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Phosphorus Applications Benefit Cotton Yields

Magnitude of benefit dependent on water supply being the primary driver of yield increases.

Summary: *Purpose of this research was to determine if multiple applications of phosphorus (P) during the greatest demand (the fruiting period) would result in greater yield of higher quality cotton seed and fiber on the Texas High Plains where night temperatures during the latter half of the fruit development period slow growth rates and delay maturation. Results clearly demonstrated that the cotton crop benefited from P applications. Magnitude of the benefit was dependent on the yield, with water supply being the primary driver of yield increases. With increasing levels of irrigation water, more P is required to maximize lint and seed production and quality. Within application methods, multiple applications of nitrogen (N) and P via fertigation were the best. Fertigation provides producers the flexibility to manage fertilizer inputs relative to the environmental constraints and yield potential.*

The Southern High Plains of Texas, the largest continuous cotton production region in the world, plants approximately four million acres of cotton annually. Adequate water supply, growing season length, and sufficient nutrient supply are the major limiting factors to cotton production in this region.

Rainfall (average of 18 inches/yr [1]) will support profitable dryland yields, but in order to maximize yield within the limits of the growing season, irrigation water must be supplemented to the growing crop. Irrigated versus the dryland production area is a virtual split, with the northern half of the area largely irrigated and the southern half predominately dryland or limited irrigation.

Temperatures during the growing season are characterized by suboptimal night temperatures during the planting/early seedling establishment period and again in the latter part of the growing season. Cool night temperatures in September and October limit the maturation of both the seed and fiber of fruit resulting from mid-August flowers.

Seed density (a measure of seed maturity) and fiber micronaire (a measure of linear density of the fiber) are frequently low in higher yielding crops. Low seed density is indicative of a high percentage of immature seed in the total seed lot. Today, about 400,000 acres of cotton seed production for commercial sale is grown on the Texas High Plains. Immaturity is the major cause of the seed being rejected for processing and also results in less vigorous seedlings being produced when planted.

Nutrient supply, largely controlled by the producer, represents the final limitation to production of cotton on the High Plains. Nutrient management can affect rate of crop maturity, as well as water use efficiency. More efficient nutrient management strategies, particularly N and P, are needed to maximize fiber as well as seed yield and quality as governed by water supply and night temperatures. Soil conditions on the Southern High Plains (high soil pH, >7.6, and large quantities of $CaCO_3$) result in very low quantities of soluble P available to the growing plants, especially during the period of peak demand (the boll growth period). Cotton seed and associated fiber need adequate quantities of C, N, P, and K to grow and develop at maximum rates allowed by prevailing temperatures. Phosphorus plays an important role in plant metabolism. The most essential function of P in plants is in energy storage and transfer. Almost every metabolic reaction of any significance proceeds via P derivatives.

Fertigation is an ideal conduit for supplying nutrients to developing cotton plants throughout the growing season, thereby increasing seed production and quality, as well as maximizing water use efficiency. Water supply, which directly impacts the supply of reduced C and N for growth and development, determines the number of bolls retained on the plant. Nutrient uptake parallels dry matter accumulation rate. Nitrogen and P accumulation increase very rapidly beginning at first flower and reaching a peak about three weeks later. As a result of the uptake curve, it is highly probable that the P supply in the top third of the fruit of the plant limits seed growth rate more than temperature limitations. An adequate amount of P has been shown to be crucial to the development of reproductive parts and seed formation. Currently, the primary method of applying P is either by all preplant or a sidedress application (10-34-0) after the crop has begun growing. Nutrient management in conjunction with water supply should increase retention of fruit from the first three to four weeks of flowering, which will allow seed and fiber development to occur under more optimal temperature conditions. Also, by providing a readily available, soluble supply of P throughout boll development, seed development of the late-set bolls may occur in a more normal manner.

