Corn Yield Response to Tillage and Fertilizer Placement

Effects of Tillage and Fertilizer Placement on Corn Yield in Texas Blackland Soils

Coker, D.L., McFarland, M.L., Abrameit, A., and Mazac Jr., F.J.
Texas Cooperative Extension, Texas A&M University

Abstract

Under dry conditions common to Central Texas, root activity of corn in the upper few cm of soil may be extremely limited thus impeding acquisition of immobile nutrients such as P. Deep placement of fertilizer P to enhance corn yield was evaluated in reduced and conventional tillage systems. During the 2001 growing season, cotton was planted on two adjacent sites, followed by corn in 2002, 2003, and 2004 on one of the sites and in 2002 and 2004 on the other site in an alternate-year rotation with cotton. The soil type at both sites is a Burleson clay. The study design was a randomized complete block with experimental units replicated three times. Conventional, strip, and no till tillage treatments represented main plots, which were split into 8-row sub plots with fertilizer placed at either 5 or 15 cm below the soil surface with a knife-type applicator. Soil samples collected across sites and years from plots under conventional tillage with shallow fertilizer placement showed that P was stratified in the surface 23 cm. Interactive effects of tillage and fertilizer placement on corn yields were not found in the current studies irrespective of crop rotation. For the cotton-corn rotation, tillage had no effect on corn yield during 2002 or 2004. Deeper fertilizer placement increased corn yield in 2002, a noticeably dry season, but not in 2004. In continuous corn, fertilizer placement did not statistically affect yield; however, increased levels of tillage increased corn yields in 2003 and 2004. Deep placement of P fertilizer for corn grown in the Texas Blackland may be beneficial to enhance positional availability in dry seasons.

Introduction

Interest in reduced tillage is increasing due to potential economic and environmental benefits. Reduced tillage systems have been shown to conserve additional moisture from rainfall and/or supplemental irrigation during the season (Zibilske et al., 2002). Phosphorous (P) uptake by pearl millet was limited by low soil moisture (Payne, et al., 1995). Thus, the yield of millet could potentially show a better response to added P fertility under reduced tillage as compared to conventional tillage.

Studies have indicated that proper placement of nutrients particularly non-mobile elements such as phosphorous and zinc is of paramount importance in reduced tillage systems (Schwab et al., 2006). According to Bauer et al. (2002), use of conservation tillage systems eventually result in vertical stratification of plant nutrients in the soil profile. Studies have shown that P is one of several plant nutrients that accumulate near the surface in no-tillage culture (Lal, 1976; Dick, 1983). Though the levels of organic matter, microbial activity, and available P are generally higher in the surface layers of no-tillage systems (Pierce et al., 1994), Weil et al. (1988) showed no increase in organic P levels within the plant rooting depth of no-tillage compared to conventional tillage soils.

As reduced tillage systems become more widely utilized, the importance of understanding the advantages and limitations of this management practice under varied environmental conditions and cropping systems becomes greater (Zibilske et al., 2002). Therefore, additional information was needed about the relationship of corn yield to phosphorous placement and tillage management in an area representative of the Blackland soils located in Central Texas (Fig. 1).

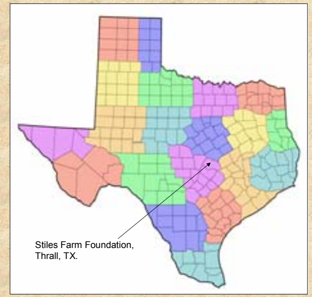

Fig. 1. Location of trial on Blackland soils in central Texas.

Objectives

To determine the effect of tillage and fertilizer placement on corn yield under two different rotation schemes.

Materials and Methods

In 2001, cotton was planted into a Burleson clay at two adjacent sites on the Stiles Farm Foundation in Williamson County, Texas. For the next three seasons, corn would alternate with cotton or continuous corn would be planted (Table 1). The experimental design of this study was a randomized complete block with experimental units (treatments) replicated three times. Consideration about the significance of treatment interactions was determined by ANOVA F test.

Table 1. Crop rotation sequence for study sites at the Stiles Farm Foundation, Williamson County, TX.

Location	2001	2002	2003	2004
1	Cotton	Corn	Cotton	Corn
2	Cotton	Corn	Corn	Corn

For each location, three methods of tillage (conventional, strip and no till) represented main plots (primary treatment factor), which were split into 8-row subplots. Sub plots (secondary treatment factor) consisted of liquid phosphorous fertilizer placement at either 5 or 15 cm below the soil surface with a knife-type applicator (Plate 1). Individual plots were 122 m in length and 7.7 m wide.

