4-1-1998

Arkansas Soil Fertility Studies 1997

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ARKANSAS SOIL FERTILITY STUDIES 1997

Wayne E. Sabbe, editor

ARKANSAS AGRICULTURAL EXPERIMENT STATION

Division of Agriculture | University of Arkansas

April 1998 | Research Series 459

Editing and cover design by Nancy G. Wyatt

Agricultural Experiment Station, University of Arkansas Division of Agriculture, Fayetteville. Milo J. Shult, Vice President for Agriculture and Director; Charles J. Scifres, Associate Vice President for Agriculture. PS1.1M497.

The Arkansas Agricultural Experiment Station follows a nondiscriminatory policy in programs and employment. ISSN: 0099-5010 CODEN: AKAMA6.

Arkansas Soil Fertility Studies
– 1997 –

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INTRODUCTION

The 1997 Soil Fertility Studies includes research reports on numerous Arkansas commodities and on several research areas including several topics associated with precision agriculture. For 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 1997 growing season. This set of data includes data for counties, soil associations, physiographic areas and selected cropping systems.

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

Readers are reminded that the 1996 Arkansas Soil Fertility Studies, Research Series 455, contains the index to articles in the previous Arkansas Soil Fertility Research Series.

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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ACKNOWLEDGMENT

Arkansas fertilizer tonnage fees funded the publication of this research series.

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CONTENTS

SOIL TEST AND FERTILIZER SALES DATA: SUMMARY FOR THE GROWING SEASON — 1997 —

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 Lab during the period 1 September 1996 through 30 August 1997 were categorized according to geographic area, county, soil association number (SAN) and selected cropping system. This sampling period roughly corresponds to the 1997 crop growing season; therefore, those samples should represent the soil fertility of that cropping season. The geographic area and SAN were from the General Soil Map, State of Arkansas (December 1982). The statistical interpretation of the soil test data included categorical ranges for pH, 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 the soil fertility level.

RESULTS

Crop Acreage and Soil Sampling Intensity

In the interval from 1 September 1996 through 30 August 1997, soil samples representing a total of 1,175,788 acres were submitted through the University of Arkansas Soil Testing Program (Tables 1-4). These 51,053 samples resulted in fertilizer and lime recommendations in all counties, with each sample representing an average of 23 acres. Samples by geographic area were dominated by bottom land and terrace and loessial plain, which also had the greatest acres/sample. The county average ranged from 2 to 66 acres/sample. The lowest county sample number was 32, and the highest county sample number was 2186.

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 rangeland 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 5 to 8 pertain to the fertility status of the soils as categorized by geographic area, county, SAN or the suggested 1997 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 non-irrigated 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 18% 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 77% for each in the lowest category.

Table 8 contains the median (Md) for each of the cropping system categories. The median—being the soil test value that has equal number of entries 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. Fertilizer consumption by county and by form for the state (Tables 9-10) illustrate the wide use of fertilizer, predominantly in row-crop counties and in bulk form.

Practical Applications

The data can be viewed with the perspective of establishing a state-wide, 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 Fee is appreciated.

Table 1. Sample number and acreage by geographic area in Soil Test Program from September 1996 through August 1997.

Geographic Area	Acres Sampled	Number of Samples	Acres/Sample
Ozark Highland			
- Cherty Limestone and Dolomite	95,723	5,984	16
Ozark Highland			
- Sandstone and Limestone	6,728	396	17
Boston Mountain	47,852	3,166	15
Arkansas Valley and Ridge	78,847	6,671	12
Ouachita Mountain	26,268	4,016	7
Bottom Land and Terrace	501,042	15,943	31
Coastal Plain	49,648	3,746	13
Loessial Plain	348,558	9,688	36
Loessial Hill	17,645	1,284	14
Blackland Prairie	3,477	159	22

Table 2. Sample number and acreage by county in Soil Test Program from September 1996 through August 1997.

County	Acres Sampled	No. of Samples	Acres/ Sample	County	Acres Sampled	No. of Samples	Acres/ Sample
Arkansas (DE)	44,473	889	50	Lee	29,588	955	31
Arkansas (ST)	62,603	1,499	42	Lincoln	9,821	345	29
Ashley	28,281	899	32	Little River	6,777	133	51
Baxter	3,151	479	7	Logan (BO)	1,834	161	11
Benton	24,425	1,764	14	Logan (PA)	5,256	257	21
Boone	14,087	659	21	Lonoke	70,425	2,063	34
Bradley	1,176	204	6	Madison	7,445	433	17
Calhoun	317	41	8	Marion	2,439	152	16
Carroll	10,175	546	19	Miller	1,976	221	9
Chicot	10,534	31	34	Mississippi (BL)	23,399	951	25
Clark	3,803	335	11	Mississippi (OS)	9,669	284	34
Clay (CO)	11,457	459	25	Monroe	15,723	445	35
Clay (PI)	11,228	371	30	Montgomery	4,060	271	15
Cleburne	3,750	416	9	Nevada	2,832	182	16
Cleveland	505	32	16	Newton	1,940	139	14
Columbia	1,245	235	5	Ouachita	543	185	3
Conway	14,735	538	27	Perry	3,677	226	16
Craighead	62,456	2,132	29	Phillips	37,300	1,175	32
Crawford	9,291	458	20	Pike	3,467	203	17
Crittenden	38,522	2,056	19	Poinsett	60,288	1,620	37
Cross	69,760	1,451	48	Polk	5,845	252	23
Dallas	1,197	82	15	Pope	18,677	789	24
Desha (DU)	1,032	54	19	Prairie (DA)	11,493	263	44
Desha (MC)	22,541	1,521	15	Prairie (DB)	17,153	409	42
Drew	2,710	273	10	Pulaski	4,971	2,042	2
Faulkner	4,402	534	8	Randolph	8,150	438	19
Franklin (CH)	758	36	21	Saline	1,241	234	5
Franklin (OZ)	2,867	210	14	Scott	408	93	4
Fulton	5,899	301	20	Searcy	3,875	190	20
Garland	2,234	1,216	2	Sebastian (FS)	3,990	1,090	4
Grant	559	117	5	Sebastian (GF)	2,639	168	16
Greene	28,065	1,222	23	Sevier	6,489	234	28
Hempstead	5,218	307	17	Sharp	5,257	311	17
Hot Spring	2,160	267	8	St. Francis	19,204	493	39
Howard	5,894	298	4	Stone	3,466	228	15
Independence	13,812	604	23	Union	1,988	267	8
Izard	7,495	365	5	Van Buren	4,818	376	13
Jackson	30,903	825	38	Washington	34,639	2,186	16
Jefferson	26,742	1,130	24	White	23,585	2,176	11
Johnson	3,203	302	11	Woodruff	39,212	597	66
Lafayette	11,237	331	34	Yell (DN)	4,730	264	18
Lawrence	47,000	1,725	27	Yell (DR)	1,197	56	21

Table 3. Sample number and acreage by Soil Association in Soil Test Program from September 1996 through August 1997.

Soil Association Number - Soil Association	Acres Sampled	No. of Samples	Acres/ Sample
1-Clarksville-Nixa-Noark	25,743	1,283	20
2-Gepp-Doniphan-Gassville-Agnos	17,924	1,272	14
3-Arkana-Moko	14,639	741	20
4-Captina-Nixa-Tonti	35,968	2,586	14
5-Captina-Doniphan-Gepp	253	23	11
6-Eden-Newnata-Moko	1,196	79	15
7-Estate-Portia-Moko	3,299	158	21
8-Brockwell-Boden-Portia	3,429	238	14
9-Linker-Mountainburg-Sidon	7,830	486	16
10-Enders-Nella-Mountainburg-Steprock	40,022	2,680	15
11-Falkner-Wrightsville	389	22	18
12-Leadvale-Taft	32,919	2,678	12
13-Enders-Mountainburg-Nella-Steprock	8,010	443	18
14-Spadra-Guthrie-Pickwick	1,817	107	17
15-Linker-Mountainburg	35,712	3,421	10
16-Carnasaw-Pirum-Clebit	12,767	2,371	5
17-Kenn-Ceda-Avilla	1,887	87	22
18-Carnasaw-Sherwood-Bismarck	8,498	1,385	6
19-Carnasaw-Bismarck	756	28	27
20-Leadvale-Taft	768	51	15
21-Spadra-Pickwick	1,592	94	17
22-Foley-Jackport-Crowley	107,043	3,290	33
23-Kobel	20,666	570	36
24-Sharkey-Alligator-Tunica	40,115	1,428	28
25-Dundee-Bosket-Dubbs	122,849	3,152	39
26-Amagon-Dundee	40,017	1,367	29
27-Sharkey-Steele	8,544	217	39
28-Commerce-Sharkey-Crevasse-Robinsonville	16,969	647	26
29-Perry-Portland	31,609	1,540	21
30-Crevasse-Bruno-Oklared	139	21	7
31-Roxana-Dardanelle-Bruno-Roellen	10,618	312	34
32-Rilla-Hebert	88,559	3,023	29
33-Billyhaw-Perry	5,158	171	30
34-Severn-Oklared	6,915	120	58
35-Adaton	403	21	19
36-Wrightsville-Louin-Acadia	917	39	24
37-Muskogee-Wrightsville-McKamie	521	25	21
38-Amy-Smithton-Pheba	2,170	185	12
39-Darco-Briley-Smithdale	371	12	31
40-Pheba-Amy-Savannah	5,153	553	9
41-Smithdale-Sacul-Savannah-Saffell	19,963	1,169	17
42-Sacul-Smithdale-Sawyer	14,911	1,535	10
43-Guyton-Ouachita-Sardis	7,080	292	24
44-Calloway-Henry-Grenada-Calhoun	228,358	6,967	33
45-Crowley-Stuttgart	120,200	2,721	44
46-Loring	2,558	146	18
47-Loring-Memphis	14,419	1,085	13
48-Brandon	668	53	13
49-Oktibbeha-Sumter	3,477	159	22

Table 4. Sample number and acreage by crop in Soil Test Program from September 1996 through August 1997.

Crop	Acres Sampled	No. of Samples	Acres/ Sample
Soybean - nonirrigated	64,222	1,908	34
Soybean - irrigated	364,138	9,454	39
Cotton	194,582	6,226	31
Rice	90,054	2,175	41
Wheat	16,648	449	37
Double-crop wheat-soybean - nonirrigated	15,469	462	34
Double-crop wheat-soybean - irrigated	28,705	701	41
Warm season grass - establish	6,368	342	19
Warm season grass - maintain	93,664	4,217	22
Cool season grass - establish	909	52	18
Cool season grass - maintain	75,308	3,266	23
Grain sorghum	17,631	528	33
Corn	46,922	1,322	36
All garden	7,671	3,636	2
Turf and ground cover	8,430	6,539	1
Fruit and nut	1,842	545	3
Vegetable	387	16	24
Other	142,838	9,215	16

Table 5. Soil test data by geographic area from samples submitted from September 1996 through August 1997.

	PH			P (lb/acre)					K (lb/acre)				NO_3 -N (lb/acre)			EC (µmhos/cm)		
Geographic Area	<5.5	5.5-6.5	>6.5	<26	26-44	45-100	300	>300	<176	176-220	221-350	>350	<26	26-100	>100	<100	101-500	>500
	Percentage of Sampled Acreage																	
Ozark Highland																		
- Cherty Limestone and Dolomite	16	59	25	9	10	23	34	24	23	12	29	36	65	29	6	50	47	3
Ozark Highland																		
- Sandstone and Limestone	18	62	20	18	16	27	28	11	36	15	25	24	77	20	3	69	30	1
Boston Mountain	25	60	15	12	12	22	31	23	30	14	25	31	65	29	6	60	39	1
Arkansas Valley and Ridge	25	60	15	15	14	27	32	12	35	17	29	19	74	23	3	63	36	1
Ouachita Mountain	35	53	12	11	9	22	35	23	38	17	28	17	72	22	6	62	37	1
Bottom Land and Terrace	9	66	25	15	17	44	23	1	19	15	36	30	90	9	1	82	18	0
Coastal Plain	31	56	13	16	11	20	31	22	46	15	22	17	83	15	2	72	28	0
Loessial Plain	10	57	33	38	29	26	6	1	52	21	21	6	93	6	1	85	15	0
Loessial Hill	23	53	24	24	22	30	17	7	28	16	36	20	84	14	2	69	30	1
Blackland Prairie	10	47	43	23	23	19	25	10	16	7	26	51	80	18	2	40	60	0
Average	20	57	23	18	16	22	26	18	32	15	28	25	78	19	3	65	34	1

Table 6. Soil test data by county from samples submitted from September 1996 through August 1997.

	PH			P (lb/acre)				K (lb/acre)				NO_3-N (lb/acre)			EC (µmhos/cm)		
		5.5-			26-	45-			176-	221-			26-			101-	
Geographic Area	<5.5	6.5	>6.5	<26	44	100	300	>300	<176	220	350	>350	<26	100	>100	<100	500	>500
	Percentage of Sampled Acreage																	
Arkansas (DE)	4	51	45	50	31	14	5	0	52	25	18	5	95	5	0	85	15	0
Arkansas (ST)	12	66	22	48	30	16	5	1	56	21	17	6	91	8	1	84	16	0
Ashley	8	60	32	8	11	49	32	0	14	15	42	29	88	11	1	85	15	0
Baxter	3	33	4	9	12	31	28	20	27	11	31	31	73	23	4	46	52	2
Benton	19	62	19	2	5	18	38	37	16	8	28	48	56	34	10	37	60	3
Boone	10	70	20	9	11	30	36	14	28	12	26	37	66	31	3	52	47	1
Bradley	14	45	41	8	7	17	38	30	36	13	23	28	76	19	5	36	29	2
Calhoun	42	51	7	17	12	24	34	13	66	10	12	12	78	15	7	81	15	4
Carroll	16	58	26	7	10	24	33	26	13	11	38	38	59	36	5	52	48	0
Chicot	4	55	41	5	20	45	30	0	5	5	22	68	79	21	0	54	46	0
Clark	53	39	8	28	12	19	27	14	58	15	18	9	88	11	1	69	28	3
Clay (CO)	6	79	15	34	31	30	5	0	55	21	18	6	95	5	0	90	1	9
Clay (PI)	16	67	17	25	23	40	11	1	27	22	37	14	79	20	1	79	20	1
Cleburne	26	60	14	15	15	19	29	22	36	16	26	22	72	24	4	66	33	1
Cleveland	19	59	22	22	9	41	9	19	28	13	44	15	84	13	3	75	25	0
Columbia	49	43	8	9	11	26	38	16	55	17	18	10	85	15	0	78	21	1
Conway	34	54	12	13	13	26	27	21	34	14	25	27	86	12	2	79	21	0
Craighead	8	67	25	14	16	40	28	2	19	15	38	28	90	9	1	77	23	0
Crawford	20	62	18	12	17	29	25	17	31	13	30	26	76	20	4	70	29	1
Crittenden	13	60	27	32	19	35	13	1	36	9	21	34	89	11	0	87	13	0
Cross	5	41	54	32	37	27	3	1	49	19	17	15	92	7	1	81	19	0
Dallas	42	45	13	28	11	24	28	9	60	13	18	9	94	4	2	82	16	2
Desha (DU)	13	43	44	4	13	50	32	1	30	15	32	23	89	9	2	72	24	4
Desha (MC)	4	49	47	9	14	51	24	2	9	14	40	37	92	8	0	72	27	1
Drew	24	58	18	21	19	28	27	5	27	18	38	17	84	15	1	74	26	0
Faulkner	32	54	14	27	14	24	24	11	40	19	27	14	81	17	2	63	36	1
Franklin (CH)	44	44	12	22	28	33	14	3	47	17	22	14	89	8	3	78	22	0
Franklin (OZ)	30	60	10	11	15	27	31	16	34	16	28	22	70	27	3	60	40	0
Fulton	12	59	29	18	19	39	21	3	31	15	25	29	78	17	5	69	30	1

continued

Table 6. continued.

Geographic Area	PH			P (lb/acre)					K (lb/acre)				NO_3-N (lb/acre)			EC (µmhos/cm)		
	<5.5	5.5-6.5	>6.5	<26	26-44	45-100	300	>300	<176	176-220	221-350	>350	<26	26-100	>100	<100	101-500	>500
	---Percentage of Sampled Acreage---																	
Garland	37	53	10	13	7	29	37	14	40	16	27	17	61	27	12	55	43	2
Grant	29	63	8	21	12	18	33	16	58	15	15	12	92	8	0	84	16	0
Greene	13	71	16	25	24	28	21	2	32	24	31	13	92	7	1	92	7	1
Hempstead	24	53	23	15	16	24	25	20	41	15	23	21	81	18	1	61	39	0
Hot Spring	18	68	14	7	11	17	29	36	45	14	18	23	75	22	3	63	37	
Howard	32	61	7	6	6	12	32	44	25	14	25	36	72	25	3	54	45	1
Independence	22	63	15	16	16	31	23	14	33	15	32	20	70	23	7	65	32	3
Izard	13	66	21	15	20	26	29	10	47	18	17	18	83	16	1	77	23	0
Jackson	20	69	11	22	27	40	9	2	32	22	34	12	84	15	1	81	19	0
Jefferson	16	57	27	7	10	45	34	4	22	10	41	27	93	6	1	88	11	1
Johnson	26	52	22	12	16	28	30	14	31	17	31	21	80	17	3	73	26	1
Lafayette	11	39	50	6	13	45	28	8	20	11	20	49	82	17	1	69	31	0
Lawrence	7	75	18	43	26	24	6	1	40	23	28	9	95	4	1	79	21	0
Lee	8	73	19	6	15	64	15	0	18	20	44	18	93	7	0	88	11	1
Lincoln	25	62	13	16	13	33	27	11	33	14	35	18	88	10	2	77	23	0
Little River	26	47	27	29	13	29	22	7	37	13	22	28	72	24	4	62	38	0
Logan (BO)	10	67	23	22	17	17	32	12	35	6	32	27	75	19	6	65	30	5
Logan (PA)	22	62	16	12	18	34	24	12	39	8	24	29	74	23	3	69	31	0
Lonoke	12	71	17	24	22	36	16	2	35	18	29	18	92	7	1	85	15	0
Madison	28	64	8	6	10	23	38	23	23	17	24	36	72	21	7	62	36	2
Marion	12	56	32	13	11	31	34	11	28	10	29	33	68	26	6	56	42	2
Miller	26	52	22	21	18	17	27	17	49	15	18	18	85	13	2	80	19	1
Mississippi (BL)	12	74	14	1	4	44	50	1	6	10	47	37	91	8	1	92	8	0
Mississippi (OS)	11	59	30	4	6	62	24	4	5	3	34	58	84	15	1	72	28	0
Monroe	9	61	30	21	23	37	17	2	27	15	36	22	82	16	2	72	27	1
Montgomery	26	61	13	13	9	19	33	26	38	15	28	19	73	25	2	72	28	0
Nevada	25	61	14	19	8	19	33	21	47	14	19	20	95	3	2	80	20	0
Newton	25	53	22	9	11	33	34	13	32	17	27	24	67	28	5	58	40	2

continued

Table 6. continued.

