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Arkansas Soil Fertility Studies 1996

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Wayne E. Sabbe, Editor

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Arkansas Soil Fertility Studies
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INTRODUCTION

The Arkansas Soil Fertility Studies 1996 includes an index of articles in this and previous issues (1989-1996). The index is arranged by commodity. Within each commodity the indexing is sorted by nutrients. This addition will allow readers to review current and past issues for information on the soil fertility program in Arkansas.

The 1996 Soil Fertility Studies includes research reports on numerous Arkansas commodities and on several research areas including soil salinity. If the reader wishes more information on any included topic please contact the author(s). Also included is a summarization of soil test data from samples submitted for the 1996 growing season. This set of data includes data for counties, soil associations and selected cropping systems.

Funding for the associated soil fertility research programs came from several commodity check-off funds, the state, the federal government, the fertilizer industry and lime vendors. The fertilizer tonnage fee not only provided research funds but also provided funds for publication of this research series.

Extended thanks are given to state and county extension staffs, staffs at Extension and Research Centers and branch stations, farmers, and cooperators and fertilizer industry personnel who assisted with the planning and execution of the programs.

This publication is available online at http://www.uark.edu/depts/agripub/Publications/researchseries/. Additional printed copies of this publication can be obtained free of charge from Agricultural Publications, Agricultural Building 110, University of Arkansas, Fayetteville, AR 72701.

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ASU = Arkansas State University; CES = Cooperative Extension Service; PPI = Phosphate Potash Institute; RREC = Rice Research and Extension Center; SEREC = Southeast Research and Extension Center; UAM = University of Arkansas, Monticello; USDA = U.S. Department of Agriculture.

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Soil Test Data: Summary for the Growing Season — 1996 —

R.E. DeLong, S.D. Carroll, W.E. Sabbe and W.H. Baker

Background Information

Soil test data from samples submitted by Arkansas farmers and growers to the University of Arkansas Soil Test Laboratory from 1 September 1995 to 30 August 1996 were categorized according to county, soil association number (SAN) and selected cropping system. This sampling period roughly corresponds to the 1996 crop growing season; therefore, those samples should represent the soil fertility of that cropping season. The SANs are from the General Soil Map, State of Arkansas (December 1982). The statistical interpretation of the soil test data include categorical ranges for pH, soil test P, K, NO_3-N and soluble salts. Soluble salts and NO_3-N can be indexes for possible soil contents that may lead to adverse soil-growing conditions or leaching potentials. Soil pH plus soil test (Mehlich III) values indicate soil fertility level.

Results

Crop Acreage and Soil Sampling Intensity

In the interval from 1 September 1995 to 30 August 1996, soil samples representing a total of 1,489,082 acres were submitted through the University of Arkansas Soil Testing Program (Tables 1-3). These 58,982 samples resulted in fertilizer and lime recommendations in all counties with each sample representing an average of 25 acres. The county average ranged from 3 to 50 acres/ sample. The lowest county sample number was 46, and the highest county sample number was 2891.

The average by SAN indicates the predominance of row crops and pasture. The higher values originate either from the Delta SAN where cotton, rice, wheat and soybean prevail or from the pasture SAN where cool- and warm-season hay and pasture production occurs.

The crops involved indicate that, in addition to row crops and pasture, turf and garden enterprises contributed largely to the samples submitted to the program.

Soil Test Data

Values in Tables 4 to 6 pertain to the fertility status of the soils as categorized by county, SAN or the suggested 1996 crop category. Soil test values relate to the fertility of a soil but not necessarily to the productivity of the soil. Therefore, it may not be realistic to compare soil test values among SAN without knowledge of location and cropping system. Likewise, county values need knowledge of SAN and the profile of cropping systems. Soil test data for cropping systems can be compared; however, the specific cropping systems dictated past fertilizer practices and, hence, current soil test values. For example, cotton has a history of intensive fertilization; whereas, nonirrigated soybean has not been subjected to intensive fertilization. Similarly, rice can be produced on soils low in P and K, and those soil test values for the commodity reflect that fact. The acidity of Arkansas soils is demonstrated by the 20% sampled acreage that has a pH less than 5.5. From a beneficial standpoint, the accumulation of soluble salts and leachable nitrogen (NO_3- N) is low with approximately 69% for each in the lowest category.

Table 6 contains the median (Md) for each of the cropping system categories. The median (the soil test value that has an equal number of entities above and below) should be a better interpreter of a soil's fertility status than the percentage profile of the samples. Among row crops, the lowest P and K median values appear for rice and irrigated soybeans. As expected, the highest P and K median values are for cotton.

Practical Application

The data can be viewed with the perceptive of establishing a statewide, county-wide or commodity educational program on soil fertility and fertilization practices. The data are rather general, and more specific categories (e.g., soybean in Arkansas county for SAN 44) should be generated for those purposes. Comparisons and contrasts among counties, SAN or cropping systems would give the specific data needed for these programs.

Acknowledgment

Financial support from the Arkansas fertilizer tonnage fees is appreciated.

Table 1. Sample number and acreage by county in Soil Test Program from September 1995 through August 1996.

County	Acres Sampled	No. of Samples	Acres / Sample	County	Acres Sampled	No. of Samples	Acres / Sample
Arkansas (DE)	40412	977	41	Lee	34006	952	36
Arkansas (ST)	96445	2343	41	Lincoln	7886	269	29
Ashley	27949	1086	26	Little River	4203	158	27
Baxter	7202	521	14	Logan (BO)	3705	201	18
Benton	29940	2083	14	Logan (PA)	5435	276	20
Boone	22196	891	25	Lonoke	98068	2628	37
Bradley	1438	209	7	Madison	9613	486	20
Calhoun	577	58	10	Marion	4069	224	18
Carroll	17680	843	21	Miller	7460	316	24
Chicot	10024	242	41	Mississippi (BL)	36786	946	39
Clark	4964	401	12	Mississippi (OS)	12858	358	36
Clay (CO)	23391	865	27	Monroe	23122	725	32
Clay (PI)	20148	637	32	Montgomery	3616	267	14
Cleburne	4431	444	10	Nevada	4133	221	19
Cleveland	988	75	13	Newton	4434	268	17
Columbia	1982	263	8	Ouachita	1028	138	8
Conway	11393	466	25	Perry	2412	138	18
Craighead	89223	2681	33	Phillips	23180	875	27
Crawford	14427	532	27	Pike	3741	245	15
Crittenden	34008	1380	25	Poinsett	58008	1450	40
Cross	75236	2658	28	Polk	3769	248	15
Dallas	297	58	5	Pope	16338	710	23
Desha (DU)	9059	327	28	Prairie (DA)	14743	363	41
Desha (MC)	60141	1534	39	Prairie (DB)	25596	571	45
Drew	5588	224	25	Pulaski	6343	1758	4
Faulkner	10516	1621	7	Randolph	21766	721	30
Franklin (CH)	881	46	19	Saline	1431	297	5
Franklin (OZ)	3022	161	19	Scott	1859	128	15
Fulton	8795	447	20	Searcy	6864	218	22
Garland	4125	1188	4	Sebastian (FS)	1755	519	3
Grant	928	144	6	Sebastian (GR)	3835	287	13
Greene	46087	1858	25	Sevier	4965	205	24
Hempstead	6719	313	22	Sharp	6771	374	18
Hot Spring	1892	170	11	St. Francis	22069	596	37
Howard	6752	337	20	Stone	3396	290	12
Independence	13849	504	28	Union	1897	175	11
Izard	11931	573	21	Van Buren	4366	324	14
Jackson	32755	770	43	Washington	26341	1823	15
Jefferson	38800	1408	28	White	46135	2891	16
Johnson	7606	383	20	Woodruff	38522	779	50
Lafayette	15524	428	36	Yell (DN)	7535	377	20
Lawrence	51675	1820	28	Yell (DR)	4027	118	34

Table 2. Sample number and acreage by SAN in Soil Test Program from September 1995 through August 1996.

Soil Association Number/Soil Association	Acres Sampled	No. of Samples	Acres/ Sample	Soil Association Number/Soil Association	Acres Sampled	No. of Samples	Acres/ Sample
1-Clarksville-Nixa-Noark	31811	1435	22	26-Amagon-Dundee	52127	1403	37
2-Gepp-Doniphan-Gassville-Agnos	24517	1421	17	27-Sharkey-Steele	19604	509	39
3-Arkana-Moko	22585	1229	18	28-Commerce-Sharkey-Crevasse-Robinsonville	20990	725	29
4-Captina-Nixa-Tonti	40372	2782	15	29-Perry-Portland	37826	1168	32
5-Captina-Doniphan-Gepp	814	45	18	30-Crevasse-Bruno-Oklared	1349	51	27
6-Eden-Newnata-Moko	3238	123	26	31-Roxana-Dardanelle-Bruno-Roellen	13251	456	29
7-Estate-Portia-Moko	5671	219	26	32-Rilla-Hebert	148789	4121	36
8-Brockwell-Boden-Portia	9168	459	20	33-Billyhaw-Perry	13242	224	59
9-Linker-Mountainburg-Sidon	14234	650	22	34-Severn-Oklared	4642	86	54
10-Enders-Nella-Mountainburg-Steprock	38865	2558	15	35-Adaton	535	17	32
11-Falkner-Wrightsville	954	52	18	36-Wrightsville-Louin-Acadia	1841	54	34
12-Leadvale-Taft	33783	3150	11	37-Muskogee-Wrightsville-McKamie	466	16	29
13-Enders-Mountainburg-Nella-Steprock	8375	508	17	38-Amy-Smithton-Pheba	3009	211	14
14-Spadra-Guthrie-Pickwick	4892	181	27	39-Darco-Briley-Smithdale	576	17	34
15-Linker-Mountainburg	47619	3710	13	40-Pheba-Amy-Savannah	4559	469	10
16-Carnasaw-Pirum-Clebit	12023	2065	6	41-Smithdale-Sacul-Savannah-Saffell	12275	1164	11
17-Kenn-Ceda-Avilla	1880	110	17	42-Sacul-Smithdale-Sawyer	18560	1463	13
18-Carnasaw-Sherwood-Bismarck	9107	1414	6	43-Guyton-Ouachita-Sardis	9290	361	26
19-Carnasaw-Bismarck	212	18	12	44-Calloway-Henry-Grenada-Calhoun	272976	8617	32
20-Leadvale-Taft	2137	107	20	45-Crowley-Stuttgart	164487	3826	43
21-Spadra-Pickwick	2412	119	20	46-Loring	3180	101	32
22-Foley-Jackport-Crowley	143247	4506	32	47-Loring-Memphis	29796	1543	19
23-Kobel	29582	699	42	48-Brandon	850	65	13
24-Sharkey-Alligator-Tunica	56593	1643	35	49-Oktibbeha-Sumter	6776	268	25
25-Dundee-Bosket-Dubbs	103995	2844	37				

Table 3. Sample number and acreage by crop in Soil Test Program from September 1995 through August 1996.

Crop	Acres Sampled	Number of Samples	Acres/ Sample
Soybean - nonirrigated	125374	3350	37
Soybean - irrigated	433903	10959	40
Cotton	261631	7032	37
Rice	141626	3925	36
Wheat	30833	742	42
Double-crop wheat-soybean - nonirrigated	22220	538	41
Double-crop wheat-soybean - irrigated	17912	491	37
Warm season grass - establish	6716	362	19
Warm season grass - maintain	97774	4189	23
Cool season grass - establish	1546	95	16
Cool season grass - maintain	80186	3427	23
Grain sorghum	17811	498	36
Corn	19176	534	36
All garden	7653	3919	2
Turf and ground cover	9603	6771	1
Fruit and nut	2887	642	5
Vegetable	140	32	4
Other	212091	11476	19

Table 4. Soil test data by county from samples submitted from September 1995 through August 1996.

	pH			P (lb/A)				K (lb/A)				NO_3-N (lb/A)			EC (umhos/cm)		
County	<5.5	5.5-6.5	>6.5	<26	26-44	45-100	101-300	>300	<176	176-220	221-350	>350	<26	26-100	>100	<100	101-500	>500
	Percentage of Sampled Acreage																	
Arkansas (DE)	11	42	47	30	41	24	4	1	42	26	26	6	81	16	3	44	55	1
Arkansas (ST)	15	52	33	47	28	19	5	1	50	22	21	7	85	14	1	56	43	1
Ashley	23	55	22	10	13	38	37	2	18	11	35	36	83	15	2	65	35	0
Baxter	4	35	61	8	13	25	34	20	20	10	31	39	68	25	7	40	58	2
Benton	20	60	20	2	5	16	41	36	19	10	26	45	55	36	9	33	64	3
Boone	13	65	22	8	11	33	37	11	28	11	25	36	66	29	5	48	51	1
Bradley	23	47	30	12	9	19	37	23	38	12	31	19	74	23	3	64	36	0
Calhoun	35	62	2	5	12	24	47	12	50	12	24	14	76	19	5	74	26	0
Carroll	10	60	30	12	8	25	38	17	26	11	27	36	61	34	5	44	55	1
Chicot	7	53	40	13	29	37	18	3	12	6	19	63	68	29	3	36	63	1
Clark	35	49	16	20	13	19	34	14	49	14	22	15	84	13	3	70	27	3
Clay (CO)	11	69	20	32	30	32	6	0	55	21	20	4	93	7	0	78	22	0
Clay (PI)	19	71	10	12	23	49	15	1	26	29	36	9	90	8	2	82	18	0
Cleburne	27	60	13	15	19	26	22	18	35	13	28	24	71	25	4	59	40	1
Cleveland	36	51	13	19	7	17	33	24	39	16	24	21	83	12	5	71	28	1
Columbia	43	46	11	7	9	22	38	24	38	18	26	18	82	16	2	65	33	2
Conway	35	53	12	17	19	30	18	16	34	13	24	29	81	16	3	72	28	0
Craighead	12	59	29	17	21	38	22	2	25	16	31	28	87	12	1	67	33	0
Crawford	10	56	34	13	16	34	29	8	29	17	35	19	72	24	4	68	31	1
Crittenden	13	63	34	14	8	52	25	1	10	4	26	60	92	8	0	80	20	0
Cross	5	44	51	38	37	24	1	0	41	25	22	12	88	11	1	44	56	0
Dallas	31	59	10	21	9	31	24	15	50	12	31	7	90	10	0	83	17	0
Desha (DU)	10	43	47	2	22	48	26	2	21	17	27	35	75	23	2	43	56	1
Desha (MC)	10	63	27	4	7	46	42	1	8	10	36	46	81	18	1	54	46	0
Drew	39	42	19	33	15	24	21	7	49	17	22	12	80	17	3	69	30	1

Continued

Table 4. Continued.

Faulkner	39	55	6	15	23	33	22	7	32	22	33	13	78	19	3	60	40	0
Franklin (CH)	26	72	2	33	26	17	22	2	61	26	9	4	96	4	0	85	15	0
Franklin (OZ)	37	55	8	30	19	19	17	15	47	11	20	22	81	16	3	65	34	1
Fulton	19	66	15	18	17	35	27	3	33	15	27	25	79	19	2	67	32	1
Garland	33	54	13	5	7	25	40	23	25	14	31	30	48	31	21	29	65	6
Grant	28	67	5	17	15	22	36	10	52	13	24	11	89	8	3	81	19	0
Greene	17	67	16	26	30	29	15	0	37	21	30	12	93	6	1	82	18	0
Hempstead	25	41	34	9	12	22	34	23	38	12	16	34	77	19	4	52	46	2
Hot Spring	31	61	8	12	21	27	25	15	45	11	24	20	73	22	5	66	34	0
Howard	34	54	12	9	8	13	30	40	27	14	27	32	69	27	4	45	52	3
Independence	21	59	20	16	18	30	26	10	39	16	27	18	74	23	3	61	39	0
Izard	14	66	20	18	20	31	25	6	45	15	23	17	85	12	3	68	31	1
Jackson	14	70	16	18	28	36	16	2	34	21	33	12	82	16	2	75	25	0
Jefferson	20	58	22	7	10	46	32	5	21	16	36	27	78	19	3	66	33	1
Johnson	24	61	15	14	15	21	28	22	37	11	25	27	74	23	3	70	29	1
Lafayette	16	46	38	5	9	38	37	11	23	12	26	39	67	31	2	50	49	1
Lawrence	10	70	20	31	31	27	10	1	34	21	32	13	88	11	1	65	34	1
Lee	14	72	14	3	13	64	18	2	14	13	41	32	83	16	1	80	20	0
Lincoln	29	52	19	10	10	35	33	12	26	14	32	28	72	23	5	60	39	1
Little River	19	58	23	17	11	32	34	6	32	10	25	33	65	30	5	49	51	0
Logan (BO)	21	68	11	24	18	25	23	10	39	13	29	19	75	21	4	54	44	2
Logan (PA)	29	54	17	16	20	24	27	13	42	12	22	24	76	21	3	61	37	2
Lonoke	15	62	23	18	21	42	16	3	22	18	35	25	83	16	1	65	34	1
Madison	21	68	11	8	9	25	33	25	25	11	27	37	68	26	6	52	45	3
Marion	8	63	29	5	13	29	41	12	25	9	34	32	72	25	3	51	48	1
Miller	24	50	26	10	12	27	30	21	38	14	24	24	82	16	2	63	37	0
Mississippi (BL)	8	71	21	0	3	56	39	2	6	10	53	31	94	5	1	89	11	0
Mississippi (OS)	8	74	18	3	5	64	27	1	6	6	28	60	91	7	2	89	10	1
Monroe	14	59	27	15	23	42	19	1	19	21	36	24	80	18	2	66	34	0
Montgomery	34	59	7	14	12	18	27	29	40	7	23	30	69	27	4	63	37	0

Continued

Table 4. Continued.

Nevada	38	53	9	8	15	14	33	30	34	20	27	19	85	13	2	70	29	1
Newton	16	69	15	10	10	35	38	7	27	12	30	31	69	27	4	56	44	0
Ouachita	34	54	12	17	7	20	36	20	49	16	21	14	86	12	2	65	33	2
Perry	38	51	11	34	15	13	23	15	41	9	25	25	74	22	4	62	34	4
Phillips	12	59	29	4	17	54	22	3	18	13	41	28	84	15	1	71	29	0
Pike	44	47	9	14	10	16	30	30	53	12	18	17	81	16	3	73	27	0
Poinsett	4	44	52	32	28	32	8	0	47	19	19	15	83	17	0	60	40	0
Polk	36	59	5	10	15	19	34	22	39	18	23	20	76	19	5	69	30	1
Pope	31	53	16	15	17	29	26	13	34	12	28	26	76	22	2	64	35	1
Prairie (DA)	13	48	39	47	36	11	4	2	55	14	25	6	87	11	2	64	36	0
Prairie (DB)	11	61	28	28	42	24	5	1	48	24	21	7	85	13	2	72	28	0
Pulaski	37	46	17	8	8	17	39	28	30	18	30	22	70	24	6	51	47	2
Randolph	14	71	15	33	27	31	7	2	39	22	28	11	90	9	1	80	20	0
Saline	35	52	13	20	13	20	29	18	44	13	24	19	86	11	3	65	31	4
Scott	38	57	5	25	20	25	27	3	38	23	26	13	77	22	1	54	45	1
Searcy	29	55	16	10	12	30	40	8	32	11	28	29	73	24	3	59	40	1
Sebastian (FS)	28	52	20	9	10	30	37	14	21	14	37	28	57	37	6	43	55	2
Sebastian (GR)	25	53	22	29	17	22	24	8	39	15	21	25	76	23	1	64	35	1
Sevier	37	54	9	11	8	19	28	34	31	10	23	36	62	33	5	55	43	2
Sharp	20	51	29	28	13	28	20	11	37	14	23	26	66	29	5	53	45	2
St. Francis	18	59	23	12	20	56	9	3	22	21	43	14	85	14	1	76	24	0
Stone	22	58	20	2	12	26	37	23	26	13	28	33	63	31	6	52	47	1
Union	24	59	17	11	6	18	41	24	38	12	25	25	76	19	5	61	36	3
Van Buren	26	63	11	9	14	38	25	14	39	15	26	20	74	20	6	68	32	0
Washington	17	60	23	4	9	21	38	28	25	12	28	35	58	37	5	44	53	3
White	20	61	19	16	22	28	29	5	33	17	32	18	72	23	5	54	45	1
Woodruff	9	71	20	17	35	36	11	1	41	23	30	6	84	16	0	67	33	0
Yell (DN)	40	57	3	24	15	16	30	15	43	14	23	20	82	15	3	74	26	0
Yell (DR)	25	65	10	15	11	32	33	9	35	7	32	26	71	22	7	53	46	1
Average	23	58	19	16	17	29	27	11	34	15	28	23	76	19	5	62	37	1

Table 5. Soil test data by SAN from samples submitted from September 1995 through August 1996.

Soil Association Number	pH			P (lb/A)					K (lb/A)				NO_3-N (lb/A)			EC (umhos/cm)		
and Soil Association	<5.5	5.5-6.5	>6.5	<26	26-44	45-100	101-300	>300	<176	176-220	221-350	>350	<26	26-100	>100	<100	101-500	>500
	Percentage of Sampled Acreage																	
1-Clarksville-Nixa-Noark	16	66	18	8	12	30	36	14	30	12	26	32	67	28	5	49	50	1
2-Gepp-Doniphan-Gassville-Agnos	13	50	37	18	17	29	24	12	26	14	30	30	75	21	4	54	45	1
3-Arkana-Moko	11	62	27	10	14	32	35	9	33	13	26	28	69	26	5	52	47	1
4-Captina-Nixa-Tonti	20	54	26	3	7	19	39	32	21	11	27	40	56	36	8	36	61	3
5-Captina-Doniphan-Gepp	27	67	6	36	22	11	29	2	49	11	24	16	91	9	0	71	29	0
6-Eden-Newnata-Moko	28	60	12	6	11	33	42	8	28	14	31	27	74	24	2	61	39	0
7-Estate-Portia-Moko	15	59	26	7	11	28	37	17	27	10	32	31	69	27	4	53	45	2
8-Brockwell-Boden-Portia	25	61	14	37	20	22	17	4	51	13	21	15	78	19	3	73	27	0
9-Linker-Mountainburg-Sidon	19	60	21	21	10	23	31	15	35	11	25	29	72	25	3	57	42	1
10-Enders-Nella-Mountainburg-Steprock	20	61	19	8	11	23	34	24	25	13	28	34	64	32	4	52	47	1
11-Falkner-Wrightsville	25	64	11	38	15	21	17	9	62	19	14	5	90	10	0	79	21	0
12-Leadvale-Taft	32	56	12	16	19	29	26	10	33	17	31	19	73	24	3	56	43	1
13-Enders-Mountainburg-Nella-Steprock	33	60	7	23	23	30	16	8	43	18	21	18	78	21	1	70	29	1
14-Spadra-Guthrie-Pickwick	33	61	6	18	15	28	24	15	40	16	25	19	83	13	4	73	27	0
15-Linker-Mountainburg	25	58	17	13	15	27	33	12	34	14	29	23	73	24	3	57	42	1
16-Carnasaw-Pirum-Clebit	37	48	15	10	9	18	36	27	33	16	27	24	72	23	5	53	45	2
17-Kenn-Ceda-Avilla	31	61	8	11	16	11	39	23	34	21	21	24	72	23	5	64	36	0
18-Carnasaw-Sherwood-Bismarck	37	53	10	6	7	23	39	25	30	14	30	26	54	28	18	38	58	4
19-Carnasaw-Bismarck	17	83	0	17	22	11	28	22	33	17	33	17	72	28	0	61	39	0
20-Leadvale-Taft	28	50	22	20	16	31	23	10	33	9	22	36	88	11	1	77	22	1
21-Spadra-Pickwick	37	49	14	27	16	24	20	13	45	8	24	23	76	20	4	68	29	3
22-Foley-Jackport-Crowley	11	70	19	28	33	30	8	1	39	22	29	10	89	10	1	70	30	0

Continued

Table 5. Continued.

