Cotton Response to Multiple Applications of Phosphorus Fertilizer

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Texas is the largest cotton-producing state in the U.S. Most of the state's cotton is produced on the High Plains. Water supply, growing season length, and nutrient supply are generally the most limiting factors in cotton production in this region. This study evaluated different methods of phosphorus (P) fertilizer application to cotton, and nitrogen (N) to P ratio in fertigation. Phosphorus fertilizer significantly increased yield. Multiple applications through fertigation was the most effective method of delivery. The companion fertigation study, where N:P_2O_5 ratio was investigated, showed that cotton response to P fertilizer is largely determined by water supply.

The Southern Great Plains of Texas is the largest contiguous cotton-producing region in the world, with about 3.8 million (M) acres planted each year. Approximately one-half of the area's total cotton acreage receives some supplemental irrigation. Cotton producers on the High Plains have made great strides in increasing yield in recent years. In fact, reports of yields in excess of 5 bales/A are no longer uncommon in irrigated production when water is adequate. Cotton production in this region hit record levels in 2004...preliminary estimates indicate that total production was about 4.88 M bales on 3.27 M harvested acres...an average of about 1.5 bales/A.

Water supply, growing season length, and nutrient supply are generally the most limiting factors in cotton production on the South Plains. In irrigated production supply is often considerably less than demand, hence deficit water management is routine. The use of LEPA (low energy precision application) rather than spray application of the irrigation water is common, reducing the evaporation losses of applied water. Growing season length is limited by heat unit accumulation rather than frost-free days since both spring and fall can be rather cool at night. The major yield factor left to the producer's control is crop nutrition.

Nutrient management can affect cotton yield determinates such as fruit retention and boll size, which in turn influences water use efficiency. Nitrogen requirements and application timing relative to water supply have been established for the region in previous work conducted at Texas Tech University. The development of efficient P fertilizer management strategies has not been advanced to the same degree as N strategies. A major concern with P fertilization is the potential for formation of sparingly soluble calcium phosphate reversion products in the alkaline and alkaline-

LEPA (low energy precision application) greatly reduces evaporation losses when irrigating cotton.

calcareous soils of the region. Multiple applications of a balanced nutrient blend in small amounts through the irrigation water during the time of peak crop use is a reasonable approach to increasing the use efficiency of water and nutrients, including P.

This study compared different methods of P fertilizer application (pre-plant banded, side-dressed, fertigation, and no P control) to cotton. In a companion study, the ratio of $N:P_2O_5$ in fertigation was investigated to determine the proper balance between these nutrients. The ratios were 5:0, 5:1, 5:2, and 5:3 (lb N:lb P_2O_5 per in. of total water).

The experiment was conducted over a 3-year period at the Crop Production Research Lab near Brownfield in Terry County. The soil is an Amarillo fine sandy loam with a pH of 7.7. The initial soil test P level at the site was high…27 parts per million (ppm), Olsen method. The center pivot irrigation system used in the study was equipped with LEPA application technology and nozzled to apply 2, 3, and 5 gallons per minute per acre (GPMA), which corresponds with 33%, 50%, and 90% potential evapotranspiration (PET) replacement, respectively. These water supplies are representative of the irrigation capabilities of the region. The irrigation frequency was on a 5-day schedule starting at first square and adjusted according to rainfall. Application method treatments and $N:P_2O_5$ fertigation ratio treatments were applied in blocks within each water supply. The N to water ratio was 10 lb N/in. of irrigation water. Pre-plant P was banded (3 to 6 in. deep and 8 in. from row) with a knife rig 4 weeks prior to planting. Side-dressed P was banded (3 to 6 in. deep and 8 in. from row) with the knife rig and split into three equal applications at pre-plant, first square, and first flower. Ammonium polyphosphate (10-34-0) was used in the side-dress and pre-plant treatments. The P rates used in the pre-plant and side-dress treatments were adjusted according to expected yield based on water supply. The ratio used was 10 lb P_2O_5 per 1 GPMA (2 GPMA=20 lb P_2O_5; 3 GPMA=30 lb P_2O_5; 5 GPMA=50 lb P_2O_5). Fertigation was started at first square and continued through peak bloom. Fertilizer sources used in fertigation blends included 10-34-0, urea-ammonium nitrate (32-0-0), and ammonium thiosulfate (12-0-0-26). Cotton development and boll distribution were monitored during the season by plant mapping at first flower, peak bloom, and at harvest. Yields were determined by hand harvesting samples and ginned in a plot gin. Lint samples were taken for fiber quality measurements at the International Textile Center in Lubbock.