Geographic Area	PH			P (lb/acre)					K (lb/acre)				NO_3-N (lb/acre)			EC (µmhos/cm)		
	<5.5	5.5-6.5	>6.5	<26	26-44	45-100	300	>300	<176	176-220	221-350	>350	<26	26-100	>100	<100	101-500	>500
	---Percentage of Sampled Acreage---																	
Ouachita	30	60	10	17	4	16	42	21	61	15	19	5	92	7	1	71	29	0
Perry	40	54	6	30	10	19	26	15	42	20	23	15	83	13	4	75	22	3
Phillips	12	63	25	4	15	65	16	0	13	17	37	33	86	12	2	81	19	0
Pike	42	49	9	10	10	16	27	37	46	14	19	21	77	19	4	70	30	0
Poinsett	4	44	52	35	24	26	14	1	47	18	22	13	96	4	0	83	17	0
Polk	30	63	7	4	8	19	39	30	40	16	24	20	79	18	3	73	27	0
Pope	28	55	17	15	10	22	36	17	34	14	27	25	80	15	5	69	30	1
Prairie (DA)	10	51	39	49	34	12	3	2	67	17	11	5	94	6	0	87	13	0
Prairie (DB)	8	77	15	42	36	15	6	1	57	24	14	5	94	5	1	88	12	0
Pulaski	36	48	16	12	11	20	34	23	34	18	32	16	75	20	5	60	39	1
Randolph	10	79	11	29	25	33	11	2	35	26	26	13	90	7	3	72	27	1
Saline	33	55	12	11	14	24	35	16	50	15	23	12	76	20	4	64	34	0
Scott	33	60	7	28	9	8	48	7	48	23	23	6	80	20	0	67	33	0
Searcy	37	52	11	8	11	28	45	8	24	14	35	27	72	24	4	62	37	1
Sebastian (FS)	27	54	19	11	15	34	33	7	26	23	37	14	59	35	6	48	50	2
Sebastian (GF)	18	63	19	26	17	23	22	12	35	10	25	30	65	29	6	54	44	2
Sevier	33	60	7	12	5	17	36	30	31	10	27	32	74	22	4	64	36	0
Sharp	9	56	35	15	18	22	29	16	26	15	31	28	76	20	4	58	40	2
St. Francis	16	58	26	10	25	49	14	2	21	18	34	27	89	9	2	77	23	0
Stone	30	65	5	8	7	22	40	23	31	18	28	23	63	34	3	55	44	1
Union	23	66	11	6	3	13	30	48	38	15	28	19	84	15	1	76	24	0
Van Buren	32	57	11	17	14	34	21	14	41	15	23	21	71	23	6	70	29	1
Washington	21	58	21	9	9	17	35	30	26	11	25	38	56	37	7	50	50	0
White	16	69	15	16	16	28	33	7	39	18	29	14	76	22	2	62	37	1
Woodruff	8	74	18	19	28	40	12	1	31	18	41	10	94	6	0	88	12	0
Yell (DN)	31	64	5	28	15	15	29	13	42	10	26	22	86	12	2	79	21	0
Yell (DR)	34	63	3	13	18	34	29	6	27	18	36	19	71	23	6	70	29	1
Average	21	59	20	17	16	29	26	12	35	15	27	23	81	17	2	71	28	1

Table 7. Soil test data by Soil Association from samples submitted from September 1996 through August 1997.

Geographic Area	PH			P (lb/acre)					K (lb/acre)				NO_3-N (lb/acre)			EC (µmhos/cm)		
	<5.5	5.5-6.5	>6.5	<26	26-44	45-100	300	>300	<176	176-220	221-350	>350	<26	26-100	>100	<100	101-500	>500
	Percentage of Sampled Acreage																	
1. Clarksville-Nixa-Noark	19	63	18	9	9	27	37	18	24	14	31	31	62	32	6	53	46	1
2. Gepp-Doniphan-Gassville-Agnos	9	49	42	18	16	30	24	12	26	14	30	30	76	20	4	58	41	1
3. Arkana-Moko	11	65	24	11	16	24	31	18	32	14	22	32	72	25	3	63	37	0
4. Captina-Nixa-Tonti	19	59	22	4	6	18	37	35	18	9	28	45	58	34	8	41	57	2
5. Captina-Doniphan-Gepp	35	52	13	22	9	13	30	26	44	9	26	21	70	13	17	65	26	9
6. Eden-Newnata-Moko	15	65	20	1	10	35	42	12	19	17	39	25	66	33	1	39	58	3
7. Estate-Portia-Moko	16	60	24	10	10	30	41	9	27	13	28	32	66	29	5	59	41	0
8. Brockwell-Boden-Portia	20	64	16	24	20	25	20	11	42	17	24	17	84	14	2	77	23	0
9. Linker-Mountainburg-Sidon	20	65	15	14	16	24	28	18	31	15	30	24	70	24	6	65	32	3
10. Enders-Nella-Mountainburg-Steprock	26	60	14	11	11	21	32	25	29	14	24	33	64	30	6	59	40	1
11. Falkner-Wrightsville	55	23	22	18	23	36	18	5	41	27	18	14	82	18	0	77	23	0
12. Leadvale-Taft	26	57	17	17	16	28	29	10	32	17	31	20	69	27	4	58	40	2
13. Enders-Mountainburg-Nella-Steprock	26	64	10	16	19	28	25	12	43	16	26	15	76	20	4	72	26	2
14. Spadra-Guthrie-Pickwick	26	65	9	22	14	12	32	20	37	11	25	27	83	13	4	70	30	0
15. Linker-Mountainburg	25	62	13	14	12	26	36	12	37	16	29	18	77	20	3	65	34	1
16. Carnasaw-Pirum-Clebit	34	51	15	13	10	20	34	23	38	17	29	16	76	20	4	63	36	1
17. Kenn-Ceda-Avilla	25	64	11	6	6	14	45	29	43	9	20	28	74	21	5	74	26	0
18. Carnasaw-Sherwood-Bismarck	37	54	9	9	8	28	37	18	39	16	27	18	63	27	10	57	42	1
19. Carnasaw-Bismarck	50	46	4	11	14	36	29	10	54	18	11	17	93	7	0	86	14	0
20. Leadvale-Taft	45	53	2	22	18	16	35	9	41	8	37	14	82	18	0	86	14	0
21. Spadra-Pickwick	29	63	8	19	40	22	32	17	35	23	29	13	87	11	2	78	21	1
22. Foley-Jackport-Crowley	7	73	20	38	29	27	6	0	40	23	27	10	93	7	0	81	19	0
23. Kobel	13	72	15	26	23	28	22	1	28	20	34	18	89	10	1	85	14	1
24. Sharkey-Alligator-Tunica	10	61	29	9	25	54	11	1	3	4	21	72	85	15	0	79	21	0
25. Dundee-Bosket-Dubbs	9	74	17	6	12	51	30	1	14	17	42	27	91	9	0	88	12	0
26. Amagon-Dundee	12	71	17	10	8	39	41	2	12	11	44	33	87	12	1	86	14	0

continued

Table 7. Continued.

Geographic Area	PH <5.5	PH 5.5-6.5	PH >6.5	P (lb/acre) <26	P 26-44	P 45-100	P 300	P >300	K (lb/acre) <176	K 176-220	K 221-350	K >350	NO_3-N (lb/acre) <26	NO_3-N 26-100	NO_3-N >100	EC (µmhos/cm) <100	EC 101-500	EC >500
	---Percentage of Sampled Acreage---																	
27. Sharkey-Steele	4	70	26	1	10	65	23	1	6	1	32	61	92	8	0	82	18	0
28. Commerce-Sharkey- Crevasse-Robinsonville	6	60	34	3	6	48	41	2	3	4	31	62	85	14	1	73	27	0
29 .Perry-Portland	7	49	44	14	24	45	17	0	12	13	33	42	94	6	0	71	29	0
30. Crevasse-Bruno-Oklared	29	52	19	14	19	33	19	15	43	10	24	23	86	10	4	67	33	0
31. Roxana-Dardanelle- Bruno-Roellen	28	51	21	22	12	29	25	12	30	17	35	18	79	20	1	69	31	0
32. Rilla-Hebert	7	64	29	4	8	52	33	3	14	14	46	26	91	8	1	87	13	0
33. Billyhaw-Perry	5	30	65	13	19	44	19	5	14	5	14	67	88	11	1	61	39	0
34. Severn-Oklared	3	32	65	6	8	53	33	0	9	8	34	49	81	16	3	69	31	0
35. Adaton	0	81	19	24	10	57	9	0	38	0	33	29	100	0	0	95	5	0
36. Wrightsville-Louin-Acadia	15	80	5	41	3	18	33	5	51	26	18	5	97	3	0	97	3	0
37. Muskogee-Wrightsville-McKamie	36	60	4	52	8	16	4	20	60	12	8	20	84	8	8	72	24	4
38. Amy-Smithton-Pheba	34	57	9	18	15	28	29	10	45	14	29	12	80	14	6	70	29	1
39. Darco-Briley-Smithdale	0	100	0	42	0	17	33	8	50	33	17	0	92	0	8	92	8	0
40. Pheba-Amy-Savannah	38	51	11	21	9	16	27	27	50	13	18	19	81	16	3	66	33	1
41. Smithdale-Sacul- Savannah-Saffell	31	55	14	14	9	18	34	25	46	15	21	18	81	16	3	69	30	1
42. Sacul-Smithdale-Sawyer	28	58	14	15	12	22	29	22	46	16	24	14	86	13	1	77	23	0
43. Guyton-Ouachita-Sardis	37	56	7	14	7	16	33	27	35	11	26	28	76	20	4	67	33	0
44. Calloway-Henry- Grenada-Calhoun	10	55	35	34	28	30	7	1	52	20	21	7	93	7	0	85	15	0
45. Crowley-Stuttgart	9	65	26	49	30	15	5	1	53	23	19	5	93	6	1	84	16	0
46. Loring	36	53	11	28	27	29	10	6	49	13	26	12	86	12	2	81	19	0
47. Loring-Memphis	21	54	25	24	21	31	19	7	25	16	38	21	84	14	2	67	31	2
48. Brandon	42	34	24	23	26	23	19	9	36	13	28	23	72	25	3	60	40	0
49. Oktibbeha-Sumter	10	45	45	23	23	19	25	10	16	7	26	51	80	18	2	39	60	1
Average	22	59	19	18	14	29	27	12	33	14	27	26	81	16	3	71	28	1

Table 8. Soil test data by crop from samples submitted from September 1996 through August 1997.

Geographic Area	PH				P (lb/acre)						K (lb/acre)					NO_3-N (lb/acre)				EC (µmhos/cm)			
	<5.5	5.5-6.5	>6.5	Md[z]	<26	26-44	45-100	300	>300	Md	<176	176-220	221-350	>350	Md	<26	26-100	>100	Md	<100	101-500	>500	Md
	Percentage of Sampled Acreage																						
Soybean - nonirrigated	13	69	18	6.0	18	22	50	10	0	53	25	21	32	22	230	92	7	1	7	89	11	0	58
Soybean - irrigated	7	60	33	6.3	37	34	27	2	0	32	47	20	19	14	181	95	5	0	6	88	12	0	66
Cotton	5	68	27	6.2	2	4	53	40	1	92	4	11	50	35	309	91	8	1	7	89	11	0	60
Rice	7	60	33	6.3	58	25	16	1	0	22	57	17	15	11	163	96	4	0	5	65	35	0	84
Wheat	26	56	18	5.8	13	24	47	16	0	55	25	21	34	20	229	82	17	1	11	78	22	0	71
Double-crop wheat-soybean - nonirrigated	17	68	15	5.9	8	20	60	12	0	59	22	21	39	18	239	88	12	0	9	89	10	1	58
Double-crop wheat-soybean - irrigated	4	58	38	6.4	22	30	43	4	1	43	38	23	27	12	195	91	8	1	8	88	12	0	66
Warm season grass - establish	21	69	10	5.8	20	14	23	26	17	80	40	13	27	20	210	81	18	1	10	72	27	1	69
Warm season grass - maintain	26	64	10	5.8	11	12	24	30	23	110	37	13	25	25	222	76	21	3	12	67	32	1	79
Cool season grass - establish	29	60	11	5.8	10	23	25	37	5	80	35	14	31	20	238	69	29	2	10	54	44	1	88
Cool season grass - maintain	23	66	11	5.8	10	12	24	34	20	113	27	13	27	33	262	64	31	5	17	60	40	0	85
Grain sorghum	22	59	19	6.0	22	25	42	11	0	46	29	19	26	26	226	92	7	1	5	84	15	1	63
Corn	8	72	20	6.2	9	22	54	15	0	61	25	21	36	18	234	82	17	1	10	75	25	0	73
All garden	15	46	39	6.3	6	6	15	34	39	235	19	11	27	43	313	63	29	8	17	48	50	2	102
Turf and ground cover	26	56	18	5.9	9	11	29	42	9	106	32	19	34	15	218	71	24	5	14	55	44	1	93
Fruit and nut	36	45	19	5.7	11	18	28	33	10	78	35	13	28	24	229	75	20	5	11	62	37	1	85
Vegetable	6	63	31	6.4	6	0	25	44	25	118	6	19	44	31	308	69	25	6	11	63	19	18	77
Other	27	56	17	5.8	21	15	25	25	14	70	38	14	25	23	212	79	18	3	9	67	32	1	77
Average	18	61	21		16	18	34	23	9		30	17	30	23		81	17	3		72	27	1	

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

Table 9. Fertilizer sales in Arkansas counties from 1 July 1996 through 30 June 1997.

County	Total	County	Total
	ton		ton
Arkansas	90,222	Lee	22,407
Ashley	40,629	Lincoln	18,644
Baxter	3,383	Little River	2,594
Benton	9,100	Logan	3,624
Boone	8,268	Lonoke	38,940
Bradley	2,567	Madison	8,274
Calhoun	197	Marion	1,207
Carroll	4,568	Miller	5,485
Chicot	16,269	Mississippi	62,510
Clark	3,306	Monroe	41,775
Clay	54,217	Montgomery	9
Cleburne	3,136	Nevada	2,872
Cleveland	52	Newton	1,456
Columbia	1,850	Ouachita	35
Conway	5,252	Perry	1,792
Craighead	57,098	Phillips	47,334
Crawford	6,406	Pike	454
Crittenden	24,626	Poinsett	82,749
Cross	47,196	Polk	1,930
Dallas	5	Pope	3,687
Desha	40,902	Prairie	41,484
Drew	6,171	Pulaski	26,267
Faulkner	5,599	Randolph	20,569
Franklin	3,621	St. Francis	38,200
Fulton	4,031	Saline	1,203
Garland	1,396	Scott	22
Grant	475	Searcy	7,446
Greene	30,423	Sebastian	2,525
Hempstead	4,141	Sevier	16,253
Hot Spring	2,978	Sharp	1,168
Howard	2,189	Stone	2,590
Independence	12,488	Union	1,066
Izard	2,486	Van Buren	7,941
Jackson	41,539	Washington	5,548
Jefferson	39,645	White	26,419
Johnson	1,298	Woodruff	34,399
Lafayette	4,102	Yell	1,977
Lawrence	28,597	State	1,193,282

Table 10. Fertilizer sales in Arkansas from 1 July 1996 through 30 June 1997.

Fertilizer	Bulk	Bag	Fluid	Total
	------------------------------------ton------------------------------------			
Mixed	392,220	71,611	30,817	494,648
Nitrogen	452,821	7,014	132,805	592,640
Phosphate	14,689	347	2	15,038
Potash	43,508	2,025	929	46,462
Other	34,637	9,286	571	44,494
Total	937,875	90,283	165,124	1,193,282

USING GRID SOIL SAMPLING IN THE MANAGEMENT OF PROBLEM SOILS

M.B. Daniels, S.L. Chapman, R. Matlock and A. Winfrey

RESEARCH PROBLEMS

Underlying soil fertility problems such as high sodium levels, excess soluble salts and micronutrient imbalances can limit plant response to nitrogen (N), phosphorus (P) and potassium (K) fertilizers and lime even when soil test recommendations warrant such additions. Management options for these soils are sometimes limited due to practical and economic constraints. The objective of this study was to determine if the use of precision agricultural technology could provide information that would increase fertility management options on problem soils.

BACKGROUND INFORMATION

Grid soil sampling is primarily being used as a basis for variable rate application of fertilizers and lime. Regardless of variable rate fertilizer technology, grid soil sampling may be an important management tool. It provides information at a level of detail that may be necessary for other purposes, such as setting realistic yield goals, explaining yield variability and trouble-shooting problem soils.

Plant response can vary within a field with problem soils, ranging from seedling death in some locations to normal growth and yield at other locations. This variability can make it difficult to diagnose and remedy the problem with normal composite soil sampling from good and bad areas. Intensive soil sampling may provide information so that the problem can be adequately identified and the spatial extent of the problem adequately delineated. Ultimately, this increased knowledge may lead to increased management strategies for problem soils.

RESEARCH DESCRIPTION

The study was conducted in the spring of 1997 in southwestern Hot Spring County in a 70-acre production field. Historically, soybean yields in parts of this field have been severely limited due to excess soluble salts. Within this field, the soils are mapped as Adaton, Gurdon and Sardis silt loams. The Gurdon series is closely related in texture and landscape position to the Foley silt loam, which is characterized by a natric (high sodium content) horizon.

In order to determine the distribution of soluble salts and sodium within the field, soil samples were obtained on approximately a 2.5-acre grid while the field was fallow. The grid points were somewhat irregular (Fig. 1) and more dense where there was visual evidence of salt problems (lack of vegetation) to ensure that problem areas smaller than 2.5 acres were not excluded from the sampling. At each grid point samples were collected with an NRCS probe truck using a 3-in.-diameter collection tube. Samples were taken from four depths down to 24 in. in 6-in. increments. The samples were shipped to the University of Arkansas Soil Test Lab at Marianna for routine soil analysis.

The latitude and longitude coordinates were determined for each grid point with a hand held Differential Global Positioning System (DGPS, Post Processing). Coordinates for the perimeter of the field were also recorded. Soil nutrient maps were constructed using SSToolbox GIS software (SST Development Group, Inc.). Soil test point data were converted to surface data using kriging procedures.