23-Kobel	18	64	18	23	33	30	14	0	31	21	37	11	86	13	1	76	24	0
24-Sharkey-Alligator-Tunica	11	60	29	9	19	55	17	0	6	6	20	68	88	12	0	68	32	0
25-Dundee-Bosket-Dubbs	10	70	20	9	13	45	32	1	17	14	40	29	87	12	1	80	20	0
26-Amagon-Dundee	11	71	18	10	8	45	35	2	17	15	47	21	92	7	1	85	14	1
27-Sharkey-Steele	6	59	35	3	16	64	16	1	6	5	24	65	87	12	1	72	28	0
28-Commerce-Sharkey-Crevasse-Robinsonville	4	56	40	2	7	50	40	1	1	4	26	69	79	20	1	64	36	0
29-Perry-Portland	13	55	32	11	19	43	24	3	13	11	30	46	78	20	2	51	48	1
30-Crevasse-Bruno-Oklared	10	73	17	2	8	51	39	0	20	8	41	31	75	25	0	65	35	0
31-Roxana-Dardanelle-Bruno-Roellen	13	49	28	11	13	40	28	8	25	17	34	24	78	19	3	71	29	0
32-Rilla-Hebert	17	61	22	5	9	50	35	1	14	14	41	31	84	15	1	67	33	0
33-Billyhaw-Perry	10	30	60	3	9	52	34	2	14	9	20	57	65	34	1	49	50	1
34-Severn-Oklared	8	36	56	12	13	33	40	2	20	12	40	28	64	35	1	49	51	0
35-Adaton	65	6	29	35	24	12	12	17	59	24	12	5	94	6	0	35	59	6
36-Wrightsville-Louin-Acadia	13	46	41	15	19	43	15	8	32	15	17	36	89	11	0	69	31	0
37-Muskogee-Wrightsville-McKamie	0	81	19	13	19	25	38	5	19	13	50	18	69	31	0	63	31	6
38-Amy-Smithton-Pheba	33	57	10	14	18	19	30	19	42	15	23	20	69	23	8	56	43	1
39-Darco-Briley-Smithdale	53	35	12	12	18	12	24	34	47	18	12	23	59	41	0	59	41	0
40-Pheba-Amy-Savannah	36	51	13	21	16	19	29	15	46	15	23	16	80	17	3	67	31	2
41-Smithdale-Sacul-Savannah-Saffell	34	51	15	14	8	19	34	25	39	14	25	22	77	19	4	61	37	2
42-Sacul-Smithdale-Sawyer	30	56	14	12	11	21	34	22	41	15	25	19	80	16	4	68	31	1
43-Guyton-Ouachita-Sardis	33	54	13	16	17	21	22	23	37	13	22	28	74	22	4	60	37	3
44-Calloway-Henry-Grenada-Calhoun	11	53	36	28	31	32	7	2	42	23	26	9	84	14	2	60	39	1
45-Crowley-Stuttgart	14	51	35	42	31	21	5	1	45	24	23	8	83	15	2	54	44	2
46-Loring	31	51	18	27	26	26	12	9	50	17	17	16	78	18	4	64	36	0
47-Loring-Memphis	27	54	19	23	21	37	16	3	27	18	31	24	85	13	2	66	33	1
48-Brandon	15	68	17	48	22	17	11	2	32	11	34	23	91	6	3	82	15	3
49-Oktibbeha-Sumter	16	37	47	14	18	22	30	16	22	8	22	48	75	20	5	33	63	4
Average	22	56	22	17	17	29	27	10	32	14	27	27	77	20	3	62	37	1

Table 6. Soil test data by crop from samples submitted from September 1995 through August 1996.

Crop	pH <5.5	pH 5.5-6.5	pH >6.5	pH Md[z]	P (lb/A) <26	P 26-44	P 45-100	P 101-300	P >300	P Md	K (lb/A) <176	K 176-220	K 221-350	K >350	K Md	NO_3-N (lb/A) <26	NO_3-N 26-100	NO_3-N >100	NO_3-N Md	EC (umhos/cm) <100	EC 100-500	EC >500	EC Md
	Percentage of Sampled Acreage																						
Soybean/nonirrigated	16	65	19	6.0	18	26	45	11	0	50	29	19	31	21	227	88	11	1	11	80	20	0	71
Soybean/irrigated	8	53	39	6.4	30	36	31	3	0	35	43	22	23	12	187	87	11	2	12	67	33	0	86
Cotton	11	69	20	6.1	1	4	53	42	0	94	5	12	48	35	306	87	12	1	11	79	21	0	70
Rice	9	58	33	6.3	46	29	24	1	0	28	41	20	24	15	192	88	12	0	10	37	63	0	114
Wheat	18	61	21	6.1	16	26	41	17	0	53	28	18	36	18	227	66	32	2	17	56	44	0	93
Double-crop wheat-soybean/nonirrigated	18	66	16	5.9	5	11	65	19	0	68	16	18	34	32	272	76	21	3	13	78	22	0	68
Double-crop wheat-soybean/irrigated	11	55	34	6.3	8	28	51	12	1	52	31	17	27	25	228	86	14	0	13	74	26	0	80
Warm-season grass establish	29	64	7	5.7	20	20	26	20	14	60	42	16	23	19	200	77	22	1	12	66	33	1	81
Warm-season grass maintain	27	62	11	5.8	13	13	24	30	20	101	34	13	26	27	231	74	23	3	13	61	38	1	85
Cool-season grass establish	39	53	8	5.6	32	20	36	7	5	41	36	12	35	17	229	85	15	0	9	73	27	0	75
Cool-season grass maintain	21	67	12	5.9	10	12	26	36	16	108	29	12	26	33	258	68	28	4	16	54	45	1	94
Grain sorghum	18	68	14	5.9	17	27	39	17	0	50	32	21	30	17	215	83	15	2	11	75	25	0	75
Corn	13	61	26	6.1	6	25	49	20	0	61	26	22	30	22	224	86	14	0	12	72	28	0	80
All garden	14	44	42	6.4	3	5	14	34	44	259	14	10	26	50	351	53	35	12	24	37	59	4	123
Turf/ground cover	28	53	19	5.9	6	11	28	45	10	114	26	17	36	21	240	70	24	6	14	46	53	1	104
Fruit and nut	33	52	15	5.7	5	13	30	37	15	107	26	15	32	27	253	71	24	5	13	54	44	2	92
Vegetable	16	41	43	6.4	0	13	22	38	27	146	9	22	31	38	270	78	13	9	18	56	34	10	89
Other	28	57	15	5.8	21	18	26	24	11	61	40	14	24	22	207	75	21	4	11	61	38	1	84
Average	20	58	22		14	19	35	23	9		28	17	30	25		78	19	3		63	36	1	

[z]Md=median. The number is actual value, not the percentage.

Soil Test Characteristics of Major Land Areas in Arkansas — 1996 —

Stanley L. Chapman, Mike Daniels,
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Introduction

The University of Arkansas Soil Testing Laboratory tests about 55,000 to 75,000 routine soil samples each year for agricultural clientele. This service is paid for by a fee on commercial fertilizers and liming materials. Nearly 58,000 soil samples representing 1.5 million acres were routinely tested by the University of Arkansas Soil Testing Lab in FY 96. The results of these tests were used to make fertilizer and lime recommendations for agricultural producers, homeowners and other Extension Service clientele. A summary of all samples tested showed definite trends in soil test values from the nine major land areas of the state (Table 1).

Methods and Materials

Soil samples collected by farmers, landholders and consultants are submitted to the University Lab by way of the county Extension offices. At the lab, samples are processed and tested according to standard procedures for agricultural soils. Nutrients are extracted by Mehlich III and determined by ICAP instrumentation. Nitrates, pH and soluble salts are measured by selective electrodes. Results and recommendations are printed out and returned to the appropriate county Extension office for review by the agent before being mailed to the person who submitted the sample.

Results and Discussion

Soil pH and Primary Plant Nutrients

The most acid soils occurred in the Ouachita Mountains (50% below pH 5.6). The lowest phosphorus (P) readings came from Loessial Plains (silt loam rice soils). Nearly a fourth (21%) of these soils contained less than 21 lb P per acre. Two-thirds (68%) tested below 46 lb per acre. High P readings (above 300 lb/acre) occurred in 15-18% of the sample acreage from the Ozark Highlands, Boston Mountains, Arkansas River Valley and the Coastal Plains. This reflects the application of poultry manure on pastures.

Potassium (K) was very low (below 100 lb/acre) on 13-15% of the soils of the Ouachita Mountains and the Coastal Plains. Nearly half the tested acreage (41-45%) of the Loessial Plains and Loessial Hills tested below 175 lb K per acre.

Secondary Elements and Nitrate - N

Calcium was low or very low (below 1000 lb/acre) in 28-29% of the tested acreage from the Ouachita Mountains and Coastal Plains. Lime needs are not being met on most of these low-calcium soils. In contrast, two-thirds of the tested acreage from the Blackland Prairies was high or very high in calcium (more than 4500 lb/acre). This reflects the derivation of these mostly clay soils from calcitic chalk.

Very low magnesium (below 76 lb/acre) occurred on 14% of the Coastal Plains acreage. High magnesium (above 650 lb/acre) occurred on 30% of the Loessial Hills and 38% of the Bottomland and Terrace soils. Sulfur was low or very low (less than 21 lb/acre) on 24% of the Bottomland and Terrace soils.

Nitrate - N was lowest (less than 6 lb/acre) in soils of the Arkansas Valley (26%) and the Ouachita Mountains (32%). Nitrate - N was highest (above 50 lb/acre) in soils of the Ozark Highlands (I 1%), Boston Mountains (10%) and Blackland Prairies (10%).

Micronutrients

Copper was low or very low (below 3.1 lb/acre) in the loess derived soils of eastern Arkansas (76-84% of the Loessial Plains and Hills). Copper was high (above 12 lb/acre) in 11 to 12% of the tested acreage from the Boston Mountains and the Ouachita Mountains. This may reflect either natural occurrence in the Ouachitas or a buildup from poultry manure applications in both areas.

Iron was low or very low (below 51 lb/acre) in 13% of the tested acreage from the Blackland Prairies. Very high iron levels (above 400 lb/acre) occurred in 29% of the Loessial Plains acreage. These high readings probably reflect the residual impacts of irrigation and anaerobic soil conditions on iron availability.

Low and very low manganese readings (below 50 lb/acre) occurred in half of the Blackland Prairie soil acreage tested. High manganese readings (above 400 lb/acre) occurred in 11-13% of the tested acreage from the Ozark Highlands, Boston Mountains and Arkansas Valley uplands. This is indicative of the need for lime on highly acid soils.

Low or very low zinc readings (below 3.1 lb/acre) occurred on 17% of the Loessial Plains soils (where rice is commonly grown). High zinc readings (above 18 lb/acre) occurred on 22-27% of the tested acreage from the Ozarks Highlands, Boston Mountains, Ouachita Mountains and Blackland Prairies.

These trends agree well with previous annual summaries and observations (DeLong et al., 1996; Snyder et al., 1995). They reflect both natural and man-made occurrences.

Literature Cited

1. DeLong, R.E., S.D. Carroll, W.E. Sabbe and W.H. Baker. 1996. Soil test data: Summary for the growing season - 1995. *In:* W. E. Sabbe (ed.). Arkansas Soil Fertility Studies 1995. Ark. Agri. Exp. Sta. Res. Ser. 450:81-93.
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Table 1. Predominant high and low soil test values for major land areas.

Land Area*	Predominant Soil Test Characteristics and Percent of Acreage
Ozark Highlands	High P (16%), $N0_3$-N (11%), manganese (13%) and zinc (27%)
Boston Mountains	High P (I 5%), $N0_3$-N (10%), copper (11%), manganese (11%), and zinc (25%)
Arkansas Valley Uplands	High manganese (11%)
Ouachita Mountains	Acid soils (50% below pH 5.6), high P (18%), very low K (13%), low calcium (28%), very low $N0_3$-N (32%), high copper (12%), and high zinc (22%)
Bottomlands and Terraces	High magnesium (38%), and low sulfur (24%)
Coastal Plains	High P (16%), very low K (15%), low calcium (29%) and very low magnesium (14%)
Loessial Plains	Very low P (21 %), low K (45%), low copper (84%), high iron (29%) and low zinc (17%)
LoessialHills	Low K (41%), high magnesium (30%), and low copper (76%)
Blackland Prairies	High pH (13%), high calcium (67%), high sulfur (63%), high $N0_3$-N (10%), low iron (13%), low manganese (40%), and high zinc (24%)

*According to General Soil Map State of Arkansas (December 1982).

Slow-Release Soil and Foliar Fertilizer on Cotton

D.M. Oosterhuis and A. Steger

Research Problem

Current fertilizer practices involve applying fertilizer to the soil at or prior to planting with additional applications during the growing season. A programmed release fertilizer could increase efficiency by releasing nutrients according to crop requirements while at the same time reducing traffic across a field. The objectives of the current research are to evaluate a new programmed release nitrogen and potassium fertilizer for use in cotton production. These fertilizer products release their nutrients as temperatures increase during the season at the same time as crop requirements increase. The product has the potential advantages of (a) less ground water contamination, (b) one time fertilization, (c) custom-designed fertilizers for release according to crop requirements for high efficiency, and (d) an efficient return per dollar spent on fertilizer.

Background Information

Traditionally, fertilizer is applied to soil at planting and sidedressed late in the season, necessitating additional costs to a grower with wheel traffic causing compaction in the field. Due to potential problems with salinity and seedling growth, the entire amount of fertilizer cannot be placed at planting. A programmed soil-release fertilizer would allow for a one-time fertilizer application and an efficient return per dollar spent.

Research Description

Two studies were conducted at the Southeast Branch Station in Rohwer. Preplant soil K levels were 192 lb acre^{-1} and 163 lb acre^{-1} at the 0- to 6-in. and 6- to 12-in. depths, respectively. On 6 May 1996, the cotton cultivar Suregrow

125 was planted into a moderately well-drained Hebert silt loam soil (fine-silty, mixed, mesic Typic Fragiudult). Plots consisted of four rows spaced 38 in. apart and 40 ft in length. Insect and weed control were according to standard cotton recommendations. The trial was furrow irrigated as needed. Fertilizer was applied to the treatments listed below:

Slow Release N Fertilizer

Fertilizer for K and P was applied uniformly according to soil test results. Treatments consisted of (a) a control with conventional tillage and full N treatment (110 lb N/acre), (b) Meister mixture of T15 (full N treatment, (c) Meister mixture of T15 (80% ot total N) and (d) Meister mixture of T15 (60% of total N).

Slow Release K Fertilizer

Fertilizer for N and P was applied uniformly according to soil test results. Treatments consisted of (a) a control with conventional tillage (full K treatment of 60 lb K/acre), (b) Meister mixture of T20 (full K treatment, (c) Meister mixture of T20 (80% ot total K) and (d) Meister mixture of T20 (60% of total K).

The in-furrow planting fertilizer application of Meister was made according to treatment using special planter boxes constructed by Dr. Howard (University of Tennessee). Petiole analysis was conducted weekly from pinhead square to four weeks after first flower using five petioles/plot pooled across replications. Soil maximum and minimum temperatures were recorded daily. The experiment was mechanically harvested at 60% open boll.

Results

Slow Release N Fertilizer

The control treatment had a consistently lower concentration of petiole NO_3-N when compared with all other treatments (Table 1). At the end of the sampling period, the Meister treatment receiving 80% of total N and had the highest concentration of petiole NO_3-N.

Lint yield among treatments is shown in Table 1. The Meister treatments with reduced total N (80 and 60% of total N) yielded similar to the control.

Slow Release K Fertilizer

The Meister treatment receiving 80% of total K at planting had the highest concentration of petiole K at the end of the sampling period (Table 2). The control treatment had the lowest concentration when compared with all other treatments.

Lint yield results (Table 2) are difficult to explain. The control and the Meister treatment receiving 60% total K at planting produced significantly higher ($P = 0.05$) yields than all other treatments.

Practical Applications

This study provides data showing that a programmed, release, soil-applied fertilizer can potenially provide a one-time fertilizer application at planting with no detrimental effect to seedling growth and yield. Reduced traffic can alleviate soil compaction and man hours in the field.

Acknowledgment

The authors gratefully acknowledge the support of Helena Chemicals.

Table 1. Lint yield and petiole NO_3 concentration with Meister Programmed Release N Fertilizer.

Treatment	Lint Yield	Petiole NO_3 June 13	Petiole NO_3 July 31
	(lb/acre)	(ppm)	(ppm)
Full N (110 lb N/acre)	1630 a	24,700	659
Meister mixture T15 Full N	1562 a	30,300	6,000
Meister mixture T15 80% Full N	1693 a	32,000	6,400
Meister mixture T15 60% Full N	1675 a	34,200	4,350

[1] Numbers followed by same letter within a column are not significantly different (P = 0.05).

Table 2. Lint yield and petiole K concentration with Meister Programmed Release K Fertilizer.

Treatment	Lint Yield	Petiole K June 13	Petiole K August 7
	(lb/acre)	(ppm)	(ppm)
Full K (60 lb N/acre)	1648 a[1]	6.92	3.09
Meister mixture T20 Full K	1489 b	7.24	4.05
Meister mixture T20 80% Full K	1531 ab	7.39	3.69
Meister mixture T20 60% Full K	1636 a	7.44	3.54

[1] Numbers followed by same letter within a column are not significantly different (P = 0.05).

Physiological Research on Plant Potassium Nutrition at the University of Arkansas

D.M. Oosterhuis, A. Steger and C.A. Bednarz

Research Problem

Potassium (K) deficiencies in Arkansas field-grown cotton (*Gossypium hirsutum* L.) often occur in the mid to late season when root growth is reduced and developing bolls become strong sinks for available K. Present tissue sampling techniques can give unreliable results in determining if there is sufficient K available in the plant. Soil K availability and boll load can also affect petiole K status. The objectives of the current research is to observe the effect of soil K fertilization versus foliar fertilization, the timing of foliar fertilization, the effect of soil K status and boll load on petiole K status and yield, and physiological changes during the onset of K deficiency.

Background Information

In recent years, the occurrence of K deficiencies across the Cotton Belt has increased, and signs of K deficiencies are appearing on young leaves at the top of plants with a heavy fruit load. Previously, deficiency symptoms have been observed on mature leaves due to the mobility of K within the plant. In situations in whch a heavy fruit load exists, decreased root growth and a high demand for K may cause K to be depleted from plant tissue at a faster rate than uptake occurs. Accurate detection of a pending K deficiency at an earlier stage of growth may serve to improve fertilizer efficiency, lint yield and lint quality.

Research Description

Growth room and field studies were used. The growth room at the Altheimer laboratory in Fayetteville was programmed for 12-hour days and $30/25^{0}$C day/night temperatures with a relative humidity of about 60%. A field site at the

University of Arkansas Main Experiment Station, Fayetteville, with replicated low and high K plots has been established over the past three years. Preplant soil K levels were 155 kg ha^{-1} and 107 kg ha^{-1} at the 0- to 6-in. and 6- to 12-in. depths, respectively, in the high soil K plots and 131 kg ha^{-1} and 104 kg ha^{-1} at the 0- to 6-in. and 6- to 12-in. depths, respectively, in the low soil K plots. Potassium chloride was broadcast in the high soil K plots in the Soil K/ Boll Load Size Study three weeks after planting to raise soil K levels. At mid-season, levels were 334 and 148 kg ha^{-1} at the 0- to 6-in. and 6- to 12-in. depths, respectively. On 10 May 1996, the cotton cultivar DPL 20 was planted into a moderately well-drained Captina silt loam soil (fine-silty, mixed, mesic Typic Fragiudult).

Physiological Changes During the Onset of K Deficiency

Growth room studies in which K was withheld from the plants at two weeks after planting and changes in dry matter of plant components, photosynthesis, carbohydrates, chlorophyll and ATP were monitored during the onset of K deficiency were measured at weekly intervals for four weeks.

Soil vs. Foliar-Applied K Study

Soil-applied K applied at first flower (FF) + one week at 33.6 kg K ha^{-1}.

Foliar-applied K applied at FF + one week at 11.2 kg K ha^{-1}.

Soil K Status and Boll Load Size on Petiole K Status

Low and high soil K status (main plot).

Low and high boll load (split plot). Low boll load was achieved by weekly hand removal of two bolls smaller than a quarter in size per plant. High boll load was as developed on the plant.

Timing Foliar-Applied Potassium

Control with no foliar-applied K.

Early treatment with 15 kg ha^{-1} K_2SO_4 foliar-applied at FF+1wk, FF+2wk, and FF+3wk.

Mid-season treatment with 15 kg ha^{-1} K_2SO_4 foliar-applied at FF+3wk, FF+4wk, and FF+5wk.

Late treatment with 15 kg ha^{-1} K_2SO_4 foliar-applied at FF+5wk, FF+6wk, and FF+7wk.

Petioles were sampled weekly from node 4 in the Soil vs. Foliar Study and from nodes 4 and 8 in the Soil K/Boll Load Study beginning at FF. Two-meter lengths of row from each plot within each study were handpicked to determine yield and boll weight.

Results

Physiological Changes During the Onset of K Deficiency

Dry matter and K concentration were significantly decreased seven days after K was withheld from the pants. This was followed by significant changes in leaf photosynthesis, chlorophyll and soluble carbohydrates. The decreases in photosynthesis and the buildup of sugars in the leaf resulted in higher levels of ATP.

Soil vs. Foliar-Applied K Study

Petiole K concentration (%) was consistently higher in the foliar treatment throughout the sampling period. Lint yield (kg ha^{-1}) was numerically higher in the foliar treatment when compared with the soil-applied treatment. Boll weight (g) and the number of open bolls at harvest was also higher in the foliar-applied treatment.

Soil K Status and Boll Load Size on Petiole K Status

High petiole K levels were observed in the high soil K/high boll load plots at both nodes 4 and 8 (Figure 1). Lint yield, boll weight and open boll number was also greatest in these plots. Lint yield was significantly higher than the high soil K/low boll load and the low soil K/low boll load plots ($P = 0.05$).

Timing Foliar-Applied Potassium

No significant yield differences were observed among the treatments, although the late-season foliar application had a numerically higher yield than all other treatments.

Practical Applications

Mid- and late-season potassium deficiencies continue to be a problem for many growers across the Cotton Belt. Sufficient soil K levels and timely fertilizer applications can alleviate symptoms; however, knowledge of petiole K status and boll load are necessary. Physiological responses to K deficiency help to predict optimum sampling methods to predict a pending K deficiency. Petiole sampling from node 8 (low in the canopy) rather than from node 4, may signal an impending K deficiency when there is high demand due to developing bolls.

