MAXIMIZING COTTONSEED QUALITY THROUGH NUTRIENT MANAGEMENT STRATEGIES

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Abstract

The Southern High Plains of Texas plants between 3.5 to 4.0 million acres of cotton annually, representing the largest cotton production region in the world. To plant this acreage approximately 70 to 80 million pounds of cottonseed are needed; all of which is grown on the High Plains. Due to the large amount of seed required, the increased use of transgenics, and associated high costs, maximizing seed quality has become a concern. Water supply, growing season length, and nutrient supply are the major limiting factors to cotton production in this region. Cotton will utilize between 20-22 inches water throughout the growing season. With an average rainfall of 18 inches yr^{-1}, water must be supplemented to the developing crop to maximize production. The prevailing temperatures are characterized by marginal heat unit accumulation during the early and latter parts of the growing season. The cool temperatures in September and October limit the maturation of both the seed and fiber of bolls resulting from flowers in mid-August. The nutrient supply, highly 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. Because of this, more efficient nutrient management strategies, particularly N and P, are needed to maximize seed production as governed by water supply and heat unit accumulation. The soil conditions on the Southern High Plains results in very low quantities of soluble P available to the growing plants (high soil pH, >7.6, and high quantities of $CaCO_3$). Supplying a balanced blend of nutrients through the irrigation water during the early fruiting period will increase the soluble P fraction and reduce the potential for P limiting fruit retention and seed growth rates resulting in more seed of the highest quality. This study compared different methods of phosphorus application (no phosphorus, pre-plant, sidedress, fertigation) and evaluated the effect that each had upon seed production and quality. This study also compared the ratio of N: P and established the most optimal rate of fertigation to maximize seed production and quality. The N: P ratios are 5:0, 5:1, 5:2, and 5:3 (# N: # P_2O_5) per inch of irrigation water. Three years of data indicate that fertigation is an acceptable method producing the greatest seed yields with adequate seed indexes and seed density. The ratio of N: P indicates that with increasing levels of irrigation more P is required. Through the use of fertigation, producers will be able to manage nutrient inputs as governed by the growing season and yield potential.

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Introduction

Cottonseed need adequate quantities of nutrients to grow and develop at maximum rates allowed by the prevailing temperatures. Seed and fiber maturity are dependent upon the supply of C, N, P, and K. The soil conditions on the Southern High Plains result in very low quantities of soluble phosphorus available to the growing plants. Phosphorus has been found to be the life limiting element in natural ecosystems because it is often bound in highly insoluble compounds in the soil rendering it unavailable for plant uptake or utilization (5). The high soil pH (> 7.6) and the high quantities of $CaCO_3$ result in precipitation of phosphorus which reduces the soluble P supply. The P in soil solution, which constitutes the smallest fraction of total soil P, is the only form readily available for plant uptake and utilization (6). Phosphorus plays an important role in plant metabolism. The most essential function of P in plants is in energy storage and transfer. During photosynthesis, light energy is absorbed and utilized to produce ATP and NADPH. These two molecules provide the energy needed for biosynthetic reactions in the plant (1). The reactions form organic compounds, which are subsequently used for growth and development. Almost every metabolic reaction of any significance proceeds via phosphate derivatives (6). Phosphorus is also prevalent in many of the biochemical compounds. It has been identified as a major structural component in nucleic acids (DNA and RNA), nucleotides, phosphoproteins, phospholipids, and in three coenzyme systems (3, 4). The amount of nutrients readily available and the ability of the plant to produce and supply C will determine the number of bolls retained on the plant. The number of bolls developing on the plant will directly affect the rate of maturity. If the assimilates become a limiting factor at any point between square initiation and pollination, the fruiting site will be aborted. This could lead to further vegetative growth and formation of new reproductive sites, in turn delaying maturity. If adequate amounts of C, N, P, and K are available, then the abortion of the developing fruit will not occur. By fruit retention increasing, assimilates produced by the plant will go directly to the seed and fiber rather than to vegetative growth; cutout will be reached quicker. This will enable the seed and fiber maturation to occur under optimum environmental conditions. An adequate amount of P has shown to be crucial to the development of reproductive parts and seed formation. Phosphorus uptake by the plant follows N uptake, as well as dry matter accumulation. Thus, P accumulation increases very rapidly at first flower before peaking late in the season at 50% open boll, essentially when all dry matter production has ceased. 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 the temperature limitations encountered. Currently, the primary method of applying nutrients is by traditional chisel methods prior to planting and/or split applications throughout the growing season. Fertigation offers the ability to supply nutrients to the developing cotton plant throughout the growing season increasing seed production and quality, as well as maximizing water use efficiency. Nutrient management in conjunction with water management should increase retention of fruit from the first 3-4 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 phosphorus throughout the growing season, seed development of the late set bolls may occur in a normal manner.

