REPORT OF PROGRESS 719

KANSAS FERTILIZER RESEARCH
1994

AGRICULTURAL EXPERIMENT STATION.
Kansas State University, Manhattan
Marc A. Johnson, Director

INTRODUCTION

The 1994 edition of the Kansas Fertilizer Research Report of Progress is a compilation of data collected by researchers over all of Kansas. Information included was contributed by staff members of the Department of Agronomy and Kansas Agricultural Experiment Station and agronomists at the various Agronomy Experiment Fields and Agricultural Research or Research-Extension Centers.

This report provides a summary of the latest research results in soil fertility and as such does not constitute publication of the finalized form of the various investigations. No part of this report may be duplicated or reproduced without the written consent of the individual researchers involved.

The investigators whose work is cited in this report greatly appreciate the cooperation of many county agents; farmers; fertilizer dealers: fertilizer equipment manufacturers; agricultural chemical manufacturers; and the representatives of the various firms who contributed time, effort, land, machinery, materials, and laboratory analyses. Without their support, much of the work reported here would not have been possible.

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NOTE: Trade names are used to identify products. No endorsement is intended, nor is any criticism implied of similar products not mentioned.

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TABLE OF CONTENTS

Precipitation Data (Inches)

1993	Manhattan	S.W. KS RES-EXT. CTR Tribune	S.E. KS EXP. STA. Parsons	E. CEN EXP. FLD. Ottawa
August	6.61	5.27	2.30	1.89
September	3.99	0.46	13.88	8.29
October	0.83	1.28	1.37	2.31
November	1.17	0.67	2.38	2.10
December	1.06	0.08	1.75	1.07
Total 1993	56.38	16.29	51.38	52.90
Dept. Normal	23.50	1.03	12.87	14.63
1994				
January	0.32	0.52	1.28	0.58
February	0.48	0.17	3.33	0.91
March	0.24	0.27	1.53	1.22
April	4.17	3.71	13.62	9.08
May	3.22	1.37	2.62	1.95
June	5.86	4.12	1.39	5.41
July	4.07	3.79	6.74	2.70
August	3.18	0.80	4.37	5.75
September	0.43	0.29	1.94	2.25

1993	N. CEN EXP. FLD. Belleville	KANSAS RV VALLEY EXP. FLD.	S. CEN. EXP. FLD. Hutchinson	FT. HAYS EXP. STN. Hays
August	5.56	5.29	1.83	6.26
September	2.87	7.03	1.76	2.24
October	1.67	1.36	0.76	0.55
November	0.65	1.12	1.11	0.40
December	1.28	0.90	0.42	1.06
Total 1993	49.46	46.52	33.59	37.99
Dept. Normal	18.42	11.29	6.28	16.19
1994				
January	0.92	0.51	0.67	0.75
February	0.96	0.43	0.77	0.48
March	0.09	0.55	0.16	0.09
April	2.01	4.09	4.38	2.71
May	1.50	1.30	0.62	1.04
June	8.45	5.39	4.27	0.72
July	5.59	2.99	6.48	5.50
August	0.62	8.54	0.70	0.27
September	1.03	1.34	1.65	0.67

WHEAT FERTILIZATION STUDIES
KANSAS STATE UNIVERSITY, DEPARTMENT OF AGRONOMY

MANAGEMENT ALTERNATIVES FOR WHEAT PRODUCTION ON ACID SOILS

A.J. Suderman, R.E. Lamond, D.A. Whitney, S.R. Duncan, R. Baragenana, and G.M. Pierzynski

Summary

Research done on acid, high KCl-extractable aluminum (Al) soils confirms that liming will raise soil pH, reduce soil aluminum levels, and improve wheat production. If liming isn't possible, banding P with the seed has proven very effective in increasing wheat yields on these soils. Variety selection is also important, because some varieties are more sensitive to Al than others. Our recommendation to producers is to lime when possible, but consider reduced rates of lime, banded P, and variety selection as short-term alternatives for wheat production on acidic soils.

Introduction

Acid soils have existed in southcentral Kansas for many years, but response to lime application was not demonstrated until 10 to 15 years ago. Awareness of potential lime response has prompted producers to do more soil testing of poor-producing fields and spots in fields. More than a third of the soil samples from this area tested by the KSU Soil Testing Lab last year were of pH 5.5 or less.

With lime quarries more than a 100 miles from much of this acidic soil area, producers are interested in alternatives to ag-lime. Phosphate fertilizer is known to react with soluble soil Al and perhaps could be used to reduce Al toxicity. The objective of this research was to evaluate the effectiveness of phosphate fertilizer as an alternative to ag-lime for wheat production on extremely acidic soils. The studies also compared the responses of wheat varieties with different tolerances to Al.

Procedure

Studies were continued on a cooperator's field in Sedgwick County. The site is on a Farnum silt loam. Selected chemical characteristics of the site are shown in Table 1. One study, initiated in the fall of 1991, consisted of three lime rates (0, 3750, and 7500 lb ECC/a); three P treatments (0, 40 lb P_20_5/a broadcast, and 40 lb P_20_5/a banded with the seed); and two varieties (Karl, fairly sensitive to Al, and 2163, somewhat tolerate to Al) in a split-plot design with lime rates being the main plots and the P rates and varieties the subplots. For the 1994 crop, however, only the lime effects were studied, and the whole study was planted to Karl. The lime was applied in late July, 1991 with incorporation by the cooperator. The 1994 crop was the third crop since lime application.

A second study evaluated a full rate of broadcast lime (7500 lb ECC/a) incorporated prior to seeding, 100 and 200 lb ECC/a lime banded with seed at planting, 20 and 40 lb P_20_5/a banded with seed at planting, 100 lb ECC/a lime plus 20 lb P_20_5/a band with seed, and a check treatment. Karl wheat also was used in this study.

Results

Results from these studies are summarized in Tables 2 and 3. Yields in 1994 were doubled by liming (Table 3), and test weights also were increased significantly. The half-rate of lime was effective. Table 2 shows how lime has affected soil pH and Al levels at this site. Even though the half rate of lime has raised pH and reduced Al levels, it's apparent that using reduced rates of lime will necessitate reliming more often.

Results of the second study are summarized in Table 4. The full rate broadcast lime treatment and the banded P treatments produced significantly higher yields than the check. Banded lime was not as effective.

Table 1. Selected chemical characteristics of study location.

Chemical Analysis	Sedgwick Co.
Soil pH	4.7
SMP Lime, lb ECC/a	7500
Bray-1 P, ppm	53
Exch. K, ppm	135
KCl-Ext. Al, ppm	47

0-6" soil samples

Table 2. Effect of lime rate on soil pH and KCl-extractable Al 23 months after application, Sedgwick Co., KS.

Lime	Soil pH		KCl-Extractable Al	
Rate	0-3"	3-6"	0-3"	3-6"
lb ECC/a			- - ppm - -	
0	4.7	4.9	50	50
3750	5.5	5.0	1	23
7500	6.2	5.2	0	10

Incorporation by field cultivator

Table 3. Effect of lime on wheat, Sedgwick Co., KS.

	1994		
Lime Rate	Yield	Test Weight	3-Year Avg. Yield
lb ECC/a	bu/a	lb/bu	bu/a
0	23	46	33
3750 (1/2 rate)	42	60	48
7500 (full rate)	46	61	48
LSD (0.05)	16	5	--

Soil pH: 4.7, Variety: Karl
Lime applied in August, 1991.

Table 4. Lime and P management on Karl wheat, 1994, Sedgwick Co., KS.

Treatment*	Yield	2-Year Avg Yield
	bu/a	bu/a
Check, 0 lime, 0 P_20_5	32	31
7500 lb ECC/a, broadcast	39	41
100 lb ECC/a, banded	36	33
200 lb ECC/a, banded	35	32
20 lb P_20_5/a, banded	42	42
40 lb P_20_5/a, banded	38	41
100 lb ECC/a + 20 lb P_20_5/a, banded	31	33
LSD (0.05)	NS	--
LSD (0.10)	7	--

* Broadcast lime applied in August, 1992. All banded treatments applied each year.

EFFECTS OF CHLORIDE RATES ON WINTER WHEAT IN KANSAS

R.E. Lamond, K. Rector, and J.C. Baker

Summary

Research to date on Cl shows significant yield response in eastern Kansas in about 60% of the studies. Chloride does seem to affect progression of some leaf diseases by suppressing or slowing infection; however, it does not eliminate diseases. Chloride responses have been noted even in the absence of disease, suggesting that some Kansas soils may not be able to supply needed amounts of Cl. Chloride fertilization significantly and consistently increases wheat leaf tissue Cl concentrations. Research on this project will continue in 1995.

Introduction

For wheat and some other cereal grains, chloride (Cl) has been reported to have an effect on plant diseases, either suppressing the disease organism or causing the plant to be able to withstand infection. Yield increases may be due to these effects. Researchers from several states have been able to show yield increases from chloride-containing fertilizers. The most common source is potassium chloride, KCl. In many cases, soil test K levels are high, and most soil test recommendations call for no additional K. However, when small increments of KCl are used, some yield increases have been reported.

The objective of these studies was to evaluate the effects of chloride fertilization on yields of hard red winter wheat in Kansas.

Procedure

Studies were continued in 1993 at two sites in Marion County and one site in Cowley County.

Potassium chloride (KCl) or magnesium chloride ($MgCl_2$) were topdressed at rates of 10, 20, or 30 lb Cl/a. Nitrogen was balanced at all locations.

Leaf tissue samples were taken during grain fill and analyzed for Cl content. Grain yields were determined, and grain samples were retained for analyses.

Results

Chloride significantly increased wheat grain yields in 1993 at one of three sites (Table 5). Chloride fertilization also significantly increased Cl concentrations in wheat leaf tissue at all sites. The Cowley County site, where Cl fertilization increased yields, had some disease pressure, whereas the Marion County sites had low levels of disease. Over the past couple of years, our work shows 2163 to be more responsive to Cl than Karl.

Table 5. Effects of chloride rates and sources on wheat, 1994.

Cl		Cowley Co.		Marion Co. West		Marion Co. East	
Rate	Source	Yield	Tissue Cl	Yield	Tissue Cl	Yield	Tissue Cl
lb/ac		bu/a	%	bu/a	%	bu/a	%
0	--	65.7	0.20	50.0	0.33	49.7	0.13
10	KCl	68.8	0.28	48.0	0.34	51.0	0.18
20	KCl	71.6	0.36	51.0	0.43	54.3	0.25
30	KCl	75.5	0.50	50.5	0.49	50.8	0.37
10	$MgCl_2$	69.5	0.22	50.0	0.38	50.0	0.14
20	$MgCl_2$	71.0	0.28	53.5	0.43	50.5	0.22
30	$MgCl_2$	70.0	0.29	50.0	0.40	49.9	0.28
LSD (0.05)		NS	0.09	NS	0.09	NS	0.10
LSD (0.10)		5.0	0.07	NS	0.07	NS	0.08

Cowley Co.: 2163
Marion Co. West: 2163
Marion Co. East: Karl

ZINC FERTILIZATION ON WHEAT

R.E. Lamond and V.L. Martin

Summary

Previous work in Kansas has shown that wheat does not respond to Zn fertilization, even when DTPA Zn soil test levels are low. Current KSU recommendations do not suggest applying Zn to wheat. This study evaluated Zn on three wheat varieties on a soil that tested very low in Zn. Cimarron and Triumph 64 responded to Zn, whereas 2163 did not. Results suggest more work is needed on Zn fertilization of wheat.

Introduction

Relative to corn or soybeans, wheat does not respond to Zn, and Zn fertilization of wheat in Kansas has not been recommended. In recent years, suspected Zn deficiency on certain wheat varieties has been reported. This study was initiated to evaluate Zn fertilization on three wheat varieties on a low Zn test soil.

Procedure

Zinc rates (0, 2 lb/a) and time of application (fall - just after seeding, spring) were evaluated on three wheat varieties (Cimarron, Triumph 64, and 2163) at the Sandyland Experiment Field in Stafford County. Cimarron and Triumph 64 were selected because they had shown possible Zn deficiency symptoms in previous years at this site. The site has a very sandy, low organic matter soil with a DTPA Zn test of less than 0.5 ppm, which is considered deficient. Zinc was applied as Zn chelate (9% Zn). Leaf samples were taken, and Zn concentrations determined. Grain yields also were determined.

Results

Results of this study are summarized in Table 6. Visual responses to Zn were not readily apparent anytime during the growing season, and the Zn deficiency symptoms that had been observed, particularly on Cimarron, did not show up in 1994. In spite of this, grain yields of both Cimarron and Triumph 64 were increased by Zn fertilization. In light of these results, this work will be repeated and likely expanded in 1995.

Table 6. Zinc fertilization on wheat, 1994, Sandyland Expt. Field.

Zn		Grain			Tissue Zn	
Rate/Time*	Variety	Yield	Moisture	Test Wt.	Early	Boot
lb/a		bu/a	%	lb/bu	- - ppm - -	
0	Cimarron	27.8	10.4	61	21	18
2-Fall	Cimarron	33.3	10.4	61	21	19
2-Spring	Cimarron	31.3	10.3	61	20	21
0	Triumph 64	31.0	10.4	61	23	21
2-Fall	Triumph 64	33.0	10.3	61	22	21
2-Spring	Triumph 64	36.3	10.3	62	22	22
0	2163	31.5	10.0	58	22	20
2-Fall	2163	31.0	9.9	57	21	22
2-Spring	2163	31.5	10.0	58	20	23
LSD (0.05)		NS	0.2	1	NS	3
LSD (0.10)		3.7	--	--	NS	--
Mean Values:						
Zn	0	30.1	10.3	60	22	20
Rate/Time	2-Fall	32.4	10.2	60	21	20
	2-Spring	33.0	10.2	60	21	22
	LSD (0.05)	NS	NS	NS	NS	2
	LSD (0.10)	2.1	NS	NS	NS	--
Variety	Cimarron	30.8	10.4	61	21	19
	Triumph 64	33.4	10.4	61	22	21
	2163	31.3	10.0	57	21	22
	LSD (0.05)	NS	0.1	1	NS	2
	LSD (0.10)	NS	--	--	NS	--

* Zn applied as Zn chelate, broadcast
Zn by variety interaction was nonsignificant

EFFECT OF TIME OF TOPDRESSING NITROGEN ON WINTER WHEAT, CHEROKEE COUNTY, KANSAS

R.E. Wary, R.E. Lamond, D.A. Whitney, and G.L. Kilgore

Summary

A 3-year study of time of N application for winter wheat in southeast Kansas showed no significant difference between all preplant N and various winter-early spring application dates for three of six locations. Three locations had significantly lower yields for the April 15 application date compared to the March 15 date or earlier. The March 15 application date gave the highest average yield for six site-years, but it was not statistically better than several other dates.

Introduction

Splitting nitrogen (N) application for winter wheat in southeast Kansas is a common practice. Approximately 1/3 is applied preplant with phosphorous and potassium and 2/3 is topdressed post-emergence in late winter. The reason for the split application is to prevent loss of N by denitrification on our claypan soils that many times get "waterlogged" with excessive winter precipitation. The question then becomes, when is the best time to topdress it?

Procedure

Two sites were selected this year, with one being on the Don and Rod Watson farm southeast of Weir, and the other on the Gary and Neil Martin farm west of Columbus. Both sites were on claypan soil. The trial on Watson's followed a 100 bu/a grain sorghum crop, and that on Martin's followed a 38 bu/a soybean crop. Fertilizer treatments included a uniform application on all plots prior to planting. Seven treatments replicated three times were used at each site. Additional N was topdressed at different times and on different areas in the field to make a total of 100 lbs of N (63 lbs topdressed) on Martin's and 110 lbs of N (83 lbs topdressed) on Watson's. Treatments included preplant N only; preplant plus the topdressed N all applied ahead of planting; and topdressed N applied on Dec. 15, Jan. 15, Feb. 15, March 15, or April 15. Urea was the N form used for all treatments.

The details for each site, yield, and grain protein are found in Tables 7-11.

Results

Applying all of the N at planting time produced yields comparable to topdress applications (Table 8). In three of the four trials in 1992 and 1993, the March application date resulted in the highest yield, and this is reflected in the 3-year averages in Table 10. In all 3 years, yields were lowest for January and February application dates, but not significantly lower.

Highest grain proteins were obtained with the latest application dates. These results are similar to the first 2 years of the study. The average of the six site-years of data shows a half percent higher protein for the April 15 application date than all other application dates.

The authors wish to express sincere thanks to the land owners, Don and Rod Watson and Gary and Neil Martin, for their cooperation on the project and to Extension coworkers Joe Smith, Mark Davied, Jake Weber, Dean Stites, and Tom Maxwell for their help.

Table 7. Cultural practices used at experimental sites.

Item	Martin Site	Watson Site
Previous crop	Soybeans	Grain Sorghum
Previous crop yield	38 bu	100 bu
Wheat variety	Karl	Wakefield
Planting date	10-25-93	10-28-93
Preplant wheat fertilizer	37-94-123	27-69-90
Topdress nitrogen - lbs/a	63	83
Total nitrogen - lbs/a	100	110
Soil Test Date: 12-9-93		
pH	6.3	6.7
P	36	50
K	160	168
NO_3-N, lbs/a 18"	38	22

Table 8. Wheat yields as affected by time of N application, Cherokee Co., KS, 1994.

Nitrogen Treatment	Watson Site	Martin Site	2-Site Avg.
	- - - bu/a @ 13% moisture - - -		
Preplant N only	33.7	44.9	39.3
P.P. + topdress N preplant	57.0	63.0	60.0
P.P. + topdress N Dec. 15	50.2	65.9	58.1
P.P. + topdress N Jan. 15	59.3	56.7	58.0
P.P. + topdress N Feb. 15	55.0	55.5	55.3
P.P. + topdress N March 15	57.8	55.4	56.6
P.P. + topdress N April 15	58.7	60.0	59.4
LSD (0.05)	12.1	NS	----

Table 9. Wheat grain protein as affected by time of N application, Cherokee Co., KS, 1994.

Nitrogen Treatment	Watson Site	Martin Site	2-Site Avg.
	- - - - grain protein - % - - - -		
Preplant N only	8.4	9.3	8.9
P.P. + topdress N preplant	9.0	9.4	9.2
P.P. + topdress N Dec. 15	8.3	9.4	8.9
P.P. + topdress N Jan. 15	8.6	9.7	9.2
P.P. + topdress N Feb. 15	8.7	10.2	9.5
P.P. + topdress N March 15	8.7	9.2	9.0
P.P. + topdress N April 15	9.7	9.9	9.8
LSD (0.05)	0.8	0.5	---

Table 10. Effect of time of topdressing N on winter wheat following grain sorghum and soybeans, 1992-94 average, Cherokee Co., KS.

Nitrogen Treatment	After Sorghum	After Soybeans	6-Site Average
	- - - bu/a @ 13% moisture - - -		
Preplant N only	27.3	35.7	32.0
P.P. + topdress N preplant	45.4	48.5	47.0
P.P. + topdress N Dec. 15	44.0	50.6	47.3
P.P. + topdress N Jan. 15	44.4	46.8	45.6
P.P. + topdress N Feb. 15	41.7	45.2	43.4
P.P. + topdress N March 15	51.7	47.7	49.7
P.P. + topdress N April 15	41.7	47.0	44.4

Table 11. Effect of time of N topdressing on winter wheat grain protein, 1992-94 average, Cherokee Co., KS.

Nitrogen Treatment	After Sorghum	After Soybeans	6-Site Average
	- - - - - - - % - - - - - - -		
Preplant N only	9.1	9.2	9.2
P.P. + topdress N preplant	9.6	9.5	9.6
P.P. + topdress N Dec. 15	9.6	9.5	9.6
P.P. + topdress N Jan. 15	9.3	9.6	9.5
P.P. + topdress N Feb. 15	9.5	9.8	9.7
P.P. + topdress N March 15	9.4	9.6	9.5
P.P. + topdress N April 15	10.5	10.1	10.3

EFFECTS OF NITROGEN RATES ON WHEAT FOLLOWING GRAIN SORGHUM, WHEAT, AND SOYBEANS, CHEROKEE COUNTY, KANSAS

R.E. Wary, D.A. Whitney, R.E. Lamond, and G.L. Kilgore

Summary

Optimum N rate for wheat was found to be influenced by the cropping system. After 5 years of trials, results show that optimum wheat yields are reached with about 130 to 160 lbs of N following grain sorghum, 100 to 130 lbs of N following corn or soybeans, and 70 to 100 lbs of N following wheat. Although studies were not run side-by-side within a location, 5-year average wheat yields at the optimum N rate for the various cropping sequences were similar.

Introduction

Nitrogen (N) applications on wheat vary from 50 to 100 lbs/a among farms, but do they vary as the previous crop varies? Should they be different if wheat follows corn, grain sorghum, wheat, or soybeans? The objective of this trial is to see if the previous crop should change N rates and if so, how much, and to help fine-tune N recommendations for winter wheat. This is the fifth year of the trial.

Procedure

Four sites were selected this year. One site was on the Richard Weber farm, southeast of Pittsburg, where wheat followed a 53 bu/a wheat crop. The second site was on the Don and Rod Watson farm, southeast of Weir, where wheat followed a 102 bu/a grain sorghum crop. The third site was on the Neil and Gary Martin farm, west of Columbus, where wheat followed 38 bu/a soybeans. The fourth site was on the Dale Roberds farm, southeast of Pittsburg, where wheat followed 110 bu/a corn.

Fertilizer treatments included a uniform preplant application of N-P-K at each site, plus an additional N topdressing in February to make N rates equal to 70, 100, 130, and 160 lbs available N/a for a total of five treatments, replicated three times at each site.

The details for each site, yields, and grain protein are found in Tables 12 - 16.

Results

Significant yield responses were obtained this year on wheat following corn, grain sorghum, soybeans, and wheat, but higher N rates were needed to produce optimum yields. This was probably due to higher yields of previous crops depleting soil N reserves combined with higher rainfall in April, which increased N loss and lowered N efficiency.

After 5 years of the trial, results show that optimum wheat yields are reached with about 130-160 lbs of N following grain sorghum, 100-130 lbs of N following corn and soybeans, and 70-100 lbs of N following wheat. However, in drier years when higher previous crop yields are not obtained and more N is carried over to the following wheat crop, then N needs for wheat will be less.

Grain protein was increased as N rate increased for all previous crops. Protein was slightly lower in wheat following sorghum than following the other crops.

The authors again wish to express sincere thanks to the land owners, Richard Weber, Don and Rod Watson, Gary and Neil Martin, and Dale Roberds for their cooperation with the project, and to Joe Smith, Mark Davied, Jake Weber, Dean Stites, and Tom Maxwell for their help.

Table 12. Cultural practices and soil test data, Cherokee Co., KS, 1994.

Item	Wheat after Corn	Wheat after Sorghum	Wheat after Soybeans	Wheat after Wheat
Variety	Pioneer 2571	Wakefield	Karl	Pioneer 2548
Planting date	10-6-93	10-26-93	10-25-93	10-12-93
Preplant fertilizer	36-92-120	27-69-90	37-94-123	23-58-75
N-topdress date	2-14-94	2-14-94	2-14-94	2-14-94
Residual N - lbs, 18"	27	22	38	59
1 ac - top 18" profile				
Pre. crop yield	110 bu	102 bu	38 bu	53 bu
Soil test data (0-6")				
pH	6.8	6.7	6.3	6.83
P	65	50	36	85
K	246	168	160	249
Soil samples taken	12-9-93	12-9-93	12-9-93	12-9-93

Table 13. Wheat yields as affected by N rate following corn, grain sorghum, soybeans, and wheat, Cherokee Co., KS, 1994.

Nitrogen Treatment	Wheat after Corn	Wheat after Sorghum	Wheat after Wheat	Wheat after Soybeans	Avg.
- - lbs/a - -		- - - - bu/a @ 13% moisture - - - -			
Preplant only	38.5	23.5	54.8	31.5	37.1
70 lbs N	45.9	36.7	62.6	43.2	47.1
100 lbs N	52.9	50.6	66.9	52.5	55.7
130 lbs N	58.3	47.7	78.2	57.9	60.5
160 lbs N	59.7	59.7	67.6	58.5	61.4
LSD (0.05)	9.7	11.1	11.6	9.0	--

Table 14. Grain protein of wheat as affected by N rate and previous crop, Cherokee, Co., KS, 1994.

Nitrogen Treatment	Wheat after Corn	Wheat after Sorghum	Wheat after Wheat	Wheat after Soybeans	Avg.
- - lbs/a - -		- - - - - - - - - - - % - - - - - - - - - - -			
Preplant only	8.6	8.5	8.0	9.2	8.6
70 lbs N	8.8	8.4	8.1	9.2	8.6
100 lbs N	9.0	9.0	8.2	9.2	8.9
130 lbs N	9.3	9.5	9.2	10.3	9.6
160 lbs N	9.5	9.6	9.4	11.4	10.1
LSD (0.05)	0.4	1.1	0.9	0.7	---

Table 15. Wheat yields as affected by N rate and previous crop, 1990-94, 5-year average, Cherokee Co., KS.

Fertilizer Treatment	Wheat after Corn*	Wheat after Sorghum	Wheat after Wheat	Wheat after Soybeans
- - lbs/a - -		- - - bu/ac @ 13% moisture - - -		
Preplant only	36.4	31.0	44.2	31.7
70 lbs N	42.5	40.5	49.6	42.2
100 lbs N	48.7	46.0	51.0	44.3
130 lbs N	51.0	48.6	53.1	45.4
160 lbs N	50.1	51.9	50.2	47.4

* 1990-91-93-94 only

Table 16. Wheat grain protein as affected by N rate and previous crop, 1990-94, 5-year average, Cherokee Co., KS.

Fertilizer Treatment	Wheat after Corn*	Wheat after Sorghum	Wheat after Wheat	Wheat after Soybeans
- - lb/a - -		- - - - - - - - % - - - - - - - -		
Preplant only	9.1	9.1	9.5	9.9
70 lbs N	9.9	9.0	9.9	10.2
100 lbs N	10.2	9.6	10.4	10.7
130 lbs N	10.7	10.0	11.3	11.2
160 lbs N	11.0	10.5	11.6	11.6

* 1990-91-93-94 only

EFFECTS OF TURKEY LITTER AND TWO RATES OF COMMERCIAL FERTILIZER ON WHEAT IN CHEROKEE COUNTY, KANSAS

R.E. Wary, D.A. Whitney, R.E. Lamond, and G.L. Kilgore

Summary

Turkey litter has been shown to be an excellent source of nutrients for wheat production. Four tons/a of litter have given yields comparable to those with recommended commercial fertilizer rates. Ten tons/a have resulted in lodging of the wheat and, hence, lower yields than resulted from lower litter rates. Residual effects from 4 tons/a rate were found in the second crop following application.

Introduction

Twenty-two contract turkey growers in Cherokee County each produce about 70,000 birds each annually for a local turkey processing company. In addition, 800-1000 tons of litter (manure-wood chips mix) are generated annually by each grower. More growers are planning to start production. As a result, crop producers are asking about the fertilizer value of turkey litter. They also are asking, not how little is needed to produce a crop equal to that with commercial fertilizer, but what is the maximum amount that can be applied to the silt loam-claypan soils of Cherokee County without having adverse effects on crop production or the soils.

Procedure

Five sites were selected in five areas of the county, and one of these sites was in wheat in 1994 and is discussed here (Richard Weber farm southeast of Pittsburg, on a Parsons silt loam soil). Seven treatments were included at each site and were replicated three times. The treatments include: 1. no fertilizer (check); 2. commercial fertilizer based on a soil test; 3. 1 ton litter/a; 4. 2 tons litter/a; 5. 4 tons litter/a; 6. an amount of commercial fertilizer that equals 2 tons litter/a; and 7. 10 tons litter/a.

Only half of each plot was treated this year to determine yield from carryover nutrients from previous applications. These trials were started in 1990 and are planted to either wheat, corn, grain sorghum or soybeans each year.

All fertilizer and litter are spread by hand and worked into the seedbed prior to planting. The treatments are applied prior to each crop and not necessarily once a year. Wheat was the 5th crop on the Weber site.

Details about the site are found in Table 17.

Results

Commercial fertilizer at the soil test level and at the rate equal to 2 tons of litter, as well as 2 and 4 tons of litter, all produced significant yield responses over the check in 1994 (Table 18). Severe lodging occurred at the 10 tons litter rate, and yields reflected this lodging. A significant yield response to residual fertilizer also occurred for the 4-ton treatment. Why the 10-ton treatment did not produce a significant residual response is hard to understand. Grain protein was increased on the 4 and 10 ton treatments, with over a 3% increase with 10 tons (Table 19). In the residual plots, significant increases in protein were obtained at 4 and 10 ton/a.

The period-of-years yield data show that the soil test produced a 20 bu yield increase, 1 ton about an 8 bu increase, 2 tons a 17 bu increase, and 4 tons over a 24 bu increase over the check (Table 20). The 10 ton treatment produced an increase, but less than the 4 tons, so 10 tons is probably too much. Yields from 2 tons of litter and the equivalent of 2 tons as commercial fertilizer appear to be comparable. The yield of the soil test fertilizer rate was between the 2 tons and 4 tons yields, suggesting that it is equal to about 3 tons of litter, although no direct comparison was made. No increase in grain protein was obtained except with the 10 ton treatment (Table 20).

Turkey litter is a viable source of nutrients for wheat, and depending on litter and fertilizer prices, can be used economically.

The authors wish to express sincere thanks to the land owner, Richard Weber, and to Joe Smith, Dean Stites, Mark Davied, Jake Weber, and Tom Maxwell for their help.

Table 17. Cultural practices and soil test information, Cherokee Co., KS, 1994.

Item	Weber Site	
Variety	Pioneer 2548	
Planting date	10-06-93	
Harvest date	2-14-94	
Soil test fertilizer	20-30-35	
Previous crop	Corn	
Soil test results -	1990	1993
pH	7.4	7.3
P	70	83
K	228	257
Com. fert. equiv. to 2 tons litter	70-90-88	
Litter & PP fertilizer spread on:	9-10-93	
Topdress N spread on:	60-0-0	

Table 18. Effect of turkey litter and commercial fertilizer on wheat yield, Weber site, Cherokee Co., KS, 1994.

Treatment	Treated	Residual
	- - bu/a @ 13% moisture - -	
No fertilizer	43.8	46.3
Soil test fertilizer	67.7	54.5
1 ton litter	47.9	41.9
2 tons litter	56.6	51.1
4 tons litter	68.0	65.9
Com. fert. = 2 tons litter	67.9	47.8
10 tons litter	47.8	52.2
LSD (0.05)	12.2	13.0

Table 19. Effects of turkey litter and commercial fertilizer on grain protein of wheat, Weber site, Cherokee Co., KS, 1994.

Treatment	Treated	Residual
	- - - % - - -	
No fertilizer	7.8	7.6
Soil test fertilizer	7.9	7.7
1 ton litter	7.8	7.8
2 tons litter	7.6	7.7
4 tons litter	8.5	9.0
Com. fert. = 2 tons litter	7.8	7.8
10 tons litter	11.1	11.5
LSD (0.05)	0.5	0.4

Table 20. Effects of turkey litter and commercial fertilizer on wheat yield and grain protein, Cherokee, Co., KS.

Treatment	3-Year, 7-Site Avg.	
	Yield	Protein
	bu/a	%
No fertilizer	26.1	10.3
Soil test fertilizer	46.9	9.8
1 ton litter	34.4	9.4
2 tons litter	43.3	9.5
4 tons litter	50.8	10.8
Com. fert. = 2 tons litter	47.6	9.9
10 tons litter	44.5	12.4

GRASS FERTILIZATION STUDIES
KANSAS STATE UNIVERSITY - DEPARTMENT OF AGRONOMY

NITROGEN RATES AND SOURCES FOR BROMEGRASS

R.E. Lamond, W.L. Thomas, and D.A. Whitney

Summary

Previous work at Kansas State University has shown that, in most cases, commonly used N fertilizers perform similarly when topdressed on bromegrass. These trials were all topdressed during the recommended time, November through February. If topdressing is delayed, concern increases about N loss from surface-applied urea-containing fertilizers. This study evaluated effects of topdressing in March. Urea and UAN performed poorly compared to urea + NBPT (a urease inhibitor) or ammonium nitrate. NBPT will be commercially available in 1995.

Introduction

When urea-containing fertilizers (urea, UAN) are surface applied, potential exists for volatilization loss of N as urea is hydrolyzed. When these materials are topdressed on bromegrass during the recommended time frame (November-February), volatilization is usually not a major concern because soil and air temperatures are cool. When topdressing is delayed, concern about volatilization increases. This study was initiated in 1994 to evaluate N sources and a urease inhibitor, NBPT, on bromegrass when topdressed in March.

Procedure

Nitrogen rates (0, 45, 90 lb N/a) and sources ammonium nitrate, urea, urea + NBPT, and UAN were evaluated on established bromegrass at the North Agronomy Farm. All N was surface broadcast in mid March. The study was harvested in late May. Forage yields were determined, and forage was analyzed for protein content.

Results

Forage yields in 1994 were high (Table 1). Excellent responses to N were noted up to the 90 lb N/a rate. Source comparisons show that ammonium nitrate and urea + NBPT outperformed urea and UAN. Under these conditions, the urease inhibitor improved the efficiency of urea. These results suggest that if topdressing on brome is delayed, use of ammonium nitrate or urea with a urease inhibitor could improve performance.

Table 1. N rates and sources for bromegrass, North Agronomy Farm, Riley Co., KS, 1994.

