Wayne E. Sabbe
ARKANSAS
SOIL FERTILITY STUDIES
•2001•

Nathan A. Slaton, Editor

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WAYNE E. SABBE ARKANSAS SOIL FERTILITY STUDIES – 2001 –

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SUMMARY

Rapid technological changes in crop management and production require that the research efforts also be presented in an expeditious manner. The contributions of soil fertility and fertilizers are major production factors in all Arkansas crops. The studies contained within will allow producers to compare their practices with the university's research efforts. Additionally, soil test data and fertilizer sales are presented to allow comparisons among years, crops, and other areas within Arkansas.

INTRODUCTION

The 2001 Soil Fertility Studies include research reports on numerous Arkansas commodities and on several research areas including topics associated with precision agriculture. For more information on any topic, please contact the author(s). Also included is a summary of soil test data from samples submitted for the 2001 growing season. This set of data includes data for counties, soil association physiographic areas, and selected cropping systems.

Funding for the associated soil fertility research programs came from commodity check-off funds, state and federal sources, 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.

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SOIL TEST AND FERTILIZER SALES DATA: SUMMARY FOR THE GROWING SEASON – 2001 –

R.E. DeLong, S.D. Carroll, N.A. Slaton, and W.H. Baker

BACKGROUND INFORMATION

Soil test data from samples submitted to the University of Arkansas Soil Test Lab in Marianna during the period 1 September 2000 through 30 August 2001 were categorized according to geographic area, county, soil association number (SAN), and selected cropping systems. This period roughly corresponds to the 2001 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 (Base 4-R-38034, USDA, and University of Arkansas AES, Fayetteville, AR, December 1982). Descriptive statistics of the soil test data were calculated for categorical ranges for pH, phosphorus (P), potassium (K), nitrate-nitrogen (NO_3-N), and soluble salts (i.e., electrical conductivity, EC). Soluble salts and NO3-N can be indicators of adverse soil conditions that result in poor plant growth or leaching potentials. Routine analysis of NO_3-N on all soil samples was discontinued in March 2001. Soil NO_3-N is still determined on samples for corn, cotton, and all garden categories. Otherwise, soil NO_3-N is performed only upon request. Soil pH and soil test (Mehlich III) P and K values indicate the relative level of soil fertility.

RESULTS

Crop Acreage and Soil Sampling Intensity

During the interval from 1 September 2000 through 30 August 2001, 101,373 soil samples were analyzed in the University of Arkansas Soil Testing Program in Marianna. Over 8% of the total samples were the 8,448 standard checks used to ensure quality control. The 51,620 soil samples representing a total of 1,338,739 acres that were included in the report had complete data for the county, soil association number, last crop produced, geographic area, total acres, pH, P, K, EC, and month/day/year categories. Samples that did not have values in all of those categories were not included in this report. Over 77% of the excluded samples were from grid samples with special, research, and out-of-state comprising 23% of the excluded samples where only an analysis (no recommendations) was requested. Soil samples from the Bottom Lands and Terraces and Loessial Plains, primarily row crop areas, represented 53% of the total samples and 74% of the total acreage (Table 1). The county average ranged from 3 to 76 acres/sample (Table 2). Only 50 soil samples were submitted from Nevada County. In contrast, 3,705 samples were submitted from Arkansas County.

Soil association numbers show that most samples were taken from row crops and pasture (Table 3). The SAN that was most frequently associated with each commodity was SAN=44 for soybean, SAN=32 for cotton, SAN=44 for rice, SAN=45 for wheat, and SAN=15 for warm- and SAN=4 for cool-season hay and pasture production.

The crops involved indicate that, in addition to row crops and pastures, turf and garden enterprises contributed largely to the number of samples submitted, but represented a small percentage of the total acreage (Table 4).

Soil Test Data

Information in Tables 5, 6, 7, and 8 pertain to the fertility status of Arkansas soils as categorized by geographic area, county, SAN, or the crop intended for production in 2001, respectively. The soil test values relate to the potential 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 factors such as location, topography, and cropping system. Likewise, soil test values among counties cannot be realistically compared without knowledge of the SAN and a profile of the local cropping systems. Soil test data for cropping systems can be carefully compared; however, the specific cropping systems often dictate past fertilizer practices or may be unique to certain soils that would influence the current soil test values. For example, cotton has a history of intensive fertilization whereas soybean has not been subjected to intensive fertilization. Similarly, rice is commonly grown on soils low in P and K, and those soil test values for the commodity reflect these trends. The majority of Arkansas soils have a pH>5.5, but <6.5. The accumulation of soluble salts and NO_3-N is low for Arkansas soils with 76 and 56% for each in the lowest category, respectively.

Table 8 contains the median (Md) for each of the cropping system categories. The Md is the value that has an equal number of higher and lower observations and thus is a better overall indicator of a soil's fertility status than a mean value. 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 for row crops are for cotton.

Fertilizer consumption by county (Table 9) and by fertilizer nutrient and formulation (Table 10) for Arkansas illustrate the wide use of fertilizer predominantly in row-crop counties and in nitrogen and bulk forms.

PRACTICAL APPLICATIONS

The data presented, or more specific data, can be used in county or commodity-specific educational programs on soil fertility and fertilization practices. Comparisons of annual soil test information can also document trends in fertilization practices or critical areas where additional research may be required.

ACKNOWLEDGMENT

Financial support from the Arkansas Fertilizer Tonnage Fee is appreciated.

Table 1. Sample number and total acreage by geographic area for samples submitted to the University of Arkansas Soil Testing Lab in Marianna from September 2000 through August 2001.

Geographic area	Acres sampled	No. of samples	Acres/ sample
Ozark Highland - Cherty Limestone and Dolomite	137,811	7,820	18
Ozark Highland - Sandstone and Limestone	7,200	367	20
Boston Mountain	25,097	1,668	15
Arkansas Valley and Ridges	78,398	6,098	13
Ouachita Mountain	25,811	3,555	7
Bottom Land and Terrace	550,905	17,311	32
Coastal Plain	52,024	3,107	17
Loessial Plain	437,463	10,126	43
Loessial Hill	21,976	1,456	15
Blackland Prairie	2,054	112	18

Table 2. Sample number and total acreage by county forsamples submitted to the University of Arkansas Soil Testing Lab in Marianna from September 2000 through August 2001.

County	Acres sampled	No. of samples	Acres/ sample	County	Acres sampled	No. of samples	Acres/ sample
Arkansas, DeWitt	78,468	1,709	46	Lee	73,830	1,259	59
Arkansas, Stuttgart	84,333	1,996	42	Lincoln	14,184	399	36
Ashley	31,793	1,131	28	Little River	5,965	121	49
Baxter	1,778	364	5	Logan, Booneville	2,720	170	16
Benton	26,424	1,613	16	Logan, Paris	6,773	360	19
Boone	6,098	416	15	Lonoke	81,067	2,103	39
Bradley	733	150	5	Madison	15,379	971	16
Calhoun	601	55	11	Marion	2,407	173	14
Carroll	7,781	361	22	Miller	24,052	504	48
Chicot	23,051	305	76	Mississippi, Blytheville	30,216	900	34
Clark	1,811	200	9	MississippiOsceola	4,653	84	55
Clay, Corning	23,899	1,046	23	Monroe	53,912	1,028	52
Clay, Piggott	18,762	574	33	Montgomery	1,592	116	14
Cleburne	5,150	365	14	Nevada	993	50	20
Cleveland	512	76	7	Newton	2,704	197	14
Columbia	1,742	273	6	Ouachita	280	90	3
Conway	10,563	470	23	Perry	4,003	190	21
Craighead	74,326	2,690	28	Phillips	16,797	1,111	15
Crawford	4,607	408	11	Pike	4,087	229	18
Crittenden	39,120	1,241	32	Poinsett	33,841	944	36
Cross	84,816	1,514	56	Polk	4,115	387	11
Dallas	406	58	7	Pope	30,296	1,212	25
Desha, Dumas	271	12	23	Prairie, Des Arc	17,826	436	41
Desha, McGehee	24,749	1,973	13	Prairie, DeValls Bluff	6,328	238	27
Drew	2,471	273	9	Pulaski	8,112	1,735	5
Faulkner	3,761	505	8	Randolph	19,264	926	21
Franklin, Charleston	1,347	48	28	Saline	938	240	4
Franklin, Ozark	3,532	224	16	Scott	2,257	64	35
Fulton	3,616	190	19	Searcy	7,793	415	19
Garland	1,995	794	3	Sebastian, Fort Smith	2,969	570	5
Grant	424	84	5	Sebastian, Greenwood	932	99	9
Greene	32,447	1,399	23	Sevier	6,565	247	27
Hempstead	4,201	214	20	Sharp	3,061	212	14
Hot Spring	1,934	133	15	St. Francis	13,798	424	33
Howard	5,053	354	14	Stone	2,264	208	11
Independence	6,481	365	18	Union	1,512	259	6
Izard	5,415	284	19	Van Buren	5,470	379	14
Jackson	15,054	373	40	Washington	54,619	2,704	20
Jefferson	43,378	1,328	33	White	22,017	1,773	12
Johnson	6,718	485	14	Woodruff	6,741	132	51
Lafayette	7,127	281	25	Yell, Danville	5,393	294	18
Lawrence	37,318	1,182	32	Yell, Dardanelle	2,948	151	20

Table 3. Sample number and total acreage by soil association number for soil samples submitted to the University of Arkansas Soil Testing Lab in Marianna from September 2000 through August 2001.

Soil Association Number - Soil Association	Acres sampled	No. of samples	Acres/sample
1-Clarksville-Nixa-Noark	23,442	1,506	16
2-Gepp-Doniphan-Gassville-Agnos	23,687	1,506	16
3-Arkana-Moko	10,271	590	17
4-Captina-Nixa-Tonti	75,490	3,988	19
5-Captina-Doniphan-Gepp	1,909	67	29
6-Eden-Newnata-Moko	3,012	163	19
7-Estate-Portia-Moko	1,806	141	13
8-Brockwell-Boden-Portia	5,394	226	24
9-Linker-Mountainburg-Sidon	11,005	522	21
10-Enders-Nella-Mountainburg-Steprock	14,092	1,146	12
11-Falkner-Wrightsville	456	36	13
12-Leadvale-Taft	19,985	1,966	10
13-Enders-Mountainburg-Nella-Steprock	8,797	480	18
14-Spadra-Guthrie-Pickwick	1,648	115	14
15-Linker-Mountainburg	47,512	3,501	14
16-Carnasaw-Pirum-Clebit	8,972	2,258	4
17-Kenn-Ceda-Avilla	4,068	270	15
18-Carnasaw-Sherwood-Bismarck	7,487	757	10
19-Carnasaw-Bismarck	1,407	77	18
20-Leadvale-Taft	1,404	68	21
21-Spadra-Pickwick	2,473	125	20
22-Foley-Jackport-Crowley	104,330	3,407	31
23-Kobel	44,913	856	53
24-Sharkey-Alligator-Tunica	35,172	1,054	33
25-Dundee-Bosket-Dubbs	99,803	3,024	33
26-Amagon-Dundee	35,252	1,125	31
27-Sharkey-Steele	5,139	163	32
28-Commerce-Sharkey-Crevasse-Robinsonville	24,396	1,010	24
29-Perry-Portland	48,513	2,351	21
30-Crevasse-Bruno-Oklared	715	30	24
31-Roxana-Dardanelle-Bruno-Roellen	12,307	373	33
32-Rilla-Hebert	113,986	3,303	35
33-Billyhaw-Perry	16,147	349	46
34-Severn-Oklared	9,208	218	42
35-Adaton	269	9	30
36-Wrightsville-Louin-Acadia	405	19	21
37-Muskogee-Wrightsville-McKamie	350	20	18
38-Amy-Smithton-Pheba	4,405	139	32
39-Darco-Briley-Smithdale	733	52	14
40-Pheba-Amy-Savannah	4,615	418	11
41-Smithdale-Sacul-Savannah-Saffell	8,632	1,003	9
42-Sacul-Smithdale-Sawyer	25,830	1,123	23
43-Guyton-Ouachita-Sardis	7,809	372	21
44-Calloway-Henry-Grenada-Calhoun	252,785	5,952	43
45-Crowley-Stuttgart	184,678	4,174	44
46-Loring	6,360	229	28
47-Loring-Memphis	15,494	1,218	13
48-Brandon	122	9	14
49-Oktibbeha-Sumter	2,054	112	18

Table 4. Sample number and total acreage by crop for soil samples submitted to the University of Arkansas Soil Testing Lab in Marianna from September 2000 through August 2001.

Crop	Acres sampled	No. of samples	Acres/ sample
Soybean - dryland	51,244	1,340	38
Soybean - irrigated	509,984	12,094	42
Cotton	228,352	7,180	32
Rice	79,912	1,957	41
Wheat	20,627	632	33
Double-crop wheat-soybean - dryland	5,897	150	39
Double-crop wheat-soybean - irrigated	10,796	279	39
Warm season grass - establish	9,560	519	18
Warm season grass - maintain	114,361	5,087	23
Cool season grass - establish	16,735	791	21
Cool season grass - maintain	71,185	2,842	25
Grain sorghum	14,410	328	44
Corn	29,226	635	46
All garden	8,909	3,179	3
Turf and ground cover	12,481	5,253	2
Fruit and nut	1,289	455	3
Vegetable	340	23	15
Other	153,431	8,876	17

Table 5. Soil test data by geographic area for soil samples submitted to the University of Arkansas Soil Testing Lab in Marianna from September 2000 through August 2001.

	pH			P[z] (lb/acre)					K[z] (lb/acre)				EC[y] (:mhos/cm)		
Geographic area	<5.5	5.5-6.5	>6.5	<26	26-44	45-100	101-300	>300	<176	176-220	221-350	>350	<100	100-500	>500
	Percentage of sampled acreage														
Ozark Highlands - Cherty Limestone and Dolomite	13	57	30	5	9	23	35	28	23	12	27	38	62	36	2
Ozark Highlands - Sandstone and Limestone	16	53	31	17	17	29	25	12	34	15	25	26	77	22	1
Boston Mountains	16	65	19	6	9	25	37	23	27	13	29	31	74	25	1
Arkansas Valley and Ridges	21	58	21	11	14	24	34	17	33	15	26	26	71	28	1
Ouachita Mountains	27	54	19	7	14	22	33	24	39	17	27	17	73	26	1
Bottom Lands and Terraces	5	46	49	8	17	47	26	2	18	15	36	31	81	19	0
Coastal Plain	25	56	19	14	12	20	32	22	46	14	23	17	81	18	1
Loessial Plains	6	35	59	21	35	35	8	1	37	24	27	12	82	18	0
Loessial Hills	10	50	40	20	22	35	19	4	27	15	34	24	69	31	0
Blackland Prairie	16	52	32	28	21	23	16	12	44	6	21	29	71	27	2
Average	16	53	31	14	17	28	27	14	33	15	28	24	74	25	1

[z] Analysis by 1:7 soil weight:Mehlich 3 volume.
[y] EC = electrical conductivity, which is a measure of soluble salts in 1:2 soil weight:water volume.

