IMPACT OF CROP ROTATIONS AND TILLAGE FREQUENCIES AT VARYING NITROGEN FERTILITY ON CORN YIELDS

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ABSTRACT

Crop rotation and alternative tillage systems tend to maximize surface crop residue and can have a long range impact on soil particle losses due to wind and water. Their impact on plant nutrient availability through changes in soil microbial activity and mineralization of soil organic matter needs further investigation. Objectives of this study included the effects of crop rotation and tillage intensity on production of corn at varying levels of N with the inclusion of soybean in the rotation. The multi-year study was conducted on Victoria clay under rainfed conditions. Cotton and soybean were rotated with corn and compared to continuous corn under conventional tillage (CT) and minimum till (MT) systems. Results of the studies showed the rotation benefit from cotton or soybean on corn yields fluctuated with season and precipitation. Under ideal soil moisture and without N fertilization corn yields increased 74% when corn followed cotton compared to monoculture corn. Under the same conditions, the contribution from soybean increased corn yields 47%. However, in the fourth year, the soybean rotation effect was substantially greater than the effect from cotton. The influence of rotation was minimal in the two droughty years. Nitrogen fertilization appeared to decrease benefits from crop rotation. In general, tillage intensity did not have a major influence on corn yields, but the soybean rotation effect was usually most pronounced with the MT system.

INTRODUCTION

Tillage and crop rotations can influence the physical and biological environments of soils (Barber and Matocha. 1994; Matocha, et al. 2002; Wright, et al. 2005) can be influenced by tillage and crop rotations. The degree of change in these environments may be associated with the quantity and distribution of organic matter, an important constituent of soils (Matocha, et al. 1998). Response to N fertilization and plant productivity can be a function of some of these biotic and abiotic changes. The purpose of this study is to determine the influence of crop rotation and tillage intensity on grain productivity from corn at varying levels of N fertilization.

MATERIALS AND METHODS

A Victoria clay (montmorillonitic Udic Pellusterts), a vertisol with at least 30 inches of dark gray surface soil, was the experimental site. Predominate clay in this soil is a swelling and shrinking montmorillonite. The site was located at the TAMU Research Center at Corpus Christi, and had been cropped to grain sorghum and cotton on alternate two-year cycles and low N rates for the previous three years. Initially, the soil tested low to medium in available N and P and high in available K. Four crop rotation schemes using the two basic row crops (corn and cotton) grown in the region and soybean as the main blocks while two tillage systems (minimum, MT, and conventional tillage, CT) were compared in split-plot within each main block. Minimum tillage involved four tillage operations with less than 3-inch plow depth while CT had eight operations with plow depth at 6-inches. Each tillage treatment within each cropping system was split into three sub-plots which received 0, 30, and 60 lb N/ac. Nitrogen rates for the soybean crop were 0, 15, and 30 lb/ac. Phosphorus was blanketed to all plots at 20 lb P_2O_5/ac. All 24 treatments were compared in four replications. A medium maturity corn hybrid and an early maturing GP 3174 + cotton cultivar were used in the study. Soybean variety RA 452 (Group IV) was seeded in alternate years to complete the rotation scheme.

RESULTS

Extreme drought in Year 1 produced negligible grain yields, therefore yields are not reported. Results for the second year when normal rainfall was received are presented in Figures 1 and 2. The rotation effects from cotton or soybean on grain yields were considerably greater than in Year 1. Without N fertilization, corn yields under MT increased approximately 1430 lb/ac (74%) when corn followed cotton as compared to monoculture corn which produced a total yield of only 1913 lb/ac. With CT, the rotation increased yields approximately 982 lb/ac or 35% compared to continuous corn. As N rate was increased to 60 lb/ac, the net contribution from the rotation decreased to 37 and 20%, respectively, for MT and CT systems. The rotation effect from soybean under both tillage systems was generally less than with cotton. Without N fertilization, the soybean contribution ranged from 47% to 38% for the MT and CT systems, respectively. With N fertilization, the rotation effect decreased to 13 and 0% for MT and CT, respectively. The lesser contribution from soybean than cotton to the rotation effect in Year 2 may be partly attributed to the drought stressed soybean crop having restricted N fixation capabilities in the Year 1 season. The effect from crop rotation was generally accentuated when corn was grown with MT compared to CT.