RESULTS

Soil test results indicated low fertility levels of P, K and pH (Table 1). Field averages of electrical conductivity (EC) and sodium did not indicate excessive levels of soluble salts or sodium at any depth interval. However, sodium levels at all depth intervals were highly variable, ranging from 100 lb/acre to greater than 999 lb/acre (maximum value reported by lab) with coefficients of variation ranging from 62 to 80%. For a silt loam texture, it is thought that sodium values exceeding 500 lb/acre would adversely impact crop growth. The number of acres exceeding this threshold value increased from 6 acres in the top 12 in. to 7 acres at the 12- to 18-in. depth interval to 24 acres at the 18- to 24-in. depth interval (Fig. 1 and 2).

Because the farmer was considering land leveling this field, elevation data (locations recorded with DGPS) relative to a benchmark datum were obtained from Bowls Surveying (Fig. 3). Overlaying procedures using GIS software were performed on the maps in Figures 2 and 3 to determine if land leveling would expose more acreage exceeding the 500 lb/acre sodium threshold (Fig. 4). From this analysis, it was determined that potentially 4 more acres of sodium exceeding the threshold might occur in the top 12 in. if land leveling was performed.

PRACTICAL APPLICATION

The results obtained from this study have been used to help make crucial management decisions related to this field. From Fig. 1, it was determined that 8% of the field could suffer crop damage from salt. From Fig. 2, 3 and 4, it was determined that land leveling could potentially increase the sodium hazard in the top 12 in. of the root zone by 4 acres, up to a total of 13% of the acreage. The farmer proceeded with land leveling because he felt the advantage of better water management outweighed the small increase (5%) in sodium hazard.

By knowing the sodium distribution, the producer was able to prioritize his management options. Instead of focusing his attention on the 8% of the field affected by sodium, he can address the low fertility problems in the other 92% of the field where pH, P and K are limiting crop production. Before, it was assumed that poor crop production from the field as a whole was a result of high salt levels rather than poor fertility.

LITERATURE CITED

SSToolbox. 1996. SST Development Group, Inc. 824 N. Country Club Rd., Stillwater OK 74075-0918.

Table 1. Selected soil test results by depth

Depth		pH	P	K	Na	Ec
In.				lb /acre		µmhos/cm
	Mean	4.7	11	67	320	190
0-6	s.d.(+/-)	0.3	4	13	253	265
	Minimum	3.9	10	50	100	35
	Maximum	5.6	29	105	999	1,366
	Mean	4.8	11	52	328	128
6-12	s.d.(+/-)	0.5	4	8	220	140
	Minimum	3.9	10	50	113	24
	Maximum	6.8	34	105	999	620
	Mean	4.7	11	53	350	134
12-18	s.d.(+/-)	0.4	2	12	219	141
	Minimum	3.9	10	50	143	24
	Maximum	6.8	19	129	999	620
	Mean	4.6	10	57	418	153
18-24	s.d.(+/-)	0.3	—-	15	269	148
	Minimum	4.0	—-	50	136	31
	Maximum	6.2	—-	148	999	682

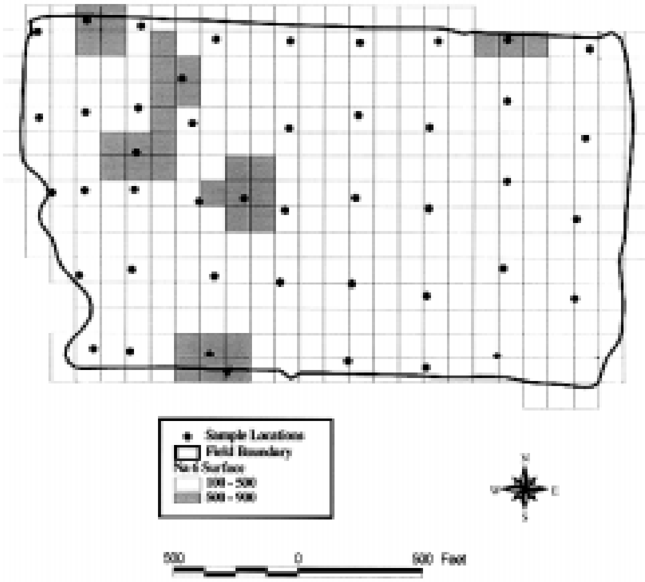

Fig. 1. Map of field boundary, soil sample location and sodium (lb/acre) distribution in the top 6 in. Grid cells represent 10,000 square feet (~0.25 acres).

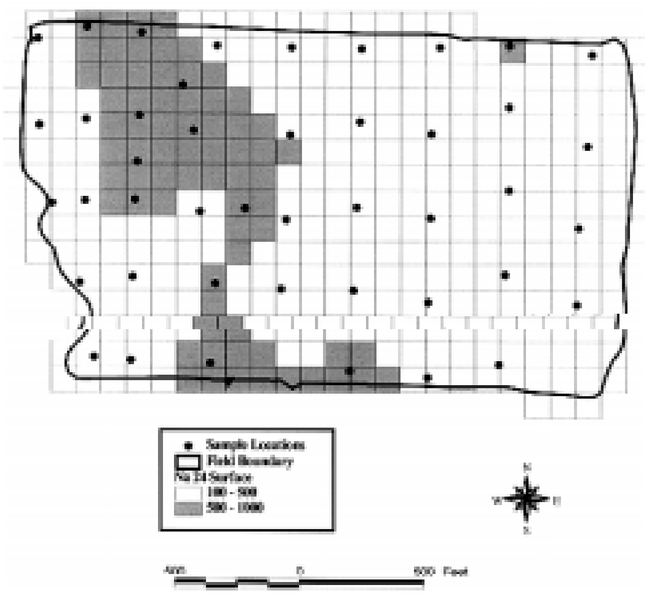

Fig. 2. Map of sodium (lb/acre) distribution at 18 to 24 in. Each grid cell represents 10,000 square feet (~0.25 acres).

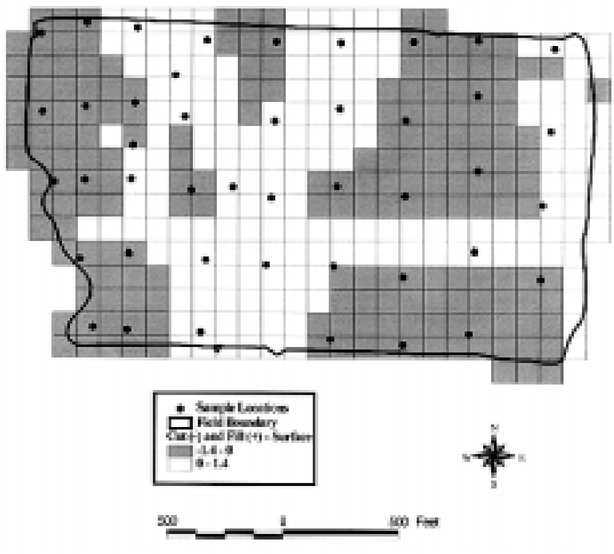

Fig. 3. Map of cut sheet used for land leveling. Positive values refer to areas of fill (ft) while negative values refer to areas of removal (ft). Data furnished by Bowls Surveying, England, Arkansas.

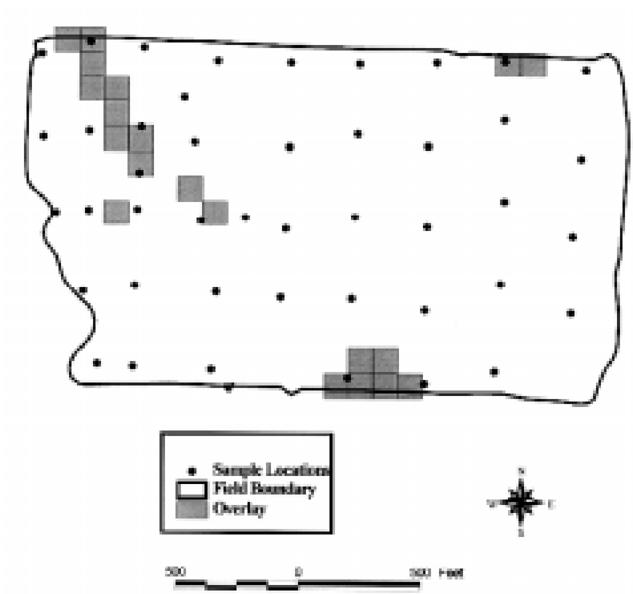

Fig. 4. Map of intersection between cut areas and sodium distribution. (>500 lb/acre) at 18 to 24 in. Map created using overlay techniques on data in Fig. 2 and 3.

ESTIMATING PLANT-AVAILABLE NITROGEN IN BIOSOLIDS

John Gilmour and Vaughn Skinner

RESEARCH PROBLEM

Specific land application limits or guidelines have been promulgated for pollutants such as metals, pathogens and disease vector attractants in biosolids. Where these factors are not limiting, biosolids are applied at the Agronomic Loading Rate where plant available nitrogen (PAN) in the biosolid is matched to crop nitrogen (N) uptake in amount and over time. PAN is the sum of inorganic N in the biosolid and the fraction of biosolid organic N that mineralizes during biosolid decomposition corrected for losses such as ammonia volatilization. Estimation of the fraction of organic N that mineralizes is the key to PAN estimation and the focus of this research project.

BACKGROUND INFORMATION

Various approaches have been taken to compute PAN for a given biosolid. Commonly, 20% of the organic N plus the inorganic N is used. This approach ignores differences in N mineralization rates among biosolids and can result in very poor estimates of biosolids PAN (Gilmour and Clark, 1988). USEPA (1994) illustrates the difficulty in developing guidelines for estimation of PAN by the phrase "assistance in designing the agronomic rate should be obtained from a knowledgeable person...."

USEPA (1995) provides much more detailed information. That document states, "Using mineralization factors recommended by regulatory agencies and land-grant universities that are based on decomposition or N mineralization studies, computer simulations that estimate decomposition, or documented field experience is advised." While this document presents the constant decay series approach for four biosolids types, it clearly recognizes that biosolids source and site variability as well as weather can dramatically alter constant decay values.

RESEARCH DESCRIPTION

1996 Field Study

Biosolids from Springdale, Arkansas; Forth Worth, Texas; and Houston, Texas, were used. The Springdale biosolids were collected the day the field experiment was initiated. The Fort Worth biosolids were shipped three weeks prior to initiation of the field experiment and kept under refrigeration prior to land application. Springdale biosolids were anaerobically digested, while the Fort Worth biosolids were anaerobically digested and then lime stabilized. Both were belt pressed to increase percent solids. The Houston biosolids were bagged and dried and stored at room temperature prior to land application.

The field experiment was conducted on a Captina silt loam (fine-silty, siliceous, mesic Typic Fragiudult) at the Main Station Farm in Fayetteville, Arkansas. The experiment was a randomized, complete block design with four blocks. Each plot was 7x15 ft. Inorganic N (ammonium nitrate) was applied at 50, 100, 150, 200 and 250 lb N/acre. The Springdale, Fort Worth and Houston biosolids were applied at 1.62, 1.76 and 2.00 dry ton/acre. Applications of inorganic fertilizer and biosolids were made 30 May 1996. All treatments were soil incorporated. The plots were drilled seeded with sorghum sudan grass (*Sorghum bicolor*) in 7-in. rows that same day. The sorghum-sudan grew very poorly (poor stand) in the plots amended with Houston biosolid; these plots were replanted 13 June 1996.

Plots were harvested 19 July with a mechanical forage harvester. Wet forage weights were obtained from the harvester. A subsample from each plot was weighed wet, dried at 60°C, ground and analyzed for total N using a LECO CN Analyzer. Nitrogen uptake was computed from dry matter yields and forage percentage N.

1997 Field Study

The 1997 field study was identical to the 1996 field study with the following exceptions. Biosolids were obtained from Springdale, Fort Worth and the Trinity River Authority (TRA) near Dallas. The TRA biosolids were a mixture (primary, secondary anaerobic digests) of lime-stabilized biosolids that had been belt-pressed. Biosolids and N fertilizers were applied and sorghum sudan grass planted 23 June. The 250-lb N/acre rate was eliminated. Application rates for Springdale, Fort Worth and TRA biosolids were 1.24, 2.39 and 4.57 dry tons/ acre. A heavy rainfall event and wind caused substantial lodging about one week prior to harvest. Harvest was 22 August.

Analytical Data

Biosolids were dried at low temperature (45°C) to determine percentage solids. Fresh biosolids were analyzed for inorganic N, while dried biosolids were analyzed for organic C and organic N. Organic C, organic N, NH_4-N and NO_3-

N methods have been described previously (Clark and Gilmour, 1983). Results are shown in Table 1.

RESULTS

Table 2 presents yields, total N contents and total N uptake values for the N fertilizer additions and biosolids. Differences in yield among treatments were not significant in 1996 and 1997, but total N contents were significantly different each year. N uptake was significantly different between some treatments in 1996, and N uptake increased with increasing N applications in 1996. In 1997, N uptake data were erratic and not significantly different.

Plots of N uptake versus fertilizer N added for 1996 are shown in Fig. 1. A polynomial relationship described the data from 0 to 250 lb N/acre ($y = 66 + 0.59x - 0.00085x^2$, $r^2 = 0.975$). A linear relationship for the 50- to 250-lb N/acre range was also found ($y = 87 + 0.31x$, $r^2 = 0.992$). In 1997, no significant relationships were found using linear and polynomial equations.

The polynomial and linear relationships were used to estimate PAN from the biosolids in 1996 (Table 3). N uptake for the Springdale biosolids was 104 lb N/acre, which corresponded to PAN values of 86 lb N/acre using the polynomial model and 79 lb N/acre using the linear model. N uptake from the Fort Worth and Houston biosolids was 104 lb N/acre, which corresponded to PAN values of 72 and 56 lb N/acre using the two models, respectively.

Table 3 also presents the two components of PAN: ammonium-N and organic N mineralized to inorganic forms. In 1996, Springdale, Fort Worth and Houston biosolids supplied 41, 13 and 1 lb N as ammonium-N. The amounts of organic N mineralized were estimated by subtracting the ammonium-N from PAN. Springdale, Fort Worth and Houston biosolids mineralized 38 to 45, 43 to 58 and 55 to 70 lb N/acre, respectively, using this approach. These amounts corresponded to 25 to 29, 40 to 54 and 19 to 24% of the organic N in these biosolids, respectively.

PRACTICAL APPLICATIONS

These results show that PAN is a unique characteristic for a biosolid. Using constant mineralization percentages could result in large errors in PAN estimation. Field studies such as this can be used to assist municipalities in planning land application programs and to verify other approaches to estimating PAN, such as computer simulation models.

LITERATURE CITED

Clark, M.D., and J.T. Gilmour. 1983. The effect of temperature on decomposition at optimum and saturated soil water contents. Soil Sci. Soc. Amer. J. 47:927-929.

Gilmour, J.T. and M.D. Clark. 1988. Nitrogen release from wastewater sludge: A site specific approach. J. Water Poll. Control Fed. 60:494-498.

U.S. Environmental Protection Agency. 1994. A plain English guide to the EPA part 503 rule. EPA/832/R-93/003.

U.S. Environmental Protection Agency. 1995. Process design manual - Land application of sewage sludge and domestic septage. EPA/625/R-95/001.

Table 1. Analytical data (dry basis).

Year	Biosolids	Organic C	Organic N	C:N	NH_4-N	NO_3-N
		----------%	---------		----------%	---------
1996	Springdale	28.8	4.79	6.0	1.26	<0.01
	Fort Worth	24.0	3.05	7.9	0.37	<0.01
	Houston	28.6	7.20	4.34	0.07	<0.01
1997	Springdale	30.4	5.06	6.0	1.34	<0.01
	Fort Worth	22.0	2.91	7.6	0.49	<0.01
	TRA	28.4	2.96	9.6	0.09	<0.01

Table 2. Yield, total nitrogen (N) content and N uptake by sorghum sudan grass.

Year	Treatment	Rate	Yield	Total N	N Uptake
		lb N/acre	lb/acre	%	lb N/acre
1996	N fertilizer	0	5362	1.12	61
		50	6739	1.54	102
		100	6750	1.76	120
		150	6447	2.03	130
		200	7032	2.08	147
		250	7206	2.30	165
	Biosolids[z]				
	SPR	---	7292	1.53	111
	FW	---	7145	1.46	104
	H	---	5924	1.77	104
$LSD_{0.05}$			NS	0.56	48
1997	N fertilizer	0	6242	1.14	70
		50	4658	1.46	68
		100	7510	1.64	124
		150	7070	1.77	124
		200	6202	1.90	119
	Biosolids[z]				
	SPR	---	7591	1.41	109
	FW	---	7146	1.46	104
	TRA	---	7203	1.58	113
$LSD_{0.05}$			NS	0.36	NS

[z] SPR = Springdale, FW = Fort Worth, H = Houston, TRA = Trinity River Authority.

Table 3. Estimates of nitrogen (N) forms in biosolids in 1996.

Biosolids	Model to estimate PAN[z]	PAN	Inorganic N	Organic N Mineralized	N Mineralization
		---------------lb N/acre--------------			%
Springdale	polynomial	86	41	45	29
	linear	79	41	38	25
Fort Worth	polynomial	71	13	58	54
	linear	56	13	43	40
Houston	polynomial	71	1	70	24
	linear	56	1	55	19

[z] PAN = Plant-available nitrogen.

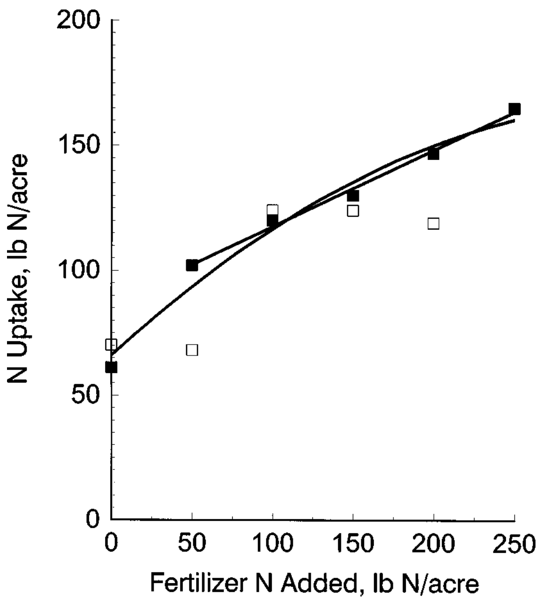

Fig. 1. Nitrogen (N) uptake by sorghum sudan grass at various fertilizer N rates for 1996 (closed squares) and 1997 (open squares). Linear and polynomial fits for 1996 data are shown as solid lines.