Table 6. Soil test data by county for soil samples submitted to the University of Arkansas Soil Testing Lab in Marianna from September 2000 through August 2001.

	pH			P^z (lb/acre)					K^z (lb/acre)				EC^y (:mhos/cm)		
Geographic area	<5.5	5.5-6.5	>6.5	<26	26-44	45-100	101-300	>300	<176	176-220	221-350	>350	<100	100-500	>500
	Percentage of sampled acreage														
Arkansas, DeWitt	1	22	77	23	45	29	3	0	34	32	29	5	92	8	0
Arkansas, Stuttgart	7	41	52	24	36	34	6	0	27	24	30	19	77	23	0
Ashley	4	30	66	8	10	44	37	1	16	15	48	21	85	15	0
Baxter	3	26	71	5	10	28	30	27	13	13	34	40	46	51	3
Benton	11	62	27	2	4	16	35	43	21	9	26	44	56	42	2
Boone	10	59	31	6	8	31	37	18	27	15	25	33	67	31	2
Bradley	10	45	45	7	8	16	33	36	37	19	22	22	90	10	0
Calhoun	20	56	24	11	7	27	36	19	58	22	20	0	91	9	0
Carroll	8	57	35	2	7	18	41	32	11	9	30	50	54	45	1
Chicot	2	25	73	9	31	42	17	1	6	6	19	69	62	38	0
Clark	25	66	9	17	14	22	31	16	52	10	22	16	84	15	1
Clay, Corning	2	59	39	19	35	37	8	1	46	23	24	7	89	11	0
Clay, Piggott	7	59	34	14	24	37	24	1	29	19	37	15	92	8	0
Cleburne	19	66	15	9	13	26	28	24	35	13	26	26	80	19	1
Cleveland	37	49	14	29	13	22	25	11	51	8	25	16	92	7	1
Columbia	23	53	24	7	8	14	42	29	44	21	22	13	76	24	0
Conway	23	61	16	11	12	23	31	23	32	14	25	29	83	16	1
Craighead	5	48	47	8	14	43	34	1	14	11	40	35	82	18	0
Crawford	13	55	32	9	9	27	36	19	28	10	32	30	77	22	1
Crittenden	7	58	35	1	9	57	31	2	4	6	39	51	86	14	0
Cross	2	15	83	22	37	37	4	0	50	24	20	6	77	23	0
Dallas	10	43	17	22	19	29	21	9	72	9	10	9	95	5	0
Desha, Dumas	0	58	42	50	0	33	17	0	50	8	8	34	83	17	0
Desha, McGehee	6	28	66	6	17	52	25	0	18	13	29	40	81	19	0
Drew	31	52	17	21	15	31	24	9	26	13	27	34	69	29	2
Faulkner	22	50	28	18	14	28	27	13	35	16	26	23	74	24	2
Franklin, Charleston	22	60	18	13	19	31	31	6	38	25	19	18	90	10	0
Franklin (OZ)	19	73	8	9	9	19	34	29	21	17	30	32	57	43	0
Fulton	7	54	39	10	20	31	29	10	30	14	26	30	77	22	1
Garland	28	54	18	4	22	23	29	22	45	17	21	17	66	32	2
Grant	30	50	20	12	18	27	32	11	44	19	25	12	91	8	1
Greene	7	56	37	16	26	36	22	0	40	15	28	17	92	8	0
Hempstead	30	57	13	9	12	29	29	21	50	14	26	10	84	14	2
Hot Spring	32	59	9	17	14	25	29	15	56	7	17	20	76	21	3
Howard	22	64	14	7	7	11	32	43	35	11	26	28	84	15	1
Independence	12	57	31	8	13	26	43	10	27	14	33	26	68	31	1
Izard	10	64	26	9	12	24	36	19	39	15	25	21	81	17	2
Jackson	5	52	43	19	32	35	10	4	31	27	31	11	85	15	0
Jefferson	9	44	47	5	12	48	31	4	19	13	41	27	70	30	0
Johnson	13	67	20	8	16	23	33	20	29	14	26	31	74	26	0

continued

Table 6. Continued.

Geographic area	pH <5.5	pH 5.5-6.5	pH >6.5	P[z] (lb/acre) <26	P[z] 26-44	P[z] 45-100	P[z] 101-300	P[z] >300	K[z] (lb/acre) <176	K[z] 176-220	K[z] 221-350	K[z] >350	EC[y] (:mhos/cm) <100	EC[y] 100-500	EC[y] >500
				Percentage of sampled acreage											
Lafayette	6	41	53	4	10	31	37	18	15	11	31	43	66	34	0
Lawrence	5	58	37	32	30	30	7	1	33	25	31	11	86	14	0
Lee	5	45	50	8	18	53	20	1	22	19	35	24	79	21	0
Lincoln	10	47	43	8	11	46	27	8	19	10	38	33	74	25	1
Little River	25	48	27	17	13	21	36	13	45	16	26	13	86	12	2
Logan, Booneville	19	67	14	25	15	27	23	10	41	15	19	25	65	34	1
Logan, Paris	20	68	12	10	13	23	38	16	35	13	28	24	73	27	0
Lonoke	12	53	35	12	23	46	17	2	17	19	40	24	76	24	0
Madison	14	69	17	6	6	20	40	28	24	13	28	35	81	19	0
Marion	5	50	45	6	19	27	30	18	23	19	23	35	64	33	3
Miller	14	50	36	18	16	27	26	13	41	13	21	25	78	21	1
Mississippi, Blytheville	7	57	36	1	3	48	47	1	3	8	52	37	90	10	0
Mississippi, Osceola	7	27	66	0	8	58	31	5	2	6	33	59	82	18	0
Monroe	4	39	57	17	31	43	9	0	32	25	27	16	86	14	0
Montgomery	31	53	16	5	8	25	32	30	42	14	20	24	75	25	0
Nevada	12	68	20	16	18	22	26	18	50	6	24	20	88	12	0
Newton	14	63	23	6	10	34	34	16	23	10	32	35	64	35	1
Ouachita	23	58	19	17	8	24	42	9	63	12	13	12	81	18	1
Perry	31	63	6	16	13	18	27	26	44	11	20	25	84	15	1
Phillips	4	33	63	1	8	56	33	2	14	13	34	39	51	49	0
Pike	30	59	11	7	7	9	29	48	43	13	29	15	83	17	0
Poinsett	2	21	77	17	34	37	12	0	42	17	23	18	75	25	0
Polk	31	49	20	5	8	21	36	30	39	15	24	22	72	26	2
Pope	30	56	14	11	15	18	32	24	31	14	27	28	73	26	1
Prairie, Des Arc	6	46	48	27	37	28	7	1	32	29	29	10	81	19	0
Prairie, DeValls Bluff	3	53	44	16	43	29	8	4	27	33	31	9	73	24	3
Pulaski	26	51	23	8	12	24	38	18	34	19	32	15	73	26	1
Randolph	4	54	42	19	28	37	12	4	42	18	21	19	77	23	0
Saline	31	50	19	7	18	23	33	19	43	14	27	16	67	30	3
Scott	16	70	14	33	20	17	16	14	61	9	13	17	83	15	2
Searcy	20	66	14	4	11	27	47	11	33	12	29	26	81	19	0
Sebastian, Fort Smith	17	57	26	7	14	27	33	19	22	21	29	28	57	40	3
Sebastian, Greenwood	11	44	45	7	15	31	28	19	28	10	23	39	62	36	2
Sevier	31	62	7	15	10	12	29	34	44	9	23	24	86	14	0
Sharp	12	44	44	15	25	29	19	12	27	12	27	34	74	25	1
St. Francis	7	33	60	13	20	45	21	1	25	12	28	35	74	25	1
Stone	16	60	24	3	6	15	53	23	23	15	28	34	63	36	1
Union	15	55	30	9	7	22	41	21	52	15	22	11	81	18	1
Van Buren	17	68	15	10	14	31	28	17	30	16	30	24	77	22	1
Washington	18	54	28	4	8	22	35	31	23	12	26	39	58	38	4
White	20	54	26	14	19	29	30	8	40	16	26	18	72	28	0
Woodruff	5	71	24	27	36	30	5	2	28	17	47	8	94	4	2

continued

Table 6. Continued.

Geographic area	pH <5.5	pH 5.5-6.5	pH >6.5	P^z (lb/acre) <26	P 26-44	P 45-100	P 101-300	P >300	K^z (lb/acre) <176	K 176-220	K 221-350	K >350	EC^y (:mhos/cm) <100	EC 100-500	EC >500
	-----	-----	-----	-----	-----	-----	-----	Percentage of sampled acreage	-----	-----	-----	-----	-----	-----	-----
Yell, Danville	28	63	9	15	11	22	34	18	41	13	21	25	83	16	1
Yell, Dardanelle	13	66	21	6	11	27	38	18	26	17	28	29	83	17	0
Average	15	53	32	12	16	30	28	14	33	16	27	24	78	22	0

[z] Analysis by 1:7 soil weight:Mehlich 3 volume.
[y] EC = electrical conductivity, which is a measure of soluble salts in 1:2 soil weight:water volume.

Table 7. Soil test data by soil association number for soil samples submitted to the University of Arkansas Soil Testing Lab in Marianna from September 2000 through August 2001.

Geographic area	pH <5.5	pH 5.5-6.5	pH >6.5	P^z (lb/acre) <26	P 26-44	P 45-100	P 101-300	P >300	K^z (lb/acre) <176	K 176-220	K 221-350	K >350	EC^y (:mhos/cm) <100	EC 100-500	EC >500
	-----	-----	-----	-----	-----	-----	-----	Percentage of sampled acreage	-----	-----	-----	-----	-----	-----	-----
1-Clarksville-Nixa-Noark	12	65	25	5	7	24	42	22	24	13	28	35	71	28	1
2-Gepp-Doniphan-Gassville-Agnos	12	48	40	9	14	29	32	16	27	14	27	32	59	39	2
3-Arkana-Moko	9	59	32	6	11	21	37	25	24	13	28	35	68	30	2
4-Captina-Nixa-Tonti	14	57	29	3	7	20	33	37	21	11	26	42	58	39	3
5-Captina-Doniphan-Gepp	9	69	22	15	13	34	21	17	33	16	28	23	70	27	3
6-Eden-Newnata-Moko	22	56	22	8	15	26	41	10	33	12	23	32	77	21	2
7-Estate-Portia-Moko	9	48	43	5	13	22	41	19	25	15	28	32	70	29	1
8-Brockwell-Boden-Portia	21	56	23	24	20	34	15	7	39	15	23	23	81	18	1
9-Linker-Mountainburg-Sidon	16	62	22	8	11	26	36	19	32	13	26	29	68	31	1
10-Enders-Nella-Mountainburg-Steprock	16	66	18	5	9	24	38	24	25	13	30	32	77	22	1
11-Falkner-Wrightsville	22	58	20	11	6	14	56	13	22	8	31	39	64	36	0
12-Leadvale-Taft	20	57	23	12	13	26	33	16	30	17	27	26	66	32	2
13-Enders-Mountainburg-Nella-Steprock	17	66	17	15	23	25	23	14	42	15	22	21	82	18	0
14-Spadra-Guthrie-Pickwick	29	62	9	11	14	24	35	16	35	20	23	22	84	15	1
15-Linker-Mountainburg	22	57	21	10	13	23	35	19	34	14	26	26	73	26	1
16-Carnasaw-Pirum-Clebit	28	51	21	7	16	24	33	20	38	18	28	16	72	27	1
17-Kenn-Ceda-Avilla	20	64	16	6	13	20	31	30	40	12	23	25	73	25	2
18-Carnasaw-Sherwood-Bismarck	27	60	13	4	9	19	34	34	40	15	26	19	74	25	1
19-Carnasaw-Bismarck	26	56	18	10	18	29	17	26	51	16	18	15	83	16	1
20-Leadvale-Taft	41	56	3	29	9	22	31	9	59	7	18	16	87	13	0
21-Spadra-Pickwick	30	57	13	18	10	18	30	24	42	11	18	29	79	17	4
22-Foley-Jackport-Crowley	3	55	42	23	33	35	9	0	36	24	29	11	86	14	0

continued

Table 7. Soil test data by soil association number for soil samples submitted to the University of Arkansas Soil Testing Lab in Marianna from September 2000 through August 2001.

	pH			P^z (lb/acre)					K^z (lb/acre)				EC^y (:mhos/cm)		
Geographic area	<5.5	5.5-6.5	>6.5	<26	26-44	45-100	101-300	>300	<176	176-220	221-350	>350	<100	100-500	>500
	Percentage of sampled acreage														
continued															
23-Kobel	4	53	42	16	32	40	12	0	32	22	26	20	95	5	0
24-Sharkey-Alligator-Tunica	7	39	54	3	20	54	22	1	9	9	29	53	65	35	0
25-Dundee-Bosket-Dubbs	4	53	43	3	12	52	33	0	13	13	42	32	91	9	0
26-Amagon-Dundee	8	58	36	2	5	42	48	3	6	10	49	35	89	11	0
27-Sharkey-Steele	4	61	35	0	7	58	33	2	1	4	25	70	72	27	1
28-Commerce-Sharkey-Crevasse-Robinsonville	2	34	64	1	4	56	39	0	4	6	32	58	67	33	0
29-Perry-Portland	7	29	64	7	20	52	20	1	18	12	28	42	76	23	1
30-Crevasse-Bruno-Oklared	23	47	30	7	13	43	30	7	33	10	30	27	87	13	0
31-Roxana-Dardanelle-Bruno-Roellen	16	42	42	14	13	37	27	9	22	15	32	31	83	16	1
32-Rilla-Hebert	6	43	51	2	9	52	36	1	11	13	47	29	75	25	0
33-Billyhaw-Perry	2	33	65	4	13	51	31	1	10	10	43	37	76	24	0
34-Severn-Oklared	10	35	55	7	19	44	25	5	22	14	34	30	81	19	0
35-Adaton	11	33	56	22	11	56	0	11	33	33	22	12	89	11	0
36-Wrightsville-Louin-Acadia	0	84	16	5	5	0	21	69	21	11	47	21	84	16	0
37-Muskogee-Wrightsville-McKamie	25	60	15	15	35	20	25	5	40	25	30	5	85	15	0
38-Amy-Smithton-Pheba	30	45	25	27	13	24	25	11	57	13	25	5	83	16	1
39-Darco-Briley-Smithdale	8	87	5	6	29	50	6	9	29	15	21	35	100	0	0
40-Pheba-Amy-Savannah	35	54	11	26	19	21	22	12	53	12	20	15	87	12	1
41-Smithdale-Sacul-Savannah-Saffell	24	54	22	9	9	17	37	28	44	16	24	16	80	19	1
42-Sacul-Smithdale-Sawyer	23	58	19	14	11	22	33	20	46	14	23	17	79	19	2
43-Guyton-Ouachita-Sardis	26	61	13	14	11	13	32	30	44	12	23	21	84	16	0
44-Calloway-Henry-Grenada-Calhoun	6	34	60	19	32	37	11	1	43	22	26	9	80	20	0
45-Crowley-Stuttgart	5	36	59	24	40	31	5	0	29	28	30	13	83	17	0
46-Loring	9	42	49	35	29	20	11	5	55	18	19	8	77	23	0
47-Loring-Memphis	10	51	39	17	21	37	21	4	22	14	37	27	67	32	1
48-Brandon	56	22	22	33	33	22	11	1	22	22	33	23	100	0	0
49-Oktibbeha-Sumter	16	52	32	28	21	23	16	12	44	6	21	29	71	27	2
Average	16	53	31	12	16	31	27	14	31	15	28	26	78	21	1

[z] Analysis by 1:7 soil weight:Mehlich 3 volume.

[y] EC = electrical conductivity; which is a measure of soluble salts in 1:2 soil weight:water volume.

continued

Table 8. Soil test data by crop for soil samples submitted to the University of Arkansas Soil Testing Lab in Marianna from September 2000 through August 2001.