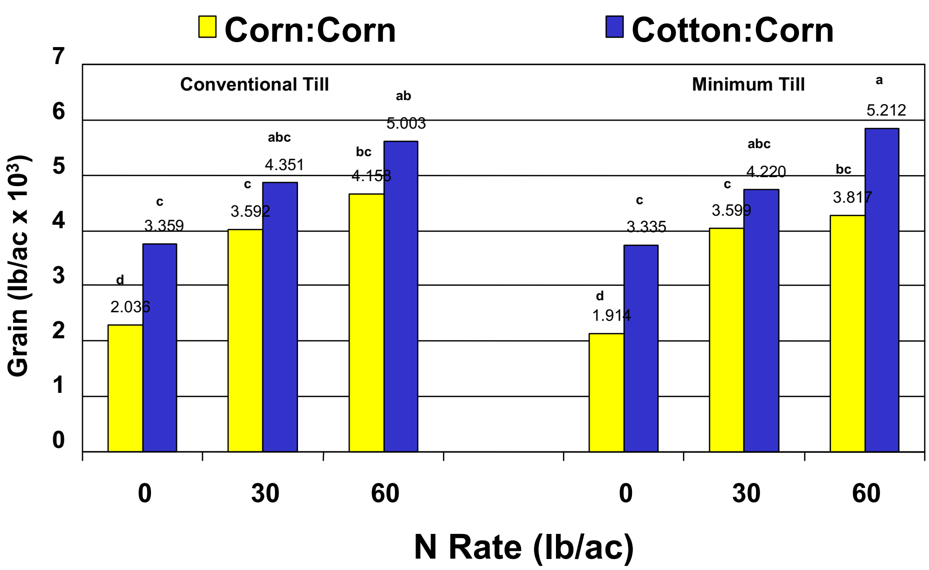

Fig. 1 Corn grain yields as influenced by cotton rotation, N rate and tillage in Year 2. Bars highlighted with the same letter are not significantly different across tillage systems, Fischer's LSD $_{0.05}$.

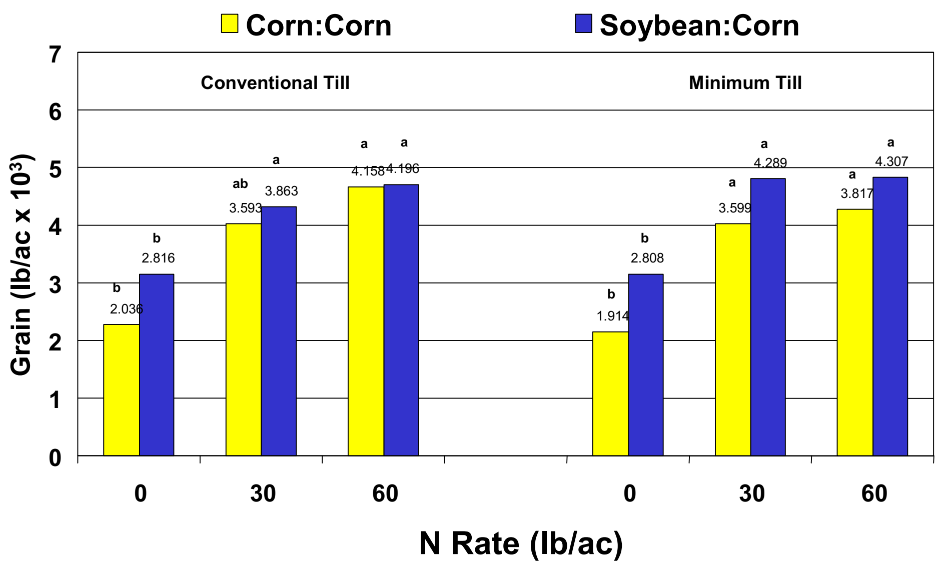

Fig. 2 Corn grain yields as influenced by soybean rotation, N rate and tillage in Year 2. Bars highlighted with the same letter are not significantly different across tillage systems, Fischer's LSD $_{0.05.}$

Soil moisture was above average starting the growing season in Year 3 but negligible rainfall throughout the growing season caused severe plant stress for moisture and final grain yields were approximately 30-40% of Year 2 yields. In Year 3, corn was grown under 12 separate treatments, six of which were in a monoculture of continuous corn cropping system and six in a cotton-corn rotation. The rotation scheme for Year 3 did not include soybean.

