USING IRRIGATION NITROGEN CREDITS FOR GRAIN CROPS

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ABSTRACT

Nitrogen contamination of surface and groundwater is not uncommon in many areas of the U.S. and Colorado is no exception. Nitrate-nitrogen (NO_3-N) in groundwater is the most common form of plant available nitrogen (N), especially in shallow, alluvial aquifers in areas with intensive irrigated agriculture. When utilized as a primary irrigation water supply, this nitrate can contribute a significant portion of a crop's N supply. Crediting water nitrate is part of Colorado N fertilizer recommendations and nutrient management plans, but growers require reliable data to credit this significant N source. We conducted replicated strip and small plot field trials to verify the benefit of high nitrate irrigation water to production and quantify a fertilizer credit. Nitrogen fertilizer rates were adjusted at 13 sites years to represent from zero to 100 percent of potential water N credit based upon the CSU N fertilizer algorithm. Cooperating farmers applied irrigation water and grew grain corn (*Zea mays*) according to their usual methods. Grain yield results from 1998 to 2005 showed that crediting 100 percent of consumptive water use prior to R3 growth stage did not significantly ($P<0.05$) reduce yields when potential was at or below yield expectations. Yield responses to additional fertilizer N were obtained when actual yields exceeded yield goals. Farmers met or exceeded their credit with irrigation water nitrate applied each year. Our results suggest that growers can credit up to 60 percent of seasonal consumptive use (approximately 15 inches) of water NO_3-N and maintain their yield goal with careful management.

INTRODUCTION

According to the U.S. Census Bureau, the estimated human population of the planet Earth has surpassed seven billion (U.S. Census, 2012). Two things that are universally true about this situation are that each and every one of these people will require food and clean water for survival. Nutrient use in agriculture is closely tied to meeting both of these basic needs. Replenishment of N to the soil system from crop removal is not only necessary for productive crops, it is also essential for the sustainability of the soil resource. While N is ubiquitous in the environment as N_2 gas, reactive Nitrogen (Nr) is the most limited nutrient for biological systems and includes reduced and oxidized forms in the environment. In most systems, Nr can be a potential pollutant for both surface and groundwater. Due to its solubility and use as a plant nutrient form, the nitrate ion (NO_3^-) form of nitrogen has been a primary concern (USEPA, 2011). Given their necessity for profitable crop production and mobility in the environment, water quality impairments from agricultural use of nutrients, primarily N and P have been well-documented and researched in many environments and cropping systems. The state of Colorado is no exception in regards to potential and current nutrient impairment of water resources from agricultural sources, especially with regards to NO_3-N contamination of groundwater (Colorado Department of Agriculture, 1998, 2000, 2002; and Bauder, et al., 2008).

Properly crediting all sources of N (legumes, manure, organic matter) in a crop N budget is considered an appropriate approach to calculating accurate fertilizer applications rates for corn (Waskom and Bauder, 2012). This approach, combined with improved irrigation management is critical to minimize nitrate leaching in irrigated systems (Ferguson et al., 1990). The adoption of water N crediting has encountered some problems in the past that have resulted in some growers discounting its reliability. Past problems with this practice include an overestimation of how much N was appropriate to credit; incomplete or ambiguous recommendations by Extension agents and crop consultants; growers using mixed water sources (surface and ground) with differing N contents; and recommendations for crediting that included irrigation amounts that don't occur during active uptake period. Another psychological barrier for adoption was that unlike fertigation, growers cannot 'see' the N in water being applied as they irrigated.

Given these circumstances, the objectives for this work were to 1) Verify the benefit of high nitrate irrigation water for crop production; 2) Quantify the appropriate N fertilizer credit for corn (Zea mays); and 3) Increase the adoption of this practice by improving the confidence of producers that they can rely on irrigation water nitrate to meet a portion of crop N requirements.

METHODS

On-farm small plot and replicated large strip field trials were conducted in Weld County, Colorado for both research and demonstration purposes. Strip trials consisted of 4 to 8 row (30-inch) field strips of 200' to 1300' in length. These strips are replicated, usually two to three times within a field. Cooperating farmers typically provided all agronomic management of field trials (planting, cultivation, irrigation, etc.). All sites utilized for this report were furrow irrigated. Yield results are obtained from weigh pads or a weigh wagon.

Nitrogen fertilizer rates were calculated using the Colorado State University Extension N fertilizer recommendation (Davis and Westfall, 2009): N recommendation = [(1.2 x yield goal) + 35] - (yield goal x 0.14 x % OM) - (8 x avg. soil NO_3-N) - other credits (water, legume, manure).

The water credit was calculated using 0 to 15 inches of irrigation and the fertilizer N rates were varied with the credit subtracted from the gross N recommendation. The NO_3-N concentration of water sources ranged from 10 to 85 milligrams per liter (mg/L or ppm). The highest irrigation water nitrate credit was based upon crop evapotranspiration (ET) from planting until the R3 growth stage of corn. Small plot treatments were no water credit, ½ credit and a full irrigation water credit based on up to 15 inches of ET.

