

NEWS & VIEWS

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Foliar Nitrogen and Potassium Fertilization of Cotton

WITH the exception of irrigated cotton in California and Arizona, foliar nitrogen (N) and potassium (K) fertilizers are not frequently used by cotton growers in much of the U.S. Cotton Belt. In the late 1970s, foliar fertilization with urea N was promoted by the University of Arkansas to reduce excessive growth associated with long-season varieties and aggressive soil-applied N rates. In the late 1980s, mid- to late-season K deficiencies were observed in many fields in the Midsouth and in California. Recently, some growers have decreased their emphasis on optimizing cotton plant nutrition.

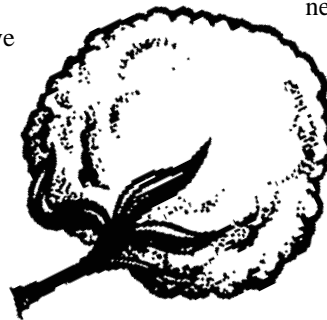
Nutritional benefits from improved fertilization are often associated with an extended boll-filling period. Regrettably, many confuse this effect with a delay in maturity, when instead, it should be considered an avoidance of premature cut-out. Most cotton producers recognize the need to develop a sound soil-applied nutrient management program to achieve yield expectations, but they also need to recognize conditions and situations under which foliar fertilizers can supplement soil-applied fertilizers in increasing nutrient use efficiency, yields and profit potential.

Uptake of soil-applied nutrients may be limited by many conditions, including: 1) a rapidly-developing, heavy boll load accompanied by a decline in the active root system, 2) reduction in root activity caused by soil compaction, soil acidity, or nematodes, 3) temporary soil moisture shortages that limit soil nutrient diffusion, 4) reduced root activity at boll filling, or 5) diseases. Knowledge of the interaction of these factors with plant nutrition can help growers determine the potential benefits of foliar N or K fertilization in cotton nutrition programs.

Nitrogen

In the Midsouth, approximately 80 lb of N/A is taken up in producing each bale of lint cotton. For irrigated sites and nonirrigated sites with a deep rooting potential and good available soil moisture, N rates from 90 to 150 lb/A are often used to produce 2.0 to 2.5 bales of lint cotton. Higher rates of N are frequently needed for higher yields under irrigated conditions, for high-clay soils and soils with reduced N utilization efficiencies. Peak N uptake (demand) has been measured at 3 to 4 lb of N/A/day and usually occurs between 60 to 80 days after planting. Cotton response to foliar N fertilization is most likely when: 1) an inadequate N rate has been soil applied, 2) when N has been lost from the soil through leaching, denitrification, volatilization, immobilization, or a combination of these loss pathways, 3) when soil moisture temporarily limits N availability, and 4) where irrigation or timely rainfall enhances the yield potential. The availability and uptake of soil and fertilizer N, prior to and during fruiting, will dictate the need for supplemental foliar N fertilization. In addition, the storage capacity for N within the plant and the plant's ability to transport N from older tissues to younger tissues also influences the need for supplemental N fertilization.

Recent research by J. Scott McConnell and others in Arkansas showed the response to 30 lb of foliar N/A ranged from 42 to 101 lb of lint/A and averaged 69 lb of lint/A at soil-applied N rates of 60 to 90 lb/A, across application times and years (**Figure 1**). At soil-applied N rates from 120 to 150 lb/A, three



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foliar applications of 10 lb of urea N in 10 gallons per acre resulted in an average lint response of 26 lb/A, with a range from -24 to 53 lb/A.

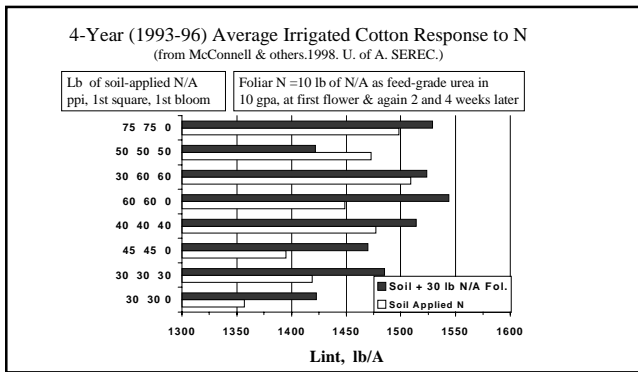


Figure 1. Cotton response to foliar N depends on soil-applied N rates.

