COTTON RESPONSE TO MUTLIPLE APPLICATIONS OF NUTRIENT MIXTURES

J. S. Reiter, D. R. Krieg and C. J. Green
Texas Tech University
Lubbock, TX

Abstract

Water supply, growing season length, and nutrient supply limit cotton (*Gossypium hirsutum*) production on the Southern High Plains of Texas. The precipitation:evaporation ratio is less than 0.25 in most years during the growing season. Approximately one-half of the total cotton acreage in the area is capable of supplemental irrigation however the supply is usually considerably less than the demand and deficit water management is common. Irrigation management is often limited by water sources that cannot be controlled by the producer. Growing season length is limited by heat unit accumulation rather than frost-free days with both cool springs and falls common. The major factor left to the producer's control is fertility. Fertility management can affect maturity of cotton which can affect water use efficiency. The development of more efficient nutrient management strategies is needed to maximize use of all available resources in cotton production. The main concern of phosphorous fertilization is that the soil system has a high pH and free calcium that forms insoluble calcium phosphates that limit phosphorous availability to cotton. Applying multiple applications of nutrients in small amounts through the irrigation water during the time of peak crop need will increase phosphorous availability and maximize use efficiency of water and other nutrients. This study will compare different methods of phosphorous application (no phosphorous, pre-plant, sidedress, and fertigation) to determine if there is a real difference in the application methods. The ratio of nitrogen:phosphorous will be compared to determine which level is most effective through fertigation. The ratios are 5:0, 5:1, 5:2, and 5:3 (lb. N:lb P_2O_5) per inch of total water. In two years of research we have found that fertigation is an acceptable method of applying phosphorous to the cotton crop and that higher phosphorous ratios give a yield response through more lint per boll. Using fertigation as an application method will give producers the opportunity to manage their fertilizer inputs based on in season yield potential saving them both time and money.

Introduction

The current method of phosphorous supplementation is based on soil applications of P_2O_5 applied several months in advance of planting. The calcareous nature of the Southern High Plains soils presents a problem with available phosphorous in the soil due to high pH (7.4-7.8) and free $CaCO_3$ often at the soil surface. The optimum soil pH range for phosphorous availability is pH 6.0-7.0. Above pH 7.0 abundant calcium causes the formation of calcium phosphates (Ca-P). These insoluble Ca-P complexes fix inorganic phosphorous from fertilizers as well as mineralized organic phosphorous (Tisdale et al., 1993). The plant utilization efficiency of phosphorous is about 5-25% of applied phosphorous due to soil fixation reactions (Lange, 1977). Phosphorous is most available immediately after soil application and over time soil reactions cause less soluble compounds to form (Olsen and Flowerday, 1973). Research by Nelson (1949) in North Carolina showed that phosphorous applications increased boll size but had little effect on boll numbers or lint quality. Nelson (1949) also concluded that the main increase in yield across all fertility treatments (N,P,K) was due to increased boll numbers. Research at Texas Tech has shown that over 80% of cotton yield variability is due to boll number per unit area. The boll size accounts for 12-15% of yield variability in cotton. A strong negative interaction exists between boll number and boll size where increased boll numbers tend to cause a decrease in boll size. Phosphorous may not have a direct effect on boll number or size but can work in tandem with other nutrients to increase boll properties. Coleman (1944) found that in Mississippi cotton and oats responded to phosphorous only when adequate nitrogen was available. He also noted that these crops with adequate nitrogen also required more phosphorous than those limited to nitrogen. This work shows that variable amounts of phosphorous are needed to correspond with variable nitrogen rates. Morrow and Krieg (1990) have demonstrated the optimum nitrogen to water ratio for maximum cotton yield. This justifies the need to examine nitrogen:phosphorous ratios for optimum yields under different water levels. Water supply is the greatest factor in determining lint yield of cotton and applying nitrogen through the water increases the water use efficiency of cotton. By applying other nutrients through the water we can increase the water use efficiency even more by ensuring these nutrients are not limiting. The use of fertigation may allow us to apply less phosphorous if it is used more efficiently when applied through the water.

Materials and Methods

This study was conducted at the Crop Production Research Lab in Terry County, Texas under a 30-acre center pivot. The pivot is equipped with LEPA application and nozzled to apply 5, 3, and 2 gallons per minute per acre (GPM/A). Within each water supply application method and N: P_2O_5 ratios are applied in blocks. The four application methods are no phosphorous (control), pre-plant, sidedress, and fertigation. All treatments received 100 lb. N and the phosphorous treatments received 40 lb. P_2O_5. The pre-plant P_2O_5 was applied with a sweep rig 4 weeks prior to planting. The sidedress was applied with the sweep rig and split into three applications at pre-plant, first square, and first flower. The fertigation was applied at least four times starting at

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first square. The $N:P_2O_5$ ratios are 5:0, 5:1, 5:2, and 5:3 (lb N:lb P_2O_5) per inch of total water. The control (5:0) received only nitrogen and the 5:2 ratio will supply 40 lbs. P_2O_5 which is the standard recommendation in the area. Each water supply will receive a different amount of nutrients based on total water supply. Yields were determined by hand harvesting samples and ginned in a plot gin.

Discussion

Water supply greatly increased the number of bolls per acre therefore increasing lint yield of cotton. As water supply increased more fruiting sites were produced though retention decreased as water supply increased. Application method showed that fertigation is as effective phosphorous application method as any mechanical means. The past two years have shown extreme weather conditions that greatly affect application method. The wet season of 1997 showed that fertigation can be used to supply phosphorous at the time of crop need. In 1998 extremely dry conditions did not supply sufficient moisture for preplant applications to precipitate to less soluble forms. The sidedress application yields were hurt by root pruning at the first flower application timing. Fertigation allowed input management throughout the season without injury to the crop and could be based on progressive yield estimates. Fertigation did show an increase in boll size. Within the fertigation treatments there is a response to phosphorous rates. Lint yield was influenced by larger boll size as the $N:P_2O_5$ ratio increased.

Summary

As water supply levels increase lint yields increase through more bolls per acre. Fertigation is an effective method for phosphorous application. The ratio of $N:P_2O_5$ in irrigation water enhances the nutrient and water use efficiency by preventing phosphorous from being a limiting nutrient.

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Table 1. Precipitation, soil moisture at planting, and heat unit accumulation May 1-Oct. 15

	1997	1998
Rainfall (mm)	283.5	138.0
Rainfall (in)	11.2	5.4
Soil moisture (mm)	101.6	101.6
Heat units (F)	2249	2922

Table 2. Total water supply per irrigation treatment

	1997			1998		
GPM/A	2	3	5	2	3	5
Irrigation (mm)	80.6	119.0	191.9	156.2	224.8	350.5
Total (mm)	465.7	504.1	577.0	395.8	464.4	590.1
Total (in)	18.3	19.8	22.7	15.6	18.3	23.2

Table 3. Lint yield by water supply (lbs./A)

GPM/A	1997	1998	Average
2	542	619	581
3	650	841	746
5	750	1073	912

Table 4. Lint yield by application method (lbs./A)

Method	1997	1998	Average
Control	629	923	776
Pre-plant	692	1105	899
Sidedress	733	903	818
Fertigation	784	1038	911

Table 5. Lint yield by $N:P_2O_5$ ratio (lbs./A)

$N:P_2O_5$	1997	1998	Average
5:0	576	762	669
5:1	654	958	806
5:2	674	785	730
5:3	758	927	843