In the third season, very small differences in treatment response were measured due to drought related abnormally low yields. In general, corn grain yields ranged from a high 2391 to a low 1351 lb/ac (Fig. 3). Averages over fertilizer treatments within cropping systems show little or no yield difference due to tillage. However, response to N fertilizer was slightly higher for continuous corn compared to the cotton-corn system under MT, while response to N was better for the cotton-corn system under the CT system. The slight decrease in yields from the cotton-corn rotation compared to continuous corn was possibly due to lower soil moisture in the soil profile to start the season when cotton preceded corn. These data show that under identical fertilization regimes, corn following cotton in the droughty season produced only a slight increase in grain compared to continuous corn when grown under CT. This rotation benefit was not evident under MT.

Grain yields during the fourth year of the study increased substantially over those for Year 3 and were about 80% of those yields for Year 2 (Fig. 4). The rotation benefit from cotton was considerably below that measured in Year 2 and ranged from 5% for MT without N fertilization to 11% for the CT system. Unlike the findings during Year 2, the rotation effect in Year 4 appeared to increase with N fertilization in both tillage systems. Highest yields were measured when corn was grown with the MT system at the high N rate.

Substituting soybean for cotton in the Year 4 rotation improved corn grain yields considerably over continuous corn when N fertilization was withheld (Fig. 5). The approximate 1072 lb/ac increase (38%) in grain due to soybean for the MT system decreased to 742 lb/ac (28% increase) for corn grown with CT, but still equaled or exceeded the soybean benefit measured earlier in the Year 2 season.

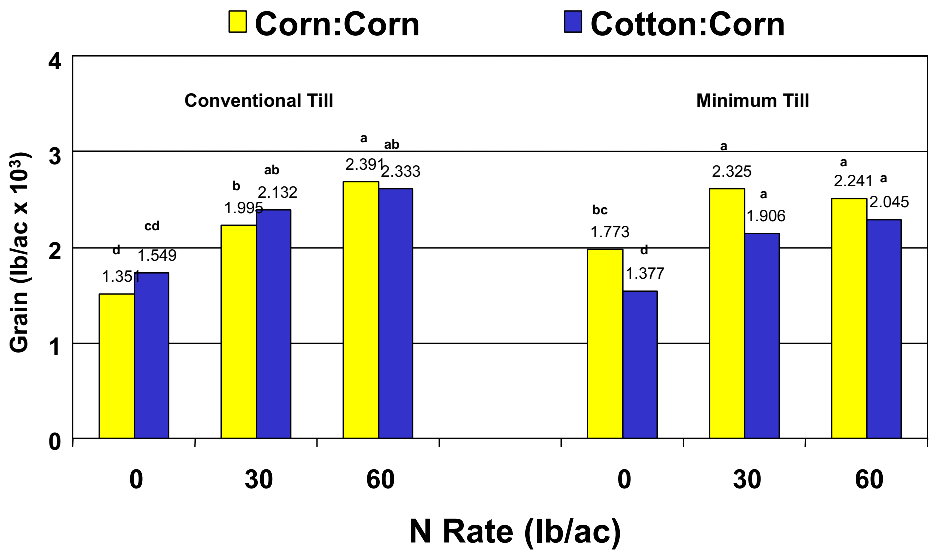

Fig. 3 Corn grain yields as influenced by cotton rotation, N rate and tillage in Year 3. Bars highlighted with the same letter are not significantly different across tillage systems, Fischer's LSD $_{0.05.}$

