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RESPONSE OF IRRIGATED CORN TO NITROGEN FERTILITY LEVEL WITHIN TWO TILLAGE SYSTEMS

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ABSTRACT

Irrigated farmers generally utilize intensive tillage to manage crop residues and prepare a seedbed for corn. Nitrogen fertilizer management practices have been developed for conventional-till (CT) irrigated corn production. Little information is available for no-till (NT) and reduced-till (RT) irrigated corn production systems. This paper compares the response of irrigated continuous corn to N fertility level under CT and NT or RT production systems on a Fort Collins clay loam soil from 1999 through 2001. Grain yields increased similarly with increasing available N level [soil NO_3-N (0-3 ft) plus fertilizer N added] in 1999, 2000, and 2001 for both tillage systems. The CT corn yields were greater than the RT or NT corn yields in 1999 and 2001, respectively. Based on the results from this study, similar N levels were required for optimum corn yields in all tillage systems. Additional years of data are needed to determine if NT will require a higher level of N fertilizer input than CT to optimize corn grain yields. Current N fertilizer recommendations for CT irrigated corn production would appear to be adequate for irrigated NT corn production.

INTRODUCTION

Irrigated farmers generally utilize intensive mechanical tillage practices to manage crop residues and prepare a seedbed, resulting in loss of soil C and a high potential for soil erosion (both wind and water) following fall tillage through the winter and spring months. Minimum- and no-till management systems have potential to reduce soil erosion and increase soil C sequestration in irrigated crop production systems. These systems may improve water and nutrient use efficiency by reducing evaporative losses from the soil surface and allowing more efficient infiltration of applied water. Managing N fertilizer to optimize N use efficiency and crop yields may reduce the potential of leaching nitrate-N below the crop root zone. Information is limited on the effects of N management and crop rotation on crop yields, C sequestration, N use efficiency, and nitrate leaching potential when utilizing minimum- and no-till systems under irrigation. Therefore, a study was initiated in 1999 to evaluate the effects of no-till on irrigated corn production and N fertilizer requirements for optimum yield compared to conventional tillage practices.

The study initiated in 1999 had the following overall objectives: a) determine effects N fertilization and crop rotation on irrigated crop productivity, economics, soil erosion potential, C sequestration, nutrient and water use efficiency, and nitrate leaching potential under a no-till environment; b) determine tillage (conventional plow vs no-till) and N fertility effects on irrigated, continuous corn yields and soil erosion potential, nitrate leaching potential, and soil C sequestration; c) determine the fate of fertilizer N within cropping and tillage systems using ^{15}N labeled fertilizer;

and d) determine changes in soil quality/productivity parameters over time. This paper reports the response of irrigated continuous corn to N fertilizer application under no-till and conventional-till environments during the first 3 years of the study.

MATERIALS AND METHODS

The crop rotations and N fertility treatments were established in 1999 on an irrigated Fort Collins clay loam soil in block 200A at Agricultural Research, Development, and Education Center (ARDEC) north of Fort Collins, Colorado. The no-till (NT) plot area had been in conventional-till (CT) continuous corn for several years. The NT continuous corn rotation included six N rates (0, 30, 60, 90, 120, and 150 lb N/a) in a randomized complete block design with three replications with the same N rate being applied to the same plot each year.

The CT continuous corn rotation used mechanical tillage (stalk shredder, disk, plow, mulcher, land leveler, etc.) for seed bed preparation and cultivation plus herbicides for within crop weed control. Four fertilizer N rates (0, 60, 120, and 150 lb N/a) with four replications were included in the CT phase of the study in 2001. The CT 1999 and 2000 N rates varied slightly from the 2001 treatments, but had a N fertility range similar to the NT plots with four replications.

Herbicides were used for weed control in both tillage systems. Nitrogen (UAN, 32%) was banded below the soil surface just prior to planting of the crop in 2000 and 2001 in both tillage systems. In 1999, urea was banded below the soil surface for each of the N treatments (80, 160, and 200 lb N/a) in NT. UAN was banded over the seed row prior to planting and watered into the soil just after planting in 1999 and 2000 in the CT plots. A banded (7" spacing, 2 inches deep) application of 0-46-0 was applied at a rate of 50 lb P/a prior to planting the 1999 crops in both tillage systems. In 2000, 5 gallons/acre of liquid 8-20-5-5 plus Zn (about 4-12-3-3 lb nutrient/a plus Zn) was banded 2 inches to the side of the corn seed as a starter fertilizer in both tillage systems.

