Crop Rotations, Reduced Tillage and N Fertilization Effects on Corn Yields And Aflatoxin Levels

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Introduction

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 change in these environments may be associated with the quantity and distribution of organic matter, an important constituent of soils (Matocha, et al. 1999). Response to N fertilization and crop productivity can be a function of some of these biotic and abiotic changes. The purpose of this study is to determine the influence of tillage intensity and crop rotation on grain productivity and aflatoxin level in corn at varying levels of N fertilization.

Materials and Methods

The experimental site was a Victoria clay (montmorillonitic Udic Pellusterts), a vertisol with at least 30 inches of dark gray surface soil. Predominate clay in this soil is a swelling and shrinking montmorillonite. The site was located at the Texas AgriLife Research and Extension 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 cotton cultivar were used in the study. Soybean variety RA 452 (Group IV) was seeded in alternate years to complete the rotation scheme.

Results

In the first year, a devastating drought stressed the corn and cotton resulting in negligible grain yields, therefore yields are not reported for year one of the study. 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 1422 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 1324 lb/ac or 65% 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 (Fig. 2). Without N fertilization, the soybean contribution ranged a disappointing 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 slightly accentuated when corn was grown with MT compared to CT.

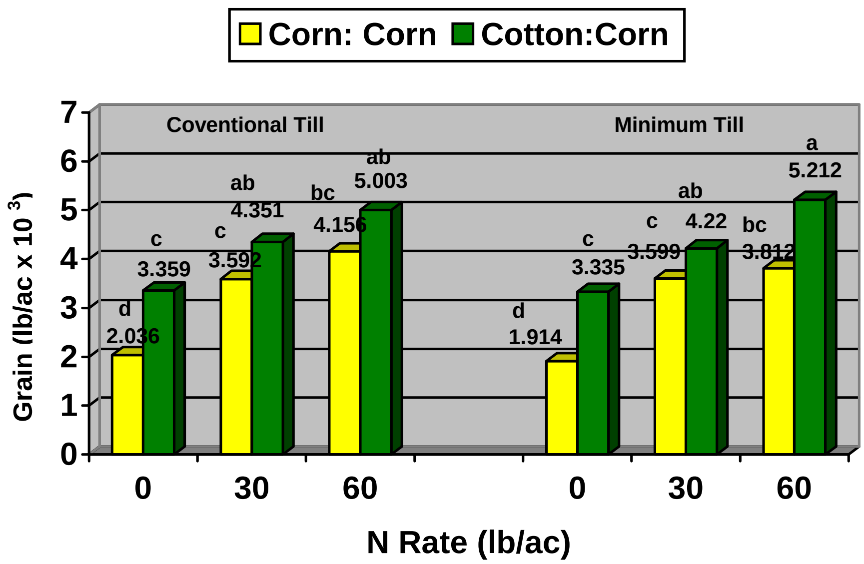

Fig. 1. Corn grain yields as influenced by cotton rotation, N rate and tillage in Year 2. Bars highlighted with the same letter are not significantly different across tillage systems, Fischer's LSD $_{0.005}$.

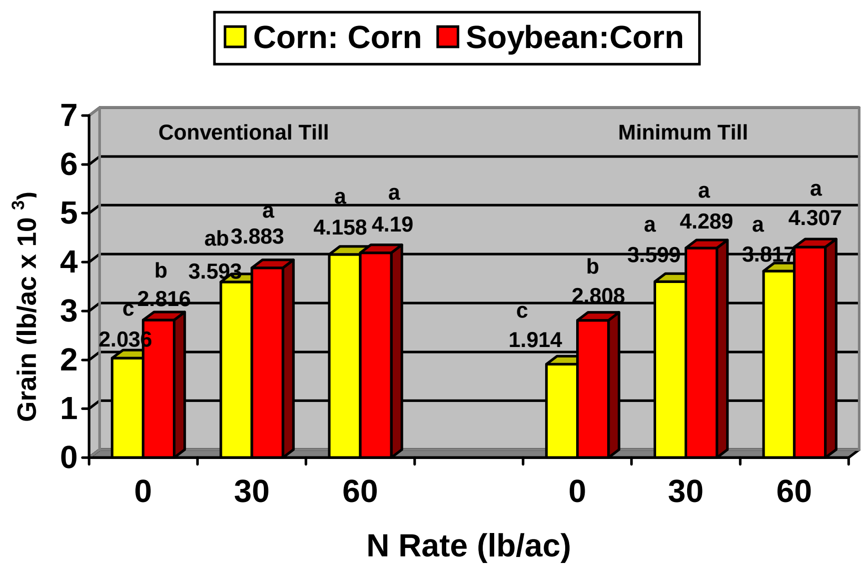

Fig. 2. Corn grain yields as influenced by soybean rotation, N rate and tillage in Year 2. (Soybean received 0,15,30lbsN/ac)