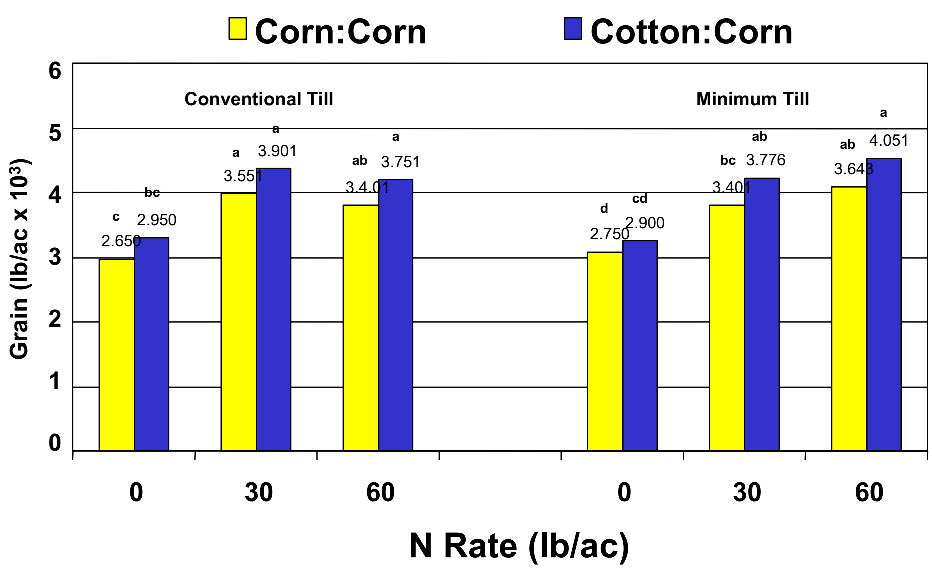

Fig. 4 Corn grain yields as influenced by cotton rotation, N rate and tillage in Year 4. Bars highlighted with the same letter are not significantly different across tillage systems, Fischer's LSD $_{0.05.}$

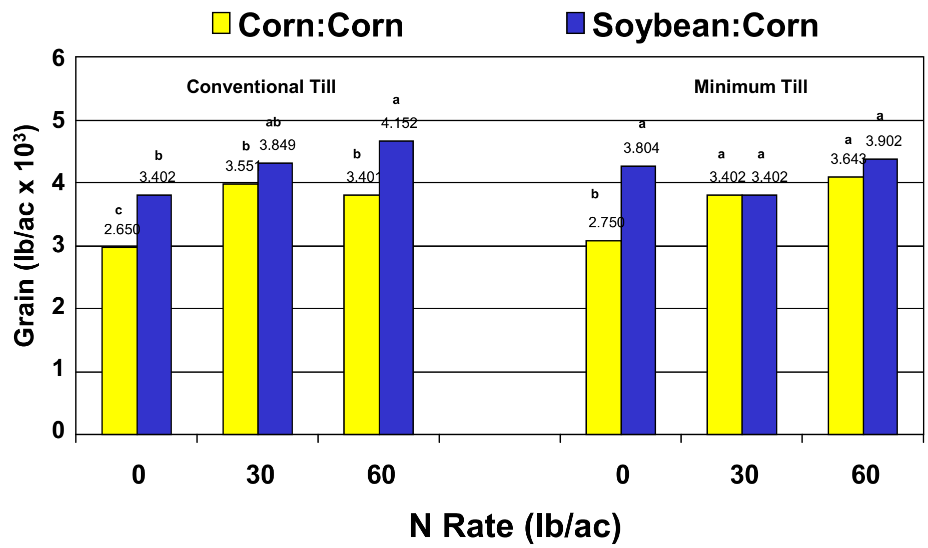

Fig. 5 Corn grain yields as influenced by soybean rotation, N rate and tillage in Year 4. Bars highlighted with the same letter are not significantly different across tillage systems, Fischer's LSD $_{0.05.}$

Using soybean in the rotation rather than cotton produced significantly higher corn yields as compared to the cotton rotation only when N fertilizer was excluded (Figs. 4-5). The benefits of the soybean rotation were greatest in the MT system.

SUMMARY

This study showed that precipitation and available soil moisture will greatly influence response of corn to crop rotation and tillage treatments. With adequate precipitation in the second study year corn following cotton produced higher yields than when following soybeans both with and without N fertilization. However, in the fourth year of the study, the contribution from soybean rotation was considerably greater than from the cotton rotation, especially at 0 N rates. These data suggest the beneficial effects from a soybean rotation with corn on soil quality and yields may have greater temporal dependency than the cotton rotation. Although tillage intensity effect appeared smaller than the rotation effect on corn yields, the positive effects from both cotton and soybean rotations were usually best expressed in the MT system.

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