Fluid JOURNAL
Official Journal of the Fluid Fertilizer Foundation
Late Spring 2009
Vol. 17, No. 3, Issue #65

Dr. Derrick Oosterhuis

Timely Foliar Applications Rectify Nutrient Deficiencies

Applications should be made either early morning or late afternoon for maximum efficiency.

Summary: *Nutrient deficiencies often occur for a variety of reasons, but can be rectified by timely applications of the deficient nutrient. This usually entails some sort of soil application but, after canopy closure during flowering and fruit development, foliar applications may be more appropriate. Foliar fertilization is a viable means of applying certain fertilizers that can supplement traditional soil methods. It can be used to improve the efficiency of a nutrient urgently required by the plant to produce maximum growth, yield, and fiber quality. In this way, foliar fertilization supplements soil applications for a more efficient supply of nutrients to the developing cotton plant for optimum yields and fiber quality. In general, foliar applications should be made early morning or late evening for maximum efficiency, and no foliar applications should be made to water-stressed plants. As with any practice, certain precautions should be observed.*

Optimal productivity in cotton requires that nutrient deficiencies, which occur for a variety of reasons, be avoided. Most of these can be rectified by timely applications of the deficient nutrient. In crop production, this usually entails a soil application or foliar applications that may be appropriate after canopy closure during reproductive development or when a specific nutrient is urgently required. There is a wealth of literature about foliar fertilization that was first used as long ago as 1844 to correct plant chlorosis with foliar sprays of iron. Foliar fertilization has only caught on in row-crop production in the last two decades, although there is still some speculation about the benefits and correct implementation of this practice.

Foliar application of specific nutrients is a method used to improve the efficiency of fertilizer use and increase yields. The increased use of foliar fertilizers in crop production in the last decade is due in part to changes in production philosophy. In cotton, for example, the change to cultivars that fruit in a shorter time and mature earlier has placed greater emphasis on understanding plant uptake and use of nutrients. Current crop monitoring techniques also focus attention on plant development and make it easier to combine concomitant nutrient monitoring, allowing remedial action on a timelier basis. Cotton also lends itself to foliar fertilization because of the large number of aerial applications that are already made for pest control. While there are many reports on research involving soil-applied fertilizer, there are relatively few definitive studies on the usefulness of foliar fertilization in cotton.

Variable yield responses to foliar fertilization have been reported. These are probably associated with incorrect timing of applications, the use of inappropriate fertilizer materials, insufficient attention to soil-available nutrients, the size of the boll load, and environmental conditions. A reliable soil analysis constitutes the basis of a successful fertilizer program and tissue analysis plays an integral part of this program for fine-tuning midseason tissue nutrient concentrations and remedying any possible deficiencies. The efficiency of foliar fertilization can be influenced by type of fertilizer, concentration and pH of the solution, use of adjuvants, and compatibility with other agrochemicals. Attention also needs to be given to rate and timing and incorporation of foliar feeding into existing production practices.

Beware water stress

The basis for foliar fertilization is that certain fertilizer nutrients are soluble in water and may be applied directly to the aerial portions of plants. The nutrient enters the leaf mainly by penetrating the cuticle or possibly through the stomata before entering the plant cell where it will be metabolized. For foliar fertilization to work, nutrients must be applied to the leaf, penetrate the cuticle or stomata to enter cells and metabolic pathways. The cuticle is a waxy layer that protects all plant surfaces thereby presenting a barrier to the absorption of foliar-applied fertilizers. For example, in cotton, water deficit has been shown to increase cuticle thickness 33 percent. More importantly, water stress also changes the composition of lipid constituents to longer chain more hydrophobic (water repelling?) lipids, thereby further impeding the uptake of foliar-applied nutrients.

Mechanisms

Cuticle vs. stomata. There are two possible channels for penetration of foliar-applied compounds into the leaf before they can produce a response. One is through the external cuticle and the other is through the stomata. However, it is generally accepted that most nutrient uptake occurs through the cuticle. Based on recent evidence, showing that the uptake of large anions can occur through the stomata, there is general agreement that the stomata might indeed represent a possible pathway through which a limited amount of nutrient might gain entry into the leaf. Organosilicon surfactants can also help, reducing aqueous surface tensions to about 20 Mn m^{-1} and allow entry via the stomates. Further stomatal penetration can occur only in the brief period after application while spray deposits remain liquid. In cotton, it is unlikely that direct penetration of solutes from the leaf surface through open stomata, into the leaf tissue, plays an important role.

The most important consideration for efficient and profitable foliar fertilization is that this practice will only be effective if the applied nutrient ultimately reaches the target site for its use--i.e., the growing points in a vegetative cotton plant and the developing fruit in a more mature reproductive plant.

Rate and timing

The timing of foliar sprays, particularly in regard to growth stages, can be critical in relation to the optimum efficacy of the foliar treatment. More attention should be given to it because the seasonal pattern of nutrient uptake varies with growth rate and stage but generally follows a sigmoidal pattern with sharp increases occurring as the boll load develops. The developing fruit load (the sink) has a high requirement for NPK, in particular, and this demand is not always completely met by the soil, especially when adverse conditions occur and as root growth declines.

Absorption

Nitrogen. Results of field research clearly demonstrate the uptake of foliar-applied nitrogen (^{15}N-labeled) urea by cotton leaves and translocation to the developing bolls. Foliar-applied ^{15}N was rapidly absorbed by the leaf to which it was applied (30% within one hour) and translocated into the closet boll within 6 to 48 hours after application. The ^{15}N moved progressively into adjoining bolls for the next few days with no translocation to other leaves. The cotton uptake of foliar applied ^{15}N was highest in the early morning and late afternoon, and lowest at midday. Water deficit significantly reduced the absorption of the foliar-applied nutrient. Total leaf wax of field-grown cotton leaves increased with increase in leaf age and this was associated with a significant decrease in ^{15}N from foliar application. This may account for the decrease in yield response to foliar-applied urea three weeks after flowering as has been reported and may warrant the use of increased rates or frequency of application of N and the use of adjuvants.

Potassium. Potassium (K) fertilizers have a high pH in solution, and adjusting the solution to a pH of 4 to 6 significantly increased uptake and yield. Furthermore, KNO_3 and K_2SO_4 were superior to the other K fertilizers tested, whereas K_2CO_3 and KOH gave the poorest results.

Advantages/disadvantages

Advantages of foliar feeding include:

- Low cost
- Quick plant response
- Lack of soil fixation
- Independent of root uptake
- Small quantities needed
- Combines easily with other agrochemicals
- Higher yields.
- Disadvantages include:
- Possible foliar burn
- Solubility problems
- Ideal weather required when applying
- Inefficient absorption when pH is too high
- Possible incompatibility with certain chemicals.

Dr. Oosterhuis is Distinguished Professor of Crop Physiology, Department of Crop, Soil, and Environmental Sciences, University of Arkansas.