PLANT UPTAKE OF SOIL AND FERTILIZER NITROGEN BY WHEAT

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

RESEARCH PROBLEM

The objectives of this study were to monitor nitrogen (N) uptake by the wheat plant and utilize the information gained to optimize N fertilizer management for wheat.

BACKGROUND INFORMATION

Nitrogen fertilizer management for wheat is vital to optimizing both grain yields and economic returns. At the present time, recommendations for N rates are based on empirical studies comparing N rates to grain yields. Using this approach, previous research has indicated that N rates of approximately 110 lb/acre on silt loam soils and 150 lb/acre on clay soils will normally optimize grain yields (Wells et al., 1995). However, on some soils such as the Arkansas River alluvium on the University of Arkansas Vegetable Substation at Kibler, Arkansas, good yields are produced at lower fertilizer N rates; thus, less N is required to optimize yields. Additionally, the recommended N rates often result in lodging and reduced grain yields (Bacon and Wells, 1991).

RESEARCH DESCRIPTION

The study was conducted on a Roxanna fine sandy loam at the University of Arkansas Vegetable Substation (VS) near Kibler, Arkansas. 'Jaypee' wheat was planted at a rate of 100 lb/acre in seven-row (7-in. spacings) plots 15 ft in length 22 November 1996. The experimental design was a strip-plot with fall N applications (0, 30 and 60 lb N/acre) applied in strips and spring N applications (0, 60, 90, 120, 150 and 180 lb N/acre with the 120 split as 90/30, the 150 split as 90/60 and the 180 split as 90/90) as the subplots. The 'fall N' was not applied until 6 January 1997 due to late planting. The 'spring N' was applied 6 March with the second split applied 27 March 1997. There were four replications. All plots received sulfur as calcium sulfate at 20 lb/acre 6 March 1997.

Plant samples (1 ft per plot) were taken 18 February, 24 April and 7 May for N analysis. At maturity a 10-ft section of the five center rows of each plot was harvested with a plot combine, and the grain yield was determined in bu/acre. All data were analyzed statistically by processes of SAS, Inc. Mean separations were by LSD at the 5% level of probability.

RESULTS

The results for grain yield are presented in Fig. 1. Our findings indicated that grain yield from wheat grown on this sandy soil did not increase with fall N application. The highest grain yields were obtained when no fall N was applied. However, these yields were not always significantly higher than when fall N was applied. Generally, any N fall/spring combination over 120 lb N /acre tended to decrease grain yield. Test weight (Fig. 2) followed the same trend as grain yield with N applications over 120 lb N /acre having a negative effect on test weight.

Plant nitrogen uptake from April plant samples is presented in Fig. 3. Nitrogen uptake increased with increasing N application rates. However, increased N uptake did not result in higher yields or test weights.

PRACTICAL APPLICATIONS

The data in this experiment suggest that it is not agronomically feasible to apply fall N fertilizer on winter wheat on sandy soils. These data also indicate that on this soil any combinations over 120 lb N /acre can be detrimental to grain yield and test weight.

LITERATURE CITED

Bacon, R.K. and B.R. Wells. 1991. High input wheat management. Arkansas Agricultural Experiment Station Bulletin 929.

Wells, B.R., R.K. Bacon, J.T. Kelly and M.D. Correll. 1995. Wheat cultivar response to nitrogen rate and fungicide treatment. p. 8-15 *In* Wayne E. Sabbe (Ed.) Arkansas Soil Fertility Studies 1994. Arkansas Agricultural Experiment Station Research Series 443.

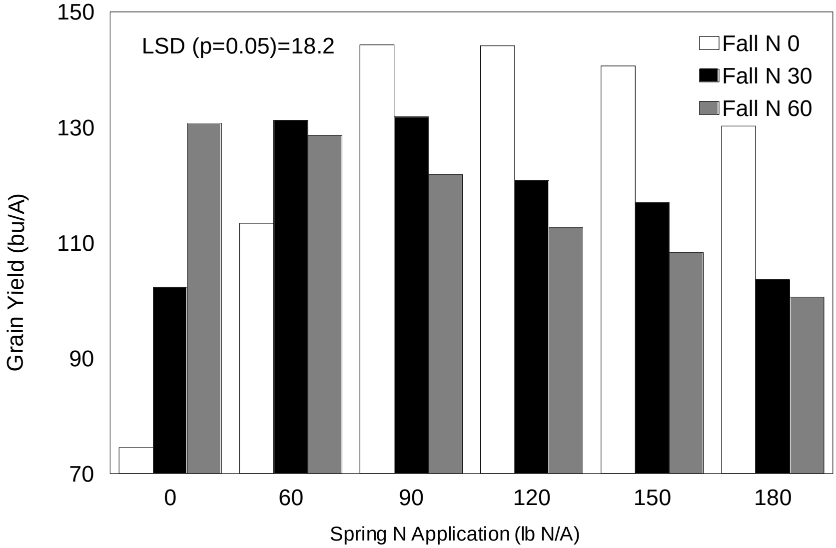

Fig. 1. Grain yield at Kibler for wheat grown with three rates (0, 30 and 60 lb N/acre) applied in the fall and six rates (0, 60, 90, 120, 150 and 180 lb N/acre) of spring-applied N.

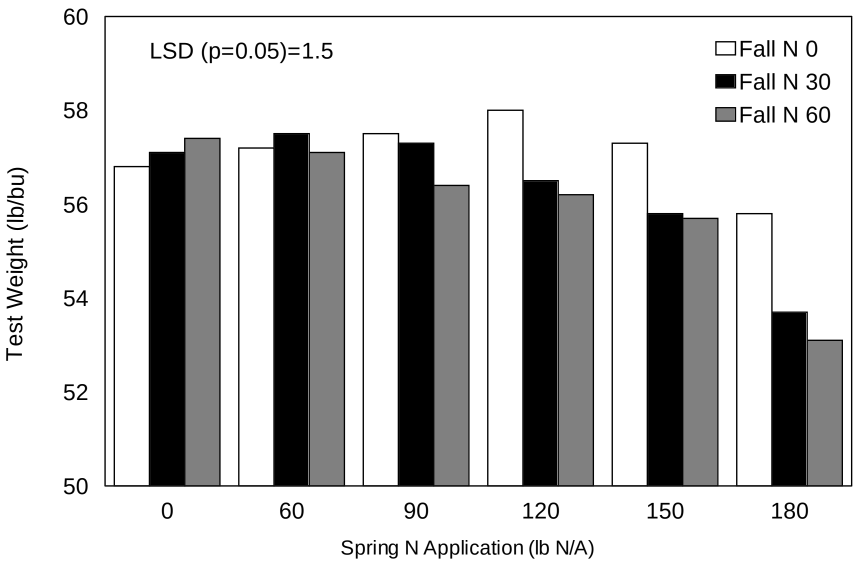

Fig. 2. Test weight at Kibler for wheat grown with three rates (0, 30 and 60 lb N/acre) applied in the fall and six rates (0, 60, 90, 120, 150 and 180 lb N/acre) of spring-applied N.

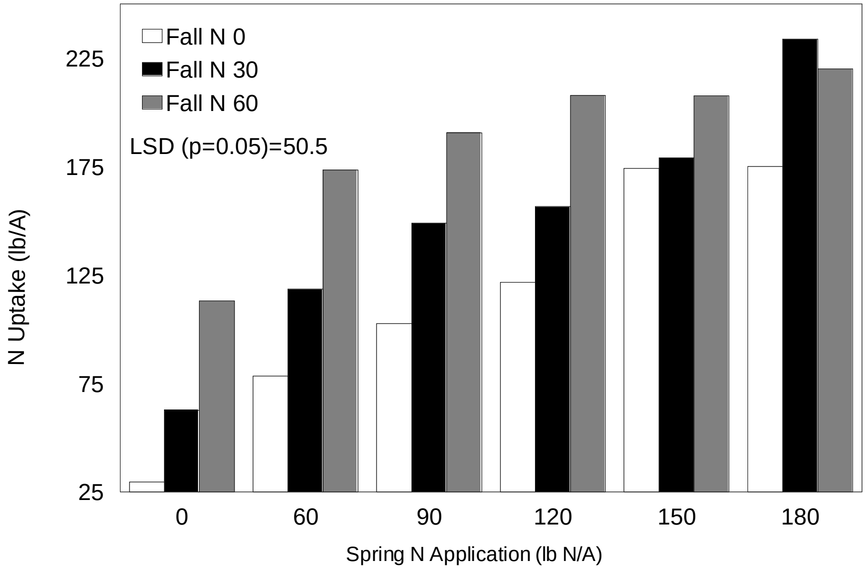

Fig. 3. N uptake at Kibler for wheat grown with three rates (0, 30 and 60 lb N/acre) applied in the fall and six rates (0, 60, 90, 120, 150 and 180 lb N/acre) of spring-applied N.

INFLUENCE OF PHOSPHORUS PLUS POTASH FERTILIZER ON GRAIN YIELD OF CONTINUOUS DRYLAND WHEAT

W.E. Sabbe and R.E. DeLong

RESEARCH PROBLEM

The predicted response of wheat 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 P and K fertilizer rate and evaluate grain yield and nutrient uptake under dryland and continuous wheat conditions.

BACKGROUND INFORMATION

Previous fertility studies with wheat have involved the crop in rotation with other row crops. The nutritional requirements for continuous wheat under dryland conditions need to be further addressed with variable P and K fertilizer applications and subsequent nutrient uptake.

RESEARCH DESCRIPTION

The North and South studies were initiated at the Pine Tree Experiment Station, Colt, Arkansas, on a Calloway (Glossaquic Fragiudalfs, fine-silty, mixed, thermic) soil. The studies were planted with 'NK Coker 9543' in 1996 with 5-ft-wide and 40-ft-long plots with 7-in. rows. The respective soil test values at the North and South studies were 26 lb P/acre and 178 lb K/acre and 22 lb P/acre and 158 lb K/acre. The two fertilizer rates were 0-0 and 60-30 (P_2O_5-K_2O) lb/acre with the fertilizer applied broadcast prior to incorporation and planting.

RESULTS

The North study had a significantly higher yield for the 60-30 P-K fertilizer treatment than for the 0-0 P-K fertilizer treatment at 78.7 to 72.9 bu/acre, respectively (Table 1). The 60-30 fertilizer treatment compared to the check had a significantly greater uptake of K with 107.4 to 98.4 mg/plant, respectively. The South study had no significant differences for yield between the two fertilizer treatments (Table 2). The 60-30 fertilizer treatment compared to the check had a significantly greater uptake of K with 112.2 to 98.8 mg/plant, respectively.

PRACTICAL APPLICATIONS

The application of phosphorus and potassium fertilizer resulted in increased K uptake in both studies and an increase in yield in one study. Further study of P and K fertilizer in these dryland sites with continuous wheat will be conducted.

ACKNOWLEDGMENT

Financial support from the Arkansas Fertilizer Tonnage Fee is appreciated.

Table 1. Dryland wheat grain yield and phosphorus (P) and potassium (K) whole plant analysis in the North Study as affected by P and K fertilizer, Pine Tree Experiment Station, Colt, Arkansas, 1997.

Fertilizer Treatment (P_2O_5-K_2O)	Grain Yield	Whole Plant[z] P	Whole Plant[z] K
lb/acre	bu/acre	------------mg/plant	------------
0-0	72.9	10.18	98.4
60-30	78.7	10.94	107.4
$LSD_{(0.05)}$	3.1	ns[y]	7.4

[z] Sampled at R3 growth stage.
[y] ns = nonsignificant.

Table 2. Dryland wheat grain yield and phosphorus (P) and potassium (K) whole plant analysis in the South Study as affected by P and K fertilizer, Pine Tree Experiment Station, Colt, Arkansas, 1997.

Fertilizer Treatment (P_2O_5-K_2O)	Grain Yield	Whole Plant[z] P	Whole Plant[z] K
lb/acre	bu/acre	------------mg/plant	------------
0-0	59.6	8.73	98.8
60-30	60.2	9.66	112.2
$LSD_{(0.05)}$	ns[y]	ns[y]	9.2

[z] Sampled at R3 growth stage.
[y] ns = nonsignificant.

SOUTHERN HIGHBUSH BLUEBERRY RESPONSE TO NITROGEN RATE: FIRST-YEAR RESULTS

J.R. Clark, J.F. Young and J.M. Phillips

RESEARCH PROBLEM

The southern highbush blueberry is a hybrid of *Vaccinium corymbosum* L. (the northern highbush blueberry) and one or more southern-adapted *Vaccinium* species, intended to provide an early-ripening, lower-chill blueberry with the fruit quality of northern highbush and adaptation to the warmer conditions of the southern U.S. This new type of blueberry holds promise for blueberry growers in central and southern Arkansas because fruit ripening could be advanced by one to four weeks compared to the rabbiteye (*V. ashei* Reade) cultivars currently grown in these areas of the state. Research on southern highbush blueberries has been conducted for several years in Arkansas in the areas of cultivar development and testing, but only limited research has been done on the cultural aspects of southern highbush production. The objective of this study was to begin to determine the appropriate nitrogen (N) rate for the southern highbush blueberry.

BACKGROUND INFORMATION

No research studies have been conducted in Arkansas that compare the response of southern highbush blueberry to varying N rates. Rates of N applied to highbush blueberry plantings in the U.S. usually range from 60-120 lb N/acre, with a foliar N content of 1.6% considered the minimum for optimum plant performance. Higher N rates are often suggested where organic mulches such as pine straw or sawdust are applied to the plants. Clark et al. (1994) reported that highbush and southern highbush blueberries were similar in foliar elemental content, while the rabbiteye blueberry differed in foliar level for many elements when fertilized at similar N rates. This study, begun in 1997 and projected to be continued for a minimum of three years, focuses on southern highbush response to a range of N levels.

RESEARCH DESCRIPTION

A planting of pine straw-mulched 'Cape Fear' southern highbush blueberry was established in late winter of 1994 at the Southwest Research and Extension Center, Hope, Arkansas, on a silt loam soil. The plants were fertilized uniformly the first three years (1994 through 1996) with ammonium sulfate. The N rate applied to all plants in 1994 was 60 lb N/acre, and in 1995 and 1996, 90 lb N/acre was applied. Nitrogen rate treatments were begun in 1997, and urea was chosen as the N source due to the pH of the planting being less than 5.3, indicating a need to use a less acidifying N source for that year. The N rates for 1997 included a range of 0 to 240 lb N/acre, all surface-applied within the drip line of the plants with the fertilizer placed on the mulched area under the plants. The urea applications were made at budbreak (19 March), 2 May and 11 June of 1997, with one-third of the total annual N applied at each date. Five replications of two-plant plots of each N level were utilized, arranged in a randomized complete block design. Fruit yields and berry weights were measured in May and June, and foliar samples were collected in early August and analyzed for elemental content. Data were collected from one of the two plants in each plot only, and the data were analyzed by SAS.

RESULTS

Foliar N and potassium (K) were influenced by urea rate, with the 120-, 180- and 240-lb N/acre rates, resulting in increased foliar N (Table 1). Foliar K was higher for 60, 180 and 240 lb N/acre, but the difference between the highest and lowest K levels was only 0.07% and not of any practical importance. All plants, independent of N rate, had foliar N levels above 1.6%, which is considered the minimum N level for northern highbush blueberry. Although no urea was applied to the control plants, the minimum foliar N level was attained, and this is probably due to the N reserves in the plant and soil from previous years. Yield, berry weight and foliar P, Ca, Mg and S were not affected by N rate in 1997 (Table 1). Foliar microelemental levels (Fe, Mn, Zn and Cu) were also unaffected by N rate (data not shown).

PRACTICAL APPLICATION

These first-year results indicate minimal effects of urea rate on Cape Fear southern highbush blueberry. This is probably due to the effect of stored N reserves in the roots, canes and stems of the plants from the previous year, which provided adequate N even in plants where no N was applied in 1997. The increased foliar N from higher N rates does indicate an influence from the higher rates, but these rate effects will need to be evaluated further to determine the optimum N fertilizer level for maximum fruit yields.

LITERATURE CITED

Clark, J.R., D. Creech, M.E. Austin, M.E. Ferree, P. Lyrene, M. Mainland, D. Makus, L. Neuendorff, K. Patten and J.M. Spiers. 1994. Foliar elemental analysis of southern highbush, rabbiteye and highbush blueberries in the southern United States. HortTechnology 4:351-355.

Table 1. Yield, berry weight and foliar macroelemental analysis of four-year-old 'Cape Fear' southern highbush blueberry as affected by nitrogen (N) fertilization level (using urea) at the Southwest Research and Extension Center, Hope, Arkansas, 1997.

N treatment	Yield[z]	Berry weight	N	P	K	Ca	Mg	S
lb/acre		g	-------------------------			% dry wt.		---------------------------
Control	6061 a[y]	0.8 a	1.74 b	0.08 a	0.35 b	0.84 a	0.31 a	0.12 a
60	5068 a	0.9 a	1.96 b	0.09 a	0.42 a	0.68 a	0.24 a	0.13 a
120	6205 a	0.9 a	1.88 a	0.09 a	0.35 b	0.78 a	0.29 a	0.12 a
180	4809 a	0.9 a	2.20 a	0.09 a	0.42 a	0.72 a	0.27 a	0.13 a
240	4922 a	0.9 a	2.19 a	0.09 a	0.43 a	0.64 a	0.24 a	0.13 a

[z] Yield in lb/acre based on a plant density of 1089 plants/acre.

[y] Mean separation by $LSD_{(0.05)}$.

HIGHBUSH BLUEBERRY RESPONSE TO NITROGEN RATE AND METHOD OF APPLICATION: FOURTH-YEAR RESULTS

J.R. Clark, J. Naraguma and A. Allen

RESEARCH PROBLEM

Highbush blueberries are most often fertilized with dry nitrogen (N) fertilizers applied to the surface of the 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 becoming more common in blueberry plantings. Numerous fertilizer applications are made with this approach, usually 10 to 14/ 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 Northwest Research and Extension Center, Fayetteville, Arkansas, on a Captina silt loam soil, and N fertility treatments were imposed on these plants in their initial year in the field. Treatments in 1997 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. The dry surface applications were begun in mid April and again at six and 12 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 influenced only foliar N, P K and S, while fertilizer N rate affected foliar N, P Mg, S, Mn and Cu (Tables 1 and 2). Neither yield nor berry weight was influenced by method or N rate (Tables 1 and 2), although the lowest yield was recorded on the control plants. There was a significant interaction of method and N rate only for foliar Ca; however, the differences in interaction means were small and of no practical value.