Soil moisture ıegligible

rainfall throughout the growing season caused severe plant stress for moisture and final grain yields were approximately 50-60% 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 this year 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 with 60 lb/ac to a low 1351 lb/ac with CT (Fig. 3). Averages over fertilizer treatments within cropping systems show little or no yield difference due to tillage. However, under CT response to N fertilizer was significant for continuous corn and the cotton-corn systems, response to N was recorded only up to 30 lb/ac for both cropping systems. The slight decrease in yields from the cotton-corn rotation compared to continuous corn was possibly due to lower residual soil moisture in the soil profile at season start when cotton preceded corn. These data show that under identical fertilization regimes and CT, corn following cotton in a droughty season will produce a slight increase in grain compared to continuous corn. No benefit from rotation was evident under MT.

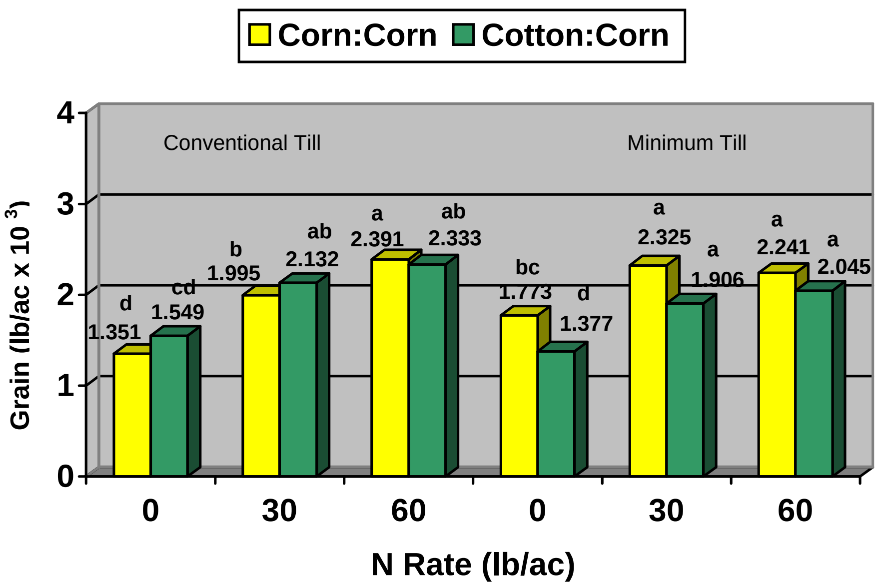

Fig. 3. Corn grain yields as influenced by cotton rotation, N rate and tillage in Year 3.

Grain yields during the fourth year of the study increased substantially over those for Year 3 and were about 90% 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 slightly with N fertilization in both tillage systems, however the yield effect was nonsignificant. Highest yields were measured when corn was grown with the MT system at the high N rate.

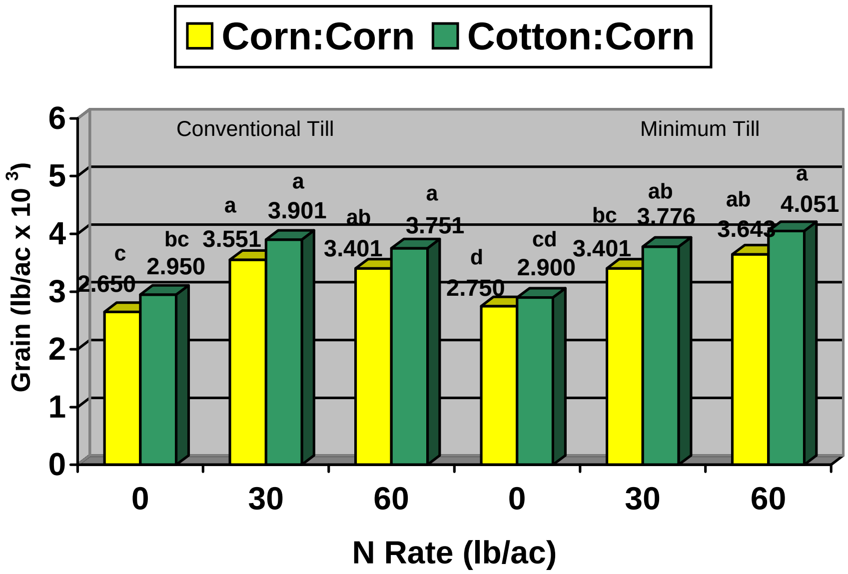

Fig.4. Corn grain yields as influenced by cotton rotation, N rate and tillage in Year 4.