Crop	pH				P[z] (lb/acre)						K[z] (lb/acre)					NO_3-N (lb/acre)				EC[y] (:mhos/cm)			
	<5.5	5.5-6.5	>6.5	Md[y]	<26	26-44	45-100	101-300	>300	Md	<176	176-220	221-350	>350	Md	<26	26-100	>100	Md	<100	100-500	>500	Md
	Percentage of sampled acreage																						
Soybean - dryland	10	56	34	6.3	13	28	46	13	0	52	24	21	35	20	232	NA[x]	NA	NA	NA	88	12	0	54
Soybean - irrigated	2	35	63	6.8	19	35	40	6	0	42	35	23	27	15	204	NA	NA	NA	NA	84	16	0	58
Cotton	3	45	52	6.6	1	4	51	44	0	95	7	9	47	37	312	89	10	1	8	84	16	0	54
Rice	6	41	53	6.6	31	35	31	3	0	35	32	20	23	25	216	NA	NA	NA	NA	64	35	1	76
Wheat	21	49	30	6.1	8	31	49	11	1	52	23	20	35	22	234	NA	NA	NA	NA	70	30	0	70
Double-crop wheat - soybean - dryland	15	65	20	6.0	1	8	57	34	0	80	15	19	35	31	272	NA	NA	NA	NA	79	20	1	60
Double-crop wheat - soybean - irrigated	1	39	60	6.5	5	19	62	14	0	63	18	23	44	15	241	NA	NA	NA	NA	90	10	0	59
Warm season grass - establish	22	60	18	5.9	13	14	25	25	23	92	32	16	26	26	231	NA	NA	NA	NA	63	37	0	75
Warm season grass - maintain	21	66	13	5.9	8	11	21	33	27	143	32	14	27	27	234	NA	NA	NA	NA	78	21	1	61
Cool season grass- establish	26	60	14	5.9	3	8	31	35	23	131	33	13	21	33	243	NA	NA	NA	NA	58	40	2	87
Cool season grass- maintain	16	67	17	6.0	7	10	23	34	26	138	26	13	27	34	270	NA	NA	NA	NA	72	26	2	68
Grain sorghum	16	54	30	6.2	13	24	48	15	0	57	24	18	40	18	237	NA	NA	NA	NA	90	10	0	52
Corn	5	53	42	6.4	6	18	53	23	0	70	20	17	37	26	255	79	20	1	14	82	17	1	58
All garden	9	38	53	6.6	3	5	14	34	44	261	15	10	27	48	344	69	24	7	15	56	41	3	91
Turf and ground cover	18	52	30	6.2	7	11	29	44	9	111	30	17	32	21	231	NA	NA	NA	NA	66	33	1	78
Fruit and nut	23	55	22	6.0	11	18	28	31	12	79	36	13	24	27	223	NA	NA	NA	NA	81	19	0	50
Vegetable	22	26	52	6.6	0	4	39	39	18	115	4	17	48	31	329	NA	NA	NA	NA	83	17	0	61
Other	21	54	25	6.0	16	17	27	26	14	74	39	15	24	22	208	NA	NA	NA	NA	74	25	1	65
Average	14	51	35		9	17	37	26	11		25	17	32	26		79	18	3		76	24	0	

[z] Analysis by 1:7 soil weight:Mehlich 3 volume.
[y] EC = electrical conductivity, which is a measure of soluble salts in 1:2 soil weight:water volume.
[x] NA = not available.

Table 9. Fertilizer sold in Arkansas counties from 1 July 2000 through 30 June 2001[z].

County	Total	County	Total
	ton		ton
Arkansas	87,572	Lee	29,928
Ashley	25,267	Lincoln	14,773
Baxter	3,245	Little River	931
Benton	9,546	Logan	3,174
Boone	6,422	Lonoke	46,198
Bradley	1,524	Madison	5,707
Calhoun	349	Marion	1,241
Carroll	3,417	Miller	8,016
Chicot	23,272	Mississippi	76,030
Clark	2,843	Monroe	36,155
Clay	51,114	Montgomery	190
Cleburne	3,137	Nevada	2,717
Cleveland	85	Newton	492
Columbia	609	Ouachita	356
Conway	7,785	Perry	1,624
Craighead	54,248	Phillips	54,314
Crawford	8,425	Pike	5,539
Crittenden	22,329	Poinsett	82,536
Cross	57,143	Polk	1,096
Dallas	1	Pope	3,056
Desha	58,311	Prairie	43,682
Drew	5,679	Pulaski	30,505
Faulkner	6,948	Randolph	21,391
Franklin	3,444	St. Francis	48,811
Fulton	2,647	Saline	2,762
Garland	244	Scott	1,205
Grant	314	Searcy	2,929
Greene	28,092	Sebastian	211
Hempstead	5,446	Sevier	5,695
Hot Spring	1,786	Sharp	1,807
Howard	1,852	Stone	2,974
Independence	12,923	Union	1,369
Izard	3,617	Van Buren	7,503
Jackson	35,346	Washington	4,780
Jefferson	33,303	White	50,415
Johnson	1,708	Woodruff	29,678
Lafayette	6,759	Yell	1,728
Lawrence	33,485		

[z] Arkansas Distribution of Fertilizer Sales By Counties 1 July 2000 - 30 June 2001, Arkansas State Plant Board, Division of Feed and Fertilizer, Little Rock, Arkansas and University of Arkansas AES, Fayetteville, Arkansas.

Table 10. Fertilizer sold in Arkansas from 1 July 2000 through 30 June 2001[z].

Fertilizer	Bulk	Bag	Fluid	Total
	---------- ton ----------			
Mixed	383,215	46,130	16,724	446,100
Nitrogen	557,389	6,564	120,314	684,267
Phosphate	20,302	168	4	20,474
Potash	61,421	354	234	62,010
Other	26,808	1,859	232	28,899
Totals	1,049,136	55,105	137,508	1,241,749

[z] Arkansas Distribution of Fertilizer Sales By Counties 1 July 2000 - 30 June 2001, Arkansas State Plant Board, Division of Feed and Fertilizer, Little Rock, Arkansas and University of Arkansas AES, Fayetteville, Arkansas.

COMPARISON OF MEHLICH 3 AND DTPA EXTRACTABLE ZINC ON ARKANSAS SOILS

A. Almeida, N.A. Slaton, and R.J. Norman

RESEARCH PROBLEM

Comparisons of soil zinc (Zn) extracted by the Mehlich 3 (Mehlich, 1984) and DTPA (Lindsay and Norvell, 1978) methods on Arkansas soils are limited. A knowledge of the relationship of Zn extracted by these two methods on Arkansas soils will aid in the interpretation of soil test data and fertilizer recommendations for Zn from other states and laboratories.

BACKGROUND INFORMATION

Previous research has shown that relative to Zn extracted, the Mehlich 3 (M3) and DTPA methods are highly correlated. Vocasek and Friedericks (1994) compared soil micronutrient extraction by the M3 and DTPA methods on 471 western Great Plains soil samples and found a significant linear relationship (M3Zn = 0.104 + 1.709×DTPA Zn) between DTPA- and M3-extractable Zn. Based on their results, M3 was suggested to be an acceptable soil extractant alternative to DTPA for Zn. Liscano-Severino (1998) also found a similar linear relationship (M3Zn = 1.84×DTPAZn) between DTPA- and M3-extractable Zn for a DeWitt silt loam (fine, smectitic, thermic, Typic Albaqualfs) in Arkansas. Although he developed an equation describing the relationship between the DTPA- and M3-extractable Zn, only one soil was used in the study.

The relationship between DTPA- and M3-extractable Zn cannot be directly used to establish a critical soil-test Zn value for crops grown on Arkansas soils, but would provide a source of information concerning the range of extractable soil Zn associated with crop response to Zn fertilization for the two extractants and different soils. The objective of this study was to establish the relationship between DTPA- and M3-extractable Zn in an array of Arkansas soils.

PROCEDURES

Soil samples were collected from 75 grower fields that differed in soil series, texture, soil pH, and Zn concentration during the spring of 1998. All fields had been cropped to soybean [*Glycine max* (Merr.) L.] the previous year. The soil series for each sample was identified on county soil survey maps. At each location, eight 2-cm diameter soil cores were taken to a depth of 10 cm and combined to make a single composite sample. The soil samples represented 13 soil series from 16 counties in eastern Arkansas (Table 1). The range of selected soil properties for the soils is listed in Table 2.

Soil samples were air-dried, ground, placed through a 2-mm stainless steel sieve, and stored at room temperature until the extractions were conducted. Subsamples of each composite soil sample were used to determine the DTPA- and M3-extractable Zn. The mean concentration of DTPA- and M3-extractable Zn was determined from five duplicated subsamples. The DTPA procedure was conducted as described by Lindsay and Norvell (1978; 0.005 *M* DTPA, 0.01 *M* $CaCl_2$ and 0.1 *M* triethanolamine). The M3 procedure was conducted as described by Mehlich (1984; 0.2 *M* CH_3COOH, and 0.25 *M* NH_4NO_3, 0.015 *M* NH_4F, 0.013 *M* HNO_3, and 0.001 *M* EDTA). The filtrates were analyzed for Zn by Atomic Absorption Spectrophotometry (AAS).

Regression analysis was performed on all soils and by soil textural classification (clay, silt loam, and silty clay loam) using JMP version 3.2.6 to determine the relationship between soil Zn extracted with the DTPA and M3 methods.

The two extraction methods were also compared on soil samples (n =128) from a lime and Zn fertilization study described by Ntamatungiro et al. (1999). The study was conducted on a DeWitt silt loam at the Rice Research and Extension Center located near Stuttgart, AR. The methods used to obtain and analyze the soil samples were identical to those previously described.

RESULTS AND DISCUSSION

Soil Zn extracted with the DTPA and M3 methods, for all soil textures, was highly related ($P < 0.0001$; Table 3 and Fig. 1A). Coefficients of determination (r^2) ranged from 0.93 to 0.96 and were similar for each soil texture and for all the soil textures combined. In general, silt loam soils had the greatest range in extractable Zn and soil pH (Table 2). This was likely related to the previous use of Zn fertilizers for rice (*Oryza sativa* L.) production based on University of Arkansas fertilizer recommendations. A nearly identical relationship between the two extraction methods was found on the DeWitt silt loam ($P < 0.0001$; Fig 1B).

Data suggest that the soil texture, previous Zn fertilizer applications, soil pH, or the previous cropping history does not significantly affect the relationship for Zn extracted by these two methods. Our data suggest that DTPA- and M3-extractable Zn are highly correlated for Arkansas soils used primarily for rice and soybean production. The relationship between these two soil test methods for Arkansas soils was comparable to relationships determined for soils in other geographical areas in the USA (Schmisek et al., 1998; Vokasek and Friedericks, 1994). The M3 method consistently extracts about 1.7 times more soil Zn than the DTPA method.

PRACTICAL APPLICATIONS

Soil test laboratories frequently use different extraction methods to estimate soil nutrient availability. This information provides an equation that can be used to convert soil Zn extracted with the DTPA method to an equivalent soil Zn concentration for the M3 extractant, which is used by the University of Arkansas to make Zn fertilizer recommendations.

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Table 1. Soil series and taxonomic names represented in soil samples collected from 75 farmers' fields.

Soil series	Taxonomic class	No. of Samples
Alligator	Very-fine, smectitic, thermic Chromic Dystraquerts	3
Bosket	Fine-loamy, mixed, active, thermic Typic Hapludalfs	2
Calhoun	Fine-silty, mixed, active, thermic Typic Glossaqualfs	2
Calloway	Fine-silty, mixed, active, thermic Aquic Fragiudalfs	5
Desha	Very-fine, smectitic, thermic Vertic Hapludolls	3
DeWitt	Fine, smectitic, thermic Typic Albaqualfs	21
Dubbs	Fine-silty, mixed, active, thermic Typic Hapludalfs	2
Henry	Coarse-silty, mixed, active, thermic Typic Fragiaqualfs	9
Hillemann	Fine-silty, mixed, active, thermic Albic Glossic Natraqualfs	6
Jackport	Fine, smectitic, thermic Chromic Epiaquerts	10
Perry	Very-fine, smectitic, thermic Chromic Epiaquerts	5
Portland	Very-fine, mixed, superactive, nonacid, thermic Vertic Epiaquepts	2
Sharkey	Very-fine, smectitic, thermic Chromic Epiaquerts	5

Table 2. Soil Zn concentration and pH ranges, by soil texture and county of origin, of soils taken from grower fields for Zn extraction with Mehlich-3 and DTPA soil test methods.

		No. of	Soil pH range		DTPA Zn range		Mehlich 3 Zn range	
Soil texture	County	Soils	Low	High	Low	High	Low	High
					---------- mg Zn kg^{-1} ----------			
Silt loam	Arkansas	13	6.4	7.6	0.9	3.2	1.9	11.6
	Ashley	2	6.4	7.0	0.9	1.4	1.2	2.0
	Craighead	1	7.1	7.1	10.6	10.6	18.9	18.9
	Cross	8	6.8	7.8	1.0	5.8	2.1	11.9
	Lawrence	2	6.3	6.5	3.0	3.1	6.8	7.8
	Poinsett	8	6.6	7.8	1.1	10.1	11.4	17.7
	Prairie	6	5.7	7.1	1.7	2.3	3.3	6.8
	St. Francis	5	7.4	7.6	0.9	1.6	3.1	3.8
	White	3	5.8	6.6	1.3	2.6	3.7	6.6
Silty clay loam	Greene	5	6.0	7.8	1.7	4.1	3.9	9.2
	Jackson	4	6.8	7.5	2.0	6.2	5.9	12.2
	Monroe	1	7.5	7.5	3.8	3.8	7.4	7.4
Clay	Crittenden	5	7.0	7.4	3.1	9.4	6.0	17.3
	Jefferson	7	6.0	7.4	1.1	4.2	2.7	7.8
	Lincoln	3	6.8	7.7	2.1	3.7	5.2	6.6
Sandy loam	Clay	2	6.4	6.8	2.4	4.6	4.9	3.0

Table 3. Relationship between the DTPA (X) and M3 (Y) extractants, by soil texture and soil pH range, from 75 commercial production fields.

Soil texture	Regression equation[z]	r^2	n
Clay	Y = 1.202 + 1.652DTPAZn	0.96	15
Silt and sandy loam	Y = 1.024 + 1.818DTPAZn	0.93	50
Silty clay loam	Y = 1.000 + 1.830DTPAZn	0.96	10
All soils	Y = 1.147 + 1.747DTPAZn	0.96	75
pH < 6.5	Y = 1.193 + 1.766DTPAZn	0.88	16
pH > 6.5	Y = 1.112 + 1.749DTPAZn	0.95	59

[z] Relationships significant at the 0.0001 level.