Because it is difficult to predict the season-long availability of soil, fertilizer, and manure N, many crop advisers, fertilizer dealers and consultants monitor plants to determine if the N fertilization program is adequate. Petiole samples or leaves are collected from the fourth main-stem node from the top of the plants. These leaves are the most recently mature, fully-expanded leaves. If the total N is low in the leaf blades, or if nitrate-N is low in petioles, foliar N fertilization may be beneficial. To date, neither leaf tissue analyses nor petiole nitrate-N analyses have proven completely accurate in predicting the need for foliar N fertilization. Many of the uncertainties in response are related to environmental effects such as variable insect pressures, crop water availability, and size of the developing boll load. Certainly, if severe shortages are detected in time, yield losses can be limited through foliar fertilization. Analytical laboratories should be consulted for tissue analysis interpretations.

Decisions to foliar apply N should be based on : 1) the rate, timing and availability of soil-applied N, 2) leaf or petiole N status, 3) the measured rate of development of the boll load, 4) good insect control, 5) adequate soil moisture, and 6) adequate time to mature the bolls targeted for response to foliar fertilization. Application of N to the soil is generally discouraged after the first few weeks of flowering, to reduce the risks associated with: 1) lush vegetative growth and excessive reliance on mepiquat chloride to control plant height, 2) delayed maturity and difficulties with defoliation and harvest preparation, and 3) prolonged plant attractiveness to insects. In nonirrigated fields, uptake of soil-applied N after first bloom is normally expected to be quite limited.

Foliar N applications need to begin at first bloom and may continue through about the sixth week of flowering. The exact number of foliar applications has not been precisely determined. Weekly or every-other-week

applications of about 5 to 10 lb of N/A as urea solution, beginning at first flower, have given good results in responsive tests. Average response to foliar N fertilization at 60 to 90 lb of soil-applied N/A was 2.3 lb of lint/lb of N, as illustrated in **Figure 1**. Yield increases up to 7 lb of lint/A per pound of N have been reported in other studies.

Foliar N fertilization with a low biuret urea (i.e. feed grade urea) solution or other non-burning, low salt index N solutions can prevent yield loss caused by N shortage if detected and addressed in time. Urea solutions (< 23 percent N) have frequently been used and are preferred in some areas. Calcium nitrate solutions may be satisfactory as foliar N sources. Studies with labeled urea in Arkansas showed that 30 percent of the N applied to first position (next to the stalk) leaves was taken into the leaves within one hour of application and found in the adjoining bolls within six hours. Within 12 to 24 hours, most of the labeled N had moved from the leaves into the bolls, with little or none remaining in the stems or petioles (**Figure 2**).

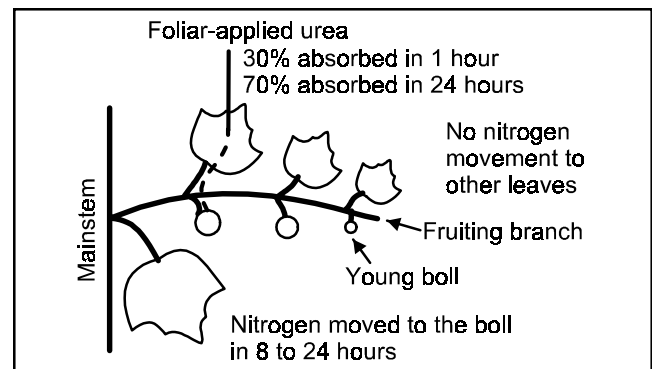


Figure 2. The uptake of foliar-applied urea by cotton leaves and movement to the boll. (From Oosterhuis and Zhu, 1989).

