**ENVIRONMENTAL CONSIDERATIONS FOR COTTON FERTILIZATION**

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**Abstract**

Cotton (*Gossypium spp.*) fertilization is conducted primarily with agronomic objectives. These objectives are commonly oriented toward optimizing lint yield and quality by maintaining good plant nutrition and health. Economic objectives are also often considered in terms of optimizing the return on the investment (lint production in relation to dollars expended on crop fertilization). Another set of considerations that are important in the fertilization of a cotton crop is that of environmental impacts. Cotton is a dynamic crop with respect to growth and yield, and therefore, the management of the vegetative/reproductive balance is very important. Accordingly, crop fertilization is important in relation to managing crop vigor and yield potential. The nutrients that are most susceptible to having a negative impact on the environment are those that are mobile in the soil system such as nitrogen (N) and sulfur (S). There is experimental evidence that crop fertilization can be managed so that agronomic, economic, and environmental efficiencies can be optimized simultaneously. Efficient crop fertilization needs to take into account the soil fertility levels for a given field, in-season crop conditions (e.g. fruit retention, vigor, and fertility status), stage of growth, and crop-specific nutrient demand characteristics. Providing applications of appropriate nutrients in-season can provide a good means of maintaining plant nutrition and fertilizer efficiencies.

## Introduction

The primary goals of nutrient use for crop production include: 1) to achieve cost-effective production of high-quality plants; 2) to have efficient use and conservation of nutrient resources; 3) maintain and enhance soil quality; and 4) protect the environment beyond the soil. The potential problems that can stem from crop fertilization are often the result of inefficient uptake and recovery of the nutrients by the crop due to inappropriate timing or over-fertilization. In both cases, nutrients can be lost to the environment.

There are several concepts that are key to conserving nutrients in a soil-plant system. The first consists of making an assessment of the plant-available nutrients present in the soil by means of appropriate soil tests. It is important to use soil test procedures that are properly correlated and calibrated with proper indices for the soils and crops in question. It is also important to make nutrient applications in line with crop uptake and utilization patterns. Therefore, the time (stage of crop growth), method, and rates of application are all very important in achieving optimum crop uptake and utilization of the applied nutrients.

The nutrients that are the most susceptible to loss to the environment are those that are mobile in the soil such as nitrate-N ($NO_3^-$ -N) and sulfate-S ($SO_4^{2-}$ -S). Due to their mobility in the soil, these nutrients are subject to losses from the soil-plant system through leaching. Leaching of nutrients will occur with percolating water downward through the soil profile. Leaching and percolation will occur only under saturated soil conditions. Therefore, nutrient and water interactions in the soil system are very important in this respect. Proper management of crop fertilization and soil-water relations are important in a rain-fed cropping system and even more critical with irrigated systems.

## Background

Olson and Kurtz (1982) described plant use and efficiency of fertilizer N as a function of: 1) time of application, 2) rate of the N applied, and 3) precipitation and climate-related variables. They also related maximum fertilizer N efficiency to the latest application being compatible with the stage of crop development associated with maximum uptake. Therefore, information pertaining to crop N requirements (e.g. amount of N needed to produce a given unit of yield) and the uptake and utilization patterns for the crop in question are considered as fundamental to developing N management strategies that optimize uptake and efficiency. With respect to cotton fertilization, McConnell et al. (1996) and Boquet et al. (1991) found that a nutrient balance approach to N management provided the best results in terms of fertilizer N uptake and recovery in both irrigated and dryland conditions. They point out the fact that over-fertilization of cotton with N can produce plants with excessive vegetative growth without gaining additional yield, in addition to providing a greater potential for loss of the N from the soil-plant system.

Uptake and utilization of N by cotton has been described in a number of crop production environments and conditions (Bassett et al., 1970; Halevy, 1976; Mullins and Burmester, 1990; and Unruh and Silvertooth, 1996). Results from these and other studies have provided estimates of N utilization by cotton. Approximately 60 to 70 lbs. N (per acre) are commonly used as estimates for the production of one bale (480 lbs. lint) of both Upland (*G. hirsutum* L.) and American Pima (*G. barbadense* L.) cotton. Peak periods of uptake and utilization of N by a cotton crop commonly occur near the formation of the first pinhead square (PHS) and again near peak bloom (PB). Silvertooth et al. (1991) found that the greatest potentials for losses of $NO_3^-$ -N in an irrigated cotton production system in Arizona occurred

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with pre-plant applications of fertilizer N and also with those occurring late in the season (after PB). These results were further corroborated in subsequent studies in Arizona (Navarro et al., 1997 and Norton and Silvertooth, 1998) that also demonstrated greater levels of N use efficiency with split applications. Work in several parts of the U.S. cottonbelt with long-term N management studies have also demonstrated the value of split applications of fertilizer N in-season for optimizing cotton fertilization (Maples et al., 1990; McCarty and Funderburg, 1990; Robinson, 1990; Tracy, 1990; Silvertooth and Norton, 1998a and Silvertooth and Norton, 1998b). Therefore, N fertilizer management recommendations for cotton commonly include the utilization of split applications of fertilizer N in-season.

In an effort to evaluate the relative efficiencies of fertilizer N applications at several stages of growth, Silvertooth et al. (1998) provided applications of fertilizer N labeled with $^{15}N$ to cotton in irrigated cotton production systems in Arizona. Applications of labeled fertilizer N were made at three stages of growth consisting of PHS, early bloom (EB), and PB at a constant rate of application (50 lbs. N/acre) with a sidedress method of application. Rates of total N uptake and percent $^{15}N$ recovery did not differ significantly for the N fertilizations made among these three stages of growth. These results support recommendations to split applications of fertilizer N between PHS and PB to realize optimum efficiencies in cotton production systems.

## Conclusions

Current N management recommendations in many cotton producing regions (McConnell et al., 1996 and Silvertooth and Norton, 1998c) include the use of split applications of fertilizer N. In Arizona fertilizer N applications are recommended between PHS and PB (referred to as the "N application window") in relation to crop condition (fruit retention, vigor, and N fertility status) and previous amounts of fertilizer N applied in-season). Utilizing stage of growth and crop condition in N fertilization is an important application of the crop monitoring systems that are being developed in many cotton producing regions (Bourland et al., 1992; Kerby et al., 1997; and Silvertooth and Norton, 1998c). The accuracy of these crop monitoring systems in relation to stage of growth and management practices such as N fertilization, are improved markedly in many cases with the use of heat unit (HU) systems to predict crop phenology (Brown, 1989).

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