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 1050 lb/ac increase (38%) in grain due to soybean for the MT system decreased to 752 lb/ac (28% increase) for corn grown with CT, but still equaled or exceeded the soybean benefit measured earlier in the Year 2 season.

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 at zero N.

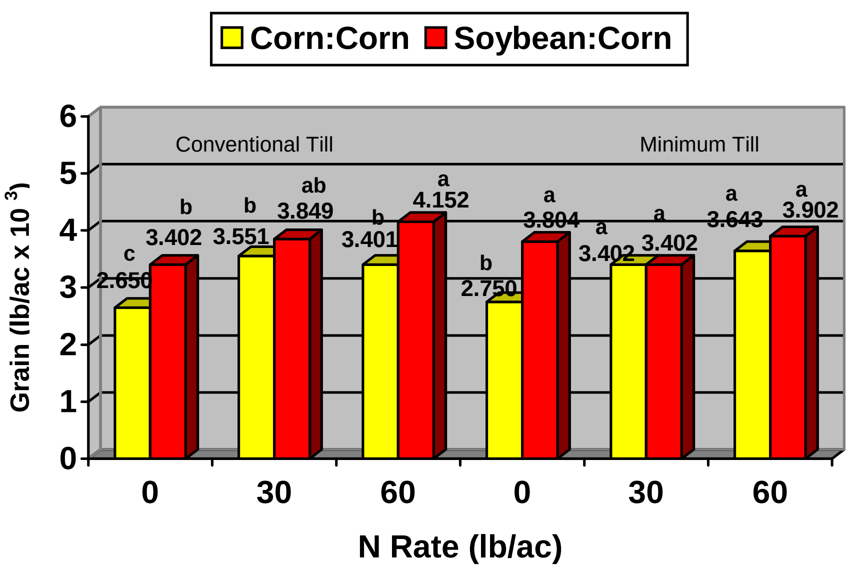

Fig.5. Corn grain yields as influenced by soybean rotation, N rate and tillage in Year 4. (Soybean received 0,15,30lbN/ac)

Aflatoxin levels in corn grain varied widely with seasons. When precipitation was average and above (Years 2 and 4), disease levels were generally below or slightly above the critical 20 ppb with an average of 16 and 22 ppb for Years 2 and 4, respectively. In these two seasons, treatment differences were relatively small but trended lower for the MT system when corn followed cotton. Corn stressed for moisture (Year 3) contained approximately a 10 fold increase in aflatoxin compared to non-stressed corn with an average of 204 ppb as compared to 21 in seasons when soil moisture was adequate. Corn following cotton produced higher disease levels as compared to monoculture corn in both tillage systems. Reduced tillage appeared to slightly lower grain aflatoxin.

Table 1. Influence of crop rotation/tillage and fertilizer N rate on aflatoxin levels in corn grain

Cropping System	[1)]Tillage	Fertilizer N		Aflatoxin (ppb)		
		Lb/Ac		Year 2	Year 3	Year 4
Continuous corn	CT	0		13	313	6
Continuous corn	CT	30		19	198	5
Continuous corn	CT	60		8	214	8
			$\bar{X}$	13	242	6
Continuous corn	MT	0		6	165	33
Continuous corn	MT	30		27	150	9
Continuous corn	MT	60		3	88	16
			$\bar{X}$	12	134	19
Cotton:corn	CT	0		15	182	25
Cotton:corn	CT	30		26	308	24
Cotton:corn	CT	60		24	159	36
			$\bar{X}$	22	216	28
Cotton:corn	MT	0		24	278	33
Cotton:corn	MT	30		16	184	15
Cotton:corn	MT	60		11	213	15
			$\bar{X}$	17	225	21

[1)] CT = conventional tillage; MT = minimum tillage

Summary and Conclusion

Results showed that precipitation and available soil moisture will greatly influence response of corn to crop rotation and tillage treatments. With adequate precipitation and no N fertilization in the second study year corn following cotton produced 74% higher yields while corn following soybeans produced a 47% yield increase. 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 with the cotton rotation. Although the tillage intensity effect appeared smaller than in the case of the rotation effect on corn yields, the positive effects from both cotton and soybean rotations were usually best expressed in the MT system. Corn following cotton produced higher grain aflatoxin compared to monoculture corn while reducing tillage somewhat suppressed disease levels. More research is needed to study the possible interactive effects.

References

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