The irrigation N credit was calculated with the following formula:

Irrigation water N credit (lbs/acre) = depth of water applied (inches) x 0.225 x NO_3-N (ppm)

Nitrogen fertilizer was typically applied at sidedress (minus farmer applied starter fertilizer) at the V4 – V8 growth stage utilizing urea ammonium nitrate fertilizer (UAN 32). Small plot site experimental design was a randomized complete block design with four replications. Small plots were hand-harvested. Ear leaf chlorophyll was measured at R1 for small and strip plot sites. Irrigation was samples were taken at 2-3 intervals throughout the growing season. Furrow flumes with data loggers were used to measure and record irrigation inflow and outflow at each site.

RESULTS AND DISCUSSION

Irrigation water N applied ranged from 65 to 255% of the calculated N credit for the farmer estimated yield goal. The amount of irrigation water N applied prior to R3 was less than the calculated N credit to meet yield goals only twice (1999 and 2001 TW). Only one site year (1999, TW) did not receive the estimated irrigation water N credit based upon the full irrigation season.

Strip-plot yields – Cooperating farmers achieved high grain yields for the area (171 - 258 bu/acre) in the sites years analyzed. Yields generally exceeded the expectation (goal) utilized to calculate fertilizer rates. Because irrigation water N applied exceeded calculated water credit during most years, no sites were responsive to N fertilizer rates above the highest N credit. No significant ($P < 0.10$) differences in relative yield were found between water N credit ranges when compared across all seven site years (Figure 1).

Small plot yields - Grain yields for the small plots also exceeded the yield goal in all treatments that were the basis for the fertilizer N rates during four of the six site years. Because yield potential was greater than expected during, we found significant responses in grain yield at two of the sites. Relative yield (Figure 2) significantly decreased with increasing water N credit when compared across sites years at two of the site years. These years had growing seasons with exceptional yield potential and water N applied was insufficient to keep up with N demand for yield potentials well above yield goals. However, the yield goals were realized with the fertilizer applications as calculated at all site years.

Implementing irrigation water nitrate crediting requires a good understanding of ET requirements of the crop for an area and its management by the producer. Approximately 75% of N uptake in corn occurs before the R1 (silk) growth stage in corn (Figure 3). Crediting N from irrigation events later in the season is currently not part of Colorado's recommendations and should be approached with caution. Colorado's approach is to suggest the N credit be applied to crop ET from emergence to R2. The actual amount varies within the state by climate and amounts to 12 to 15 inches of water (Bauder and Waskom, 2003). For producers and consultants wanting to error on the conservative side of the N crediting, subtracting average precipitation from the credited amount is appropriate, particularly in wet years or where mid and late season N application (fertigation) is not practiced. Relying on the irrigation water supply for all of a crop's N requirements, even with very high NO_3-N concentrations is not recommended. The ET demand of the crop is going to lag behind the N requirement during peak uptake.

Sampling the irrigation source several times through-out the growing season is suggested until a pattern of N concentration can be established. Shallow, alluvial wells that fluctuate widely with regard to depth to water during the growing season are more likely to also fluctuate in N content than deeper, nonalluvial aquifers. Surface water systems, particularly those downstream of municipal dischage may contain N in ammonical form as well as nitrate, but are generally limited by discharge permit requirements to amounts lower than are practical to credit. Likewise, surface water from agricultural return flows may contain some plant available N, but quantifying amounts may not be feasible unless frequently montitored at the source.

SUMMARY

Strip and small plot research trials in Northeast Colorado verified the benefit of irrigation water nitrate to corn N fertility requirements. Reducing N rates to account for nitrate in irrigation water only significantly reduced yields at site years where actual yields exceeded the predicted yield goals. Results suggested that growers can credit at least 60 percent of seasonal consumptive use (15 inches) of water NO_3-N without compromising yield potential in average yielding

growing seasons. In years when yield potential exceeds yield goals, higher water credit may reduce yield.

