No-Till and Reduced Tillage Production of Grain Sorghum Under Dryland Conditions

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Introduction

Interest in conservation tillage has generally been on the increase in the last decade in the deep South and Southwest. However, this region has been considerably slower to convert to this alternative tillage system than the Midwest and Southeast. Some of the reasons for this lack of interest are generally given as being 1) the longer growing season due to warmer temperatures and therefore greater problem with weed control and 2) difficulty in overcoming traditional practices of low crop residue on the surface or "trashless farming".

Economic factors including rising input costs for fuel, labor, other variable costs and uncertain market prices are requiring crop producers to continually strive to reduce input costs and maximize profits. Additionally, U.S. farm policy mandating soil erosion control has stimulated interest in use of conservation tillage in production of major crops. Earlier reports have described a minimum tillage system that appeared suitable for Southern Texas and possibly other parts of the South (1,2).

Reduced crop yields due to plant water stress is a common problem in the sub-humid and semi-arid regions of the South and Southwest (5). Plant stress for water due to short term droughts can also severely limit crop yields in these regions. Other problems associated with conservation tillage may involve a greater dependency on soil insecticides since more crop residue may present greater dependency from insect pests. Research in the region has shown benefits of soil-applied insecticide on production of sorghum under conventional tillage (3,4). Little or no attention has been given in the past to studying the need for soil-applied insecticides in sorghum production under conservation tillage systems. This long-term research was established to develop alternative tillage practices to minimize the adverse effects of the weather and water deficiencies. Specific purposes of this tillage experiment were 1) compare alternative tillage systems including two forms of conservation tillage with conventional tillage, deep chisel and moldboard systems of primary tillage, 2) Ascertain the need for an in-row soil insecticide treatment as related to tillage systems and the effects on production of grain sorghum.

Materials and Methods

The study was conducted on an Orelia sandy clay loam (Typic Ochraqualf) located at the Texas Agricultural Experiment Station research farm at Corpus Christi. A randomized complete block design with eight tillage treatments as major plots and three principal crops, grain sorghum, corn and cotton as sub or split-plots were each studied in four replications. Five of the eight tillage systems using grain sorghum as the indicator crop will be reported in this paper. They include 1) conventional, 2) minimum tillage, 3) no-till, 4) moldboard 12-inch depth and 5) chisel 12-inch depth. The conventional system included some 10-12 tillage operations including planting and cultivating.

Maximum tillage depth in the conventional system was 6 inches. The minimum or reduced tillage treatment consisted of a maximum tillage depth of 3 inches and used four to five tillage operations per year. A list of tillage treatments and description of the minimum till treatment are presented in Table 1.

Table 1. List of primary tillage treatments and description of minimum tillage.

1) **Conventional Tillage**
2) **Minimum Tillage**
3) **No-till**
4) **Moldboard at 30-cm depth**
5) **Chisel at 30-cm depth**

Minimum tillage treatment comprised the following: 1) disc-3 inch depth, 2) sweep plow low profile beds and root plow stalks, 3) spray herbicides for fall-winter weed control, 4) inject fertilizer, (3 inch depth), 5) plant and, 6) cultivate sorghum.

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Atrazine, paraquat and sometimes glyphosate were used in weed control in the no-till and minimum till plots. Atrazine was also used in the conventional, moldboard and chisel tillage systems.

The experiment was initiated in 1981 and continued for nine years with tillage systems repeated each year on the same plots. The soil insecticide portion of the test was conducted on grain sorghum in 1983-87 and again in 1989 on all tillage treatments. Carbofuran (Furadan) was used in the initial five years while terbufos (Counter) was used in 1989. A single rate of 0.5 Ib a.i. A-1 of each insecticide was tested with 0 lb a.i. A-1 in a split-plot comparisons across all tillage treatments. A small grain combine was used to harvest the 80 feet long and 2 row wide research split plots.

Results and Discussion

Tillage and Rainfall Effects:

Grain sorghum yields were highly variable across the nine production years. Average yields ranged from 1566 for one of the dry years to *5066* lb A-1 for a wet season (1981). Highest average yields were measured in 1981 when April-May rainfall was highest (9.0 inches). Conversely, lowest yields were measured in 1989 when Counter was used as soil insecticide and 2.68 inches of rainfall were received during April-May. Correlation analyses of fall and/or spring rainfall with average grain yields over the nine year period were not statistically significant (data not shown).