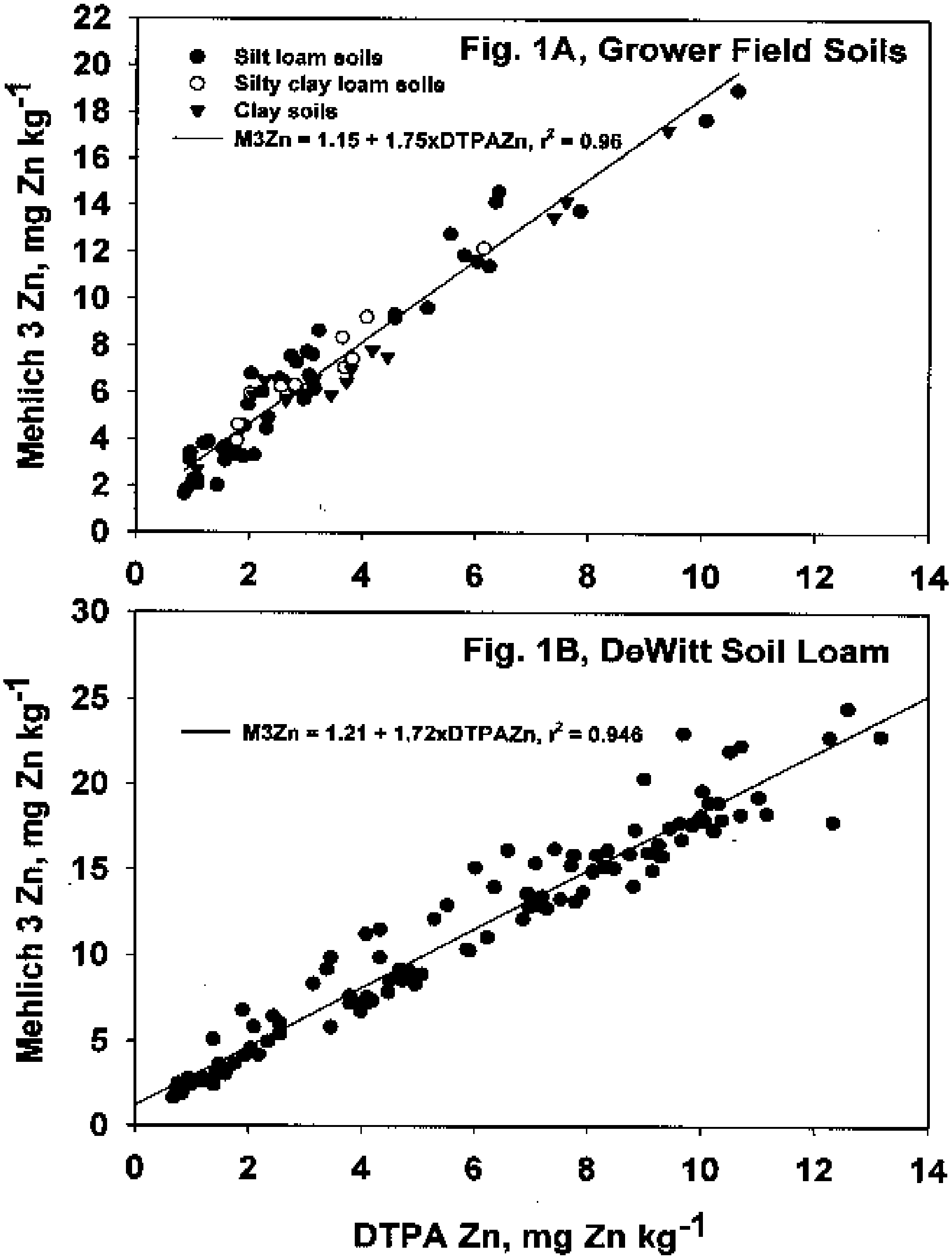

Fig. 1. Relationship between Mehlich 3 and DTPA extractable soil Zn from soil samples collected from 75 production fields (1A) and a DeWitt silt loam (1B).

SCHEDULED AND PRESCRIPTION-BASED NITROGEN FERTIGATION OF VINE-RIPENED TOMATOES

P.B. Francis and P.E. Cooper

STATEMENT OF PROBLEM

There exists a need in Arkansas to develop recommendations for drip-line injection of plant nutrients (fertigation), particularly nitrogen (N). Nitrogen fertigation has the potential to extend N availability over the season, reduce N losses from leaching which increases fertilizer efficiency, increase fruit yield and quality, and possibly alter peak harvests of fruit to expected market demands. New, affordable technology has become available to measure petiole sap NO_3-N in the field. The primary goal of this research was to evaluate the reliability of petiole sap NO_3-N-based N applications and scheduled weekly N fertigation on fruit yield and quality.

BACKGROUND INFORMATION

Commercial production of vine-ripened tomatoes is a significant source of income for many limited-resource farmers in southern Arkansas. Vine-ripened tomatoes are typically cultivated on raised, black-plastic mulched, micro-irrigated beds. This system of cultivation is ideally suited for supplying plant nutrients, particularly N, through the drip-lines (fertigation). Many producers in the region are injecting part of their total N as split N applications, but the majority of the seasonal N fertilizer is applied pre-plant. There is little information in Arkansas on N sources, rates, and timing for N fertigation of vine-ripened tomatoes. Marr (1993) has published N fertigation schedules for Kansas, but it is not clear if these recommendations are valid for the commercial vine-ripened tomatoes grown in Arkansas.

It has been shown that N rates and timing can significantly influence fruit size, fruit number, total yields, and seasonal harvest patterns (Motis et al., 1998; Francis and Cooper, 1998; Lacasio et al., 1997; Cook and Sanders, 1991; Barker and Ready, 1989). Therefore, it may be possible to use N fertigation management to increase marketable fruit yield and quality, and possibly alter seasonal yield patterns to expected market demands. New, inexpensive, and easy-to-operate technology is now available to monitor petiole sap NO_3-N concentration. Petiole sap NO_3-N levels up to 13 weeks post-transplant are related to total fruit yield and marketable fruit yields (Anderson et al., 1999). Our main objective was to evaluate scheduled weekly N fertigation programs and a petiole sap NO_3-N monitored 'prescription application' program on tomato yields and quality.

PROCEDURES

The study was conducted at the Roger Pace Farm near Monticello, Arkansas. Data from the 2001 growing season are presented. Tomatoes (var. 'Mt. Spring) were grown on raised, black-plastic mulched, micro-irrigated beds 5 ft apart with plant spacings of 21 inches. Weekly applications of N through the drip-lines were applied for 10 weeks beginning the second week after transplant to isolated plots of 6 plants each. A manifold system was used to apply 68 oz of N solution to each plot, followed by 2 to 5 hrs of main-line irrigation. Nitrogen treatments were season totals of 0, 60, 120, 180, and 240 lb N acre^{-1} (mulched) from two sources: urea and ammonium nitrate. In addition to the scheduled N treatments, a 'prescription' treatment, based on weekly NO_3-N monitoring of petiole sap from the most recently matured leaf, was added. Petiole sap was extracted from the most recently matured leaf using a garlic press and the NO_3-N measured using a Cardy nitrate meter (Spectrum Technologies). The nitrate meter and accessories cost approximately $380.00. When the average NO_3-N levels were within 50 ppm or less of the lower range of Florida recommendations (Table 1), 20 lb N acre^{-1} were injected into these plots as ammonium nitrate fertilizer. Total N applied in the 'prescription' plots in the 2001 growing season was 120 lb N acre^{-1}. Tomato fruit was harvested three times weekly for five weeks and graded to U.S. No. 1 XL, U.S. No. 1 L, U.S. No. 2, and unclassified. The experimental design was a randomized complete block with four replications.

RESULTS AND DISCUSSION

Even though the sensitivity of the nitrate meter was only 50 ppm NO_3-N, a clear relationship between petiole sap NO_3-N and N treatment existed at the initiation of fruit harvest (Table 2). The petiole sap NO_3-N in the 0-, 60-, and 120-lb N $acre^{-1}$ treatments was below recommended levels. The 'prescription'-based treatment petiole sap NO_3-N levels were at the lower threshold. Analysis of variance tests did not reveal any significant differences in petiole sap NO_3-N or fruit yields between the two N sources. The hand-held nitrate sensor was relatively easy to operate in the field. However, we did notice that the instrument needed to be kept out of the direct exposure to sunlight and that a calibration check was necessary about every 10 readings or when the air temperature changed more than 5 to 8° F.

Season-total N application of the 'prescription' treatment equaled that of the scheduled N treatment of 120 lb N $acre^{-1}$, but with four fewer injections. There were no significant differences in yields of U.S. No. 1 XL grade tomatoes (the premium grade) or total marketable fruit for N treatments of 120 lb N $acre^{-1}$ or higher (Table 3). A significant difference (Prob > F 0.03) existed between the 60-lb N $acre^{-1}$ treatment versus the other N treatments (analysis not shown). Therefore, the optimal level of N fertilization was 120 lb N $acre^{-1}$, applied either as ten weekly scheduled injections of 12 lb N $acre^{-1}$ or as needed according to petiole sap NO_3-N monitoring. Further research is needed to refine fertilizer recommendations of drip-line injected N as related to existing petiole sap NO_3-N, desired petiole sap NO_3-N, and growth stage. More information is also needed on pre-plant fertilizer rates and split-N fertigation effects on yield and fruit quality. We also noticed that even though fruit loads of the 0- and 60-lb N $acre^{-1}$ treatments were equivalent to the higher N treatments during early harvest, the lack of foliage cover for shading, which was greater for the higher N treatments, resulted in substantial fruit culling due to sun scalding. Further work in upper leaf management is needed to minimize sun scald damage without reducing early season fruit yields and size.

PRACTICAL APPLICATIONS

This research is gathering an important database to help commercial growers of vine-ripened tomatoes make decisions regarding the injection of N fertilizer through the drip lines. Eventually, we hope to be able to provide accurate guidelines for using petiole sap NO_3-N monitoring and N management in a 'diagnose - treatment' methodology to take the guess work out of N fertigation. Additionally, petiole sap NO_3-N monitoring can help in early detection of other potential yield reducing stresses, such as disease or salt injury. Nitrogen fertigation, supplying all or part of the amended N nutrition of the crop, can increase fertilizer use efficiency and thus reduce crop expenses.

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Table 1. Sufficient range of petiole sap NO_3-N for tomatoes.

Growth stage	Recommended range
	ppm NO_3-N
First buds	1000 - 1200
First open flowers	600 - 800
Fruits 2.5-cm diam.	400 - 600
Fruits 5.0-cm diam.	400 - 600
First (early) harvest	300 - 400
Second (late) harvest	200 - 400

From Hockmuth et al., 1991.

Table 2. Petiole sap NO_3-N, 67 days post-transplant, early harvest.

Nitrogen applied to date	NO_3-N
lb acre^{-1}	ppm
144	322
108	465
80[z]	307
72	268
36	142
0	101
$LSD_{0.05}$	48

[z] Prescription-based treatment.

Table 3. Tomato yields, 2001 season.

N Applied	U.S. No. 1 XL	Total marketable
lb acre^{-1}	-------------------- kg plant^{-1}	-------------------
240	6.50	16.76
180	5.99	16.27
120	5.33	16.29
120 [z]	6.32	19.47
60	4.00	16.18
0	3.10	10.06
$LDS_{0.05}$	2.51	5.02

[z] Prescription-based treatment.

EVALUATION OF NITROGEN AND POTASSIUM FERTILIZER MANAGEMENT FOR COTTON

M.A. Henslee, E. Evans, N.A. Slaton, W.H. Baker, and C. Kennedy

RESEARCH PROBLEM

Adequate nitrogen (N) and potassium (K) nutrition is critical for the production of high-yielding cotton (*Gossypium hirsutum* L.). The concentration of these nutrients in cotton petioles can be monitored to aid growers in making fertilizer decisions during the growing season. Excessive and insufficient quantities of these nutrients can have adverse affects on cotton production. This project was designed to take advantage of new precision agriculture technologies with regard to extending our understanding of cotton fertility and profitability. Changes in cotton production technology (e.g., cultivars, pest management, tillage, etc.) require that the petiole nutrient monitoring program be periodically evaluated for accuracy. Therefore, the objective of this research was to evaluate cotton yield and petiole nutrient concentration response to N and K fertilization rates.

BACKGROUND INFORMATION

Maples et al. (1977) showed that petiole NO_3-N concentration was highly correlated with cotton yields in Arkansas and could be used to refine in-season fertilizer applications via weekly monitoring. Comparison of Georgia and Arkansas petiole NO_3-N sufficiency ranges shows that the two states use vastly different information to recommend in-season N fertilizer application. The cotton petiole monitoring program was designed to help growers in making educated in-season fertilization decisions. However, use of the petiole monitoring program by Arkansas growers has declined over the past few years. Data to support our current recommendations or adjust the petiole NO_3-N concentrations are needed to build grower confidence in the petiole monitoring program for currently grown cultivars and management practices.

PROCEDURES

Two field experiments were conducted at the University of Arkansas Cotton Branch Experiment Station (CBES) in Marianna, Arkansas in 2001. The soil at the CBES is a Loring silt loam. Prior to planting, two composite soil samples were taken from each of the untreated control plots of each study. Selected soil chemical properties are listed in Table 1. Cotton ('Stoneville 4892') was planted on 5 May 2001. Each plot was 8 rows wide (spaced 38 inches apart) and 250 ft long. One study investigated K fertilizer application rate on cotton yield and petiole K concentration. Three K fertilizer rates, 0, 75, and 150 lb K_2O/A, were applied before planting and incorporated. Nitrogen was applied to all plots on 19 June (Pinhead Square) at a rate of 100 lb N/A as 32% urea ammonium nitrate.

The second study evaluated N fertilizer rate on cotton yield and petiole N concentration. Four N fertilizer rates, 0, 60, 120, and 180 lb N/A, were side-dressed at the pinhead square stage on 19 June. Soil test results showed that the N study did not require additional K or P fertilization.

In general, management guidelines for pest control and irrigation recommended by the Cooperative Extension Service were followed throughout the growing season to reduce plant stress and maximize yield potential. Petiole samples were taken for six consecutive weeks starting on 10 July and ending on 14 August. During the first two weeks, 24 petioles from the fifth node from the top were randomly collected from each plot. During the final four weeks, 16 petioles from the fifth node from the top were randomly collected from each plot. Cotton petioles were dried overnight at 70°C and ground to pass a 1-mm seive. A 0.1 g subsample was mixed with 30 mL aluminum sulfate spiked with 10 mg NO_3-N/kg and shaken for 30 minutes while stirring. Petiole NO_3-N concentration was determined using an NO_3-ion specific electrode. A 0.075 g subsample was also mixed with 21 mL of 2% acetic acid, shaken for 10 minutes, and filtered. Petiole concentrations of K, P, and S were determined by inductively coupled atomic plasma spectroscopy. At maturity, seed cotton yield was determined with a 4-row cotton picker equipped with an AgLeader (AgLeader, Ames, IA) cotton yield monitor. Yield sensors were placed only on the two outside shoots of the four-row picker. The two outside rows and two center rows of each plot were used for measuring yield data.

Each test was arranged in a randomized complete block design with four replications. Analysis of variance procedures were conducted with the PROC GLM procedure in SAS. Mean separations were performed by Fisher's protected least significant difference (LSD) method at a significance level of 0.05.

RESULTS AND DISCUSSION

Nitrogen Rate Study

Application of 60 lb N/acre produced the highest cotton yield (Table 2). Application of N rates higher or lower than 60 lb/acre produced numerically lower yields. Soil test results indicated that the entire field required 50 to 70 lb N/acre. Nitrogen fertilizer rate significantly affected petiole NO_3-N concentration at every sample date. Petiole NO_3-N concentration dramatically declined after 17 July. The 0 lb N/acre treatments were visibly shorter and began to defoliate earlier than the other N treatments. Cotton receiving 120 and 180 lb N/acre was visibly taller and stayed green much longer than the two lower N rates. Foliar N fertilizer would have been recommended for the 60 lb N/acre application rate based on the current lower NO_3-N sufficiency level; however, maximal yield was also produced by 60 lb N/acre. This suggests that the sufficiency range established with long-season cultivars may not be appropriate for use with short-season, fast-fruiting cultivars grown today.

