IMPACT OF DROUGHT AND HIGH NITRATE GROUNDWATER ON RESIDUAL SOIL NITROGEN

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Abstract

Drought can lead to reduced crop yields and elevated residual nitrate (NO_3) levels in the soil in cases in which nitrogen (N) was applied pre-drought. This may be exacerbated on irrigated acres if groundwater high in NO_3 exists. The objective of this research was evaluate the practice of accounting for existing N in irrigation water toward crop needs and the subsequent impact on crop production and N levels in the soil profile. Five fertility treatments were evaluated: 1) control; 2) N; and 3) N plus P not accounting for NO_3 in well water; 4) N; and 5) N plus P accounting for NO_3 in well water under subsurface drip and center pivot irrigation systems. Nitrogen applications were significantly reduced without compromising lint yields when well water NO_3 was credited. During the 2011 drought season, naturally occurring NO_3 in the well water provided more than 100% of crop N requirements. As a result, residual soil NO_3 levels increased, leading to greatly reduced N fertilizer application entering the 2012 season. Accounting for NO_3 in well water, as well as residual soil NO_3, can provide substantial economic savings to producers.

Introduction

The Seymour Aquifer has the highest median NO_3 concentration among nine major aquifers in Texas (13.5 mg NO_3-N L^{-1}, Hudak, 2000). Recent research has indicated that NO_3 levels have persisted, perhaps increased, over the last 40-50 years (Chaudhuri et al., 2012). As these levels exceed the EPA Safe Drinking Water Standards (10 mg NO_3-N L^{-1}), environmental concerns usually receive the most attention. However, these elevated NO_3 levels could provide a benefit to producers of irrigated cotton. A two-year study in Colorado concluded that when properly used, NO_3 crediting is a sound economic and agronomic practice (Bauder and Waskom, 1999). Thus, our hypothesis is that accounting for well water NO_3 toward crop N requirements can reduce fertilizer N inputs and subsequently reduce residual soil NO_3 and the risk of NO_3 leaching.

Materials and Methods

A study was initiated in 2010 at the Texas A&M AgriLife Chillicothe Research Station (CRS) near Chillicothe, TX. Plots within subsurface drip (SDI) and pivot systems (LESA) were 8 rows (40" row spacing) x 50 ft long. Fertility treatments included: 1) control (N from irrigation water only); 2) N applied based on soil testing and yield goal, disregarding NO_3 content in the well water (uncredited N); 3) N and P application based on soil testing and yield goal disregarding NO_3 content in the well water (uncredited N&P); 4) N application accounting for NO_3 in well water (N-credit); and 5) N and P application accounting for NO_3 in well water (N&P-credit). Treatments were replicated four times within each irrigation system in a randomized complete block design. Liquid fertilizer was applied pre-plant over the entire plot area to achieve a uniform application and incorporated. All plots were irrigated with a goal to achieve 100% ET replacement based on data obtained from the High Plains ET network. Water samples were collected weekly and analyzed for NO_3. Each plot was mechanically harvested and processed to determine lint yields.

Results and Discussion

Entering the 2010 growing season, residual soil NO_3 to a depth of 24" was 20 lb/ac. For uncredited N treatments, 130 lbs N/ac (150 lb crop need – 20 lb soil NO_3) were applied compared to 75 lb N/ac for credited treatments (Table 1). Based on historical data, it was assumed that approximately 12 ac-in of irrigation water would be applied. At CRS, 12 ac-in water would supply 55 lb N/ac (20 mg/L NO_3 in well water * 0.23 * 12 ac-in = 55 lb N/ac). In 2012, no differences in lint yield were observed among credited and uncredited N treatments (Figure 1). This initial year of the study indicated that NO_3 in the well water was being used by the plants.

Table 1. Applied fertilizer N for credited and uncredited treatments and the annual supply of N applied through irrigation water.

Irrigation System	Applied Fertilizer N when **NOT** accounting for Well Water NO_3 (lb/ac)†	Applied Fertilizer N when accounting for Well Water NO_3 (lb/ac)	N Supplied Through Irrigation Water (lb/ac)
2010			
SDI	130	75	49
Pivot	130	75	40
2011			
SDI	110	65-75	120
Pivot	130	80	131
2012			
SDI	0	0	68
Pivot	80-90	35-50	72

†Included rates for N only and N plus P treatments. P was added at equal rates across irrigation system each year.