Acknowledgment

The authors gratefully acknowledge the support of the Phosphate and Potash Institute, the Great Salt Lake Mineral Corporation, the Fluid Fertilizer Foundation and the Arkansas Cotton State Support Committee.

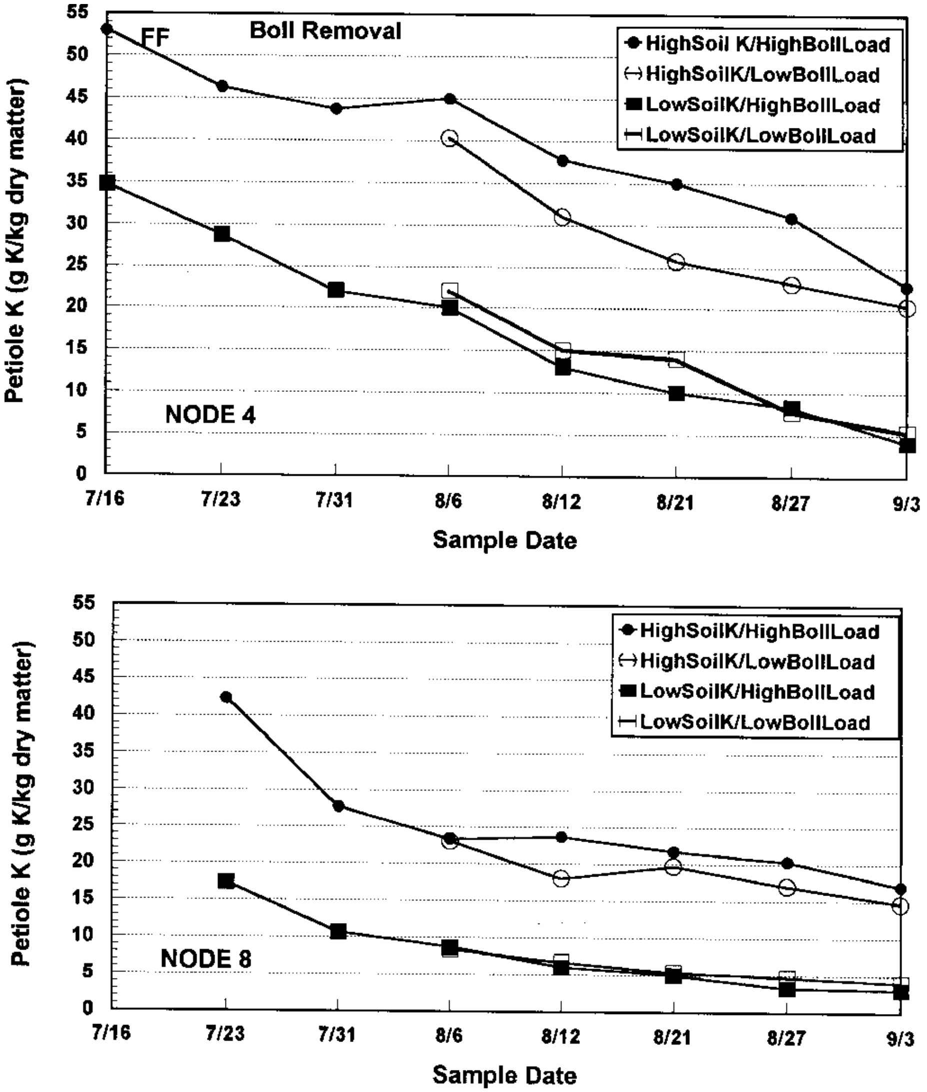

Figure 1. Effect of boll load and soil K on petiole K status.
Soil K—Boll Load Study
Fayetteville, Arkansas, 1996

Foliar Nitrogen Fertilization of Cotton in Southeast Arkansas

J.S. McConnell, W.H. Baker, B.S. Frizzell and C.S. Snyder

Research Problem

Early season, soil-applied N fertilizer may not meet full season N needs of a developing cotton (*Gossypium hirsutum* L.) crop. Early work indicated that supplemental N, either soil or foliar applied, may help meet crop N needs and increase yields (Maples and Baker, 1993). The objective of these studies is to determine when an increase in yield may be realized from foliar N applications to cotton.

Background Information

Foliar fertilization of cotton with 23% N (urea) solutions with the Cotton Nutrient Monitoring Program (CNMP) is an accepted practice among Arkansas producers to meet late-season N requirements (Snyder, 1991). Recent research indicates that the response of cotton to foliar N may not be as dramatic as observed in earlier work (Parker et al., 1993).

Research Description

A long-term study of soil-applied N fertilization and irrigation of cotton is being utilized to determine the impact of foliar N fertilization. Soil-applied N rates range from 0- to 150-lb N/acre in 30-lb N/acre increments. Three foliar N treatments (23% N (urea) solution) were applied at rates of 10 lb N/acre/treatment in 10 gal water/acre. First applications of the foliar treatments were made when the cotton reached first flower. Second and third applications were made two and four weeks after the initial application, respectively.

Results

Irrigated cotton responded to foliar fertilization treatments with increased yield when soil N was restricted to preplant and first square application totaling 120 lb N/acre or less in 1993 (Table 1). Although the foliar N X soil N interaction was not significant for yield in 1994 or 1995, the foliar N treatments significantly increased yields (Tables 2 and 3). Trends in the 1994 and 1995 results were similar to those observed in 1993.

Dryland cotton responded to foliar fertilization treatments with increased yield when soil N rates were low (0 and 30 lb N/acre) in 1993 and 1995 (Tables 1 and 3). Soil-applied N rates of 90, 120 and 150 lb N/acre did not significantly increase cotton yields compared to 60 lb N/acre. Dryland cotton did not significantly respond to either foliar N treatments or the foliar N X soil N interaction in 1994 (Table 2).

Primary differences in petiole NO_3^--N concentrations were due to the soil-applied N fertilizer (Table 3). Foliar treatments tended to raise petiole NO_3^--N levels in cotton fertilized with 150 and 90 lb N/acre in 1994 and after period 3 in 1993. Cotton that received no soil-applied N had greater petiole NO_3^--N levels without foliar N. The reason for the low values of petiole NO_3^--N levels in cotton that received no soil N but did receive foliar N is unknown.

Practical Applications

Preliminary results indicate that foliar N applications may increase cotton lint yield when soil-applied N is low. Petiole NO_3^--N concentrations were primarily dependent on soil-applied N fertilizer. Because these results are preliminary, testing should be continued before final conclusions are drawn.

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Acknowledgment

Support for this research was provided by Cotton, Inc.

Table 1. Lint yield response of cotton grown with 10 soil-applied nitrogen (N) fertilization under two irrigation methods with foliar 30 lb N/acre (Fol) and 0 lb N/acre (Untrt) in 1993.

Soil N-Rate			Irrigated			Dryland		
PP[1]	FS[1]	FF[1]	Fol	Untrt	Mean	Fol	Untrt	Mean
lb N/acre			lb lint/acre					
75	75	0	1321	1326	1324	1006	1095	1051
50	50	50	1249	1345	1292	1032	1143	1088
30	60	60	1316	1391	1358	1066	1191	1122
60	60	0	1419	1347	1383	957	1073	1022
40	40	40	1324	1339	1331	1088	1271	1179
45	45	0	1410	1247	1320	990	1138	1065
30	30	30	1379	1377	1378	1012	1104	1058
30	30	0	1335	1198	1267	930	1032	987
15	15	0	1117	1027	1067	1007	949	978
0	0	0	912	784	855	835	693	764
[2]LSD $_{(0.05)}$				216			204	
[3]LSD $_{(0.05)}$				351			334	

[1] Preplant (PP), First Square (FS) and First Flower (FF).

[2] LSD $_{(0.05)}$ for comparing two soil-applied fertilization means within the same foliar fertilization (either Foliar or Untreated) in the same irrigation.

[3] LSD $_{(0.05)}$ for comparing two soil-applied fertilization means in different foliar fertilization in the same irrigation.

Table 2. Lint yield response of cotton grown with 10 soil-applied nitrogen (N) fertilization rates and splits under two irrigation methods with foliar 30 lb N/acre (Fol) and 0 lb N/acre (Untrt) in 1994.

Soil N-Rate			Irrigated			Dryland		
PP[1]	FS[1]	FF[1]	Fol[2]	Untrt[2]	Mean	Fol[2]	Untrt[2]	Mean
lb N/acre			lb lint/acre					
75	75	0	1765	1643	1704	1423	1513	1468
50	50	50	1598	1632	1616	1640	1501	1481
30	60	60	1684	1698	1691	1519	1559	1539
60	60	0	1666	1549	1608	1424	1381	1403
40	40	40	1633	1618	1626	1417	1328	1372
45	45	0	1630	1602	1616	1310	1330	1320
30	30	30	1618	1492	1555	1349	1359	1354
30	30	0	1575	1482	1529	1344	1226	1275
15	15	0	1413	1215	1314	1219	1085	1152
0	0	0	1085	873	979	908	833	870
LSD$_{(0.05)}$					95			128
Mean			1567	1481		1337	1312	
[3]LSD$_{(0.05)}$				351			ns	

[1] Preplant (PP), First Square (FS) and First Flower (FF).

[2] No significant soil N X foliar N interactions were observed.

[3] LSD$_{(0.05)}$ for comparing foliar-applied fertilization treatment means.

Table 3. Lint yield response of cotton grown with 10 soil-applied nitrogen (N) fertilization rates and splits under two irrigation methods with foliar 30 lb N/acre (Fol) and 0 lb N/acre (Untrt) in 1995.

Soil N-Rate			Irrigated			Dryland		
PP[1]	FS[1]	FF[1]	Fol[2]	Untrt[2]	Mean	Fol	Untrt	Mean
—— lb N/acre ——			—— lb lint/acre ——					
75	75	0	1425	1393	1409	862	954	908
50	50	50	1322	1373	1348	918	1039	979
30	60	60	1434	1368	1401	859	971	915
60	60	0	1420	1376	1398	835	879	857
40	40	40	1425	1360	1393	889	1032	969
45	45	0	1230	1236	1233	895	945	920
30	30	30	1329	1280	1305	890	947	919
30	30	0	1208	1097	1153	887	852	870
15	15	0	1114	980	1047	823	781	802
0	0	0	852	704	778	695	523	609
[3]LSD $_{(0.05)}$					127			
[4]LSD $_{(0.05)}$						240		
[5]LSD $_{(0.05)}$						193		
Mean			1276	1217		856	892	
[6]LSD $_{(0.05)}$			28					

[1] Preplant (PP), First Square (FS) and First Flower (FF).
[2] No significant soil N X foliar N interactions were observed.
[3] LSD for comparing soil N treatment means in the irrigated test.
[4] LSD for comparing foliar N means in the same soil N treatment in the dryland test.
[5] LSD for comparing foliar N means in different soil N treatment in the dryland test.
[6] LSD for comparing foliar fertilization means in the irrigated test.

Table 4. Selected petiole NO_3^--N responses of irrigated cotton grown with three soil-applied nitrogen (N) fertilization rates with an additional foliar 30 lb N/acre (Fol N) in 1993 and 1994.

Soil N-Rate				Sample Period						
PP[1]	FS[1]	FF[1]	Fol N	1	2	3	4	5	6	7
—— lb N/acre ——				———————— ppm NO_3^--N ————————						
1993										
50	50	50	Yes	18765	6771	10100	7074	12242	6771	949
50	50	50	No	19339	5898	10378	4175	10663	5898	1039
45	45	0	Yes	14652	5281	6789	3009	2211	5281	581
45	45	0	No	11747	5480	7210	1190	516	5480	578
0	0	0	Yes	3440	968	1440	410	348	968	287
0	0	0	No	8491	2014	1546	2055	4455	2014	287
1994										
50	50	50	Yes	10166	10715	11072	13901	8104	2912	393
50	50	50	No	7378	8231	7978	13201	8116	3201	300
45	45	0	Yes	4639	6193	3643	1460	227	101	268
45	45	0	No	3768	5266	2564	478	63	106	204
0	0	0	Yes	148	50	236	108	58	123	249
0	0	0	No	335	59	285	154	58	106	291
1995										
50	50	50	Yes	11190	13720	7453	11374	4338	2399	674
50	50	50	No	15071	13024	5657	7639	4220	552	161
45	45	0	Yes	11201	7848	1380	522	321	122	66
45	45	0	No	—	8109	810	500	565	16	20
0	0	0	Yes	1321	1159	447	20	591	64	20
0	0	0	No	879	3364	14	20	96	9	14

[1]Preplant (PP), First Square (FS) and First Flower (FF).

Timing of Early Season Nitrogen Fertilization of Cotton

J.S. McConnell and W.H. Baker

Research Problem

The recommended timing of early-season N fertilizer to meet the needs of a developing cotton (*Gossypium hirsutum* L.) crop has not been well established (Bonner, 1995). Recommended N rates vary with soil test results, field history and the development of the crop. The objective of these studies is to determine when is the optimum time for early-season N applications to cotton.

Background Information

Arkansas cotton producers have traditionally met early-season N requirements of the crop with a preplant N application. The first soil application of nitrogen fertilizer to cotton is sometimes delayed until stand establishment due to inclement weather or seedling disease pressure (Minter Applebury, personal communication). It is speculated that delaying the first N application might result in early-season N deficiency and possible yield loss.

Research Description

A study of early-season, soil-applied N fertilization and irrigation of cotton is being utilized to determine the impact of delaying N fertilization. Five soil-applied N splits of 100 lb N/acre and a 0 lb N/acre control are being tested. The experiment is duplicated under both furrowirrigated and dryland conditions. First N applications are made approximately two to four weeks preplant. Second applications were made after the crop emerged (two to four true leaves). The third application was made when the crop reached first square.

Results

Yields were slightly higher under irrigated conditions than under dryland, but the typical large increases in yield from the use of irrigation were not observed (data not shown).

Response to the N treatments was similar in the irrigated and dryland blocks (Table 1). The unfertilized control was the lowest yielding treatment. The 100 lb N/acre preplant treatment was the next lowest yielding and not significantly different from the unfertilized control. The other four treatments were not significantly different in yield. A trend of lower yield was observed with the treatment that included a 50-lb N/acre application compared to the treatments that had later applications of N fertilizer. This trend is consistent with lack of yield increase from the 100-lb N/acre preplant treatment. A possible explanation for the ineffectiveness of the preplant treatments is the spring weather conditions experienced in 1995. Wet weather probably increased the likelihood of denitrification and leaching of nitrate. These two processes, denitrification and leaching, remove N from the soil and reduce plant uptake and may have caused the preplant treatments to be less effective than N fertilizer applied late in the growing season.

Practical Applications

Preliminary results indicate that early-season N applications shortly after emergence and at first square were more effective in meeting the N nutritional needs of cotton than preplant applications. Because these are first-year results and preliminary, testing should be continued before final conclusions are drawn.

Literature Cited

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Acknowledgment

Support for this research was provided by the Arkansas Fertilizer Tonnage Fee.

Table 1. Lint yield response of cotton grown with six early-season, soil-applied nitrogen (N) treatments under furrow irrigation and dryland conditions in 1995.

Soil N-Rate				
PP[1]	AE[1]	FS[1]	Irrigated	Dryland
—— lb N/acre ——			———— lb lint/acre ————	
0	50	50	1068	909
50	0	50	990	877
0	0	100	1086	915
0	100	0	1020	869
100	0	0	714	718
0	0	0	707	681
$LSD_{(0.05)}$			158	145

[1] Preplant (PP), after emergence (AE), first square (FS).

Irrigation Methods and Nitrogen Fertilization Rates in Cotton Production

J.S. McConnell, W.H. Baker and B.S. Frizzell

Research Problem

Management of nitrogen (N) and irrigation are two important aspects of cotton (*Gossypium hirsutum*, L.) production. The interactions of N fertilizer and irrigation are not well documented under the humid production conditions of southeastern Arkansas (McConnell et al., 1988).

The objective of these studies was to evaluate the development and yield of intensively managed cotton soil treated with soil-applied N fertilizer under several irrigation methods.

Background Information

Over- and under-fertilization may result in delayed maturity and reduced yield, respectively (Maples and Keogh, 1971). Adequate soil moisture is also necessary for cotton to achieve optimum yields. If the soil becomes either too wet or too dry, cotton plants will undergo stress and begin to shed fruit (Guinn et al., 1981).

Research Description

This study was conducted at the Southeast Branch Experiment Station on an Hebert silt loam soil. The experimental design was a split block with irrigation methods as the main blocks. N rates were tested within each irrigation method. Five irrigation methods were used from 1988 to 1993 (Table 1), but only three methods were used in 1994. Six different N rates (0, 30, 60, 90, 120 and 150 lb urea-N/acre) were tested with different application timings used for the higher (90 to 150 lb N/acre) N rates.

Results

Irrigation generally increased cotton yields except during one or more of the following conditions: an unusually wet growing season (1989–data not shown), when the crop was planted too late (1991), or when verticillium wilt was prevalent (1990-1992 and 1994) (Table 2). The method of irrigation to maximize lint yield varied year-to-year and, therefore, appeared to be less important than irrigation usage.

Generally, lint yield was found to increase with increasing N fertilization (Table 3). The N treatments that usually resulted in the greatest lint yields were applications of 90- to 150-lb N/acre depending upon the irrigation treatment. Exceptions were found for the 150-lb N/acre treatment (75 lb N/acre PP and 75 lb N/acre FS), which was found to decrease lint yield in some irrigation blocks, and the High Frequency Center Pivot block in 1990-1992 and 1994. The yields of the High Frequency block during those years were significantly influenced by verticillium wilt. The disease was more virulent in plots receiving higher N rates, thereby reducing yields with increasing N.

Practical Applications

Irrigated cotton was generally found to be higher yielding than cotton grown under dryland conditions unless verticillium wilt affected the crop. Fertilizer nitrogen requirements of cotton for maximum yield tended to be greater under irrigated production conditions than under dryland production conditions. Fertilizer nitrogen requirements of cotton for maximum yield tended to be greater for furrow-irrigated cotton than for center-pivot-irrigated cotton.

Literature Cited

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Acknowledgment

Support for this research was provided by the Arkansas Fertilizer Tonnage Fee.

Table 1. Duration, tensiometer thresholds and depths and water application rates for five irrigation methods.

Irrigation Methods	Duration	Tensiometer Threshold	Tensiometer Depth	Water Applied
		- cbar -	- in.-	- in.-
High Frequency	Planting to P.B.[1]	35	6	0.75
Center Pivot	P.B. to Aug. 15	35	6	1.00
Moderate Frequency	Planting to			
Center Pivot	Aug. 15	55	6	1.00
Low Frequency	First Irrigation	55	12	1.00
Center Pivot	Until Aug. 15	55	6	1.50
Furrow Flow	Until Aug. 15	55	12	Not Precise
Dryland	Not Irrigated	—	—	—

[1] P.B. = Peak Bloom

Table 2. Lint yield response of cotton to five irrigation methods in 1988, 1990, 1991, 1992, 1993, 1994 and 1995.

Method	1988	1990	1991	1992	1993	1994	1995
	lb/acre						
High Frequency							
Center Pivot	1567	1118	1051	1181	1103	1317	1113
Moderate Frequency							
Center Pivot	1410	1461	——	1632	1342	——	——
Low Frequency							
Center Pivot	1620	1442	1334	1460	1112	——	——
Furrow Flow	1370	1511	1231	1367	1241	1478	1217
Dryland	1271	915	1308	1246	1067	1353	892
LSD $_{(0.05)}$	159	67	77	66	66	83	59

Table 3. Lint yield response of cotton to 10 nitrogen (N) fertilization rates and splits under five irrigation methods in 1988, 1989, 1990, 1991, 1992, 1993, 1994 and 1995.

N Rate PP[1]	FS[1]	FF[1]	LF[2]	MF[2]	HF[2]	FI[2]	DL[2]
lb N/acre			lb lint/acre				
1988							
75	75	0	1906 a	1730	1524 ab	1571 ab	1378 a-c
50	50	50	1730 ab	1395	1631 ab	1627 a	1409 ab
30	60	60	1588 bc	1549	1682 a	1508 ab	1319 a-c
60	60	0	1776 ab	1439	1567 ab	1417 bc	1273 bc
40	40	40	1763 ab	1360	1683 a	1467 bc	1449 a
45	45	0	1738 ab	1153	1600 ab	1479 ab	1293 a-c
30	30	30	1756 ab	1470	1693 a	1549 ab	1400 ab
30	30	0	1632 ac	1358	1533 ab	1288 c	1215 cd
15	15	0	1328 cd	1409	1464 bc	976 d	1048 d
0	0	0	1069 d	1235	1295 c	739 e	838 e
LSD $_{(0.05)}$			314	ns	188	190	175

Continued

Table 3. Continued.

N Rate							
PP[1]	FS[1]	FF[1]	LF[2]	MF[2]	HF[2]	FI[2]	DL[2]
—— lb N/acre ——			——lb lint/acre——				
1989							
75	75	0	1115 ab	903 a-c	959 ab	1080 a-c	1294 ab
50	50	50	1067 ab	938 ab	992 ab	1066 a-c	1321 a
30	60	60	1214 a	869 a-c	942 ab	1154 a	1170 cd
60	60	0	1182 a	1069 a	976 ab	1111 ab	1227 a-c
40	40	40	1177 a	1045 ab	1071 a	998 cd	1250 a-c
45	45	0	1175 a	979 ab	855 b	1143 ab	1214 a-c
30	30	30	1170 a	842 b-d	1045 a	1173 a	1187 bc
30	30	0	993 bc	1045 ab	919 ab	1035 b-d	1058 d
15	15	0	917 c	700 cd	843 b	929 d	861 e
0	0	0	747 d	616 d	625 c	629 e	497 f
LSD $_{(0.05)}$			148	228	154	108	115
1990							
75	75	0	1474 a	1479	1018 d	1601 a	1002 a
50	50	50	1464 a	1539	1022 cd	1517 ab	1033 a
30	60	60	1542 a	1344	1011 d	1563 a	955 ab
60	60	0	1396 a	1522	1091 b-d	1531 ab	825 b
40	40	40	1525 a	1468	1191 a-c	1663 a	1000 a
45	45	0	1491 a	1582	1112 a-d	1596 a	957 ab
30	30	30	1421 a	1487	1155 a-d	1663 a	995 ab
30	30	0	1515 a	1392	1234 ab	1636 a	911 ab
15	15	0	1440 a	1571	1265 a	1374 b	867 b
0	0	0	1169 b	1238	1106 a-d	995 c	663 c
LSD $_{(0.05)}$			184	ns	172	185	133
1991							
75	75	0	1409 ab	—	939 de	1215 cd	1366 ab
50	50	50	1386 b	—	1028 b-d	1236 b-d	1444 a
30	60	60	1345 b	—	906 e	1266 b-d	1414 ab
60	60	0	1365 b	—	1031 b-d	1282 a-c	1326 bc
40	40	40	1424 ab	—	1055 bc	1272 a-d	1425 a
45	45	0	1406 ab	—	1129 ab	1302 ab	1398 ab
30	30	30	1490 a	—	1088 bc	1352 a	1373 ab
30	30	0	1426 ab	—	1230 a	1304 ab	1254 c
15	15	0	1192 c	—	1128 ab	1191 d	1245 c
0	0	0	976 d	—	986 c-e	892 e	839 d
LSD $_{(0.05)}$			108	—	106	84	99

Continued

Table 3. Continued.

