NUTRIENT MANAGEMENT, SOIL TESTING, AND FERTILIZATION IN ARKANSAS

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Essential Elements For Cotton Growth

Non-mineral plant nutrient elements are obtained by cotton from air and water. They are carbon (C), hydrogen (H) and oxygen (O). All three of these elements are used to make sugars and cellulose.

Primary fertilizer nutrient elements are nitrogen (N), phosphorus (P) and potassium (K). Cotton must obtain these elements from the soil. As the soil becomes depleted of N, P and K, fertilizers must be used to supply the crop with these nutrients. Generally, these are the first nutrients to be exhausted from the soil. Cotton uses N to make proteins. Phosphorus is used by cotton to manufacture genetic materials like RNA and DNA and energy compounds like ATP and ADP. Potassium is used in the cotton plant to regulate water movement.

Secondary fertilizer nutrient elements include calcium (Ca), magnesium (Mg) and sulfur (S). Like the primary fertilizer elements, cotton must obtain these nutrients from the soil. The secondary nutrient elements are generally needed in smaller amounts than the primary fertilizer elements and tend to become depleted in the soil at a slower rate. Calcium is used by cotton to manufacture support tissue called pectin. Magnesium is the central atom in the structure of chlorophyll. Sulfur is used by cotton to make special proteins.

There are eight micronutrient fertilizer elements. These nutrients are needed in trace amounts, usually less than 0.1 lb/acre/year, by cotton. Chlorine (Cl) is necessary for cotton to photosynthesize. Iron (Fe) is used in chlorophyll formation. Boron (B) regulates plant carbohydrates and their movement within a plant. Manganese (Mn) and zinc (Zn) are parts of growth enzymes. Copper (Cu) is necessary for proteins to form in the cotton plants. Cotton uses molybdenum (Mo) for nitrogen transformations. The functions of cobalt (Co), the most recently discovered micronutrient are unknown.

Soil Acidity and pH

Soil acidity and soil pH influences the behavior of almost all soil nutrients. Soil acidity has two components, active acidity (soil pH) and reserve acidity (replenishes active acidity). In soils where low pH limits cotton growth and development, lime may be applied to neutralizes active acidity and raises soil pH. The reaction that occurs between lime and soil acidity is:

$$CaCO_3 + 2H^+ \rightarrow Ca^{+2} + H_2O + CO_2$$

The optimum pH range for maximizing nitrogen availability is 5.5 to 6.5. Phosphorus becomes most available between pH 5.5 and 7.0. Boron is most available below pH 6.3. Typically acid soils are limed with the objective of achieving a soil pH from 6 to 7.

Estimated Nutrient Needs of Cotton

The nutrient requirements of cotton for a two bale crop on a per acre basis are approximately 120 lb N/acre, 45 lb P_2O_5/acre, 85 lbK_2O/acre, 20 lb S/acre and 0.05 lb B/acre. These nutrients are consumed by the crop and utilized in various parts of the plant including stems, branches, leaves and bolls. The cotton lint itself is composed of cellulose. Cellulose is almost exclusively C, H and O, the non-mineral plant nutrient elements.

The amounts and rates of fertilizer applied to cotton in the Arkansas Delta was estimated from survey for the 1989 growing season. This survey found that 98% of the total cotton acreage received N fertilizer and that the average rate was 88 lb/acre. Phosphorus fertilizer was used on 71% of the area cropped to cotton and the average rate was 25 lb P_2O_5/acre. The reported use of potassium fertilizer was 44 lb K_2O/acre on 72% of the cotton acreage.

Current N Recommendations for Cotton

The base recommendation of nitrogen fertilizer for cotton in Arkansas is 100 lb N/acre. This recommendation is reduced: if soil nitrates test high; soil texture is coarse; or the previous crop may have added N to the soil (soybeans, winter legumes, etc.). The base recommendation may be raised if: the yield history of the field is high; soil calcium levels are high; or if conditions that promote denitrification are present and known to occur.

The University of Arkansas fertilizer recommendations do not differentiate among N fertilizer sources. The same nitrogen rate produces the same effect in cotton regardless of the source of the N. For example: 100 lb of urea; 141 lb (12.7 gal) liquid 32% urea-ammonium nitrate; and 132 lb of ammonium nitrate all contain 45 lb of nitrogen.

Current P and K Recommendations

Fertilizer recommendations for P and K fertilization are based on interaction values of soil test determined P and K of the

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surface soil (Table 1). Fertilizer rates are given in pounds of P_2O_5 and K_2O per acre.