Materials and Methods

This experiment was conducted at the Texas Tech Crop Production Research Lab in Terry County, TX (approximately 35 miles SW of Lubbock). Four varieties of cotton were utilized to determine the effects of phosphorus application on various seed traits. All treatments were applied in a split plot design utilizing the pivot for supplemental irrigation, as well as for the fertigation treatments. The whole plot (experimental unit) consisted of the specific water supply by fertility treatment. The split plot consisted of the genetic component of the variety by fertility treatment within the respected water supply. Water was supplemented in ranges of 2, 3, and 5 gallons per minute per acre (gpma) which corresponds to 33%, 50%, and 90% PET replacement, respectively. Planting rates were adjusted according to the water supply, so that water availability per plant is equal among all levels of irrigation. The four application methods were no P, pre-plant, sidedress, and fertigation. All treatments received 100 lb. of N and 40 lb. of P_2O_5. The pre-plant application was applied 4 weeks prior to planting. The side-dress application method consisted of three equal applications at pre-plant, first square, and first flower. The fertigation method consisted of multiple applications in conjunction with the irrigation water beginning at first square. The N: P ratios were 5:0, 5:1, 5:2, 5:3 (lb. N: lb. P_2O_5) per inch of total water. The water and nutrients were applied using LEPA, which concentrates the solution in every other furrow. Furthermore, furrow dikes were used to control water movement and allow for an even distribution of water and nutrients in the furrow. During the growing season, plants from each treatment were mapped to monitor plant growth and determine boll distribution. In conjunction, heat unit accumulation was monitored to resolve maturation rates. At harvest, plants were harvested and ginned from each plot. The seed was collected and then analyzed for any variation due to fertility treatment. The seed yield, seed index, number of seed/boll, seedling vigor, seed density were used to determine any variation due to phosphorus application for each plot. Seed yield, seed/boll, and seed index establishes the quantity of seed produced. Seed yields were determined by the weight of seed produced from a ginned sample of 1/1000 of a harvested acre. The number of seed/boll establishes seed size and is calculated by Seed Cotton Weight *Turnout/ Seed Index of a 50 boll sample. Seed index is an indication of seed weight and is expressed as g/100 seed. The seed density (gm/cc) was also determined due to its direct correlation to seed quality. Seed density was determined using the method described by Bartee. The results were statistically analyzed using SAS and regression analysis to determine the effects of application method, and determine optimum N: P ratios to maximize seed production and quality.

Discussion

The past three years have shown extreme weather conditions that greatly affected the rate of development of cotton. In 1997, the growing season was characterized by cool wet weather. In 1998, the growing season was very hot and dry. Irrigation was a necessity in order to maintain the crop. Seed production and quality were above average due to the long growing season which enabled bolls in the upper portions of the plant to fully mature. In 1999, severe weather forced the planting date back into mid-June. Because of this, the developing crop was exposed to the cool fall weather without fully maturing. In a wet year such as 1997, fertigation produces the highest seed yield and seed density with pre-plant and sidedress producing relatively identical seed yields and density. In a dry year, such as 1998, Pre-plant produced the greatest seed yield and quality. Fertigation was next followed by the sidedress application. The sidedress was considerable lower than the other methods due to root pruning. In a short growing season, such as 1999, fertigation produced the greatest seed yield. The pre-plant and sidedress application were relatively identical. All methods of application are better than the control showing the need for P to maximize seed production and quality. An average of all the years indicates fertigation produced the highest seed yields as compared to the other methods of application. The fertigation ratio of N:P indicates that as irrigation levels increase, more P is needed to maximize production.

Summary

Fertigation is an acceptable method of applying nutrients to maximize seed production and quality. With increasing levels of irrigation water, more P is required to maximize seed production and quality. Fertigation provides producers the flexibility to manage fertilizer inputs relative to the environmental constraints and yield potential.

References

Arnon, D.I. 1967. Photosynthetic activity of isolated chloroplasts. Physiol Rev. 47:317-358.

Bartee, S.N. and D.R. Krieg. 1972. Influence of density on cottonseed germination, emergence, and chemical composition. Proc. Beltwide Cotton Prod. Res. Conf.

Glass, B. 1951. A summary of the symposium. p. 658-741. *In* W.D. McElroy and B. Glass (ed.) Phosphorus metabolism, vol. 1. John Hopkins Press, Baltimore, MD.

Jones, U.S., and C.E. Bardsley. 1968. Phosphorus Nutrition. p. 213-254. *In* F.C. Elliot, M. Hoover, and W.K. Porter Jr. (ed.) Advances in production and Utilization of Quality Cotton: Principles and Practices. The Iowa State University Press, Ames, IA.

Ozanne, P.G. 1980. Phosphate nutrition of plants-a general treatise. *In* F.E. Khasawneh, E.C. Sample, E.J. Kamprath (ed.) The role of phosphorus in agriculture. Am. Soc. of Agronomy. p. 559-589.

Tisdale S.L., Nelson, W.N., Beaton, J.D., Havlin, J.L., 1993. *Soil Fertility and Fertilizers*. Macmillan Publishing Company, New York.

