NUTRIENT MANAGEMENT IN COTTON-SORGHUM VS. CONTINUOUS COTTON ROTATIONS

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ABSTRACT

This study seeks to provide information to High Plains producers on soil fertility requirements for cotton grown in rotation with sorghum. The benefits of rotation on yields and soil properties are also being studied. It is known that the practice of crop rotation benefits the soil and crops from the standpoint of soil fertility, pests, and diseases. In this project we tested cotton-cotton and cotton-sorghum rotations. Within these cropping systems we had, N, P, and Zn fertility treatments. Every spring we soil sampled by depth on all 108 plots of the study and analyze for NO_3-N, P, Zn, and organic matter. The study has been conducted for four seasons, with three seasons completed with rotation information.

- We did not observe rotation effects (i.e. greater or lesser yields) of cotton following sorghum compared to cotton following cotton.
- Nitrogen fertilizer response has been observed in each of the three seasons of cotton following sorghum, but not in continuous cotton. Sorghum after cotton responded to added N in 2002 and in 2003. Phosphorus fertilizer response has been observed in continuous cotton only in 2001 and 2003.
- We have not observed build-up of soil organic matter in the cotton-sorghum rotation compared to cotton-cotton, but are confident that this will come with time.

INTRODUCTION

The main rotation crop in cotton cropping in the Southern High Plains is sorghum. Surprisingly, yield data on the cotton-sorghum rotation compared to continuous cotton for the Southern High Plains is sparse. In other regions rotating sorghum with cotton has reportably helped control nematodes in cotton (Rush and Gazaway, 1996; Hague and Overstreet, 2002). Cotton lint yield benefits from rotating with sorghum have generally not been observed (Bilbro, 1972; Hutchinson et al., 1986; Clark et al., 1996). The practice of crop rotation has been long recognized as a benefit to soil from the standpoint of pest, diseases and soil fertility. Although much soil fertility information has been generated in the last 40 years on mono-cropped sorghum and cotton, very little study has been done on the fertilizer needs of the cotton-sorghum rotation. Most studies on the soil fertility requirements of the cotton-sorghum rotation were conducted in Africa (Jagnow, 1973; Ganry et al., 1998) or in India (Somalkart et al., 1991; Rego, T.J. et al., 2003).

Starting with the year 2000 cropping season we established a limited irrigation study of cotton-sorghum vs. sorghum-cotton vs. continuous cotton. Fertilizer treatments are three rates of N fertilizer, one rate of P fertilizer and one rates of Zn.

This project will benefit producers by providing sorely needed fertilizer recommendations for the cotton-sorghum rotation. Other hypothesized benefits include yield gains by rotating versus mono-cropping and soil organic matter build-up by rotating with sorghum compared to continuous cotton.

MATERIALS AND METHODS

This field research study, located at the Lubbock Research & Extension Center, was in a split-plot design with three replicates. Main plots (8, 40-in. rows by 200 ft) were crop rotation: continuous cotton, cotton-sorghum, and sorghum-cotton. Subplots (8, 40-in. rows by 50 ft) are factorial combinations of 3 rates of N fertilizer, 2 rates of P fertilizer and 2 rates of Zn. In the spring of every year, intensive soil samples were taken from the 0-6 and 6-12, 12-24, and 24-36 in. soil layers for extractable soil NO_3^-. The 0-6 in. depth is analyzed for other nutrients such as P, K, Zn, and Fe. Additionally we analyzed the top two layers for soil organic matter by "loss on ignition" and for total soil C and N by combustion. Table 1 describes the soil test results and the rates of fertilizer applied. Phosphorus (0-18-0 as H_3PO_4 in 2000 and in 2001, 10-34-0 in 2002 and 2003) and Zn (10% EDTA-Zn) were applied pre-plant by knifing-in liquid fertilizers 3 in. deep, on top of the rows. The first rate of nitrogen (soil-test and yield goal based) and half of second rate (based on two times the first rate) was knifed-in preplant (32-0-0, urea ammonium nitrate) at 3 in. depth, four inches off the row. The second half of the 2nd nitrogen rate was applied in the same manner at first square in cotton and at the 12-inch height of sorghum. The grain yield goal for sorghum was 4000 lb/ac and the N fertilizer to be added was 70 lb N minus 0-24 in. soil NO_3-N (Zhang et al., 1998). The lint yield goal for cotton was 750 lb/ac and the N fertilizer to be added was 90 lb N minus 0-24 in. soil NO_3-N (Zhang et al., 1998).

Sorghum "Golden Acres Genetics 1506" was planted in May of each year, at the rate of 4 lb/ac. Also in May, Paymaster ® Round-up Ready 2326 cotton was planted at 18 lb/ac. Four to six alternate furrow in-season irrigations of about 2 in. each were applied during the season, plus one pre-plant irrigation of 3 in. Hand harvesting was done on four 13 ft row lengths of each plot (mid-September for sorghum and mid-October for cotton).