Potassium

Plants must take up 13 to 18 lb of K_2O/A for every 100 lb of cotton lint. Second only to N, K uptake by a two-bale cotton crop in the Midsouth is about 145 lb of K_2O/A . However, only 20 lb of K_2O/A are removed in each bale of cotton at harvest. Similar to N, during the peak demand period from 60 to 80 days after planting, K needs range from 3 to more than 4 lb of $K_2O/A/day$. With the development of a K shortage, roots suffer first, followed by above-ground tissues. So, by the time K deficiency symptoms are observed in the upper plant canopy, K shortages may have already impacted older tissues. The ability of plants to translocate significant amounts of K to young developing bolls will depend on: 1) the severity of the deficiency, 2) the growth stage at which K becomes limiting and the size of the boll load, 3) the amount of K stored in vegetative tissues, considered the plant "reservoir", and 4) the available soil moisture.

Earlier successes with foliar N fertilization and subsequent detection of K deficiencies after flowering (leaf discoloration, leaf diseases, and premature leaf drop) led to many studies evaluating cotton lint yield responses to K sources, K application timing, K rates, and K solution buffering. When soil K levels and fertilizer K rates are deficient for the crop's needs, foliar K fertilization can decrease injury from leaf spot diseases, increase yields, and improve fiber quality. However, when verticillium wilt is present, foliar K application has not decreased damage from the disease or tended to increase yields.

High soil-applied K rates are needed on low and medium testing soils (< about 250 lb Mehlich 1 or Mehlich 3 K/A) for several years to obtain the yield potential of the soil and limit losses associated with K deficiency. Recent research in west Tennessee has indicated that higher soil-applied K rates are probably needed for no-till cotton than for conventional till cotton. If soil-applied K rates are limited or low on low-testing soils (< about 150 to 160 lb of Mehlich 1 or Mehlich 3 K/A), foliar-applied K can improve yields in conservation tillage systems in west Tennessee. Foliar K proved profitable for at least two years (**Figure 3 and Figure 4**) even at relatively high soil-applied rates (as high as 120 lb of K₂O/A/year). Machinery and labor costs/A for foliar potassium nitrate (KNO₃) are estimated to be about \$9/A. Adding these costs to the cost of KNO₃ results in a total cost of about \$20/A for four weekly applications of 4.4 lb of K₂O/A.

Potassium nitrate and potassium sulfate (K₂SO₄) are the most commonly used K sources in the Midsouth region. When applied at 4.4 lb of K₂O/A in four weekly or biweekly applications beginning near first bloom, they have been the more consistent performers and are among the least likely to cause foliar "burn" injury from solution salinity on the leaf surface. Foliar K source studies have shown that buffering the spray solutions to pH 4 to 6 can improve the yield response among several different K

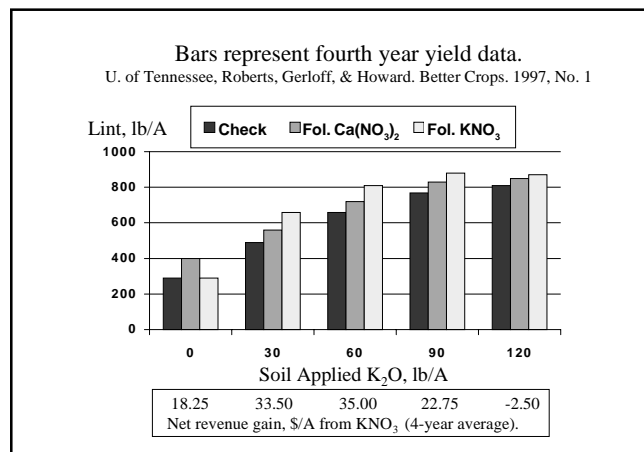


Figure 3. Cotton response to soil and foliar K fertilization in a conventional till system.

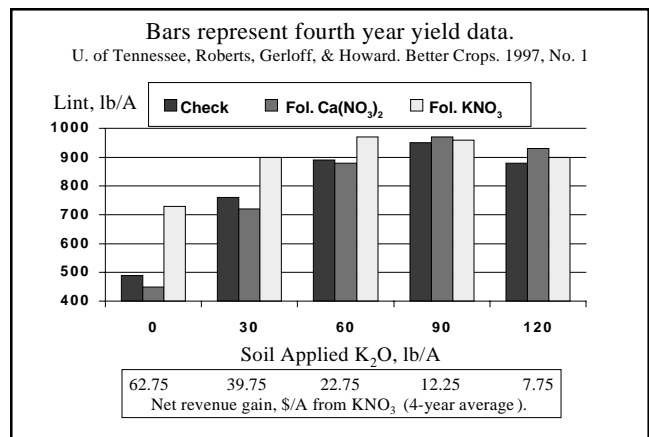


Figure 4. Cotton response to soil and foliar K fertilization in a no-till system.

sources (**Figure 5**). Potassium sources that elevate solution pH and which can cause leaf "burn", i.e. potassium hydroxide (KOH), potassium carbonate (K₂CO₃), potassium bicarbonate (KHCO₃) may not provide adequate K nutrition for optimum yield response.