The overall mean foliar N level was 2.08% for all surface-applied rates and 2.13% for fertigation, which is a rather small difference even though statistically significant. Method of delivery affected P levels less than 0.01%, although the difference again was statistically significant. Foliar K averaged 0.43% across all N-rate surface applications and 0.33% across all fertigation applications, indicating a slight but significant reduction in foliar K from fertigation. Foliar S levels from surface-applied compared to fertigation differed by less than 0.01%, again of no practical significance.

As N fertilization rate increased, mean foliar N increased from 1.77% for the 60-lb/acre N rate to 2.38% for 240 lb/acre. Significant linear trends were found for both surface-applied and fertigation for foliar N. All fertilizer rates except 60 lb N/acre were significantly different from the control for foliar N. Foliar P level for the control was 0.01 to 0.02% lower compared to all fertilizer N rates, and this difference was statistically significant although probably of little practical significance. Foliar Mg levels were decreased with increased fertilizer N rates, with Mg of 0.24% for the control, down to 0.18% for the 180 lb N/acre rate, and back up to 0.22% for the 240 lb N/acre rate. Foliar S increased with increasing N rate, with a mean S level for the control of 0.12% up to 0.18% for the 240 lb N/acre rate. Of the microelements, foliar Mn was increased from the control of 356 ppm to 956 ppm for the 240-lb N/acre rate, and a linear response was found for increased N rate for fertigation for foliar Mn. Foliar Cu was slightly decreased by increasing the fertilizer N rate, with a Cu control level of 3.6 ppm compared to 2.4 and 2.5 ppm, respectively, for 180 and 240 lb N/acre rates.

PRACTICAL APPLICATION

The data indicated that the method of application had little practical effect on any of the variables measured. Rate response was most important for foliar N level with increased foliar N with increasing ammonium sulfate rate. Using a minimum adequate foliar N level of 1.60%, the control was the only treatment that was below the adequate foliar N level. The 60-lb N/acre rate means were near deficient, while the other fertilizer N rates were sufficient and ranged up to 2.42%. The data indicated that a 120-lb N/acre rate was needed to supply adequate plant needs, and increases over this rate might have been excessive. The other major finding was that of much higher foliar Mn levels with the highest N rates. Foliar Mn levels near or above 1000 ppm are thought to be excessive and should be avoided if possible, further reducing the desirability of the highest fertilizer N rates applied in this study.

Table 1. Foliar macroelement content and analysis of variance F-test significance for method of application and nitrogen (N) rate treatments to highbush blueberries, fourth-year results (1997).

Application Method	N rate[z]	N	P	K	Ca	Mg	S
		--------	--------	-------- % dry wt.	--------	--------	--------
Control	0	1.44	0.08	0.36	0.80	0.24	0.12
Surface	60	1.77	0.07	0.40	0.98	0.24	0.13
Surface	120	2.03	0.06	0.34	0.93	0.21	0.15
Surface	180	2.19	0.06	0.53	0.71	0.16	0.15
Surface	240	2.33	0.06	0.44	0.81	0.20	0.16
Fertigation	60	1.77	0.07	0.33	0.81	0.24	0.13
Fertigation	120	2.11	0.06	0.35	0.76	0.24	0.16
Fertigation	180	2.25	0.06	0.33	0.82	0.20	0.15
Fertigation	240	2.42	0.06	0.32	0.92	0.22	0.19
F-test significance level (prob. >F)							
Source of variation							
Method		0.01	0.01	0.01	0.59	0.47	0.01
Rate		0.01	0.01	0.17	0.68	0.01	0.01
Method x Rate		0.94	0.43	0.08	0.02	0.17	0.53
Rate linear (surface)[y]		0.01	0.12	0.26	0.75	0.06	0.49
Rate quadratic (surface)		0.48	0.01	0.01	0.02	0.01	0.05
Rate linear (fertigation)		0.09	0.17	0.06	0.26	0.90	0.01
Rate quadratic (fertigation)		0.01	0.48	0.32	0.21	0.16	0.02

[z] Rate in total N in lb/acre, based on 1089 plants/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 nitrogen (N) rate treatments to highbush blueberries, fourth-year results (1997).

Application Method	N rate[z]	Yield	Berry wt.	Fe	Mn	Zn	Cu
		g/plant	g	------------- ppm dry wt.-------------			
Control	0	165	1.3	91	356	8.2	3.6
Surface	60	629	1.3	203	751	7.5	4.0
Surface	120	482	1.2	81	824	9.5	2.8
Surface	180	453	1.3	69	744	6.7	2.1
Surface	240	443	1.5	81	802	8.5	2.6
Fertigation	60	288	1.2	82	468	9.6	3.4
Fertigation	120	594	1.2	81	858	11.0	2.9
Fertigation	180	516	1.4	79	798	7.0	2.7
Fertigation	240	554	1.3	86	1110	7.8	2.6
F-test significance level (prob. >F)							
Source of variation							
Method		0.63	0.77	0.25	0.14	0.40	0.35
Rate		0.14	0.70	0.22	0.01	0.55	0.02
Method x Rate		0.96	0.44	0.20	0.47	0.23	0.31
Rate linear (surface)[y]		0.58	0.68	0.46	0.40	0.61	0.17
Rate quadratic (surface)		0.86	0.10	0.78	0.41	0.70	0.01
Rate linear (fertigation)		0.41	0.31	0.94	0.02	0.35	0.51
Rate quadratic (fertigation)		0.99	0.82	0.93	0.07	0.25	0.34

[z] Rate in total N in lb/acre, based on 1089 plants/acre.

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

THE PRODUCTION OF DALLISGRASS PASTURE NITROGEN FERTILIZED AT THREE RATES AND STOCKED AT FOUR RATES WITH STEERS

Stacey A. Gunter, J. Mike Phillips and Paul A. Beck

RESEARCH PROBLEM

Currently at the Southwest Research Extension Center (SWREC), it is recommended that producers annually apply 200 lb of nitrogen (N)/acre to warm-season grass hay meadows (primarily common bermudagrass) for optimal net return for hay production; however, is this recommendation valid for pastures grazed by stocker cattle? Stocker cattle should perform better if N fertilizer is applied because forage production is increased, resulting in an increased forage allowance/animal. With the increasing cost of fertilizer, we were interested in quantifying the animal performance response of stocker cattle to increasing levels of N fertilizer.

The purpose of this experiment was to examine the effects of N fertilization on animal performance and determine the optimal stocking rate with stocker cattle grazing dallisgrass pastures. This article summarizes the first year of a three-year study.

BACKGROUND INFORMATION

No research has been conducted in Arkansas that compares the effect of N fertilization across several fixed stocking rates on stocker cattle performance. Cattle producers have realized for many years that decreasing stocking rate increases individual animal performance. A producer that stocks his pastures at a greater rate to achieve maximum gain/acre also increases his cost of production on a per-acre basis. This relationship calls into question whether the decision to target maximum gain/acre is increasing or decreasing the net return of the stocker cattle enterprise. The most profitable stocking rate always is somewhere between maximum individual performance (average daily gain: ADG) and maximum gain per acre; however, this point is dependent on the cost of production, which is significantly affected by N fertilization rate and the selling price of feeder cattle.

RESEARCH DESCRIPTION

This experiment was conducted at SWREC (33E 42' N, 93E 31' W) in Hope, Arkansas, on 24 acres divided into 2-acre pastures. The soil type of the 12 pastures was an Una silty clay loam, which consists of deep, poorly drained, level soils (slopes, 0 to 1%) on a flood plain. This soil type has a seasonally high water table in the winter and spring and is predicted to produce approximately 7.5 animal-unit-month/acre/year. These swards were primarily dallisgrass (50.5%) but also contained common bermudagrass (31.5%), tall fescue (5.6%), other grasses (4.5%), white clover (3.3%), plus other forbs (4.6%).

Seventy-two steer calves (average body weight = 508 lb) were obtained through a local cattle buyer (F & F Cattle Company, Hope, Arkansas). After a 21-day receiving period, the steers were stratified by weight and randomly divided into 12 groups. The groups were assigned to one of the following 12 treatments: 1.5, 2.5, 3.5 or 4.5 steers/acre and 100, 200 or 300 lb of N fertilizer (i.e., 300, 600 or 900 lb of ammonium nitrate was applied)/acre. The fertilizer was applied three times (in equal amounts) during the grazing season at 52-day intervals beginning 2 May to total the amounts described in the treatments. The grazing season was from 6 May to 24 September (140 days). Steers were weighed 6 May and at 35-day intervals unshrunk at 0630. On 6 May the steers were implanted with Implus-S™ and again on 21 August. On a weekly basis, cattle were provided 1.67 lb/steer of a mineral/salt mixture[1]. Standing forage dry matter (DM) in the pastures was determined by clipping the herbage mass to the ground inside six 1.05 ft^2 quadrants/pasture three times over the grazing season (5/8, 7/17 and 10/2). Forage from quadrants was placed in paper bags and dried in a forced-air oven (60° C) for 72 hours to determine DM concentration.

The effects of stocking rate (steers/acre) and N fertilization rate (lb of N/acre) on ADG, total gain per steer, gain/acre and standing forage DM/acre were separated by using polynomial regression. The data were fitted to the following model for two independent variables: ($\gamma_i = \beta_0 + \beta_1\chi_{I1} + \beta_2\chi_{I2} + \beta_{11}\chi^2_{I1} + \beta_{12}\chi^2_{I2} + \beta_{12}\chi_{i1}\chi_{i2} + \varepsilon_I$ for which χ_{I1} equals stocking rate and χ_{i2} equals N fertilization rate.

RESULTS

Standing forage DM in the pastures was decreased (*P* = 0002) by greater stocking rates ($\gamma_i = 3566.351 - 1051.035\chi_{I1} - 4.271\chi_{I2} + 147.891\chi^2_{I2} + .0370\chi^2_{I2} - 1.876\chi_{i1}\chi_{i2}$; Table 1). Increasing the N applied/acre also increased (*P* = 0.02) the standing forage DM. It was determined by regressing ADG on

[1] Vigortone No. 32S™. Contained (% as-fed): 18.2% NaCl, 13.6% Ca, 7.0% P, .01% I, .0026% Se, trace minerals (Co, Cu, Fe, Mn, and Zn), 300,000 IU of vitamin A/lb, 30,000 IU of vitamin D_3/lb, and 100 IU of vitamin E/lb.

pounds of forage DM/acre that the ADG increased (P = 0.004) as standing forage DM increased (Fig. 1). Standing forage DM accounted for 76% of the variation (r) in ADG, suggesting that this variable is an important consideration when grazing stocker cattle.

Increasing the stocking rate decreased the number of days that cattle could be grazed to 105 from 140 when pastures were stocked at 4.5 steers/acre and 100 lb of N/acre was applied (Table 1). Also, increasing the stocking rate decreased (P = 0.0001) the ADG of the steers at a rate dependent on the amount of fertilizer applied ($\gamma_i = 1.600 + .250\chi_{I1} + .00485\chi_{I2} - .112\chi^2_{I2} + .0000125\chi^2_{I2} + .000740\chi_{i1}\chi_{i2}$; Table 1). At a rate of 100 lb of N/acre, the ADG decreased approximately .34 lb/day for every one steer increase in stocking rate ($\gamma_i = 1.241 + .324\chi_{I1} - .112\chi^2_{I1}$). For 200 lb of N/acre, the ADG decreased approximately .27 lb/day for every one steer increase in stocking rate ($\gamma_i = 1.131 + .398\chi_{I1} - .112\chi^2_{I1}$). The ADG decreased approximately .20 lb/day for every one steer increase in stocking rate when 300 lb of N/acre was applied ($\gamma_i = 1.272 + .472\chi_{I1} - .112\chi^2_{I1}$). The total gain/steer was decreased (P = 0.07) 52.3, 39.5 and 26.7 lb for every one steer/acre increase in stocking rate for 100, 200 or 300 lb of N/acre ($\gamma_i = 221.742 + 35.767\chi_{I1} - .649\chi_{I2} - 16.833\chi^2 I1 + .00154\chi^2_{I2} + .129\chi_{i1}\chi_{i2}$; Table 1). Total gain/acre responded quadratically (P = 0.0001) to stocking rate and interacted with N fertilization rate ($\gamma_i = 438.500\chi_{I1} - 2.162\chi_{I2} - 89.333\chi^2_{I1} + .00316\chi^2_{I2} + .704\chi_{i1}\chi_{i2} - 59.833$; Table 1). Gain/acre increased (P = 0.0001) more rapidly as stocking rate was increased with cattle grazing pastures fertilized with 300 lb of N than with 100 lb of N.

Cost/steer estimates in Table 2 include pasture rent, fertilizer, price slide, interest, minerals, receiving feed, veterinary service and supplies, transportation and death loss. Pasture rent was based on a yearly cost of $20.00/acre, and it was assumed that the stocker cattle enterprise used 50% of the lease ($10.00/year). The pasture rent charge/year was divided by the stocking rate, resulting in a decrease in pasture rent/steer as stocking rate was increased. Price slide, the loss in value/100 lb from the original weight of the steer, was assumed to be $2.50/100 lb of gain. When interest was calculated, we assumed that the cattle would be owned for five months and an APR of 10.00%. Veterinary services and supplies included the treatment of sick cattle, implants and vaccines. Death loss was assumed to be 1.0% of the value of the steers. The selling price of the cattle was assumed to be $70.00/100 lb.

The total cost/acre increased ($P < 0.05$) with level of stocking rate and the amount of N fertilizer applied (Table 3). The gross return of stocker cattle grazing dallisgrass pasture was simply a function of total gain/acre multiplied by the market price (Table 3). The highest gross return per acre was received with 300 lb of N fertilizer and 3.5 steers/acre (Table 3). The net return/acre by stocker cattle grazing dallisgrass pasture was dependent (P = 0.0001) on the stocking rate and N fertilization rate ($\gamma_i = 2.343 + 184.065\chi_{I1} - 1.899\chi_{I2}$ -

$47.411\chi^2_{I2} + .00302\chi^2_{I2} + .375\chi_{i1}\chi_{i2}$; Table 3). With 100 lb of N/acre applied, the most profitable stocking rate was at 2.46 steers/acre ($105.96/acre). At 200 lb of N fertilizer applied/acre, 2.66 steers/acre was the most profitable stocking rate ($99.52/acre). At lighter stocking rates, cattle grazing pasture fertilized with 200 lb of N fertilizer/acre was generally less profitable than cattle grazing pastures fertilized with 100 lb of N fertilizer/acre. Finally, at 300 lb of N fertilizer applied per acre the most profitable stocking was a 3.20 steers/acre ($159.96/acre).

PRACTICAL APPLICATION

Based on the results from the first year of this study, the most profitable stocking rates for stocker cattle grazing dallisgrass pastures were between 2.46 and 3.20 steers/acre, depending on the amount of N fertilizer applied. As more N fertilizer was applied, the most profitable stocking rate and net return/acre was also increased. The coming two years of performance data from this study should provide us with important additional information on year-to-year variation in animal performance, which is greatly needed when deciding on appropriate stocking and fertilization rates.

ACKNOWLEDGMENTS

Support for this research was provided by Arkansas Fertilizer Tonnage Fees. Special thanks is give to Ivy Laboratories, Inc. (Overland Park, Kansas) for help in supporting this experiment through product and equipment donations. Also, we wish to express our appreciation to Pat Capps, Scott Cato, Bruce Kirkpatrick, Breck Long, Mike McCorkle and Franky Powell for assisting with the completion of this research.

Table 1. Standing forage dry matter (DM), grazing days and performance of stocker steers stocked at four different rates grazing dallisgrass pasture fertilized at three different rates during the summer.

	Stocking rate, steers/acre			
Fertilizer rate/item	1.5	2.5	3.5	4.5
100 lb of N/acre				
Standing forage DM/acre	1,984	1,337	986	930
Days of grazing	140	140	140	105
ADG, lb	1.48	1.35	1.01	.44
Total gain, lb	207.3	188.5	136.2	50.1
Gain/acre, lb	317.9	469.4	442.3	236.5
200 lb of N/acre				
Standing forage DM/acre	2,387	1,552	1,013	770
Days of grazing	140	140	140	140
ADG, lb	1.48	1.43	1.16	.66
Total gain, lb	207.7	201.9	162.3	89.1
Gain/acre, lb	302.1	524.0	567.2	431.7
300 lb of N/acre				
Standing forage DM/acre	3,530	2,507	1,781	1,350
Days of grazing	140	140	140	140
ADG, lb	1.73	1.75	1.56	1.13
Total gain, lb	239.0	246.0	219.3	158.9
Gain/acre, lb	349.6	641.9	755.4	690.3

Table 2. Assumed cost required to graze stocker steers stocked at four different rates on dallisgrass pasture during the summer.

	Stocking rate, steers/acre			
Item	1.5	2.5	3.5	4.5
	----------------------------Cost/steer, $-----------------------			
Pasture rent	6.67	4.00	2.86	2.22
Fertilizer, cost/100 lb applied	14.00	8.40	6.00	1.33
Price slide/100 lb of gain	2.50	2.50	2.50	2.50
Interest, 10% APR	13.54	13.54	13.54	13.54
Minerals	10.00	10.00	10.00	10.00
Receiving feed	11.15	11.15	11.15	11.15
Veterinary services and supplies	17.35	17.35	17.35	17.35
Transportation	3.00	3.00	3.00	3.00
Death loss	3.25	3.25	3.25	3.25

Table 3. Total cost, gross return and net return ($) of stocker steers stocked at four different rates grazing dallisgrass pasture fertilized at three different rates during the summer.

	Stocking rate, steers/acre			
Fertilizer rate/item	1.5	2.5	3.5	4.5
100 lb of N/acre				
Cost/acre	157	236	297	328
Gross return/acre	216	333	353	203
Net return/acre	59	97	56	-125
200 lb of N/acre				
Cost/acre	179	261	327	367
Gross return/acre	217	350	402	303
Net return/acre	38	90	75	-64
300 lb of N/acre				
Cost/acre	206	296	373	426
Gross return/acre	363	429	538	515
Net return/acre	48	132	164	89

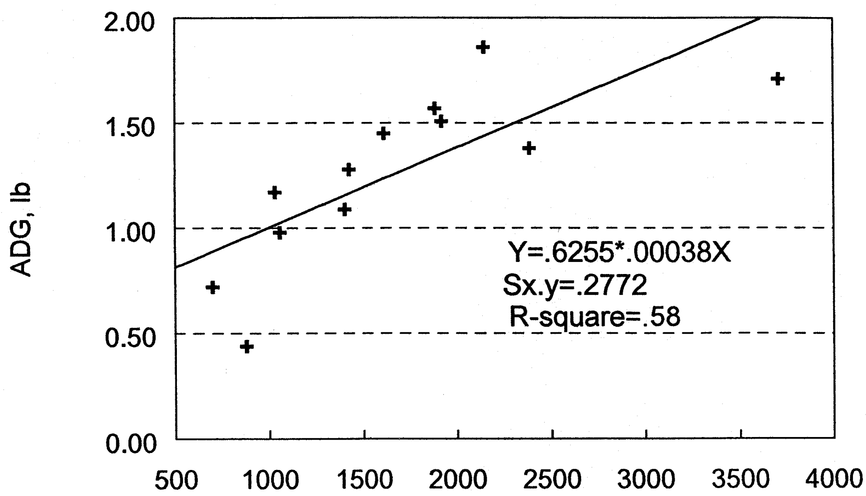

Fig. 1. Effect of standing forage dry matter (DM) on the average daily gain (ADG) of stocker cattle grazing dallisgrass pasture.

