Tillage and Soil Insecticide Effects on Dryland Corn Yields

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INTRODUCTION

Conservation tillage programs are important even on nonerodible soils. Definitive research in conservation tillage in the southwest had not been initiated extensively until the 1980s. Compliance with soil erosion guidelines, economic factors including rising inputs *costs* for equipment, fuel, labor, other variable costs, and uncertain market prices are strong incentives to develop and adapt Conservation tillage systems. Earlier reports have described conservation tillage systems that appeared suitable for southern Texas (Matocha, 1993; Matocha et al., 1991; Salinas-Garciaetal. 1997).

The specific objectives of this study were: 1) to compare alternative tillage systems including two forms of conservation tillage on plant rooting and grain yields and 2) to determine the need for soil insecticides with conservation tillage.

MATERIALS AND METHODS

The long-term dryland study was conducted from 1980 through 1995 on an Orelia sandy clay loam (hyperthermic Typic Ochraqualf) located at the Texas Agricultural Experiment Station farm at Corpus Christi A randomized complete block design with eight tillage treatments as major plots and three principal crops, grain sorghum *(Sorghum bicolor* [L] Moench), corn *(Zea **mays*** L.), and cotton *(Gosypium hirsutum* L.) as sub or split-plots were each studied in four replications. Tillage treatment response data reported in this paper are for corn as the indicator crop and include: 1) conventional (CT), 2) minimum tillage (MT), 3) no-till (NT), and deep tillage (12-inch depth) using 4) moldboard (MB) and 5) chisel (CH) plows. The conventional system includes some 10-12 tillage operations including planting and cultivating. Maximum tillage depth in the CT system was 6 in., while tillage depth in the MT treatment was maintained at 3 in.

Further description of MT and CT tillage systems is given in Table 1. Secondary tillage was performed using bedder sweeps. Atrazine, paraquat, and sometimes glyphosate were used in the NT and MT plots.

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Atrazine was also used in the CT, MB, and CH tillage systems as post-plant spray. Carbofuran (Furadan) was used in the seedrow at planting at a rate of 1.0 lb a.i./a for control of soilborne insects in 1983, 1985, and 1989. Terbufos (Counta) was used in 1991, 1993, and 1994 at label recommended rate of 1.0 lb a.i./a. In the years indicated, both soil insecticides were compared with untreated checks in split-plot design. Corn was rotated with cotton in four-year cycles with corn and cotton initiated in 1979 in split plots, corn was moved to cotton plots in 1983 and continued through 1986 followed by cotton for four years. In 1987, corn again followed cotton for a four-year project. In 1991, corn was again moved to the cotton side of the plots and continued through 1995.

Soil cores were extracted using a four-inch-diameter probe at selected depths to 24-in. at the silking stage of growth. Cores were centered directly over individual corn plants. Root mass determinations were made using a root washer and analytical balance.

RESULTS AND DISCUSSION

Tillage effects

Early plant growth. Plant growth as well as final grain yields fluctuated with season and precipitation during the growing period. In seasons with below long-term average precipitation (Table 2), plant growth was suppressed by deep primary tillage methods that caused the greatest disturbance of soil particles (12-in. moldboard vs no-till). On the other hand, if precipitation was not limiting, growth very little difference was observed among the five primary tillage systems. Growth of no-till corn was significantly less due to grassy-weed competition. Present herbicide technology using over-the-top sprays with sulfanyl urea compounds was not available during earlier years of the study, and when it later became available, the proximity of sorghum and cotton prevented its use.

Grain yields. Grain yields were variable with crop year and precipitation occurring during the period of April-June. However, April-June precipitation did not correlate highly with final grain yields. Yield data describing tillage depth effect for 16 of the 17 yr of the study are presented in Figure 1. Data for the first yr, 1979, are not shown Grain yields ranged from a low of 1020 to a high

6100 lb/a. In general, yields fluctuated with precipitation during the growing season with some exceptions. The no-till treatment represented the zero tillage depth. Data show that in nine of the 16 yr, sufficient positive yield response was measured to offset the cost of chisel sweep tillage at six-in depth. However, yield response to chisel sweep plowing at 12-in depth was sufficient to more than offset tillage costs in only two of the 16 yr of the study Complete inversion of the soil as is the case with moldboard plowing caused even more substantial reduction in crop yields in certain seasons with subaverage precipitation during the fall months. These data followed normal expectation for dryland farming since tillage methods that cause the greatest and deepest disruption of soil physical properties should affect plant available soil moisture (Cripps and Matocha, 1987).