N Rate	N Source	Forage Yield	Forage Protein
lb/a		lb/a	%
0	--	3800	8.1
45	Urea	5190	8.6
90	Urea	7280	9.3
45	Urea + NBPT	6450	8.5
90	Urea + NBPT	7890	9.9
45	Am. Nitrate	6760	8.3
90	Am. Nitrate	8210	10.7
45	UAN	5080	8.3
90	UAN	6830	8.2
LSD (0.05)		1140	1.1
Mean Values:			
N Rate	45	5870	8.4
	90	7550	9.5
LSD (0.05)		550	0.6
N Source	Urea	6330	8.9
	Urea + NBPT	7170	9.2
	Am. Nitrate	7490	9.5
	UAN	5950	8.3
LSD (0.05)		780	0.8

BROMEGRASS FERTILIZATION STUDIES

R.E. Lamond, G.L. Keeler, R.A. Miller, and S. Koch

Summary

Nitrogen (N) is the major component of cool-season grass fertilization programs; however, bromegrass used for haying or grazing removes large amounts of phosphorus (P). Results from these studies confirm that bromegrass responds to P fertilization, particularly when P soil test levels are low.

Introduction

A significant acreage of established smooth bromegrass in Kansas has low soil test levels of phosphorus (P) and/or potassium (K). Also, recent research has shown bromegrass to respond consistently to sulfur (S) fertilization. When these nutrients are deficient, bromegrass can't fully utilize applied nitrogen (N). These studies were established to evaluate N-P-K-S fertilization of bromegrass.

Procedure

Studies were continued in Douglas, Johnson, and Nemaha Counties to evaluate N, P, and S. Both Douglas and Johnson Co. sites were low in available P, whereas the Nemaha Co. site was medium in available P. All fertilizer was applied on March 10, and plots were harvested on May 27 or May 31 at all sites. Forage samples were retained for analyses.

Results

1994 results are summarized in Tables 2 and 3. In Douglas Co., good responses to N and P were noted. Addition of S tended to produce higher yields and protein levels, though the increases were not statistically significant.

In Johnson Co., excellent responses to N and P were noted. Even though P increased yields in Nemaha Co., the increases were not statistically significant. This site had a higher soil P test.

These studies will be continued in 1995.

Table 2. Bromegrass fertilization, Douglas Co., KS, 1994.

Fertilizer Rate			Forage			3-Year
N	P_2O_5	S	Yield	Protein	P	Avg. Yield
	- lb/a -		lb/a	- % -		lb/a
0	0	0	1350	8.0	.18	2920
100	0	0	2530	9.2	.17	4870
100	30	0	2750	9.9	.23	5240
100	60	0	2640	10.0	.26	5090
100	60	30	2800	10.1	.27	5240
LSD (0.05)			1010	1.1	.04	--

Table 3. Fertility management on cool-season grass, 1994.

			Johnson Co., Fescue			Nemaha Co., Brome		
N	P_2O_5	S	Yield	Protein	P	Yield	Protein	P
- lb/a -			lb/a	- % -		lb/a	- - - % - - -	
0	0	0	1610	8.8	.18	1780	8.8	.23
40	0	0	2730	8.0	.15	3590	8.5	.20
80	0	0	3380	8.7	.15	3610	9.5	.20
120	0	0	3820	9.3	.15	5340	9.3	.17
40	30	0	3470	8.0	.18	3370	8.7	.22
80	30	0	4620	8.4	.17	4540	9.0	.21
120	30	0	4840	8.7	.16	5590	9.6	.20
80	30	20	4340	8.6	.18	4900	9.2	.20
LSD (0.05)			630	NS	.02	600	0.8	.03
Mean Values:								
N	40		3100	7.7	.16	3480	8.5	.21
Rate	80		4000	8.5	.16	4080	9.3	.20
	120		4330	9.0	.15	5470	9.4	.18
LSD (0.05)			420	1.0	.01	480	0.7	.02
P	0		3310	8.7	.15	4180	9.1	.19
Rate	30		4310	8.2	.17	4500	9.1	.21
LSD (0.05)			340	NS	.01	NS	NS	.01

Soil test P: Johnson Co. low, Nemaha Co. medium.

SOIL FERTILITY RESEARCH
SOUTHWEST RESEARCH - EXTENSION CENTER

EFFECT OF A PREVIOUS SOYBEAN CROP AND NITROGEN FERTILIZER ON IRRIGATED CORN AND GRAIN SORGHUM

A.J. Schlegel, K.C. Dhuyvetter, and J.A. Schaffer

Summary

This project was initiated in 1990 to determine the benefit of including soybean in an irrigated cropping system in western Kansas. Corn following soybean yielded more and required less N than continuous corn. Without N, corn yields were 60 bu/a greater following soybean than corn, reflecting the N benefit from soybean. Maximum corn yields were 10 bu/a greater for corn in rotation with soybean than for continuous corn, regardless of N rate. Net revenue from corn was about $50/a greater following soybean than corn. The net income of the corn/soybean rotation exceeded that of continuous corn except with relatively low soybean prices and high corn prices. The benefit from a previous soybean crop was much less with sorghum than corn and appeared to be a N benefit only, because maximum sorghum yields were equal for both systems. Net revenue from sorghum was about $20/a greater following soybean than sorghum. Net revenue of sorghum following soybean was maximized without any N because of the small yield response. The net income of the sorghum/soybean rotation exceeded that of continuous sorghum at all price combinations. Soybean yields were about 65 bu/a and were slightly higher following corn than sorghum. Inclusion of soybean in an irrigated cropping system is an economically viable alternative to continuous cropping on acres not receiving any government program payments.

Procedure

This project was initiated in 1990 to evaluate the effect of a previous soybean crop on subsequent crops of corn and grain sorghum. Four irrigated cropping systems (soybean-corn, soybean-grain sorghum, corn-corn, and sorghum-sorghum) were grown at the SWREC near Garden City. Nitrogen fertilizer (0, 30, 60, 120, and 240 lb N/a) was applied prior to planting of corn and grain sorghum each year. No N fertilizer was applied prior to planting of soybean. All plots were machine harvested, and grain samples were collected for N analysis.

Economic analyses were based on estimated yield response functions (using 1991-1993 grain yields) to determine net revenue, cost of production per bushel, and economic optimal N rate. The corn rotation analysis assumed a corn price of $2.40/bu; N cost of $0.15/lb; and other variable costs of $225/a for continuous corn, $200/a for corn following soybean, and $135/a for soybean. The sorghum rotation analysis assumed a sorghum price of $2.16/bu; N cost of $0.15/lb; and other variable costs of $125/a for continuous sorghum, $110/a for sorghum following soybean, and $135/a for soybean. Government program payments were not included in the economic analysis.

Results

Corn yields averaged over 3 years were greater following soybean than corn (Table 1). The optimal N rate was much lower for corn following soybean than for continuous corn, reflecting the N fixation benefit from the previous soybean crop. Maximum corn yields were over 10 bu/a greater following soybean than corn, indicating an additional benefit from the rotation. Without N, corn yields were 60 bu/a greater following soybean than corn. Plant N uptake was also greater for corn following soybean than for continuous corn.

The economic optimal N rate for continuous corn was slightly over 190 lb/a, and yields were maximized with 210 lb/a (Figure 1). Optimal N rate for corn following soybean was about 125 lb/a, and yields were maximized with slightly over 160 lb/a (Figure 2). Net revenue for corn following soybean was over $50/a greater than that for continuous corn because of the higher yield potential and lower production cost. The average income of the corn/soybean rotation exceeded that of continuous corn at most price combinations considered (Table 4). Continuous corn was more profitable than the corn/soybean rotation with relatively low soybean prices and high corn prices.

Sorghum yields without N were 24 bu/a greater following soybean than for continuous sorghum (Table 2). However, in contrast to corn, the same maximum yields were obtained for both cropping systems with additional N. Plant uptake of N was slightly greater for sorghum following soybean than for sorghum.

The economic optimal N rate for continuous sorghum was slightly over 180 lb/a, and yields were maximized with about 230 lb/a (Figure 3). The yield response of sorghum to N following soybean was linear, but the response was not large enough to pay for the cost of N (Figure 4); thus, net revenue was maximized without any applied N. Maximum net revenue for sorghum following soybean was over $20/a greater than that for continuous sorghum because of the higher yield potential and lower production cost. The average income of the sorghum/soybean rotation exceeded that of continuous sorghum at all price combinations considered (Table 5).

Soybean yields were 2 bu/a greater following corn than sorghum when averaged across 3 years (Table 3). The N fertilizer applied to the previous corn or sorghum had no effect on soybean yield or plant N status.

Table 1. Grain yield and nutrient content of corn in rotation study, Garden City, KS 1991-1993.

Cropping System	N Rate	Grain Yield	Leaf N	Grain N	N Removal
	lb/a	bu/a	%	%	lb/a
Corn-Corn	0	136	1.82	1.07	70
	30	150	1.99	1.08	76
	60	173	2.23	1.14	94
	120	202	2.33	1.22	118
	240	213	2.37	1.30	132
Corn-Soy	0	195	2.12	1.12	103
	30	210	2.19	1.15	114
	60	213	2.30	1.24	125
	120	226	2.36	1.26	135
	240	221	2.38	1.29	135
ANOVA (P>F)					
Cropping system		0.003	0.056	0.007	0.002
N rate		0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001
Quadratic		0.001	0.001	0.001	0.001
Year		0.001	0.001	0.001	0.001
System x N rate		0.001	0.001	0.043	0.001
System x N_l		0.001	0.001	0.014	0.001
System x N_q		0.232	0.006	0.177	0.868
MAIN EFFECT MEANS					
Cropping system					
Continuous		175	2.15	1.16	98
Rotation		213	2.27	1.21	123
$LSD_{.05}$		14	0.13	0.02	8
N rate					
0		165	1.97	1.09	86
30		180	2.09	1.11	95
60		193	2.27	1.19	110
120		214	2.34	1.24	127
240		217	2.37	1.29	133
$LSD_{.05}$		10	0.07	0.04	7
Year					
1991		217	2.00	1.28	132
1992		220	2.25	1.12	118
1993		145	2.38	1.16	80
$LSD_{.05}$		8	0.05	0.03	5

Table 2. Grain yield and nutrient content of grain sorghum in rotation study, Garden City, KS, 1991-1993.

Cropping System	N Rate	Grain Yield	Leaf N	Grain N	N Removal
	lb/a	bu/a	%	%	lb/a
Sorg-Sorg	0	97	1.84	1.16	56
	30	112	1.96	1.20	66
	60	116	2.09	1.29	74
	120	126	2.21	1.38	86
	240	136	2.34	1.48	99
Sorg-Soy	0	121	2.21	1.32	78
	30	125	2.26	1.39	85
	60	129	2.38	1.43	90
	120	124	2.32	1.47	89
	240	132	2.41	1.52	98
ANOVA (P>F)					
Cropping system		0.181	0.011	0.027	0.051
N rate		0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001
Quadratic		0.126	0.002	0.001	0.023
Year		0.001	0.001	0.001	0.001
System x N rate		0.003	0.001	0.012	0.001
System x N_l		0.001	0.001	0.001	0.001
System x N_q		0.121	0.183	0.776	0.277
MAIN EFFECT MEANS					
Cropping system					
Continuous		117	2.09	1.30	76
Rotation		126	2.32	1.43	88
$LSD_{.05}$		16	0.13	0.10	12
N rate					
0		109	2.02	1.24	67
30		118	2.11	1.29	76
60		122	2.23	1.36	82
120		125	2.27	1.43	87
240		134	2.37	1.50	99
$LSD_{.05}$		8	0.08	0.05	6
Year					
1991		128	2.19	1.46	93
1992		117	2.14	1.34	77
1993		120	2.27	1.29	77
$LSD_{.05}$		6	0.06	0.04	5

Table 3. Grain yield and nutrient content of soybean in rotation study, Garden City, KS, 1991-1993.

Cropping System	N Rate	Grain Yield	Leaf N	Grain N	N Removal
	lb/a	bu/a	%	%	lb/a
Corn-Soy	0	68	3.79	5.66	201
	30	68	3.84	5.66	201
	60	63	3.84	5.70	189
	120	66	4.00	5.61	194
	240	63	4.03	5.67	189
Sorg-Soy	0	62	3.99	5.71	187
	30	62	4.01	5.65	185
	60	63	3.92	5.69	187
	120	63	3.91	5.65	187
	240	64	3.95	5.66	189
ANOVA (P>F)					
Cropping system		0.033	0.072	0.384	0.054
N rate		0.652	0.551	0.799	0.747
Linear		0.464	0.134	0.672	0.367
Quadratic		0.751	0.905	0.541	0.548
Year		0.001	0.001	0.001	0.001
System x N rate		0.370	0.157	0.976	0.401
System x N_l		0.108	0.025	0.866	0.119
System x N_q		0.608	0.273	0.950	0.609
MAIN EFFECT MEANS					
Cropping system					
Corn-Soy		65	3.90	5.66	195
Sorg-Soy		63	3.95	5.67	187
$LSD_{.05}$		2	0.06	0.04	8
N rate					
0		65	3.89	5.68	194
30		65	3.92	5.66	193
60		63	3.88	5.69	188
120		64	3.95	5.63	190
240		63	3.99	5.66	189
$LSD_{.05}$		3	0.15	0.11	10
Year					
1991		72	2.37	5.82	221
1992		59	4.76	5.62	175
1993		61	4.65	5.55	177
$LSD_{.05}$		3	0.12	0.09	8

Table 4. Economic advantage per planted acre of corn/soybean rotation compared to continuous corn[1].

Corn Price	Soybean Price $5.00	$5.50	$6.00	$6.50	$7.00
$/bu			Net return, $/a		
$1.75	$63	$79	$96	$112	$128
$2.00	$38	$54	$70	$87	$103
$2.25	$12	$29	$45	$62	$78
$2.50	-$13	$4	$20	$36	$53
$2.75	-$38	-$22	-$5	$11	$27

[1] Production costs = $225/a for continuous corn, $200/a for corn following soybean, $135/a for soybean.
N price = $0.15/lb. No government program payments included.

Table 5. Economic advantage per planted acre of sorghum/soybean rotation compared to continuous sorghum[1].

Corn Price	Soybean Price $5.00	$5.50	$6.00	$6.50	$7.00
$/bu			Net return, $/a		
$1.50	$74	$89	$105	$121	$136
$1.75	$55	$71	$87	$102	$118
$2.00	$37	$53	$68	$84	$100
$2.25	$19	$34	$50	$66	$81
$2.50	$0	$16	$32	$47	$63

[1] Production costs = $125/a for continuous sorghum, $110/a for sorghum following soybean, $135/a for soybean.
N price = $0.15/lb. No government program payments included.

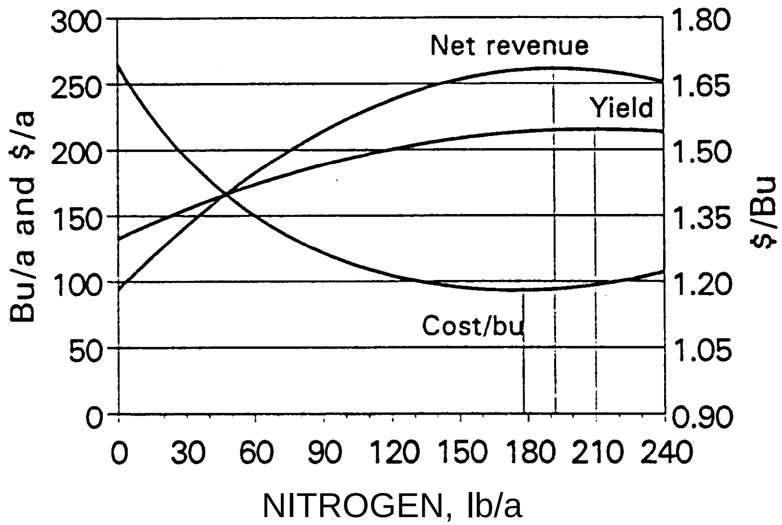


Figure 1. Optimal N rates for corn following corn

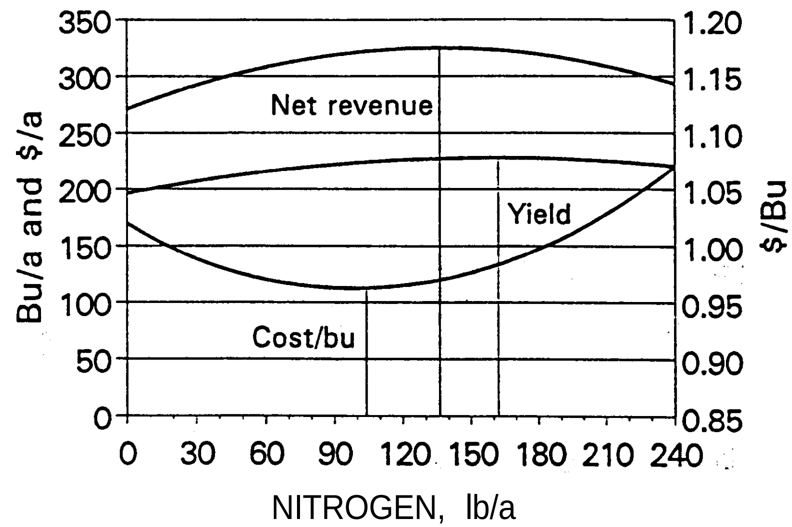


Figure 2. Optimal N rates for corn tollowing soybean

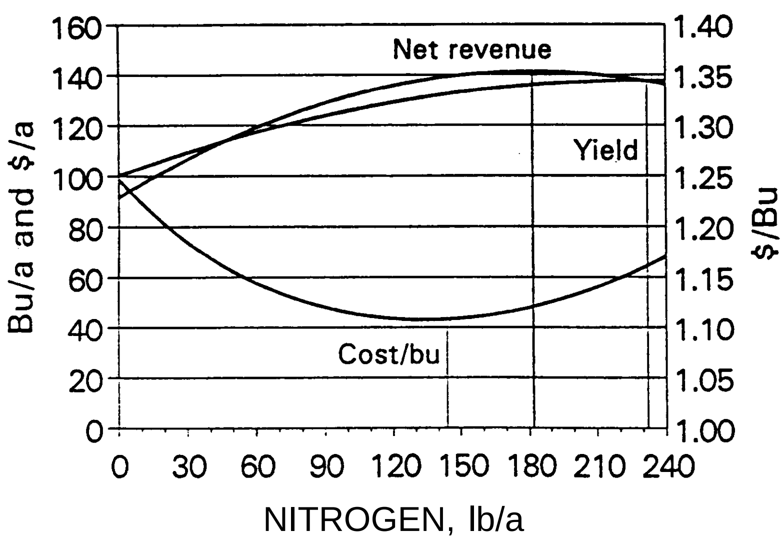


Figure 3. Optimal N rates for sorghum following sorghum

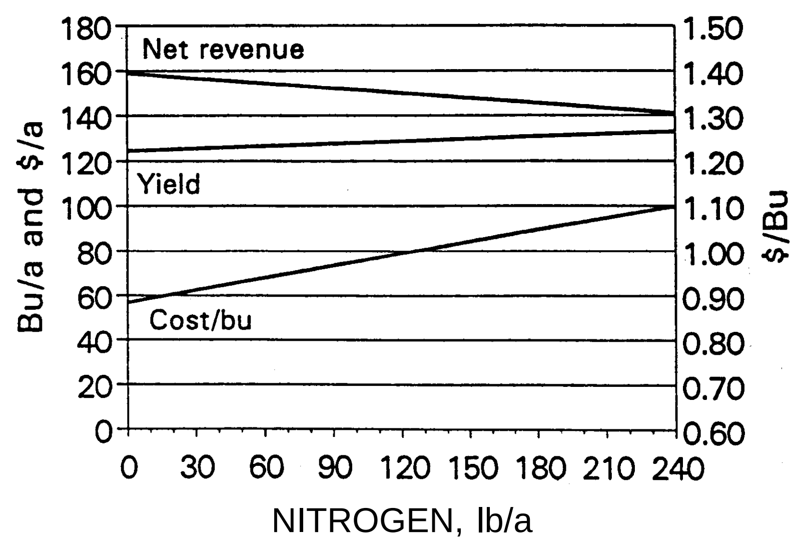


Figure 4. Optimal N rates for sorghum following soybean

NITROGEN MANAGEMENT OF DRYLAND WINTER WHEAT

A.J. Schlegel, J.L. Havlin, and K.C. Dhuyvetter

Summary

Research was initiated in 1993 to determine the N fertilizer requirement for dryland winter wheat grown under reduced tillage systems in western Kansas. Application of N fertilizer increased grain yields by 15 to 20 bu/a when residual soil N was low (< 5 ppm NH_4+NO_3 in 2 ft profile). Wheat yields were increased by N rates up to 80 lb N/a, with the best method and time of application being fall inject and the poorest being broadcast (either winter or spring). No positive yield benefit was observed with N application on sites with residual soil N above 5 ppm.

Procedure

Research was initiated in 1993 to determine the N fertilizer requirement for dryland winter wheat grown under reduced tillage systems. In conjunction with farmer cooperators, we selected five sites in western KS that tested low to medium in residual soil N levels. These sites were planted to winter wheat in the fall of 1993. Fluid N (urea-ammonium nitrate solution) was spoke injected in the fall and spring and broadcast during the winter and spring at five rates (20, 40, 60, 80, and 100 lb N/a) along with a zero N control. All plots were machine harvested, and grain yields were adjusted to 12.5% moisture.

Results

Application of N fertilizer increased grain yields by 15 to 20 bu/a at the two sites (Table 6) testing low in residual soil N (< 5 ppm NH_4+NO_3 in 2 ft profile). Wheat yields were increased by N rates up to 80 lb N/a. The best time/method of application was fall inject, and the poorest was broadcast (either winter or spring).

No positive yield benefit was observed at the two sites testing medium in residual soil N (5-10 ppm). At one site, a yield decrease occurred with increased N rate, and the other site had poor yields because of moisture stress. Nitrogen application had no effect on the site with residual soil N > 10 ppm.

Table 6. Effect of time and method of N application and N rate on grain yield of dryland wheat at five locations in western KS, 1994.

Time/Method of Application	N Rate	Grain yield Nolan	Mai	Wallace	SunEast	SunWest	Mean
	lb/a	bu/a					
Fall Inject	20	30	40	23	16	39	30
	40	38	39	29	19	37	32
	60	38	42	36	15	37	34
	80	46	42	41	12	38	36
	100	40	36	43	16	34	34
Winter Broadcast	20	27	45	21	15	38	29
	40	32	42	26	16	40	31
	60	33	42	32	18	38	33
	80	30	42	29	20	38	32
	100	37	45	30	16	39	33
Spring Inject	20	30	41	25	16	39	30
	40	30	41	31	17	38	31
	60	33	40	33	16	38	33
	80	38	36	37	17	38	33
	100	35	36	34	19	39	33
Spring Broadcast	20	25	43	17	18	42	29
	40	27	39	27	19	40	31
	60	32	42	29	18	39	32
	80	39	40	34	16	39	33
	100	35	39	36	18	36	33
Control	0	22	40	16	16	42	27
Soil NH_4+NO_3 (fall) (ppm in 0-2 ft)		4.3	11.3	3.7	6.2	8.8	
ANOVA (P>F)							
N rate		0.001	0.754	0.001	0.498	0.001	0.001
Linear		0.001	0.393	0.001	0.280	0.001	
Quadratic		0.005	0.382	0.001	0.299	0.090	
Time of appl.		0.001	0.588	0.001	0.277	0.137	0.097
Bdct vs Inj		0.003	0.445	0.001	0.324	0.139	
F/W vs spring		0.041	0.256	0.885	0.229	0.091	
Spr bdct vs inj		0.588	0.496	0.008	0.873	0.588	
N rate x Appl.		0.313	0.629	0.001	0.319	0.725	0.924
Location							0.001
Nrate x location							0.001
Time/Method x location							0.001
Nrate x time/method x location							0.026
MAIN EFFECT MEANS							
Time/Method of appl.							
Fall inject		36	41	31	15	38	32.1
Winter bdct		30	42	26	17	39	30.7
Spring inject		31	39	29	17	39	31.2
Spring bdct		30	40	27	17	40	30.9
$LSD_{.05}$		3	4	2	2	2	1.2
N rate							
0 lb/a		22	40	16	16	42	27.2
20		28	42	22	16	39	29.5
40		32	40	28	18	39	31.4
60		34	42	32	18	38	32.7
80		38	40	35	16	38	33.5
100		37	39	36	17	37	33.2
$LSD_{.05}$		4	5	2	3	2	1.4

NITROGEN MANAGEMENT OF IRRIGATED WINTER WHEAT

A.J. Schlegel and J.A. Schaffer

Summary

Grain yields of irrigated winter wheat were increased by over 40 bu/a by N fertilization averaged over 4 years. A N rate of 120 lb N/a was sufficient for maximizing grain yield. The best procedure was a single N application in the early spring. Grain yields were less with all of the N applied in the fall and not increased by split N applications. Grain protein increased linearly with increased N rates. Applying 1/3 of the N late in the growing season (3-way split) generally provided little increase in grain protein.

Introduction

Nitrogen management of irrigated winter wheat was evaluated from 1991 to 1994 near Garden City. The objectives were to determine the optimal rate and time of N application to irrigated wheat and whether split N applications were beneficial in increasing grain yield and grain protein content.

Procedure

Nitrogen fertilizer was applied annually to irrigated continuous wheat grown on a Mantor fine sandy loam near Garden City. Four rates of N (40, 80, 120, and 160 lb N/a) as urea were broadcast at four application timings; all fall, all spring (Feeke's growth stage 3 [GS3]), a 2-way split of 1/3 fall + 2/3 GS3, and a 3-way split of 1/3 fall + 1/3 GS3 + 1/3 GS8 (early boot). Plant tiller population and plant height were measured at physiological maturity. The center of each plot was machine harvested, and grain yields were adjusted to 12.5% moisture. Grain samples collected at harvest were analyzed for protein content.

Results

Nitrogen fertilizer increased wheat yields by over 40 bu/a averaged over 4 years (Table 7). Yields increased with increasing N rates up to 120 lb N/a, with no further increase with 160 lb N/a. Spring application of N produced greater yields than applying all of the N in the fall. However, split N applications were no better than a single application in the early spring (GS3). Grain protein increased linearly with increasing N rates. Protein content was about 10% with 0 and 40 lb N/a and increased about 1% for each 40 lb increment of N applied. Time of application had little effect on grain protein, except at the highest N rate where the 3-way split application of N tended to produce higher grain protein content.

Plant height was increased by about 8 inches over the control when N was applied at 120 N/a. However, time of N application had no effect on plant height. Tiller population tended to peak at about 3.5 million tillers/a with 120 lb N/a. Applying all of the N at GS3 tended to increase tiller population, and the 3-way split treatment tended to reduce tiller population.

Table 7. Effect of time of N application and N rate on grain yield, grain protein, plant height, and tiller population of irrigated winter wheat, Garden City, KS, 1991-1994.

Time of Application	N Rate	Grain Yield	Grain Protein	Plant Ht.	Plant Tiller Pop.
	lb/a	bu/a	%	inch	10^{-6}/a
Fall	40	56	10.1	30	3.0
	80	67	11.4	32	3.3
	120	70	12.1	32	3.7
	160	71	12.8	33	3.7
GS3	40	62	10.3	30	3.4
	80	70	11.7	32	3.6
	120	75	12.5	33	3.8
	160	68	13.1	32	3.8
Fall (1/3)+	40	58	10.0	30	3.1
GS3 (2/3)	80	71	11.3	32	3.4
	120	70	12.5	33	3.6
	160	71	13.3	32	3.5
Fall (1/3)+	40	55	10.4	30	2.9
GS3 (1/3) +	80	66	11.9	32	3.1
GS8 (1/3)	120	75	12.5	33	3.4
	160	73	13.8	34	3.6
Control	0	32	10.3	25	2.1
$LSD_{.05}$		7	0.6	2	0.4
MAIN EFFECT MEANS					
Time of application					
Fall		66	11.6	32	3.4
GS3		69	11.9	32	3.6
Fall+GS3		68	11.8	32	3.4
Fall+GS3+GS8		67	12.1	32	3.2
$LSD_{.05}$		3	0.3	1	0.2
N rate					
40 lb/a		58	10.2	30	3.1
80		69	11.6	32	3.3
120		72	12.4	33	3.6
160		71	13.2	33	3.6
$LSD_{.05}$		3	0.3	1	0.2

LONG-TERM FERTILIZATION OF IRRIGATED CORN AND GRAIN SORGHUM

A.J. Schlegel

Summary

Long-term research shows that phosphorus and nitrogen fertilizers must be applied for optimum grain yields of irrigated corn and grain sorghum in western Kansas. In this study, N fertilization increased corn yields by 125 bu/a and sorghum yields by 70 bu/a. Although P increased grain yields of both corn and sorghum, corn responded much more. With adequate N, corn yields were increased 80 bu/a by P applications compared to 20 bu/a for sorghum.

Procedure

This study was initiated in 1961 to determine responses of continuous corn and grain sorghum grown under flood irrigation to nitrogen (N), phosphorus (P), and potassium (K) fertilization. Corn and grain sorghum were grown on Ulysses silt loam in adjacent plot areas. Initial fertilizer treatments were N rates of 0, 40, 80, 120, 160, and 200 lb N/a without P and K; with 40 lb P_2O_5/a and zero K; and with 40 lb P_2O_5/a and 40 lb K_2O/a. In 1992, the treatments for the corn study were changed, with the K variable being replaced by a higher rate of P (80 lb P_2O_5/a).

All fertilizers were broadcast by hand in the spring prior to planting and incorporated. The corn hybrid was Pioneer 3379, and the sorghum hybrid was Mycogen TE Y-75. Both studies were furrow irrigated as needed during the growing season. The center two rows of all plots were machine harvested after physiological maturity. Grain yields were adjusted to 15.5% moisture for corn and 12.5% for sorghum.

Results

Corn yields in 1994 were increased up to 125 bu/a by N fertilizer (Table 8). Usually, 160 lb N/a is sufficient to maximize corn yields, but there was a slight yield response up to 200 lb N/a in 1994. Application of P increased yields by about 80 bu/a when applied with 120 lb N/a or more. No significant yield difference occurred between applications of 40 and 80 lb P_2O_5/a.

Grain sorghum yields in 1993 and 1994 were increased by about 70 bu/a by application of 80 lb N/a or greater (Tables 9 and 10). Phosphorus increased yields by 20 bu/a or more when applied with N. Potassium has not produced a yield increase for grain sorghum in any year of this study because of the inherently high K content of the soil.

Table 8. Effect of N and P fertilizers on irrigated corn,Tribune, KS, 1994.

N	P_2O_5	Grain Yield	Grain Moisture	Grain Test Wt.
- -lb/a - -		bu/a	%	lb/bu
0	0	47	21.4	52.5
0	40	43	21.8	52.1
0	80	48	20.6	52.7
40	0	66	22.6	52.2
40	40	104	14.9	56.4
40	80	105	15.0	56.7
80	0	66	30.0	49.7
80	40	129	15.8	56.9
80	80	127	15.3	57.2
120	0	70	31.2	49.6
120	40	147	17.2	56.1
120	80	154	16.2	57.3
160	0	78	29.2	50.2
160	40	162	20.5	54.7
160	80	167	18.0	56.1
200	0	80	29.0	50.2
200	40	171	19.9	55.0
200	80	174	19.5	55.7
ANOVA				
Nitrogen		0.001	0.001	0.001
linear		0.001	0.001	0.369
quadratic		0.001	0.006	0.001
Phosphorus		0.001	0.001	0.001
linear		0.001	0.001	0.001
quadratic		0.001	0.001	0.001
N x P		0.001	0.001	0.001
N_l x P_l		0.001	0.001	0.001
N_l x P_q		0.001	0.009	0.011
N_q x P_l		0.025	0.001	0.001
N_q x P_q		0.133	0.001	0.001
MAIN EFFECT MEANS				
Nitrogen (lb/a)				
0		46	21.3	52.4
40		92	17.5	55.1
80		107	20.4	54.6
120		124	21.5	54.3
160		136	22.6	53.7
200		142	22.8	53.6
$LSD_{.05}$		13	1.4	0.6
P_2O_5 (lb/a)				
0		68	27.2	50.7
40		126	18.4	55.2
80		129	17.4	55.9
$LSD_{.05}$		9	1.0	0.4

Table 9. Effect of of N, P, and K fertilization of irrigated grain sorghum on grain yield, Tribune, KS, 1993.

N	P_2O_5	K_20	Grain Yield	Grain Test Weight
- - -lb/a - -			bu/a	lb/bu
0	0	0	46	50.8
0	40	0	42	49.1
0	40	40	37	48.8
40	0	0	69	51.5
40	40	0	97	55.3
40	40	40	92	54.0
80	0	0	91	54.0
80	40	0	105	55.0
80	40	40	118	55.5
120	0	0	77	53.1
120	40	0	120	55.3
120	40	40	117	55.1
160	0	0	93	54.2
160	40	0	122	54.8
160	40	40	123	55.9
200	0	0	107	56.0
200	40	0	127	56.1
200	40	40	123	55.8
ANOVA				
Nitrogen			0.001	0.001
linear			0.001	0.001
quadratic			0.001	0.001
P-K			0.001	0.100
Zero P vs P			0.001	0.033
P vs P-K			0.888	0.848
N x P-K			0.006	0.173
Nl x ZeroP vs P-K			0.012	0.646
Nl x P vs P-K			0.956	0.556
Nq x ZeroP vs P-K			0.001	0.009
Nq x P vs P-K			0.325	0.713
MAIN EFFECT MEANS				
Nitrogen (lb/a)				
0			42	49.5
40			86	53.6
80			104	54.8
120			105	54.5
160			113	55.0
200			119	56.0
LSD.05			10	1.5
P_2O_5-K_2O (lb/a)				
0- 0			81	53.3
40- 0			102	54.3
40-40			102	54.2
LSD.05			7	1.0

Table 10. Effect of N, P, and K fertilization of irrigated grain sorghum on grain yield, Tribune, KS, 1994.