The effects of various systems of primary tillage including the no-till system on relative yields are presented in Figure 1. With sorghum grown in a conventional tillage system using soil insecticide as a standard of comparison (set at 100%) the data show that minimum tillage produced less grain than conventional tillage in four of nine years while the no-till system fell short of the conventional in six of nine years. The poorest comparisons for both conservation tillage systems occurred in 1982, 1983 and 1987 when averaged yield dropped 34.8, 19.4 and 23.9% respectively, below those yields for the conventional system. These relative comparisons did not appear to follow any rainfall trends.

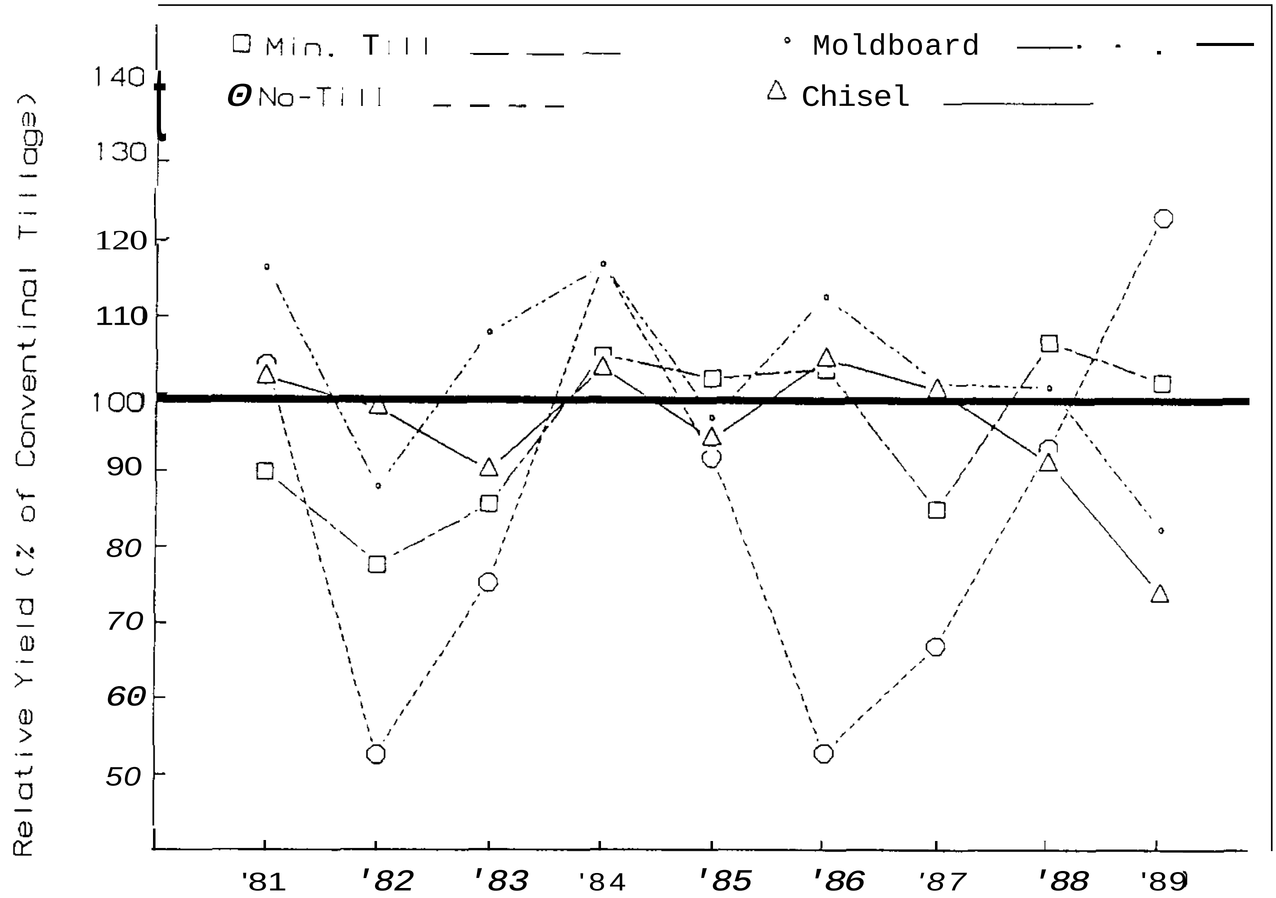

Figure 1. Relative yield of grain sorghum grown under conservation tillage and two forms of primary tillage (1981-89)