N Rate							
PP[1]	FS[1]	FF[1]	LF[2]	MF[2]	HF[2]	FI[2]	DL[2]
—— lb N/acre ——			——lb lint/acre——				
1992							
75	75	0	1533 a	1553 bc	1126	1274 bc	1372 ab
50	50	50	1547 a	1543 bc	1113	1384 ab	1338 b
30	60	60	1494 a	1518 c	1103	1317 ab	1386 ab
60	60	0	1470 ab	1556 bc	1227	1179 cd	1403 ab
40	40	40	1511 a	1666 ab	1209	1421 a	1490 a
45	45	0	1544 a	1739 a	1219	1335 ab	1439 ab
30	30	30	1526 a	1643 a-c	1172	1347 ab	1494 a
30	30	0	1493 a	1566 bc	1256	1303 b	1440 ab
15	15	0	1400 b	1707 a	1221	1123 b	1347 b
0	0	0	1079 c	1748 a	1157	803 e	966 c
LSD $_{(0.05)}$			87	132	NS	112	114
1993							
75	75	0	1179 a	1262 cd	1152 a-c	1324 a-c	1095 bc
50	50	50	1164 a	1267 cd	1181 a-c	1345 ab	1144 a-c
30	60	60	1156 a	1269 cd	1097 c	1391 a	1191 ab
60	60	0	1171 a	1394 a-c	1156 a-c	1347 ab	1073 b-d
40	40	40	1177 a	1465 ab	1126 bc	1339 ab	1271 a
45	45	0	1150 a	1525 a	1245 a	1248 bc	1139 a-c
30	30	30	1146 a	1429 ab	1212 ab	1377 ab	1104 bc
30	30	0	1092 a	1346 bc	1121 bc	1198 c	1032 cd
15	15	0	1032 b	1255 cd	992 d	1027 d	949 d
0	0	0	863 c	1185 d	833 e	784 e	966 c
LSD $_{(0.05)}$			98	143	103	136	114
1994							
75	75	0	——	——	1264 c	1600 a-c	1328 a-c
50	50	50	——	——	1256 c	1643 ab	1513 ab
30	60	60	——	——	1283 c	1633 ab	1501 ab
60	60	0	——	——	1312 bc	1602 a-c	1643 a
40	40	40	——	——	1467 a	1695 a	1559 a
45	45	0	——	——	1441 ab	1492 c	1359 a-c
30	30	30	——	——	1384 a-c	1549 bc	1381 a-c
30	30	0	——	——	1515 a	1482 c	1226 b-d
15	15	0	——	——	1313 bc	1215 d	1085 cd
0	0	0	——	——	1073 e	873 e	931 d
LSD $_{(0.05)}$			——	——	132	137	322

Continued

Table 3. Continued.

N Rate							
PP[1]	FS[1]	FF[1]	LF[2]	MF[2]	HF[2]	FI[2]	DL[2]
—— lb N/acre ——			——lb lint/acre——				
1995							
75	75	0	——	——	1127 a	1393 a	954 a-c
50	50	50	——	——	1166 a	1373 ab	1039 a
30	60	60	——	——	1193 a	1369 ab	971 ab
60	60	0	——	——	1162 a	1376 ab	879 b-d
40	40	40	——	——	1213 a	1360 ab	1032 a
45	45	0	——	——	1107 a	1236 bc	946 a-c
30	30	30	——	——	1149 a	1280 ab	947 a-c
30	30	0	——	——	1198 a	1098 cd	852 cd
15	15	0	——	——	964 b	980 d	781 d
0	0	0	——	——	838 c	704 e	532 e
LSD (0.05)			——	——	106	146	114

[1] Preplant (PP), first square (FS) and first flower (FF).
[2] Low frequency (LF), moderate frequency (MF), high frequency (HF), furrow irrigated (FI), dryland (DL).

Table 4. Percent first harvest response of cotton to five irrigation methods in 1988, 1990, 1991, 1992, 1993, 1994 and 1995.

Method	1988	1990	1991	1992	1993	1994	1995
	—— % ——						
High Frequency Center Pivot	95.7	90.6	85.4	90.3	88.6	95.0	91.6
Moderate Frequency Center Pivot	90.4	88.8	——	87.1	86.8	——	——
Low Frequency Center Pivot	92.7	90.1	86.1	88.9	84.5	——	——
Furrow Flow	91.2	93.7	90.0	90.9	91.2	95.6	94.3
Dryland	93.5	94.2	93.6	94.6	94.4	94.5	94.2
LSD (0.05)	1.8	2.1	1.4	2.0	1.9	0.9	0.8

Cotton Gin Trash as Soil Amendment for Small-Scale Vegetable Production

Tina Gray Teague and Paul W. Teague

Research Problem

There are numerous ways to recycle and reuse agricultural wastes. This is particularly important in Arkansas where agricultural waste products are abundant. In the cotton industry alone, Arkansas gins must dispose of 100 to 150 lb of gin trash per bale for each of the state's 700,000 to 1.5 million bales of cotton ginned annually. Research was conducted in 1994 in collaboration with the Arkansas Land and Farm Development Corporation (ALFDC) in Fargo, Ark., to evaluate how small-scale vegetable farmers might put this gin waste to work as soil amendments to improve productivity and profits on their farms.

Background

Addition of soil amendments such as poultry litter can result in improved yields of greens and spinach on damaged soils (Teague, 1994a; Teague, 1994b); however, the delivered cost of this material may range from $20 to $45 per ton with application rates of 1 to 2 tons generally recommended. This cost is prohibitive for most limited-resource, smallscale farmers. Costs for transportation and application of gin trash are appropriately low for limited-resource farmers. A small-scale producer, hauling his or her own gin trash from a local gin should be able to deliver and spread the material for a little as $5 to $10/ton. In many cases, gins will deliver raw gin trash to a farm site for no charge.

Materials and Methods

Because raw gin trash contains both weed seeds and plant diseasecausing microorganisms, composted gin trash was used in the evaluation. Field composting raw gin trash was done on the Ben Anthony, Jr. Farm in Lee County. Pickup truck loads of raw gin trash were obtained in fall 1993 from Mann's Gin in Marianna. The material was unloaded at the farm site and left in a pasture over the winter and spring in approximately 8 ft diameter X 6 ft high piles. The gin trash was sufficiently decayed by mid-summer that the material could be used in fall vegetable production. Contamination of the compost by weed seeds, which had blown onto the piles, was minimized by removing the outside 4 in. of the pile before transporting to the ALFDC site.

The experiment was conducted at the ALFDC Demonstration Farm in Monroe County. The field had been precision leveled three years prior to the study, and lime had been applied (2 tons/acre) to the Dubbs/Dundee silt loam the previous fall. Soil pH ranged from 5.9 to 6.3. Composted gin trash was applied at rates of 0, 1 and 2 tons/acre. The plots were four rows wide with 3.3-ft row spacing and were 30 ft long with 5-ft alleys separating plots. The experiment was arranged in a randomized complete block with four replications. Broadcast applications were made by hand on 1 September 1994. In addition, all plots received applications of NPK (60-60-60 lb/acre (N-P_2O_5-K_2O) in the form of 13-13-13). Plots were disked, and beds were formed with a disk bedder. 'Royal Crest' turnip was direct seeded in single row culture on 20 September. Irrigation was provided as needed by flooding furrows. Plots were hand harvested on 21 December in a 5-ft section in either row 2 or 3. Once-over, whole plant harvest method was employed. Analyses of compost samples and of turnip leaf samples from five plants per treatment plot taken at harvest time were performed at the UA Soil Test Lab at Marianna. Data were subjected to Anova with means separated by LSD.

Results

Mean yield of turnip greens was increased 1.76 tons/acre by addition of 2 tons composted gin trash/acre (Table 1). This is equivalent to 176 boxes (20 lb/box) of fresh market greens. Based on a $5 FOB/box price, a gross profit increase of $860/acre was produced by using the 2 ton/acre rate of composted gin trash. Turnip root yield was not significantly affected by addition of gin trash. No differences between treatments were noted in results in plant tissue analyses (Table 2). Results from lab analyses of compost are shown in Table 3.

Practical Implications

Composted gin trash appears to be affordable and practical for use by small-scale vegetable farmers as a soil amendment for remediation of soils disturbed by precision leveling. Adoption of sustainable soil management practices would be expected to increase profitability of these small-scale farms to the benefit of the farmers and the region. Problems with gin waste disposal also could be lessened if the practice became widespread.

Literature Cited

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Acknowledgments

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Table 1. Results from laboratory analyses of composted gin trash used in field trials.

Composted Gin Trash	Turnip Yield[1]	
	Roots	Greens
— lb/acre —	——— tons/acre ———	
0	1.10a	0.45 a
2,000	2.41a	1.50ab
4,000	2.77a	2.21b

Means with same letter are not significantly different (*Pr > F* (Anova) $_{0.05}$; LSD $_{0.05}$).

Table 2. Results from tissue analysis for fall turnip greens grown using composted gin trash in Monroe County, Arkansas, 1994.

Composted Gin Trash	Al	Ag	As	B	Ba	Be	Ca	Cd
—lb/acre—	ppm							
0	33.88	0.08	4.26	17.56	0.80	0.06	284.92	0.14
2000	55.08	0.01	3.75	17.66	0.90	0.00	228.44	0.06
4000	33.67	0.01	3.88	17.62	0.69	0.00	247.77	0.06
	ns[1]	ns	ns	ns	ns	ns	ns	ns
Composted Gin Trash	**Cr**	**Cu**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**Na**
0	0.21	0.08	21.02	214.76	31.62	2.86	0.86	31.71
2000	0.26	0.08	37.12	252.24	30.42	4.16	0.72	25.66
4000	0.23	0.06	22.82	269.31	30.82	2.68	0.79	40.99
	ns	ns	ns	ns	ns	ns	ns	ns
Composted Gin Trash	**Ni**	**P**	**Pb**	**S**	**Sb**	**Se**	**V**	**Zn**
0	0.09	36.44	0.25	47.65	2.44	5.76	0.14	0.93
2000	0.04	36.81	0.26	40.64	2.02	4.92	0.12	0.79
4000	0.02	41.18	0.18	45.73	2.15	5.03	0.07	0.89
	ns	ns	ns	ns	ns	ns	ns	ns

[1] ns = nonsignificant (*PR* > *F* (Anova $_{0.05}$)).

Table 3. Elemental composition of compost used in 1994 field trials with turnips.

Parameter	Concentration
	— ppm —
K	73
Ca	256
Na	2.7
Mg	50.5
Fe	11
Mn	1.2
Cu	0.1
Zn	0.5
B	0.6
S	39.1
P	62.6

Rice Nutrient Composition Response to P and K Fertilization

N. A. Slaton, S. Ntamatungiro, C. E. Wilson, Jr.,
R. J. Norman and B. R. Wells

Research Problem and Background Information

Analysis of sick rice plants is often performed by agriculture Extension agents, specialists and consultants as a means of diagnosing the nutritional cause of poor growth. Results of tissue analysis are usually expressed in concentrations of parts per million (ppm) or percentages (%). However, plants submitted for analysis after appearance of deficiency symptoms often indicate that several or no nutrients are present in deficient levels. The objective of this study was to determine if soil properties, plant part and time of sampling influenced interpretation of tissue analysis results and to build a database for predicting crop growth/yield response based on tissue analysis.

Research Description

Plots were established in grower fields at two locations in northeastern Arkansas in spring of 1996. Soil exchangeable potassium (K) and available phosphorous (P) were similar for each site, but the locations differed in soil pH (Table 1). The Poinsett County location was seeded in ‘Bengal’ and the Cross County site was seeded in ‘Kaybonnet’. Six fertilizer treatments consisting of two P rates (triple super phosphate) (0 and 40 lb P_2O_5/A) and three rates of K (muriate of potash) (0, 60, and 120 lb K_20/A) were applied to the soil surface prior to rice emergence. Plant tissue samples, both whole plant and Y-leaf (most recent fully emerged leaf) were taken at the midtillering (MT) and internode elongation (IE) growth stages.

Results

Whole Plant Analysis, Dry Matter Production and Total Uptake

Application of P significantly increased dry matter production, total P uptake, and total K uptake at the MT and IE growth stages at the Cross County location (Tables 2 & 3). At MT, greater total P uptake occurred despite a significant reduction in percent P in tissue with added P fertilizer. This suggests that P was deficient at this site. Phosphorus fertilizer increased dry matter production, diluting tissue P concentration. At IE, plants fertilized with P contained a higher percent P than untreated checks (Table 3). Application of P resulted in a significant grain yield increase at Cross County (Table 4). Application of K fertilizer had no significant effect on plant growth at Cross County but significantly effected percent K and total K uptake at Poinsett County (Table 5). Based on the critical nutrient concentration for K of 1.4%, Poinsett County suffered from K deficiency. Potassium application resulted in a significant grain yield increase but did not affect dry matter at MT or IE (Table 6).

Whole Plant vs. Y-Leaf Analysis Nutrient Analysis

The statistical significance of tissue analysis was greatly influenced by plant part sampled. For example, significant P [K rate interaction for percent K occurred at Poinsett County for both growth stages only when Y-leaf samples were taken (Table 7)]. Whole plant analysis indicated a significant interaction only at IE (data not shown). Concentration of some nutrients varied drastically depending on plant part sampled. Nutrient concentrations also differed drastically among the two locations (data not shown). Further statistical analyses are being conducted on these data to determine relationships among plant part sampled.

Practical Applications

Soil test analysis indicated that soil K values were low (< 175 lb K $acre^{-1}$) only at the Poinsett County site where K fertilization resulted in improved yields. Both locations had low soil test P, but only the high pH site, Cross County, responded to P application. Research efforts with P and K must continue to explore the relationships between soil test P and pH. Evidence suggests soil test P is not a good indication of crop response to P fertilization. Tissue analysis may help predict crop response to P and K fertilization.

Acknowledgments

Support for this research was provided by the Potash and Phosphate Institute and Arkansas Tonnage fees. Special thanks to the following county Extension agents and rice growers for their assistance: (Agents) David Annis, Van McNeely, Rick Thompson, and Rick Wimberly and (growers) Darryl Schlencker (Cross County) and Billy Joe Wright (Poinsett County).

Table 1. Soil test results using Mehlich III extractant.

Location	pH	EC[1]	P	K	Ca	Mg	Na	Mn	Zn
		µS cm^{-1}	———	———	——— lb acre^{-1} ———	———	———	———	———
Cross	7.9	375	16	266	3978	654	118	300	12
Poinsett	5.3	146	15	96	1906	312	68	84	20

[1] pH and EC determined using a 1:1 soil-water extract.

Table 2. Effects of phosphorus fertilization on dry matter, % tissue P, total P uptake, and total K uptake at midtillering growth stage in Cross County.

Phosphorus	Parameter Measured			
Rate	Dry Matter	% P	Total P Uptake	Total K Uptake
P_2O_5/acre	lb/acre	% Tissue P	lb P/acre	lb K/acre
0	430.5	0.155	0.65	7.5
40	1002.8	0.125	1.24	19.0
LSD $_{(0.05)}$	172.7	0.016	0.217	3.7
Pr > F	0.0001	0.0012	0.0001	0.0001

Table 3. Effects of phosphorus fertilization on dry matter, % tissue P, total P uptake, and total K uptake at internode elongation growth stage in Cross County.

Phosphorus	Parameter Measured			
Rate	Dry Matter	% P	Total P Uptake	Total K Uptake
P_2O_5/acre	lb/acre	% Tissue P	lb P/acre	lb K/acre
0	1763	0.123	2.7	39.8
40	3193	0.180	5.8	70.4
LSD $_{(0.05)}$	456.6	0.0141	0.788	10.8
Pr > F	0.0001	0.0001	0.0001	0.0001

Table 4. Influence of phosphorus rate on grain yield in Cross and Poinsett counties.

	Grain Yield	
P Rate	Cross Co.	Poinsett Co.
lb P_2O_5/acre	lb/acre	
0	3575	6613
40	5300	6522
LSD$_{(0.05)}$	713	ns[1]

ns = not significant

Table 5. Effect of potassium fertilization on total potassium uptake and concentration in Poinsett County.

	Growth Stage			
	K concentration		K Uptake	
K Rate	Midtillering	Internode Elongation	Midtillering	Internode Elongation
lb K_2O/acre	%		lb/acre	
0	1.40	0.96	29.3	27.6
60	2.21	1.64	55.3	61.5
120	2.76	1.95	72.5	64.5
$LSD_{(0.05)}$	0.367	0.218	20.1	23.8
Pr > F	0.0013	0.0001	0.0001	0.0081

Table 6. Influence of potassium rate on grain yield in Cross and Poinsett counties.

	Grain Yield	
K Rate	Cross Co.	Poinsett Co.
lb K_2O/acre	lb/acre	
0	4586	5868
60	4404	6760
120	4321	7075
$LSD_{(0.05)}$	ns[1]	1111

[1] ns = not significant

Table 7. Phosphorus (potassium rate interaction on potassium concentration of Y-leaf tissue in Poinsett County.

Growth Stage	P Rate	Potassium Rate		
	lb P_2O_5/acre	lb K_2O/acre		
		0	60	120
		% K in rice Y-Leaf tissue		
Midtillering	0	1.24	2.26	2.51
	40	1.33	2.04	2.81
$LSD_{(0.10)}$			0.262	
Pr > F			0.089	
Internode	0	1.06	1.71	1.80
Elongation	40	1.25	1.41	1.98
$LSD_{(0.05)}$			0.308	
Pr > F			0.010	

Influence of Phosphorus Fertilizer Source and Rate on Rice

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R.J. Norman, B.R. Wells and D. Frizzell

Research Problem

Rice (*Oryza sativa*, L.) in eastern Arkansas is often limited by low levels of available phosphorus (P). The University of Arkansas recommends 40 lb P_2O_5 $acre^{-1}$ when the soil test level (Mehlich III) is less than 25 lb P $acre^{-1}$. The objective of this study was to compare the effectiveness of three P fertilizer sources at different rates with and without the application of Zn.

Background Information

The most commonly utilized P source for rice production in Arkansas has been triple superphosphate [9 $Ca(PO_4)_2$ + 2CaF]. Because P availability is influenced by soil pH, P availability has been reduced substantially as soil pH levels have increased due to utilizing irrigation water containing high concentrations of bicarbonates. Triple superphosphate (TSP) tends to have little effect on soil pH when applied. Other fertilizers, however, such as diammonium phosphate (DAP; $(NH_4)_2HPO_4$) and monoammonium phosphate (MAP; $NH_4H_2PO_4$) tend to be slightly acidic upon reaction with soil constituents. The evaluation of various P sources was warranted because much of the P deficiencies observed in Arkansas rice fields tends to be on soils with high soil pH,

Research Description

Studies were implemented in production fields located in Craighead County seeded with 'Bengal' rice and in Cross County seeded in 'Alan' rice. Soil test characteristics indicated that the soil pH in Craighead County was high (8.0), but in Cross County the pH was relatively low (6.1) (Table 1). Three P sources

(TSP, DAP and MAP) were applied at rates of 0, 40 and 80 lb P_2O_5 acre^{-1} to the soil surface following planting but prior to emergence. An additional factor in the experiment consisted of Zinc EDTA applied at a rate of 1 lb Zn acre^{-1} at the three- to four-leaf growth stage. The plots were 8 ft wide by 16 ft in length. Urea was applied with the TSP and MAP treatments to equal the total N added with the DAP. The experiment was arranged in a randomized complete block factorial with four replications. Dry matter accumulation was determined at midtillering (MT), internode elongation (IE), and three weeks after heading. Grain yields were determined at harvest.

Results

Significantly more total dry matter accumulation (TDM) was measured at MT when DAP or MAP was applied than when TSP was applied at Craighead County (Table 2). However, P source did not affect TDM at the other growth stages at Craighead County or at any growth stage at Cross County. Increasing the P rate significantly increased TDM at both locations at the MT growth stage (Table 3). Although not statistically significant, a similar increasing trend was observed at all growth stages except at IE in Cross County. Application of Zn did not significantly affect TDM (Table 4).

A significant interaction of P rate and Zn application was observed at Craighead County for TDM at IE (Table 5). A P rate of 80 lb P_2O_5 acre^{-1} without Zn increased TDM at Craighead County compared to the control. However, when Zn was also applied, a P rate of only 40 lb P_2O_5 acre^{-1} was necessary to increase TDM relative to the control.

Grain yields were not influenced by P source at either location during 1996 (Table 6). The P rate main effects also did not significantly influence yields (Table 7). However, the Zn application significantly increased yields at Craighead County but decreased yields in Cross County (Table 8). The three-way interaction of P source, P rate and Zn rate was significant at Craighead County (Table 9). Zinc significantly increased yields without P fertilizer. However the highest yields were obtained with Zn plus 40 lb P_2O_5 acre^{-1} of TSP. The least effective P source tended to be MAP.

Practical Applications

Based on results from the first year, P applications are beneficial for optimum rice production. However, there seems to be little difference among P sources in their effectiveness.

Acknowledgments

Support for this research was provided by the Potash and Phosphate Institute and Arkansas Fertilizer Tonnage Fees. Appreciation is extended to county Extension agents (Brannon Thiesse , David Annis and Rick Wimberly) and rice producers (John Greer and Keith Thomas) for their assistance in conducting this project.

Table 1. Selected soil chemical characterisitics from test sites at Craighead and Cross counties during 1996.

	Soil Test Values	
Soil Test Parameter†	Craighead Co.	Cross Co.
pH	8.0	6.1
EC (mhos cm^{-1})	574.5	136.2
P - Olsen (mg kg^{-1})	15.5	9.6
P - Mehlich III (mg kg^{-1})	15.7	10.8
Ca (mg kg^{-1})	1671	830.3
Mg (mg kg^{-1})	199.0	197.8
Na (mg kg^{-1})	42.5	34.6
K (mg kg^{-1})	41.5	116.3
Fe (mg kg^{-1})	363.9	243.2
Cu (mg kg^{-1})	2.3	2.1
Zn (mg kg^{-1})	3.2	6.9

† Ca, Mg, Na, K, Fe, Mn, Cu, Zn determined by Mehlich III; P determined by Mehlich III and Olsen; pH and EC determined on 1:1 water:soil suspension.

Table 2. Influence of P source on total dry matter accumulation at mid-tillering (MT), 1.3-cm internode elongation (IE) and three weeks after heading (HDG) during 1996.

	Total Dry Matter					
	Craighead Co.			Cross Co.		
P Source	MT	IE	HDG	MT	IE	HDG
	g m^{-2}					
TSP	65	618	2307	94	819	2892
DAP	81	649	2327	100	745	3060
MAP	75	595	2254	85	745	2999
$LSD_{(0.05)}$	10	ns[1]	ns	ns	ns	ns

[1] ns = nonsignificant.

Table 3. Influence of P rate on total dry matter accumulation at mid-tillering (MT), 1.3-cm internode elongation (IE) and three weeks after heading (HDG) during 1996.