N	P_2O_5	K_20	Grain Yield	Grain Test Weight
- - -lb/a - -			bu/a	lb/bu
0	0	0	64	53.8
0	40	0	82	56.3
0	40	40	78	55.0
40	0	0	76	55.2
40	40	0	113	57.6
40	40	40	112	57.1
80	0	0	96	56.3
80	40	0	123	56.9
80	40	40	131	58.3
120	0	0	91	55.4
120	40	0	131	57.9
120	40	40	133	57.3
160	0	0	105	57.2
160	40	0	137	57.2
160	40	40	125	57.0
200	0	0	114	57.9
200	40	0	133	57.2
200	40	40	130	56.9
ANOVA				
Nitrogen			0.001	0.043
linear			0.001	0.007
quadratic			0.001	0.114
P-K			0.001	0.062
Zero P vs P			0.001	0.021
P vs P-K			0.734	0.658
N x P-K			0.797	0.608
Nl x ZeroP vs P-K			0.860	0.048
Nl x P vs P-K			0.777	0.748
Nq x ZeroP vs P-K			0.060	0.297
Nq x P vs P-K			0.581	0.388
MAIN EFFECT MEANS				
Nitrogen (lb/a)				
0			75	55.0
40			100	56.6
80			117	57.2
120			118	56.9
160			122	57.1
200			126	57.3
LSD.05			14	1.5
P_2O_5-K_2O (lb/a)				
0- 0			91	55.9
40- 0			120	57.2
40-40			118	56.9
LSD.05			10	1.1

Table 10. Effect of N, P, and K fertilization of irrigated grain

NITROGEN MANAGEMENT IN A WHEAT-SORGHUM-FALLOW ROTATION

A.J. Schlegel and D.L. Frickel

Summary

Grain yields of wheat and grain sorghum were increased substantially by application of N fertilizer. Although responses were not observed every year, wheat yields averaged across 3 years were increased by up to 19 bu/a. Grain sorghum yields were increased by 24 bu/a in 1993 and 31 bu/a in 1994. Tillage had no effect on wheat yields; however, grain sorghum yields in one year were greater with reduced than no tillage.

Introduction

This study was initiated to determine N fertilizer requirements for wheat and grain sorghum grown in a wheat-sorghum-fallow rotation in west-central Kansas under reduced and no tillage. Past research at this station had shown limited response to N fertilizer. However, the potential for N response increases with continued N removal in grain without application of supplemental N.

Procedure

The study was a split plot design with tillage as the main plots and N treatments as subplots. Plot size was 20 by 60 ft. The two tillage systems were reduced and no tillage. Nitrogen fertilizer as urea was broadcast in spring on wheat and near planting of grain sorghum. N rates applied were 25, 50, and 100 lb N/a to either wheat or grain sorghum or 25 and 50 lb N/a to both crops along with an untreated control. The center of each plot was machine harvested, and grain yields were adjusted to 12.5% moisture. A sample of grain collected at harvest was dried, ground, and analyzed for N content, with results reported as grain protein (% grain N times 6.25). Residual soil N content was in the medium category (less than 10 ppm N as nitrate plus ammonia in a 2-foot profile) at the start of the study.

Results

Wheat yields in 2 out of 3 years were increased by N rates up to 100 lb N/a (Table 11). Averaged across all years, wheat yields were increased 19 bu/a by the highest rate of N fertilizer. Grain protein was increased from 10.0% in the control up to 11.6% with 100 lb N/a applied to wheat. Application of N to sorghum also had a positive residual effect on subsequent wheat yield and grain protein. Tillage had no effect on wheat yield in any year.

Grain sorghum yields were increased by 25 bu/a by 100 lb N/a applied to sorghum when averaged over 2 years (Table 12). In contrast to wheat, tillage may have an effect on grain sorghum yields. In 1993, but not 1994, grain yields were considerably lower with no-till than reduced tillage. However, averaged over both years, tillage effect was not significant, no tillage by N interaction occurred in either year.

Table 11. Wheat response to N fertilizer and tillage in a wheat-sorghum-fallow rotation, Tribune, KS, 1992-94.

Treatment		Grain Yield				Grain Protein			
		1992	1993	1994	1992-94	1992	1993	1994	1992-94
N rate		- - - - bu/a - - - -				- - - - - - % - - - - -			
Wheat	Sorghum								
- lb/a -									
0	0	24	44	20	29	10.0	10.2	9.8	10.0
0	25	29	42	20	30	10.1	9.9	9.4	9.8
0	50	28	46	19	31	9.7	10.3	9.2	9.8
0	100	28	53	30	37	10.4	10.8	9.1	10.1
25	0	29	45	28	34	10.4	9.5	9.9	10.0
25	25	26	56	30	38	11.0	10.6	9.7	10.4
50	0	27	57	41	42	11.3	10.6	10.6	10.8
50	50	29	60	45	45	11.6	10.7	10.9	11.1
100	0	29	66	48	48	11.7	10.8	12.2	11.6
$LSD_{.05}$		5	11	5	4	0.9	1.1	0.7	0.6
Tillage									
Reduced		28	52	32	37	10.6	10.2	10.1	10.3
No till		28	53	31	37	10.8	10.6	10.1	10.5
$LSD_{.05}$		5	12	5	6	1.1	2.0	0.5	0.6
ANOVA									
N treatment		0.342	0.004	0.001	0.001	0.001	0.286	0.001	0.001
Tillage		0.998	0.794	0.617	0.985	0.694	0.545	0.681	0.405
N treatment x till		0.075	0.929	0.938	0.555	0.606	0.740	0.404	0.702

Table 12. Grain sorghum response to N fertilizer and tillage in a wheat-sorghum-fallow rotation, Tribune, KS, 1993-94.

Treatment		Grain Yield		
		1993	1994	1993-94
N rate		- - - - - bu/a - - - - -		
Wheat	Sorghum			
- lb/a -				
0	0	37	57	47
0	25	45	71	58
0	50	49	82	66
0	100	58	88	73
25	0	42	56	49
25	25	46	77	62
50	0	50	59	54
50	50	63	72	68
100	0	66	66	66
$LSD_{.05}$		6	10	5
Tillage				
Reduced		56	69	63
No till		46	70	58
$LSD_{.05}$		7	13	9
ANOVA				
N treatment		0.001	0.001	0.001
Tillage		0.021	0.876	0.176
N treatment x tillage		0.676	0.354	0.334

EFFECT OF PHOSPHORUS ON GRAIN MOISTURE AND PROFITABILITY

K.C. Dhuyvetter and A.J. Schlegel

Summary

Phosphorus (P) fertilization increases grain yields and hastens crop maturity. Crops that physiologically mature faster have lower grain drying cost and/or can be harvested quicker. The economic returns to P are the results of increased yields and decreased drying costs. Increased yields account for the majority of the economic benefit of P fertilization. In addition to lower drying costs, corn maturing faster provides intangible benefits such as timeliness of field operations, reduced crop lodging, and increased marketing flexibility. These positive effects of P should not be overlooked.

Introduction

Phosphorus fertilization is essential for optimum production and profitability from irrigated corn in western Kansas. Corn plants deficient in P yield less and mature later than plants receiving adequate P. The role of P in crop maturity often is overlooked when analyzing the economic benefits from P. A long-term N and P study is being conducted for irrigated corn to determine the effects fertilizer have on grain yield and moisture content at harvest.

The objectives of this study are to determine the effect P fertilizer has on grain yield and moisture content at harvest at various N rates; determine the grain drying costs with and without P; and compare the economic benefits of P with regard to grain yield and drying cost.

Procedure

Nitrogen and P fertilizers have been applied annually to irrigated corn grown on a Ulysses silt loam. Fertilizer treatments included N rates ranging from 0 to 200 lb N/a in 40 lb increments with and without P at 40 lb P_2O_5/a. Corn was not allowed to dry completely in the field. Grain moisture content was recorded at harvest and used to determine drying cost. Grain yields were adjusted to 15.5% moisture to reflect shrinkage.

Economic benefit of P was calculated for each level of N. Only costs that varied between treatments were considered when determining the economic benefit. Drying costs were calculated using a drying charge of \$0.02/bushel for each point of moisture above 15.5%. Fertilizer costs were based on \$0.15/lb for N and \$0.25/lb for P. Gross income was calculated using moisture-adjusted yields and corn prices of \$1.75, \$2.25, and \$2.75/bu.

Results

A long-term N and P study has shown that the optimal N rate for irrigated corn is about 160 lb N/a (Figure 5). Over the past 6 years (1988-1993), application of P (40 lb P_2O_5/a) has increased grain yields by about 80 bu/a. With less than 80 lb N/a, the increase in yield from P fertilizer was much less than at the higher rates of N. This interaction between N and P indicates the need for a balanced fertility program to achieve maximum economic yields.

Phosphorus is essential for seed development and hastens crop maturity. In this study, the corn was harvested at relatively high moisture levels. Earlier harvest reduces the potential for crop losses from lodging and adverse weather conditions. Earlier harvest also will increase marketing flexibility and crop rotation alternatives. Application of P significantly reduced grain moisture by an average of 5% (Figure 6). At the optimal N rate, grain moisture was reduced from 27% moisture without fertilizer P to 22% with P.

Artificial drying of corn consumes scarce natural resources and is expensive. The addition of P reduced drying costs by an average of \$0.10/bu (Figure 7). The biggest savings in drying cost occurred at N rates of 80 and 120 lb/a, but these N rates do not represent the most economical levels because of lower yields. At the optimal N rate, the drying cost was $0.24/bu without fertilizer P compared to $0.14/bu with fertilizer P.

The economic benefit from fertilizer P was calculated as the difference in net revenue at each N rate with and without P. Net revenue was calculated as gross revenue less drying and fertilizer costs. The economic benefit from P varied with corn prices and ranged from approximately $125/a with a corn price of $1.75/bu to over $200/a with a corn price of $2.75/bu (Figure 8). This indicates that, regardless of corn prices, returns on irrigated corn can be improved greatly with P when N also is applied at optimal rates.

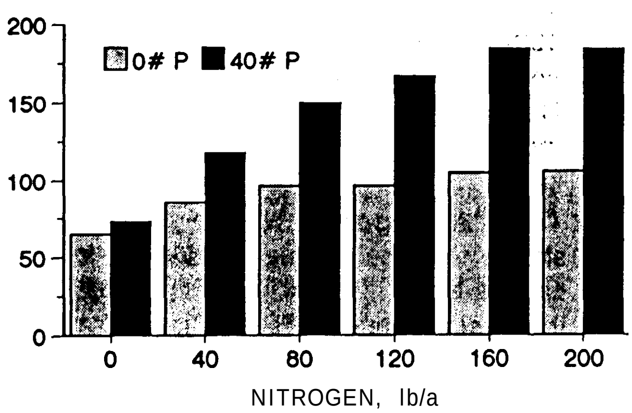


Figure 5. Phosphorus increases grain yield

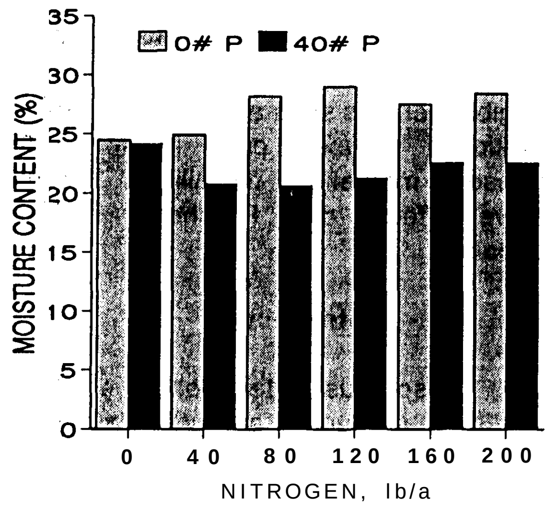


Figure 6. Phosphorus reduces grain moisture

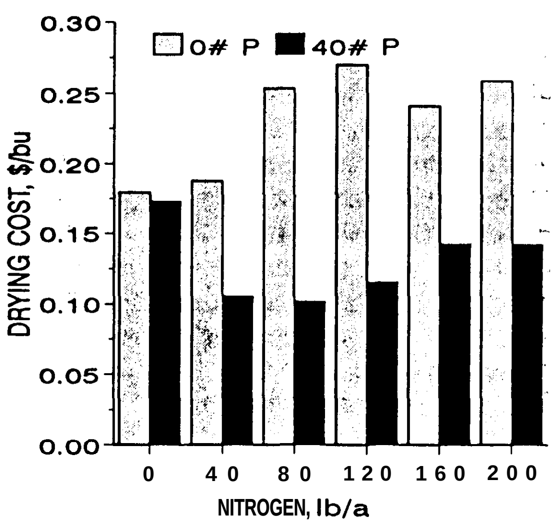


Figure 7. Phosphorus reduces grain drying cost

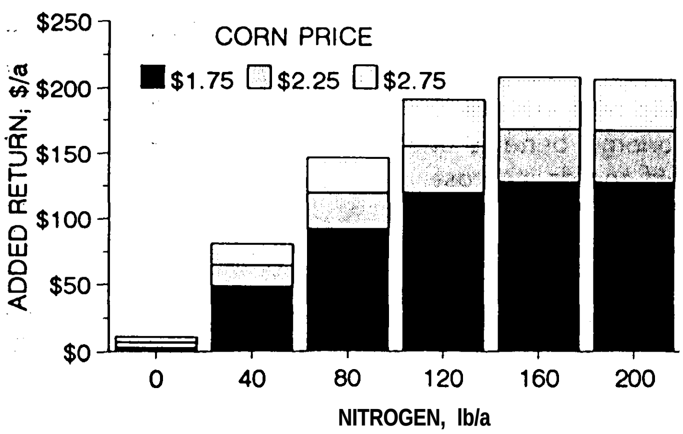


Figure 8. Phosphorus increases economic returns

SOIL FERTILITY RESEARCH
KANSAS RIVER VALLEY EXPERIMENT FIELD

MACRONUTRIENT FERTILITY ON IRRIGATED CORN FOLLOWING SOYBEANS

L. D. Maddux and P. L. Barnes

Summary

A corn-soybean cropping sequence was evaluated from 1983 through 1994 (6 years of each crop) for the effects of N, P, and K fertilization on the corn crop. The 6-year corn yield averages showed a good response to N, no response to P, and a 5 bu/a response to K fertilization. Soybean yields averaged 2.9 bu/a higher with 160 lbs N/a previously applied to corn, 3.6 and 5.2 bu/a higher with 30 and 60 lbs P_2O_5/a, and 2.0 bu/a higher with 60 lbs K_2O/a than the respective N, P, and K check treatments.

Introduction

A study was initiated in 1972 at the Topeka Unit to evaluate the effects of nitrogen (N), phosphorus (P), and potassium (K) on irrigated soybeans. In 1983, the study was changed to a corn and soybean cropping sequence and planted to corn. The objectives of the study are to evaluate the effects of applications of N, P, and K made to a corn crop on grain yield of corn and the following soybean crop and soil test values.

Procedure

The initial soil test in March, 1972 on this silt loam soil showed 47 lbs available P/a and 312 lbs exchangeable K/a in the top 6 inches of the soil profile. Rates were changed in 1976 from 50 and 100 to 30 and 60 lbs $P_2O_{5/a}$ and from 100 to 60 lbs K_2O/a. N rates included a factorial arrangement of 0, 40, and 160 lbs N/a (with single treatments of 80 and 240 lbs N/a). Soil tests taken in the spring of 1983 indicated 30, 57, and 79 lbs/a available P for the 0, 30, and 60 lbs P_2O_5 treatments and 286 and 352 lbs/a exchangeable K for the 0 and 60 lbs K_2O treatments. Soil tests were taken in October, 1994, but analysis was not completed in time for this report.

The fertilizer treatments are applied in early spring (usually mid to late March) only to the corn in the rotation (every other year). Corn hybrids planted were BoJac 603 - 1983; Pioneer 3377 - 1985, 1987, 1989; and Jacques 7820 - 1991 and 1993. Soybeans planted were Douglas - 1984; Sherman - 1986, 1988, 1990, and 1992; and Edison - 1994. Corn was planted in mid-April, and soybeans were planted in early to mid-May. Herbicides were applied preplant, incorporated each year. The plots were cultivated, furrowed, and irrigated as needed. A Gleaner E plot combine was used for harvest.

Results

A good corn yield response to N was obtained all 6 corn years of the study (Table 1). Maximum corn yield was obtained with 160 lbs N/a. In 1983 and 1987, the 240-30-60 treatment resulted in 17 and 13 bu/a higher yields than the 160-30-60 treatment (not significant at the 5% level). However, the 6-year average showed only a 2 bu/a difference in the yields of these two treatments. Yield responses to P were obtained only in 1985 and 1993, when an application of 30 lbs P_2O_5/a increased corn yield by 12 and 7 bu/a over the no-P treatment. However, because of differences in response to P in the other years, the 6- year average showed no significant difference. Increases of 9, 7, and 10 bu/a were obtained from K fertilization in 1985, 1989, and 1993. A significant increase of 5 bu/a was obtained over the 6 years for 60 lbs/a K_2O.

Previously applied N of 160 lbs/a resulted in increased soybean yields of 5.4, 4.3, and 4.1 bu/a in 1988, 1990, and 1994, but not the other 3 years (Table 2). The 6-year average yield indicated a 2.9 bu/a yield increase with 160 lbs/a of previously applied N as compared to no N. Soybeans responded to P fertilization in 5 of the 6 years, for average yield increases of 3.6 and 5.2 bu/a with 30 and 60 lbs P_2O_5/a. Yearly soybean yield increases ranged from 0.4-8.3 and 3.0-10.5 bu/a for the 30 and 60 lbs P_2O_5/a. K fertilization of corn resulted in yield increases of 3.2 and 2.9 bu/a in only 1992 and 1994. However, the same trend was present the other years of the study, and a 2.0 bu/a average yield increase for the 60 lbs K_2O/a application was obtained.

Table 1. Effect of N, P, and K applications on corn yield in a corn-soybean cropping sequence, Topeka[1].

Fertilizer Applied			Corn Yield						
N	P_2O_5	K_2O	1983	1985	1987	1989	1991	1993	Average
- - - - lbs/a - - - -			- - - - - - - - - - - - bu/a - - - - - - - - - - - -						
0	0	0	87	120	76	61	91	71	84
0	0	60	70	116	76	68	98	81	85
0	30	0	76	131	76	74	112	80	92
0	30	60	69	120	72	70	88	85	84
0	60	0	73	131	72	65	94	70	84
0	60	60	75	137	75	71	106	79	91
40	0	0	116	153	125	121	143	122	130
40	0	60	126	171	113	105	121	123	126
40	30	0	110	156	105	109	132	125	123
40	30	60	119	176	131	126	143	143	140
40	60	0	98	167	113	114	136	116	124
40	60	60	114	174	123	131	144	121	134
160	0	0	158	192	171	178	184	162	174
160	0	60	165	206	173	194	183	164	181
160	30	0	149	197	163	181	192	160	174
160	30	60	153	226	163	201	196	176	186
160	60	0	154	208	165	189	176	149	173
160	60	60	161	213	172	190	186	174	183
80	30	60	138	192	136	154	158	147	154
240	30	60	170	215	179	196	197	173	188
LSD (.05)			19	20	22	21	27	19	16
NITROGEN MEANS:									
0			75	126	74	68	98	78	87
40			114	166	118	118	136	125	130
160			157	207	168	189	186	164	179
LSD (.05)			8	9	9	9	11	8	7
PHOSPHORUS MEANS:									
	0		120	160	122	121	137	121	130
	30		113	168	118	127	144	128	133
	60		113	172	120	127	140	118	132
LSD (.05)			NS	9	NS	NS	NS	8	NS
POTASSIUM MEANS:									
		0	114	162	118	121	140	117	129
		60	117	171	122	128	141	127	134
LSD (.05)			NS	7	NS	7	NS	6	5

[1] Fertilizer applied to corn in 1983, 1985, 1987, 1989, 1991, and 1993 and to soybeans for 11 years prior to 1983.

Table 2. Effect of N, P, and K applications on soybean yield in a corn-soybean cropping sequence, Topeka[1].

Fertilizer Applied			Soybean Yield						
N	P_2O_5	K_2O	1984	1986	1988	1990	1992	1994	Average
- - - - lbs/a - - - -			- - - - - - - - - - - - - bu/a - - - - - - - - - - - - -						
0	0	0	68.8	56.0	66.5	54.9	63.5	68.6	63.1
0	0	60	70.4	56.9	66.3	57.3	66.1	66.8	63.9
0	30	0	69.3	59.4	64.2	61.7	76.0	77.4	68.0
0	30	60	69.4	61.4	68.6	62.5	69.9	80.7	68.7
0	60	0	69.6	60.5	68.1	61.9	75.1	77.8	68.8
0	60	60	72.6	63.3	75.1	63.1	76.1	79.4	71.6
40	0	0	68.7	58.1	71.1	61.3	60.0	71.5	65.1
40	0	60	67.3	62.1	66.0	62.7	67.0	75.8	66.8
40	30	0	67.6	61.4	64.6	59.4	69.5	71.7	65.7
40	30	60	71.8	64.4	75.7	63.9	74.2	81.0	71.8
40	60	0	73.0	64.5	75.5	62.7	71.3	76.5	70.6
40	60	60	71.9	61.7	69.9	64.6	74.3	81.1	70.6
160	0	0	67.8	60.3	75.0	62.2	65.1	74.1	67.4
160	0	60	70.6	60.5	74.2	61.9	67.7	74.8	68.3
160	30	0	70.4	59.4	75.7	60.9	69.2	80.5	69.3
160	30	60	67.2	63.5	74.4	69.3	80.7	80.3	72.5
160	60	0	73.6	62.9	67.8	66.0	76.1	80.8	71.2
160	60	60	71.0	63.6	73.9	66.5	79.7	84.5	73.2
80	30	60	71.1	63.7	70.2	65.7	73.0	77.9	70.3
240	30	60	72.1	62.0	69.7	66.2	70.4	82.2	70.4
LSD (.05)			NS	NS	NS	NS	9.6	6.9	5.0
NITROGEN MEANS:									
0			70.0	59.6	68.1	60.2	71.1	75.1	67.4
40			70.0	62.1	70.5	62.5	69.4	76.3	68.4
160			70.1	61.7	73.5	64.5	73.1	79.2	70.3
LSD (.05)			NS	NS	3.9	3.4	NS	2.9	2.1
PHOSPHORUS MEANS:									
	0		68.9	59.0	69.9	60.1	64.9	71.9	65.8
	30		69.3	61.6	70.5	63.0	73.2	78.6	69.4
	60		71.9	62.7	71.7	64.2	75.4	80.0	71.0
LSD (.05)			2.4	2.9	NS	3.4	4.1	2.9	2.1
POTASSIUM MEANS:									
		0	69.9	60.3	69.8	61.2	69.5	75.4	67.7
		60	70.2	61.9	71.6	63.5	72.9	78.3	69.7
LSD (.05)			NS	NS	NS	NS	3.3	2.4	1.8

[1] Fertilizer applied to corn in 1983, 1985, 1987, 1989, 1991, and 1993 and to soybeans for 11 years prior to 1983.

SOIL FERTILITY RESEARCH
SOUTHEAST AGRICULTURAL RESEARCH CENTER

EFFECT OF PREVIOUS RESIDUE MANAGEMENT AND N RATE ON YIELDS IN A CONTINUOUS SMALL GRAIN - DOUBLE-CROP SOYBEAN ROTATION

D.W. Sweeney

Summary

In general, double-crop soybean yields were low from 1983 to 1992, with a poorly defined trend for disc-only residue management to result in higher yields. However, wheat (or oat) yields often were lower where the previous double-crop soybeans were planted no-till as compared to burn and disc or disc only. Increased N rates for wheat had minimal effect on wheat or soybean yields.

Introduction

Double-cropping of soybeans after wheat or other small grains, such as oats, is practiced by many producers in southeastern Kansas. Several options exist for dealing with straw residue from the previous small grain crop. The method of managing the residue may affect not only the double-crop soybeans but also the following small grain crop. Wheat (or oat) residue that is not removed by burning or is not incorporated before planting soybeans may result in immobilization of N applied for the following small grain crop (usually wheat). Therefore, an additional objective of this study was to observe whether an increase in N rate, especially where double-crop soybeans were grown with no tillage, could increase small grain yields.

Procedure

Three wheat residue management systems for double-crop soybeans with three replications were established in spring 1983: no tillage, disc only, and burn then disc. After the 1983 soybean harvest, the entire area was disced, field cultivated, fertilized, and planted to wheat. In spring, urea was broadcast as a topdressing to all plots, so that the total N rate was 83 lb N/a. Wheat yield was determined in areas where the three residue management systems had been imposed previously. In spring 1985, residue management plots were split, and two topdress N rates were applied for wheat. These two rates were added to give total yearly N applications of 83 and 129 lb N/a. These residue management and total N rate treatments were continued through 1993, except in 1986 and 1987, when oats were planted in the spring because of wet conditions in the fall.

Results and Discussion

In general, yields of double-crop soybeans were low during the 11 crop-years of this study and were nearly always less than 20 bu/a (Table 1). The disc-only treatment tended to give higher yields in years where residue management resulted in significant differences. No tillage tended to result in lower yields, partly because of weed pressure. In 1987, 1989, and 1993, the residual N that was applied to the previous wheat crop resulted in higher soybean yields in the burn-then-disc and in the disc-only treatments. However, yield was not increased by residual N in the no-tillage plots in 1987 and 1989 (interaction data not shown).

In general, the previous residue management used for double-crop soybeans affected the subsequent wheat or oat crops (Table 2). Small grain yields were up to 20 bu/a less where soybeans were double-cropped no-till in the previous year. Often, yield differences were small between the burn-then-disc treatment and the disc-only treatment. Averaged across residue management systems, increasing the N rate resulted in an increase in small grain yield only in 1990. However, oat yields in 1987 and wheat yields in 1991 were affected by an interaction between residue management system and N rate. In 1987, increasing N rate lowered oat yields in areas where double-crop soybeans had been planted no-till, whereas increasing N rate increased oat yields where the residue management had been either burn then disc or disc only. In 1991, increasing N rate increased wheat yields only in the disc-only system.

Table 1. Soybean yield as influenced by straw residue management and residual N rates.

	Soybean Yield										
Treatment	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
	bu/a										
Residue mgmt.											
Burn then disc	7	-	15	10	13	1	11	8	5	17	5
Disc only	4	-	21	12	17	3	10	12	14	16	7
No tillage	6	-	0	9	13	6	0	3	5	10	6
LSD 0.05	NS	-	2	NS	3	2	6	4	5	2	1
N rate (lb/a)											
83	-	-	12	10	13	3	5	7	9	13	5
129	-	-	13	12	15	4	10	9	8	15	7
LSD 0.05	-	-	NS	NS	1	NS	2	NS	NS	NS	1
Interaction	-	-	NS	NS	*	NS	**	NS	NS	NS	NS

Table 2. Wheat yield in 1984, 1985, 1988, 1989, 1990, 1991, and 1992 and oat yield in 1986 and 1987 as influenced by previous straw grain residue management and N rates.

	Small Grain Yield									
Treatment	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
	bu/a									
Previous residue mgmt.										
Burn, then disc	63	59	79	51	58	40	18	23	35	37
Disc only	59	55	85	49	53	45	12	17	38	32
No tillage	43	48	64	42	50	33	7	15	26	17
LSD 0.05	13	8	6	NS	5	NS	6	3	6	10
N rate (lb/a)										
83	-	53	77	47	56	38	10	19	34	30
129	-	55	75	47	51	40	14	18	32	27
LSD 0.05	-	NS	NS	NS	5	NS	3	NS	NS	NS
Interaction	-	NS	NS	*	NS	NS	NS	**	NS	NS

LAND APPLICATION OF COMPOSTED MUNICIPAL SOLID WASTE FOR GRAIN SORGHUM PRODUCTION[1]

D.W. Sweeney and G.M. Pierzynski

Summary

Municipal solid waste compost had little effect on grain sorghum growth or yield in 1993. Cow manure or fertilizer increased growth and yield, but the response was smaller when the other also was applied.

Introduction

One of the most pressing environmental issues that will face communities in the near future is solid waste disposal. In recent years, news media coverage of landfill problems has become common. With diminishing capacity of existing landfills and the reluctance of the general populace to create new landfills at their own "back door", other alternatives to straight landfilling of municipal solid waste (MSW) need to be explored. Incineration may reduce waste volume, but likely raises as many environmental concerns as landfills. However, composting of MSW may be more environmentally acceptable and should substantially reduce waste volume. Landfill longevity could be extended further by finding alternative uses for the composted MSW. It has potential uses in agriculture, horticulture, silviculture, and reclamation. Thus, the objective of this study was to determine the effect of application rate of composted MSW, with or without cow manure and with or without commercial fertilizer, on the growth, composition, and yield of grain sorghum and on selected soil chemical properties.

Procedure

A field study was established in 1992 on a Zaar silty clay soil at an off-station site in Montgomery County. The experimental design was a split plot arrangement of a randomized complete block with three replications. The whole plots comprised a 4 x 2 factorial arrangement of four rates of MSW compost with or without cow manure. The four rates of MSW compost were 0 or 4.5, 9, and 13.5 ton/a applied each year. These rates were selected to be more in line with a "utilization-" rather than a "disposal-mentality". The cow manure rates were 0 or 4.5 ton/a applied yearly. The subplots were with or without commercial fertilizer, 100-60-30 lb N-P_2O_5-K_2O/a. Compost, cow manure, and fertilizer were applied on June 15, and grain sorghum was planted on June 16.

Results and Discussion

Adding MSW compost increased dry matter accumulation at the 9-leaf stage as compared with no compost. However, this effect was not significant at the boot or soft dough stages or in grain yield. Adding cow manure or fertilizer generally increased growth and yield of grain sorghum. Several cow manure by fertilizer interactions suggested that responses are smaller to either cow manure or fertilizer when the other also is applied.

[1] With the cooperation of Resource Recovery, Inc.

Table 3. Effect of composted municipal solid waste (MSW), cow manure (CM), and fertilizer on grain sorghum growth and yield.

	Dry Matter Production			
Treatment	9-Leaf	Boot	Soft Dough	Yield
	-------------------- lb/a	--------------------		bu/a
MSW (t/a)				
0.0	390	3220	6910	36.8
4.5	490	3260	6760	33.3
9.0	460	3230	6980	29.0
13.0	520	3730	7090	42.0
LSD 0.05	50	NS	NS	NS
CM (t/a)				
0.0	390	2880	6620	31.0
4.5	540	3840	7250	39.5
LSD 0.05	40	400	610	NS
Fertilizer (lb/a)				
0	430	3100	6540	30.0
100-60-30	500	3620	7330	40.7
LSD 0.05	60	300	660	4.2
Interaction(s)	CxF	CxF	NS	CxF

FOLIAR POTASSIUM THIOSULFATE AND BORON FERTILIZATION OF DRYLAND ALFALFA

D.W. Sweeney and J.L. Moyer

Summary

Foliar applications of K and S as potassium thiosulfate and B as Solubor did not affect total annual alfalfa yields in 1993 or 1994. Soil applications of K, S, and B at "green-up" produced small increases in total alfalfa production during the 2 years.

Introduction

Production of alfalfa under dryland conditions requires good management of plant nutrients. Besides requiring fertilization with macronutrients such as P and K, alfalfa nutritional needs also include adequate amounts of secondary and micronutrients. Data from previous studies have indicated that, in the claypan soils of southeastern Kansas, alfalfa may be more responsive to yield to P fertilization than to K. However, in those studies, K concentrations in the plant were often low. If soil-applied K is becoming partially unavailable, foliar-applied K may benefit alfalfa production. Sulfur is a secondary nutrient that may be low in the topsoils of the area, and fertilization with S also may improve production and quality. The current availability of potassium thiosulfate (KTS) liquid fertilizer gives the opportunity to apply both K and S as a foliar application. Boron is a micronutrient that is important for alfalfa production and can be marginal in the soils of southeastern Kansas. Application of K and S as KTS and B as Solubor may provide increases in yield of alfalfa.

Procedure

The experiment was conducted on a new alfalfa stand planted in fall of 1992 at the Parsons field. The experiment was a 3 x 2 x 2 factorial arrangement. The three rates of foliar KTS were i) 0 lb K_2O/a and 0 lb S/a, ii) 3.0 lb K_2O/a and 2.1 lb S/a, and iii) 6.0 lb K_2O/a and 4.2 lb S/a. Foliar applications of B were 0 or 0.5 lb B/a. Foliar applications of KTS and B were made at approximately 8 inches of growth prior to the first and second cuttings. Soil applications of K, S, and B were applied at "green-up" to supply 80 lb K_2O/a, 28 lb S/a, and 2 lb B/a. Cuttings were taken from a 3 x 25' area of each plot.

Results

During 1993 and 1994, foliar applications of KTS or B did not affect yields (data not shown). Soil applications of K, S, and B significantly increased total annual yield by 0.4 tons/a (3.8 tons/a without soil K, S, and B fertilization and 4.2 tons/a with soil K, S, and B application).

NITROGEN RATE AND PLACEMENT EFFECTS ON EASTERN GAMAGRASS UNDER 1-CUT OR 2-CUT HARVEST SYSTEMS

J.L. Moyer and D.W. Sweeney

Summary

Eastern gamagrass was fertilized with three N rates applied by broadcast or knife placement. Hay crops were taken under 1-cut or 2-cut harvest systems. Forage yield was increased under the 2-cut system as compared to 1-cut in 2 of 3 years. Nitrogen increased total yield by 40-45% with the first 45 lb/a increment and by an additional 14-18% with the next 45-lb increment. Broadcast and knife N placements were no different in total seasonal yield or in first-cut yield of either harvest system. Second-cut yields (2-cut system) were higher (P<.05) from knife compared to broadcast N placement at higher N rates in 1992 and 1993.

Introduction

Eastern gamagrass [*Tripsacum dactyloides* (L.) L.] is a warm-season perennial grass native to the North American tallgrass prairie. It has relatively better forage yield potential and quality than most other warm-season native species. Eastern gamagrass thus may respond well to more intensive management practices, such as added N and more harvests. This study was established to determine the response of eastern gamagrass to N fertilizer rates and placement under 1-cut or 2-cut harvest systems.

