Dr. D. R. Krieg

Will Continuous Supply of NH_4^+-N Increase Irrigated Crop Production?

Results of studies in the Texas South Plains showed positive responses with cotton but not sorghum.

Summary: *Purpose of this project was to determine if maintaining a relatively high supply of ammoniacal nitrogen (NH_4^+-N) throughout the major demand period of agronomic crops would reduce the biological cost of nitrogen (N) acquisition and reduction, allowing more of the daily photosynthate to be used for growth. Results obtained from our studies supported this hypothesis in the case of cotton but not for sorghum. The two species differ in photosynthetic systems with the C-4 system of sorghum being more effective than the C-3 of cotton. The two species also differ in N concentration per unit of dry matter production with cotton being higher than grain sorghum. Fertigating a majority of the crop N requirements makes good sense. Providing the proper NH_4^+:NO_3^- ratio for the most efficient use of N supply also increased yield and the efficient use of both water and N, the two most expensive inputs of irrigated agriculture.*

Specific objectives of this project included:

- Determining growth, yield, and quality of several crop species differing in chemical composition as a function of NH_4^+:NO_3^- ratios in the fertilizer solutions applied with each increment of irrigation water (center pivot).
- Determining N and water use efficiency as a function of both water supply & N form in the water.

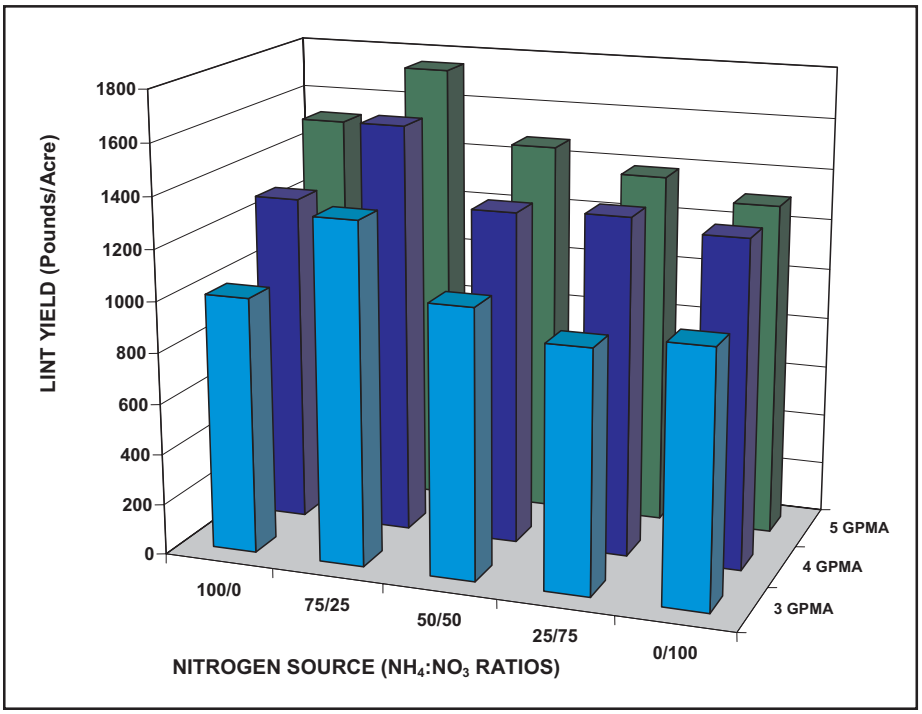

Figure 1. Lint yield response to N source in Texas South Plain studies, 2001-2002.