	Total Dry Matter					
	Craighead Co.			Cross Co.		
P Rate	MT	IE	HDG	MT	IE	HDG
lb P_2O_5 A^{-1}	———	———	g m^{-2}	———	———	———
0	47	576	2172	69	926	2754
40	73	596	2270	86	738	2963
80	81	659	2368	108	766	3066
$LSD_{(0.05)}$	11	ns[1]	ns	23	ns	ns

[1] ns = nonsignificant.

Table 4. Inlfuence of Zn EDTA on total dry matter accumulation at mid-tillering (MT), 1.3-cm internode elongation (IE) and three weeks after heading (HDG) during 1996.

	Total Dry Matter					
	Craighead Co.			Cross Co.		
Zn Rate	MT	IE	HDG	MT	IE	HDG
lb Zn A^{-1}	———	———	g m^{-2}	———	———	———
0	71	590	2216	99	822	3146
1	75	650	2380	87	731	2793
$LSD_{(0.05)}$	ns[1]	ns	ns	ns	ns	ns

[1] ns = nonsignificant.

Table 5. Influence of P rate and Zn application on total dry matter accumulation at 1.3-cm internode elongation during 1996 in Craighead County.

	Total Dry Matter Accumulation	
P Rate	without Zn	with Zn
lb P_2O_5 A^{-1}	——— g m^{-2} ———	
0	527	625
40	520	673
80	681	637
$LSD_{(0.05)}$	102	

Table 6. Influence of phosphorus source on rice grain yields during 1996.

	Grain Yields	
P Source	Craighead Co.	Cross Co.
	——— lb/acre ———	
Triple Superphosphate	7364	6037
Diammonium phosphate	7245	6005
Monoammonium phosphate	7040	6063
$LSD_{(0.05)}$	432	418
C.V.	10.3%	11.9%

Table 7. Influence of Phosphorus rate on rice grain yields during 1996.

	Grain Yields	
P Rate	Craighead Co.	Cross Co.
lb P_2O_5/acre	——— lb/acre ———	
0	7066	6027
40	7414	6174
80	7169	5909
LSD $_{(0.05)}$	432	418

Table 8. Influence of Zn application on rice grain yields during 1996.

	Grain Yields	
Zn Rate	Craighead Co.	Cross Co.
lb Zn/acre	——— lb/acre ———	
0	6941	6285
1	7492	5791
LSD $_{(0.05)}$	353	341

Table 9. Influence of P source, P rate, and Zn applications on rice grain yields at Craighead County during 1996.

	Grain Yields					
	TSP		DAP		MAP	
P Rate	w/o Zn	w/ Zn	w/o Zn	w/ Zn	w/o Zn	w/ Zn
lb P_2O_5/acre	——— lb/acre ———					
0	6564	7569	6564	7569	6564	7569
40	7132	8344	7367	7717	7410	6512
80	7701	6875	6563	7688	6603	7584
LSD $_{(0.05)}$			1059			

Influence of Phosphorus Rate, Potassium Source and Rate on Rice Production

Sixte Ntamatungiro, N. A. Slaton,
C. E. Wilson, Jr., R. J. Norman and B. R. Wells

Research Problem and Background Information

Rice (*Oryza sativa* L.) responds to phosphorus (P) and potassium (K) fertilization in some soils of eastern Arkansas. Farmers are recommended to apply 60 lb K_2O/acre for soils testing (Mehlich III) less than 175 lb K, and 40 lb P_2O_5 /acre for soils testing less than 25 lb P/acre.

This study evaluated the effect of P rate, K source and K rate on dry matter accumulation at three growth stages and on grain yield of rice grown on a high and low pH soil.

Research Description

Two locations were used for the study: one in Cross County (high pH) seeded in 'Kaybonnet' on April 9, and another in Poinsett County (low pH) seeded in 'Bengal' on April 27 (Table 1). Phosphorus and K fertilizers were surface-applied after planting but before emergence in plots measuring 8 ft in width and 16 ft in length. Phosphorus was applied as triple super phosphate [9 $Ca(PO_4)_2$ + 2CaF] (0-46-0) at 0 and 40 lb P_2O_5/acre. Potassium sources were KCl (0-0-60), K_2SO_4 (0-0-50) and KNO_3 (13-0-44). Each K source was applied at 0, 60 and 120 lb K_2O/acre. Urea (46-0-0) was applied to plots to equal the total nitrogen (N) applied to KNO_3 treatments. The experiment design was a randomized complete block factorial with four replications. Dry matter production was determined from aboveground plant material taken from 3-ft rows at midtillering (MT), internode elongation (IE) and three weeks after heading.

Results

The data were analyzed by location because of differences in soil properties and rice varieties grown. In Cross County there was a significant P response on dry matter accumulation throughout the growing season (Table 2). The application of both P and K significantly increased dry matter accumulation at MT (Table 3). However, at the 0-40-0 P rate, the high rate of KCl reduced dry matter accumulation at MT. Application of 40 lb P_2O_5/acre significantly increased dry matter accumulation at IE and heading plus three weeks (Table 4), and the application increased grain yields by 1693 lb/acre (Table 5). In Cross County, the application of KNO_3 significantly increased grain yield by 449 lb/acre (Table 6). In Poinsett County, significant treatment effects on dry matter accumulation occurred only at the heading plus three weeks growth stage (Table 2). Dry matter, at MT and IE, tended to increase with increasing K rate (Table 7). Application of 60 lb K_2O/acre significantly increased grain yields by 757 lb/acre (Table 7).

Practical Application

Rice grown on soils with high pH responded to P application, which is consistent with previous findings. Low pH soils, that also test low in available P and K, do not respond to P fertilization but do respond to K fertilization. Application of P with K seems to counter the negative effect of K on rice grown on alkaline soils.

Acknowledgments

Support for this research was provided by the Potash and Phosphate Institute and Arkansas Tonnage fees. Special thanks to the following county Extension agents and rice growers for their assistance: (Agents) David Annis, Van McNeely, Rick Thompson, and Rick Wimberly and (growers) Darryl Schlencker (Cross County) and Billy Joe Wright (Poinsett County).

Table 1. Soil analysis results of topsoil (0 to 4 in.-deep) samples from rice fields before planting.

				Mehlich III, mg kg-1									
Location	pH[1]	EC[1] µS cm-1	Olsen P, mg kg-1	P	K	S	Ca	Mg	Na	Fe	Mn	Zn	Cu
Cross	7.9	374	23	8	133	8	1989	327	59	181	150	8	2.5
Poinsett	5.3	146	9	7	49	14	953	156	34	372	43	13	1.1

[1]pH and EC measurement using 1:1 soil-water ratio

Table 2. Observed probabilities for the main effects of phosphorus rate, potassium source and potassium rate and their interaction on dry matter production at three growth stages and grain yield.

	Cross County				Poinsett County			
Factor	MT[1]	IE[2]	Heading + 3 wks[3]	Yield	MT[1]	IE[2]	Heading + 3 wks[3]	Yield
P Rate (Pr)	0.0001	0.0001	0.0001	0.001	0.7777	0.1964	0.8022	0.0756
K Source (Ks)	0.1048	0.6960	0.8350	0.0711	0.6717	0.7667	0.2953	0.8713
K Rate (Kr)	0.0701	0.356	0.7550	0.6376	0.0809	0.7532	0.0105	0.0003
Pr x Ks	0.5313	0.1796	0.0569	0.5484	0.7649	0.2097	0.6427	0.7764
Pr x Kr	0.9289	0.2652	0.4781	0.1687	0.8067	0.8171	0.3072	0.1664
Ks x Kr	0.2316	0.9366	0.1096	0.5684	0.6125	0.2535	0.7971	0.7764
Pr x Ks x Kr	0.0104	0.8937	0.9086	0.7638	0.9688	0.4439	0.6754	0.8979

[1] MT: Midtillering.
[2] IE: Internode elongation.
[3] Heading plus three weeks.

Table 3. Influence of phosphorus rate, potassium source and potassium rate on dry matter production by rice at midtillering growth stage in Cross County.

K Source	K Rate	Dry Matter P Rate, lb P2O5 A-1 0	40
	lb K_2O A^{-1}	lb Dry Matter A^{-1}	
Check	0	440.1	1029.1
KCl	60	413.8	1239.1
	120	430.2	740.0
K_2SO_4	60	684.1	1031.1
	120	491.1	986.6
KNO_3	60	661.3	1044.6
	120	519.9	1155.7
$LSD_{(0.05)}$		186.5	

Table 4. Influence of phosphorus rate on dry matter production by rice at I.E. and heading plus three weeks in Cross County[1].

P Rate	Dry Matter Internode Elongation	Heading + 3 weeks
	lb P_2O_5 A^{-1}	lb Dry Matter A^{-1}
0	1854	10581
40	2903	14336
$LSD_{(0.05)}$	412	1207

[1] No significant differences existed between K sources and K rates, and thus the data were averaged over K sources and K rates.

Table 5. Influence of phosphorus rate on rice grain yields.

P Rate	Grain Yield Cross County	Poinsett County
	lb P_2O_5 A^{-1}	lb Grain A^{-1}
0	3723	6710
40	5416	6310
$LSD_{(0.05)}$	350	443

Table 6. Influence of potassium source on rice grain yields.

K Source	Grain Yield Cross County	Poinsett County
	lb Grain $Acre^{-1}$	
KCl	4437	6568
K_2SO_4	4411	6431
KNO_3	4860	6532
$LSD_{(0.05)}$	428	ns[†]

[†] ns = nonsignificant.

Table 7. Influence of potassium rate on dry matter production by rice at two growth stages and grain yield in Poinsett County.

	Dry Matter			Grain
K Rate	Midtillering	Internode Elongation	Heading + 3 Weeks	Yield
lb K_2O A^{-1}		lb Dry Matter A^{-1}		lb Grain A^{-1}
0	2104	3271	14104	5868
60	2382	3423	16883	6625
120	2562	3628	16979	7037
$LSD_{(0.05)}$	ns[†]	ns	2142	542

[†] ns = nonsignificant.

Rice Response to Phosphorus and Potassium Fertilization at Different Soil Test Levels

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Research Problem

Optimum phosphorus (P) and potassium (K) fertilization is necessary for maximum rice (*Oryza sativa*, L.) production. University of Arkansas recommendations for P are 40 lb P_2O_5 acre^{-1} if the soil test level (Mehlich III) is less than 25 lb P acre^{-1}. Potassium is recommended at a rate of 60 lb K_2O acre^{-1} if the soil test level is between 125 and 175 lb K acre^{-1} and 80 lb K_20 acre^{-1} if the soil test level is less than 125 lb K acre^{-1}. The current study was initiated to evaluate the response of rice to P and K fertilization on an array of soil test levels of these elements.

Background Information

Phosphorus fertilization has only recently been recommended for rice. Typically, P availability increases under flooded soil conditions; however, the mechanisms involved in increasing P availability are pH dependent. As the soil pH increases above 7.0, P availability decreases and is less affected by flooding. Potassium has been recommended on rice for several years. However, on soils that have a history of salinity, many producers have been reluctant to apply K to these soils in fear of aggravating the problem. Potassium fertilization was rarely recommended on these saline soils because the levels of K were typically not deficient. As new varieties are developed, the yield potential continually increases. This increased yield potential is accompanied by an increase in the amount of P and K removed from the soil in the grain. Consequently, it has become increasingly important to evaluate the current recommendations for P and K.

Research Description

A study was initiated at the Pine Tree Branch Experiment Station near Colt, Ark., during the spring of 1996. Soil samples were collected from the area in grids to delineate areas within the field with different levels of P and K (Table 1). Each area was categorized as low or high P, and low, medium or high K depending on the utilized critical values for P and K fertilizer for a total of six soil test P and K level combinations. Phosphorus and K fertilizer was applied at either 0, 1/2, 1 or 2 times the recommended rate for each soil test level. 'LaGrue' rice was planted in plots 8 ft by 20 ft and harvested for total dry matter at three weeks after heading and grain yields at maturity. The experiment was arranged in a completely randomized factorial with five replications.

Results

Total dry matter was not influenced by the initial soil test level (Table 2). Grain yields were significantly influenced by the initial soil test levels. Except for the low P and low K combination, the grain yields increased significantly with increasing initial soil test levels. Overall, total dry matter and grain yields were not influenced by fertilizer applications (Table 3). The high yields associated with the low soil test levels may be partially explained by the interaction between the initial soil test level and the fertilizer rate (Table 4). Although the interaction was not significant, a trend for greater response to fertilizer at the low soil test levels was observed. At the low P and low K, the grain yields increased from 6948 to 7599 lb acre^{-1}. A similar trend was observed with the high P and low K combination. However, at higher rates of initial soil test P and K levels, the response to fertilizer was much less observable.

Practical Considerations

Because this is the first year of the study, no definite conclusions should be made. However, the trends observed tend to support the current P and K fertilizer recommendations for rice.

Acknowledgments

Thanks is extended to the Potash and Phosphate Institute and producers contributing to the Arkansas Fertilizer Tonnage Fees for partial support of this research.

Table 1. General soil chemical characteristics of test area. (Average of 12 samples).

	Soil Test Levels		
		Range	
Soil Test Parameter	Mean	Low	High
pH	6.0	5.2	6.4
P	25	15	40
K	183	132	269
Ca	2254	1756	2871
Mg	474	404	547

Table 2. Influence of initial P and K soil test values on rice dry matter accumulation and grain yields during 1996.

Initial Soil Test Level	Total Dry Matter	Grain Yield
	— g/m^2 —	— lb/acre —
Low P (<25 lb/acre); Low K (<135 lb/acre)	2206	7314
Low P; Medium K (135 - 175 lb/acre)	2258	6579
Low P; High K (> 175 lb/acre)	2041	6887
High P (> 25 lb/acre); Low K	2328	6973
High P; Medium K	2188	7240
High P; High K	2079	7467
$LSD_{(0.05)}$	n.s.	416
C.V. (%)	18.8	9.4

Table 3. Influence of P and K fertilizer rates on rice grain yields during 1996.

Fertilizer Rate[†]	Total Dry Matter	Grain Yield
	— g/m^2 —	— lb/acre —
0	2239	7060
1/2 X	2201	7083
1 X	2172	7145
2 X	2120	7018
$LSD_{(0.05)}$	n.s.	n.s.

[†] X = recommended fertilizer rate for particular soil test values.

Table 4. Influence of Initial soil test values and fertilizer rate on rice grain yields during 1996.

	Grain Yields*					
	High P			Low P		
Fertilizer Rate[†]	Low K	Med K	High K	Low K	Med K	High K
	lb /acre					
0	6948	6748	6970	6799	7440	7457
1/2 X	7541	6444	6817	6613	7448	7633
1 X	7168	6748	7021	7348	7237	7349
2 X	7599	6375	6739	7133	6836	7427

[†] X = recommended fertilizer rate for particular soil test values.

* Soil Test Level X Fertilizer Rate Interaction not significant at the 0.05 level of probability (P = 0.6995).

Nitrogen Fertilization of Vine-Ripened Tomatoes Following a Winter Annual Legume Cover Crop

P. B. Francis, P. E. Cooper and C. R. Anderson

Research Problem

The establishment of winter annual legume cover crops on vine-ripened tomato fields is practiced by many commercial growers. Winter annual legume cover crops can reduce soil erosion and add nitrogen and organic matter to the soil. The N contribution of the preceding legume could supply most, if not all, the needs for the tomato crop provided that the supply of mineralized N corresponds to optimum plant demand for fruit development. If not, then supplemental N may be needed. The objective of this study was to investigate rate and timing effects of supplemental N on the yield and gross revenue of vine-ripened tomatoes following an incorporated winter annual legume cover crop of Austrian winter peas.

Background Information

Winter annual legume cover crops have the benefits of reducing soil erosion, improving soil tilth, adding nitrogen to the soil and improving soil organic matter content (Evans and Sturkie, 1974; Hargrove, 1976; and Power et al., 1983). Following incorporation, the availability of legume-fixed N to the subsequent crop is related to the mineralization rates of the residue, which can be variable (Frankenberger and Abdelmagid, 1985). Supplemental N may increase fruit yield and revenue if timed appropriately. Current cultivation methods allow for precision injection of N through the micro-irrigation lines, but data are lacking to determine whether or not additional N would benefit yields and gross revenue. One objective of this study is to develop recommendations for N fertilization following legume cover crops with regard to both yield and revenue.

Research Description

This study was conducted in the 1995 and 1996 growing seasons at the Roger Pace farm near Monticello, Arkansas, on a Sacul loam soil. Austrian winter peas were incorporated in March approximately three weeks prior to tomato bed formation followed by transplant of 'Mt. Spring' cultivar in early April. Treatments consisted of total N rates of 0, 60, 120, 180 and 220 lb N/mulched acre, with or without injections of 30 lb N/mulched acre at early flowering and again at mid-fruiting. The experimental design was a split-plot with injection and total N as the main and split-plot treatments respectively using four replications. Subplots consisted of eight plants spaced 21 in. apart, the inside four plants harvested three days a week and graded to U.S. No. 1 XL (XL), U.S. No. 1 L (L), U.S. No. 2 (N2) and Unclassified (UN). The average local auction prices for each grade on the day of harvest was used to determine gross revenue/acre based on 20 lb boxes and 4000 plants/acre.

Results

Biomass estimates, obtained from population counts and whole plant/root sampling, revealed approximately two times more N subject to mineralization prior to the 1995 season compared to the 1996 cover crop due to a dry fall and early spring in 1995/96 (Table 1). Overall, yields and revenue were much higher in the 1995 season (Tables 2 - 4). In addition to the decreased cover crop biomass in 1996, a severe outbreak of thrip-transmitted spotted wilt virus drastically lowered fruit grade. The virus appeared to be uniform across N treatments and fruit symptoms appeared on seemingly healthy plants, which was unusual. Low early season market prices in 1996 also reduced income compared to the 1995 season. In both years, there were no significant advantages of additional N from either all preplant or preplant + split-injected N. In 1996, a significant injection X N interaction was noticed at the 0.05 level of significance (split-plot analysis of variance, not shown) for U.S. No. 1 XL+L fruit, with most of the increase coming from late season L-sized from the high-N treatments (Table 3). However, when gross revenue was factored in, the increases did not contribute significantly (Table 4).

Practical Applications

Two years of research show that a legume cover crop of Austrian winter peas can supply sufficient N for vine-ripened tomatoes on a loamy soil. Supplemental N up to 180 lb/mulched acre, applied pretransplant, seemed to increase yields the last two weeks of harvest, but the impact on gross revenue was minimal.

Acknowledgments

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Table 1. Preseason site characteristics.

Depth	Year	P	K	Ca	Mg	Ca:Mg
– in.–		lb/acre				
0 - 6	1995	343	421	2734	167	16:1
	1996	366	376	3175	128	25:1
6 - 12	1995	56	299	2267	268	9:1
	1996	150	215	2780	256	11:1

Winter Cover Crop: Austrian winter pea
1995 biomass: 5263 lb/acre, 3.32% N
1996 biomass: 2179 lb/acre, 4.24% N

Table 2. Cumulative yields of U.S. No. 1 XL+L in 1995.

		Harvest period, month/day				
Preplant	Injection	6/11-6/17	6/11-6/24	6/11-7/1	6/11-7/8	6/11-7/15
—lb N/ mulched/acre—		boxes/acre				
0	0	150	418	1118	1619	2310
60	0	185	462	1351	1795	2358
120	0	145	427	1408	1954	2446
180	0	163	422	1285	1716	2319
220	0	150	321	1192	1663	2332
0	60	158	392	1360	1764	2323
60	60	185	414	1408	1984	2407
120	60	145	392	1232	1729	2627
160	60	97	290	1206	1624	2482
		ns[†]	ns	ns	ns	ns

† ns = nonsignificant.

Table 3. Cumulative yields of U.S. No. 1 XL+L in 1996.

		Harvest period, month/day				
Preplant	Injected	6/17-6/24	6/17-7/1	6/17-7/8	6/17-7/15	6/17-7/22
—— lb N/ —— mulched acre		—— boxes/acre ——				
0	0	75	163	286	392	418
60	0	44	132	440	480	576
120	0	84	361	365	541	638
180	0	44	150	378	515	634
220	0	35	88	273	405	537
0	60	13	136	352	436	484
60	60	18	246	532	678	761
120	60	48	233	400	691	752
160	60	75	233	515	726	801
		ns†	179	ns	ns	ns

† ns = nonsignificant.

Table 4. Gross revenue based on average daily prices at local auction markets.

		Season	
Preplant	Injected	1995	1996
—— lb N/ —— mulched acre		—— dollar 10^3/acre ——	
0	0	32.2	19.7
60	0	34.4	22.9
120	0	34.2	20.3
180	0	32.4	21.2
220	0	32.3	21.2
0	60	32.4	19.3
60	60	33.2	21.2
120	60	35.1	21.2
160	60	33.5	21.5
		ns†	ns

† ns = nonsignificant.

Response of ‘Arapaho’ Thornless Blackberry to Nitrogen Fertilization: Third Year Results and Final Report

Joseph Naraguma and John R. Clark

Research Problem

Applications of nitrogen (N) to blackberry plantings are a common practice in Arkansas. Growers make either one application in the early spring or utilize a split application with the early spring application followed by a second application following harvest. Blackberries have a perennial root system, but the canes are biennial. First-year canes are known as primocanes, and second-year canes are called floricanes. The floricanes bear the crop and die following fruiting. The primocanes grow vegetatively the first year and develop the fruiting area for next year’s crop. A major question in fertilization of blackberries is the proper rate and timing of N applications for maximum fruit yield coupled with the full development of primocanes for next year’s crop. The continuing objective of our study was to determine the effect of N rate and time of application on ‘Arapaho’ thornless blackberry.

Background Information

Research in the area of blackberry fertilization is limited, and almost no research has been done on this topic in Arkansas. Current fertilizer recommendations have been based largely on recommendations from other states. This study was begun to address the need for information on fertility of a new blackberry from the University of Arkansas breeding program. The study was begun in 1994, and this report provides the third-year results and final report.

Research Description

This study was conducted at the University of Arkansas Fruit Substation, Clarksville. Treatments were begun in 1994, and these same treatments were continued for 1996. The treatments were as follows: 1) control - no N applied, 2) 50 lb/acre N applied in a single application in early spring, 3) 100 lb/acre N applied in a single spring application and 4) 100 lb/acre N applied in a split application with one-half applied in the spring and one-half applied immediately after harvest. Ammonium nitrate was the N source. Fruit was harvested from the plots in June, and total yield and average berry weight determined. Also, foliar samples were collected in August and elemental analysis was conducted. Primocanes in each plot were counted at the end of the growing season. The experimental design was a randomized complete block containing three replications.

Results

The effect of N rate and time of application on yield, berry weight and cane number was evaluated. Compared to 1995, the plants in 1996 had much lower yields. A freeze on 8 March 1996 (low temperature of 10°F) near the bud break period probably caused the yield reduction. As in 1995, there were no statistically significant differences in yield among the N rates (Table 1). Berry weight was not reduced by the freeze, and, as in previous years, was similar among all treatments. Primocane number from each treatment was not statistically different, although the lowest cane number was produced by the control treatment.