Procedure

Established (15-year-old) 'Pete' eastern gamagrass was burned in April of 3 years and fertilized in late April with 54 lb P_2O_5/a and 61 lb K_2O/a. Nitrogen (urea-ammonium nitrate solution, 28% N) treatments of 0, 45, or 90 lb/a were applied in late April to 8 x 20' plots by broadcast or knife (4-inch) placement.

Plots were cut with a flail-type harvester in late June and mid August for the 2-cut system and on about 10 July for the 1-cut system. Yields were determined from a 3' x 20' strip of each plot, with a subsample taken for moisture determination.

Results

Total forage yields for 1992-1994 are in Table 4. Total forage yield was increased under the 2-cut system as compared to 1 cut in 1992 and 1994, but not in 1993. Nitrogen increased total forage yield in the different years by 40-45% with the first 45 lb/a increment and by an additional 14-18% with the next 45-lb increment. Similarly, with the first 45-lb/a increment of N, yields from the 1-cut system were increased 57% (data not shown), and first-harvest yields of the 2-cut system (Fig. 1) were increased 49%. An additional 45 lb/a of N increased yields of those cuttings by 14% and 18%, respectively.

Broadcast and knife N placements resulted in no difference in total seasonal yield (Table 4) or in first-cut yield of either harvest system (data not shown). Second-cut yields (2-cut system) were higher (P<.05) from knife compared to broadcast N placement in 1992 and 1993 but not in 1994 (Fig. 2). Significant interactions between N rate and placement occurred in 1992 and 1993, because the placement response was found in 1993 at only the 90-lb N rate but in 1992 at both the 45- and 90-lb rates.

Table 4. Eastern gamagrass forage yields under two harvest systems with different nitrogen rates and placement.

Harvest System	Nitrogen Rate	Nitrogen Placement	Forage Yield 1992	1993	1994
	lb/a		--- tons/a (12% moisture) ---		
1-Cut	0	Broadcast	2.18	2.14	1.18
		Knife	2.32	2.01	1.25
	45	Broadcast	3.72	3.07	1.65
		Knife	3.45	3.44	1.79
	90	Broadcast	3.88	3.69	1.84
		Knife	4.26	3.75	2.14
2-Cut	0	Broadcast	3.07	2.25	1.47
		Knife	2.61	2.31	1.42
	45	Broadcast	3.63	2.95	2.03
		Knife	3.90	3.21	2.01
	90	Broadcast	4.12	3.57	2.30
		Knife	4.78	3.48	2.52
LSD(.05)			0.71	0.60	0.46
Means, Nitrogen Placement					
		Broadcast	3.43	2.94	1.74
		Knife	3.55	3.03	1.85
		LSD(.05)	NS	NS	NS
Means, Nitrogen Rate					
	0		2.54	2.18	1.33
	45		3.67	3.17	1.87
	90		4.26	3.62	2.20
	LSD(.05)		0.35	0.30	0.23
Means, Harvest System					
1-Cut			3.30	3.02	1.64
2-Cut			3.68	2.96	1.96
LSD(.05)			0.29	NS	0.19

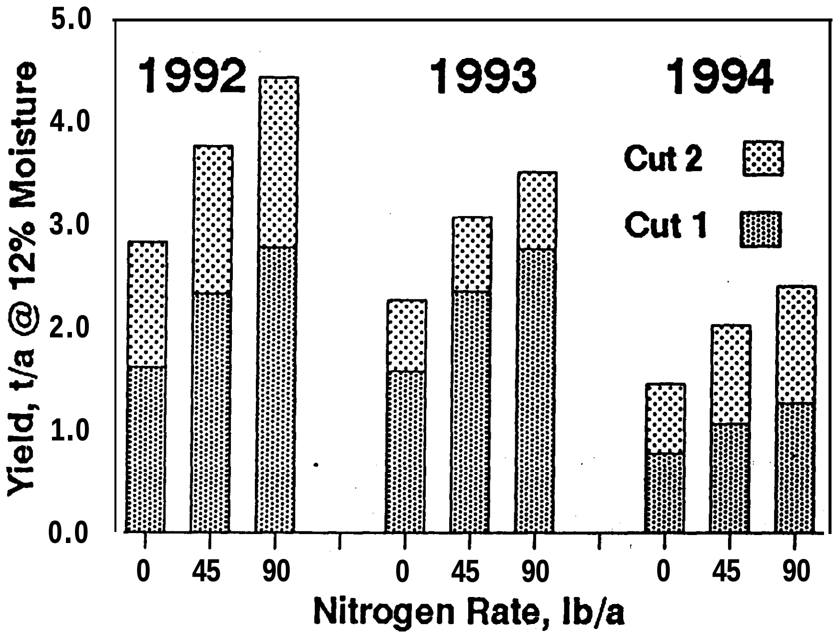


Figure 1. Effect of N fertilization rate on forage yield of eastern gamagrass under a 2-cut harvest system.

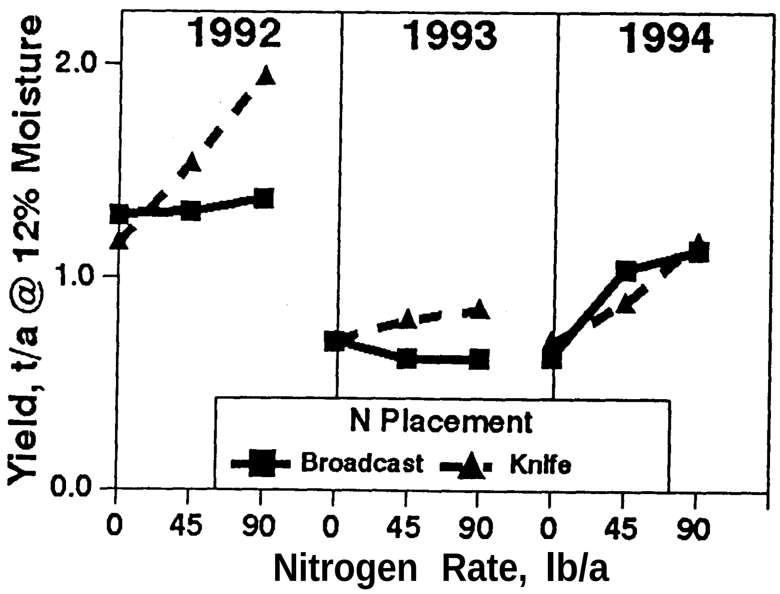


Figure 2. Effect of N fertilization rate and placement on forage yield of the second cutting of eastern gamagrass in a 2-cut system.

SOIL FERTILITY RESEARCH
EAST CENTRAL KANSAS EXPERIMENT FIELD

RESIDUAL EFFECTS FROM PHOSPHORUS FERTILIZER APPLICATIONS IN TWO TILLAGE SYSTEMS

K.A. Janssen

Summary

Residual phosphorus (P) from 4 years of P fertilizer applications was evaluated for grain sorghum in chisel-disc and no-till systems in east-central KS. Responses to residual P were similar in both tillage systems. The highest rates of original P produced the greatest residual P yield responses. The methods of P application had little influence on residual P yield. Residual P from the 10 lb/a P_2O_5 treatments produced marginally higher yield in the first year, but no response the following years. Statistically higher residual yields were produced by the 30 lb/a P_2O_5 rate in the first 2 years and by the 60 lb/a P_2O_5 rate in all 4 years of the study. Residual yield responses were less than those with fresh P in all instances, except for the first 2 residual-P years with the 60 lb/a P_2O_5 rate. Total grain production for all years (application and residual P years) showed that banded P applications were more efficient than broadcast P.

Introduction

Carryover of phosphorus (P) from fertilizer applications can provide P for succeeding crops. Some agronomists speculate that, with the use of reduced tillage (especially no-till), increased residual P could be available because of reduced soil mixing and soil tie-up of P. If this is the case, less fertilizer P or less frequent P applications should be required. The purposes of this study were to measure the residual P effects from 4 years (1987-1990) of P fertilizer applications in two tillage systems (chisel-disc and no-till), which included different P fertilizer rates and placement methods for grain sorghum and to compare these residual P responses with those from selected fresh P fertilizer applications.

Procedure

The study was conducted at the East Central Kansas Experiment Field near Ottawa, KS on an initially low P-test (12 lbs/a Bray #1 P-test) Woodson silt loam soil (fine, montmorillonitic, thermic, Abruptic Argiaquolls). The experiment was designed as a randomized complete block, split plot with the chisel-disc and no-till systems as whole plots and the P fertilizer rates and placement methods as subplots. There were three replications of each treatment.

The original P applications began in 1987 and continued on the same plots for 4 years. Treatments in each tillage system included five P fertilizer rates (0, 10, 20, 30, and 60 lbs P_2O_5/a) and four placement methods (seed-furrow, 2"x2" row banded, broadcast, and knifed) plus some combination application methods. Grain sorghum was grown in all years. However, only three crops were harvested during the P application years. In the first year, the grain sorghum crop was lost because of hail. Starting in 1991, the 5th year of the study, most P treatments were stopped and were left as residual treatments except for a select few that received annual, fresh P fertilizer of either 10, 20, or 30 lb/a P_2O_5, 2"x2" row banded. These are identified in Table 1 as "F" (fresh applications) compared to "R" for residual. The source of P fertilizer used in all treatments was liquid 7-21-7 except for some initial seed-furrow P applications, which were 9-18-9, 6-24-6, and 10-34-0 P materials. All of the broadcast P fertilizer in this study was sprayed on the soil surface and was incorporated in the chisel-disc systems. The knifed P fertilizer was knifed 5-7 inches deep on 15-inch centers through anhydrous ammonia fertilizer knives. The row-banded P was banded 2 inches to the side and 2 inches below the seed at planting. The P fertilizer applied in the seed-furrow was dribbled with the seed ahead of the seed-covering discs at planting.

Nitrogen (N) and potassium (K) fertilizers were applied as needed. The N fertilizer was knifed 5-7 inch deep on 15-inch centers, and the K fertilizer was broadcast on the soil surface. Planting dates for evaluating the residual P treatments were June 7, 1991; June 24, 1992; June 21, 1993; and June 16, 1994. Weeds were controlled each year by using a combination of early preplant and preemergence herbicides, plus hand weeding to assure no affect from weeds. All plots, including the no-till plots, were row-crop cultivated one time during the growing season.

Whole, aboveground, plant samples were collected at the 5- to 7-leaf growth stage to determine early-season, dry matter production, P content in the plant tissue, and P uptake. The center two rows of each plot were harvested for yield. All grain yields were adjusted to 12.5% moisture.

Results

Residual P responses in both tillage systems were similar except for 1994, when yield was slightly higher in the chisel-disc system than in the no-till system (Table 1). Also, a statistically significant interaction ($p < 0.05$) occurred between the tillage systems and the P fertilizer treatments for P uptake in 1994 and for residual yield when totaled for the 4-yr residual period. These effects indicate a possible increase in residual P availability with no-till.

Averaged across tillage systems, yield responses for the P treatments varied depending on the rates of original P application, from 6.0 to 14.6 bu/a in 1991, from 3.3 to 22.0 bu/a in 1992, from 0.3 to 12.9 bu/a in 1993, and from -1.5 to 14.3 bu/a in 1994. The highest rates of original P produced the greatest residual P yield responses. Residual P responses with the 10 lb/a P_2O_5 treatments were marginal in the first year and were statistically not significant in the remaining residual P years. The 30 lb/a P_2O_5 residual P treatments increased residual P yield in the first 2 years but not the second 2 years. The 60 lb/a P_2O_5 residual P treatments significantly increased residual P yield in all 4 years. All residual P responses were less compared to fresh P responses, except the first 2 residual P years with the 60 lb/a P_2O_5 residual P treatments. This suggests that residual P availability was insufficient past the first 2 residual P years, even with the highest P applications.

The methods of P application had little effect on residual P response. This differs compared to the placement effects on yield during the years of P application. This could be partially because of more efficient P use in the years of P application.

Total yield response for all study years (application and residual P years) is shown in the far right-hand column of Table 1. These figures show that the amount of P applied originally had a significant effect on initial and residual P yield responses. The data also show that, at equivalent P rates, the banded P applications were more efficient than broadcast P. Broadcast P in this study performed poorly, unless some P was concentrated near the seed.

Table 1. Grain sorghum response to residual and residual plus freshly applied P in two tillage systems (Woodson silt loam soil).

Variable	Treatment	1994 7-Leaf Whole Plant Dry Mass	1994 7-Leaf Whole Plant P	P Uptake 1994	Grain Yield[2] 1991 1st Yr Residual	1992 2nd Yr Residual	1993 3rd Yr Residual	1994 4th Yr Residual	Total Response Residual Years	Total Response All Years
		gms/ plant	%	mg/plant	bu/a	bu/a	bu/a	bu/a	bu/a	
Tillage System:										
No-till		6.1	0.27	17	67.8	65.1	20.6	71.8	225	395
Chisel-disc		5.3	0.25	14	58.5	60.2	22.6	74.3	216	386
L.S.D. 0.05		NS	NS	2	NS	NS	NS	2.2	NS	NS
P Treatment: /P_2O_5 Rate,[1] lb/a										
Check -NO P		4.2	0.23	10	(54.1)	(49.9)	(12.1)	(65.4)	(182)	(308)
R-10S, F-10RB		6.5	0.27	17	+7.1	+14.9	+14.1	+3.5	+40	+77
R-10S, F-20RB		7.9	0.28	22	+8.0	+21.3	+20.4	+17.2	+67	+109
R-10S, F-30RB		8.0	0.30	24	+4.5	+22.4	+24.7	+22.0	+74	+104
R-10S		4.1	0.23	10	+6.2	+3.3	+0.3	+0.2	+10	+40
R-10KN		5.0	0.24	13	+6.0	+6.9	+3.8	+3.6	+20	+47
R-20KN		4.7	0.24	11	+6.3	+7.0	+0.9	+2.0	+16	+62
R-30KN		5.3	0.25	14	+10.3	+7.2	+4.0	+5.5	+27	+89
R-30BC		4.7	0.25	12	+8.8	+10.1	+5.3	+2.1	+26	+50
R-30RB		5.8	0.25	15	+12.2	+6.6	+3.3	-1.5	+21	+64
R-20KN+10S		4.6	0.26	12	+6.7	+9.1	+1.2	-1.4	+15	+83
R-60KN		6.4	0.28	19	+14.6	+17.5	+12.9	+14.3	+59	+136
R-60BC		5.5	0.28	15	+12.8	+22.0	+14.8	+10.8	+60	+93
R-50BC+10S		5.3	0.27	14	+14.5	+19.7	+11.1	+13.5	+59	+123
R-50BC+10S, F-10RB		7.7	0.30	23	+16.9	+23.1	+24.9	+23.7	+89	+155
L.S.D. 0.05		1.0	0.02	3	6.2	8.0	8.3	11	17	27
Tillage x P Interaction:		NS	NS	*	NS	NS	NS	NS	*	NS
CV %		15	8	18	8	11	33	13	7	6

[1] R- = Residual from applications 1987, 1988, 1989 and 1990.
F- = Fresh application, 1991, 1992, 1993, and 1994.
S = Placed with the seed in the seed furrow.
RB = Row-banded, 2" side and 2" below the seed at planting.
BC = Broadcast pre-plant surface and then incorporated 3-5" depth by discing in chisel-disc system.
KN = Knifed 5-7" deep on 15" centers, pre-plant.

[2] Shaded residual P yield responses are not statistically better than the P control at the 0.05 level of probability.

SOIL FERTILITY RESEARCH
NORTH CENTRAL KANSAS EXPERIMENT FIELD

STARTER FERTILIZER INTERACTIONS WITH CORN HYBRIDS GROWN IN A NO-TILLAGE SYSTEM

W.B. Gordon and D.L. Fjell

Summary

Although starter fertilizer improved early-season growth for all hybrids tested, only three of the six hybrids showed a yield response to starter fertilizer.

Introduction

Early-season plant growth is often poorer in conservation tillage systems than in conventionally tilled systems. This can be a serious problem with dryland corn that is planted in early April, when soil temperature is less than optimum for corn growth. Cool soil temperature at planting time can interfere with N and P uptake by corn. Slow plant growth at low soil temperature may be due to limited root growth and reduced nutrient availability. The latter can occur on soils with high residual fertility levels. Placing fertilizer in close proximity to the seed at planting can alleviate the detrimental effects of cool soil temperature on corn growth and development. Corn hybrids may differ in rooting characteristics. This study evaluated the effects of starter fertilizer on six corn hybrids with maturities ranging from 2530 to 2850 growing degree units (GDU) grown under no-tillage, dryland conditions.

Procedure

The experiment was conducted at the North-Central Kansas Experiment Field, Belleville, on a Crete silt loam soil. The corn hybrids ICI 8599 (2530 GDU), Pioneer 3563 (2600 GDU), Pioneer 3346 (2850 GDU), Dekalb 636 (2830 GDU), Dekalb 591 (2590 GDU), and Pioneer 3394 (2690 GDU) were grown with or without starter fertilizer. Starter fertilizer (30 lb N/a and 30 lb P_2O_5/a) was applied 2 inches to the side and 2 inches below the seed at planting. Liquid ammonium polyphosphate (10-34-0) and urea-ammonium nitrate solution (28% UAN) were used as the starter fertilizer sources. Nitrogen was knife applied immediately after planting in order to supply 180 lb/a to all plots. Corn was planted on 19 April at the rate of 22,000 seed/a into corn stubble without tillage. Bray-1 P level in the experimental area was 85 lb/a (high soil test range).

Results

Temperatures in April and May of 1994 were much below normal. A low of 30^0 F was recorded on 1 May. Starter fertilizer improved the early-season growth of all hybrids tested (Table 1). When averaged over all hybrids, dry matter at the V6 stage with starter was 228 lb/a compared to only 85 lb/a without starter. Growth differences between plants treated with starter fertilizer and those not treated also were present at the V10 stage of growth (just prior to tassel). Starter fertilizer increased the tissue concentrations of N and P in 6-leaf whole plants (Table 2). When averaged over all hybrids, starter fertilizer increased the N/a amount in plant tissue 4-fold and amount of P 3-fold. N and P concentrations in earleaf tissue also were increased by the use of starter fertilizer. Hybrids differed in amounts of N and P taken up at the 6-leaf stage. Differences in N and P concentrations among hybrids also were found in earleaf tissue at silking.

When averaged over all hybrids, starter fertilizer shortened the time from emergence to mid-silk by 5 days (Table 3). Starter fertilizer hastened maturity in ICI 8599 by 2 days and in Pioneer 3346 by 6 days. Starter fertilizer increased grain yield of

Pioneer 3346, Pioneer 3394, and Dekalb 636 by 19, 15, and 18 bu/a, respectively. However, no significant improvement in yield was seen in ICI 8599 and Pioneer 3563.

Table 1. Hybrid and starter fertilizer effects on corn dry matter production at two growth stages, 1994.

Hybrid	Starter	Dry Matter	
		V6 Stage (5-20-94)	V10 Stage (6-28-94)
		- - - - - - lb/a	- - - - - -
ICI 8599	With	175	4122
	Without	50	3999
Pioneer 3563	With	227	4909
	Without	94	4288
Pioneer 3346	With	257	6738
	Without	56	2937
Dekalb 636	With	188	4499
	Without	56	2937
Dekalb 591	With	220	4402
	Without	77	4070
Pioneer 3394	With	299	5826
	Without	127	4695
<u>Hybrid</u>			
ICI 8599		113	4060
Pioneer 3563		160	4565
Pioneer 3346		173	5513
Dekalb 636		122	3718
Dekalb 591		148	4236
Pioneer 3394		213	5260
LSD (0.05)		41	NS*
<u>Starter</u>			
With		228	5083
Without		82	4035
LSD (0.05)		44	748
Hybrid x Starter		NS	NS

Table 2. Hybrid and starter fertilizer effects on tissue N and P concentrations, 1994.

Hybrid	Starter	V6 Whole Plant N	V6 Whole Plant P	Earleaf at Silking N	Earleaf at Silking P
		---lb/a---		----%----	
ICI 8599	With	6.1	0.761	2.325	0.263
	Without	1.7	0.207	2.228	0.249
Pioneer 3563	With	8.0	0.905	2.520	0.306
	Without	3.0	0.384	2.417	0.297
Pioneer 3346	With	9.9	1.122	2.628	0.283
	Without	3.3	0.368	2.585	0.272
Dekalb 636	With	7.0	0.815	2.577	0.293
	Without	1.9	0.224	2.390	0.269
Dekalb 591	With	8.0	0.978	2.695	0.304
	Without	2.7	0.304	2.582	0.287
Pioneer 3394	With	10.3	1.260	2.484	0.279
	Without	4.7	0.505	2.345	0.265
Hybrid					
ICI 8599		3.9	0.484	2.276	0.265
Pioneer 3563		5.5	0.644	2.469	0.301
Pioneer 3346		6.6	0.745	2.606	0.277
Dekalb 636		4.5	0.519	2.484	0.281
Dekalb 591		5.4	0.641	2.639	0.295
Pioneer 3394		7.5	0.882	2.414	0.272
LSD (0.05) 1.3		0.180	0.060	0.010	
Starter					
With		8.2	0.973	2.538	0.288
Without		2.9	0.332	2.424	0.273
LSD (0.05) 1.6		0.220	0.040	0.010	
Hybrid x Starter		NS*	NS	0.080	NS

* Not significant at the 5% level of probability.

Table 3. Hybrid and starter fertilizer effects on number of days from emergence to mid-silk and corn grain yield, 1994.

Hybrid	Starter		Days to Mid-Silk	Yield
			Number of Days	bu/a
ICI 8599	With		58	203
	Without		60	199
Pioneer 3563	With		57	217
	Without		62	212
Pioneer 3346	With		58	209
	Without		64	190
Dekalb 636	With		60	196
	Without		64	178
Dekalb 591	With		58	202
	Without		63	193
Pioneer 3394	With		58	222
	Without		63	207
Hybrid				
ICI 8599			59	201
Pioneer 3563			60	214
Pioneer 3346			61	200
Dekalb 636			62	187
Dekalb 591			61	198
Pioneer 3394			6	214
LSD (0.05)		0.5	9	
Starter				
With			63	208
Without			58	197
LSD (0.05)		0.5	5	
Hybrid x Starter			0.7	9

THE EFFECTS OF CROPPING SYSTEM AND NITROGEN FERTILIZER ON NO-TILLAGE GRAIN SORGHUM

W.B. Gordon and D.A. Whitney

Summary

When averaged over N rates, 1994 grain sorghum yields were 22 bu/a greater in the soybean rotation system than in the continuous grain sorghum system. When no N was applied, sorghum rotated with soybeans yielded 39 bu/a greater than continuous sorghum.

Introduction

Crop rotations were necessary to maintain soil productivity before the advent of chemical fertilizers. Biological fixation of atmospheric nitrogen (N) is a major source of N for plants in natural systems. Biological fixations through legume-<u>Rhizobium</u> associations are utilized extensively as N sources in agricultural systems. Using a legume in a crop rotation system can reduce the N requirement for the following nonlegume crop. Other benefits of legume rotations include breaking disease and insect cycles, helping weed control programs, and decreasing the toxic effects of crop residues. This study compares continuous grain sorghum to grain sorghum grown in annual rotation with soybeans in a no-tillage system.

Procedure

This experiment was established at the North Central Kansas Experiment Field near Belleville in 1981. Treatments included cropping system (continuous grain sorghum and grain sorghum rotated with soybeans) and N rates (0, 30, 60, and 90 lb/a). Grain sorghum or soybeans were planted into the old rows using Buffalo row-cleaning units mounted on a White air planter. In each year, anhydrous ammonia was knife applied beside the old rows 7-14 days before planting. Soil samples were taken to a depth of 24 inches in 6-inch increments in early April. The grain sorghum hybrid Pioneer 8699 was planted on 19 May at the rate of 50,000 seed/a. Final stands averaged 41,000 plants/a and were not affected by cropping system or N rate. The soybean variety Pioneer 9341 was planted on 10 May at the rate of 10 seed/foot.

Results

The 1994 growing season was characterized by below normal temperatures and above normal rainfall in June and July but extremely hot and dry conditions in August and September. When averaged over all N rates, 1994 yields in the rotated cropping system were 22 bu/a greater than in the continuous grain sorghum system (Table 4). At the 0 N rate, sorghum rotated with soybean yielded 109 bu/a compared to only 70 bu/a in the continuous sorghum system. Soybean yield in 1994 was 35 bu/a in plots that received 90 lb N/a in 1993 and only 22 bu/a in plots than received no N in the previous year.

Both numbers of heads/plant and seed weights were greater in the rotated than in the continuous plots (Table 5). Numbers of heads/plant and seed weights increased with increasing N rate up to the 90 lb/a rate in the continuous sorghum system but increased only up to 30 lb N/a rate in the rotated system. At all levels of N, soil nitrate levels were greater in the rotated plots than in the continuous plots.

Leaf tissue N and P concentrations both increased with increasing N rate (Table 6). At the 0 N rate, leaf tissue N concentration was 2.35 % in the rotated system but only 1.79 in the continuous sorghum system.

Table 4. Effects of cropping system and N rate on grain sorghum yields.

N Rate	Cropping System	Yield 1994	Yield 1982-1994
lb/a		- - - - - bu/a	- - - - -
0	Continuous	70	44
	Rotation	109	73
30	Continuous	94	59
	Rotation	113	80
60	Continuous	97	69
	Rotation	114	87
90	Continuous	105	77
	Rotation	117	88
System means			
	Continuous	91	62
	Rotation	113	82
N Rate Means			
	0	89	59
	30	103	70
	60	107	78
	90	111	83
LSD (0.05)	Cropping System (A)	4.4	4.5
	N Rate (B)	5.7	4.7
	A x B	7.3	8.8

Table 5. Effects of cropping system and N rate on grain sorghum yield components (number of heads/plant and 1000 seed weight) and soil nitrate nitrogen levels (0-24 inches).

N Rate	Cropping System	Heads/Plant	1000 Seed Wt.	NO_3-N 0-24 in.
lb/a		number	grams	lb/a
0	Continuous	1.0	20.5	5.9
	Rotation	1.7	23.0	21.9
30	Continuous	1.5	21.9	13.9
	Rotation	1.8	23.4	24.8
60	Continuous	1.6	22.7	20.2
	Rotation	1.9	23.6	30.2
90	Continuous	1.7	23.7	30.2
	Rotation	1.9	23.8	35.6
System Means				
	Continuous	1.5	22.2	17.6
	Rotation	1.8	23.5	27.3
N Rate Means				
	0	1.4	21.8	13.7
	30	1.6	22.7	19.4
	60	1.7	23.1	25.2
	90	1.8	23.7	31.4
LSD (0.05)	System (A)	0.05	0.3	2.0
	N Rate (B)	0.10	0.5	2.2
	A x B	0.12	0.7	3.7

Table 6. Effects of cropping system and N rate on grain sorghum leaf (leaf below the flag leaf at heading) N and P concentrations.

N Rate	Cropping System	N	P
		-----------%-----------	
0	Continuous	1.79	0.241
	Rotation	2.35	0.271
30	Continuous	2.35	0.272
	Rotation	2.40	0.280
60	Continuous	2.58	0.286
	Rotation	2.69	0.295
90	Continuous	2.74	0.293
	Rotation	2.74	0.298
System Means			
	Continuous	2.36	0.273
	Rotation	2.55	0.286
N Rate Means			
	0	2.08	0.256
	30	2.37	0.276
	60	2.64	0.290
	90	2.74	0.296
LSD (0.05)	Cropping System (A)	0.13	NS*
	N Rate (B)	0.24	0.01
	A x B	0.30	NS

* Not significant at the 5% level of probability.

SOIL FERTILITY RESEARCH
SOUTH CENTRAL KANSAS EXPERIMENT FIELD

EFFECTS OF NITROGEN RATE ON YIELD IN CONTINUOUS WHEAT AND IN ALTERNATIVE CROP ROTATIONS IN SOUTH CENTRAL KANSAS

W.F. Heer

Summary

Evaluation of nitrogen (N) rates on continuous winter wheat and in two crop rotations involving "alternative" crops for the area have been established at the South Central Field. The continuous winter wheat study was established in 1979. The first of the alternative rotations was established in 1986. This rotation involves corn followed by winter wheat followed by grain sorghum. The second rotation (established in 1990) has soybeans where the corn is in the first. Both rotations use no-till seeding into the previous crops residue. The continuous wheat was revised to utilize both conventional and no-till production practices.

Continuous Wheat Long-Term Nitrogen Rate Study

Researchers: W.F. Heer and D.E. Kissel

Introduction

A long-term N rate study was established on the South Central Kansas Experiment Field in the fall of 1979 and revised after the harvest of 1987 to include a tillage factor. The purpose of this study is to evaluate the yield response of winter wheat to six rates of N.

Procedure

After harvest. the conventional tillage plots were plowed and disced as necessary to control weed growth until wheat was planted in October 1992. Rates of 0, 25, 50, 75, 100, and 125 lb N/a were applied using 34-0-0 as the N source with a Barber spreader prior to the last tillage on the conventional and no-till plots. The plots also received 40 lbs P_2O_5/a broadcast as 0-46-0. The plots then were cross seeded to Karl winter wheat at a rate of 60 lbs/a. The data obtained from the plots are summarized by N rate in Table 1.

Results

The results of the research for 1993 were affected by a severe infestation of cheat that caused considerable yield reductions in the no-till plots at the lower N rates. As in the previous years, yields increased with increasing N rate to 75 lb/a. The yields then decreased at the top two N rates. This same trend occurred in both rotations on the field.

As a result of an infestation of cheat in the 1994 crop, the study was planted to oat in the spring of 1994 and harvested in July. The oat yield data are presented in Table 1.

Rotation 1: Corn-Winter Wheat-Grain Sorghum Rotation with Six Nitrogen Rates

Researchers: W.F. Heer, J.L. Havlin, and D.L. Fjell

Research was initiated in 1986 at the South Central Experiment Field to (1) evaluate the production potential of no-tillage, dryland, short-season corn in a corn-winter wheat-grain sorghum rotation and (2) quantify the fertilizer N response for each crop in the rotation. Nitrogen rates of 0, 25, 50, 75, 100, 125 lb/a were used.

This rotation incorporated a short-season corn planted early into the normal wheat-sorghum-fallow rotations. The corn should mature early enough to allow the soil profile water to be recharged prior to planting of wheat following corn.

Results

Corn

Corn grain yields increased with increasing N in all years of the study (Table 2). Lack of significant yield increases with higher N rates in 1987 reflect the presence of high residual N in the soil at the start of the study (soil test data not reported) and the ideal growing season precipitation (Fig. 1). As the residual soil N was removed by the cropping sequence, the higher N rates produced significantly greater corn yields than the control or the 25 and eventually (1993) the 50 lb/a N rates (Table 2). The moist warm conditions in 1988 were not ideal for corn, and thus, yields were suppressed when compared to 1987 and 1989 (Table 2). Corn yields in 1989 (Table 2) also reflect more timely precipitation (Fig. 1) and cooler growing season temperatures compared to previous years.

Insufficient precipitation during the fall and winter of 1989-90 resulted in a lack of soil moisture recharge. This lack of soil moisture coupled with the hot dry conditions in May through July of 1990 were less than ideal for grain formation in corn. Therefore, the corn crop was harvested for silage, and the yields are reported in tons/a on a dry matter basis. Lack of moisture and high temperatures also resulted in the corn being harvested for silage yields in 1991.

More favorable moisture conditions returned in 1992 and 1993 (Fig. 2). However, temperatures were lower than average in the early spring. This led to delayed development in the corn, which is reflected in the 1992 yields. The yields reported for 1993 show the effects of both the cooler temperatures and lack of herbicide efficacy. The corn yields in the rotation have consistently been slightly lower than those of the same variety in the corn variety test at the South Central Field.

Grain Sorghum

The 1987 growing season was such that grain sorghum reflected the differences in N rate from the 0 to 50 lb rate and the three highest rates when compared to the 0 and 25 lb rates. A favorable growing season for grain sorghum (moist and warm) in 1988 produced an excellent crop with no significant yield differences among N rates (Table 3). Conditions in 1989, though favorable for corn production, caused somewhat reduced yields in the grain sorghum. Significant differences in yield among N rates occurred.

The effects of the dry conditions can be seen in the yields for sorghum in 1990, which were similar to those from the KSU variety test for grain sorghum. These dry conditions carried over into the 1991 growing season and resulted in sorghum yields that were too insignificant to be included in the results.

More favorable conditions returned in 1992 and 1993. As for corn, sorghum growth was delayed in 1992 by the cool late spring and early summer temperatures. Flowering was delayed until mid August, and yields reported were much better than expected. The 1992 and 1993 yields also reflect the depletion of soil N in the 0 N plots.

Wheat

Wheat yield increases with increasing N rates were observed in 1988 and 1990 (Table 4). The extremely dry conditions from planting through early May of 1989 (Fig 1) caused the complete loss of the wheat crop in the rotation for this year. In 1988, 1990, 1991, 1992, and 1993 (Fig. 1 and 2), when timely precipitation occurred in both germination and spring regrowth periods, wheat yields following corn were comparable to those of wheat following wheat. Though not as apparent with sorghum, the effect of reduction in soil N in the 0 N plots also can be seen in the yields.

Other Observations

Nitrogen application significantly increased grain N contents in all crops. Grain phosphate levels did not seem to be affected by increased N rate.

Loss of the wheat crop after corn can occur in years when fall and winter moisture is limited. This loss has not occurred where continuous winter wheat is produced under the same N rates used in the rotation. Corn will have the potential to produce grain in favorable years and silage in nonfavorable years. In extremely dry summers, extremely low grain sorghum yields can occur.

The major weed control problem in the rotation is with the grasses. This was expected, and work is being done to determine the best herbicides and time of application to control grasses. Some new herbicides are being marketed that should aid in their control.