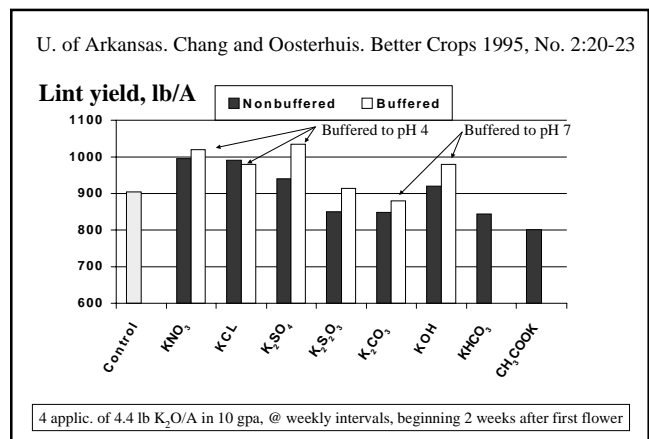


Figure 5. Cotton lint yield improves with foliar K solution buffering.

Mixing N and K Fertilizer Solutions with Insecticides

Foliar N or K fertilizers can be applied along with pyrethroid insecticides, but with special consideration. Research at the University of Arkansas has shown that the pyrethroid insecticide should be mixed with water first, before adding the fertilizer N and/or K solution. Failure to follow this mixing sequence can interfere with the action of the emulsifying agent and cause the insecticide to separate from the fertilizer solution and result in the insecticide "layering" on the surface of the tank mixture, poor insecticide application, and a possible reduction in insect control with this family of insecticides. However, when the pyrethroid insecticide was added to water first and then combined with the fertilizer solution under agitation, potential problems were eliminated.

Some organophosphate insecticides may be sensitive to elevated solution pH. Insecticide manufacturers should be consulted regarding compatibility questions before mixing any insecticides with fertilizer solutions.

Conclusions

Foliar N and K solutions may be applied to cotton beginning at first flower, at weekly or biweekly intervals, to increase yields or to prevent yield losses associated with N or K deficiencies. Most research has relied on three to four applications of 5 to 10 lb of N/A or 4.4 lb of K₂O/A in evaluating yield and physiological responses. Earlier work focused on applications two, four, six, and eight weeks after first flower. More recently, applications have been targeted at weekly intervals, beginning at first flower. These early-flowering applications are designed to: 1) supplement N and K needs provided through adequate soil application of N and K, 2) enhance uptake and utilization by leaves, before they mature and develop their waxy cuticle which limits nutrient absorption, 3) prevent the development of N or K deficiencies that could reduce individual boll weights of older more valuable bolls, and 4) avoid late season crop development that may conflict with timely harvest of the economical

fruiting sites. This strategy of foliar fertilization is consistent and compatible with use of the COTMAN cotton crop monitoring program (developed by the University of Arkansas). The COTMAN program can be used to detect abnormalities in cotton growth and development, to time economic termination of insecticide applications and to plan end-of-season harvest-aid applications for an optimum cotton-picking environment.

In a three-year study at 12 locations across the Cotton Belt, which involved low and high soil K levels with and without foliar K (Oosterhuis et al., 1994 Beltwide Cotton Conference Proceedings) numerical lint yield increases were frequently observed. Significant yield increases were measured 35 percent of the time.

Foliar application of N and/or K fertilizers can increase yields, but should only be considered as a supplement to a balanced soil-applied plant nutrition program, based on soil tests and realistic yield goals.

Perhaps the most important factor affecting the potential response to foliar N or K fertilization is the size of the boll load. If the cotton crop is healthy, insects are under control, soil moisture is adequate, and yield potential is good, cotton producers should consider foliar fertilization. ■

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