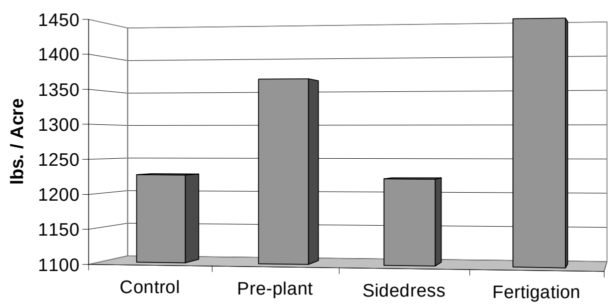

Figure 1. Seed yield as a function of application method.

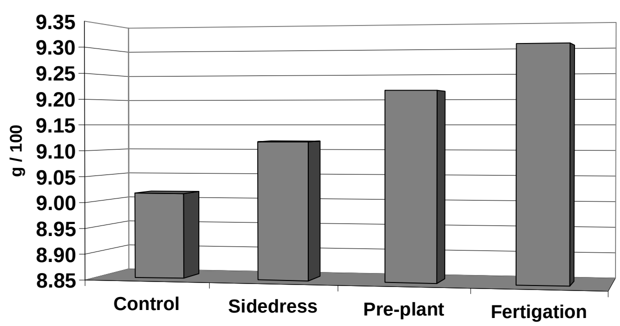

Figure 2. Seed index as a function of application method.

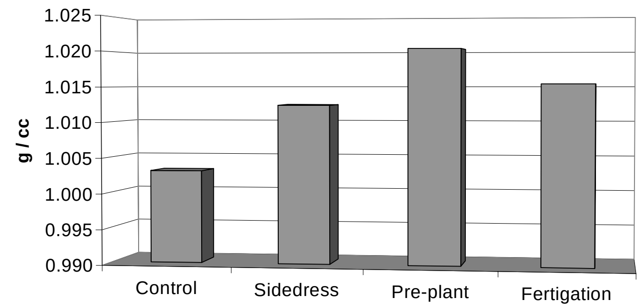

Figure 3. Seed Density as a function of application method.

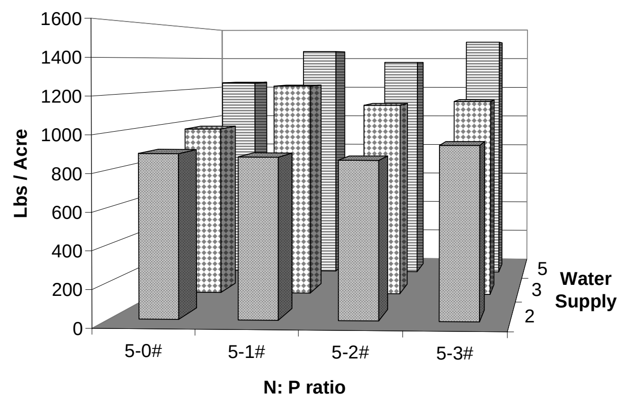

Figure 4. Seed Yield as a function of N: P ratio per inch of irrigation water.

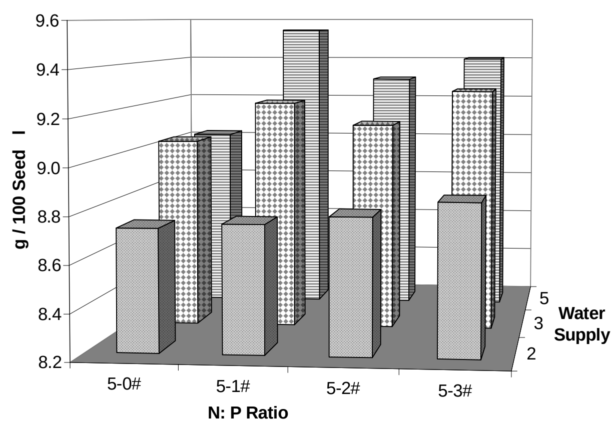

Figure 5. Seed index as a function of N:P ratio per inch of irrigation water.

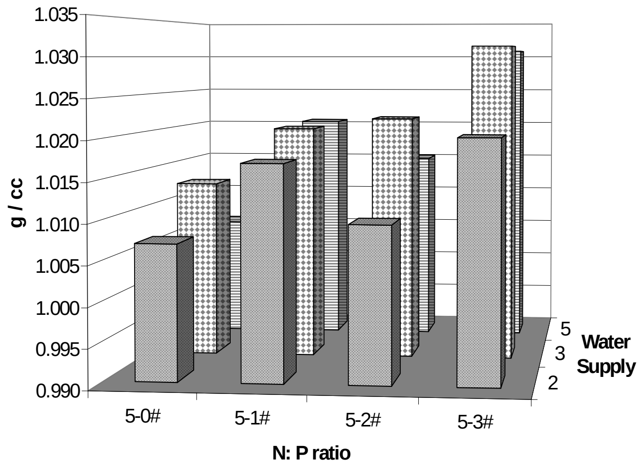

Figure 6. Seed density as a function of N: P ratio per inch of irrigation water.