Yield data averaged for seven relatively wet and five relatively dry seasons show no difference due to method of tillage at both 6-in. and 12-in. plowing depths (Figures 2-3). Yields increased approximately 50%, 60%, and 53% due to increased precipitation for CH, MB, and CT tillage *systems*, respectively, when tillage was performed to a depth of 6 in. (Figure 2).

Increasing tillage depth to 12 in. with either the CH or MB plow (Figure 3) resulted in increased averaged yields in the wet seasons by 68% and 76%, respectively, over the dry seasons while the CT system produced 53% higher yields. These yield increases of approximately 19% with 12 in tillage depth over 6-in. depth (CT) are probably due to increased rainfall harvesting and water retention in the profile. These data also show an approximate average 300 lb/a or 9% yield reduction due to deep tillage with either MB or CH plows in the dry seasons.

Yield data for five individual tillage systems are presented for four yr with high precipitation during the growing season (ppt. 150% above average) in Figure 4. Yields from MT treatment substantially exceeded from the CT yields in one of the four yr (1981) and those from NT in four or five yr. Average MT yields for these wet yr were 101% of those for the CT system while average MB yields were slightly higher, at 103% of CT. The slight increase in yield due to MB plowing to 12-in depth would not be economically justifiable.

Variable but nonsignificant response to tillage method was measured during the four seasons when April-June precipitation was less than 50% of average (Figure 5). Yields during these dry periods were less than 50% of those observed for the periods when soil moisture was adequate (Figure 4). In three of the four dry yr, 1984, 1988, and 1990, corn grown with the MT system produced 600-700 lb/a more grain than corn grown with NT. In 1984, MT corn produced substantially more grain that corn grown with the CT system. Corn yields with MT averaged for the four dry seasons were 110% of those for the CT system.

Plant rooting. Root data showed that MB tillage produced corn with slightly higher root weights than NT corn and significantly greater rooting in the surface 6 in. than MT, CT, and CH systems (Figure 6). However, these differences became less pronounced with soil depth. At the 6- to 12-in. depth, only the CT systems produced significantly greater rooting than the NT and MT systems. At the 12- to 18-in. soil depth, corn showed significantly greater root weights when grown in the CH system compared to MB. No treatment effect on rooting was apparent at soil depths below 18 in.

Soil insecticide effects

Corn grain yields comparing effects of soil insecticides for four separate tillage systems are shown for 6 yr in Figures 7-8 . Furadan was used in the first three yr while Counter was applied in the second three yr of insecticide use. Data for 1983, which was the first yr of *corn* following cotton in the four yr rotation, show only limited response to Furadan application in the seed row. Yields were limited due to subaverage rainfall during the growing season. Both conservation tillage systems produced yields equal to CT. Likewise, in 1985, the third yr of continuous corn, with average rainfall, yield data indicated no response to soil insecticide regardless of the tillage system used in seedbed preparation. In fact, a slight yield depression was evident in the conservation tillage treatments which was not expected. Similar data for the fourth yr of continuous corn is not available since soil insecticide was not used. Perhaps some response to soil insecticide could have occurred in the fourth yr.

Data for 1989, the third yr of continuous corn following the second cycle of cotton, show a trend of yield enhancement due to insecticide in all tillage treatments with the largest yield increase with NT. Generally, little or no yield enhancement is expected during the first yr or two following rotation with crops such as cotton or soybean.

Response data to tillage and soil insecticide using Counter are presented in Figure 8 for three yr in the latter part of the study. Rainfall during these three seasons was generally adequate to excessive as shown in Table 2. The data show in paired comparisons the application of Counter at recommended rate produced no significant increase in grain yields regardless of tillage system. However, small increases due to insecticide use occurred, but generally ranged from minus 190 lb/a to positive 770 lb/a outside of the conservation tillage treatments. Within the two conservation tillage treatments, yield influence ranged from a low of 230 (NT) to a high of 660 lb/a (MT). The higher response was measured during the fourth yr of continuous corn.