Potassium Rate Study

Potassium fertilizer rate did not affect cotton yields (Table 3). Soil test K in the untreated controls averaged 314 lb K/acre which is above the soil critical level required to obtain a recommendation for K fertilizer application to cotton. Potassium concentration in cotton petioles suggested that K was not limiting at any time during the growing season. Petiole K concentration declined dramatically in all K rates after 31 July 2001.

PRACTICAL APPLICATIONS

Application of 60 lb N/acre was required to produce maximum cotton yields. Compared to the NO_3-N sufficiency ranges used in Arkansas (Table 2), petiole NO_3-N concentrations were adequate for the duration of the season only for the 180 lb N/acre rate. The highest yielding N rate, 60 lb N/acre, had sufficient petiole NO_3-N concentrations only at the first two sample dates. Data suggest that the current NO_3-N sufficiency concentrations may be too high. Based on the yield data, sufficiency levels used in Georgia, which are lower than those used in Arkansas, may be more appropriate. Potassium fertilizer applications failed to increase cotton yields indicating that soil test K values above 300 lb K/acre are adequate to sustain normal cotton growth. The results from this test are preliminary as this is the second year of a three-year study. Final conclusions should not be drawn from this data; however it is clear that petiole data should be collected from numerous cultivars, soils, and environments and correlated to cotton yield.

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ACKNOWLEDGMENTS

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Table 1. Selected soil chemical properties of N and K fertilizer rate studies conducted at the Cotton Branch Experiment Station during 2001. Values are the average of 12 composite samples from each plot.

Test	pH^z	Soil NO_3-N^y	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn
			Mehlich 3 extractable soil nutrients[x]									
			---- lb/acre ----									
N rate	6.8	22	123	308	1841	469	41	21	336	208	3.0	4.3
sd[w]	0.1	11	31	64	264	100	6	2	48	30	0.5	0.9
K rate	6.7	54	114	314	1948	518	44	24	310	197	2.9	4.4
sd	0.3	47	24	42	301	122	7	5	36	45	0.5	1.3

[z] Soil pH measured by glass electrode in a 1:2 soil weight:water volume ratio.
[y] NO_3-N measured by nitrate ion-specific electrode.
[x] A Mehlich 3 extraction ratio of 1:10 was used.
[w] sd is abbreviation for standard deviation.

Table 2. Effect of N fertilizer rate on cotton lint yield and petiole NO_3-N concentration in a study conducted at the Cotton Branch Experiment Station during 2001.

N rate	Seedcotton yield	10 July[z]	17 July	24 July	31 July	8 August[y]	14 August
		Petiole NO_3-N concentration by sample date					
lb N/acre	lb/acre	---- mg NO_3-N/kg or ppm ----					
0	2,259	2,064	1,016	224	134	279	134
60	2,597	12,748	11,845	2,352	266	245	134
120	2,109	17,248	20,644	10,145	2,447	430	267
180	1,870	21,092	23,796	17,492	7,353	3,518	2,257
Lower sufficient level, Arkansas[x]		>10,000	>9,000	>7,000	>5,000	>3,000	>2,000
Lower sufficient level, Georgia[x]		>4,500	> 3,500	>2,500	>1,500	>1,000	>1,000
LSD(0.10)	NS	4,963	5,033	3,463	1,803	1,923	1,295
P-value	0.209	<0.0001	<0.0001	<0.0001	<0.0001	0.0077	0.015
C.V., %	20.7	24.0	19.2	23.3	40.6	110.5	132.9

[z] First bloom on 9 July.
[y] Cut-out occurred on 5 August. First open boll on 23 August.
[x] Sufficient NO_3-N concentrations from Mitchell and Baker (2000).

Table 3. Effect of K fertilizer rate on cotton lint yield and petiole K concentration in a study conducted at the Cotton Branch Experiment Station during 2001.

N rate	Seedcotton yield	10 July[z]	17 July	24 July	31 July	8 August[y]	14 August
		Petiole K concentration by sample date					
lb N/acre	lb/acre	---- % ----					
0	1,996	5.15	6.65	5.90	6.03	3.18	3.03
75	2,087	6.08	7.50	6.78	6.38	4.13	3.58
150	2,086	6.75	8.03	7.15	7.20	4.83	3.88
$LSD_{(0.05)}$	NS[x]	0.60	0.54	0.67	0.89	0.93	0.74
P-value	0.861	0.0009	<0.0011	<0.0069	0.0418	0.0104	0.077
C.V., %	12.9	6.1	4.5	6.2	8.4	14.0	13.0

[z] First bloom on 9 July.
[y] Cut-out occurred on 5 August. First open boll on 23 August.
[x] NS = not significant at the 0.05 probability level.

VARIETAL RESPONSES OF COTTON TO NITROGEN FERTILIZATION

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

RESEARCH PROBLEM

Growth and yield response of cotton (*Gossypium hirsutum* L.) varieties to nitrogen (N) fertilization is an ongoing concern of cotton producers in Arkansas (Maples and Frizzell, 1985). New varieties, both genetically engineered and traditional, are continually introduced into the Delta production systems. Advantages of these new varieties include enhanced pest resistance, superior lint quality, faster maturity, and other new characteristics. The objective of this study was to determine the responses of new varieties to N fertilization.

BACKGROUND INFORMATION

Development and release of new cotton cultivars has increased the diversity of cotton in the Delta. Varieties now available for use in the Delta may possess genetically engineered traits for pest resistance as well as superior yield, rapid maturity, and improved fiber properties. The genetic variability of currently available varieties indicates that crop growing practices, such as fertilization, might differ to achieve optimal yields. Optimizing N fertilization for individual cotton varieties is a possible way of tailoring production practices to achieve optimal economic returns.

RESEARCH DESCRIPTION

Evaluation of responses of cotton varieties to N fertilization began at the Southeast Branch Experiment Station in 1989 (McConnell et al., 1993). The varieties tested change as new varieties are introduced into the Delta region. Four years of data, 1997 through 2000, are available from the current test. Varieties under evaluation from 1997 to 1999 were Deltapine 20, Deltapine 5415, Stoneville 474, and Nucot 32B. Deltapine 20 was replaced with Deltapine 747, a rapid-maturing variety, for the 2000 growing season. Fertilizer treatments ranged from 0 to 150 lb urea-N/acre in 50 lb N/acre increments. The N fertilizer treatments are split applied. These tests were furrow-irrigated.

The measurements taken on the cotton varieties included seed cotton yield, lint fraction, plant height, and plant population. All data were analyzed using the Statistical Analysis System (SAS). The experimental design was a randomized complete block. Differences among treatments were identified by least significant differences (LSD) calculated at the a=0.05 level of probability.

RESULTS

The N fertilizer rate that tended to produce near optimal seedcotton yields for all four varieties and over all years was 100 lb N/acre (Table 1). The N fertilization rate necessary to produce maximal yield was 100 lb N/acre for Deltapine 20 and Stoneville 474. Although a trend of higher yield was observed with greater N rates, the differences were not significant from the 100-lb N/acre treatment. In 1998, Stoneville 474 yields declined when N was increased from 100 to 150 lb N/acre. Yield trends with Deltapine 5415 and Nucot 32B differed slightly from the two faster maturing varieties. A trend of increasing yield with more N was observed for Deltapine 5415 and Nucot 32B but the differences were not always significantly greater than the 100-lb N/acre treatment.

PRACTICAL APPLICATION

The results from this test are preliminary. Final conclusions should not be drawn from these data. The yield response of all cultivars seemed to maximize near 100 lb N/acre. Generally, yields were not found to significantly increase with N rates above 100 lb N/acre.

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ACKNOWLEDGMENTS

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Table 1. Lint yields of four cotton varieties – Deltapine 20 (DP20), Stoneville 474 (ST474), Deltapine 5415 (DP5415), and Nucot 32B (NU32B) – grown with 0, 50, 100, and 150 lb urea-N/acre at the Southeast Branch Experiment Station near Rohwer, AR, during 1998 and 1999. Deltapine 747 (DP 747), Stoneville 474 (ST 474), Deltapine 5415 (DP 5415), and Nucot 32B (NU32B) were used in 2000.

	Varieties			
N-Rate	DP 20	ST 474	DP 5415	NU 32B
lb N/acre	---------- lb lint/acre ----------			
1998				
150	1,218	1,247	1,159	1,217
100	1,097	1,321	1,241	1,216
50	992	1,130	1,049	1,084
0	687	691	548	615
$LSD_{(0.05)}$=104				
1999				
150	1,207	1,393	1,213	1,298
100	1,145	1,255	1,156	1,246
50	1,021	1,022	1,000	1,026
0	726	686	609	614
$LSD_{(0.05)}$=118				
	Varieties[z]			
N-Rate	DP 747	ST 474	DP 5415	NU 32B
lb N/acre	---------- lb seedcotton/acre ----------			
2000				
100	3,227	3,469	3,259	3,390
100	3,107	3,419	3,044	3,120
50	2,709	2,528	2,473	2,775
0	1,822	1,304	1,284	1,496
$LSD_{(0.05)}$=165				

[z] Lint yield may be estimated by dividing the seedcotton yield by 3.

LONG-TERM IRRIGATION METHODS AND NITROGEN FERTILIZATION RATES IN COTTON PRODUCTION: THE LAST FIVE YEARS

J.S. McConnell and R.C. Kirst, Jr.

RESEARCH PROBLEM

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

The objectives of these studies were to evaluate the growth, development, and yield of intensively-managed cotton grown on soils previously treated with different rates of soil-applied N fertilizer that resulted in different levels of residual soil N 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 optimal 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

Studies were conducted at the Southeast Branch Experiment Station on an Hebert silt loam soil. Five irrigation methods were used from 1988 to 1993, but only three have been used since 1993 (Table 1). Six different total 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. Ten total N treatments were tested within each irrigation method (Table 2). Nitrogen fertilizer was not applied to the 2000 cotton crop to examine the effects of residual soil N on cotton development. From 1996 to 2000 the experimental design was a split block with irrigation methods as the main blocks. Each treatment was replicated five times.

RESULTS

The method of irrigation that maximized cotton lint yield varied among years. Therefore, the method of irrigation appeared to be less important than irrigation usage (Table 3). Generally, lint yield increased with increasing N rate (Table 2). The N treatments that usually resulted in the greatest lint yields were applications of 60 to 150 lb N/acre, depending upon the irrigation treatment and year. 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. The yields of the High Frequency Irrigation block were significantly influenced by verticillium wilt during some years. The disease was more virulent in the plots receiving higher N rates, thereby reducing yields with increasing N rate.

In 2000, cotton response to the residual N seemed to mirror the N-fertilizer rates applied in previous years. Presumably, as the residual N is consumed by subsequent crops, residual soil N will have less impact on cotton development and yield.

PRACTICAL APPLICATIONS

Irrigated cotton was generally found to be higher yielding than cotton grown under dryland conditions unless verticillium wilt affected the crop. Fertilizer N requirements of cotton for maximal yield tended to be greater under irrigated production than under dryland production. Fertilizer N requirements of cotton for maximal yield tended to be greater for furrow-irrigated cotton than for center-pivot irrigated cotton. Residual soil N was sufficient the first year to maintain cotton yields when previous years of N-fertilization were above 60 to 120 lb N/acre.

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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 three irrigation methods.

Irrigation methods	Duration	Tensiometer threshold	Tensiometer depth	Water applied
		cbar	------------------- inches	-------------------
High frequency center-pivot	Planting to PB[z]	35	6	0.75
High frequency center-pivot	PB to Aug. 15	35	6	1.00
Furrow flow	Until Aug. 15	55	12	Not precise
Dryland	Not irrigated	--	--	--

[z] PB = Peak bloom

Table 2. Cotton lint yield response to ten nitrogen (N) fertilization treatments under three irrigation methods from 1996 to 1999, and seedcotton yield response to residual soil N from previous N treatments in 2000.

N Rate					
PP[z]	FS[z]	FF[z]	HF[y]	FI[y]	DL[y]
----------	lb/acre	-------------	------------------------------	lb/acre	------------------------------
1996					
75	75	0	1315	1630	1067
50	50	50	1411	1543	1116
30	60	60	1331	1572	1078
60	60	0	1383	1522	1035
40	40	40	1431	1576	1174
45	45	0	1382	1495	1050
30	30	30	1440	1527	1059
30	30	0	1461	1633	1059
15	15	0	1309	1167	1048
0	0	0	979	868	752
$LSD_{(0.05)}$			114	251	155
1997					
75	75	0	1491	1739	1682
50	50	50	1491	1679	1777
30	60	60	1384	1576	1867
60	60	0	1528	1547	1629
40	40	40	1491	1751	1799
45	45	0	1507	1582	1615
30	30	30	1420	1368	1754
30	30	0	1477	1457	1338
15	15	0	1157	1102	1067
0	0	0	1086	764	683
$LSD_{(0.05)}$			156	207	217

continued

Table 2. Continued.

N Rate					
PP[z]	FS[z]	FF[z]	HF[y]	FI[y]	DL[y]
---------- lb/acre -------------			---------- lb/acre ----------		
1998					
75	75	0	1230	1519	767
50	50	50	1154	1495	721
30	60	60	1096	1520	777
60	60	0	1185	1281	641
40	40	40	1237	1490	816
45	45	0	1259	1410	837
30	30	30	1413	1437	883
30	30	0	1226	1331	779
15	15	0	1195	1107	712
0	0	0	1116	817	589
$LSD_{(0.05)}$			161	220	171
1999					
75	75	0	1595	1533	656
50	50	50	1468	1431	788
30	60	60	1467	1463	706
60	60	0	1552	1405	636
40	40	40	1545	1587	783
45	45	0	1445	1454	756
30	30	30	1406	1203	740
30	30	0	1446	1280	791
15	15	0	1105	847	799
0	0	0	1057	677	605
$LSD_{(0.05)}$			169	257	NS
2000[x]					
75	75	0	2968	2161	1245
50	50	50	3034	2126	1295
30	60	60	3138	2223	1255
60	60	0	2783	1923	1186
40	40	40	2882	1999	1382
45	45	0	2753	1951	1233
30	30	30	2541	2003	1314
30	30	0	2784	1885	1182
15	15	0	2329	1665	1312
0	0	0	2643	1677	1027
$LSD_{(0.05)}$			280	203	157

[z] Pre-plant (PP), first square (FS), and first flower (FF).
[y] High frequency (HF), furrow irrigated (FI), and dryland (DL).
[x] Lint yield may be estimated by dividing the seedcotton yield by 3.

Table 3. Lint yield response of cotton to four irrigation methods from 1996 to 1999, and seed cotton yield in 2000.

Method	1996	1997	1998	1999	2000
	---------- lb/acre ----------				
High frequency center-pivot	1344	1400	1211	1401	2801
Furrow-flow	1463	1458	1341	1288	1961
Dryland	1057	1521	750	728	1242
$LSD_{(0.05)}$	108	99	129	120	248

NITROGEN FERTILIZATION OF ULTRA-NARROW-ROW COTTON

J.S. McConnell, R.C. Kirst, Jr., R.E. Glover, and R. Benson

RESEARCH PROBLEM

Recent developments in cotton (*Gossypium hirsutum* L.) production technology in the Delta include drill planting cotton. Ultra-narrow-row (UNR) cotton is a low-input production system designed to maximize economic returns. Research that provides information on production parameters is scant. Optimal nitrogen (N) fertilization rates are unknown. The objectives of these studies were to determine how UNR cotton responds to N fertilization.