The effect of N treatments on foliar elemental levels was studied. Only foliar levels of calcium (Ca) and manganese (Mn) were affected by N rate or time of application for 1996 (Table 2). Calcium was highest when no N was applied, and Mn level was greatest at the higher N rates. The foliar N levels were influenced by N rate in 1994 and 1995; the control had the lowest N rate in each of those years. In 1996, however, there were no significant differences in the foliar N levels although the trend in the data was for higher foliar N with higher N rate.

Practical Application

Results are inconclusive in determining the optimum N rate and time of application. Foliar N was usually increased by higher N rates, and various other elements were affected in some years of the study. However, yield was not significantly influenced in any year by increasing N rate or by split application. Berry weight was affected in one of the three years, but the effect was minimal. Although further data analysis is needed to fully evaluate differences among years, preliminary conclusions do not indicate a benefit from the split application nor the increased N rate. Further research, possibly testing higher N rates than those evaluated in this study, might determine if a greater response on ‘Arapaho’ can be achieved.

Table 1. Yield, berry weight and primocane number of 'Arapaho' thornless blackberry as influenced by N fertilization.

Treatments	Yield[z]	Berry wt. (g)	Cane no.[y]
Control	1999	4.2	20
50 lb Spring	3436	4.5	29
100 lb Spring	2544	4.1	22
100 lb Split	1998	4.1	22
Significance[x]	ns	ns	ns

[z] Yield in grams/10' plot.

[y] Total primocanes for a 10' plot produced in 1996.

[X] Significance by F test; ns = nonsignificant, 0.05 level.

Table 2. Elemental composition of 'Arapaho' blackberry primocane leaves as influenced by N fertilization, August 1996.

Treatments	N	P	K	Ca	Mg	S	Fe	Mn	Zn
	—% dry wt.—						—ppm dry wt.—		
Control	2.06	0.12	1.16	0.75a[z]	0.31	0.13	46	284b	27
50 lb Spring	2.21	0.12	1.10	0.61b	0.26	0.14	42	388b	22
100 lb Spring	2.35	0.11	1.06	0.59b	0.26	0.14	38	516a	22
100 lb Split	2.38	0.13	1.15	0.57b	0.27	0.14	39	491ab	24
Significance[y]	ns	ns	ns	0.007	ns	ns	ns	0.04	ns

[z] Mean separation within columns by Student Newman Keuls test.

[Y] Significance by F test; ns = nonsignificant, 0.05 level.

Blueberry Response to Nitrogen Rate and Method of Application: Third-year Results

John R. Clark and Joseph Naraguma

Research Problem

Highbush blueberries are most often fertilized with dry N fertilizers applied to the surface of a blueberry row. Split application of these dry materials has been recommended, usually with the total N applied in three applications. The application of fertilizer by injection in the drip irrigation system (fertigation) is used in some blueberry plantings. Numerous fertilizer applications are made with this approach, usually 10-14 per season, but with smaller amounts of fertilizer applied each time as compared to the dry application method. The continuing objective of this study was to compare N rates and methods of application (fertigation and surface-applied) on highbush blueberries in Arkansas.

Background Information

No research studies have been conducted in Arkansas that compare the response of blueberry to fertilizer application methods. Also, information is not available that compares the response of blueberries to fertilizer rates using these methods. Rates of fertilizer on blueberry plantings in the United States usually range from 60-120 lb N/acre, with a foliar content of 1.6% considered the minimum for optimum plant performance. Higher N rates are often suggested where organic mulches such as sawdust are applied to the plants.

Research Description

A planting of sawdust-mulched ‘Bluecrop’ highbush blueberries was established in March, 1994, at the University Farm, Fayetteville, on a Captina silt loam soil, and N fertility treatments were imposed on these plants in their initial year in the field. Treatments in 1996 included a range of N rates from 0 to 240 lb N/acre, either surface-applied or by fertigation. Ammonium sulfate was the N material used in 1996. The dry, surface-applications were begun in mid April and again at six and twelve weeks later. Fertigation was begun at the time of the first dry application, and the total N was applied in 12 applications at approximately 10- to 14-day intervals with the application period extending into early August. Six replications of two-plant plots of each treatment combination were utilized, arranged in a randomized complete block design. Fruit yields and berry weights were measured in June, and foliar samples were collected in early August and analyzed for elemental content. Data were analyzed by SAS.

Results

Method of application of ammonium sulfate did not affect any variables measured including yield, berry weight or foliar elemental levels (Tables 1 and 2). There were significant interactions of method and N rate for magnesium (Mg) and zinc (Zn), but the differences among the interaction means were small and not important for practical use or interpretation.

The effect of N rate on yield, berry weight and foliar levels was also evaluated. There were significant F-test rate effects only for foliar N, sulfur (S), iron (Fe), Mn and Zn (Tables 1 and 2). In the regression analysis for significant trends in the data, linear increases for both surface-applied and fertigation for foliar N, S, Fe and Mn and yield with increased rate of ammonium sulfate were found (Tables 1 and 2). Significant trends were found for phosphorus (P), Ca and Zn, but the actual differences in foliar values were small and of little practical value for interpretation.

Practical Application

Results indicate that the method of application made no difference in any of the variables measured, reflecting no impact on plant performance from how the fertilizer was applied. Increasing ammonium sulfate rate resulted in increased yields; the highest yields were with the 240 lb/acre N rate. For foliar values, the major findings were the increased N, S, Fe and Mn with increasing N rate. Using a minimum adequate foliar N level of 1.60%, the control and 60 lb/acre N were deficient, while the other levels were sufficient and ranged up to 2.34%. Levels of S and Fe were increased from the increased application of ammonium sulfate, but the highest values of these elements were only slightly greater than the lower N-rate levels. Of note is the much higher Mn levels at the highest N rate, and a concern exists that the higher rates may contribute to possible Mn toxicity. Although no toxicity symptoms were seen, close examination in subsequent years is needed to determine if excess Mn is a problem in high N-rate plants.

Table 1. Foliar macroelement content and analysis of variance F-test significance for method of application and N rate treatments to highbush blueberries, third-year results (1996).

Application Method	N rate[z]	N	P	K	Ca	Mg	S
		% dry wt.					
Control	0	1.25	.07	.45	.56	.16	.09
Surface	60	1.55	.07	.45	.59	.18	.12
Surface	120	1.86	.07	.52	.58	.15	.13
Surface	180	1.79	.07	.56	.60	.14	.13
Surface	240	2.22	.07	.53	.65	.15	.15
Fertigation	60	1.54	.06	.52	.57	.15	.11
Fertigation	120	1.83	.06	.45	.63	.17	.13
Fertigation	180	2.18	.06	.46	.70	.16	.14
Fertigation	240	2.34	.06	.44	.83	.20	.15
F-test significance level (*P* > F)							
Source of variation							
Method		.14	.11	.11	.11	.18	.70
Rate		.01	.19	.89	.11	.45	.01
Method x Rate		.25	.25	.12	.48	.04	.67
Rate linear (surface)[y]		.01	.52	.13	.41	.25	.01
Rate quadratic (surface)		.78	.56	.74	.80	.96	.22
Rate linear (fertigation)		.01	.01	.32	.01	.07	.01
Rate quadratic (fertigation)		.68	.77	.65	.37	.31	.35

[z] Rate in total N in lb/acre.

[y] Linear and quadratic responses include the data from the control (0 N rate) in the analysis.

Table 2. Yield, berry weight and foliar microelement content and analysis of variance F-test significance for method of application and N rate treatments to highbush blueberries, third-year results (1996).

Application Method	N rate[z]	Yield	Berry wt.	Fe	Mn	Zn	Cu
		(g/plant)	(g)	———ppm dry wt.———			
Control	0	7	1.4	54	142	9.2	2.8
Surface	60	132	1.9	52	278	7.5	3.0
Surface	120	110	1.8	62	513	7.9	3.3
Surface	180	194	1.7	53	624	7.0	2.8
Surface	240	227	1.9	65	781	9.0	3.2
Fertigation	60	73	2.0	56	263	8.2	3.5
Fertigation	120	186	1.9	60	455	9.1	3.9
Fertigation	180	169	1.8	60	743	7.4	3.5
Fertigation	240	294	1.8	66	793	7.8	3.3
F-test significance level (*P* > F)							
Source of variation							
Method		.76	.89	.23	.82	.36	.60
Rate		.16	.49	.01	.01	.01	.60
Method x Rate		.69	.93	.50	.80	.02	.82
Rate linear (surface)[y]		.03	.20	.04	.01	.52	.64
Rate quadratic (surface)		.76	.30	.47	.82	.01	.77
Rate linear (fertigation)		.01	.37	.01	.01	.01	.43
Rate quadratic (fertigation)		.96	.09	.66	.89	.86	.06

[z] Rate of actual N in lb/acre.

[y] Linear and quadratic responses include the data from the control (0 N rate) in the analysis.

Effect of Nitrogen Rate And Method of Application on Highbush Blueberry Fruit Quality

Victorine Alleyne and John R. Clark

Research Problem

Commercial highbush blueberry production is an important and growing industry in North America. In only 10 years (1982-1992), production acreage has more than doubled (Moore, 1994). This results in a large volume of berries on the fresh market. Growers need to produce high-quality fruit capable of shipment to distant markets, and N fertilization is an important management practice within that goal, but some growers believe that high rates of N produce soft blueberries with poor keeping quality, as with strawberries. The objective of this study was to determine the effect of N rate and method of application on highbush blueberry fruit quality in Arkansas.

Background Information

Previous work conducted elsewhere has indicated that N fertilization increased highbush blueberry firmness (DeFrancesco et al., 1986). But N also tended to decrease acidity, which may enhance spoilage (Ballinger et al., 1963; Ballinger et al., 1969; DeFrancesco et al., 1986). Thus, the fruit quality response in Arkansas needs to be addressed.

Research Description

'Bluecrop' highbush blueberry plants established in 1994 at the Main Experiment Station, Fayetteville, Arkansas, on a Captina silt loam were used in this 1996 study. The N rates were 120 and 240 lb/acre and the application methods were dry, surface-applied and fertigation. The five treatments were as follows: 1) control; 2) dry, surface application-120 lb/acre N; 3) fertigation-120 lb/acre N; 4) dry, surface application-240 lb/acre N; and 5) fertigation-240 N.

The dry, surface treatments were made in three applications, at budbreak and again at six and 12 weeks later. The fertigation treatments were achieved in 12 applications. Ammonium sulfate was the N source. Three replications of two-plant plots of each treatment in a randomized complete block design were utilized. Fruit from two harvests in 1996 were evaluated. The fruit quality characteristics measured were as follows: fruit N (%), pH, firmness (Newtons), fructose (%), glucose (%), soluble solids (%), titratable acidity (%), sugar/acid ratio and anthocyanin content (mg/l).

Results

Neither N rate nor method of application affected blueberry fruit N significantly, but there was a definite trend toward increasing fruit N as N application rate increased (Table 1).

Method of application of N fertilizer had no effect on fruit N, pH, firmness, fructose and glucose (Table 1), or sucrose, soluble solids, titratable acidity, sugar/acid ratio and anthocyanin content (data not shown).

N rate affected firmness, and fructose and glucose concentration, but there was a significant method by rate interaction (Table 1). The firmest berries were produced by surface application at 120 lb/acre, and the softest berries were from the surface application of 240-lb/acre at the first harvest. At the second harvest, all N treatments produced firmer berries than the control, but there was no difference in firmness among treatments. A similar trend, toward increasing firmness with N, was observed by DeFrancesco et al. (1986). Glucose and fructose were highest in berries from the 120-lb/acre surface application treatment and generally higher at the lower N rates.

Practical Applications

Preliminary results indicate that the response of highbush blueberry fruit to N rate of application was influenced by the method of application. A trend toward increased firmness with increasing N was evident. Most other quality characteristics were not affected. Moderately increasing N levels may be beneficial for improving fruit quality by increasing firmness without adversely affecting other quality characteristics. However, because these results are preliminary, further evaluation should be conducted before final conclusions are drawn.

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Table 1. Fruit quality characteristics of highbush blueberries as influenced by N rate and method of application.

	Fruit quality measurements[z]				
N treatments	Fruit N[y]	pH	Firmness (N)[x]	Fructose[y]	Glucose[y]
			First harvest		
Control	0.77 a	2.9 b	2.3 b	25.3 b	24.3 c
Surface-120 lb/acre	0.90 a	3.2 b	2.8 a	29.0 a	28.1 a
Fertigation-120 lb/acre	0.89 a	3.3 a	2.4 b	27.0 b	26.1 b
Surface-240 lb/acre	1.07 a	3.4 a	1.7 c	25.4 b	24.5 b
Fertigation-240 lb/acre	1.04 a	3.3 a	2.5 b	25.4 b	24.5 b
			Second harvest		
Control	0.60 a	3.1 b	2.2 a	22.7 a	21.8 a
Surface-120 lb/acre	0.75 a	3.3 a	2.7 b	23.0 a	22.1 a
Fertigation-120 lb/acre	0.68 a	3.3 a	2.6 b	21.8 a	21.3 a
Surface-240 lb/acre	0.90 a	3.4 a	2.7 b	19.8 b	19.6 b
Fertigation-240 lb/acre	0.73 a	3.2 b	2.7 b	21.5 ab	21.1 b
F-test significance (*P* > F)					
Source of variation					
Method	0.42	0.27	0.18	0.40	0.50
Rate	0.13	0.10	<0.01	<0.01	<0.01
Method (Rate	0.67	0.06	<0.01	0.02	0.03
Method (Harvest	<0.01	0.04	0.02	0.17	0.14
Rate (Harvest	0.03	0.07	<0.01	0.32	0.16

[z] Mean separation within columns by LSD at $P \leq = 0.05$. Means followed by the same letter are not significantly different.
[y] Fruit N, glucose and fructose are expressed as percent dry weight.
[x] Firmness is expressed in Newtons.

Wheat Yield Response from Spring Nitrogen Sources, Application Methods and Rates

L. G. Stauber, D. M. Freeze and R. A. Klerk

Introduction

Typically, the fertility of clay soils of the northeastern Arkansas Delta Region are limited only in nitrogen. The high fertility of these soils may on occasion require phosphorus inputs and pH adjustments. These soils lend themselves to properties of expansion and contraction directly related to excess or absence of available soil moisture. These dramatic physical characteristics immediately cause nitrogen losses from denitrification and volatilization. The growers who depend on these soil types must use their best judgment on fertilizer application methods. Environmental conditions aggravate nitrogen uptake into the wheat plant. An obvious correction to the problem is increasing nitrogen rates for each application. The wheat plant can only tolerate certain levels of this type of practice. The resulting condition of the wheat plant under Arkansas conditions usually gives negative effects of lodging, delayed maturity, depressed yields and severe disease pressure (Wells et al., 1995). Recent research has updated nitrogen recommendations for wheat on clay soils by increasing the total spring requirements from 100 to 140 lb N/acre (Chapman et al., 1991). Not all growers are convinced of this practice and are unclear about the amounts of nitrogen per application. The financial aspects of fertilizer sources do confuse the issue of effective utilization of nitrogen by the wheat plant. The stability of nitrogen in its marketed form undergoes soil and bacterial chemical changes that are influenced by temperatures, humidity and soil moisture.

The following study was conducted to contribute to nitrogen effectiveness for wheat production on clay soils. These studies were part of the Cooperative Extension staffs' efforts to assist growers in improved wheat production.

Methodology

Fertility studies were conducted on a Sharkey silty clay soil at locations of

West Memphis, Arkansas, (Location A) and a Tunica clay at Osceola, Arkansas, (Location B). Locations were geographically in the Delta Region of the state. Both tests were conducted over one year during 1995/1996. Prior crop rotations consisted of soybeans and rice, respectively.

The experimental design for both locations was a randomized complete block with four replications. The nitrogen treatments as urea for Location A were as follows: 1) single low input of 85 lb N/acre, 2) 100 lb N/acre, 3) 130 lb N/acre, 4) 150 lb N/acre and 5) 180 lb N/acre. All treatments excluding the single low input were applied as two-way or three-way splits, which totaled nine treatments. The nitrogen rates were evenly applied at three-week intervals using sand as a filler to help distribute the lower plot amounts. The entire test area was previously fertilized with 85 lb N/acre on 2 March 1996. Urea treatments were supplemented above the 85 N unit base to accommodate the specific treatment level on the same day. The plot size consisted of seven rows (7in. spacing) 20 ft in length. The wheat cultivar 'Pioneer 2684' was drillseeded at a rate of 100 lb/acre. This cultivar was chosen for its excellent disease resistance against various common pathogens and grain yield. A uniform application of 100 lb/acre of ammonium sulfate was applied at planting on 12 October 1995. The Location B evaluated three factors as follows: fertilizer sources as urea and ammonium nitrate; nitrogen rates of 120, 150, and 180 lb N/acre; and three application timings. This gave an 18-treatment test. Fertilizer applications were evenly distributed at four-week intervals beginning on 15 February 1996. The test area had previously been fertilized with 100 lb/acre of 18-46-0 prior to planting on 30 September 1995. The plot size consisted of seven rows (7-in. spacing) 20 ft in length. The wheat cultivar 'NK Coker 9543' was no-till, drilled-seeded at a rate of 100 lb/acre.

Individual plots were harvested with a small plot combine removing the center four rows. Plot grain weights were adjusted to 13.5% moisture prior to statistical analysis. Analyzed parameters included grain test weights and yields at maturity. Data were analyzed by Analysis of Variance, and differences were determined by the least significance difference test at the 5% level of probability ($LSD_{0.05}$).

Results and Discussion

Location A

Average weather conditions during this growing season did not interfere with nitrogen uptake in the wheat plant based on growth and yield results. An average wheat test weight of 57.6 lb/bu resulted since there were no statistically differences from application timings on nitrogen rates ranging from 85 to 180 lb/acre. The low input treatment resulted in a grain yield of 66.9 bu/acre, and the highest nitrogen rate yielded 82.3 bu/acre. Interactions between application timings and nitrogen rates were not statistically different. Application timings were not found significant between two-way and three-way nitrogen splits. Nitrate rates were, however, found statistically different among each other. A general trend of increased yields occurred as nitrogen rates were also increased from 85 to 180 units/acre. Mean separation methods determined that 85 units were statistically different from all other treatments. The 100 and 130 nitrogen rates were not significant from each other but were lower yielding than the remaining treatments (Figure 1). Yield means from the 150 and 180 nitrogen rates were also not statistically inseparable yet yielded approximately 6 bu more than 100 and 130 units of nitrogen. The grain yields from Location A show nitrogen levels above the recommended level are advantageous. The Pioneer 2684 cultivar responds to elevated nitrogen inputs in this particular cropping season. This variety does not respond to application methods. A single application of the total spring nitrogen treatments was not investigated against two-way and three-way splits. The single application of 85 units of nitrogen was unusual in producing a yield of 66.9 bu/acre.

Location B

Grain test weights were not found statistically different for this test. Thus, an average was determined at 56.8 lb/bu. Several variable interactions were tested for grain yields. The nitrogen rate and nitrogen timings were significant. The nitrogen sources comparing urea to ammonium nitrate were also not found significant. Data generated from the nitrogen rates showed an increase in yields from the lowest to the highest rate. The 180 lb N/acre rate did show numerically a negative yield effect but was not statistically different from the 150-lb/acre rate. This is typical of excess nitrogen for most wheat cultivars. The grain yield ranged from 55 to 60.3 bu/acre, with the 180 lb N/acre yielding 58.6 bu/acre. This reaction is demonstrated in Figure 2. The nitrogen timings comparing a single application, two-way split and three-way split, generated grain yield effects that increased with multiple applications. Grain yields improved by five bushel increments as application timings increased in frequency. The single nitrogen application resulted in a 52.7 bu/acre yield. The best application treatment was the three-way split, which resulted in a 64.2 bu/acre yield (Figure 3). Results at this location demonstrated this cultivar also generated maximum yields at 150 lb N/acre. The Coker 9543 cultivar did show a positive response to multiple applications of the total spring nitrogen this growing season.

Acknowledgments

The authors wish to thank the producers Alan Cox, III and Randy Veach for allowing the tests to be accomplished on their farm. Appreciation is also extended to Howard Black and Dr. William Johnson for statistical inputs. Contributions and funding for this research was provided by Chickasaw Chemical Company and the Wheat Promotion Board.

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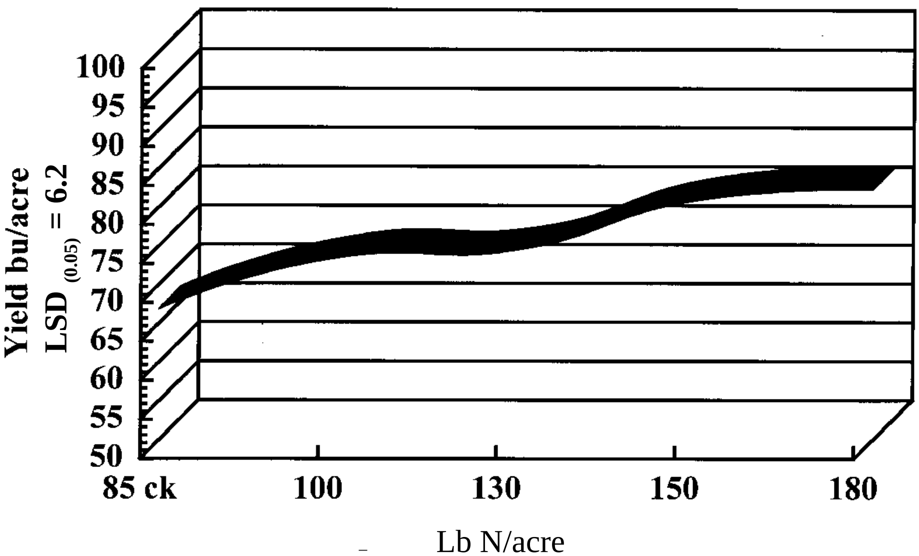

Figure 1.Wheat yields as affected by fertilizer N. Rates range from 0 to 180 lb N/acre.

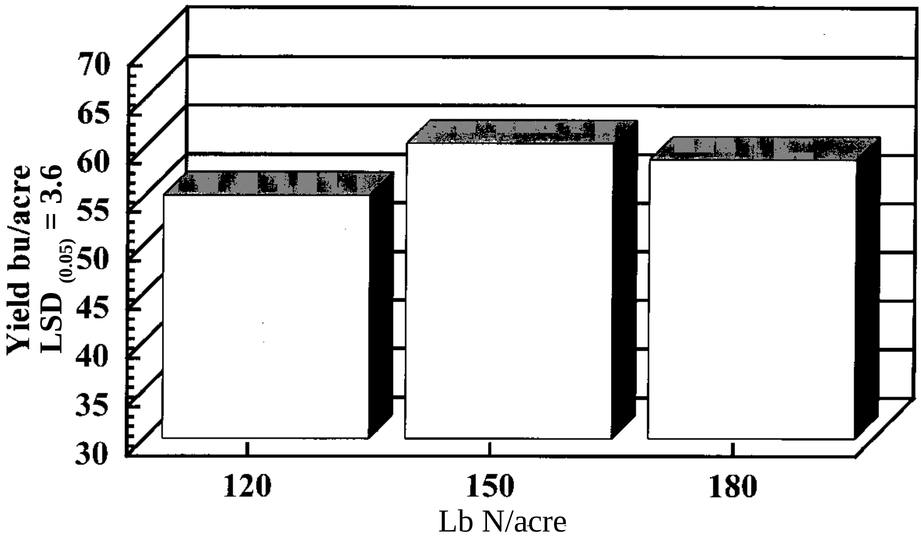

Figure 2. Effect of specific N rates on wheat yields.