Fertilizer application rates in 2011 were similar as 2010 (Table 1). Growing conditions during 2011 were characterized by an exceptional drought, leading to below normal lint yields and above average irrigation requirements. There was no response to N fertilizer additions compared to the control, which only received N from naturally occurring NO_3 in the well water (Figure 1). As presented in Table 1, NO_3 in the well water provided 120 lb N/ac in the SDI system and 130 lb N/ac in the pivot system. Hence, more than 100% of crop N requirements were met due to elevated NO_3 concentrations in the well water. As may be expected, this resulted in an increase of residual soil NO_3 concentrations (Figure 2). The increase was more dramatic in the clay loam soil of the SDI system compared to the pivot system consisting of a sandy loam soil. In addition, water was applied daily in the SDI system compared to 1 to 2 times per week in the pivot system. Heavier, more infrequent irrigations in the pivot system could also increase leaching potential compared to the lighter, frequent irrigation pattern in SDI.

As residual soil NO_3 increased after the 2011 growing season, fertilizer N applications were dramatically reduced in 2012 (Table 1). Within SDI, no fertilizer N was applied. As expected, there was no treatment effect on lint yield within the SDI system. Within the pivot system, yields remained similar among N treatments, indicating use of well water NO_3 by the crop. For the CRS location, N applications were reduced by 55 lb/ac when accounting for well water NO_3 toward crop N needs. Based upon summer 2012 quotes for UAN (28-0-0) placing N costs at \$0.79/lb, 55 lb N/ac is valued at \$43.45/ac

Summary

In our study, N applications were reduced by as much as 56% when accounting for well water NO_3 toward crop N needs without reducing lint yields. During the 2011 drought, when yields were well below estimated yield goals and irrigation requirements were greater than expected, NO_3 in the well water supplied 100% of the crop N needs. As a result, there were no differences among treatments and residual NO_3 levels increased. This increase was more dramatic in clay loam soils within SDI than sandy loam soils within the pivot system. Crediting well water NO_3 toward crop N requirements can provide substantial savings in fertilizer costs and reduce the risk of leaching without compromising cotton lint yields. For cases in which yield goals are not achieved and/or elevated NO_3 in well water is not accounted for, NO_3 levels in the soil can rapidly buildup or leach through the profile.

Acknowledgements

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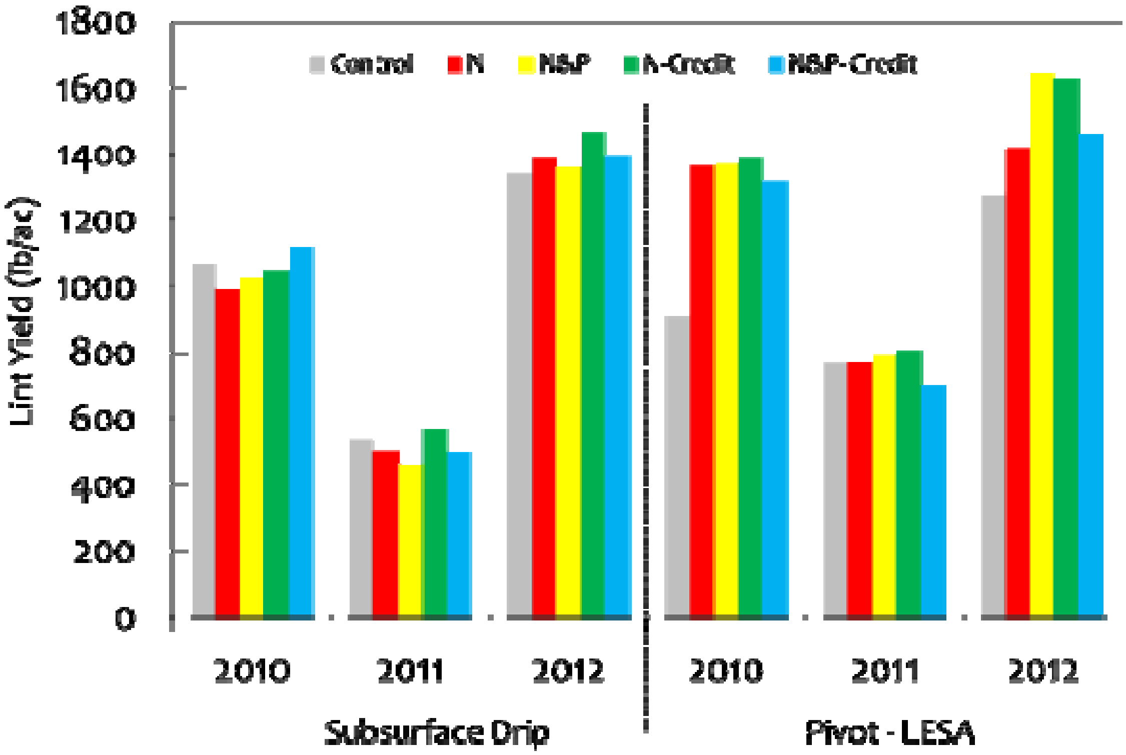