BACKGROUND INFORMATION

Technology development for UNR cotton production has increased recently. It has long been known that plants grown in very narrow rows intercept and utilize sunlight more efficiently. Potential benefits of UNR cotton production include: reduced production costs, 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: increased weed pressure in low-stand areas; different equipment requirements from conventionally row-spaced cotton (precision drill planter, finger stripper harvester); and lint quality may decline. Varietal differences, fertility requirements, effect of planting date, and other parameters for optimal growth and yield of UNR cotton are unknown.

RESEARCH DESCRIPTION

A pilot study to evaluate UNR response to N fertilization was conducted in 1997. 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 test was expanded in 1998 to include N-rates of 0, 25, 50, 75, 100, and 125 lb urea-N/acre. The test design was randomized complete block with 8 replications. Nitrogen fertilizer treatments were applied as the crop reached the true two-leaf stage. The test was further expanded in 1999 to include a second study site at the Northeast Research and Extension Center (NEREC) near Keiser, Arkansas, with identical treatments.

Measurements taken on the UNR cotton included cotton lint yield, plant height, plant population, boll load, and boll weight. All data were analyzed using the Statistical Analysis System (SAS). Differences among treatments were identified using least significant differences (LSD) calculated at the α=0.05 level of probability.

RESULTS

In the 1997 pilot study, UNR cotton fertilized with either 50 or 100 lb N/acre, regardless of N source, did not differ in lint yield (Table 1). Boll loads and boll weights were not significantly different for the UNR cotton that received N fertilizer. Cotton receiving no N fertilizer produced significantly lower yield, boll load, and boll weight than cotton that received N fertilizer.

The results of the first year (1998) of the expanded study correlated well with the pilot study. The N fertilization rate necessary to produce maximal yield, boll load, and boll weight was 50 lb N/acre (Table 2). Although trends of higher numerical lint yields were observed with the greater N rates, the differences were generally not significantly different from the 50-lb N/acre treatment. Plant height increased with increasing N fertilization up to 100 lb N/acre.

Results from 1999 at SEBES indicated that severe drought conditions masked the impact of N fertilization of cotton (Table 4). Nitrogen fertilization of conventionally row-spaced cotton has been shown to be ineffective under severe water deficit (McConnell et al., 1998). The N treatments were not found to significantly affect any of the measured parameters.

Results from the NEREC were similar to the first year at SEBES. Maximal yields were achieved with only 25 lb N/acre. Plant height significantly increased in treatments up to 75 lb N/acre. No significant differences among N rates were observed in either the plant populations or boll loads at the NEREC.

PRACTICAL APPLICATION

The preliminary responses of UNR cotton to N fertilization treatments indicates that the N required for maximal yield will be less than 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 usually maximized both the boll load and boll weight at SEBES. The parameters measured in these studies indicate that the N fertilization management of UNR cotton may be substantially different from conventionally grown cotton.

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ACKNOWLEDGMENTS

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

Table 1. Seedcotton yield, plant height, plant population, boll load, and boll weight of cotton grown 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, AR, in 1997.

N Rate	Seedcotton yield	Plant height	Plant population	Boll load	Boll weight
lb N/acre	lb/acre	inches	plants/acre	boll/acre	g/boll
100(M)[z]	2,938	24.9	115,360	393,675	3.36
100	,3008	31.3	140,368	392,869	3.44
50	3333	29.9	108,099	416,263	3.58
0	1529	20.4	118,587	242,820	2.87
$LSD_{(0.05)}$	1099	6.1	NS	119,875	0.38

[z] Meister N.

Table 2. Lint yield, plant height, plant population, boll load, and boll weight of cotton grown in ultra-narrow rows with 0, 25, 50, 75, 100, and 125 lb urea-N/acre at the Southeast Branch Experiment Station near Rohwer, AR, from 1998 to 2000.

N Rate	Lint yield	Plant height	Plant population	Boll load	Boll weight
lb N/acre	lb/acre	inches	plants/acre	boll/acre	g/boll
1998					
125	1060	27.5	153,074	349,710	3.31
100	1033	30.5	168,199	327,928	3.39
75	1034	26.3	160,334	341,844	3.30
50	899	24.4	175,460	321,273	3.12
25	745	20.4	177,275	278,921	2.93
0	468	19.9	171,225	191,796	2.84
$LSD_{(0.05)}$	153	4.2	NS	48,066	0.28
1999					
125	700	10.6	130,687	264,400	2.70
100	638	11.4	139,763	253,077	2.55
75	598	12.8	157,914	223,863	2.76
50	548	12.1	148,233	230,950	2.45
25	547	11.4	140,368	233,863	2.41
0	474	12.2	150,048	191,796	2.49
$LSD_{(0.05)}$	NS	NS	NS	NS	NS
2000					
125	648	25.5	107,091	271,055	2.67
100	527	23.7	104,671	232,333	2.46
75	482	22.8	113,326	218,417	2.41
50	384	18.9	98,621	182,115	2.34
25	335	18.8	114,784	183,239	1.98
0	310	17.6	117,982	147,628	2.22
$LSD_{(0.05)}$	110	2.9	NS	40,124	2.94

Table 3. Lint yield, plant height, plant population, and boll load of cotton grown in ultra-narrow rows with 0, 25, 50, 75, 100, and 125 lb urea-N/acre at the Northeast Research and Extension Center near Keiser, AR, in 1999.

N rate	Lint yield	Plant height	Plant population	Boll load
lb N/acre	lb/acre	inches	plants/acre	boll/acre
125	989	20.7	212488	341,499
100	1004	20.4	261816	333,910
75	958	23.7	239049	314,938
50	965	20.4	292171	417,387
25	883	17.5	250432	394,621
0	608	16.7	250432	318,732
$LSD_{(0.05)}$	267	2.7	NS	NS

CORN RESPONSE TO NITROGEN AND PHOSPHORUS AS STARTER FERTILIZER

J.H. Muir and J.A. Hedge

RESEARCH PROBLEM

The early spring planting dates required for optimal corn production in Arkansas often expose corn seedlings to lower than optimal soil temperatures. The low soil temperatures may result in slow root growth and phosphorus (P) deficiency even though soil test levels of available P are considered adequate.

BACKGROUND INFORMATION

Placing small amounts of starter fertilizer (usually N and/or P) with or near the seed has increased early-season corn plant height and grain yield and decreased the number of days to silking of corn in northeast Louisiana (Mascagni and Boquet, 1996).

RESEARCH DESCRIPTION

A study was initiated on the Arkansas State University campus in the spring of 1999 to determine the response of corn to starter N and P fertilizer. Nitrogen at 5 lb/acre and P at 8 lb/acre alone and together was applied with the seed in 1999. Nitrogen at 15.5 lb/acre and P at 25 lb/acre alone and together was applied approximately 2 inches to the side and 2 inches below the seed in 2000. Rates included in 2001 were 15 lb N/acre alone, 13 lb P/acre alone, and 15 lb N/acre + 11 lb P/acre in combination.

RESULTS

There was some indication that stands were reduced with some treatments in 1999 when fertilizer was placed with the seed (Table 1), even though rates of N and P were at levels that literature references indicated to be safe. Although there were no statistically significant yield differences in 1999, there was a trend for a yield increase with starter fertilizer for hybrids P3335 and P4343. There was a significant response to starter P alone in 2000 (Table 2). There was a trend for the N and NP treatments to yield more than the control. This response to starter fertilizer was the same for all varieties. There was a significant response to N alone and to P alone in 2001 (Table 2).

PRACTICAL APPLICATIONS

The first three years' data indicate that starter fertilizer for corn increases yield and may be a worthwhile practice.

LITERATURE CITED

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ACKNOWLEDGMENTS

Support for this research was provided by the Arkansas Corn and Grain Sorghum Promotion Board.

Table 1. Influence of starter fertilizer on corn yield. 1999. Arkansas State University, Jonesboro, Arkansas.

Hybrid	Starter fertilizer	Plant population	Yield
		1000/acre	bu/acre
P 3335	N	15,488	118
P 3335	NP	17,061	113
P 3245	P	16,698	111
P 3335	P	16,998	107
P 3245	N	15,730	106
NK 7590	NP	16,577	104
P 3335	Control	15,730	103
NK 7590	Control	19,844	103
P 3245	Control	14,399	103
NK 454	Control	16,214	102
NK 7590	P	14,762	99
NK 454	N	15,125	99
NK 454	NP	17,424	98
P 3245	NP	12,705	95
NK 7590	N	15,609	94
NK 454	P	13,310	86
$LSD_{(0.05)}$		3,598	23

Table 2. Influence of starter fertilizer on corn yield. Arkansas State University, Jonesboro, Arkansas, (2000), and Pine Tree Experiment Station, Arkansas, (2001).

	Yield	
Starter fertilizer	00	01
	---------- bu/acre ----------	
P	146.6	110.9
N	127.4	114.2
NP	127.0	105.5
Control	113.7	91.7
$LSD_{(0.05)}$	17.7	16.3

CORN RESPONSE TO PHOSPHORUS AND POTASSIUM FERTILIZATION AT DIFFERENT SOIL TEST LEVELS

J.H. Muir and J.A. Hedge

RESEARCH PROBLEM

Modern corn hybrids, more intensive management systems, and crop rotations not previously used may influence the phosphorus (P) and potassium (K) requirements for corn. Studies on N requirements for corn in Arkansas in the 1980s identified a need to modify N recommendations for modern hybrids on fine-textured soils (Muir et al., 1992). These studies were initiated in 1997 to evaluate the response of corn to P and K fertilization on a range of soil test P and K levels.

BACKGROUND INFORMATION

Phosphorus and K recommendations for corn based on studies conducted years ago may not be adequate for corn grown in current production systems. Calibration studies to confirm current P and K recommendations or to provide evidence for modifying recommendations were warranted.

RESEARCH DESCRIPTION

Phosphorus and K calibration studies were initiated on a Calloway silt loam soil at Arkansas State University (ASU), Jonesboro, Arkansas. A site with a range of soil P and K levels was located in order to impose fertilizer treatments on blocks of varying soil-test levels. The site had a range of soil K levels, but had a limited soil P range. Soil K levels ranged from 85 to 272 lb/acre, and soil P ranged from 17 to 50 lb/acre. Phosphorus and K fertilizer rates of 0, 0.5, 1.0, and 2.0 times the recommended rate for the lowest soil-test levels were applied broadcast and incorporated before planting each year.

RESULTS

Application of K increased corn grain yield on soils with low, moderately-low, and medium K soil-test levels in 1998 and 1999, at low and moderately-low levels in 2000, and at the low level in 2001 (Table 1). There was a yield response to applied P in 1998 and 1999 on soils with low P soil-test levels and in 1999 on soils with medium soil-test values for P (Table 2). By fall 1999, P soil-test levels were very similar in plots initially low and medium in P. Although there was not a significant difference in yields due to applied P, there was a trend for increased yield with increased applied P rates in 2000 (Table 3). A significant yield increase was obtained with applied P in 2001 (Table 3).

PRACTICAL APPLICATIONS

Results to date indicate that corn responds to applied P and K at soil-test levels that currently result in recommendations to apply P and K. Results do not show a response to applied P and/or K at soil-test levels too high to warrant a recommendation under the current guidelines.

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ACKNOWLEDGMENTS

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

Table 1. Corn grain yield and soil-test K levels as affected by applied K on soils with different initial soil-test K levels. Arkansas State University, Jonesboro, Arkansas.

		Soil-test K[z]					Yield				
Soil K	K rate	Initial[y]	Fall 97	Fall 98	Fall 99	Fall 00	97	98	99	00	01
		lb/acre					bu/acre				
Low	0	111	72	113	125	103	154	125	136	179	183
	45	106	99	130	182	129	158	128	146	184	199
	90	108	107	139	199	160	169	151	174	198	203
	180	109	144	189	277	166	168	150	156	209	194
Moderately low	0	135	95	126	158	117	169	118	146	191	189
	45	138	106	173	188	119	159	121	140	189	198
	90	133	109	157	189	127	150	138	160	203	192
	180	138	158	228	291	199	182	131	161	211	198
Medium	0	157	104	147	165	119	176	138	152	186	188
	45	165	113	158	210	144	184	133	155	195	167
	90	162	139	173	242	144	181	150	161	196	195
	180	159	187	238	294	241	164	147	169	197	192
High	0	226	121	151	200	129	177	147	160	187	178
	45	195	128	164	213	131	183	127	167	192	181
	90	204	160	214	280	172	183	143	163	181	176
	180	245	212	280	333	232	179	135	150	180	154
$LSD_{(0.05)}$		11	25	21	25	28	16	9	12	15	13

[z] Mehlich 3, 1:7 extraction ratio.
[y] Spring 1997

Table 2. Corn grain yield and soil-test P levels as affected by applied P on soils with different initial soil-test P levels. Arkansas State University, Jonesboro, Arkansas.

		Soil-test P[z]			Yield		
Soil P	P rate	Initial[y]	Fall 97	Fall 98	97	98	99
		lb/acre			bu/acre		
Low	0	21	19	17	159	133	142
	35	22	25	23	152	136	152
	70	21	27	22	165	142	164
	140	23	53	27	173	145	153
Medium	0	31	24	20	168	134	148
	35	29	28	22	173	134	151
	70	27	37	23	182	138	164
	140	28	62	30	174	138	165
$LSD_{(0.05)}$		5	12	3	16	9	12

[z] Mehlich 3, 1:7 extraction ratio.
[y] Spring 1997.

Table 3. Corn grain yield and soil-test P levels as affected by applied P on soils with different soil-test P levels. Arkansas State University, Jonesboro, Arkansas.

	Soil-test P[z, y]		Yield	
Applied P	99	00	00	01
	lb/acre		bu/acre	
0	21	16	185	173
35	26	22	191	187
70	32	29	196	141
140	52	56	198	190
$LSD_{(0.05)}$	5	7	15	13

[z] Mehlich 3, 1:7 extraction ratio.
[y] Fall 1999

EVALUATION OF SOIL AND FOLIAR FERTILIZATION WITH BORON IN ARKANSAS

D.M. Oosterhuis, W.C. Robertson, J.S. McConnell, and R.S. Brown

RESEARCH PROBLEM

Boron (B) is routinely applied in commercial cotton production as soil- and foliar-applications, irrespective of soil B status. However, this recommendation was based largely on research conducted 30 years ago, and there has been no recent work to substantiate this with modern cultivars and production practices. Furthermore, there is only a limited understanding of B use by the cotton plant and the effect on the physiology of the cotton plant has not clearly been documented. The objective of this study was to evaluate yield response of soil- and foliar-applied boron at low and high soil nitrogen levels. In a companion study, the effect of boron deficiency on the growth of the cotton plant was characterized (Oosterhuis and Zhao, 2001).

BACKGROUND INFORMATION

Boron is an essential element required by cotton for optimal growth and development. Current production recommendations in Arkansas call for initial preplant soil applications of 1.0 lb to 2.0 lb B/acre or two and up to six foliar applications of 0.1 lb to 0.2 lb B/acre. This is based largely on research conducted by Miley (1966), Baker et al. (1956), and Maple and Keogh (1963). Recently, reports of yield response to soil or foliar applications of B have been inconsistent. For example, Howard and Gwathmey (1998), Abaye et al. (1998), and Heitholt (1992) reported no yield response to B utilizing non-buffered spray solutions, whereas Howard and Gwathmey (1998) observed that buffering B spray solutions to pH 4.0 increased yields relative to buffering to pH 6.0.