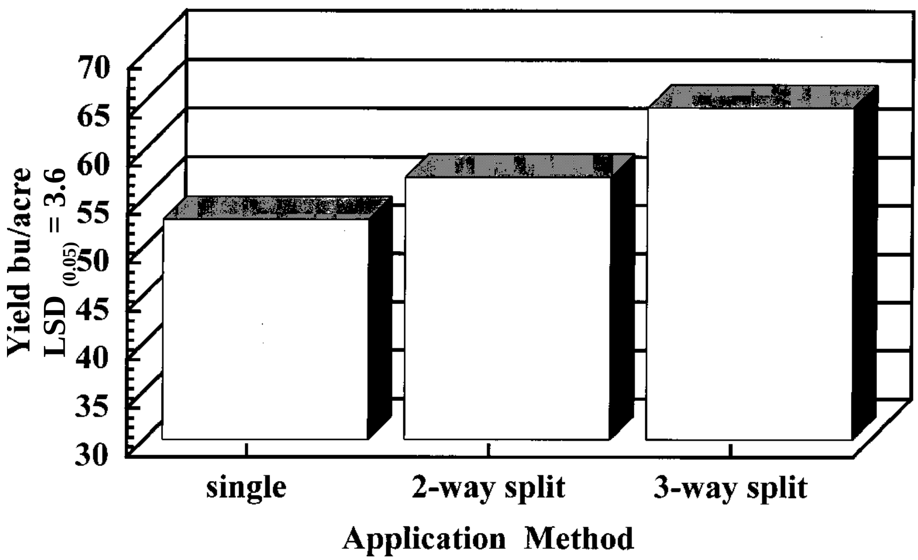

Figure 3. Effect of applications on wheat yield.

Limestone Requirements for Soybean

J.H. Muir, C.S. Snyder, W.E. Sabbe and J.A. Hedge

Research Problem

Soil acidity is a major soil fertility concern in Arkansas. Limestone use has been decreasing for the past 20 years while limestone needs have been increasing, due largely to the increased use of acid-forming nitrogen fertilizers.

The objective of this study was to determine whether soybean and any other crop(s) in rotation indicated agronomic yield response to current limestone recommendations.

Background Information

No field limestone research data were generated from the 1970s until the early 1990s in Arkansas. Also, current methods of estimating limestone requirements by the University of Arkansas Soil Testing Laboratory may underestimate true requirements.

Research Description

Experimental sites were located in farmers' fields with low pH. Treatments were 0, 0.5, R and 2R with R equal to current University of Arkansas limestone recommendation. Treatments were applied only once at each location. Treatment effects were determined for several years at each site.

Sites monitored were in Crittenden and Greene counties and at the Pine Tree Experiment Station (PTES). The Crittenden County site is a clay soil. All other sites are silt loam soils. The Crittenden County and PTES sites were in a wheat-soybean, double-crop rotation. The experimental design was a randomized complete block with four replications.

Soil Samples were collected periodically throughout the growing season, and pH was determined. Leaf samples were collected at the early bloom growth stage for nutrient analyses.

Results

No yield response to applied limestone has been reported at the Greene County site in five years (Table 1).

No response to limestone has been reported with either soybeans or wheat at the Crittenden County site (Table 2).

Soybean yields at PTES were low at this dryland site, and no response to applied limestone has been reported with either soybeans or wheat (Table 3).

Practical Application

Application of limestone to acid soils has increased pH in the year of application at every site in this study. At no time has there been a soybean yield nor wheat yield response to applied limestone. Although drought has limited yield at some sites in some years, no response has been obtained in years with adequate rainfall.

Acknowledgment

Financial support from the Arkansas Fertilizer Tonnage Fee is appreciated.

Table 1. Influence of limestone treatments on soybean yields at Greene County, Arkansas, 1992-1996.

Limestone	Yield				
Treatment	1992	1993	1994	1995	1996
	bu/acre				
0.0R[y]	42.9	13.3	28.6	20.6	39.4
0.5R	44.9	15.4	26.6	21.7	41.0
1.0R	40.2	18.4	28.8	21.4	40.8
1.5R	41.3	12.4	28.3	21.2	41.6
2.0R	41.0	15.4	25.5	20.7	41.0
$LSD_{(0.05)}$	5.4	3.0	8.4		

[y] R = current limestone recommendation of 1.0 tons limestone/acre.

Table 2. Influence of limestone treatments on soybean and wheat yields at Crittenden County, Arkansas, 1993-1996.

Limestone	Soybean	Soybean	Wheat	Soybean
Treatment	1993	1994	1996	1996
ton/acre	bu/acre			
0.0	30.2	19.1	53.3	24.4
1.5	33.0	20.2	50.4	26.5
3.0	33.3	16.7	50.1	24.3
5.5	33.1	20.1	47.8	22.8
8.0	33.2	19.8	51.2	23.5
$LSD_{(0.05)}$	8.2	5.5	8.4	6.1

Table 3. Influence of limestone treatments on soybean and wheat yields at the Pine Tree Experiment Station, Colt, Arkansas, 1995-1996.

Limestone Treatment	Soybean 1995	Wheat 1996	Soybean 1996
		bu/acre	
0.0R[y]	15.2	38.3	7.5
0.5R	14.3	37.7	6.4
1.0R	12.9	40.4	7.0
1.5R	14.6	25.3	4.4
2.0R	14.0	36.4	3.7
$LSD_{(0.05)}$	7.7	12.3	6.5

[y]R = current limestone recommendation of 2.0 tons limestone/acre.

Wheat Response to Nitrogen and Phosphorus Fertilization

B.R. Wells, M.D. Correll, R.K. Bacon and J.T. Kelly

Research Problem

Arkansas wheat farmers are constantly faced with choosing from a wide array of wheat varieties with new varieties being introduced at a rapid rate by both public and private breeding programs. New varieties have increased grain yield potential. This increased yield potential means the crop is placing high demands on the nutrient-supplying power of the soil. The two nutrients that are most limiting for wheat yields on Arkansas soils are nitrogen (N) and phosphorus (P). Research must constantly be updated to be sure that soil fertility recommendations for N and P are adequate to supply the needs of the new varieties. The objective of this study was to evaluate an array of the new wheat varieties in terms of response to N and P and to use these data to update soil test recommendations for the crop.

Background Information

Research conducted with N fertilization over the past several years shows that the new wheat varieties require more fertilizer N to achieve optimum yields as compared to the older varieties such as ‘Caldwell’ and ‘Florida 302’. Additionally, these studies show that more fertilizer N is required for wheat growing on clay soils as compared to silt loam soils. Other studies show that P is limiting for optimum wheat growth and yield, especially on silt loam soils where rice is included in the rotation. Other studies show that P fertilizer may be applied to a wheat crop anytime from planting until early March without limiting grain yields. This allows a wheat farmer flexibility in managing cash flow throughout the crop year.

Research Description

The studies were conducted on a Crowley silt loam soil at the University of

Arkansas Rice Research and Extension Center (RREC) near Stuttgart, Arkansas, and on a Calhoun silt loam at the University of Arkansas Pine Tree Station (PTS) near Colt, Arkansas. The studies consisted of four fall P fertilizer rates, four spring N fertilizer rates and four wheat varieties arranged in a strip, split plot experimental design. Recommended management practices were followed. The P fertilizer rates were 0, 40, 80 and 120 lb P_2O_5/acre as triple superphosphate (0-46-0). The N rates were 60, 110, 160 and 210 lb/acre as urea (46-0-0). The wheat varieties were ‘Wakefield’, ‘Hazen’, ‘Jackson’ and ‘Coker 9543’.

Results

Fall P fertilizer applications significantly increased grain yields of wheat at the RREC location; however, P fertilizer had no effect on grain yields at the PTS location (Table 1-a). Soil test levels for P were 13 lb/acre at RREC and varied from 20 to 50 lb/acre across replicates at the PTS location. Spring N fertilizer applications of 60 lb/acre were sufficient to optimize grain yields at both locations (Table 1-b). This optimum N rate is considerably lower compared to optimum N rates from previous years. The resultant effect is probably related to an array of factors including soil N release, time of planting (late at RREC) and cold damage to the wheat, particularly from a cold episode that occurred in mid-March. Coker 9543 had highest grain yields at RREC and lowest grain yields at PTS (Table 1-c). Test weights were not influenced by P fertilizer applications at PTS but were increased by the first P fertilizer increment (40 lb P_2O_5) at RREC (data not shown). Test weights were decreased by increasing increments of N fertilizer at both locations.

Practical Applications

These studies continue to emphasize that both N and P are limiting for wheat production on silt loam soils of eastern Arkansas. The P and N rates required to optimize yields are a function of soil N and P levels as well as cultural practices such as date of seeding and weather conditions. These studies, coupled with the earlier studies on P fertilizer timing, indicate that wheat varieties can be managed successfully to produce high yields with minimum management risk by delaying N and P fertilization until mid to late February. Cash flow can be managed to minimize interest costs, thus reducing the overall cost of production.

Table 1. Grain yields of soft red winter wheat as influenced by P rate, N rate and variety at two locations, 1995/1996.

Item	Grain Yield RREC[1]	Grain Yield PTS[2]
	bu/acre	bu/acre
1-a.		
Fall P rate (lb P_2O_5/acre)		
0	21	71
40	48	74
80	60	72
120	63	72
$LSD_{(0.05)}$	11	ns
1-b.		
Spring N rate (lb/acre)		
60	53	77
110	48	75
160	46	70
210	46	67
$LSD_{(0.05)}$	3	7
1-c.		
Variety		
Wakefield	47	75
Hazen	45	71
Jackson	47	74
Coker 9543	54	69
$LSD_{(0.05)}$	3	4

[1] Rice, Research and Extension Center, Stuttgart, Arkansas.
[2] Pine Tree Station, Colt, Arkansas.

Influence of Poultry Litter and Phosphorus on Soybean Grown on Saline Soils

J.H. Muir and J.A. Hedge

Research Problem

Soil salinity is a problem in some areas of Arkansas. The problem is often caused by irrigating with water containing excessive amounts of soluble salts. The salinity problem has evidently become more widespread with the increased use of irrigation. Long-term solutions may involve removing salt from irrigation water or finding sources of water that contain lower levels of soluble salts. Short-term solutions would be helpful in allowing continued crop production until long-term solutions are available.

Background Information

Observations from studies in rice indicate that additions of poultry litter may be beneficial in reclaiming saline soils. There are also indications that phosphorus may compete with chlorides and reduce salt damage. The objective of this study was to determine whether poultry litter and phosphorus amendments might reduce damage to soybeans grown on saline soils.

Research Description

Studies were initiated in 1995 in Monroe County, which has a history of a high chloride problem due to use of irrigation water with high chloride levels. A second site was established at Arkansas State University (ASU), where a saline condition was created. An 'includer' soybean cultivar was grown at each location.

Monroe County:

Experimental design: Factorial experiment in a randomized complete design

Poultry litter treatments: 0, 250, 500, 1000, 2000 and 4000 lb/acre.
Phosphorus treatments: 0, 40, 60 and 80 lb P2O5/acre.

Arkansas State University:
Experimental design: randomized complete block with a split-plot arrangement of treatments.
Main plots: 0, 2000 and 4000 lb/acre KCl.
Subplots: factorial arrangement of a) 0, 2000 and 4000 lb/acre poultry and b) 0, 40 and 80 lb/acre P2O5.

Results

There were no significant treatment effects at the Monroe Co. site in 1995. The site was not irrigated, and there was an extended drought. Yields averaged less than 10 bu/acre. The site was too wet in the fall of 1996 to harvest the plots.

Applied KCl significantly reduced soybean yield at ASU in 1995. The highest rate of KCl resulted in reduced stands and small, pale green plants. Applied KCl did not significantly affect yields in 1996. However, poultry litter did increase yields regardless of KCl treatment (Table 1).

Practical Application

It is too early to draw conclusions from this study. The added poultry litter and phosphorus at the Monroe Co. site have had little chance to react in the soil during the first year due to extremely dry conditions most of the growing season. More time may be required for the amendments to equilibrate at both sites.

Acknowledgment

Financial support of the Arkansas Soybean Promotion Board is appreciated.

Table 1. Influence of applied poultry litter and phosphate on soybean yield at Arkansas State University, Jonesboro, Arkansas, 1996.

Poultry Litter	Phosphate	Yield
lb/acre		bu/acre
4,000	80	38.3
4,000	0	35.4
4,000	40	34.1
2,000	0	33.5
2,000	40	32.7
2,000	80	30.1
0	40	29.9
0	0	28.7
0	80	28.6
$LSD_{(0.05)}$		5.6

Effect of Salt Type on Soybean Growth

H. J. Pulley and C.A. Beyrouty

Research Problem

Salt-affected soils are common in semiarid and arid climates where evapotranspiration exceeds precipitation and salts accumulate near the soil surface. However, salinity has also been identified as a problem in the humid southern regions of the United States. Elevated salt levels in Arkansas are often caused by application of irrigation water high in soluble salts. The prolonged use of this poor quality irrigation water can cause salts to accumulate in the soil at a rate that cannot be leached by rainfall. Soil salinity can decrease the amount of water available to plants and facilitate an imbalance in the influx of ions into roots that may cause toxicities. Salinity has also been shown to suppress uptake of some nutrients in plants, as well as suppression of other metabolic processes. Previous research has concluded that the concentration of salt as well as type of salt can alter plant growth and nutrient uptake.

Background Information

Most soybean problems with salts can be attributed to application of poor quality irrigation water. Sodium, calcium and magnesium chlorides constitute the bulk of salts found in soils and irrigation water of Arkansas. Variations in chloride tolerance among soybean cultivars has been identified and classified by other researchers. Soybean cultivars are grouped into three categories regarding chloride: includer, excluder and segregating. Includer varieties accumulate chloride throughout the plant roots and shoots, and excluders restrict accumulation of chloride to the roots. Segregating cultivars contain both includer and excluder plants. Research on a number of vegetable crops shows that cultivars with low amounts of salt accumulation in the leaves produce high yields on saline soils. Therefore, excluder cultivars that prevent chloride uptake and distribution throughout the plant may be better suited for growth on saline soils than includers.

Research Description

A greenhouse study was conducted with two chloride includers (‘Deltapine 105’ and ‘Hutcheson’) and two chloride excluders (‘Hartz 5164’ and ‘NK S59-60’) soybean cultivars. Three seeds of each cultivar were planted in pots on a Captina silt loam amended with NaCl and $CaCl_2$ at the following rates: 0.10% NaCl, 0.10% $CaCl_2$ and 0.05% each of NaCl and $CaCl_2$ on a dry weight of soil basis. At the V1 stage, plants were thinned to one plant per pot and grown for 84 days. Plants were harvested at late vegetative stage (V11 to V13). Measurements of shoot dry weight, leaf area and plant height were made, and elemental analyses of shoot and root tissue were made.

Results

Includers were generally sensitive to all types of salinity, showing decreases of 61, 52 and 73% in shoot dry weight (SDWT) and leaf area (LA) for NaCl, $CaCl_2$ and NaCl/$CaCl_2$ additions, respectively (Table 1). Excluders were sensitive to NaCl, indicated by a 59 and 32% decrease in SDWT and LA, respectively. Additions of $CaCl_2$ and NaCl/$CaCl_2$ to the excluders did not significantly affect LA or SDWT. There were no significant differences in plant height in response to treatments in either includers or excluders (data not shown).

Root and shoot tissue concentrations of Na and Ca were not affected by salt treatments (Table 2). Potassium shoot concentrations were significantly reduced in excluders subjected to addition of all salts (Fig. 1). Cations from salt may compete with K for sites along the root surface where active K uptake occurs. Cations such as Na can substitute for K in many metabolic processes without inhibiting growth. However, when the Na concentration exceeds a critical concentration in tissue, toxicity can occur, and disruption of many physiological processes will result in reduction in plant growth and yield. It may be possible to enhance K uptake by excluders on salt-affected soils by applying K fertilizer without contributing to soil salinity. This hypothesis needs to be tested further to develop fertilizer strategies for soybean grown on salt-affected soils.

Practical Applications

The results of this study suggest that soybean cultivars appear to differ in their response to salinity based upon the capacity to include or exclude chlorides. Shoot and root growth of the includers were most sensitive to all types of salts, and growth of the excluders appeared to be reduced mainly by addition of NaCl. In contrast, K tissue concentrations in shoots were reduced only in the excluders by addition of all salts. It is interesting that this reduction in K concentration did not manifest into a parallel reduction in shoot growth. However, the study was not taken to reproductive development, and the influence of low concentrations of K in shoots on pod formation was not obtained. This study also showed that salt concentration should be taken into consideration when planting soybean, but it is not the only parameter that needs to be addressed. Cation composition of the salt should be examined when choosing a cultivar. The proportion of salt that is Na should be considered in soil testing and fertilizer management.

Table 1. Shoot dry weight and leaf area of chloride includers and excluders in response to salt treatments.

	Shoot Dry Weight		Leaf Area	
Salt Treatment	Includer	Excluder	Includer	Excluder
	g/plant		cm^2	
No Salt	16.1a[†]	10.0a	3718a	2375b
NaCl	6.2a	4.1a	2180a	1626a
$CaCl_2$	7.7a	9.2a	2627a	2110a
$NaCl/CaCl_2$	4.3a	8.7b	1961a	1867a

[†] Means within the same treatment and growth parameter followed by the same letter are not significantly different at $P = 0.05$.

Table 2. Nutrient concentrations in soybean includer and excluder shoot tissue as affected by salt treatment.

	Na		Ca		K	
Salt Treatment	Inc[†]	Exc[‡]	Inc	Exc	Inc	Exc
	mg/kg		%			
No Salt	32a[§]	28a	1.2a	1.5a	2.2a	2.2a
NaCl	126a	75a	1.6a	1.6a	2.3a	2.0b
$CaCl_2$	38a	30a	1.7a	1.7a	2.2a	1.8b
$NaCl/CaCl_2$	62a	51a	1.8a	1.5a	2.2a	1.7b

[†] Inc = chloride includers.
[‡] Exc = chloride excluders.
[§] Means within the same treatment and element followed by the same letter are not significantly different at $P = 0.05$.

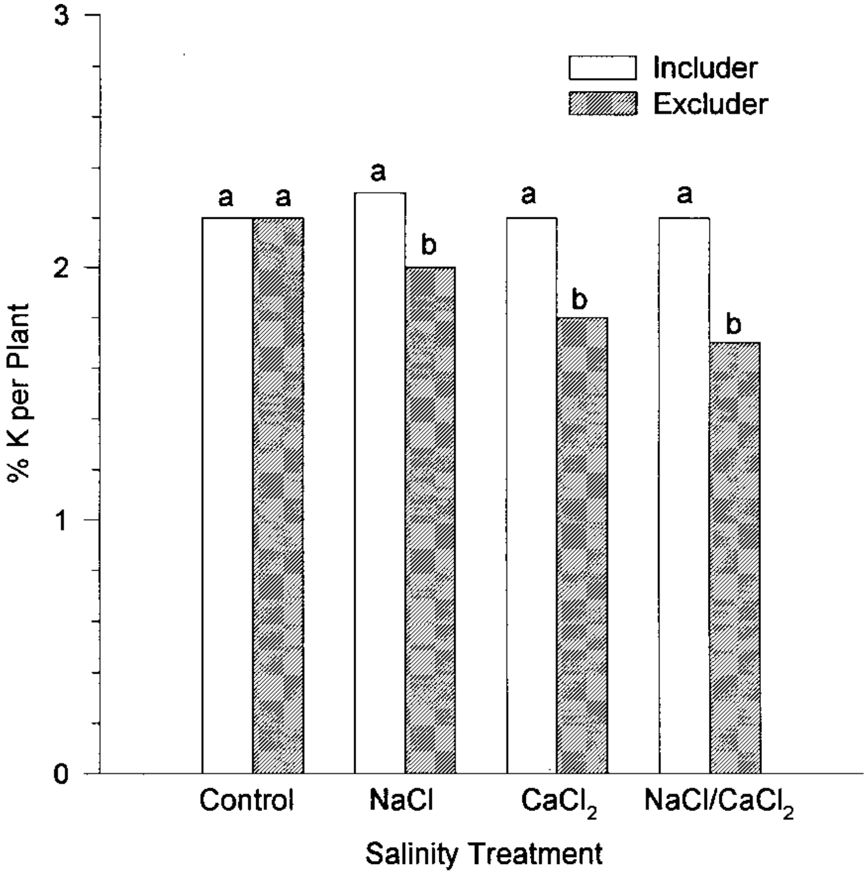

Figure 1. Percentage potassium (K) in shoot tissue of soybean chloride includers and excluders as affected by salt treatment. Means within the same treatment followed by the same letter are not significantly different at *P* = 0.05.

Grain Yield of Maturity Group IV and V Dryland and Irrigated Soybean as Affected by Fertilizer Rates and Row Width

W.E. Sabbe and R.E. DeLong

Research Problem

An increase in potential soybean grain yield should increase the probability of a response to fertilizer application. The use of a cultural management practice such as irrigation to increase yield potential should provide an opportunity to compare the recommended fertilizer rate with higher fertilizer rates.

Background Information

Soybean fertilization studies in Arkansas have resulted in moderate annual rates of fertilizer rather than an occasional high rate or annual high rates. These studies, which occurred prior to 1980, were located primarily on dryland fields with limited yield potential. With high grain yields requiring more nutrients, the need for higher or more frequently applied nutrient amendments may include higher fertilizer rates.

Research Description

The study at the Main Experiment Station, Fayetteville, Arkansas, consisted of two sites with six replications each. Cultivars H5164 and 'Hutcheson' were planted in 1995 and 1996, respectively. The first site was a comparison between irrigation and dryland with P rates of 0, 45 or 180 on a Captina (Typic Fragiudults, fine-silty, mixed, mesic) soil with an initial Mehlich III where P=38 and K=270. The second site was a comparison of no fertilizer with a higher-than-recommended P and K fertilizer rate of 80-120 under irrigation on a Pickwick (Typic Hapludults, fine-silty, mixed, thermic) soil with an initial Mehlich III where P=21 and K=180 lb/acre.

The study at the Vegetable Branch Substation, Kibler, Arkansas, was a comparison between 16 starter fertilizer rates at a 7-in. row width with four replications. Cultivars H4464 and NK S42-60 were planted in 1995 and 1996, respectively. The soil was a Roellen silty clay loam (Vertic Haplaquolls, fine, montmorillonitic, thermic), and the Mehlich III soil test recommended no fertilizer with the P = 102 and K = 450 lb/acre.

Results

Main Experiment Station

On the Captina silt loam site the dryland yields were better than average, and the irrigation yields were average (Table 1). There were no significant differences among fertilizer rates for the dryland site, but there was a significant (P = 0.05) increase in irrigated yields for 1996 as the fertilizer rate was increased from 0-0-0 to 0-180-0. The Pickwick silt loam site had average irrigated grain yields with a significant (P = 0.05) increase in yield of 4.0, 9.2 and 11.7 bu/acre for 1994, 1995 and 1996, respectively, with the addition of fertilizer.