Current Lime Recommendations

Most cotton grown in Arkansas is monoculture and not rotated with rice. Irrigation water from rice typically contains carbonates which neutralize acidity, thereby reducing the lime requirement. Under production conditions that do not include a rotation with rice, lime rates for acid cotton fields range from 0 to 3 tons ag lime/acre (Table 2). Soil testing factors used to determine the lime requirement of a cotton soil are pH and calcium (Ca) content of the soil. Soil Ca is used to estimate the texture and salinity of the soil.

Cotton Nutrient Monitoring Program (CNMP)

The CNMP is a system for determining rates and amounts of additional fertilizer that might be needed during the growing season. These rates and amounts are usually small compared to the rates recommended by soil testing. Triggers for fertilizer applications in the CNMP are based on petiole sampling and analysis. Cotton petioles are first sampled at first square. Sampling continues then for ten weeks.

Features of the CNMP include:

- May recommend soil or foliar nitrogen.
- May recommend soil or foliar potassium.
- May recommend foliar boron.
- May recommend soil applied phosphorus.
- May suggest a sulfur application.

Arkansas Scientists Researching Soil Fertility/Plant Nutrition

University of Arkansas Agricultural Experiment Station scientists with ongoing programs in soil fertility/plant nutrition include:

- William H. Baker. Soil Testing Laboratory. Marianna, Arkansas.
- J. Scott McConnell. Southeast Research and Extension Center. Monticello, Arkansas.
- Derrick M. Oosterhuis. Crops, Soils and Environmental Sciences Department. Fayetteville, Arkansas.

Recently, three scientists have retired who contributed ground breaking research in soil fertility and plant nutrition for cotton in Arkansas. These men are:

- Richard L. Maples. Formerly of the Soil Testing Laboratory. Marianna, Arkansas.
- Woody N. Miley. Formerly of the Cooperative Extension Service. Little Rock, Arkansas.
- Wayne E. Sabbe. Formerly of the Agronomy Department. Fayetteville, Arkansas.

Current Research in Cotton Soil Fertility/Plant Nutrition

Ongoing research projects in cotton soil fertility and plant nutrition, the location of the work, and the coordinating scientist:

- Satellite imagery for crop variability. Soil Testing Laboratory. Baker.
- Grid soil sample for field/soil variability. Soil Testing Laboratory and Cooperative Extension Service. Baker.
- Varieties and nitrogen fertilization. Southeast Branch Experiment Station. McConnell.
- Nitrogen fertilization of ultra narrow row cotton. Southeast Branch Experiment Station and Northeast Research and Extension Center. McConnell.
- Potassium foliar fertilization and nutrition, deficiency, and distribution within the plant. Various locations. Oosterhuis.

Interactions of boron fertilizers and fertilization with crop production factors. Various locations. Oosterhuis.

Possible Future Research in Cotton Soil Fertility/Plant Nutrition

Possible future cotton research projects being considered by University of Arkansas scientists in the area of soil fertility and plant nutrition:

- Calibration of nutrient monitoring for ultra narrow row production systems.
- Environmental studies (nitrogen, phosphorus and soil erosion).
- Calibration of recommendations of nitrogen, phosphorus and potassium fertilizer rates.
- Foliar fertilization with nitrogen and potassium.
- Studies of nutrient movement, utilization and dynamics within the plant.
- Fertilization and soil fertility under conservation tillage.

Table 1. Current University of Arkansas fertilizer phosphorus (P_2O_5) and potassium (K_2O) recommendations based on soil test P and K values.

	Soil Test K (lb K/acre)			
Soil Test P	**>350**	**250-350**	**150-249**	**<150**
- lb P/acre -	**- recommended P_2O_5 and K_2O (lb/acre) -**			
> 100	0-0-0	0-0-30	0-0-60	0-0-90
45-100	0-30-0	0-30-30	0-30-60	0-30-90
< 45	0-60-0	0-60-30	0-60-60	0-60-90

Table 2. Current University of Arkansas recommendations for lime rates in ton/acre based on soil test pH and calcium values.

	Soil Test Calcium (lb/acre)			
Soil pH	**<1000**	**1000-3000**	**3001-4500**	**>4500**
	- recommended lime rate (ton/acre) -			
>5.7	0	0	0	0
5.3-5.7	1.0	1.5	2.0	2.5
5.0-5.2	1.5	2.0	2.5	3.0
<5.0	2.0	2.5	3.0	3.0