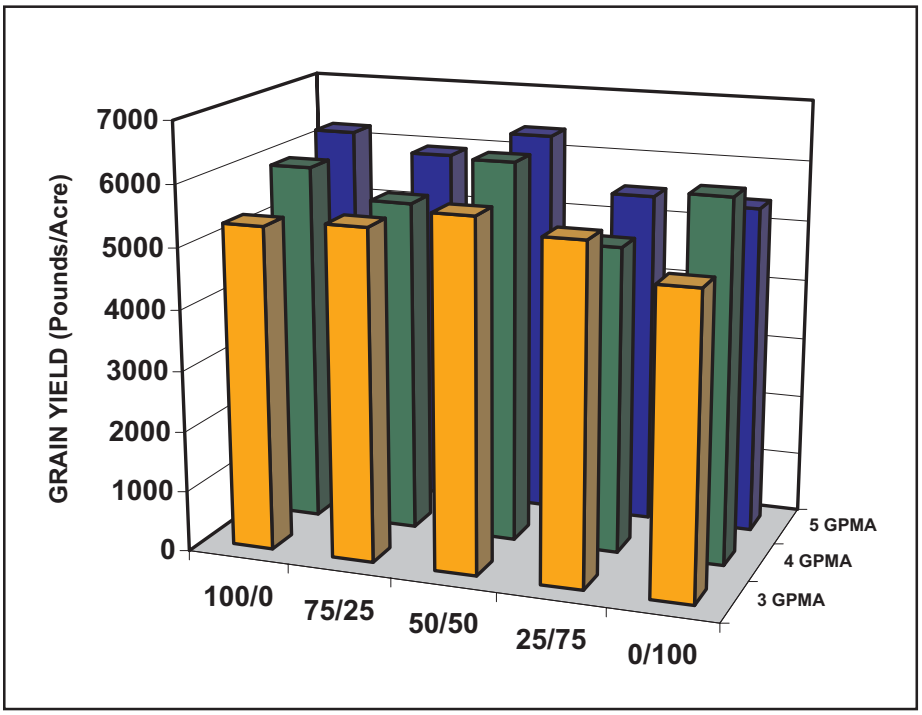

Figure 2. Grain sorghum yield response to N sourcein Texas South Plain studies, 2001-2002. GPMA = gallons per minute per acre.

Introduction

Although N exists in various forms in the soil system, the vast majority of land plants take up N as nitrate (NO_3^-). This is primarily because in warm, moist soils with adequate aeration, soluble N is rapidly oxidized to NO_3^- by the bacterial system. Nitrate-N has to be reduced in the growing plant before it can be incorporated into amino acids for protein synthesis or incorporated into other organic-N compounds. The reduction process requires 8 e^- for each NO_3^- molecule—the equivalent of a half mole of glucose (3 reduced carbon [C] molecules). This is not only very expensive, from an energy standpoint, but reduces the amount of reduced C that could be used for dry matter assimilation by the plant. The concept is well recognized and extensive research for the past 25 years has been directed toward nitrification inhibitors, which are primarily aimed at the bacterial population. The effort has been less than successful.

The use of center pivot irrigation in the Great Plains offers a possibility to enhance N-use efficiency (yield per unit of applied N) and, in many cases, water-use efficiency (yield per unit of water supply) by optimizing the NH_4^+:NO_3^- ratios in the irrigation water being applied. We have previously conducted hydroponics studies with cotton and tomato and found that a 3:1 NH_4^+:NO_3^- ratio produced the greatest growth rates. We have also determined that cotton requires 5 to 6 pounds of N for each inch of water it has available for maximum productivity of lint and seed within the constraints of the temperature environment.

Cotton response

We proposed to determine whether we could enhance productivity and product quality by managing the NH_4^+:NO_3^- ratios through frequent fertigation using center pivot irrigation systems.

The project was conducted from 2000 to 2002 on a sandy loam soil in West Texas. The three years differed significantly as to weather and insect problems (2000 was the worst, 2002 the best). A center pivot was nozzled such that each span applied different volumes of water ranging from 3 gallons per minute per acre (GPMA) to 5 GPMA. These volumes represent 0.15, 0.20, and 0.25 inches/day replacement. Nitrogen solutions ranging in NH_4^+:NO_3^- ratios were injected at a rate of 10 lbs N/inch of water beginning at the onset of reproductive development and continuing through the third week after flowering.

Cotton yields differed between years and water supplies within years as expected. Lint yields showed a consistent response to N source across years and water supplies (Figure 1). The 75:25 NH_4^+:NO_3^- ratio produced the highest yields. The 0:100 NH_4^+:NO_3^- ratio produced the lowest yields. The yield response to N source was due to N form rather than quantity. The sources with increasing NO_3 levels had no opportunity to leach out of the root zone during the growing season. The 75:25 NH_4^+:NO_3^- ratio source was 32-0-0 and made this source not only the best from a yield perspective but also from an availability perspective.

Water supply has always altered yield due to change in boll number. We were expecting N source to have its primary effect on boll size but that was not the case. Retention of fruit was the cause of increased boll number due to N source, which supports our hypothesis that reducing the energy requirement for N acquisition and reduction should provide more reduced carbon (C) for growth.

Sorghum response

Grain sorghum yield response to N source was not as defined as observed in cotton (Figure 2). In general, the 50:50 ratio produced the highest yields, but not by a statistically significant amount. The N demand per unit of dry matter gain was less for sorghum than for cotton. Therefore, the cost of N acquisition and reduction may not have been a yield deterrent.

Dr. Krieg is professor of crop physiology in the Plant and Soil Science Department of Texas Tech University. ❑