AGRONOMICS OF TRADITIONAL VERSUS SITE-SPECIFIC FERTILIZATION

W.E. Sabbe and R.E. DeLong

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. Traditional fertilization applied fertilizer to the entire field based on a field average. 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 20 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 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 Main Experiment Station, Fayetteville, Arkansas, with four replications on a Captina (Typic Fragiudults, fine-silty, mixed, thermic) soil. Cultivar H5218 was planted in 1997 with 10-ft-wide by 25-ft-long plots with 38-in. rows. The study was a comparison between P and K fertilizer response based on application methods of nontreated, field average and site specific. The field average for P was 53 lb/acre and K was 156 lb/acre, and the corresponding recommended fertilizer rate was 40 lb/acre P and 60 lb/acre K. The fertilization rates for the site-specific areas were 0-0, 0-30, 0-60, 40-30, 40-60, 40-90, 45-90 and 60-120 P-K lb/acre, respectively. P and K fertilizer rates for the field-average and site-specific method were applied broadcast and incorporated before planting.

RESULTS

Grain yield for fertilizer treatments ranged from 48.6 to 58.8 bu/acre with no trend among the treatments (Table 1). The grain yield response to the method of fertilizer placement was not significant, with all treatments averaging 55.3 bu/acre (Table 2). Nutrient uptake shown by leaf and whole plant analysis for P and K was not significant for fertilizer treatment or method of fertilizer placement (data not shown).

PRACTICAL APPLICATIONS

With the advent of a technology that allows the application of variable rates of fertilizer, the results from this experiment are a first step in helping to understand the influence of various recommended fertilizer rates on soils with specific P and K soil test levels compared to traditional fertilization based on the field average. 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 as affected by phosphorus (P) and potassium (K) fertilizer, Main Experiment Station, Fayetteville, Arkansas, 1997.

Fertilizer Treatment (P_2O_5-K_2O)	Grain Yield
lb/acre	bu/acre
0-0	55.3
0-30	58.8
0-60	56.6
40-30	48.6
40-60	55.3
40-90	55.2
45-90	57.2
60-120	53.1
$LSD_{(0.05)}$	5.5

Table 2. Irrigated soybean grain yield as affected by phosphorus and potassium fertilizer as applied by field-average or site-specific methods, Main Experiment Station, Fayetteville, Arkansas, 1997.

Fertilizer Response Treatment (P_2O_5-K_2O)	Grain Yield
lb/acre	bu/acre
Nontreated	55.3
Field Average	55.3
Site Specific	55.4
$LSD_{(0.05)}$	ns[z]

[z] ns = nonsignificant.

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 the 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

A location was selected with a Calloway series (Typic Glossaquic, fine-silty, mixed, thermic) loessial soil at the Cotton Branch Experiment Station (CBS), Marianna, Arkansas. A dryland site and an irrigated site were utilized. The soil test values at CBS were 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 eight cultivars in 1997 included two in MG IV (Manokin and TV4479), four in MG V (A5403, H5050, H5545 and Hutcheson) and two in MG VI (A6711 and P9611). Individual plots consisted of four 38-in. rows with a length of 20 ft and 12 replications. The two fertilizer rates were 0-0 and 60-120 (P_2O_5-K_2O) lb/acre with the fertilizer applied broadcast prior to incorporation and planting.

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 and 35.0 to 54.7 bu/acre for dryland and irrigated sites, respectively. The average yields among cultivars in 1996 ranged from 27.9 to 48.5 and 49.0 to 57.4 bu/acre for dryland and irrigated, respectively. The average yields among cultivars in 1997 ranged from 18.6 to 33.9 and 50.0 to 60.7 bu/acre for dryland and irrigated, respectively. In three years there was a significant difference among cultivars and between dryland and irrigated sites. There were no significant responses to the fertilizer treatment for either the dryland or irrigated sites. The significant differences among maturity groups were evident, with MG V appearing to have the highest yield for 1995 and MG VI for 1996 and 1997.

PRACTICAL APPLICATIONS

Selection of cultivar had a greater effect than fertilizer rate in obtaining higher yields. Obviously irrigation did produce the greatest yields, but even at that higher yield potential, maturity group and cultivar selection produced grain yield difference whereas fertilizer application rates did not affect yields.

ACKNOWLEDGMENT

Financial support from the Arkansas Fertilizer Tonnage Fee is appreciated.

Table 1. Interaction of phosphorus and potassium fertilizer, maturity group and irrigation on soybean cultivar grain yields, Cotton Branch Experiment Station, Marianna, Arkansas, 1995-1997.

	Dryland						Irrigated					
	0-0[z]			60-120			0-0			60-120		
Cultivar (MG)	1995[y]	1996	1997	1995	1996	1997	1995	1996	1997	1995	1996	1997
	bu/acre											
H4715 (IV)	20.5	30.6	*	20.1	29.5	*	38.5	50.4	*	*	50.4	*
Manokin (IV)	23.2	37.2	31.2	23.4	38.5	40.6	45.1	55.7	58.8	46.1	57.4	57.1
TV4479 (IV)	*	*	26.0	*	*	26.6	*	*	53.8	*	*	54.2
A5403 (V)	17.2	28.3	26.0	17.3	27.9	26.4	37.7	50.4	59.4	38.4	50.3	56.2
H5050 (V)	*	*	27.3	*	*	26.4	*	*	52.7	*	*	56.2
H5545 (V)	*	30.7	18.6	*	31.9	18.4	*	49.0	50.0	*	49.3	52.1
Hutcheson (V)	27.0	35.9	33.9	23.7	38.3	30.7	54.7	55.5	54.0	52.7	57.0	52.5
RS577 (V)	19.6	*	*	18.5	*	*	42.1	*	*	42.0	*	*
TV5797 (V)	*	43.4	*	*	41.3	*	*	50.1	*	*	50.0	*
A6711 (VI)	*	48.5	31.6	*	48.1	33.8	*	54.3	57.6	*	52.0	53.4
A6297 (VI)	19.1	*	*	18.5	*	*	35.0	*	*	36.5	*	*
H6688RR (VI)	17.4	*	*	17.6	*	*	39.1	*	*	42.6	*	*
P9611 (VI)	*	46.1	32.7	*	45.0	31.8	*	51.4	60.7	*	50.2	58.9
P9641 (VI)	21.0	*	*	17.3	*	*	42.9	*	*	45.4	*	*
$LSD_{(0.05)}$	3.1	5.4	5.1	3.1	5.4	5.1	4.8	3.8	4.3	4.8	3.8	4.3

	1995	1996	1997
Main Factors	bu/acre		
6. Irrigation			
None	20.1	37.6	28.3
Irrigated	42.2	52.1	55.5
$LSD_{(0.05)}$	6.5	4.3	2.9
7. Fertilizer			
0-0-0	31.3	44.8	42.1
0-60-120	31.1	44.8	41.7
$LSD_{(0.05)}$	ns[x]	ns	ns
8. Maturity Group			
IV	31.7	43.7	42.3
V	32.6	43.1	40.1
VI	29.4	49.4	45.1
$LSD_{(0.05)}$	3.2	4.8	3.7

[z] lb/acre P_2O_5-K_2O.
[y] * = Cultivar was not included in the test.
[x] ns = nonsignificant.

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 to the salinity problem would be helpful in allowing continued crop production in these areas until long-term solutions are available.

BACKGROUND INFORMATION

Observations from studies in rice have indicated 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

A study was initiated in 1995 at a Monroe County site with a history of a high chloride problem due to use of irrigation water containing high levels of chloride. A second site was established at Arkansas State University (ASU), where a saline condition was artificially 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, 1,000, 2,000 and 4,000 lb/acre
Phosphorus treatments: 0, 40, 60 and 80 lb P_2O_5 /acre

ASU

Experimental design: randomized complete block with a split-plot arrangement of treatments

Main plots: 0, 2,000 and 4,000 lb/acre KCl

Subplots: factorial arrangement of a) 0, 2,000, and 4,000 lb/acre poultry and b) 0, 40 and 80 lb/acre P_2O_5

RESULTS

There were no significant treatment effects at the Monroe County site in either 1995 or 1996. The site was not irrigated, and there was an extended drought both years. Yields averaged less than 10 bu/acre in 1995 and less than 23 bu in 1996.

Applied KCl significantly reduced soybean yield at ASU every year (Table 1). Poultry litter increased yields only in 1996, regardless of KCl treatment (Table 2).

PRACTICAL APPLICATION

Poultry litter and phosphorus have had no effect on soybean yields at the Monroe County site during the first two years of the trial. Yield was increased with applied poultry litter in one year in three at ASU but was unrelated to salt level.

ACKNOWLEDGMENT

Financial support of the Arkansas Soybean Promotion Board is appreciated.

Table 1. Influence of applied KCl on soybean yield at Arkansas State University, Jonesboro, Arkansas, 1995-1997.

KCl	1995	1996	1997
lb/acre		------bu/acre------	
0	35.7	36.1	39.9
2000	22.3	31.7	36.8
4000	14.8	29.3	35.4
$LSD_{(005)}$	3.1	3.3	3.0

Table 2. Influence of applied poultry litter and phosphate on soybean yield at Arkansas State University, Jonesboro, Arkansas 1995-1997.

Poultry Litter	Phosphate	1995	1996	1997	Litter Average
----------lb/acre----------		------------------------------bu/acre----------------------------			
4,000	80	25.4	38.3	39.9	33.2
4,000	0	23.0	35.4	28.4	—
4,000	40	28.2	34.1	36.6	—
2,000	0	25.9	33.5	28.1	61.6
2,000	40	25.3	32.7	39.6	—
2,000	80	23.2	30.1	36.1	—
0	40	22.2	29.9	36.5	29.2
0	0	23.3	28.7	37.0	—
0	80	22.0	28.6	34.2	—
$LSD_{(0.05)}$		ns[z]	5.6	ns	

[z]ns = nonsignificant.

EVALUATION OF SOYBEAN RESPONSE TO SOIL TEST LEVELS AND ASSOCIATED FERTILIZATION RATES IN ARKANSAS

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

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 20 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 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

East Study

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 1997 with 10-ft-wide by 30-ft-long plots with 30-in. rows. The study was a comparison among 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 <=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, 0.5, 1 and 2 times the recommended rate on each of the specific soil test P and K treatment combinations were applied broadcast and incorporated before planting.

West Study

The study was conducted at the Pine Tree Experiment Station, Colt, Arkansas, with five replications on a Calloway (Glossaquic Fragiudalfs, fine-silty, mixed, thermic) soil. Cultivar 'Hutcheson' was planted in 1997 with 7.5-ft-wide by 20-ft-long plots with 30-in. rows. The study was a comparison between low and high soil test levels for P and low, medium and high soil test levels for K and their combinations of Low-Low, Low-Medium, Low-High, High-Low, High-Medium and High-High where low P was <25 and K <135 lb/acre, medium K was 135-175 lb/acre, and high P was >=25 and high K was >=175 lb/acre. P and K fertilizer rates of 0, 0.5, 1 and 2 times the recommended rate for last year's crop rice on each of the specific soil test P and K treatment combinations were applied broadcast and incorporated before planting.

RESULTS

East Study

Grain yield for the initial P and K soil test levels was significantly higher for the High-High than for the Low-Low soil test level with 38.0 and 29.5 bu/acre, respectively (Table 1). Significant differences were present for the analyses of plants sampled at the R3 growth stage for P and K for leaves and whole plants with no discernible trend from the initial soil test levels. Grain yield for the initial P and K soil test levels was significantly higher for the High-High than for the Low-Low soil test level at the 0X recommended P and K fertilizer rate with 40.2 and 31.6 bu/acre, respectively, and at the 0.5X recommended P and K fertilizer rate with 39.7 and 27.1 bu/acre, respectively (Table 3). Significant differences were present for the analyses of plants sampled at the R3 growth stage for P and K for leaf at the 0X rate, P and K for leaf and whole plant at the 0.5X rate, P and K for leaf at the 1X rate and P and K for leaf and whole plants at the 2X rate. Significant differences were present for the analyses of plants sampled at the R3 growth stage for P and K for leaf and whole plant with no discernible trends from the initial soil test levels.

West Study

Grain yield for the initial P and K soil test levels was not significantly higher for the High-High than for the Low-Low soil test level (Table 2). Significant differences were present for the analyses of plants sampled at the R3 growth stage for P and K for leaves and whole plants with no discernible trends from the initial soil test levels. Grain yield for the initial P and K soil test levels was not significantly higher for the High-High than for the Low-Low soil test level for any recommended P and K fertilizer rate (Table 4). Significant differences were present for the analyses of plants sampled at the R3 growth stage for K for leaf and P for whole plant at the 0X rate, P for whole plant at the 0.5X rate, K for leaf and P and K for whole plant at the 1X rate and P for leaf and whole plants at the 2X rate. Significant differences were present for the analyses of plants sampled at the R3 growth stage for P and K for leaf and whole plants with no discernible trends from the initial soil test levels.

PRACTICAL APPLICATIONS

With the advent of a technology that allows the application of variable rates of fertilizer, the results from this experiment are 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 Phosphate Potash Institute and the Arkansas Fertilizer Tonnage Fee is appreciated.

Table 1. Irrigated soybean grain yield and plant analysis in the East study as affected by phosphorus (P) and potassium (K) fertilizer on low, medium and high P and K soil test levels, Pine Tree Experiment Station, Colt, Arkansas, 1997.

Soil Test Level	Grain	Leaf Analysis (R3 Stage)		Whole Plant Analysis (R3 Stage)	
(P-K)[z]	Yield	P	K	P	K
lb/acre	bu/acre	---------%---------		--------mg/plant--------	
Low-Low	29.5	0.30	1.10	30.3	154.7
Low-Medium	33.3	0.30	1.19	28.6	141.5
Low-High	39.6	0.31	1.29	31.6	173.7
Medium-Low	35.8	0.30	1.11	35.8	184.4
Medium-Medium	36.5	0.29	1.11	28.0	149.0
Medium-High	37.1	0.31	1.24	30.8	171.2
High-Low	41.8	0.29	1.12	27.5	141.0
High-Medium	35.8	0.29	1.04	29.6	158.8
High-High	38.0	0.30	1.15	28.8	141.5
$LSD_{(0.05)}$	5.4	0.01	0.10	5.5	33.4

[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.

Table 2. Irrigated soybean grain yield and plant analysis in the West study as affected by phosphorus (P) and potassium (K) fertilizer on low, medium and high P and K soil test levels, Pine Tree Experiment Station, Colt, Arkansas, 1997.

Soil Test Level (P-K)[z]	Grain Yield	Leaf Analysis (R3 Stage) P	Leaf Analysis (R3 Stage) K	Whole Plant Analysis (R3 Stage) P	Whole Plant Analysis (R3 Stage) K
lb/acre	bu/acre	---------%---------		--------mg/plant--------	
Low-Low	40.0	0.26	1.40	28.7	144.1
Low-Medium	43.9	0.28	1.32	23.9	127.0
Low-High	36.7	0.27	1.31	31.5	145.1
High-Low	41.2	0.27	1.32	37.2	172.3
High-Medium	44.3	0.26	1.26	22.0	118.8
High-High	39.9	0.27	1.35	28.5	139.0
$LSD_{(0.05)}$	4.5	0.02	0.07	5.3	25.7

[z] Low - P<=25 and K<=135 lb/acre, Medium- K=135-175, and High - P>=25 and K>=175 lb/acre according to Mehlich III.

Table 3. Irrigated soybean grain yield and plant analysis in the East study as affected by recommended phosphorus (P) and potassium (K) fertilizer rates on soils with low, medium and high P and K soil test levels, Pine Tree Experiment Station, Colt, Arkansas, 1997.

Soil Test Level	Recommended P and K Fertilizer Rates																			
	0X					0.5X					1X					2X				
	Grain	Leaf[y]		Whole[y]		Grain	Leaf		Whole		Grain	Leaf		Whole		Grain	Leaf		Whole	
(P-K)[z]	Yield	P	K	P	K	Yield	P	K	P	K	Yield	P	K	P	K	Yield	P	K	P	K
lb/acre	bu/acre	------%------		--mg/plant--		bu/acre	------%------		--mg/plant--		bu/acre	------%------		--mg/plant--		bu/acre	------%------		--mg/plant--	
Low-Low	31.6	0.29	1.00	29.4	159.7	27.1	0.30	1.16	30.4	152.5	33.3	0.29	1.11	31.6	154.4	24.0	0.30	1.15	29.9	152.1
Low-Medium	33.3	0.31	1.24	30.9	148.3	29.5	0.32	1.24	36.3	164.6	31.6	0.32	1.21	22.4	114.7	39.0	0.31	1.29	28.1	137.6
Low-High	38.8	0.32	1.27	38.8	196.3	38.9	0.32	1.33	26.1	147.3	41.5	0.30	1.28	29.9	165.0	39.6	0.32	1.28	31.4	186.0
Medium-Low	34.8	0.30	1.05	30.9	159.2	33.9	0.31	1.18	27.5	142.3	37.0	0.30	1.12	31.4	158.3	37.4	0.31	1.18	38.6	197.8
Medium-Medium	36.0	0.30	1.13	27.5	140.6	37.6	0.29	1.15	31.5	177.3	39.3	0.29	1.12	27.3	139.3	37.7	0.28	1.04	30.9	152.8
Medium-High	38.4	0.32	1.26	30.6	174.7	34.4	0.30	1.19	29.3	160.2	35.5	0.31	1.20	30.3	169.3	39.9	0.32	1.32	32.9	180.7
High-Low	42.6	0.30	1.15	33.0	156.4	41.1	0.29	1.11	30.8	157.7	41.8	0.29	1.08	25.1	136.5	41.9	0.30	1.16	21.2	113.4
High-Medium	33.1	0.28	1.00	29.3	163.0	38.3	0.30	1.05	34.3	179.3	34.8	0.29	1.03	20.7	114.2	37.1	0.30	1.07	34.2	176.6
High-High	40.2	0.29	1.14	27.8	136.8	39.7	0.30	1.23	31.3	151.8	38.2	0.30	1.12	25.4	135.4	33.7	0.30	1.10	30.8	141.9
$LSD_{(0.05)}$	7.8	0.02	0.15	ns[x]	ns	8.8	0.02	0.14	9.9	ns	7.8	0.02	0.15	ns	ns	11.5	0.02	0.17	16.9	79.7

[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]ns = nonsignificant.