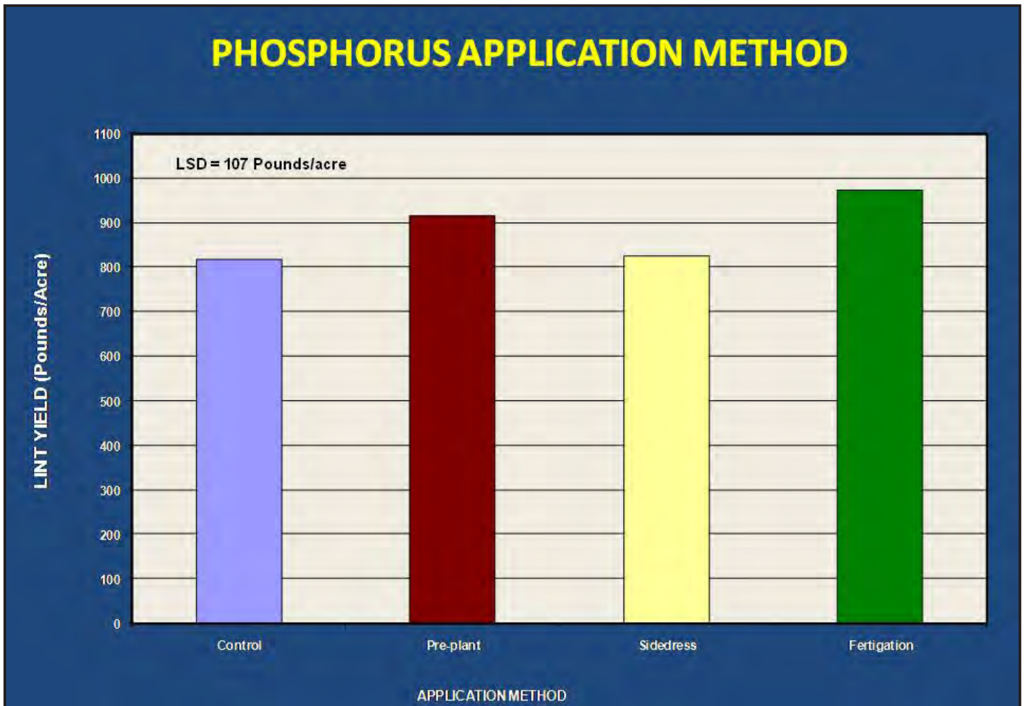

Figure 1. Lint and seed yield as a function of P application method averaged across years, varieties, and water supplies.