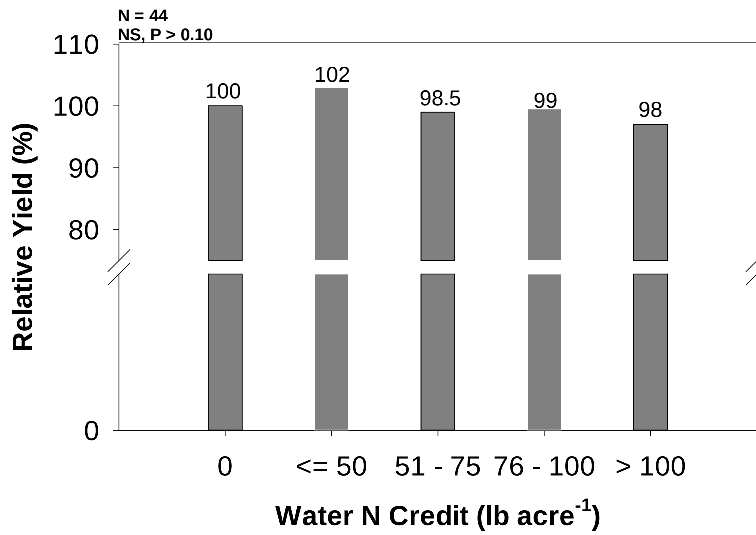

Figure 1. Relative yield of strip plots as affected by increasing irrigation N credit over seven sites years.

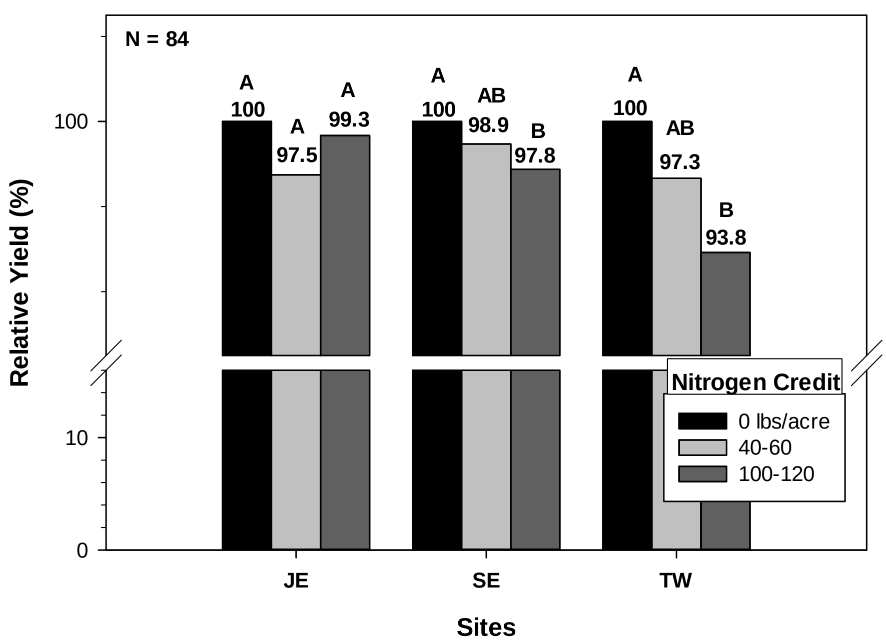

Figure 2. Relative yield of small plots as affected by increasing irrigation water N credit at three sites. TW site is the average of three years, JE and SE one year each**.**

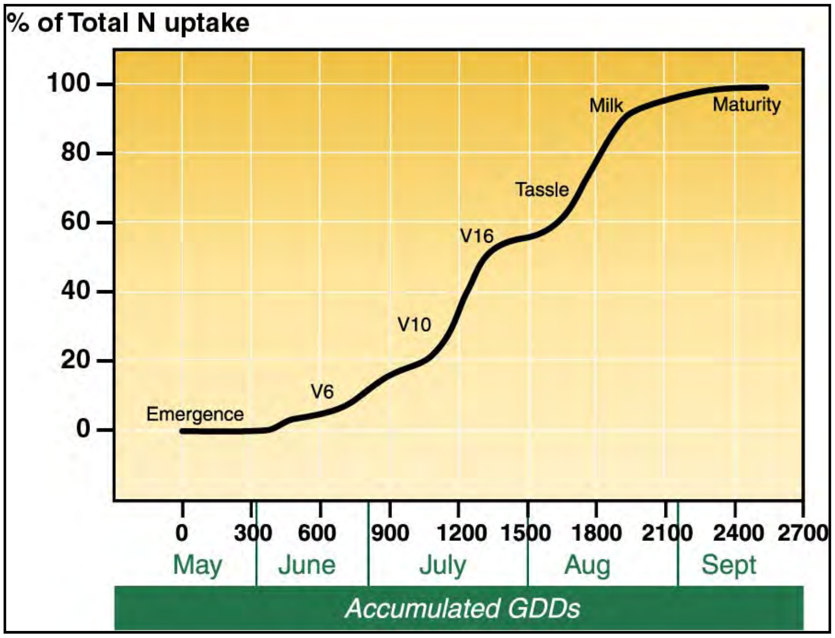

Figure 3. Percent N uptake for corn from planting to maturity.

While this work was useful in evaluating N credits for furrow-irrigated grain corn, additional research for other crops with different irrigation requirements and N uptake patterns is necessary. Utilizing irrigation water N credits for ET during the entire crop growing season and water credits when using higher efficiency irrigation water systems such as center pivot and drip irrigation should also be evaluated.

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