Vegetable Branch Substation

The grain yield increased greatly from 1995 to 1996 (Table 2). The yield range in 1995 was 27.2 to 37.0 bu/acre, and in 1996 the range was 49.0 to 61.8 bu/acre. A significant increase in yield occurred in 1996 between the highest yielding fertilizer treatment and the no fertilizer treatment.

Practical Applications

The fertilizer rate recommended by soil test levels appears to be sufficient for a wide range of soybean grain yields. Also, where a recommendation for both P and K is given, it is imperative that both nutrients be applied. What isn’t known is the residual effect of excess fertilizer for succeeding crops. Therefore, the current recommendation of an annual fertilizer application seems prudent.

Acknowledgment

Financial support from the Arkansas Fertilizer Tonnage Fee is appreciated.

Table 1. Irrigated soybean grain yield as affected by high phosphorus (P) or high P and potassium (K) rates, Main Experiment Station, Fayetteville, Arkansas, 1994-1996.

	Fertilizer Treatment	Dryland			Irrigation		
Soil	N-P_2O_5-K_2O	1994	1995	1996	1994	1995	1996
	— lb/acre —	——— bu/acre ———			——— bu/acre ———		
Captina silt loam	0-0-0	33.2	24.7	34.7	52.2	47.6	48.3
	0-45-0	35.8	26.1	36.3	54.2	46.2	51.7
	0-180-0	32.2	25.1	35.8	54.0	46.2	55.4
	$LSD_{(0.05)}$	ns[†]	ns	ns	ns	ns	6.6
Pickwick silt loam	0-0-0				43.7	58.6	45.2
	0-80-120				47.7	67.8	56.9
	$LSD_{(0.05)}$				2.8	4.0	3.0

[†] ns = nonsignificant.

Table 2. Dryland soybean (Group IV) grain yield as affected by starter fertilizer, Vegetable Branch Substation, Kibler, Arkansas, 1995-1996.

Starter Fertilizer	Grain Yield	
N-P_2O_5-K_2O	1995	1996
—— lb/acre ——	——— bu/acre ———	
0-0-0	35.0	53.3
60-0-0	31.9	59.4
120-0-0	29.8	55.2
0-60-0	32.3	57.8
0-120-0	32.6	55.7
0-240-0	30.9	56.0
0-0-60	31.2	58.9
0-0-120	27.4	61.8
0-0-240	27.3	52.2
0-240-240	27.4	55.7
60-60-0	30.8	59.2
60-0-60	32.9	60.2
0-60-60	27.2	55.9
60-60-60	34.8	52.3
30-30-30	35.7	49.0
120-120-120	37.0	49.9
$LSD_{(0.05)}$	6.2	8.5

Influence of Phosphorus Plus Potash Fertilizer and Irrigation on Grain Yields of Soybean Cultivars

W.E. Sabbe and R.E. DeLong

Research Problem

The predicted response of soybean grain yield to phosphorus (P) and potassium (K) fertilizer indicates that the size of the response increases as yield potential increases. This proportional response dictates that fertilizer applications are most economical when cultural management practices allow a high yield potential. The objective of this study was to vary the cultural management practices of irrigation and cultivar selection such that the effect of a fertilizer application could be evaluated under various yield potentials.

Background Information

Previous fertility studies have involved only a single cultivar at each location. Grain yield response to fertilizer applications has been reported on both alluvial and loessial soils with the response to K fertilizer occurring more often than response to P fertilizer. Also, as a soil's clay content increases, the level of response decreases, regardless of soil fertility levels, probably due to an increase in the soil's replenishment capacity. Arkansas climate allows for the success of several soybean cultivar maturity groups (MG) IV to VII, with the majority of acreage devoted to MG V and VI under dryland situations. The interaction of soybean cultivars, irrigation and fertilizer application at various locations has not been investigated.

Research Description

Two locations were selected such that an alluvial soil at the Southeast Branch Station (SEB), Rohwer, Arkansas, and a loessial soil at the Cotton Branch Station (CBS), Marianna, Arkansas, were included. The alluvial soil was the Desha series (Vertic Hapludolls, very-fine, mixed, thermic), and the loessial soil was the Calloway series (Typic Glossaquic, fine-silty, mixed, thermic). At each location a dryland site and an irrigated site were utilized. The respective soil test values at SEB and CBS were 67 lb P/acre and 220 lb K/acre and 34 lb P/acre and 190 lb K/acre. The eight cultivars in 1995 included two in MG IV (H4715 and 'Manokin'), three in MG V (A5403, 'Hutcheson' and RS577) and three in MG VI (A6297, H6686RR and P9641). The eight cultivars in 1996 included two in MG IV (H4715 and 'Manokin'), four in MG V (A5403, H5545, 'Hutcheson' and TV5797) and two in MG VI (A6711 and P9611). The two fertilizer rates were 0-0-0 and 0-60-120 ($N-P_2O_5-K_2O$) pounds per acre with the fertilizer applied broadcast prior to incorporation and planting. Individual plots consisted of four 38-in. rows with a length of 20 ft and 12 replications at CBS and five 19-in. rows with a length of 25 ft and 8 replications at SEB.

Results

The 1995 growing season included an extended dry period, which resulted in low dryland grain yields (Table 1). The average yields among cultivars in 1995 ranged from 17.2 to 27.0, 35.0 to 54.7, 4.1 to 20.4 and 33.1 to 51.5 bu/acre for CBS dryland, CBS irrigated, SEB dryland and SEB irrigated sites, respectively. The average yields among cultivars in 1996 ranged from 27.9 to 48.5, 49.0 to 57.4, 25.8 to 36.0 and 37.7 to 54.6 bu/acre for CBS dryland, CBS irrigated, SEB dryland and SEB irrigated sites, respectively. There were no responses to the fertilizer treatment for either the dryland or the irrigated sites at either location. The significant differences among maturity groups were evident for both locations with MG V appearing to have the highest yield except for MG VI at CBS in 1996.

Practical Application

Selection of cultivar had a greater affect than fertilizer rate in the obtainment of high yields. Irrigation did produce the greatest yields, but high yield potential, maturity group and cultivar selection appeared to have a greater effect than fertilizer application.

Acknowledgment

Financial support from the Arkansas Fertilizer Tonnage Fees is appreciated.

Table1. Interaction of location, phosphorus (P) and potassium (K) fertilizer, maturitygroup (MG) and irrigation on soybean cultivar grain yields, 1995-1996.

	Cotton Branch Station								Southeast Branch Station							
	Dryland				Irrigated				Dryland				Irrigated			
	0-0-0		0-60-120		0-0-0		0-60-120		0-0-0		0-60-120		0-0-0		0-60-120	
Cultivar (MG)	1995[z]	1996	1995	1996	1995	1996	1995	1996	1995	1996	1995	1996	1995	1996	1995	1996
	bu/acre															
A4715 (IV)	20.5	30.6	20.1	29.5	38.5	50.4	37.0	50.4	15.8	28.7	14.9	25.8	36.4	38.1	36.6	37.7
Manokin (IV)	23.2	37.2	23.4	38.5	45.1	55.7	46.1	57.4	17.9	29.5	17.7	33.0	41.2	45.8	42.1	46.8
A5403 (V)	17.2	28.3	17.3	27.9	37.7	50.4	38.4	50.3	15.9	29.3	17.9	29.4	42.5	41.0	42.6	44.0
H5545 (V)	*	30.7	*	31.9	*	49.0	*	49.3	*	36.0	*	34.2	*	52.7	*	53.1
Hutcheson (V)	27.0	35.9	23.7	38.3	54.7	55.5	52.7	57.0	18.3	34.8	20.4	36.0	51.5	54.6	50.7	54.3
RS577 (V)	19.6	*	18.5	*	42.1	*	42.0	*	15.4	*	15.4	*	48.5	*	44.5	*
TV5797 (V)	*	43.4	*	41.3	*	50.1	*	50.0	*	34.5	*	29.6	*	42.3	*	41.3
A6711 (VI)	*	48.5	*	48.1	*	54.3	*	52.0	*	34.8	*	35.8	*	45.2	*	42.7
A6297 (VI)	19.1	*	18.5	*	35.0	*	36.5	*	4.2	*	4.1	*	33.0	*	33.1	*
H6688RR (VI)	17.4	*	17.6	*	39.1	*	42.6	*	10.0	*	8.2	*	43.9	*	44.4	*
P9611 (VI)	*	46.1	*	45.0	*	51.4	*	50.2	*	30.7	*	27.9	*	45.6	*	45.4
P9641 (VI)	21.0	*	17.3	*	42.9	*	45.4	*	11.0	*	13.0	*	46.3	*	44.1	*
$LSD_{(0.05)}$	3.1	5.4	3.1	5.4	4.8	3.8	4.8	3.8	3.1	5.9	3.1	5.9	3.3	4.5	3.3	4.5

Continued

Table 1. Continued.

	CBS[y]		SEB	
Main Factors	1995	1996	1995	1996
	bu/acre			
1) Irrigation				
None	20.1	37.6	13.7	31.9
Irrigated	42.2	52.1	42.6	45.7
$LSD_{(0.05)}$	6.5	4.3	3.2	3.1
2) Fertilizer				
0-0-0	31.3	44.8	28.2	39.0
0-60-120	31.1	44.8	28.1	38.6
$LSD_{(0.05)}$	ns	ns	ns	ns
3) Maturity Group				
IV	31.7	43.7	27.8	35.7
V	32.6	43.1	32.0	40.4
VI	29.4	49.4	24.6	38.5
$LSD_{(0.05)}$	3.2	4.8	6.4	1.7

[Z] Cultivar was not included in the test.
[Y] CBS=Cotton Branch Station, Marianna, Arkansas; SEB=Southeast Branch Station, Rohwer, Arkansas.

Grain Yield of Double Crop Wheat and Soybean as Affected by Fertilizer, Lime and Irrigation

W.E. Sabbe and R.E. DeLong

Research Problem

Cropping systems allow for the input of fertilizer at various times during the cycle of the system. The timing can be a decision based on fertilizer price, suitability of weather and field conditions and economic return based on specific crops. The objectives of this study were to include the inputs of fertilizer rate and timing, lime application and irrigation on a wheat-soybean cropping system (two crops per year).

Background Information

The wheat-soybean cropping system is popular in Arkansas and allows several opportunities for inputs. Also, this intensive cropping system (two crops per year) should demonstrate responses to lime and fertilizer. The inclusion of irrigation vs dryland involves the parameter of soil moisture into the expected responses. Current recommendations apply P and K fertilizer during the wheat portion of the cycle; however, no timing recommendation is given for limestone during this cycle, nor is irrigation a factor in the timing of either fertilizer or limestone application..

Research Description

The wheat-soybean double crop study was conducted at the Pine Tree Experiment Station, Colt, Arkansas, and consisted of three sites with four replications each. Wheat cultivars ‘Jackson’ and NK Coker 9543 and soybean cultivars H5164 and ‘Hutcheson’ were harvested in 1995 and 1996, respectively. The first site was irrigated, and a comparison between a starter P_2O_5-K_2O rate of 60-30 or 80-80 lb/acre with subsequent fertilizer treatment of 80-80 in the fall of 1995 was conducted. The second site was irrigated, and a comparison of none and a recommended lime rate of 2.5 tons/acre was conducted. The third site was dryland, and a comparison between a P_2O_5-K_2O fertilizer rate of 80-80:0-0:60-30:0-0 or 80-80:40-60:80-80:40-60 lb/acre for the four cropping seasons was conducted. Sites were located on a Calloway (Glossaquic Fragiudalfs, fine-silty, mixed, thermic) soil with an initial Mehlich III value where P=33 and K=284.

Results

In the first study (Table 1) there were no significant differences between the two starter fertilizer rates for the two years or crops. In the second study (Table 2) a significant difference was evident in 1996 for soybean with a 2.7 bu/acre increase in yield for 2.5 tons/acre of lime. In the third study (Table 3) there were no significant differences between the two fertilizer rates for the two crops or years.

Practical Applications

Statistically the data revealed no consistent effects due to P and K fertilizer timing nor limestone application. The trends were directed toward a soybean grain yield response from the limestone application. However, continued research will be needed to justify the differences.

Acknowledgment

Financial support from the Arkansas Fertilizer Tonnage Fee is appreciated.

Table 1. Irrigated double crop wheat and soybean grain yield as affected by phosphorus and potassium starter fertilizer, Pine Tree Experiment Station, Colt, Arkansas.

Starter	Wheat		Soybean	
Fertilizer (P2O5-K2O)	1995	1996	1995	1996
—lb/acre—	——— bu/acre ———		——— bu/acre ———	
60-30	61.1	50.1	37.3	45.4
80-80	59.3	48.4	35.2	44.3
LSD $_{(0.05)}$	ns[†]	ns	ns	ns

[†] ns = nonsignificant.

Table 2. Irrigated double crop wheat and soybean grain yield as affected by lime, Pine Tree Experiment Station, Colt, Arkansas.

	Wheat		Soybean	
Lime	1995	1996	1995	1996
— T/acre —	——— bu/acre ———		——— bu/acre ———	
0	62.6	50.6	35.3	36.4
2.5	62.3	56.0	39.4	39.1
LSD $_{(0.05)}$	ns[†]	ns	ns	2.1

[†] ns = nonsignificant.

Table 3. Dryland double crop wheat and soybean grain yield as affected by phosphorus and potassium fertilizer, Pine Tree Experiment Station, Colt, Arkansas.

Treatment (Fall 1994, Spring 1995,	Wheat		Soybean	
Fall 1995, Spring 1996)	1995	1996	1995	1996
—— P_2O_5-K_2O lb/acre ——	——— bu/acre ———		——— bu/acre ———	
80-80, 0-0, 60-30, 0-0	61.1	62.5	17.3	34.0
80-80,40-60,80-80,40-60	58.5	64.8	15.7	33.0
LSD $_{(0.05)}$	ns[†]	ns	ns	ns

[†] ns = nonsignificant.

Evaluation of Soybean to Soil Test Levels and Associated Fertilization Rates in Arkansas

W.E. Sabbe, R.E. DeLong, N.A. Slaton,
C.E. Wilson, R.J. Norman and B.R. Wells

Research Problem

The advent of precision agriculture with its inclusion of monitoring yield on a small area allows for fertilizer application via variable rate technology. Prior to precision agriculture the goal of soil sampling was to obtain a sample that contained the mean values of a field. Precision agriculture allows for numerous fertilizer and application rates within a field based on the soil analyses for each specific area. Therefore, the correlation and calibration data must be precise to allow for grower and applicator confidence in the process. Additionally, the cropping system that contains the soybean response must be documented as to nutrient uptake and nutrient removal to facilitate the timing and rates of fertilizer application.

Background Information

Soybean response to fertilizer phosphorus (P) on soils having low soil test P values has been inconsistent over the past twenty years. The yield responses have been low (2 to 5 bu/acre) and the fertilizer rate responsible for those increases varies among locations and years. While responses to potassium (K) fertilizer have been more nearly consistent than responses to P fertilizer, variations still exist. A recent study on Arkansas soils indicated that P and K fixation values ranged up to 60% of the applied P and 30% of the applied K. Much of the P fixation occurred within 16 hours after application; whereas, the K fixation values were higher at 60 days after application.

Research Description

The study was conducted at the Pine Tree Experiment Station, Colt, Arkansas, with four replications on a Calloway (Glossaquic Fragiudalfs, fine-silty, mixed, thermic) soil. Cultivar 'Hutcheson' was planted in 1996 with 10 ft wide by 30 ft long plots with 30-in. rows. The study was a comparison of low, medium and high soil test levels for P-K and their combinations of Low-Low, Low-Medium, Low-High, Medium-Low, Medium-Medium, Medium-High, High-Low, High-Medium and High-High where low P was < = 33 and K was < = 165 lb/acre, medium P was 34-44 and K was 166-200 lb/acre, and high P was > = 45 and K was > = 201 lb/acre. P and K fertilizer rates of 0, and 1/2, 1, and 2 times the recommended rate on each of the specific soil test P and K treatment combinations was applied broadcast and incorporated before planting.

Results

Grain yield for the initial P and K soil test levels was significantly higher for the High-Medium than the Low-Low soil test level with 47.3 and 41.9 bu/acre, respectively (Table 1). The grain yields for the High-High plots were not included due to low yields caused by poor drainage. Significant differences were present for the analyses of plants sampled at the R3 growth stage for P and K for leaves and P for whole plants. The P for the leaf and whole plant analyses were significantly higher for the High-High than for the Low-Low soil test levels at 0.13 and 0.11 %, and 11.2 and 7.1 mg/plant, respectively. Grain yield for the initial P and K soil test levels was significantly higher for the High-Medium than for the Low-Low soil test level at the 0X recommended P and K fertilizer rate with 48.7 and 41.8 bu/acre, respectively (Table 2). The grain yields for the High-High plots were not included due to low yield caused by poor drainage. Significant differences were present for the analyses of plants sampled at the R3 growth stage for P and K for whole plant at the 0X rate, P for leaves at the 1/2X rate, P for leaves and whole plants at the 1X rate, and P and K for leaves and whole plants at the 2X rate. The P and K for the whole plant analyses at the 0X rate was significantly higher for the High-High than Low-Low soil test levels at 14.2 and 8.0 mg/plant, and 101.2 and 58.0 mg/plant, respectively. The P for the whole plant analyses at the 1X rate was significantly higher for the High-High than for the Low-Low soil test levels at 13.8 and 7.8 mg/plant, respectively. The P for the whole plant analyses at the 2X rate was significantly higher for the High-High than for the Low-Low soil test levels at 10.2 and 5.1 mg/plant, respectively.

Practical Applications

With the advent of a technology that allows the application of variable rates of fertilizer, the results from this experiment is a first step in helping to understand the influence of various recommended fertilizer rates on soils with specific P and K soil test levels. This greater understanding will assist fertilizer applicators in the application of P and K fertilizer to specific areas of a field that may require different amounts of fertilizer.

Acknowledgment

Financial support from the Arkansas Fertilizer Tonnage Fee is appreciated.

Table 1. Irrigated soybean grain yield and plant analysis as affected by phosphorus (P) and potassium (K) fertilizer on low, medium and high P and K soil test levels in 1996, Pine Tree Experiment Station, Colt, Arkansas.

Soil Test Level (P-K)[z]	Grain Yield	Leaf Analysis (R3 Stage)		Whole Plant Analysis (R3 Stage)	
		P	K	P	K
— lb/acre —	— bu/acre —	— % —		— mg/plant —	
Low-Low	41.9	0.11	0.85	7.1	53.0
Low-Medium	43.1	0.11	0.79	8.6	68.1
Low-High	45.0	0.13	0.82	10.2	65.5
Medium-Low	42.0	0.12	0.83	9.3	65.4
Medium-Medium	41.4	0.12	0.82	7.7	66.4
Medium-High	43.6	0.14	0.85	8.5	62.8
High-Low	43.8	0.13	0.79	9.5	66.4
High-Medium	47.3	0.14	0.76	8.2	59.2
High-High	[y]	0.13	0.91	11.2	73.6
LSD $_{(0.05)}$	3.6	0.02	0.11	3.4	ns[x]

[Z] Low - P < = 33 and K < = 165 lb/acre, Medium - P = 34-44 and K = 166-200 lb/acre, and High - P > = 45 and K > = 201 lb/acre according to Mehlich III.
[Y] Not included since poor drainage led to low grain yield.
[x] ns = nonsignificant.

Table 2. Irrigated soybean grain yield and plant analysis as affected by recommended phosphorus (P) and potassium (K) fertilizer rates on soils with low, medium and high P and K soil test levels in 1996, Pine Tree Experiment Station, Colt, Arkansas.

	Recommended P and K Fertilizer Rate																			
	0X					1/2X					1X					2X				
		Leaf[y]		Whole[y]			Leaf		Whole			Leaf		Whole			Leaf		Whole	
Soil Test Level (P-K)[z]	Grain Yield	P	K	P	K	Grain Yield	P	K	P	K	Grain Yield	P	K	P	K	Grain Yield	P	K	P	K
—lb/a—	bu/a	——%——		mg/plant		bu/a	——%——		mg/plant		bu/a	——%——		mg/plant		bu/a	——%——		mg/plant	
Low-Low	41.8	0.12	0.88	8.0	58.0	41.1	0.11	0.81	7.4	50.6	41.0	0.11	0.93	7.8	65.6	43.6	0.11	0.79	5.1	37.8
Low-Med	43.3	0.12	0.80	7.2	60.0	41.2	0.11	0.82	8.5	72.5	42.7	0.11	0.83	9.7	73.8	43.9	0.12	0.73	9.0	66.0
Low-High	42.2	0.13	0.84	13.0	81.1	46.6	0.13	0.85	9.0	62.1	44.6	0.15	0.81	10.3	71.5	47.2	0.13	0.77	8.5	63.2
Med-Low	40.9	0.12	0.83	7.9	48.7	43.0	0.13	0.87	9.0	55.3	44.1	0.12	0.85	9.8	77.4	42.9	0.12	0.77	10.5	80.4
Med-Med	41.9	0.12	0.81	8.0	77.4	40.1	0.12	0.78	6.5	49.4	38.3	0.12	0.85	8.5	66.1	38.7	0.12	0.85	7.8	72.8
Med-High	44.9	0.13	0.89	6.5	51.3	41.3	0.15	0.91	9.2	65.5	42.1	0.13	0.89	8.6	65.0	45.9	0.14	0.73	9.9	69.4
High-Low	44.7	0.14	0.72	8.4	52.9	42.3	0.14	0.78	10.3	69.2	43.1	0.12	0.87	10.6	78.9	45.0	0.14	0.79	8.6	64.5
High-Med	48.7	0.13	0.73	5.1	38.6	44.4	0.15	0.77	10.1	67.6	47.8	0.15	0.77	8.3	60.7	48.1	0.14	0.79	9.1	69.7
High-High	[x]	0.15	0.90	14.2	101.2	[x]	0.12	0.83	6.4	41.3	[x]	0.12	0.94	13.8	84.0	[x]	0.13	0.95	10.2	67.8
LSD $_{(0.05)}$	5.9	ns[x]	ns	5.8	41.0	6.0	0.04	ns	ns	ns	6.6	0.03	ns	4.8	ns	5.9	0.03	0.18	4.6	30.1

[Z] Low - P < = 33 and K < = 165 lb/acre, Medium - P = 34-44 and K = 166-200 lb/acre, and High - P > = 45 and K > = 201 lb/acre according to Mehlich III.

[Y] Analysis at R3 growth stage.

[x] Not included since poor drainage led to low grain yield.

[x] ns = nonsignificant.

ARKANSAS SOIL FERTILITY STUDIES – INDEX

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Rice	Rice Response to Zinc-Phosphorus Fertilization	450	1995	19
Rice	Sodium and ‘Ca’ Interaction on ‘K’ Influx in Salinity Tolerance	450	1995	22
Rice	Rice Response to Fertilizer Applications	450	1995	15
Rice	Delayed Flood on Nitrogen Management and Rice Yield	411	1990	51
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