CONCLUSIONS

Grain yields were highly variable with yr and precipitation during the 15 growing seasons. Method of primary tillage usually has little or no effect on final grain yields except in droughty seasons when yield reductions were associated with deep primary tillage with either moldboard or chisel plows. A minimum tillage system developed for southern Texas produced 110% of the CT system corn yields in seasons with subaverage precipitation and 101% with above average precipitation. Plant rooting in the surface 6 in was most intense for NT and MB systems and highest with CT in the 6- to 12-in soil layer. Small and inconsistent responses in final grain yields to both Furadan and Counter soil insecticides suggest their use in CT and MB tillage systems would not be economically feasible. However, data for NT and MT suggest a possible economic response.

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Table 1. Description of conventional and minimum tillage systems.

Conventional (10-11 tillage trips)	Minimum Till (5 tillage trips)
1. Shred and disc corn stalks	1. Disc corn stalk
2. Middlebuster corn rows	2. Root plow corn row and form slight bed over row
3. Rebed with middlebuster plow	3. Spray atrazine or paraquat as needed for fall-winter weed control
4. Plow middles between beds using busters and sweeps run through beds to control weeds, 2-4 times during fall and winter depending upon rainfall.	4. Knife in fluid fertilizer
5. Knife in fluid fertilizer	*5. Plant using JD Model 6100 planter
6. Plant using sweep-type planter (JD Model 6100)	6. Cultivate once
7. Cultivate twice	*No-till was planted with JD Maxi emerge

Table 2. Monthly rainfall in inches at Corpus Christi, TX, 1980-1995 and long-term average (LTA).

	LTA	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95
January	1.71	1.64	1.66	0.13	0.35	6.32	2.40	1.41	1.85	0.81	1.72	0.44	1.78	3.03	0.40	0.79	0.63
February	1.96	0.79	1.80	8.36	2.00	0.26	3.20	1.54	3.82	1.20	1.87	2.23	1.43	3.40	1.58	0.85	2.38
March	0.94	0.32	1.63	0.22	2.18	0.09	1.93	0.50	0.19	0.92	0.40	2.46	0.91	4.11	2.76	2.23	3.51
April	1.72	0.06	1.46	0.79	0.00	0.00	2.63	0.80	0.76	0.69	2.68	4.53	3.23	2.29	2.13	2.26	0.3
May	3.33	2.28	7.45	1.73	3.25	1.32	3.76	3.80	3.13	1.10	0.00	0.75	3.59	7.67	6.80	1.55	3.18
June	3.09	0.00	2.27	0.30	2.13	0.41	4.23	3.27	7.93	0.66	3.10	0.43	8.56	2.26	8.49	3.20	2.25
Total March-June	9.37	2.66	12.81	3.04	7.56	1.82	12.55	8.37	12.01	3.37	6.18	8.17	16.29	16.33	20.18	9.24	8.97

Table 3. Effect of tillage system on early growth of corn for growing seasons with different precipitation patterns (values followed by the same letter within columns do not differ significantly).

System	Below Average Precipitation	Above Average Precioitation
No-Till	281 la	4390 c
Min. Till	2242ab	5824ab
Conventional	2806ab	5723ab
Moldboard -12-inch	1848 b	5286 b
Chisel - 12-inch	1928ab	5421 b