Rotation 2: Soybean-Winter Wheat-Grain Sorghum Rotation with Six Nitrogen Rates

Researchers: W.F. Heer and J.L. Havlin

Research was initiated in 1990 at the South Central Experiment Field to (1) evaluate the production potential of no-tillage, dryland, short-season soybeans in a soybean-winter wheat-grain sorghum rotation and (2) quantify the fertilizer N response for each crop in the rotation. Nitrogen rates of 0, 25, 50, 75, 100, 125 lb/a were used.

This rotation incorporated a short-season (group 1) soybean for the fallow portion of the normal wheat-sorghum-fallow rotations. The soybeans should early enough to allow the soil profile water to be recharged prior to planting of wheat following the soybean crop.

Results

<u>Soybeans</u>

The soybeans have been planted in late May each year. The plots that are planted into soybeans are fertilized with 40 units of P_2O_5 placed in the furrow at planting. The variety Hardin was selected based on yield data from the Harvey County Experiment Field. Soybeans were first planted in 1991. This proved to be a less than ideal year for the production of dryland soybeans in the south central region of Kansas. The lack of timely precipitation resulted in very low yields (Table 5). The soybean season for 1992 proved to be the exact opposite of 1991. It was moist and cool with timely precipitation. Thus, yields were extremely good for this area of Kansas. The 1993 growing season started out to be a repeat of 1992. However, things changed in mid July, and July, August, and September were extremely dry. As expected, the early beans had already set their pods and were able to produce respectable yields as reported in Table 5. Seed N increased slightly. These increases were significant only at the higher N rates.

<u>Grain Sorghum</u>

The grain sorghum is planted at the same time for both the corn-wheat-grain sorghum and soybean-wheat-grain sorghum rotations. The grain sorghum in the soybean rotation did make it through the adverse season in 1991, when it also failed in the corn rotation. However, in the soybean rotation, the plots seeded to sorghum were following 2 years of wheat, because rotation had not cycled sufficient times to show the effects of the two previous crops in the rotation on the third. In 1992 and 1993, when sorghum followed wheat that had followed soybeans, the grain yields for sorghum were similar to those for sorghum in the corn rotation (Table 6). Seed N also increased with increasing N rate.

<u>Wheat</u>

Wheat yields also reflect the differences in N rate. However, when comparing the wheat yields from the soybean rotation with those from the corn rotation, the latter seem to show the effects of residual N from soybean production in the previous year. This is especially true through the 0 to 75 lb N rates in 1993 (Table 7). We hope that, as the rotation continues to cycle, this difference will move to the higher rates of N, indicating the potential to reduce chemical N applications where wheat follows soybeans.

Table 1. Long-term effects of N-rate on continuous wheat-1993 and oat-1994.

N Rate	Yield	Dry Matter	Height	Seed N	Seed P	1994 Oat
lb/a	bu/a	lb/a	In.	%	%	bu/a
0	14.9	1.3	22	2.2	0.45	29.2
25	17.0	2.2	30	2.2	0.42	53.3
50	15.7	2.2	24	2.2	0.41	60.6
75	21.0	2.2	30	2.2	0.43	72.4
100	18.5	2.5	32	2.3	0.42	71.2
125	15.1	2.0	24	2.3	0.40	69.6
LSD.01*	5.2	1.0				
			11.9	0.15	0.036	12.4
CV (%)	22.3	34.5	27.7	8.03	6.73	13.0
CONV	28.5	3.2	32.2	2.18	0.40	58.0
N-T	5.57	0.94	21.2	2.29	0.45	61.0

* Unless two yields differ by at least the amount of the Least Significant Difference, (LSD), little confidence can be placed in one being greater than the other.

Table 2. Effects of N on corn in a corn-wheat-sorghum rotation, Hutchinson, KS.

N	Yield						
Rate	1987	1988	1989	1990	1991	1992	1993
lb/a	- - - - bu/a - - - -			- - - t/a - - -		- - - bu/a - - -	
0	62	37	60	2.3	1.5	19	13
25	63	45	65	2.4	1.9	34	15
50	66	49	78	2.5	2.0	56	29
75	65	48	94	2.3	2.2	53	53
100	68	50	96	2.2	1.8	52	56
125	71	54	100	2.5	1.9	65	55
$LSD_{0.1}$*	NS	7	12	NS	0.4	18	29
$CV_{(*)}$	13	14	14	4	19	29	44

* Unless two yields differ by at least the amount of the Least Significant Difference, (LSD), little confidence can be placed in one being greater than the other.

Table 3. Effects of N on sorghum in a corn-wheat-sorghum rotation, Hutchinson, KS.

N	Yield					
Rate	1987	1988	1989	1990	1992	1993
lb/a	- - - - - - - - - - - - - - - - bu/a - - - - - - - - - - - - - - - -					
0	50	82	66	29	66	76
25	57	82	61	36	87	91
50	69	80	69	35	98	106
75	73	83	71	39	101	106
100	75	81	72	35	99	106
125	76	80	74	36	102	96
$LSD_{0.1}$*	10	NS	6	5	16	16
CV (%)	14	7	8	14	13	9

* Unless two yields differ by at least the amount of the Least Significant Difference, (LSD), little confidence can be placed in one being greater than the other.

Table 4. Effects of N on wheat in a corn-wheat-sorghum rotation, Hutchinson, KS.

N	Yield				
Rate	1988	1990	1991	1992	1993
lb/a	- - - - - - - - - - bu/a - - - - - - - - - -				
0	9	21	44	34	18
25	13	31	71	47	24
50	17	43	76	49	34
75	19	53	61	47	37
100	17	54	62	47	47
125	19	55	62	44	49
$LSD_{0.1}$*	5	4	7	5	9
CV (%)	27	8	10	8	15

* Unless two yields differ by at least the amount of the Least Significant Difference, (LSD), little confidence can be placed in one being greater than the other.

Table 5. Effects of N on soybean in a soybean-wheat-sorghum rotation, Hutchinson, KS.

N	Yield			Seed N		
Rate	1991	1992	1993	1991	1992	1993
lb/a	- - - - - bu/a - - - - -			- - - - - - - % - - - - - -		
0	5.81	53	31	5.58	6.04	5.87
25	5.43	50	32	5.76	6.03	5.90
50	5.31	52	31	5.56	5.97	5.98
75	5.33	51	30	5.69	5.97	6.00
100	5.86	51	28	5.71	6.01	6.12
125	5.56	53	29	5.56	5.98	6.00
$LSD_{0.1}$*	1.08	7	4	0.30	0.13	0.20
CV (%)	10.8	7	7	2.91	1.15	1.82

* Unless two yields differ by at least the amount of the Least Significant Difference, (LSD), little confidence can be placed in one being greater than the other.

Table 6. Effects of N on sorghum in a soybean-wheat-sorghum rotation, Hutchinson, KS.

	Yield			Seed N		
Rate	1991	1992	1993	1991	1992	1993
lb/a	- - - - - bu/a - - - - -			- - - - - - % - - - - - -		
0	34	52	67	1.90	1.18	1.48
25	35	72	82	1.88	1.12	1.49
50	38	80	96	2.03	1.30	1.43
75	44	91	97	2.02	1.42	1.52
100	51	91	88	2.10	1.51	1.68
125	45	94	95	2.06	1.55	1.57
$LSD_{0.1}$*	15	11	14	0.10	0.09	0.70
CV (%)	21	7	9	2.72	3.80	25.4

* Unless two yields differ by at least the amount of the Least Significant Difference, (LSD), little confidence can be placed in one being greater than the other.

Table 7. Effects of N on wheat in a soybean-wheat-rorghum rotation, Hutchinson, KS.

N	Yield			Seed N		
Rate	1991	1992	1993	1991	1992	1993
lb/a	- - - - - bu/a - - - - -			- - - - - - % - - - - - -		
0	52	31	24	2.33	2.25	1.92
25	55	36	34	2.36	2.10	1.84
50	55	37	41	2.41	2.20	1.01
75	52	37	46	2.35	2.28	1.81
100	51	35	45	2.38	2.35	1.91
125	54	36	46	2.42	2.40	1.97
$LSD_{0.1}$	7	4	6	0.14	0.10	0.12
CV(%)	7	6	9	3.24	2.34	3.55

* Unless two yields differ by at least the amount of the Least Significant Difference, (LSD), little confidence can be placed in one being greater than the other.

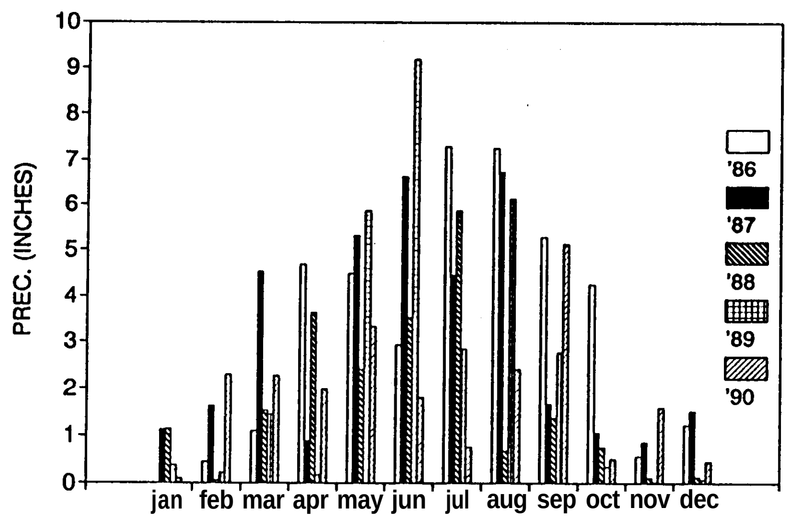


Figure 1. Precipitation at South Central Kansas Experiment Field, 1986-90.

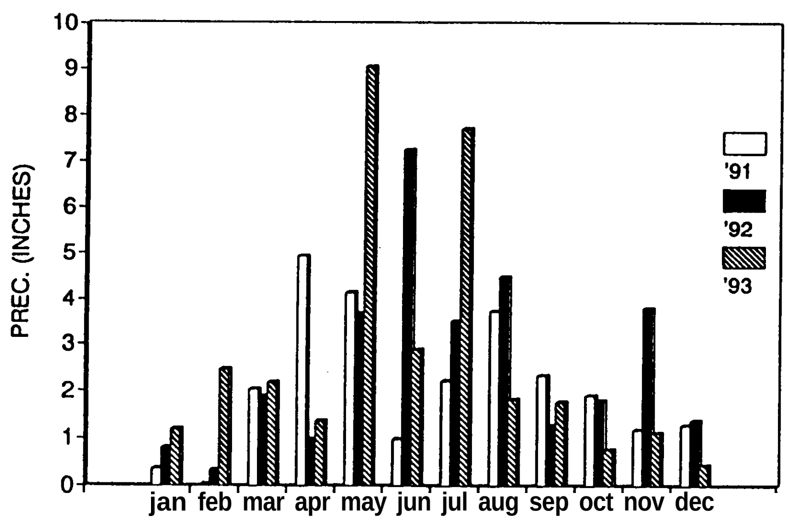


Figure 2. Precipitation at South Central Kansas Experiment Field, 1991-93.

SOIL FERTILITY RESEARCH
KSU AGRICULTURAL RESEARCH CENTER-HAYS

EFFECTS OF TILLAGE SYSTEMS AND NITROGEN RATES ON DRYLAND WINTER WHEAT AND GRAIN SORGHUM

C.A. Thompson

Summary

Information about long-term effects of nitrogen (N) fertilizer and conservation tillage systems on crop production in the central Great Plains is limited. This study was conducted on a nearly level, fertile, Harney, silt loam soil to determine the effect of four N levels on clean-till, reduced-till, and no-till systems in a dryland winter wheat-grain sorghum-fallow crop rotation. The tillage systems used various types of tillage tools and herbicides. Grain yields and crop residue amounts and soil cover percentages were increased in each tillage system by N fertilizer. Yields of winter wheat from clean- and reduced-till systems were similar but significantly higher than no-till yields. This trend held true for grain sorghum also, except yields from the reduced-till system were significantly higher at the 60 lb N rate than yields from either clean- or no-till systems.

Therefore, the reduced-till system is recommended for both crops on fertile soils. To optimize yields and plant growth (to ensure good ground cover), N rates for both winter wheat and grain sorghum should range between 30 to 50 lbs N/a, depending on the depth of moist soil and price of fertilizer.

Introduction

Conservation compliance mandates are requiring more crop residue on the soil surface to control soil erosion by wind and water. Increased residue amounts can be achieved by fewer tillage operations, use of undercutting-type tillage implements, use of herbicides in place of tillage to control weeds, or combinations of the above.

Long-term results of comparative tillage systems with nitrogen (N) variables are lacking in the dryland regions of Kansas. This report gives yields and crop residue results from a 20-year study using three tillage systems and four levels of N fertilizer in a winter wheat-grain sorghum-fallow rotation under dryland conditions.

Procedure

Although the tillage portion of this study was initiated in the fall of 1966, the four N levels were not included until 1975. Each of the four replications contained winter wheat, grain sorghum, and fallow each year. The soil was a nearly level, fertile, Harney, silt loam.

The three tillage systems were clean-till, reduced-till, and no-till. On the clean-till plots, incorporating-type tillage tools (disc, spring-tooth harrow, and mulch-treader) were used to control weeds and prepare a seedbed. On the reduced-till plots, undercutting-type tillage tools (V-blade, sweep, rod-weeder, and mulch-treader) were used to control weeds and prepare a seedbed. On the no-till plots, only herbicides were used for weed control.

Herbicides for the wheat plots in recent years included Landmaster, Glean, and 2,4-D. Current herbicides for grain sorghum plots included Landmaster, atrazine, and Dual. Fewer herbicides were used on the clean-till and reduced-till plots than for no-till.

Nitrogen fertilizer, in the form of ammonium nitrate (34-0-0), was preplant applied at rates of 0, 20, 40, and 60 lb N/a. Anhydrous ammonia (82-0-0) and liquid N (28-0-0) in numerous other studies in the past have resulted in yields as good as or better than those from ammonium nitrate. Therefore, if the reader wishes to calculate profit using any of the N carriers mentioned above, the yield response should be similar.

Winter wheat was planted with a grain drill in either 10- or 12-inch row spacing at a seeding rate of 60 lb/a. September 28 was the average seeding date. Several adapted, high-yielding varieties were used over the 20-year period. A row crop planter was used to plant grain sorghum in 30-inch row spacing from 1975 to 1987 at a seeding rate of about 30,000 seeds/a in late May or early June. From 1988 to the present, "superthick" sorghum management was used. An adapted grain sorghum hybrid was used for each of the management systems.

From 1975 to present, a plot combine was used to harvest wheat. From 1975 to 1990, the mature grain sorghum heads were harvested by hand, and grain was separated with a stationary thresher. From 1991 to present, a plot combine was used to harvest the plots. All data were analyzed using the ANOVA program of SAS.

Results

Winter Wheat

Following summers with very high evaporation and below normal precipitation, surface soils of no-till plots for winter wheat were very hard and dry. Surface cracks developed, resulting in vertical drying. Thus, at planting, good soil to seed contact was difficult to obtain. In a few years, this resulted in less acceptable stands. In the past 5 years, a drill with newly designed openers has helped to correct this potential stand problem.

The average grain yields of winter wheat over the 20-year period (1975-1994) as affected by tillage systems and N rates are shown in Figure 1. Yields of clean- and reduced-till systems were similar, but no-till had significantly lower production. Yields increased with each level of added N fertilizer. However, for clean- and reduced-till systems, the yield increase with over 40 lbs N/a was small. Because of a higher level of microbial activity near the soil surface on the no-till plots, about 20 lbs extra N was required to produce yields comparable to those of the other two tillage systems.

As expected, the more aggressive tillage operations destroyed more crop residue, as shown in Figures 2 and 3. Thus, no-till, which had no soil disturbance prior to planting, had the highest level of crop residue. Nitrogen fertilizer increased plant growth, thus producing more pounds of crop residue/a. The percent ground cover paralleled the pounds of crop residue. "Superthick" sorghum management produces finer stems and better distribution of sorghum residue than conventional wide-rowed sorghum.

Because federal mandates exist for keeping more crop residue on the surface than in the past and because the yield differences between clean- and reduced- till systems were small, the reduced-till system is recommended. Producers should try to keep their field trips to a minimum during the fallow period.

Grain Sorghum

When spring precipitation was higher than normal, damp wheat straw on no-till plots for grain sorghum sometimes caused difficulty in establishing an acceptable stand. Use of coulters or disc-type openers with side-type press wheels has largely eliminated this problem.

Yields from clean- and reduced-till systems were similar (Figure 4) and significantly higher than those from no-till, except at the N rate of 60 lb/a. At that rate, yields from clean- and no-till systems were nearly the same, but the reduced-till yielded significantly higher. Yields from the reduced-till system appeared to be leveling off at about 40 lbs N/a, whereas yields from clean- and no-till systems continued to increase at 60 lbs N/a.

The trend for the wheat residue remaining on the soil surface (Figure 5) at sorghum planting was similar to that described above for grain sorghum residue. Because the texture of wheat residue is finer, the percent ground cover (Figure 6) at sorghum planting was slightly higher than that shown for winter wheat. Residue levels from the reduced- and no-till systems meet or exceed present government mandates.

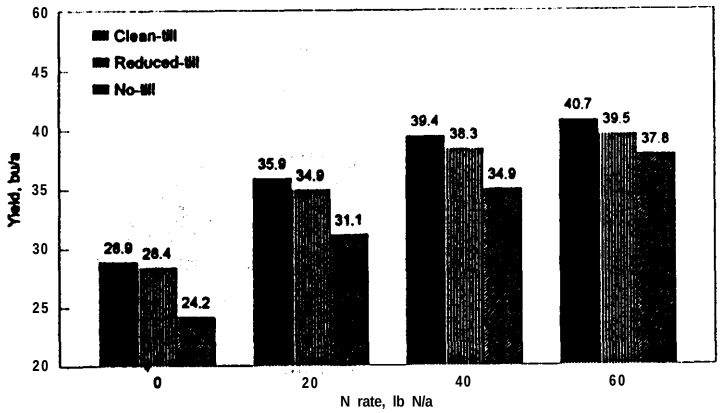


Figure 1. Effect of tillage systems and nitrogen rates on yields of dryland winter wheat (W-S-F rotation), averaged from 1975 to 1994, KSU Agricultural Research Center-Hays

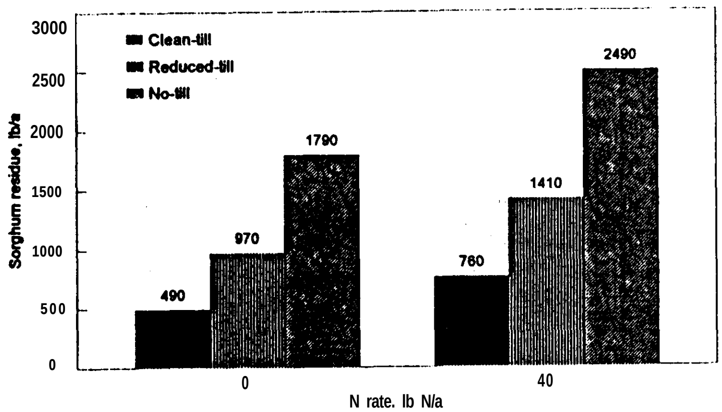


Figure 2. Effect of tillage systems and nitrogen rates on pounds of sorghum residue at planting of dryland winter wheat (W-S-F rotation), averaged from 1975 to 1994, KSU Agricultural Research Center-Hays.

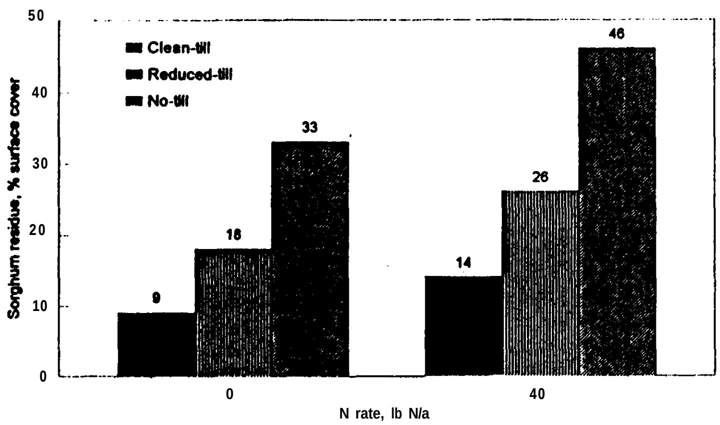


Figure 3. Effect of tillage systems and nitrogen rates on percent ground cover (from previous sorghum crop) at planting of dryland winter wheat (W-S-F rotation), averaged from 1975 to 1994, KSU Agricultural Research Center-Hays

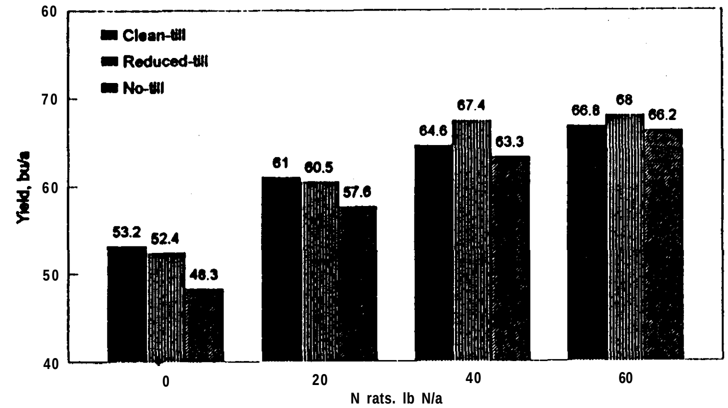


Figure 4. Effect of tillage systems and nitrogen rates on yields of dryland grain sorghum (W-S-F rotation), averaged from 1975 to 1994, KSU Agricultural Research Center-Hays.

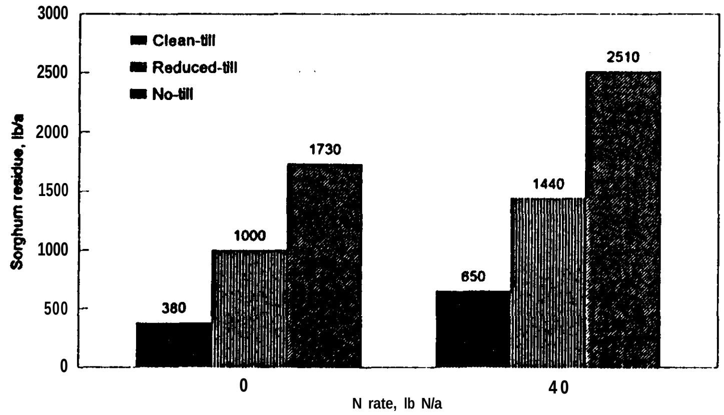


Figure 5. Effect of tillage systems and nitrogen rates on pounds of wheat residue at planting of dryland grain sorghum (W-S-F rotation), averaged from 1975 to 1994, KSU Agricultural Research Center-Hays

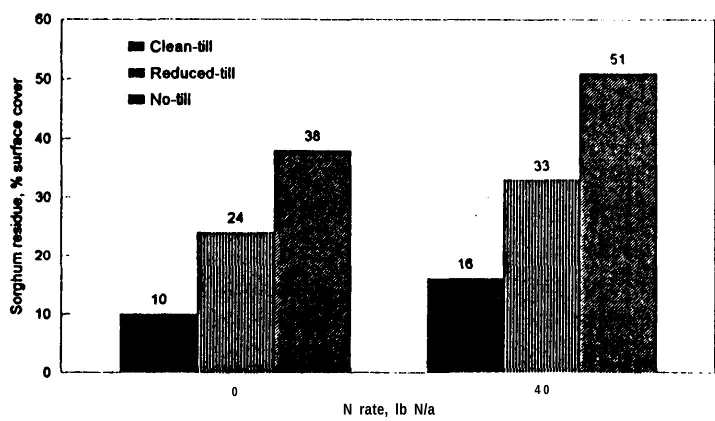


Figure 6. Effect of tillage systems and nitrogen rates on percent ground cover (from previous wheat crop) at planting of dryland grain sorghum (W-S-F rotation), averaged from 1975 to 1994, KSU Agricultural Research Center-Hays

GRAIN SORGHUM, CORN, AND SOYBEAN FERTILIZATION STUDIES
KANSAS STATE UNIVERSITY, DEPARTMENT OF AGRONOMY

NITROGEN MANAGEMENT FOR NO-TILL CORN AND GRAIN SORGHUM PRODUCTION

**R.E. Lamond, D.A. Whitney, L.D. Maddux, W.B. Gordon,
V.L. Martin, D. Key, and S. Koch**

Summary

Surface-applied urea-containing fertilizers have potential for volatilization and immobilization losses of N, particularly when residue levels are high. Results of this research indicate that urea and UAN perform less efficiently than ammonium nitrate or urea with a urease inhibitor (NBPT) in high residue, no-till production systems. Results were similar regardless of type of previous crop residue (corn or soybean).

Introduction

Careful management of nitrogen (N) is critical in conservation tillage production systems where large amounts of old crop residue are left on the soil surface to help alleviate wind and water erosion. Conservation tillage acreage in Kansas will likely increase as we enter the conservation compliance phase of the current farm program. Previous work at Kansas State University has shown that knifed placement of N in high-residue production systems was superior to broadcast N applications. This research was begun to evaluate N rates, sources, urease inhibitor, and the effect of type of residue in no-till corn and grain sorghum production systems.

Procedure

Four corn and three grain sorghum sites were established in 1994. Nitrogen rates (varied depending on crop and cropping sequence) and N sources (urea, urea + NBPT ammonium nitrate, and urea - ammonium nitrate solution (UAN)) were evaluated. NBPT is a urease inhibitor. All N was surface broadcast just prior to or shortly after planting. All sites were no-till.

Early plant (V-6 stage, data not shown) and boot or tassel leaf samples were taken, and N content was determined. Chlorophyll meter readings were taken at V-6 and boot/tassel stages with a Minolta SPAD 502 chlorophyll meter. Grain yields were determined at all sites by either hand or machine harvest. Individual grain samples were retained for moisture, test weight, and N determinations.

Results

Corn results are summarized in Tables 1-4, and grain sorghum results are in Tables 5-7.

With average to excellent corn yields, response to N was quite dramatic. Nitrogen source comparisons indicated that the urease inhibitor, NBPT, was effective in improving performance of urea. The urease inhibitor has potential to reduce both volatilization and immobilization by slowing urea breakdown and allowing the urea to get into the soil. Both volatilization and immobilization can be problems with surface- applied N in high-residue production systems. Ammonium nitrate and urea with NBPT performed better than urea and UAN.

The impact of kind of previous crop residue also was evaluated. Soybean residue has a lower carbon:nitrogen (C:N) ratio than corn residue, and soybeans produce less residue cover than corn, so volatilization and immobilization should cause less of a problem with soybean residue. Even though an early July storm caused severe damage to the Shawnee County corn-after-soybean site, resulting in no yield determinations, six-leaf and tassel leaf N concentrations were higher with urea + NBPT than with urea.

Grain sorghum results indicate excellent grain yield response to N at all sites. Urea with NBPT and ammonium nitrate again tended to produce higher yields than urea and UAN, though the differences were not as great as those noted for corn.

The use of urease inhibitors has potential where urea-containing N fertilizers are surface broadcast in conservation tillage production systems. At least one inhibitor will be test marketed in 1994 and likely will be available in 1995. This work will continue in 1995.

Table 1. Nitrogen management on no-till corn following grain sorghum, North Agronomy Farm, Manhattan, KS, 1994.

		6-Leaf			Tassel		Grain	
N Rate	N Source	N	N Uptake	Chlor Meter	N	Chlor Meter	Yield	N
lb/a		%	lb/a	SPAD	%	SPAD	bu/a	%
0	--	2.70	22	42	1.37	34	49	1.01
50	Urea	3.45	29	47	2.01	51	68	1.08
100	Urea	3.60	44	51	2.27	51	84	1.12
150	Urea	3.61	36	54	2.53	63	99	1.26
50	Urea + NBPT	3.64	41	50	2.04	50	74	1.07
100	Urea + NBPT	3.64	49	51	2.46	58	106	1.23
150	Urea + NBPT	3.72	54	51	2.65	59	105	1.36
50	Am. Nit.	3.57	39	50	2.26	53	79	1.01
100	Am. Nit.	3.68	49	51	2.62	58	95	1.27
150	Am. Nit.	3.77	54	51	2.67	60	122	1.47
LSD (0.05)		0.20	16	3	0.30	6	20	0.08
Mean Values								
N	50	3.55	36	49	2.10	52	74	1.05
Rate	100	3.64	47	51	2.45	55	95	1.21
	150	3.70	49	52	2.62	61	108	1.36
LSD (0.05)		0.10	9	NS	0.18	4	12	0.04
N	Urea	3.55	37	51	2.27	55	84	1.15
Source	Urea + NBPT	3.66	49	51	2.38	56	96	1.22
	Am. Nit.	3.67	47	51	2.52	57	98	1.25
LSD (0.05)		0.10	9	NS	0.18	NS	12	0.04

Table 2. Nitrogen management on irrigated no-till corn following wheat, Sandyland Expt. Field, 1994.

		6-Leaf			Boot			
N	N		N	Chlor		Chlor	Grain	
Rate	Source	N	Uptake	Meter	N	Meter	Yield	N
lb/a		%	lb/a	SPAD	%	SPAD	bu/a	%
0	--	3.14	15	31	2.21	41	143	1.08
60	Urea	3.28	26	42	2.74	53	174	1.19
120	Urea	3.58	28	43	2.80	55	190	1.39
180	Urea	3.50	29	46	2.78	57	196	1.37
60	Urea + NBPT	3.56	28	43	2.71	55	188	1.30
120	Urea + NBPT	3.60	21	42	2.81	56	192	1.41
180	Urea + NBPT	3.71	20	47	2.87	61	198	1.46
60	Am. Nit.	3.23	27	44	2.65	53	184	1.28
120	Am. Nit.	3.55	30	45	2.78	57	191	1.44
180	Am. Nit.	3.53	28	45	2.90	57	204	1.46
60	UAN	3.17	26	43	2.60	51	190	1.20
120	UAN	3.29	18	42	2.75	53	182	1.35
180	UAN	3.47	22	40	2.83	57	197	1.37
60	Urea + DCD	3.32	28	44	2.65	50	174	1.19
120	Urea + DCD	3.65	31	46	2.64	54	183	1.42
180	Urea + DCD	3.59	28	47	2.88	57	183	1.42
60	Urea + DCD + NBPT	3.30	30	46	2.70	54	176	1.27
120	Urea + DCD + NBPT	3.69	23	45	2.78	58	202	1.40
180	Urea + DCD + NBPT	3.65	25	46	2.81	60	186	1.52
LSD (0.05)		0.32	9	8	0.21	4	25	0.12
Mean Values								
N	60	3.35	27	44	2.68	53	181	1.25
Rate	120	3.56	25	42	2.76	55	190	1.40
	180	3.57	25	44	2.85	58	194	1.43
LSD (0.05)		0.13	NS	NS	0.07	2	9	0.05
N	Urea	3.53	28	44	2.77	55	186	1.34
Source	Urea + NBPT	3.62	23	41	2.80	57	193	1.39
	Am. Nit.	3.44	28	45	2.78	56	193	1.39
	UAN	3.31	22	42	2.73	53	190	1.31
	Urea + DCD	3.52	29	46	2.72	54	180	1.34
	Urea + DCD + NBPT	3.55	26	42	2.77	57	188	1.40
LSD (0.05)		0.19	NS	NS	NS	2	NS	0.07

Table 3. Nitrogen management on continuous no-till corn, Kansas River Valley Expt. Field, 1994.

		6-Leaf			Tassel	
N	N		N	Chlor		Chlor
Rate	Source	N	Uptake	Meter	N	Meter
lb/a		%	lb/a	SPAD	%	SPAD
0	--	2.66	5	44	2.13	35
60	Urea	3.16	11	51	2.50	46
120	Urea	3.24	7	46	2.73	60
180	Urea	3.50	9	52	2.96	62
60	Urea + NBPT	3.43	7	44	2.57	53
120	Urea + NBPT	3.65	9	48	2.99	60
180	Urea + NBPT	3.91	9	51	2.98	61
60	Am. Nit.	2.87	7	54	2.63	49
120	Am. Nit.	3.42	7	50	2.93	58
180	Am. Nit.	3.55	8	46	2.91	61
60	UAN	2.71	7	49	2.53	50
120	UAN	3.24	9	48	2.83	56
180	UAN	3.83	9	45	2.94	58
LSD (0.05)		0.39	2	NS	0.24	5
Mean Values						
N	60	3.04	8	49	2.56	49
Rate	120	3.37	8	48	2.87	58
	180	3.70	9	48	2.95	60
LSD (0.05)		0.18	NS	NS	0.12	3
N	Urea	3.27	9	49	2.73	56
Source	Urea + NBPT	3.66	8	47	2.84	58
	Am. Nit.	3.28	8	50	2.82	56
	UAN	3.26	8	47	2.76	54
LSD (0.05)		0.21	NS	NS	NS	NS

Because of severe stalk breakage resulting from a storm, yields were not taken.

Table 4. Nitrogen management for irrigated no-till corn following soybeans, Kansas River Valley Expt. Field, 1994.