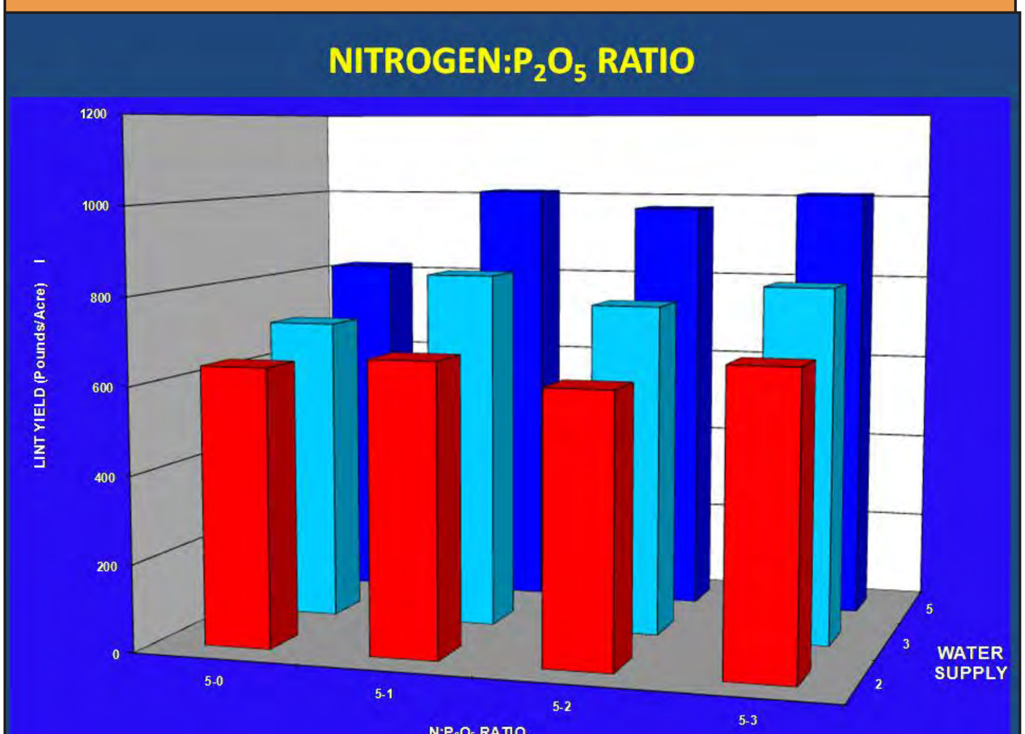

Figure 2. Lint yield as a function of P application method and N:P ratios using fertigation across irrigation water supply. Data are averaged across 3 years and 4 varieties.

Fertigation Excels

The three years of trials offered considerable difference in both rain and temperature, which affected seed and fiber yield and quality. Averaged across years and water supplies, fertigation produced the highest seed and fiber yields as compared to other methods of P applications (Figure 1). Preplant P out-yielded sidedress applications largely due to root pruning by sidedressing at the flowering stage. Within the fertigation treatments, 5:2 N:P ratio was always lower yielding than the 5:1 or 5:3 ratios. Interestingly, the most common recommendation of private and public labs is 5:2.

Again, as water supply increased, both seed and fiber yields increased with the response to method of application being consistent (Figure 2). Increasing N:P ratios increased yields only slightly, with the 5:2 consistently being the lowest producer of the three ratios being compared.

Seed index

Seed yield increases were due to both more harvested bolls/A and increased seed size as indicated by the seed index (Figure 3). Seed index responses to P differed from that seen for total seed yield. The anomaly seen in the 5:2 N:P ratio was due to fewer harvested bolls resulting in heavier seed weights for each fruit.

Fiber Micronaire

Fiber and seed maturity as measured by fiber micronaire and seed density were significantly affected by both application method and N:P ratio within the fertigation treatments (Figure 4). Fiber maturity declined with increasing yield as water supply increased for both the control and the preplant P treatments. Sidedress applications significantly increased fiber maturity due to both reduced boll numbers (resulting from root pruning) and enhanced P supply during the fruiting period as compared to the preplant treatment. Increasing the P supply during the fruiting period through fertigation resulted in increases in micronaire as water supply increased yield. Increased seed and fiber maturity means better prices for both seed and lint from the producer perspective and better finished products from the consumer perspective.

Seed Density

Seed density is indicative of seed maturity and seedling vigor. Seed density less than 1.0 g/cm^3 is indicative of immaturity and results in reduced viability and reduced seedling vigor. Averaged across years and varieties, seed density was found to be greater when in-season P was fertigated on the cotton crop (Figure 5). As lint and seed yields increased due to increasing water supplies, seed maturity remained fairly constant when fertigated, whereas fiber