RESULTS AND DISCUSSION

Soil at the start of the study tested 39 lb NO_3-N/ac (0 - 24 in.), and 20 ppm Mehlich-3-extractable P (0 - 6in.) and 0.25 ppm DTPA-extractable Zn (0 - 6 in.) (Table 1). Soil test P in minus-P plots tended to climb up to about 30 ppm for reasons not clear to us. Soil test Zn in minus-Zn plots remained between 0.25 and 0.30 ppm. Soil test P and Zn in fertilizer addition plots increased in all cases (Table 1). Spring extractable NO_3-N in 0-24 in. soil were on average 39 lb N less in plots following sorghum compared to continuous cotton plots.

In the establishment year of the study, 2000, sorghum grain yields and cotton lint yields averaged 5500 and 740 lb/ac, respectively (data not shown). Nitrogen, P, or Zn fertilizer responses were not observed. Discussion from this point on will focus on the three season's data of 2001 – 2003, where rotation data applies.

Cotton lint yields were similar following sorghum compared to cotton following cotton for all three years (Table 2). On average, 39 more fertilizer-N/ac was applied to the 1X N rate for cotton following sorghum compared to continuous cotton (Table1). In 2001, sorghum grain yields were about half of the expected yield, while in 2002 and 2003, sorghum yields were

greater and similar to the 4000 lb/ac yield goal. Cotton lint yields in continuous cotton equaled the expected yield goal of 750 lb/ac in 2001 and 2003 and cotton in both rotations exceeded the yield goal in 2002. The summer of 2001 was hotter and drier than average and both crops suffered from water stress.

Nitrogen fertility response was observed in all three years in cotton following sorghum but was absent in the cotton-cotton rotation (Table 2). Grain sorghum responded to N fertility in 2002 only. Phosphorus response was observed in continuous cotton only and only in 2001 and 2003. No Zn fertility responses were observed in any rotation or in any year.

Important in understanding N fertility at this site is that the Acuff sandy loam soil probably contributes 50 lb N/ac from mineralization of soil organic matter (Bronson et al. 2001). Lack of P response in most rotations is probably because soil test P was near the recommended (Zhang et al., 1998) critical level of 33 ppm (Table 1). Soil Zn was likewise near the critical levels of 0.29 ppm for cotton and sorghum (Table 1) (Zhang et al., 1998).

The lack of a positive cotton lint yield response following sorghum compared to mono-cropped cotton was a surprise. In the stormy spring of 2003, the ground cover of about 30 % of sorghum residue protected cotton seedlings from wind and blowing sand damage suffered in the continuous cotton. Never-the-less, no positive rotation effect in yield was observed at harvest. Conservation compliance and protection of cotton seedlings, therefore is another benefit of rotating sorghum with cotton. Soil organic N and C (average of 0.06 and 0.55 %, respectively) analyzed from spring 2002 soil samples did not yet show rotation affects after three years and one or two sorghum crops. We expect soil organic matter buildup after several years of the rotation.

Table 1. Soil test results (fertilized plots after 2000) and fertilizer rates applied to cotton following cotton, cotton following sorghum, and sorghum following cotton, 2000-2003, Lubbock, TX, 2001

Current Crop	Previous Crop	Soil NO_3-N	1st N Rate	2nd (2x) N fert. Rate	Soil P	P Rate	Soil Zn	Zn Rate
		---------- lb/ac ---------			Ppm	lb P_2O_5/ac	ppm	lb/ac
					Spring 2000			
Cotton	N/A	39	51	102	20	45	0.25	2
Sorghum	N/A	39	31	62	20	40	0.25	4
					Spring 2001			
Cotton	Cotton	99	0	0	35	0	0.33	2
Cotton	Sorghum	22	68	136	27	30	0.36	0
Sorghum	Cotton	75	0	0	28	20	0.45	0
					Spring 2002			
Cotton	Cotton	52	38	76	39	0	0.32	0
Cotton	Sorghum	20	70	140	29	30	1.4	0
Sorghum	Cotton	54	16	32	30	20	0.41	2
					Spring 2003			
Cotton	Cotton	23	67	135	45.5	0	0.38	0
Cotton	Sorghum	14	76	153	39.1	0	0.71	0
Sorghum	Cotton	24	46	93	34.8	0	0.53	2

Table 2. Yields of cotton and sorghum as affected by previous crop and N, P, or Zn response, 2000-2003, Lubbock, TX

2001 Crop	2000 Crop	2001 Yields	Standard dev.	N response	P response	Zn response
		--------- lb/ac ---------				
Cotton	Cotton	765	79	No	Yes	No
Cotton	Sorghum	630	79	Yes	No	No
Sorghum	Cotton	2356	410	No	No	No
2002 Crop	2001 Crop	2002 Yields				
Cotton	Cotton	1086	42	No	No	No
Cotton	Sorghum	1096	42	Yes	No	No
Sorghum	Cotton	5096	487	Yes	No	No
2003 Crop	2002 Crop	2003 Yields				
Cotton	Cotton	763	166	No	Yes	No
Cotton	Sorghum	654	201	Yes	No	No
Sorghum	Cotton	4095	880	No	No	No

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