Residual soil NO_3-N was determined prior to N application each crop year. The soil NO_3-N level in the 0 to 3 ft soil depth was added to the fertilizer N rate to obtain an estimate of total available N supply for each N treatment. Soil residue cover after planting was measured in 2000 and 2001 on each plot using the line-transect method. In 1999, a reduced tillage system was used rather than NT in order to level out the furrows and ridges created with cultivation of the 1998 corn crop. The reduced tillage system was disked once at a 2 to 4 inch depth and mulch treaded before planting in 1999. This became the NT system in 2000 and 2001.

Growing season precipitation (May through September) totaled 8.73, 4.78, and 5.17 inches for 1999, 2000, and 2001 respectively. In 1999, 10 irrigations totaling 16.6 inches of water were applied to the corn. In 2000, 13 irrigations totaling 17.2 inches of water were applied to the CT corn plots and 11 irrigations totaling 14.6 inches of water were applied to the NT corn plots. In 2001, 11 irrigations totaling 18.1 inches of water were applied to the corn crop.

The corn crops were planted on May 14, 1999 (Pioneer 3790), April 27, 2000 (Pioneer 38B22Bt,LL), and on April 30, 2001 (DeKalb 440RR/YG). Grain yields were measured at physiological maturity in October each year by collecting the ears from two 25 ft long rows per plot. The corn was shelled and grain yields are expressed at a 15.5% water content.

RESULTS AND DISCUSSION

Soil residue cover (using line transect method) after corn planting averaged 78% for NT and 20% for CT systems in 2000. In 2001, crop residue cover after corn planting was 88% for NT system and 12% with the CT system. These residue data demonstrate the value of the NT system in maintaining crop residue on the soil surface compared to the CT system. The potential for reducing soil erosion by wind and water is significant with the NT system.

Grain yields in 1999 increased with increasing level of available N in both tillage systems (Figure 1). The CT system had a higher yield than the reduced-till (RT) system. The lower yield with the RT system in 1999 than with CT may have resulted from a lower plant population in the RT compared to the CT system. The lower plant stand (28,600 plants/a) in the RT system compared to the CT system (estimated at >31,000 plants/a) may account for some of the yield difference between the two systems. The response to N was similar in both systems in 1999.

Average grain yields in 2000 ranged from 75 bu/a at the low N levels to about 160 bu/a at the higher N levels in the NT system (Figure 2). Grain yields ranged from 85 bu/a at the low N levels to about 170 bu/a at the higher N levels in the CT system (Figure 2). The grain yield response to N fertility level (soil NO_3-N plus fertilizer N) was similar in both tillage systems for the low and medium levels of N, but NT had slightly lower yields than CT at the highest N levels. Average corn stand counts in 2000 were 29,685

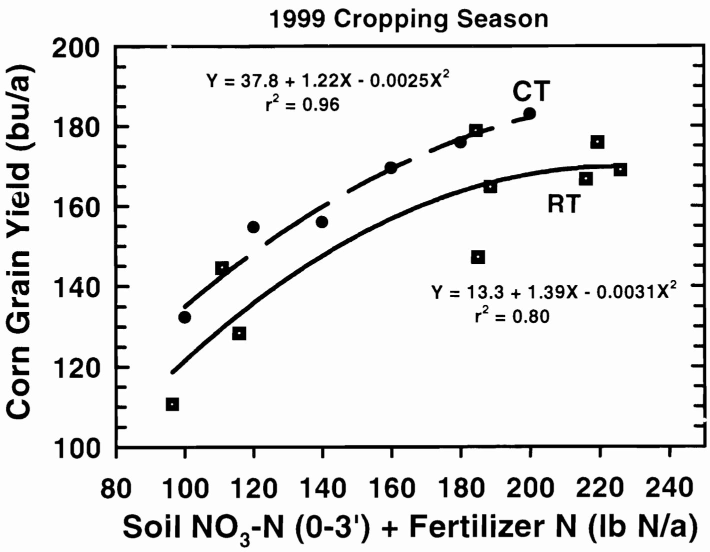

Figure 1. Irrigated corn grain yields in 1999 as a function of N fertility level for conventional till (CT) and reduced till (RT) systems.