Figure 1. 2010-2012 lint yields for SDI and Pivot irrigation systems.

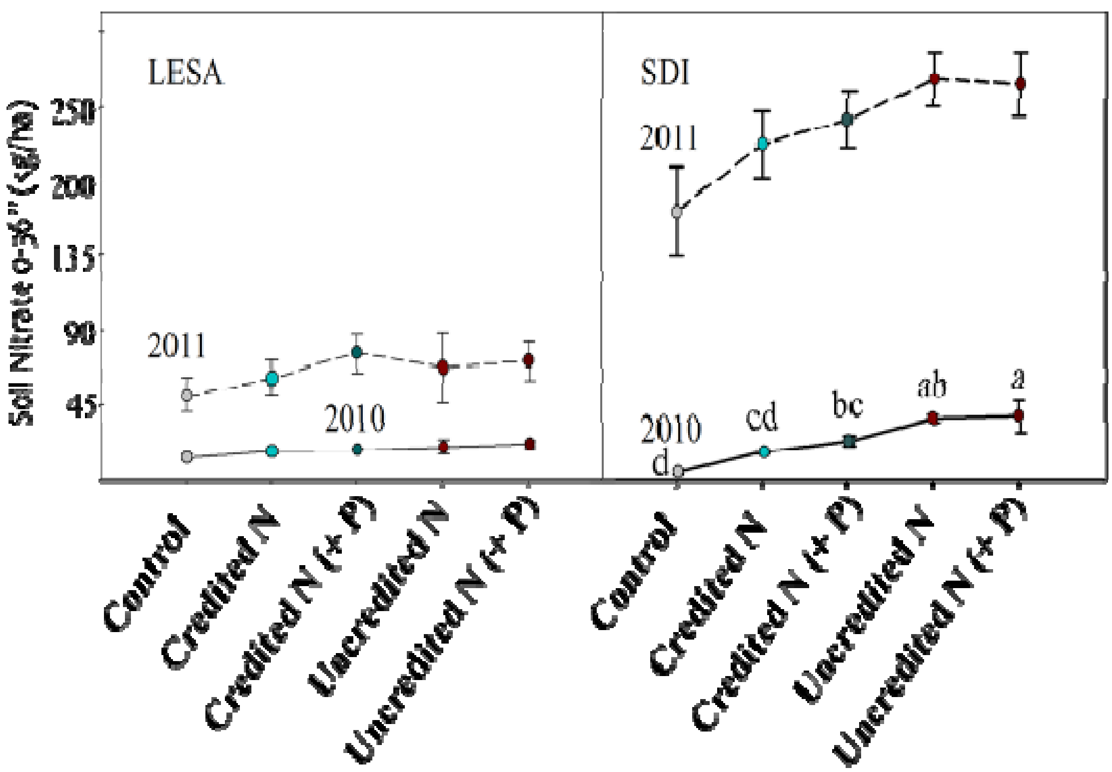

Figure 2. Residual nitrate in the soil profile to a depth of 36" following the 2010 and 2011 growing seasons.

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