Plate 1. Liquid applicator used to apply N and P fertilizers at varying depths into Blackland soil. Thrall, TX.

Applications of nitrogen, phosphorous, and potassium fertilizers were made to all plots based on soil test results from pre-season samples collected at depths of 0 to 7.6 cm and 7.6 to 23 cm. These pre-season soil samples were collected from conventional tilled main plots where previous P fertilizer had been applied at the 5 cm depth. At location 1, preseason soil P levels from 0 to 7.6 cm were 32 (moderate) and 57 (high) $kg\ ha^{-1}$ in 2002 and 2004, respectively. Preseason soil P levels from 7.6 to 23 cm were 24 (moderate) and 44 (high) $kg\ ha^{-1}$ in 2002 and 2004, respectively. At location 2, preseason soil P levels from 0 to 7.6 cm were 25, 21 and 54 $kg\ ha^{-1}$ in 2002, 2003 and 2004, respectively. Preseason soil P levels from 7.6 to 23 cm were 13.4 (low), 9 and 29 $kg\ ha^{-1}$ in 2002, 2003 and 2004, respectively. Corn was harvested at both locations in 2002 by hand pulling ears from an area 3 m in length by four rows (total 3.85 m width), then grain weights were determined by hand thrashing the samples. In 2003 and 2004, corn was harvested with a commercial combine. Yield was determined by unloading grain from the combine into a truck from each whole-plot area and weighing the truck.

Results & Discussion

In the cotton-corn rotation (location 1), corn yield showed no significant tillage by fertilizer placement interactions during 2002 or 2004. Tillage had no significant impact on grain yield from the cotton-corn rotation in 2002(Fig. 2a). However, placement of fertilizer at the 15 cm depth increased grain yield compared to the 5 cm placement (Fig. 2b) and is similar to a report by Schwab et al., (2006). This outcome may have been due in part to dry conditions during critical parts of the growing season whereby, corn root development was promoted at greater depths as well as P acquisition. In 2004, tillage and fertilizer placement showed little influence on grain yield (Fig. 2c and 2d, respectively). Unlike 2002, the corn crop received above normal rainfall during 2004. Likely, dry conditions and buildup of P levels during 2003 contributed to the lack of fertilizer placement effect on grain yield in 2004.

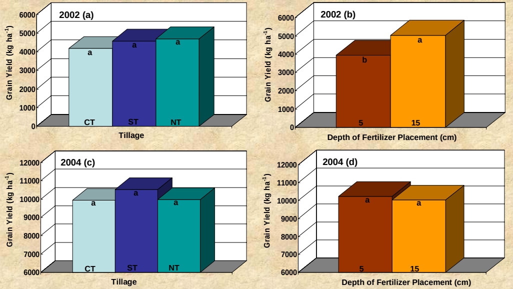

Fig. 2a-e. Effect of conventional tillage (CT), strip tillage (ST), no tillage (NT) and fertilizer placement on yield of corn grown in a cotton-corn rotation during 2002 (a and b) and 2004 (c and d) near Thrall, Texas. Different letters indicate that treatment means were different according to LSD ($P \leq 0.05$).

Preseason soil samples collected at the continuous corn rotation site (location 2) indicated P stratification beginning with the 2002 season and continuing during 2003 and 2004. Corn yields showed no significant tillage by fertilizer placement interactions during 2002, 2003 or 2004. Tillage had no significant impact on grain yield at this site in 2002 (Table 2). Placement of fertilizer at the 15 cm depth showed a 15 percent increase in grain yield compared to the 5 cm placement although the difference wasn't significant.

Table 2. Effects of tillage and fertilizer placement on yield of corn grown in a continuous corn rotation, Thrall, Texas. 2002.

Tillage System	Depth of Fertilizer Placement 5 cm	15 cm	$\bar{x}$
	---kg/ha---		
Conventional	2390	3117	2753 a†
Strip Till	2697	2835	2766 a
No Till	2515	2816	2666 a
$\bar{x}$	2534 a‡	2923 a	-§

† Within columns, means followed by the same letter are not significantly different according to LSD ($P \leq 0.05$).
‡ Within rows, means followed by the same letter are not signficantly different according to LSD ($P \leq 0.05$).
§ Not a treament comparison.