		6-Leaf			Tassel	
N Rate	N Source	N	N Uptake	Chlor Meter	N	Chlor Meter
lb/a		%	lb/a	SPAD	%	SPAD
0	--	2.18	6	40	2.45	40
30	Urea	2.84	8	49	2.52	52
60	Urea	3.23	8	52	2.78	57
120	Urea	3.20	11	53	2.74	62
30	Urea + NBPT	2.78	9	51	2.60	52
60	Urea + NBPT	3.36	9	44	2.88	58
120	Urea + NBPT	3.78	11	48	2.96	60
30	Am. Nit.	2.93	12	48	2.57	57
60	Am. Nit.	2.96	10	49	2.83	57
120	Am. Nit.	3.29	11	54	3.00	60
30	UAN	2.39	6	52	2.57	55
60	UAN	2.95	10	53	2.50	54
120	UAN	3.49	11	49	2.97	62
LSD (0.05)		0.44	4	NS	0.26	7
Mean Values						
N	30	2.73	9	50	2.57	54
Rate	60	3.12	9	50	2.75	56
	120	3.44	11	51	2.92	61
LSD (0.05)		0.23	NS	NS	0.13	3
N	Urea	3.09	9	51	2.68	57
Source	Urea + NBPT	3.31	10	48	2.81	57
	Am. Nit.	3.06	11	50	2.80	58
	UAN	2.94	9	52	2.68	57
LSD (0.05)		0.26	NS	NS	0.15	NS

Because of severe stalk breakage resulting from a storm, yields were not taken.

Table 5. Nitrogen management for continuous no-till grain sorghum, Nemaha County, KS, 1994.

		6-Leaf			Boot		Grain	
N Rate	N Source	N	N Uptake	Chlor Meter	N	Chlor Meter	Yield	N
lb/a		%	lb/a	SPAD	%	SPAD	bu/a	%
0	--	2.17	29	37	2.31	34	107	1.04
50	Urea	2.71	45	48	2.90	50	134	1.19
100	Urea	2.91	48	49	2.98	54	141	1.30
150	Urea	3.11	50	48	3.25	57	139	1.44
50	Urea + NBPT	2.90	50	49	2.88	55	140	1.18
100	Urea + NBPT	3.01	56	49	3.20	55	144	1.46
150	Urea + NBPT	3.16	53	50	3.35	57	144	1.54
50	Am. Nit.	2.54	40	47	2.78	51	128	1.11
100	Am. Nit.	3.05	52	50	2.96	56	138	1.36
150	Am. Nit.	3.20	55	49	3.20	57	131	1.58
50	UAN	2.59	36	45	2.78	46	127	1.10
100	UAN	2.77	42	48	2.92	52	140	1.22
150	UAN	2.77	43	47	3.07	56	144	1.42
50	Urea + DCD	2.67	43	51	2.79	52	137	1.15
100	Urea + DCD	2.86	45	46	2.92	55	132	1.36
150	Urea + DCD	2.92	48	51	3.23	55	143	1.45
LSD (0.05)		0.38	10	7	0.22	5	18	0.13
Mean Values								
N	50	2.68	43	48	2.83	51	133	1.15
Rate	100	2.92	49	48	2.99	54	139	1.34
	150	3.03	50	49	3.22	56	142	1.48
LSD (0.05)		0.17	4	NS	0.09	2	NS	0.06
N	Urea	2.91	48	48	3.04	53	139	1.31
Source	Urea + NBPT	3.02	53	49	3.15	56	143	1.39
	Am. Nit.	2.93	49	49	2.98	54	132	1.35
	UAN	2.71	41	46	2.92	51	137	1.25
	Urea + DCD	2.82	46	50	2.98	54	137	1.32
LSD (0.05)		0.22	6	NS	0.11	2	NS	0.07

Table 6. Nitrogen management on continuous no-till grain sorghum, North Central Expt. Field, Belleville, KS, 1994.

		6-Leaf			Boot		Grain	
N Rate	N Source	N	N Uptake	Chlor Meter	N	Chlor Meter	Yield	N
lb/a		%	lb/a	SPAD	%	SPAD	bu/a	%
0	--	1.57	10	32	1.32	20	37	1.07
50	Urea	2.66	36	46	1.84	38	85	1.11
100	Urea	3.46	41	51	2.27	50	107	1.25
150	Urea	3.51	44	48	2.64	54	112	1.44
50	Urea + NBPT	2.70	40	45	1.74	41	88	1.18
100	Urea + NBPT	3.58	42	49	2.33	53	116	1.27
150	Urea + NBPT	3.61	45	52	2.55	55	118	1.47
50	Am. Nit.	2.63	32	44	1.75	38	90	1.21
100	Am. Nit.	3.04	36	47	2.20	52	108	1.25
150	Am. Nit.	3.41	40	50	2.63	55	118	1.38
LSD (0.05)		0.47	14	3	0.25	6	11	0.17
Mean Values								
N	50	2.67	36	45	1.78	39	88	1.20
Rate	100	3.36	39	49	2.26	52	110	1.26
	150	3.51	43	50	2.61	54	115	1.43
LSD (0.05)		0.26	7	2	0.14	4	7	0.10
N	Urea	3.21	40	48	2.25	47	101	1.30
Source	Urea + NBPT	3.30	42	49	2.21	50	107	1.31
	Am. Nit.	3.01	36	47	2.19	48	105	1.28
LSD (0.05)		0.26	NS	NS	NS	NS	6	NS

Table 7. Nitrogen management on irrigated no-till grain sorghum following soybeans, North Central Expt. Field, Belleville, KS, 1994.

		6-Leaf			Boot		Grain	
N	N		N	Chlor		Chlor		
Rate	Source	N	Uptake	Meter	N	Meter	Yield	N
lb/a		%	lb/a	SPAD	%	SPAD	bu/a	%
0	--	2.79	38	46	2.05	37	114	1.21
25	Urea	3.03	65	47	1.87	47	127	1.19
50	Urea	3.37	65	48	2.34	51	138	1.26
100	Urea	3.71	67	50	2.45	53	150	1.52
25	Urea + NBPT	3.08	58	49	2.28	47	127	1.31
50	Urea + NBPT	3.50	73	49	2.21	51	146	1.38
100	Urea + NBPT	3.50	64	50	2.58	53	158	1.52
25	Am. Nit.	3.27	60	48	2.44	48	120	1.34
50	Am. Nit.	3.22	68	50	2.58	53	144	1.40
100	Am. Nit.	3.63	75	47	2.58	53	161	1.41
LSD (0.05)		0.33	22	3	0.31	7	18	0.18
Mean Values								
N	25	3.13	61	48	2.20	47	125	1.32
Rate	50	3.36	69	49	2.38	52	143	1.35
	100	3.61	68	49	2.54	53	156	1.48
LSD (0.05)		0.19	NS	NS	0.19	3	11	0.11
N	Urea	3.37	65	48	2.21	50	138	1.37
Source	Urea + NBPT	3.36	64	49	2.36	50	144	1.40
	Am. Nit.	3.38	68	48	2.54	51	142	1.38
LSD (0.05)		NS	NS	NS	0.19	NS	NS	NS

EVALUATION OF ALTERNATIVE NITROGEN SOURCES FOR NO-TILL CORN AND GRAIN SORGHUM PRODUCTION

R.E. Lamond, A.J. Schlegel, W.L. Thomas, and K. Rector

Summary

Several alternative nitrogen (N) sources are available that have potential to reduce volatilization losses from urea-containing fertilizers that are surface broadcast in high residue, no-till, production systems. This research evaluated some chloride (Cl)-containing, urea-based products. Results indicate few differences between the N sources evaluated in 1994 on either corn or grain sorghum.

Introduction

Careful management of N is critical in conservation tillage production systems where large amounts of old crop residue are left on the soil surface to help alleviate wind and water erosion. Conservation tillage acreage in Kansas will likely increase as we enter the conservation compliance phase of the current federal farm program. This research was begun to compare alternative N sources containing Cl to urea or UAN S when surface applied in no-till, corn and grain sorghum, production systems.

Procedure

Nitrogen sources were evaluated on two grain sorghum sites (dryland) and one corn site (irrigated). Nitrogen rates varied, depending on crop. N sources evaluated included: N-Cal® (23-0-0-7Ca-12.5%Cl), 27-0-0-5Cl, 28-0-0 (UAN) urea, ammonium nitrate, and UAN with KCl. All materials were not included at each site (depending on available space). All N was surface broadcast shortly after planting. All sites were no-till.

Early plant (V-6 stage) and boot or tassel leaf samples were taken, and N content was determined. Chlorophyll meter readings were taken at both V-6 and boot/tassel stages with a Minolta SPAD 502 chlorophyll meter. Grain yields were determined by either machine or hand harvest. Individual grain samples were retained for moisture, test weight, and N determinations.

Results

Results of this work are summarized in Tables 8-10. On the irrigated corn site at Tribune, excellent yields were obtained and excellent responses to N were noted. Ammonium nitrate produced significantly higher grain yields than any of the urea-based N materials. The Cl-containing N sources did not improve N efficiency compared to urea at this site.

At the Marion County south site for grain sorghum, mid and late summer drought severely reduced yields and limited effects of N rate and source. At the Marion County north site for grain sorghum, excellent responses to N were noted, but N source caused no significant differences.

This work will be continued in 1995.

Table 8. Nitrogen management on irrigated continuous no-till corn Southwest Research Center, Tribune Field, 1994.

		6-Leaf			Tassel		Grain	
N	N		N	Chlor		Chlor		
Rate	Source	N	Uptake	Meter	N	Meter	Yield	N
lb/a		%	lb/a	SPAD	%	SPAD	bu/a	%
0	--	2.14	7	33	1.20	31	62	1.02
60	Urea	2.51	11	37	1.58	39	110	0.98
120	Urea	3.00	12	38	2.07	37	141	0.96
180	Urea	3.08	17	43	2.36	42	186	1.02
60	Am.Nit	2.46	11	37	1.73	38	112	1.03
120	Am. Nit	2.94	14	41	2.26	38	159	0.98
180	Am. Nit	3.06	15	41	2.42	41	192	1.02
60	N-Cal	2.27	10	37	1.41	33	105	1.02
120	N-Cal	2.67	11	37	1.63	36	133	0.96
180	N-Cal	2.75	11	41	1.80	40	174	0.98
60	28-0-0-5Cl	2.29	10	37	1.61	36	99	1.01
120	28-0-0-5Cl	2.56	12	39	1.78	37	124	0.96
180	28-0-0-5Cl	2.71	11	38	1.82	37	167	0.95
60	28-0-0-5Cl + NBPT	2.57	11	41	1.59	37	102	0.94
120	28-0-0-5Cl + NBPT	2.61	13	38	1.94	37	143	0.99
180	28-0-0-5Cl + NBPT	2.87	15	41	2.15	39	175	0.97
LSD (0.05)		0.29	5	4	0.19	6	16	NS
Mean Values								
N	60	2.42	10	38	1.59	37	106	0.99
Rate	120	2.76	12	39	1.94	37	140	0.97
	180	2.87	14	41	2.10	39	179	0.99
LSD (0.05)		0.13	2	2	0.09	2	7	NS
N	Urea	2.87	13	39	2.01	39	145	0.99
Source	Am. Nit	2.82	13	40	2.14	39	154	1.01
	N-Cal	2.56	11	38	1.61	37	138	0.98
	28-0-0-5Cl	2.52	11	38	1.74	36	130	0.97
	28-0-0-5Cl + NBPT	2.68	13	40	1.90	38	140	0.96
LSD (0.05)		0.17	NS	NS	0.11	NS	9	NS

Table 9. Nitrogen management on grain sorghum, Marion County south site, 1994.

		6-Leaf			Boot		Grain	
N	N		N	Chlor		Chlor		
Rate	Source	N	Uptake	Meter	N	Meter	Yield	N
lb/a		%	lb/a	SPAD	%	SPAD	bu/a	%
0	--	3.36	12	44	2.42	44	56	1.49
40	Uan	3.59	15	45	2.42	51	56	1.52
80	Uan	3.92	15	46	2.74	55	60	1.76
120	Uan	4.09	14	45	2.75	57	53	2.06
40	N-Cal	3.37	13	43	2.47	51	55	1.59
80	N-Cal	3.91	14	45	2.69	53	58	1.90
120	N-Cal	3.83	14	45	2.58	57	48	2.21
40	27-0-0-5	3.38	11	45	2.41	49	58	1.47
80	27-0-0-5	3.89	15	45	2.60	55	50	2.01
120	27-0-0-5	3.91	15	46	2.75	54	48	2.09
40	UAN + KCl	3.71	12	42	2.42	50	53	1.65
80	UAN + KCl	3.65	11	43	2.54	52	49	1.71
120	UAN + KCl	3.93	14	45	2.53	55	49	2.12
LSD (0.05)		0.29	NS	NS	0.26	6	NS	0.22
Mean Values								
N	40	3.51	13	44	2.43	50	55	1.56
Rate	80	3.84	14	45	2.64	54	54	1.85
	120	3.94	14	45	2.65	56	50	2.12
LSD (0.05)		0.16	NS	NS	0.13	3	NS	0.11
N	Uan	3.86	14	45	2.64	54	56	1.78
Source	N-Cal	3.71	14	44	2.58	54	54	1.90
	27-0-0-5	3.73	14	45	2.59	52	52	1.86
	UAN + KCl	3.76	13	43	2.50	52	50	1.83
LSD (0.05)		NS	NS	NS	NS	NS	NS	NS

Table 10. Nitrogen management on grain sorghum, Marion County north site, 1994.

		6-Leaf			Boot		Grain	
N Rate	N Source	N	N Uptake	Chlor Meter	N	Chlor Meter	Yield	N
lb/a		%	lb/a	SPAD	%	SPAD	bu/a	%
0	--	3.65	11	38	2.00	36	58	1.02
40	Uan	4.10	15	43	2.40	50	81	1.20
80	Uan	3.80	14	47	2.12	51	90	1.14
120	Uan	4.07	14	48	2.69	55	107	1.37
40	N-Cal	3.65	12	43	2.12	42	76	1.08
80	N-Cal	3.81	13	46	2.05	53	87	1.11
120	N-Cal	3.96	16	47	2.88	55	107	1.51
40	UAN + KCl	3.79	13	44	2.00	40	67	1.01
80	UAN + KCl	3.88	15	46	2.55	52	94	1.27
120	UAN + KCl	4.12	14	45	2.80	57	106	1.52
LSD (0.05)		NS	NS	NS	0.36	7	29	0.13
Mean Values								
N	40	3.84	13	43	2.16	44	75	1.10
Rate	80	3.83	14	46	2.24	52	91	1.17
	120	4.05	15	47	2.79	56	107	1.46
LSD (0.05)		NS	NS	NS	0.23	4	17	0.07
N	Uan	3.99	14	46	2.40	52	92	1.24
Source	N-Cal	3.81	14	45	2.35	50	90	1.23
	UAN + KCl	3.93	14	45	2.44	50	89	1.27
LSD (0.05)		NS	NS	NS	NS	NS	NS	NS

NITROGEN - TILLAGE SORGHUM STUDY

G.M. Pierzynski, D.A. Whitney, R.E. Lamond, and S.L. Glaze

Summary

Since 1982, the response of grain sorghum to tillage system, N rate, N source, and N placement has been investigated. Nitrogen sources and placements used were ammonium nitrate, broadcast and urea-ammonium nitrate, either broadcast or knifed, at rates of 0, 30, 60, 120 lbs N/a. The tillage systems used were no-till or conventional. This year's results indicated that flag leaf N concentrations were higher for conventional tillage and broadcast ammonium nitrate compared with no-till and broadcast urea ammonium nitrate or knifed urea ammonium nitrate. However, because of below average rainfall, tillage and N placement did not significantly affect grain and stover yields.

Introduction

Tillage methods can influence the yield of grain sorghum through a number of mechanisms. Residue that accumulates at the soil surface under no-till systems can affect soil moisture content. Changes in soil moisture can directly influence yields, as well as alter N availability from mineralization of organic matter. Nitrogen placement also has the potential to affect yields of no-till vs conventional tillage systems. A large amount of surface residue can act as a physical barrier and prevent fertilizer-soil contact when fertilizers are broadcast. In addition, the residue layer is enriched in urease, which can enhance ammonia volatilization and reduce the efficiency of urea-containing fertilizers, especially when they are broadcast applied.

To address potential changes in N availability under no-till sorghum production, a study was initiated in 1982 at the North Agronomy Farm in Manhattan to determine the response of grain sorghum to N rate, N source, and method of application under two tillage systems.

Procedure

Three N source/placement treatments at three N rates each (30, 60, 120 lb N/a) were used. These were broadcast ammonium nitrate (BR-AN), broadcast UAN(BR-UAN), and knifed UAN(KN-UAN). The two tillage methods used were conventional tillage, consisting of discing three times between harvest and planting (two discings after N application), and no tillage. A check plot without N was included in each tillage method. The treatments were replicated three times and arranged in a split-plot design with tillage as the main plot treatment and N source/placement by N rate as the subplot treatments. An equipment failure when applying BR-UAN at 30 lbs N/a made the data from those treatments unusable, and they were omitted from all statistical analyses. Planting (Cargill 837), flag leaf sampling, and harvesting were done on 25 May, 29 July, and 13 October, respectively.

Results

Generally, grain yield was significantly higher at 60 or 120 lbs N/a compared to 30 lbs N/a at a given N source and placement combination, with no difference between the two high N rates (Table 11). Flag leaf N concentrations indicated a higher N availability at 120 lbs N/a compared to 60 lbs N/a, but this effect did not influence grain yields. This is likely due to the below average rainfall during the growing season. Grain yields were not influenced by tillage or N source placement. As in years past, flag leaf N concentrations were significantly higher for conventional tillage compared to no-till. Flag leaf N concentrations were also significantly higher for BR-AN than for BR-UAN or KN-UAN. Tables 12 and 13 summarize long-term tillage effects.

Table 11. Nitrogen sorghum study - North Agronomy Farm, Manhattan, KS, 1994.

Tillage	N Source Placement	N Rate lb/a	Yield[1] bu/a	Flag Leaf N (%)	Variable	Yield bu/a	Flag Leaf N (%)
No-Till	Check	--	38.7	1.56	Tillage:[2]		
	BR-AN	30	68.5	2.00			
		60	100.6	2.27	No-Till	92.7	2.29
		120	89.6	2.69	Conv	91.1	2.73
					LSD (.05)	9.4	0.08
	BR-UAN	60	75.1	2.10	N Source placement:		
		120	95.9	2.17	BR-AN	93.1	2.74
	KN-UAN	30	63.6	1.91	BR-UAN	88.7	2.39
		60	98.2	2.14	KN-UAN	94.1	2.42
		120	97.1	2.38	LSD (.05)	11.5	0.10
Conv	Check	-	45.8	1.90	N Rate:		
	BR-AN	30	82.8	2.32			
		60	102.8	2.80	60	94.1	2.37
		120	79.2	3.19	120	89.8	2.65
					LSD (.05)	9.4	0.08
	BR-UAN	60	94.7	2.48	Treatment effects: PR>F		
		120	89.1	2.79	N-Rate(N)	0.3502	0.0001
					Source(S)	0.5897	0.0001
	KN-UAN	30	75.2	2.21	Tillage(T)	0.6487	0.0197
		60	93.1	2.45	NXS	0.1021	0.0735
		120	87.9	2.69	TXS	0.4482	0.0757
	LSD (.05)		18.2	0.20	TXN	0.1267	0.3310
					NXSXT	0.6036	0.2735

[1] Yield calculated at 12.5% moisture.
[2] Data from 30 lb N/a not included in determination of tillage, N source/placement, and N rate effects.

Table 12. Grain yields for tillage treatments across time in check plots and across all N rates and placement methods, North Agronomy Farm, Manhattan, KS, 1982-1987.

		Grain Yield[1] - bu/a					
Tillage	Treatment	1982	1983	1984	1985	1986	1987
No-Till	Checks	85.7	42.0	66.3	53.1	62.1	53.2
Conv	Checks	68.8	22.9	60.7	58.4	55.5	30.0
	LSD (.05)	NS	11.4	NS	NS	NS	19.0
No-Till	All plots	91.4	49.8	85.1	91.9	97.0	73.5
Conv	All plots	92.2	51.7	83.8	98.7	101	69.4
	LSD (.05)	NS	NS	NS	NS	5.8	NS

Table 13. Grain yields for tillage treatments across time in check plots and across all N rates and placement methods, North Agronomy Farm, Manhattan, KS, 1988-1994

		Grain Yield[1] - bu/a						
Tillage	Treatment	1988	1989	1990	1991	1992	1993	1994
No-Till	Checks	56.5	24.7	49.8	48.9	29.0	27.6	38.7
Conv	Checks	41.7	33.3	69.0	54.0	28.7	17.1	45.8
	LSD(.05)	NS	NS	2.4	NS	NS	NS	NS
No-Till	All plots	88.5	37.9	101.9	65.1	91.3	52.5	92.7
Conv	All plots	86.0	42.1	111.3	69.9	102.3	49.1	91.1
	LSD(.05)	NS	NS	1.2	NS	7.6	NS	NS

[1] Grain yield calculated at 12.5% moisture.

THE EFFECT OF SULFUR RATE AND SOURCE ON EARLY-PLANTED, SHORT-SEASON CORN

G.M. Pierzynski, S.L. Glaze, and R.E. Lamond

Summary

Responses of early-planted, short-season corn to sulfur (S) rate and source were investigated on a coarse-textured soil. S sources used were ammonium thiosulfate and potassium thiosulfate at rates of 0, 15, or 30 lbs S/a. At the V6 stage dry matter, yield was significantly higher at a rate of 30 lbs S/a compared to no S. However, grain and stover yields were not significantly affected by S rate or source.

Introduction

This study was initiated to investigate the response of early-planted, early-season corn to various S rates and sources applied as starter fertilizers. Grain yield responses are most likely when the corn is planted into coarse-textured soils and cool conditions prevail. A coarse-textured soil typically will have less organic S available for mineralization, and cool temperatures will suppress the mineralization process overall. In addition, a coarse-textured soil will have a high leaching potential and plant-available sulfate may move below the rooting zone.

Procedure

Pioneer variety 3751 was planted at approximately 27,330 seed/a on March 31 at the Ashland Research Farm. The soil is mapped as a Haynie very fine sandy loam. The treatments formed a factorial arrangement of S rate (0, 15, or 30 lbs S/a) and S source (ammonium thiosulfate (ATS) or potassium thiosulfate (KTS)) placed 2 inches below and beside the seed with the planter. Four replications were used. The 0 and 15 lbs S/a treatments received supplemental N or K, so that the N application rates for all ATS treatments were the same, and the K application rates for all KTS treatments were the same. The ATS solutions did not contain any K, and the KTS solutions did not contain any N. A blanket application of 150 lbs N/a as urea was made to all plots after planting. Aboveground dry matter yields were taken at approximately the V6 stage of development and at grain harvest (stover).

Results

Selected 1994 results are shown in Table 14. The S rate by S source interaction was not significant for any of the parameters; therefore, only the rate and source means are provided. We continue to see early growth response to S, with the dry matter yields at the V6 stage being significantly higher with 30 lbs S/a than 0 lbs S/a. This is similar to the early growth response induced by P with the early-planted, early- season corn. At the V6 stage, plant tissue N concentrations were not influenced by S rate, whereas S concentrations were significantly higher at 15 or 30 lbs S/a compared to 0 lbs S/a. The N/S ratio in this sampling was significantly reduced by the two S rates compared to no S. The literature suggests that a value of approximately 19 is ideal for young whole corn plants. Grain and stover yields were not affected significantly by S rate.

Sulfur source did not significantly influence any of the measured parameters. It is interesting to note that S source had no effect on V6 N or K concentrations (K data not shown). The inclusion of N in ATS and K in KTS as starter fertilizers had no effect on plant tissue composition at this early growth stage.

Table 14. Selected yield and plant tissue composition data, S starter fertilizer study, Ashland, KS, 1993.

Sulfur Rate	Aboveground Dry Matter (V6)	Whole Plant N Conc.	Whole Plant S Conc.	Whole Plant N/S Ratio	Grain Yield	Stover Yield
lbs/a	lbs/a	- % -	mg/kg		bu/a	lb/a
0	363 a[1]	3.4 a	959 a	36.6 a	129 a	3202 a
15	428 ab	3.3 a	1508 b	23.4 b	119 a	3432 a
30	446 b	3.3 a	1577 b	21.8 b	120 a	3233 a
Sulfur Source[2]						
ATS	413 a	3.3 a	1342 a	27.7 a	119 a	3223 a
KTS	412 a	3.4 a	1353 a	27.1 a	126 a	3255 a

[1] Means followed by the same letter in the same column are not significantly different using LSD P=0.05.
[2] ATS-ammonium thiosulfate, KTS-potassium thiosulfate.

PHOSPHORUS AND SULFUR NUTRITION IN EARLY CORN/WHEAT ROTATION

M. Ashraf, G. M. Pierzynski, and W. B. Gordon

Summary

The effects of P rates, S rates and sources on short-season corn along with the effects of residual P on wheat were investigated at two sites in Kansas. Sulfur sources used were ammonium thiosulfate (ATS) or potassium thiosulfate (KTS) at rates of 0, 7.5, or 15 lbs S/a. Phosphorus rates used were 0, 30, 60, and 90 lbs P_20_5. This year's data represent the second growing season for corn and the first for wheat.

At Rossville, corn V6 yields and grain yields were significantly higher at 30 lbs P_20_5 than with no P. These yields were also significantly higher at 60 and 90 lbs P_20_5 than at 30 lbs P_20_5/a. S source or rate caused no significant differences for any of the measured parameters. At Norway, P rate, S rate, or source caused no significant differences for any of the measured parameters.

At Rossville, wheat grain yields and test weights were significantly higher with P applied at planting than without. Grain yields were also significantly higher for 30, 60, and 90 lbs P_20_5 of residual P compared with no residual P. At Norway, wheat grain yields and boot stage yields were significantly higher with P applied at planting than without. The effects of residual P rate on grain yield, grain moisture, and test weights were mixed.

Introduction

Short-season corn planted early is gaining popularity in the Central Plains region. This is a water-use strategy, whereby short-season corn is planted approximately 2 weeks prior to the average date of the last 28EF freeze. The corn passes through its critical stages prior to the typical hot and dry summer conditions. Harvest occurs from late August through September, which allows wheat to be planted after corn. This study was designed to compare the effects of P rates, S rates, and S sources on early-maturing corn planted early. The P rates were high, and the residual effect of the P on the wheat will be demonstrated this year.

This study was started in 1993 with a corn/wheat rotation. First-year data for wheat and second-year data for corn are reported here.

Procedure

The study was conducted on two sites in 1994. Corn variety Garst 8599 was planted on March 30 at Norway (near Scandia) and March 29 at the Kansas River Valley Experiment field near Rossville. The experimental design was a randomized complete block with a 4x3x2 factorial arrangement replicated four times at each site. The 4x3x2 factorial represents P rates (0, 30, 60, and 90 lbs P_2O_5/a); sulfur rates (0, 7.5, and 15 lbs S/a); and sulfur sources (ammonium thiosulfate) and potassium thiosulfate), respectively. Fertilizer combinations were made using urea ammonium nitrate (UAN) solution, ammonium polyphosphate (APP), KTS, ATS, and potassium chloride (KC1) fertilizers. Each treatment was mixed and diluted in a separate container. Starter fertilizer treatments were placed in a band 2 inches below and 2 inches beside the seed. Stand counts and plant samples were taken at the V6 stage (approximately) of development. Grain and stover yields were measured. Corn was harvested on September 12 at Rossville and September 13 at Norway.

Winter wheat variety 2163 was planted at 60 lbs/a on October 4, 1993 at Rossville and October 1, 1993 at Norway. At planting, plots were split into two. APP at a rate of 60 lbs P_2O_5/a was applied to half of the plot and the other half plot did not receive any fertilizer; therefore, wheat in these plots used residual fertilizer. Wheat leaf samples were taken at boot stage, and grain yield was measured at harvest.

Results

Rainfall during the growing season was adequate, and the corn stand was good early in the season at both sites. At Rossville, the crop was damaged by a heavy storm on July 1. Selected results for corn in 1994 at Rossville site are given in Table 15. No significant interactions occurred for any of the parameters shown in the table. Stand count was influenced by P rate, being significantly higher with 30 lbs P_2O_5/a than no P and with 60 or 90 lbs P_2O_5/a than 30 lbs P_2O_5/a. The aboveground dry matter (V6) yield with 30 lbs P_2O_5/a was significantly higher than that with zero P, with yields with 60 or 90 lbs P_2O_5/a again being higher than those with 30 lbs P_2O_5/a. Grain yield was 18% higher with 30 lbs P_2O_5/a than without P, and no differences in grain yield occurred among 30, 60, or 90 lbs P_2O_5/a. A similar response was seen with stover yield. Sulfur rate or source caused no differences in stand count, aboveground dry matter (V6) yield, grain yield, and stover yield.

Results for the 1994 corn crop at Norway are given in Table 16. P rates, S rate, or S source caused no differences in stand count, aboveground dry matter (V6) yield, grain yield, or stover yield. No significant interactions occurred for any of the parameters shown in the table. The aboveground dry matter (V6) yield and grain yield increased with increasing P rate, but the increases were not significantly different.

At Rossville, wheat grain yield and test weight were 8 and 1% higher, respectively, with P applied at planting (60 lbs P_2O_5/a) than without (Table 17). Grain yields were also significantly higher with 30 to 90 lbs P_2O_5/a of residual P compared to no residual P. The residual P rate by fresh P application interaction was significant for aboveground dry matter (boot stage) yield and wheat grain moisture (Table 18). Without P applied at planting, aboveground dry matter yield increased as the residual P rate increased. This effect was not present when P was applied at planting. Similarly, a residual P effect on grain moisture occurred when no P was applied at planting but not when P was used.

At Norway, wheat grain yield and aboveground dry matter yield at boot stage yield were 9 and 19% greater, respectively, with P applied at planting as compared to no P applied at planting (Table 19). The effects of residual P rate on grain yield, moisture, and test weight were variable.

Table 15. Grain yield, aboveground dry matter yield (V6), stand count, and stover yield data for early corn at Rossville, 1994.

P Rate	S Rate	S Source[1]	Grain Yield	Above-ground V6 Yield	Stand Count	Stover Yield
lb/a	lb/a		bu/a	lb/a	no./a	lb/a
0			90	459	24103	4084
30			106	697	25301	4586
60			108	825	26408	4692
90			109	882	26500	4801
LSD (0.05)			8	85	1045	492
	0		102	698	25333	4532
	7.5		103	717	25523	4498
	15		103	732	25877	4593
LSD (0.05)			NS	NS	NS	NS
		ATS	105	717	25565	4469
		KTS	101	714	25591	4413
LSD (0.05)			NS	NS	NS	NS

[1] ATS = Ammonium Thiosulfate, KTS = Potassium Thiosulfate

Table 16. Grain yield, aboveground dry matter yield (V6), stand count, and stover yield data for early corn at Norway (Scandia), 1994.

P Rate	S Rate	S Source[1]	Grain Yield	Above-ground V6 Yield	Stand Count	Stover Yield
lb/a	lb/a		bu/a	lb/a	no/a	lb/a
0			144	516	23883	5687
30			149	570	25044	5690
60			143	534	24064	5306
90			152	568	23810	5487
LSD (0.05)			NS	NS	NS	NS
	0		144	524	23955	5575
	7.5		149	569	24309	5725
	15		147	549	24336	5327
LSD (0.05)			NS	NS	NS	NS
		ATS	144	550	24173	5423
		KTS	150	544	24227	5662
LSD (0.05)			NS	NS	NS	NS

[3] ATS = Ammonium Thiosulfate, KTS = Potassium Thiosulfate

Table 17. Grain yield, grain moisture, test weight, and aboveground dry matter yield at boot stage for winter wheat at Rossville, 1994.

P Applied at Wheat Planting	Residual P Rate[1]	Grain Yield	Grain Moisture	Test Wt.	Aboveground Dry Matter Yield
lb P_2O_5/a	lb P_2O_5/a	bu/a	%	lb/bu	lb/a
0		48	11.9	59.8	3306
60		52	10.9	60.5	4795
LSD (0.05)		2.3	0.24	0.33	205
	0	45	11.9	59.8	3749
	30	50	11.4	60.0	4100
	60	52	11.1	60.4	4057
	90	52	11.3	60.4	4294
	LSD(0.05)	3.2	0.35	0.47	290

[1] P rate applied with corn.

Table 18. Residual P rate by fresh P application interaction for aboveground dry matter (boot stage) yield and wheat grain moisture content at Rossville, 1994.

	P Applied at Planting (lb P_2O_5/a)			
Residual	Dry Matter Yield		Grain Moisture	
P Rate	0	60	0	60
lb P_2O_5/a	lb/a		%	
0	2669	4829	12.8	11.0
30	3350	4849	11.9	10.9
60	3306	4807	11.4	10.8
90	3896	4692	11.5	11.0
LSD (0.05)	407	407	0.49	0.49

Table 19. Grain yield, grain moisture, test weight, and aboveground dry matter yield at boot stage of winter wheat at Norway (Scandia), 1994.

P Applied at Wheat Planting	P Rate[1]	Grain Yield	Grain Moisture	Test Wt.	Aboveground Dry Matter Yield
lb P_2O_5/a	lb P_2O_5/a	bu/a	%	lb/bu	lb/a
0		32	12.0	56	2643
60		35	12.0	55	3154
LSD (0.05)		2.4	NS	NS	166
	0	32	11.9	55.4	2881
	30	34	11.6	56.7	2853
	60	32	12.3	54.8	2867
	90	35	12.2	55.3	2994
LSD (0.05)		3	0.48	1.5	NS

[1] P applied with corn.

WHEAT, CORN, AND GRAIN SORGHUM RESPONSE TO NITROGEN FOLLOWING SOYBEANS

F. Altidor, C.W. Rice, and B.H. Marsh

Summary

Yields of nonleguminous crops usually tend to increase when grown in rotation with legumes. This study was designed to determine the effect of N fertilizer on the yields of wheat, corn, and grain sorghum following soybeans. The results of this study suggest that the yield response of small grains following soybeans can be affected by soil temperature, fertilizer N rate, and tillage practices. Wheat yield showed the lowest response compared to corn and grain sorghum. Without N fertilizer, grain yields were significantly lower for the three crops with no tillage. Although increase in N rate did not affect yield significantly, corn and grain sorghum seemed to respond to the highest N rate with conventional tillage. Warmer soil temperatures for summer crops may result in a better synchronization between N mineralization and crop N need.