RESEARCH DESCRIPTION

The study has been conducted for three years at three locations across the state (northeast, central, and southeast Arkansas). The locations, cultivars used, planting dates, and initial soil B level (SBL) are presented in Table 1.

Fayetteville and Rohwer locations were on University Experiment Stations and were conducted utilizing small plot studies. Nitrogen rates for the low and high N treatments were 50 and 100 lb/acre, respectively. County locations were conducted utilizing large plots/strips in producer fields. Treatments were replicated at all locations. Soil-applied B consisted of 1.0 lb B/acre, and foliar B applications consisted of three 0.2 lb B/acre applications 1, 2, and 4 weeks after first flower. 'Buffer Xtra Strength' (manufactured by Helena Chemical) was used to buffer the spray solution to a pH of 4.0 to 5.0.

RESULTS

In general, soil or foliar B treatments had only small, non-significant effects on lint yields, and in only one out of ten field trials was a significant yield advantage recorded (Table 2). In general, at Clarkedale and in Desha/Jefferson and St. Francis Counties, the B treatments had no significant effect on yield. At Rohwer, significant differences were observed in the irrigated study in 1999 with B increasing yields in the low N plots. No significant differences were observed in the dryland study and the high N plots of the irrigated study. Buffered foliar applications did not significantly affect lint yield (data not shown, see Oosterhuis et al., 2001).

PRACTICAL APPLICATION

Results of this three-year study indicated that soil- or foliar-applied fertilizer B may not have been necessary to obtain high cotton yields. There were no positive responses to applied soil-B or foliar-B in the high N soil level in any of the locations. There was only one situation where the low N treatments responded to applied B. No positive responses were observed to buffered spray solutions of B at either of the two locations. These results should be interpreted in relation to the initial soil B status. This study indicates that the application of additional B as a routine procedure may not be necessary.

ACKNOWLEDGMENTS

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Table 1. The locations, cultivars used, planting dates (PD), and initial soil B level (SBL).

	1999			2000			2001		
Location	Cultivar	PD	SBL[z]	Cultivar	PD	SBL[z]	Cultivar	PD	SBL[z]
			lb/acre			lb/acre			lb/acre
Fayetteville	SG 125	4 June	0.5	SG 747	12 May	0.5	----	----	----
Desha Co.	ST BXN47	14 May	----	----	----	----	----	----	----
St. Francis Co.	PM 1560BG	11 May	----	PM 1218BG/RR	21 May	0.6	----	----	----
Rohwer	ST 474	14 May	0.1	----	----	----	----	----	----
Jefferson Co.	----	----	----	DP 451B/RR	9 May	1.6	DP 451B/RR	11 May	3.2
Clarkedale	----	----	----	----	----	----	SG 747	8 May	0.9

[z] Mehlich 3 extractable B, 1:7 extraction ratio.

Table 2. Effect of soil and foliar B application on cotton yields for test locations in Arkansas in 1999 and 2000.

	Lint yield												
	Fayetteville			Desha Co.	Jefferson Co.		St. Francis Co.		Rohwer				
	Irrigated	Clarkedale		Irrigated	Irrigated[z]		Irrigated		Irrigated		Dryland		
Treatment	1999	2000	2001	1999	2000	2001	1999	2000	1999	2000	1999	2000	
	lb/acre												
High N- control	1173	1348	965	1187	1063	1003	986	—[y]	1432	—[x]	883	---	
High N- soil B	1149	1462	921	1196	1041	909	955	1291	1466	---	942	---	
High N- foliar B	1181	1302	911	1209	1041	953	944	1250	1420	---	945	---	
Low N- control	1236	1296	998	---	---	---	---	---	721	---	896	---	
Low N- soil B	1072	1352	961	---	---	---	---	---	1024	---	963	---	
Low N- foliar B	1044	1392	902	---	---	---	---	---	1037	---	929	---	
$LSD_{(0.05)}$	NS[w]	NS	NS	NS	NS	NS	NS	NS	184	---	NS	---	

[z] Field oversprayed with 1 lb B/acre three weeks after the first flower.
[y] Treatment not included.
[x] Hail destroyed the study.
[w] NS = Not significant (P= 0.05).

BORON DEFICIENCY OF SOYBEAN IN ARKANSAS

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RESEARCH PROBLEM

Boron (B) is an essential micronutrient required for plant growth and reproduction. Plants require only small amounts of B for normal growth and yield production. Boron fertilization of crops grown in Arkansas has historically been limited to cotton (*Gossypium hirsutum* L.). There has been little evidence to justify the need for the investigation of crop response to B fertilization on crops other than cotton in Arkansas (Keogh and Maples, 1969). However, Al-Molla (1985) found a significant soybean [*Glycine max* (L.) Merr.] yield response to B fertilization in Poinsett and Craighead counties, AR. Researchers in other soybean-producing states have also documented soybean yield increases from B fertilization (Gascho, 1993; Woodruff, 1979). Studies conducted in the early 1990s in several Midwestern states showed significant yield increases in only 7 of 29 studies (Oplinger et al., 1993). Some states make recommendations for foliar B fertilization of soybean grown on sandy, coastal plains soils at the R2 growth stage.

DESCRIPTION OF BORON DEFICIENCY SYMPTOMS

Plant symptoms resembling those described for B deficiency (Hall and Schartz, 1993; Sinclair, 1993) were noted in numerous Arkansas soybean fields during the summer of 2001. Symptoms included the death of the primary growing point; short, stunted plants with stacked and swollen nodes; and thick, leathery leaves that often cupped or twisted. Examination of soybean plants in several of the affected fields showed that the primary growing point had died, but growth of the lateral branches gave the field a normal appearance in many areas. The most severely affected areas did not show any signs of recovery (new growth) and failed to set and fill pods. Generally, only small, scattered areas (~0.25 to 0.50 acre) were severely affected, but mild to moderate deficiency symptoms could be found over much larger areas. These symptoms have been previously observed in Arkansas, but were generally regarded as insignificant due to their infrequent occurrence. It is also noteworthy to mention that soybean growth appeared "normal" where irrigation levees had been the previous year.

In 2001, many growers had finished the season's first irrigation when they noticed the stunted areas during the first week of July. Symptoms were reported and documented in Clay, Cross, Jackson, Lawrence, Poinsett, and Woodruff counties west of Crowley's Ridge. The soils in these counties are predominately alkaline (mildly calcareous) Calloway, Calhoun, and Hillemann silt loams where soybeans are grown in rotation with rice. Boron deficiency is most likely to occur on low-organic matter, sandy soils with a soil pH of 7.0 or higher. Symptoms were noted following both rice and soybean in rice-soybean and rice-soybean-soybean rotations, respectively. Most of the fields with documented B deficiency were seeded in Roundup Ready cultivars. Symptoms were also noted in some fields seeded with non-Roundup Ready cultivars. Roundup Ready, chloride-excluding cultivars were seeded on the majority of the soybean acreage in these counties. There is some preliminary evidence to suggest that some soybean cultivars may be more sensitive to B deficiency than others (Gascho, 1993).

SOIL AND TISSUE ANALYSIS

Soil samples (0- to 2-inch depth) were taken from several of the production fields exhibiting B deficiency symptoms and analyzed for Mehlich 3 extractable nutrients (Mehlich, 1984), including B, and hot-water-extractable B (Isaac, 1992). Additional soil samples, taken from the 2- to 4- and 4- to 6-inch soil depths, were also analyzed and showed similar results as the 0- to 2-inch depth increment (data not shown). Electrical conductivity was measured in a 1:2 soil weight:water volume ratio and generally ranged between 40 and 60 µmhos/cm (data not shown). Results of selected soil chemical analyses are listed in Table 1.

Whole soybean plants, representing “sick” (B deficient) and “healthy” (no B deficiency symptoms) areas of production fields, were cut at the soil surface, gently washed to remove soil, ground to pass a 20-mesh (0.85-mm) sieve, and a 0.25g sub-sample was digested with concentrated HNO_3 and 30% H_2O_2 (Tables 2 and 3). Plants from several fields were also separated into stems, and top, middle, and bottom leaves, and digested as described above to examine B concentrations in different plant parts (Table 4). Plant growth had been affected for at least two weeks when the tissue samples were taken.

Elemental concentrations of soil extracts and plant digests were analyzed by inductively coupled atomic plasma spectroscopy. Soils from the North American Proficiency Testing Program, with known concentrations of hot-water-soluble B, were used as standard check soils to assess the accuracy of B concentrations in soils taken from grower fields.

RESULTS AND DISCUSSION

Soil analysis showed that both Mehlich 3 and hot-water-extractable B concentrations were higher in soils taken from field areas supporting normal soybean growth (Table 1). Hot-water-extractable soil B from the two fields listed in Table1 failed to show B concentration differences that could be classified as sufficient or deficient. However, Mehlich 3 extractable B showed that samples with >0.35 mg B/kg (0.70 lb B/acre) supported “normal” soybean growth, whereas soil with Mehlich 3 extractable B <0.15 mg B/kg (0.30 lb B/acre) showed severe B deficiency symptoms. Although further research is needed to calibrate Mehlich 3-extractable soil B concentrations to soybean yields and tissue-B concentrations, preliminary results suggest the Mehlich 3 extractant shows promise as a means of predicting where soybean will respond to B fertilization.

The sufficiency range of B concentration in the most recently matured trifoliate leaves of soybean at the R2 growth stage is 20 to 55 mg B/kg (Mills and Jones, 1996). Boron concentrations of soybean categorized as ‘Sick’ in Tables 2 and 3 were below the lower sufficiency level of 20 mg B/kg. Tissue analyses from these and other fields (data not shown) support the visual diagnosis concluding that B was indeed deficient. Although tissue-B concentrations were nearly always higher in the “Healthy” tissues, B concentrations were frequently below the lower sufficiency level. Boron concentrations of deficient soybean plants were usually lowest in the top leaves (youngest leaves) and increased as leaf age increased (Table 4). In contrast, the B concentration of plants not showing B deficiency symptoms tended to be highest in the top leaves. Tissue concentrations of P and K were also near or below the reported sufficiency ranges in many of these fields. In general, the concentrations of P and K were lower in soybean plants exhibiting B deficiency symptoms while Ca and Cu were nearly always higher. Mills and Jones (1996) suggested that the tissue Ca:B ratio of nutritionally healthy soybean plants should be about 500:1. The Ca:B ratio in many of the samples shown in Tables 2 and 3 exceeded this value, while only a few of the “healthy” samples had Ca:B ratios near 500:1. One grower in Cross County routinely applies B fertilizer to rice grown in the rotation. Tissue analysis of soybean from one of his fields showed whole plant-B concentrations of 42.9 mg B/kg at the R2 growth stage and soil-B (Mehlich 3 and hot water extractable) concentrations of 0.5 to 0.6 mg B/kg. Boron deficiency symptoms were not found in his fields.

Boron fertilizer was applied to soybean foliage in several of the fields exhibiting B deficiency symptoms. However, growth was not stimulated by B fertilization in severely stunted plants. This indicates that application of B fertilizer should likely be initiated before or during early vegetative growth to prevent the onset of B nutritional stress.

PRACTICAL APPLICATIONS

The widespread appearance of B deficiency symptoms in the 2001 soybean crop suggests that direct application of B fertilizer to soybean may be required on some soils used for soybean and rice production in Arkansas. Farmers, consultants, and extension and research personnel should be aware of the symptoms associated with B deficiency described in this report. Greenhouse studies have been initiated to validate that soybean will respond to B fertilization when grown on the soils that showed severe B deficiency during 2001. Field research will also be conducted in production fields in 2002 to begin developing research-based B-fertilizer recommendations for rice and soybean in Arkansas. The tentative recommendation for the 2002 growing season will be to broadcast apply 1.0 lb B/acre (e.g., 7 lb of 14.3% Granulbor™/acre) before seeding soybean. Because B deficiency symptoms were first reported in early July, B fertilizer should likely be applied before or shortly after planting until specific crop response data can be collected. Boron fertilizer (0.25 to 0.50 lb B/acre) can also be tank-mixed with some pesticides (always read and follow pesticide label instructions) to reduce production costs. Most states with existing B- fertilizer recommendations for soybean suggest 0.25 lb B/acre applied to soybean foliage at the R2 growth stage. Growers are cautioned that plants have a narrow range between B deficiency and toxicity.

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Table 1. Selected soil properties taken from the 0- to 2-inch depth in field areas with healthy and sick (B deficient) soybean plants in Cross County, AR during the 2001 growing season.

	Plant	Soil	Mehlich 3-extractable nutrients[y]											Hot water
Grower	status[z]	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Zn	Cu	B	B
			mg/kg											
Schlenker	Healthy	8.2	36	46	2392	245	57	13	255	79	1.1	4.9	0.45	0.50
	Sick	7.5	31	78	2433	297	45	9	237	71	1.3	3.6	0.10	0.22
Thomas	Healthy	6.9	40	118	1510	253	44	11	175	62	1.0	1.6	0.35	0.24
	Sick	8.0	23	80	1689	255	42	12	185	58	1.2	1.6	0.15	0.20

[z] Healthy plants represent field areas that did not show symptoms of B deficiency. Sick plants represent field areas that did show symptoms of B deficiency.
[y] A modified Mehlich 3 procedure (1:7 extraction ratio) was used to extract soils.

Table 2. Summary of tissue analysis of soybean from fields with suspected B deficiency in Woodruff and Lawrence counties, AR, during 2001.

Element	Coley Woodruff Co.		Pribble Woodruff Co.		Swaitzlander Lawrence Co.		Keating Woodruff Co.		Little Woodruff Co.	
plant status	Healthy	Sick	Healthy	Sick	Healthy	Sick	Healthy	Sick	Healthy	Sick
Cultivar-Part	*Hartz 5999RR -WP*[z]		*Caviness - WP*		*P9492 RR - TF*[z]		*DK5661 - WP*		*DPL5915 - WP*	
N, %	2.37	2.23	3.21	3.91	2.70	1.32	5.08	3.95	4.06	4.04
P, %	0.23	0.21	0.18	0.23	0.44	0.30	0.29	0.26	0.25	0.25
K, %	1.67	1.02	1.20	1.25	2.09	1.31	1.37	1.11	1.56	1.08
Ca, %	1.24	1.69	1.30	1.84	1.07	1.51	1.43	1.98	1.22	1.05
Mg, %	0.33	0.41	0.25	0.35	0.37	0.44	0.37	0.39	0.40	0.32
S, %	0.17	0.20	0.17	0.22	0.32	0.24	0.27	0.29	0.23	0.24
Na, %	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.008	0.005	0.005
Fe, mg/kg	159	428	229	182	101	438	149	264	119	100
Mn, mg/kg	222	278	409	272	95	122	90	175	146	123
Zn, mg/kg	47.5	33.1	28.6	38.0	63.0	68.7	21.0	27.0	42.4	43.8
Cu, mg/kg	7.4	5.8	4.4	4.8	14.9	12.1	9.4	8.8	9.5	8.0
B mg/kg	25.4	7.2	10.7	12.1	29.0	8.8	15.2	8.0	17.8	13.2
Cl, mg/kg	6639	16939	5460	14445	--	--	7500	13700	867	975

[z] WP, abbreviation for whole plant used in tissue analysis; TF, abbreviation for trifoliate leaves used in tissue analysis.

Table 3. Summary of tissue analysis of soybean from fields with suspected B deficiency in Cross County, AR, during 2001.

