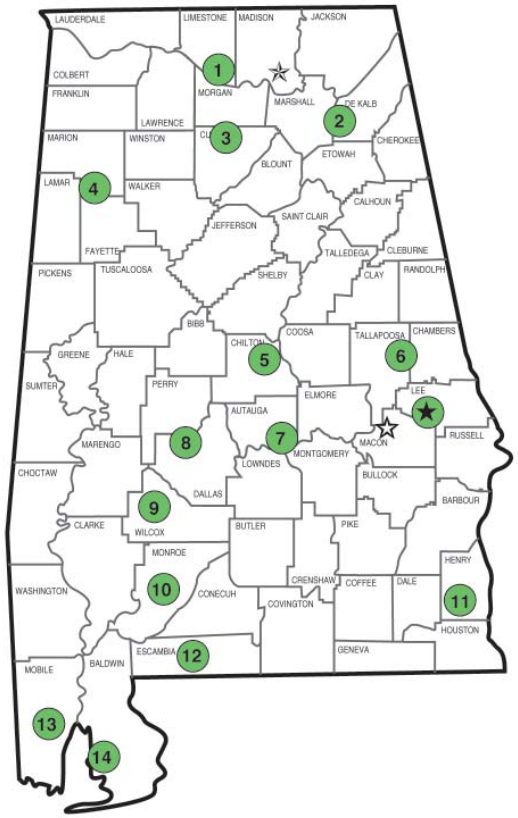
Web publication, June 2010

http:www.auburn.edu
http:www.aaes.auburn.edu

Website for Cullars Rotation:
http://www.ag.auburn.edu/agronomy/cullars.htm

Alabama's Agricultural Experiment Station
AUBURN UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the state has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.
★ Alabama A&M University.
☆ E. V. Smith Research Center, Shorter.

1. Tennessee Valley Research and Extension Center, Belle Mina.
2. Sand Mountain Research and Extension Center, Crossville.
3. North Alabama Horticulture Research Center, Cullman.
4. Upper Coastal Plain Agricultural Research Center, Winfield.
5. Chilton Research and Extension Center, Clanton.
6. Piedmont Substation, Camp Hill.
7. Prattville Agricultural Research Unit, Prattville.
8. Black Belt Research and Extension Center, Marion Junction.
9. Lower Coastal Plain Substation, Camden.
10. Monroeville Agricultural Research Unit, Monroeville.
11. Wiregrass Research and Extension Center, Headland.
12. Brewton Agricultural Research Unit, Brewton.
13. Ornamental Horticulture Research Center, Spring Hill.
14. Gulf Coast Research and Extension Center, Fairhope.