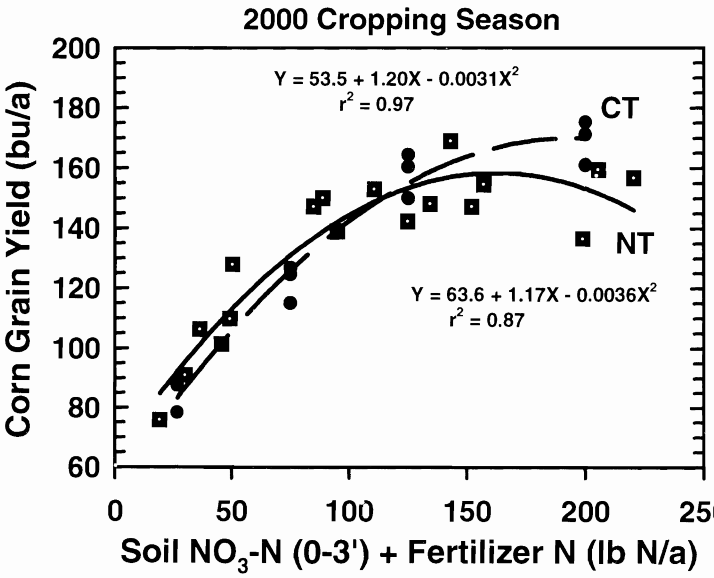

Figure 2. Irrigated corn grain yields in 2000 as a function of N fertility level for conventional till (CT) and no till (NT) systems.

plants/a in NT and 33,372 plants/a in the CT plots. The exact reasons that the yields leveled off at the higher N levels with NT compared to CT are not known. The lower plant density in NT may have become a factor at the higher yield levels. In 2000, a hail storm on May 17th damaged the corn in both systems.

Grain yield response to N fertility level in 2001 was similar to that in 1999 and 2000, except that CT yields were considerably greater than those with NT (Fig. 3). The entire 2001 corn growing season was very dry, with a very cool April and May. The corn in the NT plots emerged slowly compared to the CT plots probably due to cooler soil temperatures in the NT system. In 2001, the corn in the NT plots was shorter than in the CT plots until about tasseling. The CT plots tasseled several days earlier than the corn in the NT plots. Corn stands in 2001 averaged 33,183 plants/a in the NT and 35,487 plants/a in the CT. Plant population or plant density was excellent in both systems in 2001, but still slightly higher in CT system than in NT system. Grain yield response to increasing N fertility level was greater with CT than with NT at the medium to high N levels.

Combining the yield data from all three years, corn grain yields were near maximum in the NT system with a N fertility level of about 200 lb N/a (Figure 4). In the CT system, corn grain yields were near maximum with

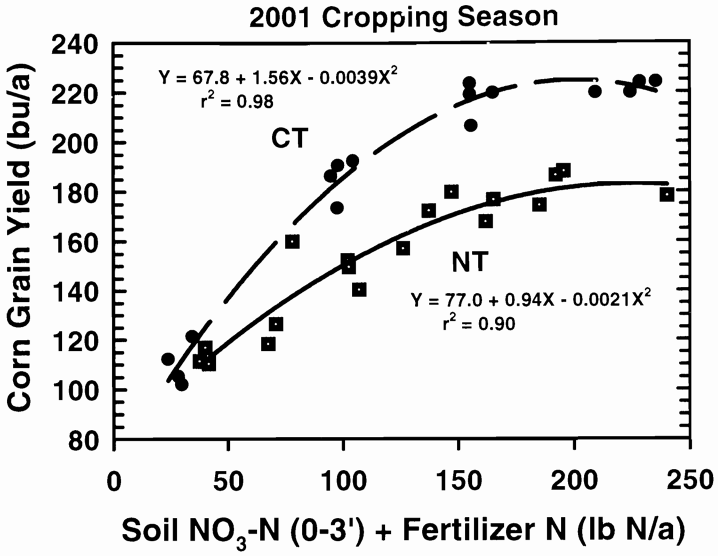

Figure 3. Irrigated corn grain yields in 2001 as a function of N fertility level for conventional till (CT) and no till (NT) systems.