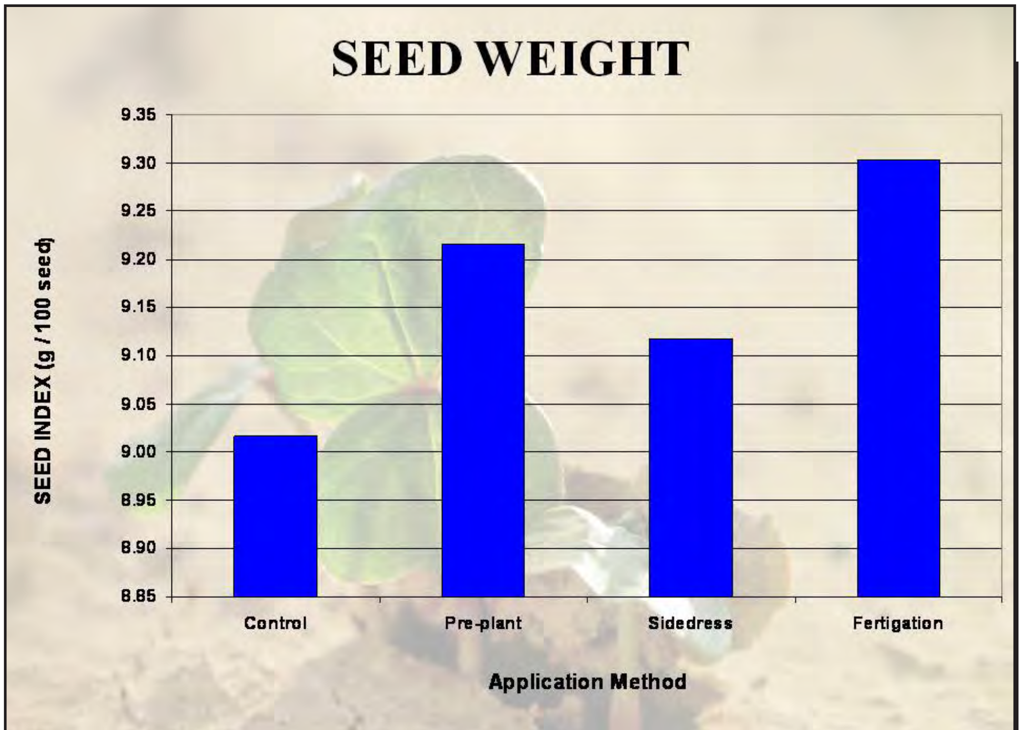

Figure 3. Seed index as a function of P application method and N:P ratios using fertigation across irrigation water supply. Data are averaged across 3 years and 4 varieties.