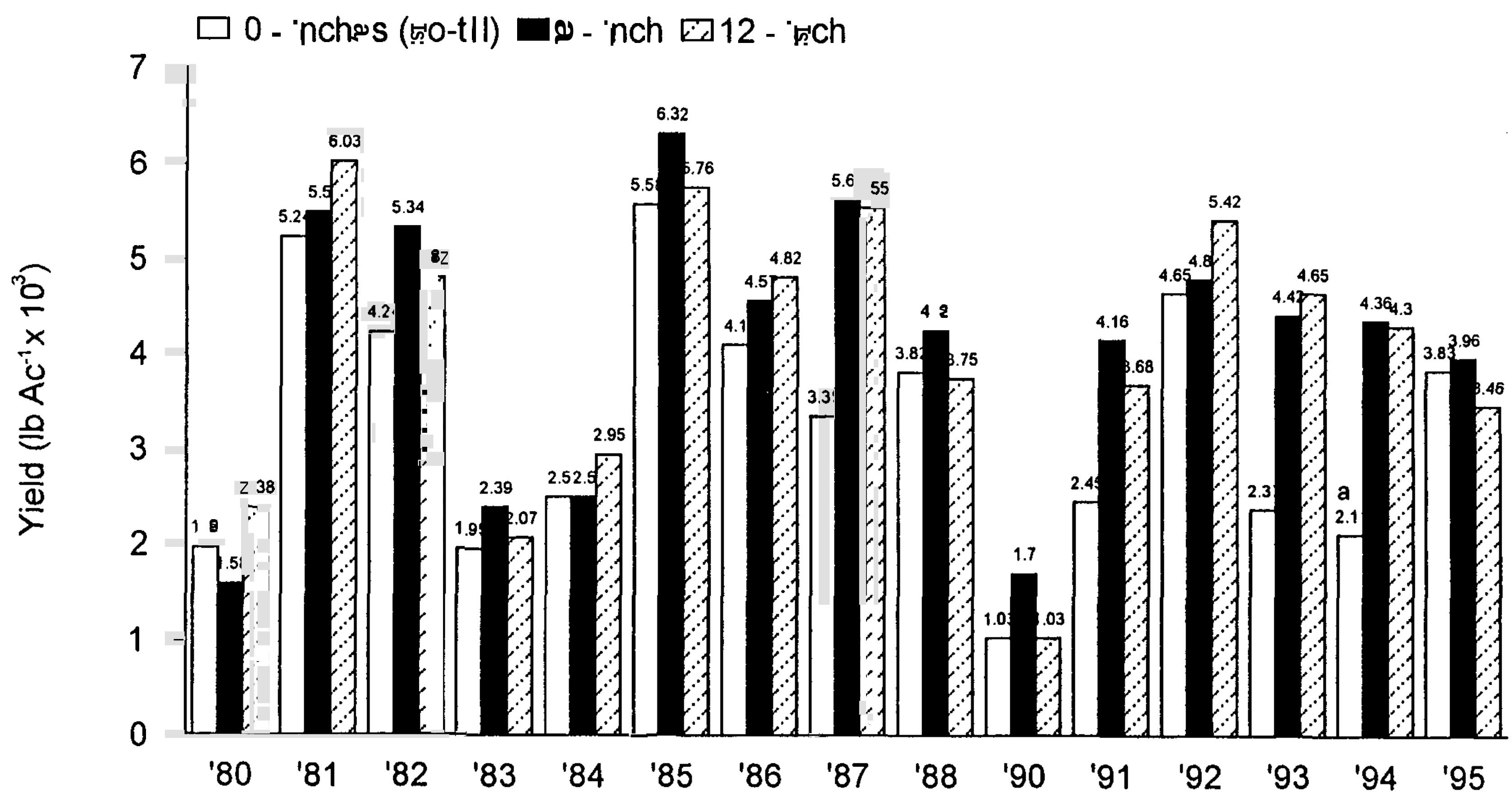

Figure 1. Influence of plowing depth on grain yield of corn over 16 seasons (chisel sweep used in 6 and 12 -inch depths).