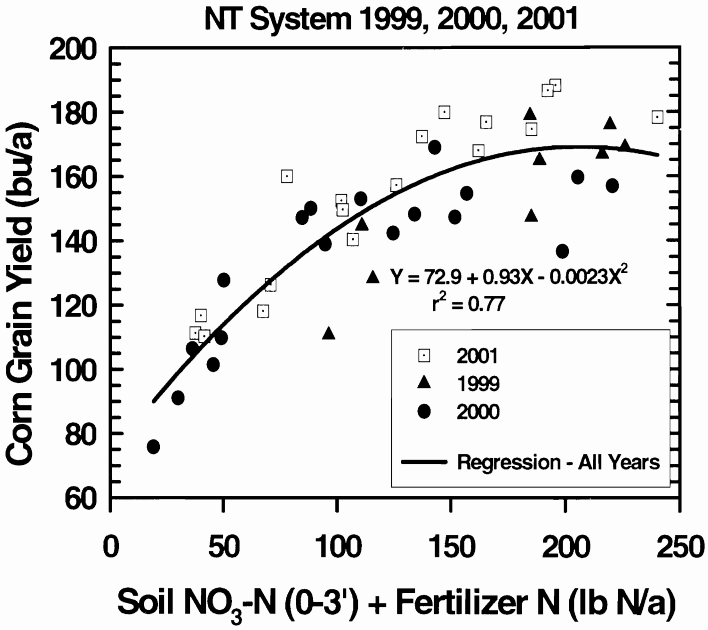

Figure 4. Corn grain yields as a function of N fertility level for the NT system over 3 years.

about 225 lb N/a (Figure 5). In contrast to the NT yield data which was similar over years and N levels, the 2001 CT corn yields were considerably greater than for 1999 and 2000. The regression equations relating yield to N fertility level for the two tillage systems are similar when averaged over the three years.

In dryland systems, NT has tended to sequester more total soil N than CT systems. Thus, one might expect that more N fertilizer may need to be added to an irrigated NT corn production system than to a CT corn production system to attain optimum yield levels. The preliminary data from this irrigated corn study indicates that similar levels of available N will be needed in both tillage systems to optimize grain yield potential.

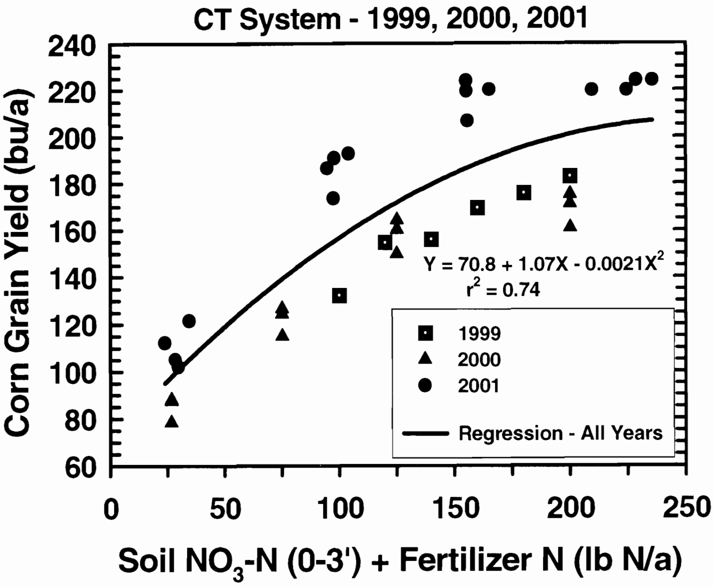

Figure 5. Corn grain yields as a function of N fertility level in the conventional till (CT) system over 3 years.

Additional years of data are needed to determine if N fertilizer recommendations will need to be modified for NT from those currently used for CT corn production systems. As the surface residue level builds up with time in the NT system, some of the organic soil N may start to cycle back into the production system and not require additional fertilizer N to attain the same yield level as with CT. The authors anticipate that grain yields in the NT system will equal those of the CT system in future years. The first three years in the NT/RT system have been challenging on this Fort Collins clay loam soil.

In summary, it appears that similar levels of available N are needed to optimize irrigated corn grain yields in CT and NT production systems. At high yield goals (>200 bu/a), additional fertilizer N may enhance NT yields during the first few years in NT. Additional years of comparison are needed between NT and CT production systems to determine a need to modify current fertilizer N recommendations for NT irrigated corn production compared to CT.

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