Introduction

The yields of corn and small grains tend to increase when they are grown in rotation with soybeans. This increase in yield often is attributed to improved N supply. However, the available N from soybeans can be affected by many factors, such as tillage and time of plant N need in relation to N mineralization.

Procedure

A field experiment was designed to study N availability to wheat, corn, and grain sorghum following soybean with no tillage and conventional tillage. The study was done at the Cornbelt Experiment Field near Powhattan, Kansas on a Grundy silty clay loam soil. In 1993, soybeans were grown on the field. After soybean harvest, the field was prepared in October 1993, and a 2x4 factorial study with three replications was established. The experimental plots were 10 ft by 50 ft. Winter wheat (Tomahawk), corn (ICI8285), and grain sorghum (AgroPro AP 9670) were planted after soybean. Wheat was drilled in October 1993 in 7½" row spacing at a seeding rate of 90 lb/a. Corn was planted on April 25, 1994 at 18,848 seeds/a, and sorghum on May 27, 1994 at 70,007 seeds/a in 30" row spacing. Weed control for corn included 2-4,D, Broadstrike + Dual, and Roundup at rates of 1.5, 2.5, and 1.5 pints/a, respectively. Roundup and Ramrod/Atrazine were used preemergence at rates of 1.5 and 5 qts/a to control weeds in sorghum. Nitrogen fertilizer was applied as 34-0-0 at rates of 0, 25, 50, 75 lb N/a to wheat; 0, 40, 80, 120 lb N/a to corn; and 0, 30, 60, 90 lb N/a to sorghum. Wheat was harvested in July 1994, and corn and sorghum in September 1994.

Results

With no tillage, wheat yields increased with application of 25 lbs N/a (Table 20). However, maximum yield in conventional tillage was reached at 50 lbs N/a. Tillage did not significantly affect wheat yield. A significant tillage by N interaction affected wheat yield. Higher N applications decreased yield in no-till. Grain sorghum yields at 0 lbs N/a were significantly lower with no tillage compared to conventional tillage. Regardless of tillage practice, increase in N level did not affect yield. A statistically significant interaction occurred between tillage and fertilizer ($P>0.05$). Highest yield occurred in the conventional tillage system with application of 90 lb N/a (Table 21).

Corn yields were significantly lower at 0 lb N/a with no tillage compared to the other treatment combinations. Similar to sorghum, corn yield did not increase significantly with increasing N. A significant interaction occurred between tillage and N fertilizer. Although increase in yield was not significant, conventional tillage with 120 lb N/a produced the highest corn yield (Table 22).

The lower grain yields at the 0 N rate for no-till corn and grain sorghum can be attributed to the fact that N mineralization may be slower in no tillage. This may be due to lower contact between soybean residue and the soil. Higher soil moisture and cooler soil temperatures in early spring may slow soil microbial activity. Cool soil temperatures in spring for winter wheat also may reduce the benefit from N mineralization.

Table 20. Effect of tillage and nitrogen fertilizer on wheat grain yield.

N Rate	Tillage	
	No Tillage	Conventional Tillage
- - lb/a - -	- - - - - - - - bu/a - - - - - - - -	
0	47.3	42.8
25	59.1	47.9
50	54.4	61.6
75	40.8	59.5

Table 21. Effect of tillage and nitrogen fertilizer on sorghum grain yield.

N Rate	Tillage	
	No Tillage	Conventional Tillage
- - lb/a - -	- - - - - - - - bu/a - - - - - - - -	
0	91 b†	122 a
30	124 a	106 a
60	116 a	138 a
90	115 a	147 a

†Means with the same letter are not significantly different at 0.05 level.

Table 22. Effect of tillage and nitrogen fertilizer on corn grain yield†.

N Rate	Tillage	
	No Tillage	Conventional Tillage
- - lb/a - -	- - - - - - - - bu/a - - - - - - - -	
0	77 b‡	100 a
40	100 a	120 a
80	110 a	130 a
120	134 a	124 a

†Grain yield at 15% moisture. ‡Means with same letter are not significantly different at 0.05 level.

NITROGEN SOURCE AND TILLAGE EFFECTS ON CORN YIELD, SOIL NITROGEN, AND DENITRIFICATION

C.E. Madison, C.W. Rice, J.G. Harris, and R.E. Lamond

Summary

This long-term corn study (5 yrs.) exhibited a trend toward higher yields with no tillage and/or manure as the N source. Denitrification was important in its contribution of removing potentially leachable nitrate. Weather was the primary factor influencing both corn grain yield and denitrification through soil moisture and possibly nitrate levels.

Introduction

This study was begun in 1990 to assess the fates of N from different sources and rates under two tillage systems planted to corn. Losses of N from leaching and denitrification have prompted research into various management options for sustaining groundwater supplies and crop yields. Such management options include no tillage and manure application, which were evaluated in comparison with chemical fertilizer and conventional tillage in this study. However, other studies have shown increased groundwater contamination with no tillage and/or manure application from macropore flow and lack of synchrony between N availability and plant uptake. This research provides a better understanding of the effects of agricultural practices on denitrification and corn grain yield.

Procedure

The study was located at the North Agronomy Farm in Manhattan on a Kennebec silt loam (fine-silty, mixed, mesic Cumulic Hapludoll). This was the fifth year of this study in which all plots have received the same treatments each year. The tillage regime included no tillage and conventional tillage, which consisted of fall chiseling and spring discing, N source incorporation, planting, and cultivation. The N treatments were as follows: no N, 75 and 150 lb N/a as ammonium nitrate, and 75 and 150 lb N/a as cattle manure.

N application and incorporation (conventional tillage system only) and corn planting occurred on 12 May 1994. Multiple samples were taken from the manure applied for analysis of N content because it varied. The actual amounts of N applied in the manure were 85 and 170 lb N/a. The corn was planted at a rate of 22,000 seeds/a. On 23 June 1994, 1 qt. 2-4,D LVE and 1/2 pt. Banvel/a were applied for broadleaf weed control along with 1/4 qt Accent and Beacon/a for grassy weed control on all plots.

Corn was sampled at V-6, V-T, and harvest for N uptake. At the V-6 and V-T stages, tissue was dried and ground for total N content, whereas at harvest, tissue was dried for biomass and then ground for total N. Ears in 20 ft. of row were hand harvested on September 9, 1994 and then shelled for yield and grain moisture.

Bulk soil samples and intact core samples were taken on a biweekly and weekly basis, respectively, throughout the growing season to determine the impact of denitrification on nitrate content and yield. These samples then were analyzed for actual (no amendments) and potential denitrification (amendments of N, C, water, and anaerobic conditions). Moisture and nitrate-N contents also were determined on these samples.

Results

Long-term data indicate that good yields were achieved only in 1990 and 1992, probably because of optimum weather conditions during these growing seasons. (As expected, excess rainfall and subsequent flooding produced decreased yields in 1993, whereas insufficient rainfall and high temperatures decreased yields in 1991.) Overall, the 5-yr. average indicates a trend for higher yields with no tillage than conventional (Table 23), which is probably a result of higher moisture and possibly organic matter. N-source also played an important role in yield, with a trend toward higher yields in manure plots than fertilizer plots. The impact of manure addition on water conservation could have influenced this trend. All plots receiving N produced higher yields than the control plots, as expected. However, it is interesting to note that the control plots seemed to maintain yield over the 5-year period, which also indicates the native high fertility of this site.

Potential denitrification (denitrification that could occur given proper conditions)(Figure 1) was determined for both tillage systems and for the control and high rates of N. Weather was the primary controlling factor in potential denitrification. Warming temperatures and increased rainfall in the spring and early summer served to increase potential denitrification across all treatments. This increase could have decreased leaching of nitrate not taken up by the plant. Nitrogen source exhibited more of an influence on potential denitrification than tillage. However, no tillage experienced higher rates of potential denitrification than conventional tillage, probably because of overall higher soil moisture contents. The addition of C and N in an organic medium through manure application could have enhanced microbial activity, along with providing somewhat higher moisture and nitrate contents (Figures 2 and 3) in the manure treatment plots. However, mineralization of organic N in the manure throughout the season contributed to the overall higher potentially leachable nitrate levels. Denitrification losses during the season possibly served as a control for the leaching of this nitrate.

Table 23. Effects of tillage, N source, and N rate on corn grain yield,1990-1994.

Tillage	N Source	Rate	1990	1991	1992	1993	1994	5-yr. avg.
		lb N/a	------------------------------			bu/a	---------------------------	
NT	None	0	143	29	98	45	61	75
	Fertilizer	75	145	47	131	69	85	95
		150	155	56	141	96	101	110
	Manure	75	151	37	129	79	107	100
		150	148	70	137	73	93	104
CT	None	0	149	19	95	55	81	80
	Fertilizer	75	144	29	118	82	104	95
		150	147	37	134	114	111	109
	Manure	75	156	34	114	62	97	92
		150	145	48	136	76	100	101

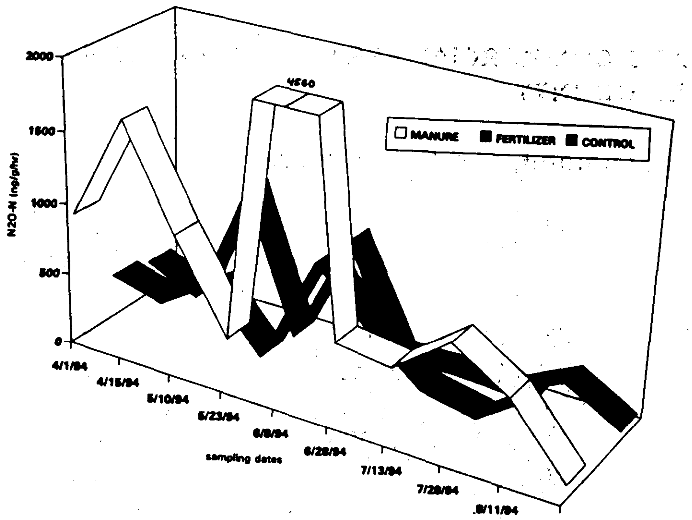


Figure 1. N-source effects on potential denitrification.

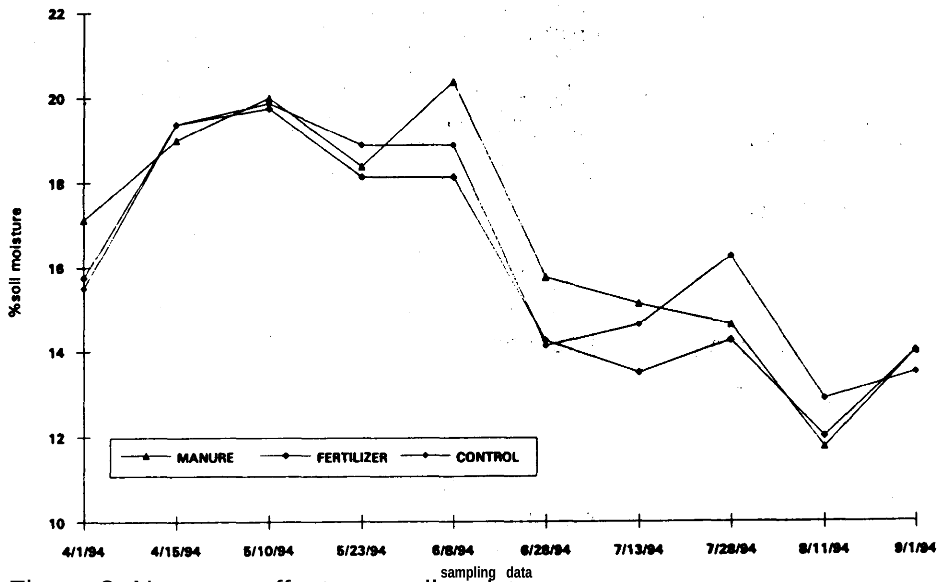


Figure 2. N-source effects on soil moisture.

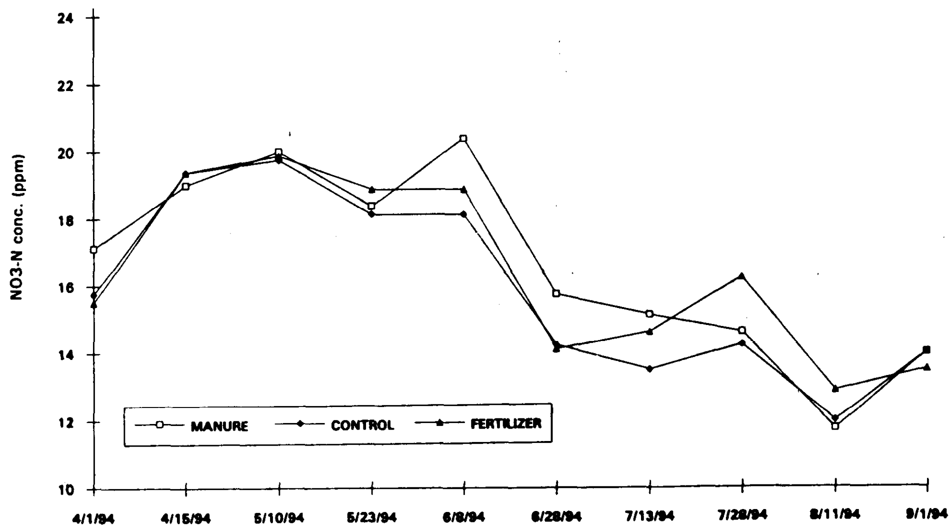


Figure 3. N-source effects on nitrogen concentration.

EFFECTS OF TURKEY LITTER COMPARED TO COMMERCIAL FERTILIZER ON CORN IN CHEROKEE COUNTY

R.E. Wary, D.A. Whitney, R.E. Lamond, and G. L. Kilgore

Summary

In 1994, 10 tons of turkey litter gave the highest corn yield, but it was not significantly better than the yield with the recommended soil test treatment (120-30-70). This is in contrast to previous years' data on corn or grain sorghum following soybeans, where yield from 1 to 2 tons of litter was comparable to that from higher litter rates.

Introduction

Twenty-two contract turkey growers in Cherokee County each produced about 70,000 birds annually for Butterball (Con-Agra) Turkey Company at Carthage, MO. In addition, 800-1000 tons of litter (manure-wood chips mix) are produced by each grower annually. More growers are planning to start production. As a result, crop producers are asking about the fertilizer value of turkey litter. They also are asking, not how little is needed to produce a crop equal to that with commercial fertilizer, but what is the maximum amount that can be applied to the silt loam-claypan soils of Cherokee County without having adverse effects on crop production or the soils.

Procedure

Five sites were selected in 1990 in five areas of the county for a research trial. One was on the Richard Weber farm southeast of Pittsburg and one on the Don Watson farm southeast of Weir, both on a Parsons silt loam; another on the Gary and Neil Martin farm west of Columbus, on a Dennis silt loam; and the other site was on the Scott Jarrett farm west of Baxter Springs on a Taloke silt loam soil. Seven treatments were included at each site and were replicated three times. The treatments included: 1. no fertilizer (check); 2. commercial fertilizer based on a soil test; 3. 1 ton litter/a; 4. 2 tons litter/a; 5. 4 tons litter/a; 6. an amount of commercial fertilizer that equals 2 tons of litter/a; and 7. 10 tons of litter/a. The fifth site is at the Marion W. Atkinson farm, southeast of Columbus on bermuda grass.

All fertilizer and litter are spread by hand and worked into the seedbed prior to planting. The treatments are applied to each crop and not necessarily once a year.

In 1994, the Watson site was planted to corn, the seventh crop grown on the site since the trial was established in 1990. Cultural practices at this site are summarized in Table 24. Treatments were applied in late March. Heavy rains caused severe flooding, eroding several inches of topsoil, so treatments were reapplied on April 21. The site was replanted.

Results

Significant yield increases in 1994 occurred for all treatments compared to the check, even though yields were lower than in previous years (Table 25). In previous years, where corn or grain sorghum followed soybeans, 1 to 2 tons of litter gave yields comparable to those from the soil test fertilizer treatment. This year, more than 4 tons of litter were needed to equal the soil test treatment. In looking at the 2-year, three-site, average data, between 2 and 4 tons of litter compares with soil test fertilizer rates in yield

In summary, this trial continues to indicate that turkey litter can be used to replace commercial fertilizer for growing crops in Cherokee County.

Appreciation is again expressed to the landowners, Don and Rod Watson, and co-workers Joe Smith, and Tom Maxwell for their excellent help with this trial.

Table 24. Cultural practices used at the site.

Hybrid	NC+ 1991
Planting date (replant)	4-25-94
Harvest date	9-9-94
Soil test fertilizer	120-30-70
Commercial fertilizer equal to 2 tons litter	40-75-72
Previous crop	Double-crop soybeans
Soil test results	12-1-93
pH	6.7
P	40
K	168
Litter & fertilizer treatments applied	
First time	3-22-94
Second time	4-21-94

Table 25. Effect of turkey litter and commercial fertilizer on corn yields.

Treatment	1994	1992 & 94, 3 site yrs. avg.
	--------------------------bu/a, 13% moisture --------------------	
No fertilizer (check)	45.5	76.9
Soil test treatment	93.0	128.6
1 ton litter	58.4	109.9
2 tons litter	62.1	123.6
4 tons litter	78.4	129.8
Commercial fertilizer = 2 tons litter	69.1	123.2
10 tons litter	109.6	135.4
LSD (.05)	10.8	--

NITROGEN FERTILIZATION OF GRAIN SORGHUM

D.A. Whitney, R.E. Lamond, W.B. Gordon, T. Maxwell, and D. Key

Summary

The profile nitrogen test ($N0_3$-N in the top 24 inches) was effective in predicting sorghum grain yields response to N fertilization in the six N-rate studies conducted this year. The two locations with high profile N soil tests (Nemaha and Saline locations) did not respond to N fertilization. The preplant profile N appears to be as effective as in-season presidedress testing for available N. More site-years of data are needed to quantify the effectiveness of a pound of available N in the soil to a pound of fertilizer N.

Introduction

Only limited calibration of nitrogen (N) soil tests has been done for grain sorghum in northeast Kansas. Several site-years of data were collected in 1991 and 1992 by Brian Shreve as part of his M.S. research. This research is a continuation of the calibration research started in 1991. Research initiated in 1993 is funded through a cooperative CSRS grant with the University of Nebraska. The objective of this research is to further calibrate the preplant profile N test.

Procedure

Three locations were established in 1993 at the Irrigation Experiment Field and in Nemaha and Osage counties. Three additional locations were established in 1994. The Irrigation Field location also was continued for a second year. In addition, two new N rate studies were established on adjacent areas on the field where no N was applied and a blanket 300 lbs/a of N were applied in 1993. Table 26 summarizes the soil series, soil test, and some cultural data for the four locations. Soil samples by replication were taken to a depth of 48 inches prior to fertilizer application, with the first foot split into two 6-inch increments and deeper depths into foot increments. Soil samples to a depth of 2 feet using the same depth increments were taken at the 6- to 8- leaf stage from each no-N plot. A leaf sample and chlorophyll meter readings also were taken at the 6- to 8-leaf and early boot stages from each plot. Nitrogen rates were in 25-lb increments to a high of 125 lb/a on the nonirrigated and in 30-lb increments to a high of 150 lb/a on the irrigated locations. Ammonium nitrate was used as the N source at all locations. Each study consisted of four replications with individual plots four rows wide by 30 feet long. Planting, hybrid selection, and weed and pest control were done by the cooperators. Grain yields were taken at maturity by hand harvest of one center row in Nemaha, Saline, and Osage counties and by machine harvest of the two center rows at the Irrigation Field. A portion of the grain sample after weighing was retained for determinations of moisture and test weight and nutrient analysis. All yields were corrected to 14% moisture.

Results

A very marked grain yield response to N fertilization was found at the Irrigation Field (all three studies) and Osage County locations (Tables 27 and 29). This was not unexpected, because of the low profile N soil test results on the preplant soil samples. The low residual $N0_3$-N on the 300-lb N site was surprising, but perhaps not unexpected considering the above-normal rainfall in 1993. The Saline (Table 30) and Nemaha (Table 28) locations had high profile N soil tests, and no significant yield increase with N fertilization were found. At the Saline location, a significant decrease in yield was observed with the highest sidedress N rate compared to no fertilization. Soil samples to a depth of 2 feet taken at the 6- to 8-leaf stage from the no-N treatments were found to be similar to the preplant samples for nitrate soil test results. The Irrigation Field and Osage locations had low N soil tests, whereas the Saline and Nemaha locations had N soil tests.

The leaf-sample N concentrations and

chlorophyll meter readings paralleled the grain yield responses. Leaf N concentrations significantly increased with increasing N rates at the Irrigation Field and Osage locations, but leaf N concentrations did not increase with N fertilization at the Nemaha and Saline locations. The Irrigation Field studies also showed an increase in leaf P concentration with an increase in N application.

Although more site-years of data are needed for quantification of the response, adjustment of N fertilizer rates for profile NO_3-N is justified.

Table 26. Site characterization data for the four locations.

	Irr. Field			Nemaha	Osage	Saline
Variable	Resid.	ON	300N			
Soil Test: pH	6.4	6.4	6.4	6.6	6.3	5.5
Bray P, lbs/a	98	84	61	140	24	61
Exch. K., lb/a	1080	1020	1040	680	480	540
DTPA Zn, ppm	1.3	1.2	0.6	1.9	0.6	0.9
Org. Mat., %	3.0	2.8	2.8	3.6	2.6	3.0
Profile N, lbs/24"	27	42	16	109	16	115
Profile N, lbs/48"	--	56	20	154	20	175
Boot, NO_3-N, lbs/24"	8	15	12	140	28	150
Soil type	Crete Sicl			Wymere Sicl	Eram Sicl	Detroit Sicl
Planting date				May 17	June 16	May 26
Previous crop	sorghum			alfalfa	sorghum	sorghum
Hybrid	Pioneer 8699			NC+ 371	Cargill 837	Pioneer 8505
Boot-stage leaf sample:	July 18			July 17	August 24	July 20

Table 27. Effect of N rates on sorghum grain yield and N concentrations, leaf tissue N and P concentrations, and chlorophyll meter readings at two growth stages, Irrigation Experiment Field, Scandia.

N	Grain		8- to 9-Leaf			Boot-E. Head		
Rate	Yield	N	N	Chlor	P	N	Chlor	P
lb/a	bu/a	%	%	SPAD	%	%	SPAD	%
Second year of treatments								
0	85	1.21	2.06	41	.35	1.57	39	.26
30	126	1.33	2.59	47	.39	2.00	48	.30
60	140	1.13	2.91	51	.40	2.40	53	.35
90	148	1.42	3.03	54	.43	2.86	54	.41
120	156	1.39	3.24	53	.36	2.78	58	.38
150	164	1.38	3.16	55	.40	2.95	60	.39
LSD (.05)	17	0.13	0.12	6	NS	0.28	4	.05
No N applied in previous year								
0	93	1.20	2.40	43	.32	1.85	45	.27
30	138	1.35	2.86	49	.35	2.44	52	.31
60	151	1.38	3.04	49	.36	2.56	55	.35
90	155	1.36	3.19	51	.38	2.76	56	.37
120	162	1.45	3.18	50	.35	2.94	58	.37
150	165	1.54	3.28	50	.36	3.03	56	.37
LSD (.05)	14	0.20	0.22	6	NS	0.32	4	.04
300 lb/a of N in previous year								
0	58	1.13	2.39	42	.36	1.77	40	.28
30	93	1.16	2.85	45	.38	2.04	47	.29
60	111	1.19	3.24	48	.39	2.54	52	.33
90	132	1.19	3.12	49	.39	2.63	55	.36
120	142	1.26	3.41	49	.40	2.99	55	.39
150	152	1.24	3.40	50	.39	3.07	58	.40
LSD (.05)	19	NS	0.38	5	NS	0.26	4	.03

Table 28. Effect of N rates on grain yield and N concentration, leaf tissue N and P concentrations, and chlorophyll meter readings at two growth stages, R. Meyer Farm, Nemaha Co., KS.

N	Grain		6- to 8-Leaf			Boot		
Rate	Yield	N	N	Chlor	P	N	Chlor	P
lb/a	bu/a	%	%	SPAD	%	%	SPAD	%
0	107	1.64	4.45	47	.43	2.88	57	.39
30	94	1.64	4.41	50	.43	2.95	54	.39
60	95	1.69	4.40	49	.42	2.97	56	.39
90	99	1.70	4.43	49	.43	3.09	57	.40
120	101	1.72	4.34	50	.42	3.02	55	.38
150	87	1.72	4.50	49	.43	3.07	56	.39
LSD (.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 29. Effect of N rates on sorghum grain yield and N concentration, leaf tissue N and P concentrations, and chlorophyll meter readings at two growth stages, T. Davis Farm, Osage Co., KS.

N	Grain		6- to 8-Leaf			Boot-Head		
Rate	Yield	N	N	Chlor	P	N	Chlor	P
lb/a	bu/a	%	%	SPAD	%	%	SPAD	%
0	24	1.41	2.93	35	.18	2.14	47	.26
25	30	1.43	3.26	41	.18	2.15	54	.26
50	35	1.60	3.22	42	.17	2.74	57	.28
75	50	1.51	3.40	40	.18	2.71	61	.27
100	59	1.60	3.25	42	.16	2.71	61	.27
125	54	1.61	3.17	40	.15	2.76	61	.27
LSD (.05)	14	NS	NS	NS	NS	0.40	5	NS

Table 30. Effect of N rate and time of application on grain yield and N concentration, leaf tissue N and P concentrations, and chlorophyll meter readings at two growth stages, C. Stevenson Farm, Saline Co., KS.

N Rate		Grain		6- to 7-Leaf			Boot-E. Head		
Preplant	Sidedress	Yield	N	N	Chlor	P	N	Chlor	P
lb/a		bu/a	%	%	SPAD	%	%	SPAD	%
0	0	140	1.68	3.63	51	.30	2.80	57	.36
0	30	141	1.69	3.56	51	.29	3.00	58	.35
0	60	125	1.79	3.56	51	.27	2.98	58	.34
0	90	120	1.74	3.56	51	.27	3.00	59	.36
0	120	127	1.74	3.47	53	.28	3.13	59	.36
0	150	115	1.80	3.70	52	.29	3.04	59	.35
60	0	139	1.75	3.68	52	.29	2.94	60	.36
60	30	131	1.84	3.56	51	.28	3.03	57	.34
60	60	113	1.86	3.61	53	.28	3.05	61	.38
60	90	132	1.89	3.50	52	.27	3.12	60	.35
60	120	101	1.88	3.63	50	.27	3.00	60	.35
60	150	114	1.86	3.56	51	.26	3.03	61	.36
120	0	132	1.90	3.58	53	.27	3.04	60	.36
120	30	133	1.82	3.66	51	.28	3.14	57	.36
120	60	133	1.85	3.59	54	.27	3.09	59	.35
120	90	128	1.92	3.58	51	.27	3.10	59	.36
120	120	132	1.88	3.62	53	.28	3.08	60	.35
120	150	115	1.86	3.65	52	.28	3.08	57	.36
30	0	137	1.75	3.60	52	.27	2.94	57	.34
90	0	135	1.78	3.54	54	.27	2.98	57	.36
150	0	127	1.78	3.68	50	.28	2.98	58	.34
LSD (.05)		21	0.10	NS	NS	NS	NS	NS	NS

ZINC FERTILIZATION OF GRAIN SORGHUM

**B.G.Hopkins, D.A.Whitney, R.E.Lamond,
V.L.Martin, and L.D.Maddux**

Summary

The Kansas State University zinc (Zn) fertilizer recommendations for sorghum are in based partly on those for corn, although sorghum generally is not as responsive as corn to Zn. This study is part of a research project aimed at determining the Zn fertilizer requirements for sorghum. The results of this study show that grain yield of sorghum does not increase with Zn fertilization, even when grown in soil with very low soil test Zn levels. However, Zn fertilization of sorghum does result in increased Zn concentration in the plant. Additions of a high rate of phosphorus (P) to these soils, in an attempt to induce Zn deficiency, resulted in reduced Zn uptake, but no yield decreases were observed. The current interpretation guidelines for Zn soil test results recommend application of Zn when DTPA-extractable Zn is less than 1 ppm for irrigated and 0.5 ppm for nonirrigated sorghum. These guidelines are in need of adjustment, because no yield response was observed at any of the field sites in 1992, 1993, or 1994. These results also support the findings of recent greenhouse studies showing that sorghum is generally not responsive to Zn application.

Introduction

Zinc (Zn) deficiency in corn has been well documented, with numerous studies providing an adequate research base for Zn fertilizer recommendations. Less is known about Zn nutrition and fertilizer response of sorghum. The Kansas State University Zn fertilizer recommendations for sorghum are based partly on those for corn, although sorghum generally is not as responsive as corn to Zn. Past studies of Zn fertilization on sorghum were largely inconclusive in establishing its Zn needs. Recent greenhouse studies have shown sorghum to be very efficient in its use of indigenous soil Zn, even when high rates of P or lime are applied, which have been shown to suppress Zn uptake.

The objective of this study was to evaluate Zn fertilizer response in sorghum grown in low soil test Zn soils amended with high rates of P and/or lime.

Procedure

Pioneer 8505 safened grain sorghum seed was planted during the summer of 1994 at three locations (Table 31). Liquid fertilizer Zn and P treatments were band applied in a 2X2 placement at planting. Equal volumes of solution were applied to all plots to avoid soil moisture differences, with water applied to the plots not receiving P and/or Zn. The treatments included combinations of 0 and 100 lbs P_2O_5/a as 10-34-0, 0 and 4000 lbs ECC/a as ag-lime and 0 and 10 lbs Zn/a as Nulex 20% Zn (Nutra-Flo Company, P.O. Box 2334, Sioux City, IA 51107-0334). Lime treatments were broadcast applied and tilled into the soil approximately 1 month prior to planting. N rates (Table 31) were based upon soil test recommendations. Pest control and other management practices were performed as needed. The Ashland location was irrigated on 19 Aug. to avoid crop failure.

Soil test values were determined prior to fertilization or addition of lime (Table 32). Whole plant samples were taken at the 4- to 5-leaf stage; flag leaf samples were taken prior to the boot stage; and grain samples were taken at harvest for analysis of N, P, and Zn concentrations. Grain yields were determined at harvest. Statistical analysis was performed by ANOVA for the Ashland and Kansas River Valley data. The Sandyland data were analyzed using GLM because of an unbalanced data set (two plots were lost). Differences among treatments were determined by LSD.

Results

Yield results are summarized in Table 33. Sorghum grain yields were not increased by Zn fertilization at any of the three locations, even when a high rate of P and/or lime was added to the soil. Phosphorus fertilization resulted in increased grain yields at the Kansas River Valley and Ashland locations, but not at Sandyland, which had greater soil test P values.

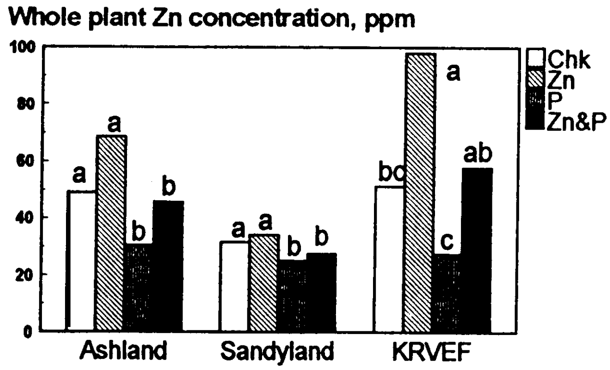
Although yields were not influenced, Zn fertilization resulted in increased plant Zn concentration both at the 4- to 5-leaf stage (Fig. 1) and the boot stage (Fig. 2). As anticipated, P fertilization resulted in decreased tissue Zn concentration at both sampling stages. A Zn X P interaction affected whole-plant Zn concentrations at the Kansas River Valley location, presumably because of dilution from the magnitude of the P response. Lime addition did not result in increased Zn concentration, except for the whole-plant samples at the Kansas River Valley location. Additionally, a Zn X lime interaction affected tissue Zn concentrations for the leaf samples at Sandyland. The whole-plant and leaf Zn concentrations were mostly above the published critical value (C.V.) for sorghum, despite low soil test Zn values (Figs. 1 & 2).

Table 31. Cultural practices for Zn fertilization study.

Location	Planting Date	Seeding Rate	N Fertilizer
		seeds/a	lbs/a
KSU Agronomy Farm-Ashland	2 June	65,000	100
Sandyland Ex. Field-St. John	6 June	50,000	50
Kansas River Valley Ex. Field-Silver Lake	13 June	65,000	130

Table 32. Properties of soils used in Zn fertilization study.

Location	DTPA-Zn	Bray-P1	pH	K	OM	Soil Description
	ppm	lbs/a		lbs/a	%	
Ashland	0.65	43	6.5	490	1.6	Eudora sandy loam
Sandyland	0.15	58	5.6	160	0.7	Pratt sand
Kansas River V.	0.25	13	6.2	240	1.0	Eudora silt loam



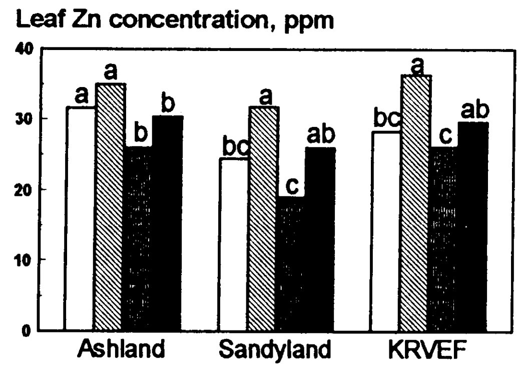


Fig. 1. Zn concentration of sorghum whole-plant tissue sampled at the 4- to 5 leaf stage. Concentrations with the same letter are not significantly different (LSD 0.05).

Fig. 2. Zn concentration of sorghum leaf tissue sampled prior to the boot stage. Concentrations with the same letter are not significantly different (LSD 0.05).