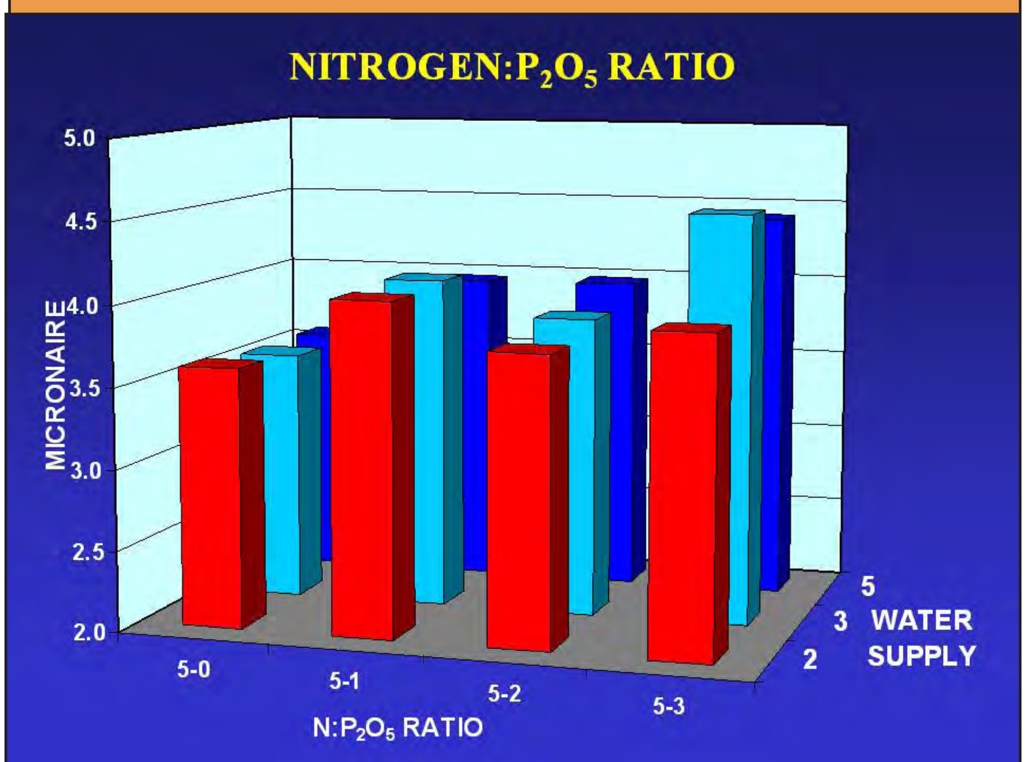

Figure 4. Fiber micronaire as affected by water supply as well as P application method and rate.

maturity increased. This response indicates that seed development has priority over fiber development when resources are limited. From a seed company perspective, this means that the percent of marketable seed produced has increased with a resulting increase in profit margin. From a cotton producer's perspective this means that in the bag he has purchased, the percent of seed that will produce a rapidly growing seedling has increased and he can reduce his seeding rate in the confidence he will get a uniform stand of vigorous seedlings.

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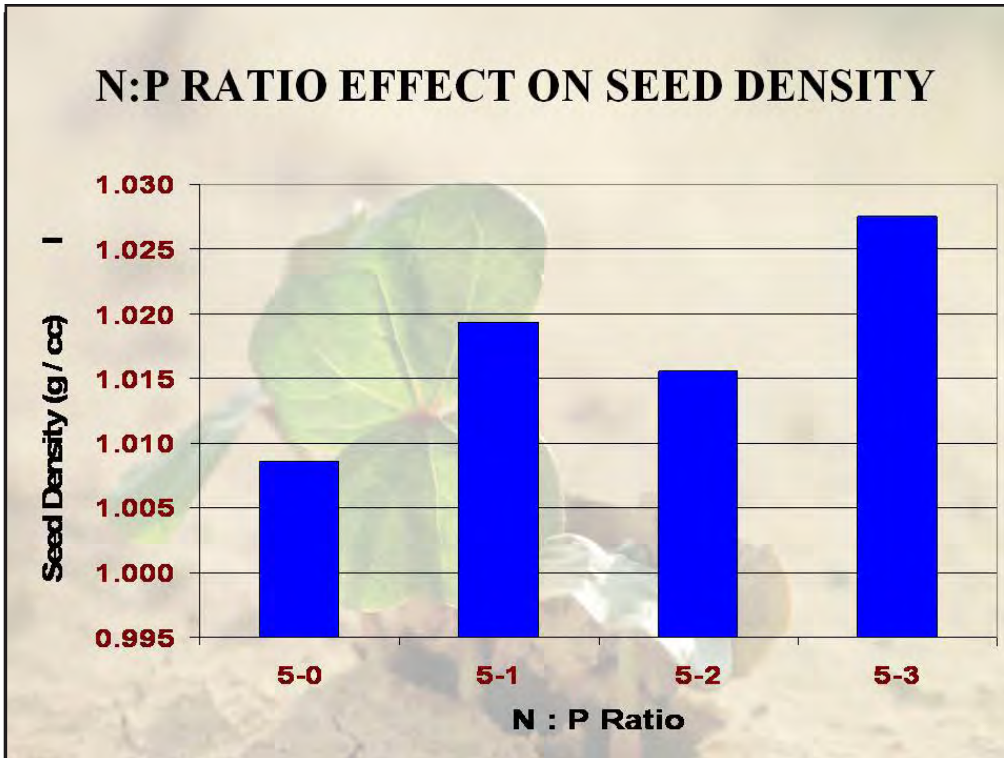

Figure 5. Percent of seed with a density greater than 1.00 as affected by water supply and P application method and rate. Seed density less than 1.0 g/cm^3 represents immature seed.