Table 4. Irrigated soybean grain yield and plant analysis in the West study as affected by recommended phosphorus (P) and potassium (K) fertilizer rates on soils with low, medium and high P and K soil test levels, Pine Tree Experiment Station, Colt, Arkansas, 1997.

Soil Test Level	Recommended P and K Fertilizer Rates																			
	0X					0.5X					1X					2X				
	Grain	Leaf[y]		Whole[y]		Grain	Leaf		Whole		Grain	Leaf		Whole		Grain	Leaf		Whole	
(P-K)[z]	Yield	P	K	P	K	Yield	P	K	P	K	Yield	P	K	P	K	Yield	P	K	P	K
lb/acre	bu/acre	------%------		--mg/plant--		bu/acre	------%------		--mg/plant--		bu/acre	------%------		--mg/plant--		bu/acre	------%------		--mg/plant--	
Low-Low	37.4	0.28	1.42	31.5	153.5	39.9	0.26	1.38	25.9	133.1	39.6	0.27	1.44	31.4	144.3	43.2	0.25	1.36	25.8	145.6
Low-Medium	47.3	0.28	1.31	23.6	127.3	42.2	0.28	1.27	22.3	118.9	42.4	0.28	1.34	23.5	125.3	43.6	0.28	1.36	26.1	136.5
Low-High	36.2	0.27	1.39	28.1	139.6	37.6	0.27	1.30	30.7	131.2	35.7	0.27	1.26	34.3	163.2	37.4	0.26	1.28	32.8	146.2
High-Low	37.7	0.28	1.19	31.4	148.9	42.4	0.26	1.31	37.9	182.8	42.5	0.27	1.39	43.7	195.2	42.3	0.26	1.38	35.9	162.4
High-Medium	44.3	0.26	1.34	20.4	116.7	47.7	0.27	1.25	28.7	143.6	42.2	0.25	1.20	20.0	112.3	43.0	0.27	1.25	19.0	102.5
High-High	40.0	0.28	1.44	35.8	163.2	37.8	0.27	1.36	25.8	127.7	40.0	0.27	1.30	27.2	125.8	41.7	0.28	1.32	25.1	139.3
$LSD_{(0.05)}$	8.1	ns	0.20	12.0	ns	6.0	ns	ns	14.8	ns	ns	ns	0.23	9.8	44.5	5.3	0.03	ns	10.1	45.9

[z]Low - P<25 and K<135 lb/acre, Medium - K=135-175 lb/acre, and High - P>=25 and K>=175 lb/acre according to Mehlich III.
[y]Analysis at R3 growth stage.
[x]ns = nonsignificant.

COTTON PETIOLE AND LEAF NUTRIENT RESPONSES TO DECREASED LIGHT INTENSITY AND SAMPLING TIME

D. Zhao and D.M. Oosterhuis

RESEARCH PROBLEM

Nutrient analysis of cotton (*Gossypium hirsutum* L.) petioles and leaves has been widely used to monitor the nutrient status of plants. However, the effect of changes in the environment on petiole nutrient contents is not clearly understood. For example, cloudy, overcast weather frequently occurs in the mid-South during the growing season and could influence tissue nutrient status. Furthermore, light intensity, which changes considerably during a single day, can also influence sampling tissue results and resultant diagnosis. Therefore, a better understanding of the effects of decreased light intensity and diurnal sampling time on nutrient concentrations of cotton petioles and leaves may help to improve the accuracy of nutrient diagnosis.

BACKGROUND INFORMATION

The amount of light is an important factor affecting crop photosynthesis, growth and yield. Low light infiltration into the plant canopy is usually associated with adverse weather conditions or excessive vegetative growth. Previous studies have shown that shade during fruiting significantly decreased the photosynthetic rate of cotton leaves and increased fruit abscission (Zhao and Oosterhuis, 1994), resulting in low lint yield and poor fiber quality (Pettigrew, 1994, 1995; Zhao and Oosterhuis, 1994, 1996). However, little is known about how shade and time of sampling affect the concentrations of mineral nutrients in petioles and leaves of field-grown cotton. The objective of this study was to determine the effects of shading at different growth stages and sampling time within a day on mineral nutrients in cotton petioles and leaves.

RESEARCH DESCRIPTION

The experiment was conducted at the Arkansas Agricultural Research and Extension Center, University of Arkansas, Fayetteville, Arkansas. Cotton cultivar DPL 20 was planted 26 May 1993, 17 May 1994 and 19 May 1997.

Preplant fertilizer was applied at a rate of 45-30-75 kg N-P-K/ha, and a side-dressing of 56 kg N/ha was given at the early square stage on 13 July 1993, 28 June 1994 and 14 July 1997. Control of insects and weeds and furrow irrigation were according to Arkansas cotton production recommendation.

Five treatments were used (Table 1) in a randomized complete block design with three replications in 1993 and 1994. The shade shelters were made from PVC pipe with the black shade cloth, providing an approximately 63% reduction in sunlight. The shelters were 5 m^2 and 1.9 m tall.

Ten leaf blades and petioles from the uppermost fully-expanded main-stem leaves were sampled from each plot at 1300 h (CDT) at 2, 4, 6 and 8 days after the initiation of shade treatments in 1993 and 1994 and analyzed for mineral nutrients and nonstructural carbohydrates. At peak flower stage on 4 August 1997 (sunny day), petiole samples were collected at 800, 1300, 1600 and 1900 h to investigate diurnal change in petiole nutrient concentrations within a day.

RESULTS

Petiole NO_3-N, Phosphorus, Potassium and Sulfur Concentrations

Petiole NO_3-N, P, K and S concentrations declined sharply with plant age under normal growing conditions in the control (Table 2). Shade at any growth stage significantly increased petiole NO_3-N, P and K concentrations except petiole K at first flower (FF). Petiole S concentration of plants shaded at FF increased 46% whereas shading at the peak flower (PF) stage did not significantly affect the S concentration and plants shaded at the boll development (BD) stage showed a significant decline in petiole S concentration compared to unshaded control plants.

Petiole nutrient concentrations were also affected significantly by sampling times within a day (Table 3). Among the four sampling times, petioles at 1300 h and 1900 h exhibited the lowest and highest nutrient concentrations, respectively. The differences may be associated with the changes in light intensity within a day.

Leaf Total Nitrogen, Phosphorus, Potassium and Sulfur Concentrations

Under normal (unshaded) growing conditions, leaf total N, P and K concentrations showed a trend similar to that of petiole NO_3-N, P and K concentrations with a gradual decrease with increasing plant age. However, changes in the leaf N, P and K with increased plant age were much smaller than those in the petiole. Leaf S concentration remained almost constant during flowering and fruiting (Table 4).

Shading at any growth stage increased leaf total N (17 to 21%) and P (18 to 39%) concentrations (Table 4). Leaf K concentration for shaded cotton was also significantly higher than that of unshaded control plants except for the treatment of shade at the FF stage. Shade at PHS, FF and PF stages also increased the leaf S, Ca, and Mg concentrations, but shade at the BD stage did not significantly affect the concentrations of these three elements in leaves (data not shown).

Nonstructural Carbohydrate Concentrations and Carbon/Nitrogen Ratio

An eight-day period of shade significantly decreased total nonstructural carbohydrate (TNC) concentrations of leaves (Table 5). Averaged across the four growth stages of PHS, FF, PF and BD, the TNC concentrations of the leaves of shaded plants decreased by 56% compared to unshaded control plants. The C/N ratios of leaves of shaded cotton were significantly lower (65% decrease) than those of unshaded control plants. These results were associated with decreased photosynthesis and less carbon fixation under the low light conditions.

PRACTICAL APPLICATION

Petiole NO_3-N, P, K and S concentrations were significantly increased under shade conditions. Petiole nutrient status was also affected by sampling times within a day. Leaf nutrient status was affected in a manner similar to that of petioles, and nonstructural carbohydrate concentrations and C/N ratio decreased. The results of our studies show that carbohydrate concentrations and mineral nutrient status of field-grown cotton plants are very sensitive to light intensity. To improve the accuracy of tissue sampling for nutrient status, both weather conditions and diurnal sampling time must be considered.

REFERENCES

Pettigrew, W.T. 1994. Source-to-sink manipulation effects on cotton lint yield and yield components. Agron. J. 86: 731-735.

Pettigrew, W.T. 1995. Source-to-sink manipulation effects on cotton fiber quality. Agron. J. 87: 947-952.

Zhao, D. and Oosterhuis, D.M. 1994. Effects of shading on cotton photosynthesis, yield and yield components. *In* Proc. Arkansas Cotton Res. Meeting Ark. Agric. Exp. Stn., Special Report 166:131-135.

Zhao, D. and Oosterhuis, D.M. 1996. Effects of shading on fiber quality of field-grown cotton. *In* Proc. Arkansas Cotton Res. Meeting Ark. Agric. Exp. Stn., Special Report 178:92-95.

Table 1. Treatments showing the plant growth stage when shade was imposed in 1993 and 1994.

Treatments	Growth stages[z]			
	PHS	FF	PF(FF+12d)	BD(FF+24d)
1. Control	---[y]	---	---	---
2. Shade at PHS	S[x]	---	---	---
3. Shade at FF	---	S	---	---
4. Shade at PF	---	---	S	---
5. Shade at BD	---	---	---	S

[z]PHS, FF, PF and BD show pinhead square, first flower, peak flower and boll development stages, respectively. Shade treatment at the PHS stage was given only in 1994.

[y]No shade.

[x]Duration of an eight-day period of shade.

Table 2. Changes in petiole NO_3-N, P, K and S concentrations of unshaded control and shaded cotton plants with an eight-day period of shade at first flower (FF), peak flower (PF) and boll development (BD). Each value is the mean of 1993 and 1994 over four sampling times (2, 4, 6 and 8 days) in three replicates.

Growth stages	NO_3-N			P			K			S		
	Control	Shade		Control	Shade		Control	Shade		Control	Shade	
	---g DW/kg---											
FF	6.8	13.2	***	2.3	2.5	**	42	46	ns[z]	1.3	1.9	***
PF	1.6	3.6	*	1.8	2.2	***	22	30	***	0.9	1.0	ns
BD	0.1	0.2	**	1.1	1.2	0	11	15	**	0.8	0.7	*

*, ** and *** are significant at 0.05, 0.01 and 0.001 probability level, respectively.

[z]ns = Not significant.

Table 3. Effect of sampling time within a day on petiole nutrient concentrations in 1997. Samples were collected on 4 August (sunny day). Data are means ± SE of three replications.

Sampling time	Petiole Nutrient Concentration			
	NO_3-N	P	K	S
	---g DW/kg---			
800	3.8 ± 0.1 ab[z]	1.9 ± 0.6 a	48 ± 1 b	1.2 ± 0.2 a
1300	2.6 ± 0.6 b	1.5 ± 0.1 b	32 ± 1 c	0.8 ± 0.0 c
1500	4.1 ± 0.4 a	1.8 ± 0.4 a	48 ± 1 b	1.0 ± 0.0 b
1900	4.3 ± 0.4 a	2.0 ± 0.2 a	53 ± 1 a	1.2 ± 0.1 a

[z]The values with a same letter within a column are not significant ($P > 0.05$).

Table 4. Changes in leaf total N, P, K and S concentrations of unshaded control and shaded cotton plant with an eight-day period of shade at pinhead square (PHS), first flower (FF), peak flower (PF) and boll development (BD). Each value is the mean of 1993 and 1994 over four sampling times (2, 4, 6 and 8 days) in three replications.

Growth stages	Total N Control	Total N Shade		P Control	P Shade		K Control	K Shade		S Control	S Shade	
	-----------	-----------	-----------	-----------	g DW/kg	-----------	-----------	-----------	-----------	-----------	-----------	-----------
PHS	41	49	**	3.5	4.4	***	11.2	13.5	*	5.1	6.7	**
FF	39	46	***	3.8	4.9	****	8.6	8.3	ns[z]	5.5	7.4	****
PF	31	37	***	3.2	4.5	****	7.4	9.6	**	5.2	6.2	****
BD	27	32	***	2.6	3.1	**	5.5	7.0	**	5.5	5.6	ns

*, **, *** and **** are significant at 0.05, 0.01, 0.001 and 0.0001 probability level, respectively.

[z]ns = Not significant.

Table 5. Effects of an eight-day shade period on total nonstructural carbohydrate (TNC) and N concentrations of the leaves. Data are means ± SE of the results from the four growth stages of pinhead square, first flower, peak flower and boll development stages for 1993 and 1994.

Treatments	TNC	Total N	C/N ratio[z]
	-----------	g DW/kg	-----------
Control	234 ± 22**[y]	34.5 ± 1.5	6.8 ± 0.2**
Shade	103 ± 22	41.0 ± 1.8**	2.4 ± 0.4

[z]C/N ratio=total nonstructural carbohydrate concentration/total N concentration.

[y] ** significant at the 0.01 probability level between two treatments.

MEETING NITROGEN AND POTASSIUM REQUIREMENTS IN COTTON USING A PROGRAMMED RELEASE SOIL FERTILIZER

Derrick Oosterhuis and Adele Steger

RESEARCH PROBLEM

Current fertilizer practices involve applying fertilizer to the soil at or prior to planting with additional applications early in 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 the field. The objectives of the current research were to evaluate a new polyolefin-coated, Meister programmed-release nitrogen (MPR N) and potassium (MPR K) fertilizer for use in cotton production. These fertilizer products release their nutrients in response to increasing soil temperatures during the growing season, coinciding with increasing crop nutrient requirements. The product has the potential advantages of 1) reducing groundwater contamination, 2) providing a single fertilizer application, 3) customizing fertilizer application according to crop requirements for increased efficiency and 4) providing a more efficient return per dollar spent on fertilizer.

BACKGROUND INFORMATION

Fertilizer management is an important component of successful cotton production. Both N and K are required in differing amounts during the season for optimum growth and development. Traditionally, N fertilizer is applied at planting and sidedressed at early squaring. Potassium is supplied by preplant soil applications and, if necessary, mid-season sidedress or foliar applications. Due to potential problems with salinity and seedling growth, the entire amount of fertilizer cannot be placed at planting. MPR fertilizers, applied in-furrow at planting, are designed to increase nutrient availability in accordance with soil temperatures and seasonal demand. This study was designed to provide a field evaluation of two programmed-release, soil-applied fertilizers. The product's polyolefin coating is designed to release the nutrient according to an increase in soil temperature, which coincides with maximum crop N and K uptake.

RESEARCH DESCRIPTION

The two studies were conducted at the Southeast Branch Station in Rohwer, Arkansas, in 1996 and 1997. The cotton cultivar Suregrow 125 was planted into a moderately well-drained Hebert silt loam soil (fine-silty, mixed, mesic Typic Fragiudult) on 6 May 1996 and 7 May 1997. 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. Petiole analysis for N and K was conducted weekly from pinhead square to four weeks after first flower using 5 petioles/plot, pooled across replications. Maximum and minimum air temperatures were recorded daily. Soil temperature at the 6-in. depth was recorded daily. The center two rows of each plot were machine harvested at 60% open boll. Fertilizer treatments are listed in Table 1.

RESULTS

Meister Programmed-Release Nitrogen

There were no significant differences in lint yield among the treatments in 1996 (Table 2). However, there was a trend towards numerically higher (4%) yields in both years in the treatment receiving 80% MPR N when compared with the 100% control treatment. In 1997, lint yield was significantly higher (P = 0.05) in the 80% MPR N treatment compared with the 100% conventional N treatment. Figure 1 shows that fertilizer N rate could be reduced to between 60 and 40% of the recommended rate using the MPR N fertilizer without any detrimental effect on yield. The MPR N treatments had a higher concentration of N in petioles from pinhead square through first flower (data not shown), indicating a greater release of nutrients in response to increasing plant demand and to increasing soil temperatures according to the formulation of the polyolefin coating.

Meister Programmed-Release Potassium

Meister Programmed-Release potassium fertilizer showed potential because there was not a reduction in yield compared to the control with reduced MPR K rates down to 60% in 1996 and 40% in 1997 of the conventional K treatment (Table 3). The 100% control and the 40% MPR K treatments had higher yields, 10 and 9%, respectively, than the 100% MPR K treatment in 1996. In 1997, lint yield was numerically highest in the 80% MPR K treatment. Fiber quality (HVI) results from the K study in 1996 showed a significantly higher (P = 0.05) fiber elongation in the treatments receiving MPR K when compared with the control (data not shown).

PRACTICAL APPLICATIONS

This study provides data showing the potential use of MPR fertilizers in cotton production. There was a yield advantage from the 80% MPR N fertilizer compared to the conventional control. Furthermore, there was evidence in 1997 that, by using MPR N, the total quantity of N fertilizer could be reduced by 40% without a yield decrease below the conventionally applied fertilizer. There was a similar trend with MPR K. Meister Programmed-Release N and K fertilizers have the potential to decrease groundwater contamination and to increase nutrient uptake efficiency. There is also the advantage of a single fertilizer application reducing field traffic.

ACKNOWLEDGMENT

The authors gratefuly acknowledge the support of Helena Chemicals.

Table 1. Treatments for evaluating Meister Programmed-Release nitrogen (N) and potassium (K) fertilizers in Arkansas.

	Nitrogen Study		Potassium Study	
Treatment	1996	1997	1996	1997
	--------lb N/acre-------		--------lb P/acre-------	
100% Control	110[z]	110	50[y]	50
100% Meister	110	100	50	50
80% Meister	87	87	39	39
60% Meister	65	65	29	29
40% Meister[x]	---	43	---	19
60% Control	---	65	---	29

[z] NH_4NO_3 used as an N source.
[y] KCl used as a K source.
[x] Treatments not tested in 1996.

Table 2. Effect of Meister Programmed-Release nitrogen (N) fertilizers on lint yield in 1996 and 1997.