Further breakdown of tillage treatment response indicates that moldboard tillage at 30-cm depth resulted in sorghum becoming less productive in seasons with subnormal fall and spring rainfall. The chisel system of primary tillage (30-cm depth) disturbs soil aggregates considerably less than the moldboard system. However, sorghum responded to this system quite similarly to the moldboard in most seasons. The moldboard system appeared to improve sorghum yields above the conventional system in four of the nine seasons. Also, when moldboarding was used as a method of primary tillage, only three of nine years were less productive than the conventional system. Subnormal rainfall was recorded during two of those less productive seasons. At the same time, yields dropped in four of nine years when chiseling was the form of primary tillage. Lowest yields were experienced with no-till farming in years with above normal rainfall and this was usually associated with problems in weed control.

Soil Insecticide Effects:

Relative yields of grain sorghum as affected by placement of soil insecticide in the seedrow are presented for six years with the initial year in 1983 and the final year 1989 (Table 2). Soil insecticide comparisons were not made in 1988 due to a split-plot comparison of two sorghum hybrids.

Table 2. Relative response of grain sorghum to in-row soil insecticide as affected by conservation tillage and seedbed preparation. Percent increase or decrease in yield due to soil insecticide.

Tillage System	1983[1]	1984[1]	1985[1]	1986[1]	1987[1]	1989[2]	Avg.
				%			
Conventional	116.1	113.0	132.9	90.7	98.3	68.9	103.3
Min. Till	107.7	112.8	118.0	113.6	113.9	86.2	108.7
No-till	79.0	127.2	114.9	84.8	137.5	91.5	105.8
Moldboard	114.0	127.7	104.4	109.0	135.9	61.7	108.8
Chisel	147.3	123.8	113.1	102.5	94.3	64.5	107.6
$\bar{X}$	1128	120.9	116.7	1W.1	116.0	74.6	

[1]0.50 lb a.i. ac-1 of carbofuran in seedrow.
b.5 lb a.i. ac-1 of terbufos in seedrow.

As indicated earlier, grain yields fluctuated widely over the six production seasons. Yields averaged across tillage treatments and the six years were 3409 lb A-1 for the insecticide treated plots and 3076 lb A-1 for the check plots. Relative yields averaged over tillage treatments for individual years ranged from a low of 74.6% (1989) to a high 120.9% (1984). Although treatment means averaged across years show only slight changes due to the type of primary tillage, treatment differences within season were quite substantial. The largest spread in relative yields **as** a function of insecticide and method of tillage **occurred** in 1983 and 1987 with the extend approximating ***68*** and 43%, respectively. The larger treatment variation was recorded during the droughty season in 1983.

There did not appear to be a consistent relationship between method of tillage and response to soil-applied insecticide. In seasons when the relative response to insecticides showed the greatest disparity due to tillage system, insecticide treatment produced a negative response (79%) in the no-till system while in the 30-cm chisel system the same treatment showed the highest response (147%). However, in the season with the second highest treatment response spread (1987) and less plant stress for water, no-till sorghum showed the highest response to insecticide (137.5%) while the chisel method produced no response (94.3%). The yield fluctuations were not associated with consistent changes in plant population in response to the soil-applied insecticide.

The relative yield for treated sorghum averaged across tillage systems for 1989 was less than 75% of yield for sorghum not receiving soil insecticide. This severe suppression of yields was not due to adverse effects on plant population but apparently a result of phytotoxic effects from terbufos on the plants. Visual observations indicated stunted growth and some chlorosis of sorghum foliage. Carbofuran used in the previous five years showed no phytotoxicity or stunted growth. Recent greenhouse experiments on a similar soil showed severe stunting and induced interveinal chlorosis of foliage in sorghum plants treated with terbufos while similar symptoms were not noted on sorghum treated with carbofuran.

Summary

Results of this long-term experiment indicate grain sorghum grown in a minimum reduced tillage system can produce as much or more grain in five of nine years as sorghum grown in a conventional tillage system. Based on relative yields averaged for the nine years, grain sorghum grown with minimum tillage can be 95% as productive as that grown under the conventional system.

The six-year evaluation of the need for a soil-applied system insecticide for control of sorghum pests indicated that sorghum response as measured by final grain yields will be highly variable with cropping season. Yield response averaged over seasons with minimum tillage showed an approximate nine percent increase in sorghum grain yield. This compared to six and three percent for no-till and conventional tillage, respectively.

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