Table 3. Grain sorghum yields with Zn and P fertilization and lime, 1994.

			Yield		
Zn Rate	P_2O_6 Rate	Lime Rate	Ashland	Sandyland	Kansas River V.
lbs/a	lbs/a	lbs/a	- - - - - - - - - - - bu/a - - - - - - - - - - -		
0	0	0	128.5 c	82.4 ab	81.6 b
0	100	0	137.0 abc	87.0 ab	114.9 a
0	0	4000	133.2 abc	93.5 a	81.1 b
0	100	4000	142.9 ab	93.8 a	113.6 a
10	0	0	134.3 abc	88.0 ab	73.3 b
10	100	0	142.5 ab	79.3 b	114.1 a
10	0	4000	131.2 bc	88.0 ab	78.0 b
10	100	4000	144.6 a	83.8 ab	116.6 a
Zn Treatment Means					
0			135.4 a	89.4 a	97.8 a
10			138.1 a	84.7 a	95.5 a
P Treatment Means					
	0		131.8 b	88.0 a	78.5 b
	100		141.7 a	86.0 a	114.8 a
Lime Treatment Means					
		0	135.6 a	84.3 a	96.0 a
		4000	138.0 a	89.5 a	97.3 a

Yields followed by the same letter are not significantly different (LSD 0.05).

LATE-SEASON N APPLICATION ON HIGH-YIELD POTENTIAL IRRIGATED SOYBEANS

R.E. Lamond, T. Wesley, D.A. Whitney, and V.L. Martin

Summary

Irrigated soybean yields in Kansas can be exceptional. Several producers are producing irrigated soybeans with yields in the 70-80 bu/a range. With these yields and the high protein levels of soybeans, N demand during grain fill is quite high, and producers have been questioning a need for supplemental N. Four sites were established to evaluate N rates and sources on irrigated soybeans. Nitrogen was applied at the R-3 growth stage. Results from 1994 indicate that N application consistently increased soybean yields and tended to increase soybean protein levels. Samples are being analyzed for oil content. Few differences related to N source were noted.

Procedure

Four sites (Brunker Farm, Johnson Co.; Parr Farm, Shawnee Co.; Seck Farm, Reno Co.; and the Sandyland Experiment Field) were selected to evaluate N rates (0, 20, 40 lb/a) and sources (UAN, ammonium nitrate, urea, urea + NBPT). Nitrogen was applied at the R-3 stage of growth (first pods 1/4-1/2 inch long). The UAN was applied as a foliar spray in 40 GPA total volume, and the dry N materials were broadcast. Leaf samples were taken 3-4 weeks after N application, and grain yields were determined by hand harvest. Grain samples were retained for protein and oil analyses.

Results

Average to excellent yields were obtained (Table 34) in 1994. The foliar-applied UAN produced noticeable leaf burn, particularly at the 40 lb/a N rate. This probably reduced yield potential, although the plants recovered nicely. Application of N significantly increased soybean yields and protein levels at three of four sites. Samples are also being analyzed for oil content. Few differences related to N source were noted.

This work will be continued in 1995.

Table 34. Effects of late-season N on irrigated soybeans.

		Brunker Farm Johnson Co.			Parr Farm Shawnee Co.			Seck Farm Reno Co.			Sandyland Field Stafford Co.		
N Rate	N Source	Leaf N	Yield	Pro	Leaf N	Yiel d	Pro	Leaf N	Yield	Pro	Leaf N	Yiel d	Pro
lb/a		%	bu/a	%	%	bu/a	%	%	bu/a	%	%	bu/a	%
0	--	4.97	64	35.9	5.09	75	34.9	4.96	56	36.1	5.60	35	34.9
20	UAN	4.87	70	36.5	5.07	76	35.8	5.07	75	35.3	5.71	39	35.9
40	UAN	4.82	65	35.8	5.16	73	35.7	5.21	59	35.3	5.63	37	35.5
20	Am. Nit.	4.69	64	37.1	5.03	78	35.6	5.04	61	35.9	5.72	38	35.7
40	Am. Nit.	4.95	69	35.9	5.03	76	35.3	5.09	61	35.9	5.58	35	35.1
20	Urea	5.07	67	36.3	5.18	76	36.0	4.99	69	35.8	5.59	37	35.8
40	Urea	4.83	70	36.1	4.98	74	36.1	5.03	67	35.8	5.66	43	36.0
20	Urea + NBPT	5.01	64	37.0	5.06	79	34.7	5.14	82	35.9	5.68	41	36.2
40	Urea + NBPT	5.08	70	36.2	5.15	83	36.5	4.83	67	36.0	5.80	42	35.1
LSD (0.05)		NS	NS	NS	NS	NS	NS	NS	15	NS	NS	NS	NS
LSD (0.10)		NS	5	1.1	NS	7	1.0	NS	11	NS	NS	NS	0.8
Mean Values													
N	20	4.91	66.1	36.7	5.08	77	35.5	5.06	72	35.8	5.67	38	35.9
Rate	40	4.92	68.6	36.0	5.08	77	35.9	5.04	63	35.8	5.67	39	35.4
LSD (0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LSD (0.10)		NS	2	NS	NS	NS	NS	NS	7	NS	NS	NS	NS
N	UAN	4.84	67	36.1	5.11	75	35.8	5.14	67	35.3	5.67	38	35.7
Source	Am. Nit.	4.82	66	36.5	5.03	77	35.5	5.07	61	35.9	5.65	36	35.4
	Urea	4.95	69	36.2	5.08	75	36.1	5.01	68	35.8	5.62	40	31.9
	Urea + NBPT	5.04	67	36.6	5.11	81	35.6	4.98	74	36.0	5.74	41	35.6
LSD (0.05)		NS	NS	NS	NS	NS	NS	NS	11	NS	NS	NS	NS
LSD (0.10)		0.19	NS	NS	NS	NS	NS	NS	8	0.6	NS	5	NS

SIDEDRESSED NITROGEN ON YELLOW SOYBEANS

D.A. Whitney, R.E. Lamond, T. Wesley, and W.L. Thomas

Summary

Several fields of soybeans in the eastern half of Kansas showed yellowing in 1994, probably because of excessive rainfall in 1993 that may have reduced Rhizobium bacteria populations in the soil. The yellow fields were poorly nodulated and indicated severe N deficiency. Two studies were established in Nemaha County to evaluate sidedressed N on these fields. Results indicate that late-season (R-3) sidedressed N applied to N-deficient soybeans can effectively increase soybean leaf N concentrations, grain yields, and protein levels.

Procedure

Nitrogen rates (0, 30, 60, 120 lb/a) were evaluated at two sites where soybeans were exhibiting severe N deficiency because of very poor nodulation. Nitrogen was surface broadcast as ammonium nitrate on July 29 at about the R-3 stage of growth. Leaf samples were collected at the Rempe site on September 9. Grain yields were determined at the Wassenberg site, and grain samples were retained for protein analysis. Grain yields were lost from the Rempe site.

Results

Even though sidedressed N was applied late, dramatic responses were noted (Table 35) at the Rempe site. Leaf N concentrations taken about 5 weeks after N application verified that the soybeans were very N deficient; however, the sidedressed N dramatically increased leaf N concentrations. At the Wassenberg site, sidedressed N significantly increased grain yields and protein content. Results suggest that sidedressed N can be effective in overcoming N deficiency in soybeans caused by poor nodulation.

Table 35. Nitrogen on yellow soybeans, Nemaha Co., KS.

N	Wassenberg Farm		Rempe Farm*
Rate	Yield	Protein	Leaf N
lb/a	bu/a	%	%
0	27	30.7	1.41
30	31	32.0	1.58
60	34	32.1	1.83
120	35	32.3	2.48
LSD (0.05)	NS	NS	0.19
LSD (0.10)	8	1.4	--

* Yields not determined at this site. All N as applied ammonium nitrate.

RESIDUAL PHOSPHORUS EFFECTS ON WINTER WHEAT AND GRAIN SORGHUM

R.E. Brown, J.L. Havlin, and A.J. Schlegel

Summary

This paper presents the effects of residual fertilizer P on crop yields and soil test levels in wheat-sorghum-fallow and wheat-fallow-wheat systems. Residual available P from previous fertilizer bands was plant available and detected in the soil 20 and 24 months after application. Grain yields were increased significantly when fertilizer P was band applied to previous crops, although additional fertilizer P was needed to maximize grain yield.

Introduction

The use of reduced tillage cropping systems and band application of fertilizer phosphorus (P) has increased. Quantifying the residual value of banded fertilizer P to subsequent crops is needed to ensure adequate P availability, while maximizing fertilizer P efficiency. The residual availability of banded fertilizer P is dependent on factors such as soil test P level, P application rate, row spacing, band disturbance by tillage, and time between application and uptake by subsequent crops. The objective of this study was to quantify the residual value of banded fertilizer P to subsequent crops.

Procedure

The experiments were initiated on two low P sites in western Kansas in 1991. Site one was located in Ford County on a Harney sil with an initial soil test value of 10 ppm Bray-1 P. Site two was located in Greeley County on a Ulysses sil with a 4 ppm Bray-1 P concentration. Two sets of plots were established at each site to quantify residual fertilizer P effects under wheat-fallow-wheat and wheat-sorghum-fallow cropping systems. Fertilizer P was band applied at 30, 60, and 90 lb P_2O_5 as dicalcium phosphate (0-46-0) in the fall of 1991 at wheat planting time. Treatments were arranged in a randomized complete block design with four replications. Wheat plots were harvested to determine yield response and P uptake (data not shown). In the spring of 1993, wheat-sorghum-fallow fertilizer main plots (6 x 150 ft) were split into subplots (6 x 25 ft) and fertilizer P was band applied at 0, 15, 30, and 45 lb P_2O_5 as ammonium polyphosphate (10-34-0) at sorghum planting. Liquid fertilizer solutions were balanced for N content with urea-ammonium nitrate (28-0-0). Fertilizer bands were placed 2 inches below the seed. Sorghum plots were topdressed with 70 lb N/a as urea. Pioneer 8500 was planted at 30,000 plants/a on 22" spacing. Sorghum plots were planted on May 26 and May 27 and hand harvested on Oct. 18 and 19, 1993 for Ford County and Greeley County respectively. The wheat-fallow-wheat system received the same fertilizer treatments as the wheat-sorghum-fallow system. Tam 107 was planted at 60 lb/a on 12" spacing. Wheat plots were planted on Sept. 20 and Sept 21, 1993 and harvested on June 20, and 27 1993 for Ford County and Greeley County, respectively. Wheat plots were topdressed with 50 lb N/a as urea. Soil samples were taken at sorghum and wheat planting times prior to fertilizer application to determine the residual value of the fertilizer bands. Soil samples were collected by placing a 12-inch template on the soil surface perpendicular to band direction. A 1.25-inch diameter soil probe was inserted to a 6-inch depth into the soil at 1.25-inch spacings on the template. Samples were dried and ground to pass a 2-mm sieve and analyzed for Bray-1 P.

Results

Sorghum grain yield responses to residual fertilizer P and fresh fertilizer P were similar for both locations (Table 36). Sorghum grain yields were higher at the Ford Co. site, partly because of increased precipitation at this location. 1993 sorghum grain yields were significantly increased when fertilizer P was applied in the fall of 1991 to the previous wheat crop. Grain yield was significantly increased as the previous fertilizer P rate increased, except at the 90 lb P_2O_5 rate at Ford County. When no additional fertilizer P was applied at sorghum planting, application of 30 lb P_2O_5 to wheat in the fall of 1991 increased grain yield 15.3 and 5.0 bu/a in Ford and Greeley Co., respectively. Maximum yield from residual fertilizer was obtained at 60 lb P_2O_5 at Ford Co. and 90 lb P_2O_5 at Greeley Co. Grain yields at both locations also were increased by fresh application of fertilizer P. Grain yields generally increased as rates of residual fertilizer P and fresh P application increased. Maximum yield was obtained with applications of 90 lb P_2O_5 in 1991 and 45 lb P_2O_5 in 1993.

Wheat grain yield responses to residual and fresh fertilizer P were similar to those of grain sorghum (Table 37). Previous application of fertilizer P significantly increased grain yield at both sites; however, grain yield was not increased significantly as the residual rate increased at Ford Co. At Greeley Co., grain yield was increased with increasing residual P rate except at the 90 lb P_2O_5 rate, possibly because of fertilizer application problems at this site. Similar to grain sorghum, wheat grain yield increased with fresh application of fertilizer P. Maximum grain yield was obtained with high residual and fresh application rates.

Fertilizer P band applied in the fall of 1991 significantly increased soil P concentration at sorghum and wheat planting time (Figures 1-4). Significant increases in soil P concentration were detected 20 months after fertilizer application at sorghum planting time (Figures 1 and 2) in both Ford and Greeley Co. Similar results were found in the wheat-fallow-wheat plots 24 months after fertilizer P application (Figures 3 and 4). In all cases, soil P concentration in the residual bands was increased with increasing P application rate.

Residual fertilizer P availability was maximized when fertilizer P was band applied at high rates. Grain yield and soil P concentrations indicate that a considerable amount of fertilizer P was still available 24 months after initial applications. Both sorghum and wheat grain yield were significantly increased by previous fertilizer application; however, additional fertilizer P was needed to maximize grain yield.

Table 36. Effect of residual and fresh fertilizer P on 1993 sorghum grain yield in Ford and Greeley Counties.

P Rate (1991)	Ford Co. P Rate 1993: 0	15	30	45	Greeley Co. P Rate 1993: 0	15	30	45
	- - - - - - bu/a - - - - - -				- - - - - - bu/a - - - - - -			
0	71.4	80.1	84.6	91.1	38.1	42.2	46.6	49.4
30	86.7	90.0	91.1	92.9	43.1	45.2	48.8	51.3
60	93.2	95.9	94.1	100.8	45.9	47.9	49.1	58.3
90	90.5	90.5	97.1	101.8	48.6	49.5	56.8	60.1
LSD (.10)	5.5				4.0			

Table 37. Effect of residual and fresh fertilizer P on 1993 wheat grain yield in Ford and Greeley Counties.

P Rate	Ford Co. P Rate 1993				Greeley Co. P Rate 1993			
(1991)	0	15	30	45	0	15	30	45
	- - -- - - bu/a - - - - - -				- - - - - - - bu/a- - - - - - -			
0	38.2	43.6	44.5	44.9	25.0	27.0	28.1	28.8
30	41.9	44.3	46.0	45.2	27.7	28.3	29.6	30.1
60	40.3	43.5	45.6	48.9	29.3	30.3	30.2	30.8
90	41.4	45.8	46.5	49.3	26.4	30.5	30.7	31.4
LSD (.10)	3.8				3.3			

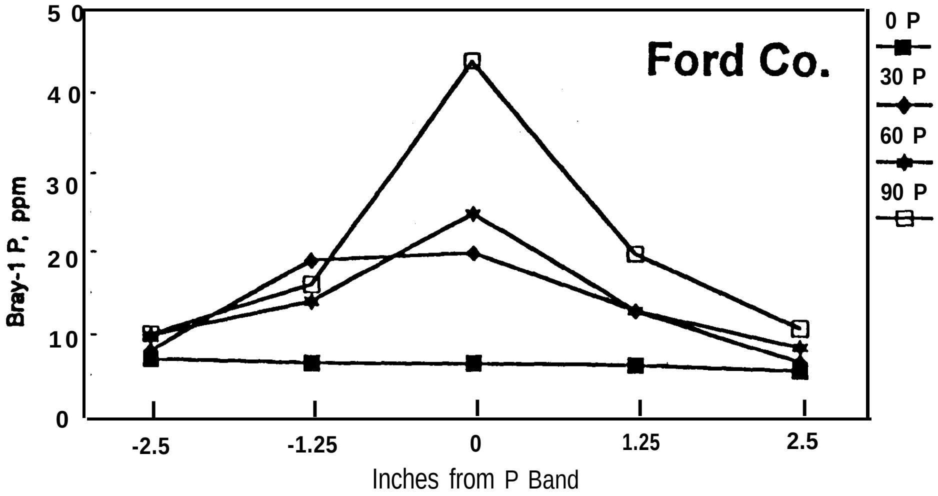


Figure 1. Residual fertilizer band concentration wheat-sorghum-fallow.

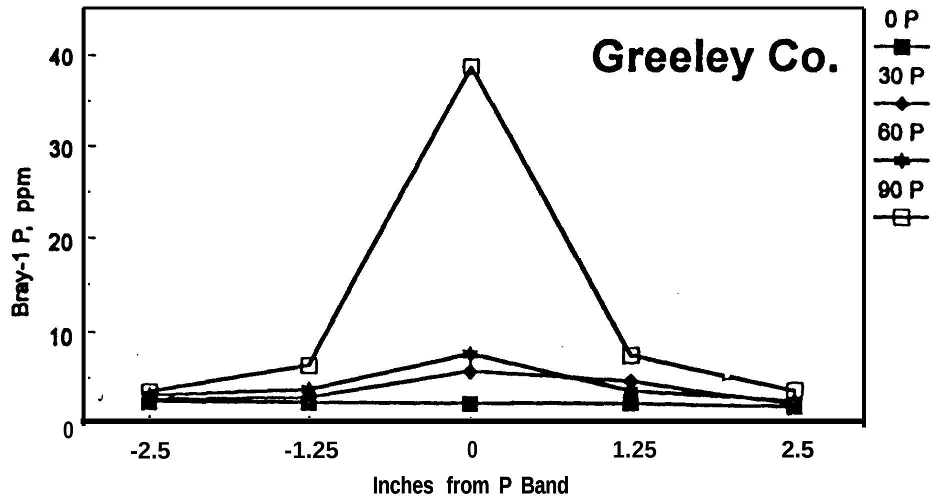


Figure 2. Residual fertilizer band concentration wheat-sorghum-fallow.

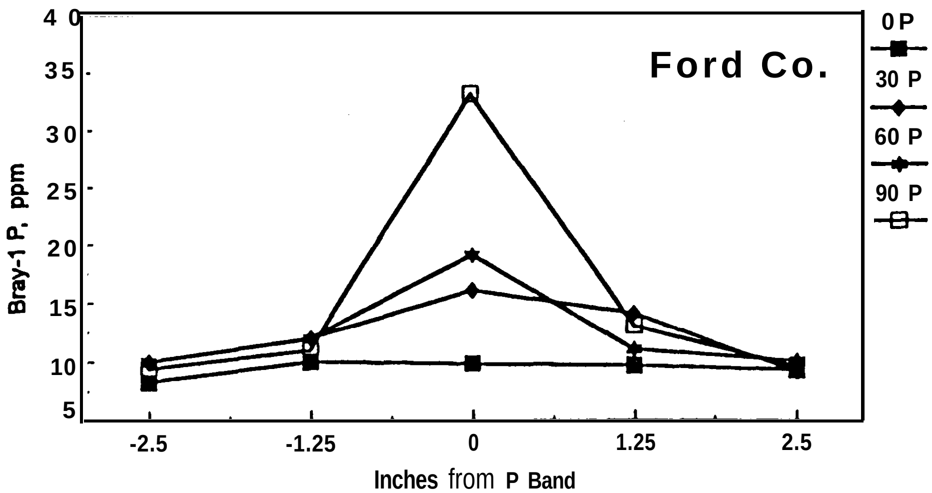


Figure 3. Residual fertilizer band concentration wheat-fallow-wheat.

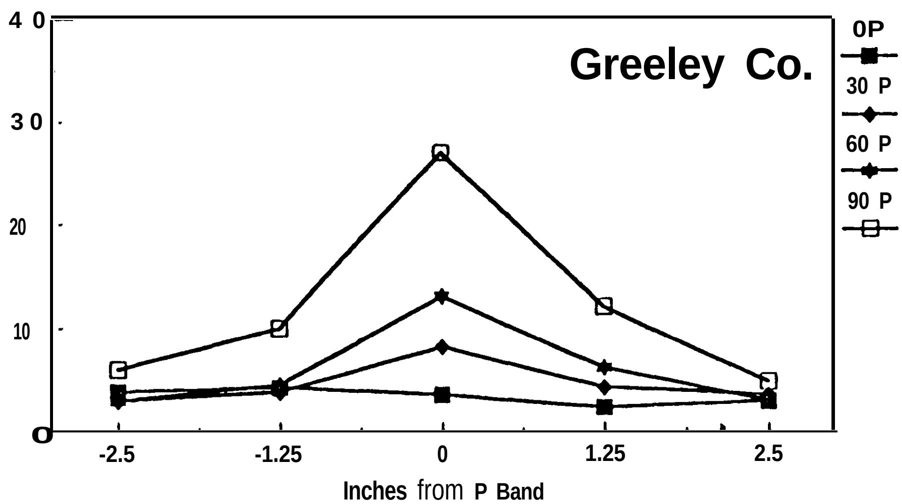


Figure 4. Residual fertilizer band concentration wheat-fallow-wheat.

VARIABLE NITROGEN MANAGEMENT: THE IMPORTANCE OF YIELD MAPPING

C.A. Redulla, J.L. Havlin, G.J. Kluitenberg, M.D. Schrock, and N. Zhang

Summary

Variable application of nitrogen (N) is being compared to traditional or uniform N management of irrigated corn grown on sandy soils. Based on spatially variable yield goal and preplant soil-profile NO_3^- concentration, spatially distributed N recommendations were developed using the Kansas State University N recommendation model. Although yield response data have not been summarized at this printing, one conclusion can be made. First, yield goal as determined by combine monitoring of grain yield in the previous year influences the distribution of N recommendations more than preplant profile NO_3^- concentration. In fact, drastically reducing the number of profile soil samples used to establish the spatial distribution of profile NO_3^- had little effect on the spatial distribution of N recommendations.

Introduction

National concern for groundwater quality has generated numerous studies documenting agriculture's role in groundwater contamination by pesticides and fertilizers. Although nitrate (NO_3^-) contamination of groundwater has been reported in almost every state, the areas of greatest concern occur in heavily populated states and in semi-arid states with intensive irrigated agriculture. Over 12 million acres are irrigated in Nebraska, Colorado, and Kansas. Recent studies have documented considerable groundwater nitrate contamination under center-pivot irrigation, especially on coarse-textured soils. The major factors contributing to groundwater NO_3^- under center-pivots include irrigation /fertilizer nitrogen (N) rates above that required for optimum production, shallow depth to groundwater, irrigation during non-crop periods to leach soluble salts, and NO_3^- in the irrigation water not considered as plant available N.

Reducing the potential for NO_3^- contamination of groundwater under irrigated soils primarily depends on reducing the quantity of fertilizer N remaining in the soil after harvest. Many studies have reported as much as 100 lb/a/yr NO_3^- in the soil profile after harvest. Fertilizer N application timing, method of application, nitrification inhibitors, and N credits for manure and legume mineralizable N and for N in the irrigation water are important management practices for reducing NO_3^- leaching potential. However, the most important factor in reducing the quantity of N remaining in the soil after harvest is to apply the 'correct' fertilizer N rate.

Fertilizer N rates are determined by models generally represented by:
N recommendation =
a(yield goal) - b(soil test N) - c(factors)

The 'factors' term includes adjustments or corrections for previous crops. Soil test N represents extractable inorganic N determined prior to planting. Soil profile NO_3^- is correlated highly to yield response to fertilizer N and is used routinely in making N recommendations in the Great Plains. In the above model, 'yield goal' influences the quantity of fertilizer N recommended more than any other term.

Quantifying the spatial distribution in yield and soil test N will enable development of spatially distributed yield goals and soil N, which can be used subsequently to provide spatially variable N recommendations. Variable application of N, based on spatially variable yield goals and soil N, should reduce overapplication of N and the quantity of leachable N left in the soil after harvest and, thus, also reduce nonpoint source pollution hazard.

Procedure

Two center pivot-irrigated cornfields

in south central Kansas, Phillips and Rice, were chosen for this study. The Phillips and Rice fields averaged 84 and 91% sand and 9 and 6% clay contents, respectively. The 1993 yield map was obtained using a flow-sensor equipped combine. Yield goals were adjusted based on average yields for the last 5 years. Grid sampling on 180 by 180 ft. grids was done in March 1994 to determine the soil nitrate for the 0 to 2 ft. soil depth. These data then were used in the N recommendation model for each 180 by 180 ft. cell.
The equation used was:

$$N_{rec} = (1.35 \times YG \times 1.1) - (7.5 \times NO_3)$$

where,

N_{rec} = N fertilizer rate (N lb/a)
YG = cell yield goal (bu/a)
1.1 = textural factor for sandy soil
NO_3 = nitrate content for 0-2 ft. soil layer (lb/a)

The following procedure was used to test the relative importance of the soil nitrate map and the yield goal map in predicting N_{rec} on these fields.

1. Delete one-half of the soil nitrate data, i.e., every other cell datum.
2. Use geostatistical tools, namely the semivariogram and kriging, on remaining half to estimate the other half of data.
3. Use this new set of data (½ original data and ½ kriged data) in the N_{rec} equation.
4. Apply some statistical tests to compare original N_{rec} map with the new N_{rec} map.
5. Repeat from Step 1 using other half of data. Also done on yield goal data.

Results

The relative contribution of yield goal (*A*) to the N recommendation is almost six times greater than the contribution of soil nitrate (*B*) (Table 38). The sum of the squares for all the cells is presented in Table 39 and shows that yield mapping is essential in obtaining the variable-rate N_{rec} map. However, the Wilcoxon matched pair signed-rank test showed that, for all the modified N_{rec} maps, H_0 ($\mu = 0$) or the null hypothesis cannot be rejected. Basically, all the modified N_{rec} maps have the same average N rate recommendation as the original N_{rec} map. Figures 1 and 2 show the soil nitrate and yield maps for Phillips' field. To compare the modified N_{rec} maps to the N_{rec} maps in Figs. 3 and 4, a simple statistical test was done. For each cell, the difference of the two N_{rec} values was calculated and then squared. Note that in the Rice field, the N_{rec} increases in the west-east direction. This was due to the same trend observed in the yield map for this field.

Table 38. Some descriptive statistics of the original N_{rec} maps of the two fields, which were based on the equation: $N_{rec} = \underbrace{(1.35 \times YG \times 1.1)}_{A} - \underbrace{(7.5 \times NO_3)}_{B}$

	Phillips Field				Rice Field			
Term	Avg.	Min.	Max.	S.D.	Avg.	Min.	Max.	S.D.
N_{rec}	243	99	316	48	227	96	341	57
YG	11066	6283	13837	1803	10661	5245	15573	2395
NO_3	54	36	84	13	59	33	81	13
A	293	167	367	48	283	139	413	64
B	51	34	79	12	55	31	76	12

Table 39. Sum of the squared difference for the modified N_{rec} maps (1/2 of either soil nitrate or yield goal data is estimated) when compared to the original N_{rec} map (x = cell value of the original N_{rec} map, x_i = cell value of the modified N_{rec} map) using the six levels to total N rate.

Field	$\Sigma(x - x)^2$			
	Soil Nitrate		Yield Goal	
	(a)	(b)	(a)	(b)
Phillips	4557	4557	95912	107063
Rice	4356	5579	104891	95911

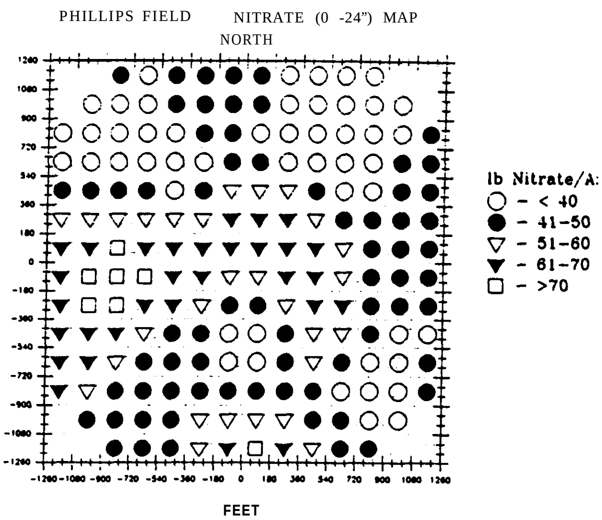


Figure 1. Soil nitrate (0-2 ft.) map of Phillips field, spring 1994.

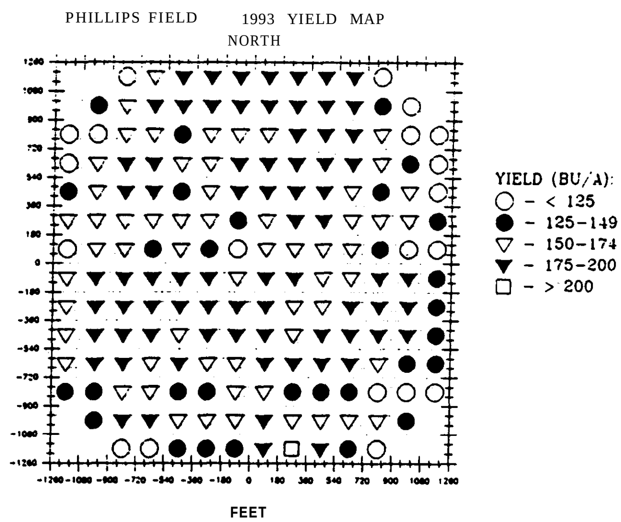


Figure 2. 1993 corn yield in Phillips field.

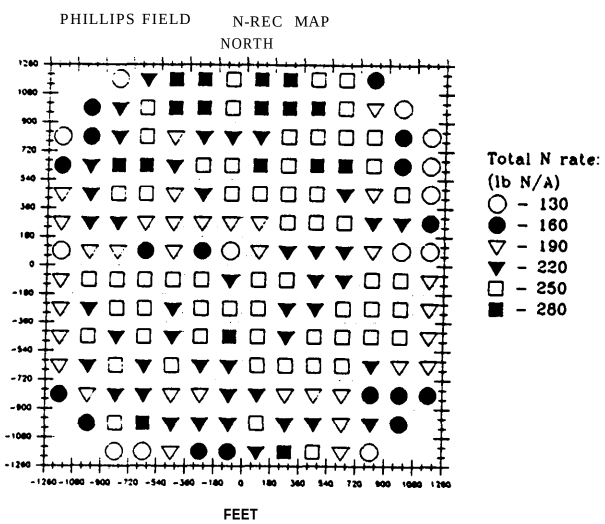


Figure 3. The N_{rec} of Phillips field for the 1994 corn crop.

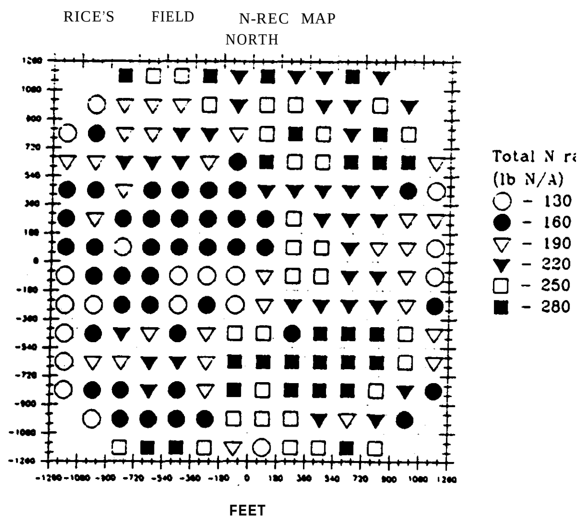


Figure 4. The N_{rec} of Rice field for the 1994 corn crop.

CROP

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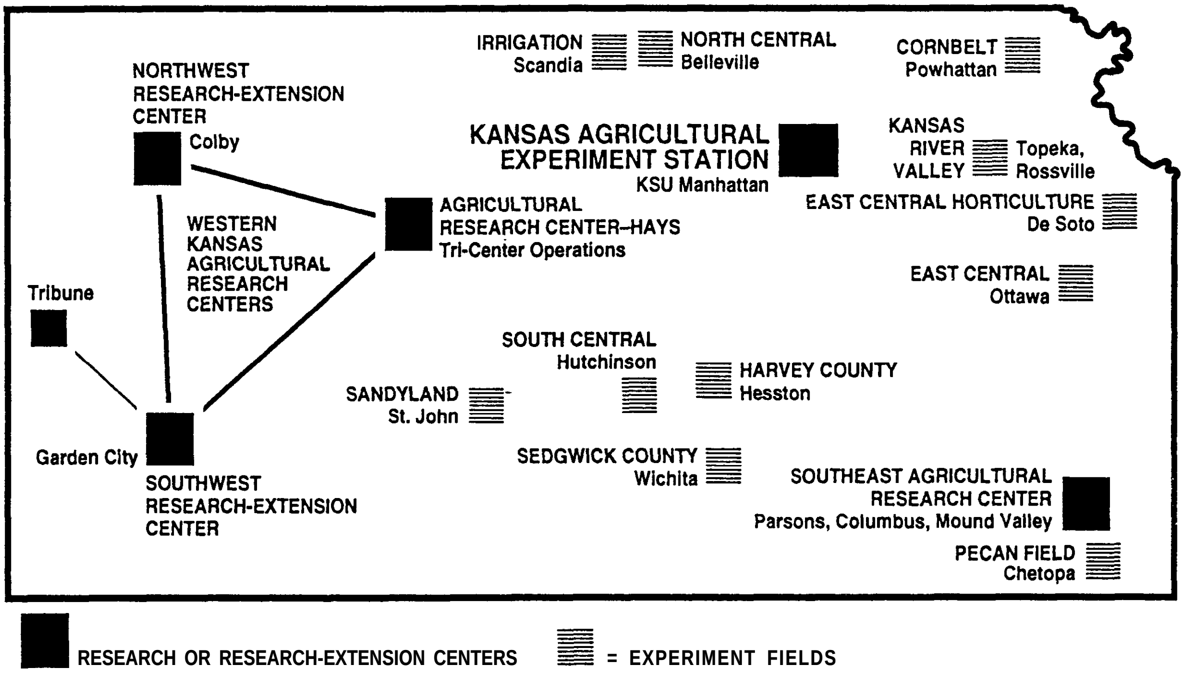

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