In 2003, conventional till yielded 9.4 and 15.9 percent more grain compared to strip till and no till treatments, respectively (Table 3). Depth of fertilizer placement had no significant impact on grain yield. In 2004, conventional till yielded 4 percent more grain compared to no till and the difference was significant (Table 4). Grain yield from the strip-till treatment was also significantly 5 percent greater compared to that from the no till treatment. These results contrast with those of studies conducted on ligher-textured soils but agree with Zibilske et al. (2002) about crop response to tillage on clay soils. There was no effect on grain yield by varying the depth of P placement in 2004. Given the amounts of P applied and dry conditions (limited plant use) that prevailed in the two previous seasons, incrementally less P fertilizer was recommended in 2003 and 2004 based on soil test results. Thus, a yield response to increased depth of P placement was less likely in 2004 as compared to 2002.

Table 3. Effects of tillage system and fertilizer placement on yield of corn grown in a continuous corn rotation, Thrall, Texas. 2003.

Tillage System	Depth of Fertilizer Placement 5 cm	15 cm	$\bar{x}$
	---kg/ha---		
Conventional	3794	3907	3851 a†
Strip Till	3550	3481	3519 b
No Till	3330	3318	3324 b
$\bar{x}$	3556 a‡	3569 a	-§

† Within columns, means followed by the same letter are not significantly different according to LSD ($P \leq 0.05$).
‡ Within rows, means followed by the same letter are not significantly different according to LSD ($P \leq 0.05$).
§ Not a treament comparison.

Table 4. Effects of tillage and fertilizer placement on yield of corn grown in a continuous corn rotation, Thrall, Texas. 2004.

Tillage System	Depth of Fertilizer Placement 5 cm	15 cm	$\bar{x}$
	---kg/ha---		
Conventional	9596	9540	9571 a†
Strip Till	9703	9615	9659 a
No Till	9126	9276	9201 b
$\bar{x}$	9477 a‡	9477 a	-§

† Within columns, means followed by the same letter are not significantly different according to LSD ($P \leq 0.05$).
‡ Within rows, means followed by the same letter are not significantly different according to LSD ($P \leq 0.05$).
§ Not a treament comparison.

Summary

- ✓ Deep placement of P fertilizer for corn grown in the Blacklands of central Texas increased yield in a dry season by enhanced positional availability of nutrients, irrespective of tillage.
- ✓ With continuous corn or corn rotated with cotton, phosphorous stratification was evident within the top 23 cm of a Blackland soil, even under conventional tillage.
- ✓ Corn yield under strip tillage was not statistically different from conventional tillage in four out of five years under continuous corn or a cotton-corn rotation.

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References

Bauer, P.J., J.R. Frederick, and W.J. Busscher. 2002. Tillage effect on nutrient stratification in narrow- and wide-row cropping systems. Soil Till. Res. 66:175-182.

Dick, W.A.. 1983. Organic carbon, nitrogen, and phosphorous concentrations and pH in soil profiles as affected by tillage intensity. Soil Sci. Soc. Am. J. 47:102-107.

Lal, R.. 1976. No-tillage effects on soil properties under different crops in western Nigeria. Soil Sci. Soc. Am. J. 40:762-768.

Payne, W.A., L.R. Hossner, A.B. Onken, and C.W. Wendt. 1995. Nitrogen and phosphorous uptake in pearl millet and its relation to nutrient and transpiration efficiency. Agron. J. 87:425-431.

Pierce, F.J., M.C. Fortin, and M.J. Staton. 1994. Periodic plowing effects on soil properties in a no-till farming system. Soil Sci. Soc. Am. J. 58:1782-1787.

Schwab, G.J., D.A. Whitney, G.L. Kilgore, and D.W. Sweeney. 2006. Tillage and phosphorous management effects on crop production in soils with phosphorous stratification. Agron. J. 98:430-435.

Weil, R.R., P.W. Benedetto, L.J. Sikora, and V.A. Bandel. 1988. Influence of tillage practices on phosphorous distribution and forms in three Ultisols. Agron. J. 80:503-509.

Zibilske, L.M., J.M. Bradford, and J.R. Smart. 2002. Conservation tillage induce changes in organic carbon, total nitrogen and available phosphorous in a semi-arid alkaline subtropical soil. Soil Till. Res. 66:153-163.