	Lint Yield		Boll Weight	
Treatment	1996	1997	1996	1997
	----------lb/acre---------		-----------g/boll---------	
100% Control	1625	1294[z]	5.13	6.12
100% MPR N	1556	1446	5.04	5.87
80% MPR N	1687	1511[z]	5.07	6.14
60% MPR N	1669	1412	4.93	6.10
40% MPR N[y]	---	1333	---	6.17
60% Control[y]	---	1383	---	6.20
LSD (P = 0.05)	NS	232	NS	NS

[z] Significant at the 0.05 probability level.
[y] Treatments not tested in 1996.

Table 3. Effect of Meister Programmed-Release potassium (K) fertilizers on lint yield in 1996 and 1997.

Treatment	Lint Yield 1996	Lint Yield 1997	Boll Weight 1996	Boll Weight 1997
	---------lb/acre--------		----------g/boll---------	
100% Control	1643[z]	1396	5.04	5.97
100% MPR N	1484[z]	1445	4.91	6.10
80% MPR N	1526	1514	4.61	6.09
60% MPR N	1630[z]	1353	4.99	6.53[z]
40% MPR N[y]	---	1461	---	6.26
60% Control[y]	---	1381	---	5.86[z]
LSD (*P*=0.05)	130	NS	NS	0.6

[z]Significant at the 0.05 probability level.
[y]Treatments not tested in 1996.

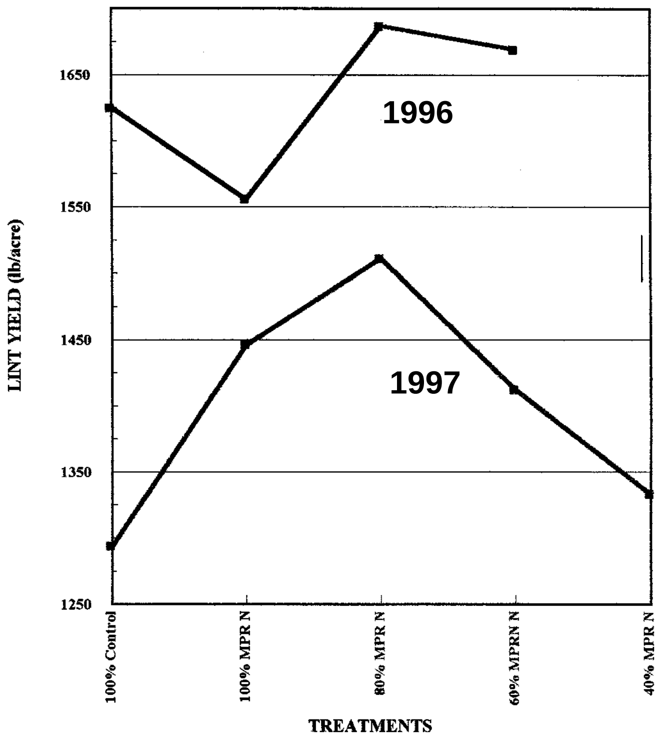

Fig. 1. Effect of rates of nitrogen (N) fertilizer as Meister Programmed-Release N and conventionally fertilized control on lint yield in 1996 and 1997.

NITROGEN FERTILIZATION OF ULTRA-NARROW-ROW COTTON: A PILOT STUDY

J.S. McConnell, L.D. Earnest and R.C. Kirst, Jr.

RESEARCH PROBLEM

Ultra-narrow-row cotton (*Gossypium hirsutum* L.) represents a unique development in cotton production for Arkansas. Ultra-narrow-row (UNR) cotton is a drill-planted, stripper-harvested, non-irrigated, low-input production system designed to maximize economic returns. Research that provides information on production parameters is scant. Optimum nitrogen (N) fertilization rates and how UNR cotton utilizes N are unknown. The objective of this pilot study was to gain experience with UNR cotton production and to determine how UNR cotton would respond to N fertilization.

BACKGROUND INFORMATION

Recently, interest in UNR cotton production has increased. It has long been known that plants grown in very narrow rows intercept and utilize sunlight more efficiently than plants in conventional rows. Potential benefits of UNR cotton production include reduced production costs (irrigation, insecticide application and harvest equipment), utilization of poorer soils, decreased soil erosion and utilization of the same equipment for cotton, soybeans and cereal crops. Potential drawbacks of UNR cotton include the following: weed pressure is increased in low stand areas, different equipment is required (precision drill planter, finger stripper harvester), and lint quality may decline. Variety differences, fertility requirements, effect of planting date and many other production parameters for optimum growth and yield of UNR cotton grown in Arkansas are unknown.

RESEARCH DESCRIPTION

A block of UNR cotton was planted 19 May 1997 at the Southeast Branch Experiment station at Rohwer, Arkansas, with a John Deere 750 drill. Fertilizer treatments of 100 lb urea-N/acre, 100 lb Meister-N/acre, 50 lb urea-N/acre and 0 lb N/acre were strip applied with a fertilizer buggy just prior to squaring. The measurements taken on the UNR cotton included seedcotton yield plant height, plant population, boll load and boll weight. All data were analyzed using the

Statistical Analysis System (SAS). F-tests and least significant differences (LSD) were calculated at the $\alpha = 0.05$ level of probability.

RESULTS

UNR cotton fertilized with either 50 or 100 lb N/acre, regardless of N source, did not differ in yield (Table 1). Cotton receiving no N fertilizer was significantly lower yielding than cotton that received N fertilizer. Tallest plants were found in plots receiving 100 and 50 lb N/acre. The unfertilized cotton was shortest while the 100-lb Meister-N/acre cotton was intermediate in height. Although plant populations were found to differ by as much as 32,000 plants/ acre, no significant differences were found as a function of N treatment. Boll load and boll weight were both greatest and not significantly different for the fertilized UNR cotton and lowest for the untreated cotton.

PRACTICAL APPLICATION

The results from this test are preliminary. Final conclusions should not be drawn from these data. The response of UNR cotton to N fertilization treatments indicates that the N required for maximum yield will be less than that for cotton grown in conventionally spaced rows. Yields were not found to increase with N rates above 50 lb N/acre. Additionally, the 50-lb N/acre treatment was found to maximize both the boll load and the boll weight. The parameters measured in this study indicate that the growth and management of UNR cotton may be substantially different from those of conventionally grown cotton.

This study should be continued and expanded to more accurately determine the impact of N fertilization on UNR cotton. Parameters such as timing of N, sources of N and N application methods should be examined.

Table 1. Seedcotton yield, plant height, plant population, boll load and boll weight of cotton growth in ultra narrow rows with 0, 50 and 100 lb urea-N/acre and with 100 lb N (Meister)/acre at the Southeast Branch Experiment Station near Rohwer, Arkansas, in 1997.

N-Rate	Seedcotton Yield	Plant Height	Plant Population	Boll Load	Boll Weight
lb N/acre	lb/acre	in.	plt/acre	boll/acre	g/boll
100 (M)	2,938	24.9	115,360	393,675	3.36
100	3,008	31.3	140,368	392,869	3.44
50	3,333	29.9	108,099	416,263	3.58
0	1,529	20.4	118,587	242,820	2.87
$LSD_{(0.05)}$	1,099	6.1	NS	119,875	0.38

TIMING OF EARLY-SEASON NITROGEN FERTILIZATION OF COTTON

J.S. McConnell and W.H. Baker

RESEARCH PROBLEM

The recommended timing of early-season nitrogen (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 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 pre-plant 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 furrow-irrigated and dryland conditions. First N applications were made approximately two to four weeks pre-plant. 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 in 1995 but much greater in yield in 1996 (data not shown).

Trends in the response to the N treatments were similar in the irrigated and dryland blocks in 1995 and the irrigated block in 1996 (Table 1). Treatments did not significantly affect yields in dryland cotton in 1996 The unfertilized control was the lowest yielding treatment. The 100 lb N/acre pre-plant 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 pre-plant treatment. A possible explanation for the ineffectiveness of the pre-plant treatments is the spring weather conditions. Rainy, 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 pre-plant treatments to be less effective than N fertilizer applied later 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 pre-plant applications. Because these are preliminary results, testing should be continued before final conclusions are drawn.

LITERATURE CITED

Bonner, C.M. 1995. 1995 Cotton production recommendations. Univ. Of Ark. Coop. Ext. Serv. AG422-4-95.

ACKNOWLEDGMENTS

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

Table 1. Lint yield response of cotton grown with early-season soil-applied nitrogen (N) treatments under furrow irrigation and dryland conditions in 1995 and 1996.

Soil N-Rate			1995		1996	
PP[z]	AE	FS	Irrigated	Dryland	Irrigated	Dryland
----lb N/acre----			-----lb lint/acre-----			
0	50	50	1068	909	1747	1308
50	0	50	990	877	1721	1263
0	0	100	1086	915	1602	1293
0	100	0	1020	869	1475	1203
100	0	0	714	718	1267	1336
0	0	0	707	681	983	1069
LSD $_{(0.05)}$			158	145	173	NS

[z]Pre-plant (PP), after emergence (AE), first square (FS).

FOLIAR NITROGEN FERTILIZATION OF COTTON IN SOUTHEASTERN ARKANSAS

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

RESEARCH PROBLEM

Early-season, soil-applied nitrogen (N) fertilizer may not meet the 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 pre-plant 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, 1995 or 1996, the foliar N treatments significantly increased yields (Tables 2, 3 and 4). Trends in the 1994 through 1996 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, 3 and 4). 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 dependant on soil-applied N fertilizer. Because these results are preliminary, testing should be continued before final conclusions are drawn.

LITERATURE CITED

Maples, R.L., and W.H. Baker. 1993. Foliar and soil applications of nitrogen for cotton during the growing season: Yield response. Univ. of Ark. Agric. Exp. Sta. Bull. 938.

Parker, P.W., W.H. Baker, J.S. McConnell and J.J. Varvil. 1993. Cotton response to foliar nitrogen applications. Proc. Beltwide Cotton Conf. pp. 1364-1365.

Snyder, C.S. 1991. Summary report of the 1991 Arkansas nutrient monitoring participant survey. Univ. of Ark. Coop. Ext. Serv. Pub.

ACKNOWLEDGMENTS

Support for this research was provided by Cotton, Inc.

Table 1. Lint yield response of cotton grown with 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[z]	FS	FF	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
$LSD_{(0.05)}$[y]			216			204		
$LSD_{(0.05)}$[x]			351			334		

[z]Pre-plant (PP), first square (FS) and first flower (FF).

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

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

Table 2. Lint yield response of cotton grown with 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[z]	FS	FF	Fol	Untrt	Mean	Fol	Untrt	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	
$LSD_{(0.05)}$[x]			351			NS		

[z]Pre-plant (PP), first square (FS) and first flower (FF).

[y]No significant soil N x foliar N interactions were observed.

[x]$LSD_{(0.05)}$ for comparing foliar applied fertilization treatment means.

Table 3. Lint yield response of cotton grown with 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[z]	FS	FF	Fol[y]	Untrt	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
LSD $_{(0.05)}$[x]					127			
LSD $_{(0.05)}$[w]						240		
LSD $_{(0.05)}$[v]						193		
Mean			1276	1217		856	892	
LSD $_{(0.05)}$[u]			28					

[z]Pre-plant (PP), first square (FS) and first flower (FF).
[y]No significant soil N X foliar N interactions were observed.
[x]LSD for comparing soil N treatment means in the irrigated test.
[w]LSD for comparing foliar N means in the same soil N treatment in the dryland test.
[v]LSD for comparing foliar N means in different soil N treatments in the dryland test.
[u]LSD for comparing foliar fertilization means in the irrigated test.

Table 4. Lint yield response of cotton grown with 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 1996.

Soil N-Rate			Irrigated			Dryland		
PP[z]	FS	FF	Fol[y]	Untrt	Mean	Fol	Untrt	Mean
---lb N/acre---			---lb lint/acre---					
75	75	0	1604	1630	1617	1043	1067	1055
50	50	50	1517	1543	1530	939	1116	1027
30	60	60	1660	1578	1619	1013	1078	1045
60	60	0	1671	1522	1597	1010	1035	1021
40	40	40	1675	1589	1627	1090	1164	1127
45	45	0	1610	1495	1552	1105	1050	1078
30	30	30	1615	1527	1571	1047	1126	1086
30	30	0	1575	1652	1613	1103	1059	1081
15	15	0	1416	1167	1291	1107	1048	1074
0	0	0	1102	868	998	843	752	802
LSD $_{(0.05)}$[x]					164			
LSD $_{(0.05)}$[w]							214	
LSD $_{(0.05)}$[v]							447	
Mean			1542	1469		1028	1056	
LSD $_{(0.05)}$[u]			55					

[z]Pre-plant (PP), first square (FS) and first flower (FF).
[y]No significant soil N X foliar N interactions were observed.
[x]LSD for comparing soil N treatment means in the irrigated test.
[w]LSD for comparing foliar N means in the same soil N treatment in the dryland test.
[v]LSD for comparing foliar N means in different soil N treatments in the dryland test.
[u]LSD for comparing foliar fertilization means in the irrigated test.

Table 5. Selected petiole NO_3^--N responses of irrigated cotton grown with soil-applied nitrogen (N) fertilization rates with an additional foliar 30 lb N/acre (Fol N) in 1993, 1994, 1995 and 1996.

Soil N-Rate				Sample Period						
PP[z]	FS	FF	Fol N	1	2	3	4	5	6	7
---lb N/acre---				---ppm NO_3^--N---						
1993										
50	50	50	Yes	18,765	6,771	10,100	7,074	12,242	6,771	949
50	50	50	No	19,339	5,898	10,378	4,175	10,663	5,898	1,039
45	45	0	Yes	14,652	5,281	6,789	3,009	2,211	5,281	581
45	45	0	No	11,747	5,480	7,210	1,190	516	5,480	578
0	0	0	Yes	3,440	968	1,440	410	348	968	287
0	0	0	No	8,491	2,014	1,546	2,055	4,455	2,014	287
1994										
50	50	50	Yes	10,166	10,715	11,072	13,901	8,104	2,912	393
50	50	50	No	7,378	8,231	7,978	13,201	8,116	3,201	300
45	45	0	Yes	4,639	6,193	3,643	1,460	227	101	268
45	45	0	No	3,768	5,266	2,564	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	11,190	13,720	7,453	11,374	4,338	2,399	674
50	50	50	No	15,071	13,024	5,657	7,639	4,220	552	161
45	45	0	Yes	11,201	7,848	1,380	522	321	122	66
45	45	0	No	——	8,109	810	500	565	16	20
0	0	0	Yes	1,321	1,159	447	20	591	64	20
0	0	0	No	879	3,364	14	20	96	9	14
1996										
50	50	50	Yes	10,744	11,443	8,631	8,421	7,816	4,425	1,913
50	50	50	No	10,341	9,631	4,727	6,546	4,544	2,268	459
45	45	0	Yes	9,816	9,639	4,062	1,243	671	314	66
45	45	0	No	9,090	7,506	1,821	878	571	68	155
0	0	0	Yes	207	258	371	359	168	21	66
0	0	0	No	975	256	268	304	168	21	13

[z]Pre-plant (PP), first square (FS) and first flower (FF).

IRRIGATION METHODS AND NITROGEN FERTILIZATION RATES IN COTTON PRODUCTION

J.S. McConnell, W.H. Baker and R.C. Kirst, Jr.

RESEARCH PROBLEM

Management of nitrogen (N) and irrigation are two very 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, Rohwer, Arkansas, on an Hebert silt loam soil. The experimental design was a split block with irrigation methods as the main blocks (Table 1). N rates were tested within each irrigation method. Five irrigation methods were used from 1988 to 1993 (Table 1), but only three 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 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 in 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 the 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 with irrigated production conditions than with 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

Guinn, G., J.R. Mauney, and K.E. Fry. 1981. Irrigation scheduling effects on growth, bloom rates, boll abscission and yield of cotton. Agron. J. 73:529-534.

Maples, R., and J. G. Keogh. 1971. Cotton fertilization studies on loessial plains soils of eastern Arkansas. Univ. of Ark. Agric. Exp. Sta. Bull. 825.

McConnell, J. S., B. S. Frizzell, R. L. Maples, and G. A. Mitchell. 1988. Relationships of irrigation methods and nitrogen fertilization rates in cotton production. Univ. of Ark. Agric. Exp. Sta. Rep. Ser. 310.

ACKNOWLEDGMENTS

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 Method	Duration	Tensiometer Threshold	Tensiometer Depth	Water Applied
		cbar	in.	in.
High Frequency	Planting to P.B.[z]	35	6	0.75
Center Pivot	P.B. to Aug. 15	35	6	1.00
Mod. 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	---	---	---

[z]P.B. = Peak bloom

Table 2. Lint yield response of cotton to five irrigation methods in 1988, 1990-1996.

Method	1988	1990	1991	1992	1993	1994	1995	1996
	lb/acre							
High Frequency Center Pivot	1567	1118	1051	1181	1103	1317	1113	1344
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	1463
Dryland	1271	915	1308	1246	1067	1353	892	1057
LSD $_{(0.05)}$	159	67	77	66	66	83	59	108

what about 1996???

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, 1995 and 1996.

N Rate							
PP[z]	FS	FF	LF[y]	MF	JF	FI	DL
---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
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 $_{(0.05)}$							

continued

Table 3. continued.

N Rate							
PP[z]	FS	FF	LF[y]	MF	JF	FI	DL
---lb N/acre----			----------------------------lb lint/acre--------------------------------				
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	
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 bc	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

continued

Table 3. continued.

N Rate PP[z]	FS	FF	LF[y]	MF	JF	FI	DL
---lb N/acre----			----------------------------		lb lint/acre	-------------------------------	
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
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
1996							
75	75	0	——	——	1315 c	1630 a	1067 a
50	50	50	——	——	1411 a-c	1543 a	1116 a
30	60	60	——	——	1331 bc	1572 a	1078 a
60	60	0	——	——	1383 a-c	1522 a	1035 a
40	40	40	——	——	1431 ab	1576 a	1174 a
45	45	0	——	——	1382 a-c	1495 a	1050 a
30	30	30	——	——	1440 ab	1527 a	1059 a
30	30	0	——	——	1461 a	1633 a	1059 a
15	15	0	——	——	1309 c	1167 d	1048 a
0	0	0	——	——	979 d	868 c	752 b
LSD $_{(0.05)}$			——	——	114	251	155

[z]Pre-plant (PP), first square (FS) and first flower (FF).

[y]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 1989, 1990, 1991, 1992, 1993, 1994 and 1995.

Method	1989	1990	1991	1992	1993	1994	1995	1996[z]
	----------	----------	----------	----------	%	----------	----------	----------
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	——

[z] Plots were treated with ethephon at the boll opening rate and harvested one time.

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