Table 1. Planting dates, rainfall, and heat unit accumulation.

	1997	1998	1999
Planting date	May 19	May 12	June 15[1]
Rainfall, in.	8.5	5.4	6.3
Heat units[2], °F	2,121	2,811	1,871

[1]Replanted due to hail.
[2]Heat unit = [(daily maximum temperature + daily minimum temperature) ÷ 2] - 60

The weather throughout the 3-year study provided a range of conditions representative for the area. Heat unit accumulation, rainfall, and planting date varied considerably from year to year (**Table 1**). Total water applied in the irrigation treatments is shown in **Table 2**.

The application method comparison showed that fertigation is effective in supplying P to the cotton crop and increases lint yield (**Figure 1**). Fertigation allowed pulse feeding of a balanced nutrient blend in a moist soil region where a large percentage of plant roots are located and proved to be the most consistent method of increasing yield across the 3 years of the study. Banded pre-plant application of P

Table 2. Total water supply per irrigation treatment.

	1997			1998			1999		
GPMA	2	3	5	2	3	5	2	3	5
Irrigation, in.	3.2	4.7	7.6	6.2	8.9	14	3.1	4.7	7.7
Total, in.	12	13	16	12	14	19	9	11	14

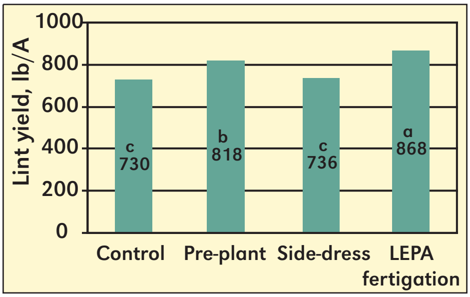

Figure 1. Effect of P fertilizer application method on irrigated cotton lint yield (3-year average across all water supplies).

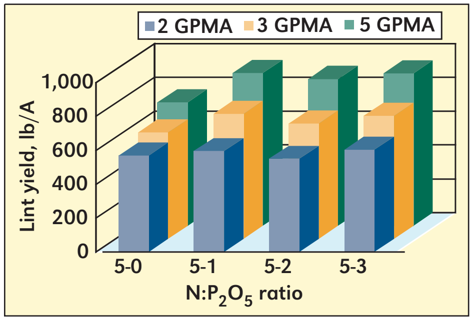

Figure 3. Effect of $N:P_2O_5$ ratio on irrigated cotton lint yield. All N and P were applied through fertigation (3-year average).

produced more cotton than the control and side-dress method. Late season cultivation negated the benefits of multiple nutrient applications by side-dressing due to severe root pruning that interrupted water uptake at the critical flowering stage of development. Lint yield increase from P fertilization was due to an increased number of bolls and boll size. The increased boll size observed with P fertilization was a function of increased micronaire (**Figure 2**). In fact, P fertilization increased micronaire into the premium range, demonstrating the impact that nutrient management can have on crop quality.

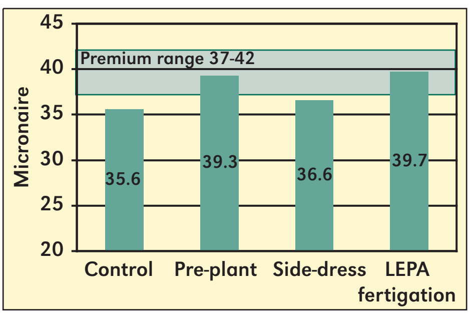

Figure 2. Effect of P fertilizer and delivery method on micronaire of irrigated cotton (3-year average). The horizontal green bar represents the premium range for micronaire (37 to 42).

The companion fertigation study, where $N:P_2O_5$ ratio was investigated, showed that cotton response to P fertilizer is largely determined by water supply (**Figure 3**). The 2 GPMA water supply did not respond to added P since water was the most limiting factor. At the 3 and 5 GPMA water supply, lint yield responded to added P; however, the higher P rates did not significantly affect lint yield above the 5:1 ratio. The lack of a significant yield response to higher levels of P relative to N was consistent with boll number response. Increasing P did increase the boll size and micronaire, owing to more mature fibers in the bolls.

This 3-year project has shown that fertigation is an effective method of applying P to cotton. However, before attempting P fertigation, measures should be taken to ensure that the irrigation system and water are compatible with this practice. **Using fertigation to apply P fertilizer, where compatible with water quality, gives producers added flexibility in managing this important input.** BC

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