Element	Schlenker Cross Co.		Thomas Cross Co.		Mike Wood Cross Co.		Coffee Cross Co.		Nicholson Cross Co.	
Plant status	Healthy	Sick	Healthy	Sick	Healthy	Sick	Healthy	Sick	Healthy	Sick
Cultivar-Part	*AS 5501 - TF*[z]		*NK 559-V6RR - TF*		*P5900RR - TF*		*P95B53 - WP*[z]		*Manokin - TF*	
N, %	5.30	3.72	5.08	3.77	4.32	3.42	4.35	3.85	4.53	3.76
P, %	0.35	0.26	0.35	0.27	0.30	0.21	0.25	0.24	0.26	0.24
K, %	1.58	1.22	1.64	0.99	1.86	1.25	1.36	1.44	1.03	1.16
Ca, %	0.96	1.07	0.96	1.54	1.26	1.02	1.14	1.39	1.46	1.52
Mg, %	0.28	0.27	0.40	0.45	0.53	0.27	0.23	0.24	0.28	0.39
S, %	0.25	0.20	0.31	0.24	0.23	0.21	0.22	0.24	0.25	0.23
Na, %	0.005	0.005	0.003	0.004	0.006	0.004	0.01	0.01	0.004	0.003
Fe, mg/kg	131	296	226	225	258	242	119	127	215	257
Mn, mg/kg	86	128	69	106	120	74	105	139	140	113
Zn, mg/kg	43.1	35.4	26.9	26.4	28.9	21.9	42.1	45.2	24.7	29.2
Cu, mg/kg	11.7	7.6	10.3	9.0	10.3	7.5	5.3	5.8	9.6	8.8
B mg/kg	20.9	8.0	11.1	6.9	18.9	6.6	12.8	7.8	11.8	9.0
Cl, mg/kg	783	1761	666	1164	1275	1593	2058	5370	405	900

[z] TF, abbreviation for trifoliate leaves used in tissue analysis; WP, abbreviation for whole plant used in tissue analysis.

Table 4. Boron concentration of healthy (i.e., B sufficient or no symptoms) and sick (i.e., B deficient) soybean plant tissues sampled from several soybean fields in Cross County, AR, during 2001.

	Thomas		Schlenker		Woods field 1		Woods field 2		Volk	Schlenker field 2[z]
Plant part	Healthy	Sick	Healthy	Sick	Healthy	Sick	Healthy	Sick	Sick	Healthy
	mg B/kg									
N, %	5.30	3.72	5.08	3.77	4.32	3.42	4.35	3.85	4.53	3.76
Top leaves	11.5	9.2	16.5	7.6	18.3	8.7	13.2	5.1	6.2	19.9
Middle leaves	15.8	9.7	11.6	10.7	16.2	10.4	7.2	4.9	7.3	11.0
Bottom leaves	15.0	11.7	13.9	14.5	14.7	15.0	9.5	4.7	9.5	12.7
Stems	9.1	8.4	9.8	7.5	11.0	6.9	7.0	2.9	6.1	11.2
Whole plant	11.0	10.8	10.2	9.7	14.2	9.8	7.7	4.9	6.8	12.3

[z] Samples were taken from this field, which showed no B deficiency symptoms, to compare to other soybean tissues from fields exhibiting B deficiency.

SOYBEAN RESPONSE TO POTASSIUM FERTILIZER RATE FOLLOWING RICE IN ROTATION

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RESEARCH PROBLEM

Silt loam soils used for rice (*Oryza sativa* L.) and soybean [*Glycine max* (L.) Merr.] production in eastern Arkansas are capable of producing high-yielding rice and soybean crops. However, most of the nutrient deficiencies (e.g., P and K) observed in the rice and soybean crops produced in Arkansas also occur in silt loam soils. Maintaining the productivity of these soils may require annual fertilizer applications to replace nutrients removed by the harvested crops. Growers have commented that soil-test concentrations of phosphorus (P) and potassium (K) have remained low or declined when the University of Arkansas P and K fertilizer recommendations were followed. The long-term objectives of this project are: i) to document the response of rice and soybean, grown in rotation, to different K fertilizer rates; and ii) to monitor soil test K response to K fertilizer rate over time in a rice-soybean rotation.

BACKGROUND INFORMATION

The University of Arkansas fertilizer recommendations are based on a "fertilize the crop" philosophy, which is considered the most economical means of fertilization. The "fertilize the crop" philosophy means that fertilizer is recommended only when a crop yield response is expected. This philosophy may also contribute to a gradual reduction of soil test P and K concentrations when soil test P and K concentrations are above the critical soil test threshold and fertilizers are not recommended. Soybean removes about 0.34 lb P/bu (0.80 lb P_2O_5/bu) and 1.16 lb K/bu (1.40 lb K_2O/bu) from the soil. Rice removes about 0.13 lb P (0.30 lb P_2O_5/acre) and 0.13 K (0.16 lb K_2O/acre) from the soil. Soil nutrients may also be lost via other pathways (e.g., leaching, runoff, erosion, burning, nutrient cycles, etc.) that may contribute to gradual reductions in soil nutrient concentrations. Under some situations, nutrients may be present in forms (i.e., fixation) in the soil that cannot be extracted by routine soil testing. Soil samples taken shortly after harvest in the fall, when available plant nutrient concentrations in the soil are at their lowest, may also show low soil-test concentrations. This research was established to monitor crop yields and soil-test nutrient concentrations in a rice-soybean rotation.

PROCEDURES

An area was established for K research in the spring of 2000 at the Pine Tree Branch Experiment Station. In 2000, rice was grown with five K fertilizer application rates ranging from 0 to 120 lb K_2O/acre. Rice response to K fertilizer rate and application timing during the 2000 growing season was reported by Slaton et al. (2001). Plot boundaries were marked and composite soil samples were taken in March of 2001 to evaluate the effect of K rates applied in 2000 on soil-test K (Table 1). Soil samples were extracted with Mehlich 3 solution (1:7 extraction ratio) and nutrient concentrations were determined by inductively coupled argon plasma spectroscopy (ICAP).

Soybean ('Caviness' cv.) was drill-seeded (7-inch row spacing) into a conventionally tilled seedbed on 22 June 2001. Phosphorus fertilizer (100 lb triple super phosphate/acre) was broadcast applied to the plots shortly after seeding. Potassium fertilizer (KCl, 60% K_2O or 50% K) treatments were applied to the soil surface on 2 July. The same K fertilizer rates that were applied to rice in 2000 were also applied to soybean in 2001. At the R2 growth stage (8 August), whole-plant samples were removed at the soil surface from a randomly selected 2 linear row-ft section from each plot. Samples were dried in a forced draft oven at 60°C to a constant weight, weighed, ground to pass a 1-mm sieve, and a 0.25 g sub-sample was digested with concentrated HNO_3 and 30% H_2O_2. The digests were analyzed for Ca, Mg, Na, K, Fe, Mn, Zn, Cu, P, and S by ICAP. Total K uptake was calculated from dry matter and tissue-K concentration. At maturity, a 100 ft^2 area was harvested with a small-plot combine for yield determination. Yields were adjusted to a uniform moisture content of 13%.

The experiment was arranged in a randomized complete block design with eight replications. Analysis of variance procedures were conducted with the PROC GLM procedure in SAS. Mean separations were performed by Fisher's protected least significant difference (LSD) method at a significance level of 0.05 or 0.10.

RESULTS AND DISCUSSION

The initial soil-test K, before K fertilizer treatments were applied in May 2000, averaged 161 lb K/acre (Slaton et al., 2001). Soil-test K, measured in March of 2001, was significantly affected by the five K fertilizer rates applied to rice (Table 1). Rice harvested from plots in 2000 removed an estimated 18 lb K/acre. Potassium inputs were greater than crop K removal at all K application rates greater than 0 lb K/acre. Soil-test K increased or decreased by approximately one-half the net gain/loss of K. The estimated K removal by the 2001 soybean crop resulted in a net loss of K at all rates less than 75 lb K/acre. The recommended K fertilizer rate (50 lb K/acre or 60 lb K_2O/acre) for irrigated soybean balanced crop K removal (net loss of -3.2 lb K/acre). However, higher soybean yields would have increased crop K removal and resulted in a net loss of soil K at the recommended K fertilizer rate. Soil test results from Spring 2002 will be reported in next year's research summary. The balance of K added (fertilizer) and removed (K in harvested soybean seed) suggests that soil test K should decrease in plots receiving 0 and 30 lb K_2O/acre, remain constant in plots receiving 60 lb K_2O/acre, and increase in plots receiving 90 and 120 lb K_2O/acre.

Dry matter accumulation at the R2 growth stage was not significantly affected by K fertilizer rate in 2001, but tended to increase when K fertilizer was applied (Table 2). Whole-plant tissue K concentration increased as K rate increased. Whole-plant concentrations of other nutrients were within the sufficiency ranges (data not shown). Similar to dry-matter accumulation, total K uptake at the R2 growth stage was not significantly affected by K fertilizer rate, but tended to increase as K fertilizer rate increased. Application of K fertilizer increased soybean yields above the untreated control, regardless of the K rate applied.

PRACTICAL APPLICATIONS

Fertilizer recommendations that are based on routine soil testing must be calibrated with crop response under the typical crop rotations and production systems. Rice and soybean are commonly grown in rotation and information from these studies will improve our K fertilizer recommendations. Based on soybean yields measured in 2001, the University of Arkansas K fertilizer recommendations are appropriate, but high soybean yields (> 50 bu/acre) may result in a net loss of soil K with the current recommendations. However, application of the recommended K rates to rice in the rotation should offset the net K loss in soybean since K removal by rice is relatively low.

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Table 1. Effect of K fertilizer rate and crop K removal on soil test K changes between May 2000 and March 2001 in a K fertilization study conducted at the Pine Tree Branch Experiment Station, Colt, AR.

Annual K fertilizer rate	March 2001 soil-test K[z]	K removal by 2000 rice[y]	2000 net K gain/loss[x]	Net soil-test change[w]	K removal by 2001 soybean[y]	2001 net K gain/loss[x]
			lb K/acre (lb K_2O/acre)			
0	156	18	-18	-5	48.5	-48.5
25 (30)	166	18	7	5	52.3	-27.3
50 (60)	177	18	32	16	53.2	-3.2
75 (90)	186	18	57	25	52.3	22.7
100 (120)	198	18	82	37	55.1	44.9
$LSD_{(0.05)}$	18	--	--	--	--	--
P-value	0.0004	--	--	--	--	--
C.V., %	10.1	--	--	--	--	--

[z] Mehlich 3-extractable K. Modified K extraction procedure - 1:7 extraction ratio.
[y] Crop K removal is based on average rice yield produced in 2000 (140 bu/acre) and an average of 0.13 lb K/bu. Soybean K removal based on actual soybean yields for each K rate and an average of 1.16 lb K/bu.
[x] Net gain or loss is calculated difference between fertilizer K rate and estimated crop K removal.
[w] Mean soil-test K, averaged across 40 soil samples taken in May of 2000, was 161 lb K/acre (std deviation = 15 lb K/acre). Net change is the March 2001 soil-test K - May 2000 soil test K.

Table 2. Effect of K fertilizer rate on soybean dry-matter accumulation, whole-plant tissue K concentration, total K uptake at the R2 growth stage, and yield at maturity in a K fertilization study conducted at the Pine Tree Branch Experiment Station, Colt, AR, during 2001.

Annual K fertilizer rate		Dry matter	Tissue K	Total K	Yield	K removal[z]
lb K_2O/acre	lb K/acre	lb/acre	%	lb K/acre	bu/acre	lb K/acre
0	0	3380	1.44	50.0	41.8	48.5
30	25	3493	1.47	50.7	45.5	52.3
60	50	3655	1.52	56.9	45.9	53.2
90	75	3919	1.66	61.6	45.5	52.3
120	100	3627	1.68	57.8	47.5	55.1
$LSD_{(0.10)}$		NS	0.17	NS	2.5	--
P-value		0.724	0.087	0.353	0.021	--
C.V., %		21.7	11.3	21.0	6.3	--

[z] Estimated from harvested yield and soybean content of 1.16 lb K/bu.

ADAPTATION OF SOYBEAN CULTIVARS TO RESTRICTIVE SOIL ENVIRONMENTS

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RESEARCH PROBLEM

Soybean cultivars available to producers in Arkansas are capable of producing yields of over 60 bu/acre when grown in high-yield environments. However, some soybean producers have reported decreasing yield trends over the past 20 years in specific fields. In fields used for soybean-rice rotations, rice yields have been decreasing as well. Although highly productive cultivars have been grown on these fields using currently recommended fertilization and cultural practices, seed yields are lower than a decade or more ago when older cultivars were grown. This research is being conducted in conjunction with an ongoing breeding program to identify factors that limit soybean seed yield in certain fields and to develop new cultivars, which produce higher yields than conventional cultivars when grown in fields with a history of limited productivity.

BACKGROUND INFORMATION

Yield potential of cultivars developed by conventional breeding programs is estimated by growing experimental strains in environments that maximize seed production. Growers who have fields that restrict seed yield because of unidentified factors do not have a source of cultivar performance information in environments that are closely related to their own.

RESEARCH DESCRIPTION

Four fields located in Craighead, Cross, and Monroe Counties have been used in this study. Each field has produced progressively lower seed yields in recent years, although the cultivars grown have been highly productive in the Arkansas Soybean Performance Tests. Soil test results from two of the fields have been described in a previous publication (Widick and Harrell, 1999). Each year a variety of diverse soybean genotypes are grown in these yield-restrictive fields. Sources of these genotypes include commercial cultivars, experimental strains, plant introductions, and old cultivars. New germplasm is added for evaluation each year as new cultivars and experimental strains become available. Yield, agronomic characters, and foliar nutrient composition are measured. Leaflets of the uppermost trifoliolate leaves are sampled at R3 (Fehr and Caviness, 1977). Selections for crossing are based on seed yield and plant growth each year. Foliar data are used to determine whether any nutrients are present in deficient or toxic levels. Seed of promising populations derived from crosses is increased at the Northeast Research and Extension Center (NEREC) at Keiser, AR. Newly developed populations will undergo additional cycles of selection in restrictive environments. Tests to determine the effects of deep tillage and added potassium (K) have been conducted in past years to help identify the factors responsible for yield decreases.

RESULTS

Approximately 200 strains derived from crosses among selections made in fields where seed yields have been decreasing in recent years were grown and evaluated at NEREC and at the Pine Tree Branch Experiment Station in 2001. This was done in order to increase seed of the strains sufficiently to test it in the restrictive environments and to evaluate its yield potential in more productive environments. In 1998, a study at Monroe County, AR, showed that not all cultivars responded positively to deep tillage (Widick and Harrell, 1999). In 2000 a test comparing two of the same cultivars – Cache, which did not respond to deep tillage, and Manokin, which produced higher yields following deep tillage – was conducted in a randomized complete block factorial design to determine how they would respond to added K where the K level was marginal. A significant interaction ($P<0.05$) occurred for cultivar x fertilizer effects. Seed yield of Cache increased while that of Manokin decreased when 202 kg/ha of K as muriate of potash was added.

PRACTICAL APPLICATIONS

Tests conducted in addition to genotype selection suggest that soil compaction may be one of the factors limiting seed production on some fields. Further study of the effects of various deep tillage methods is needed for this type of environment. The interaction between cultivar and K fertilizer rate indicates a need for further study of cultivar fertilizer interactions. Cultivars being developed will increase productivity of environments that restrict yield of currently available cultivars.

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