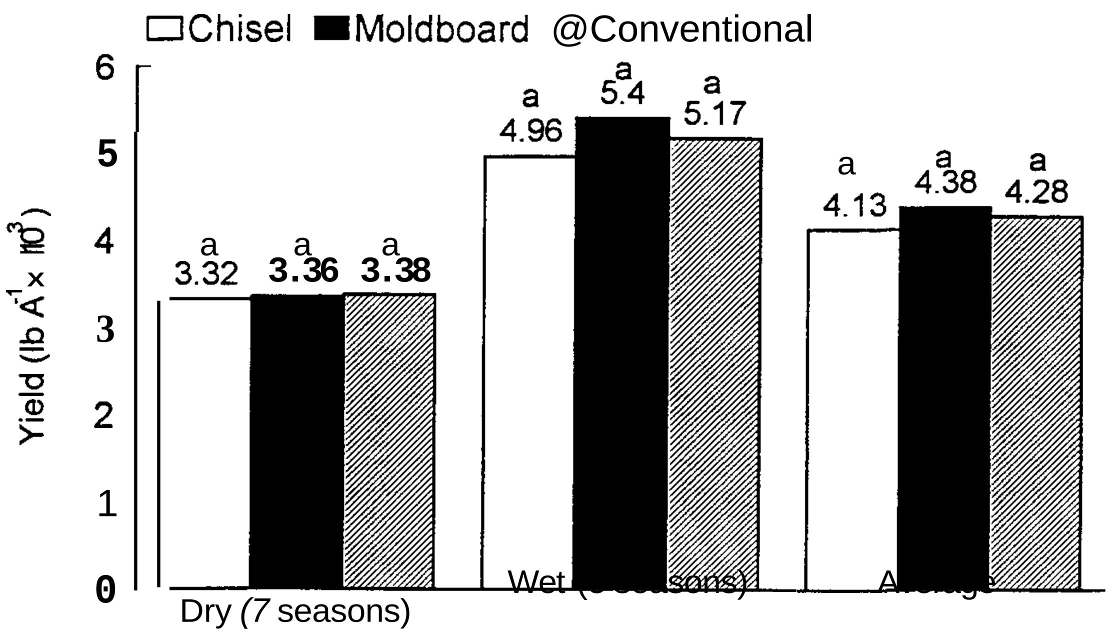

Figure 2. Effect of primary tillage methods and precipitation on corn yields. Values followed by the same letter within seasons are not significant at 0.05 (6-Inch tillage depth, chisel & moldboard).

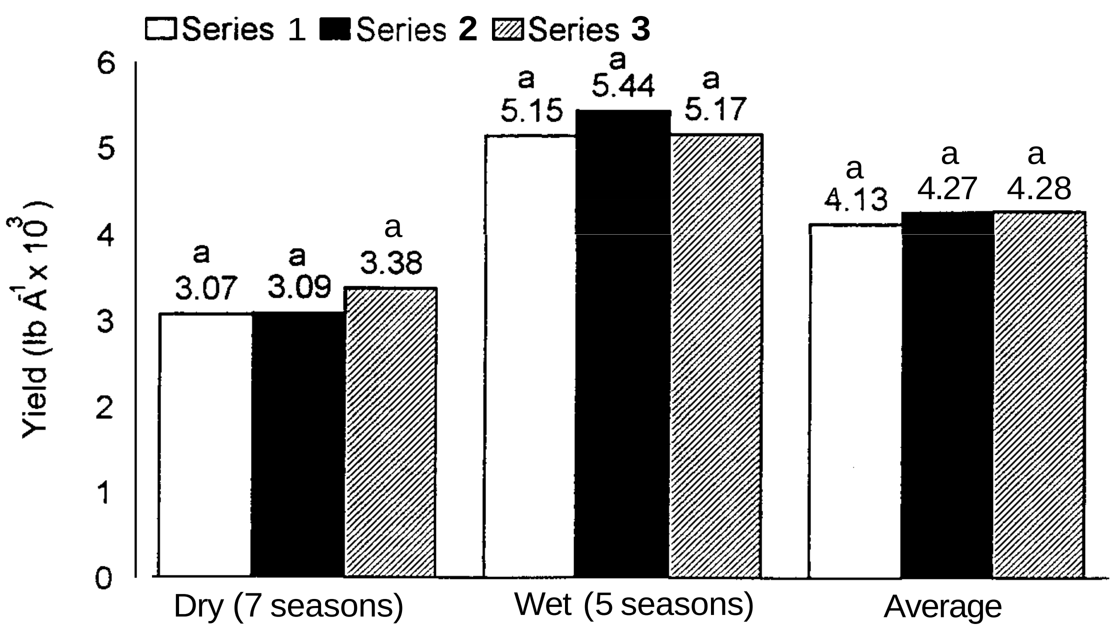

Figure 3. Effect of primary tillage methods and precipitation on corn yields. Values followed by the same letter within seasons are not significant at 0.05 (12-inch tillage depth, chisel & moldboard).

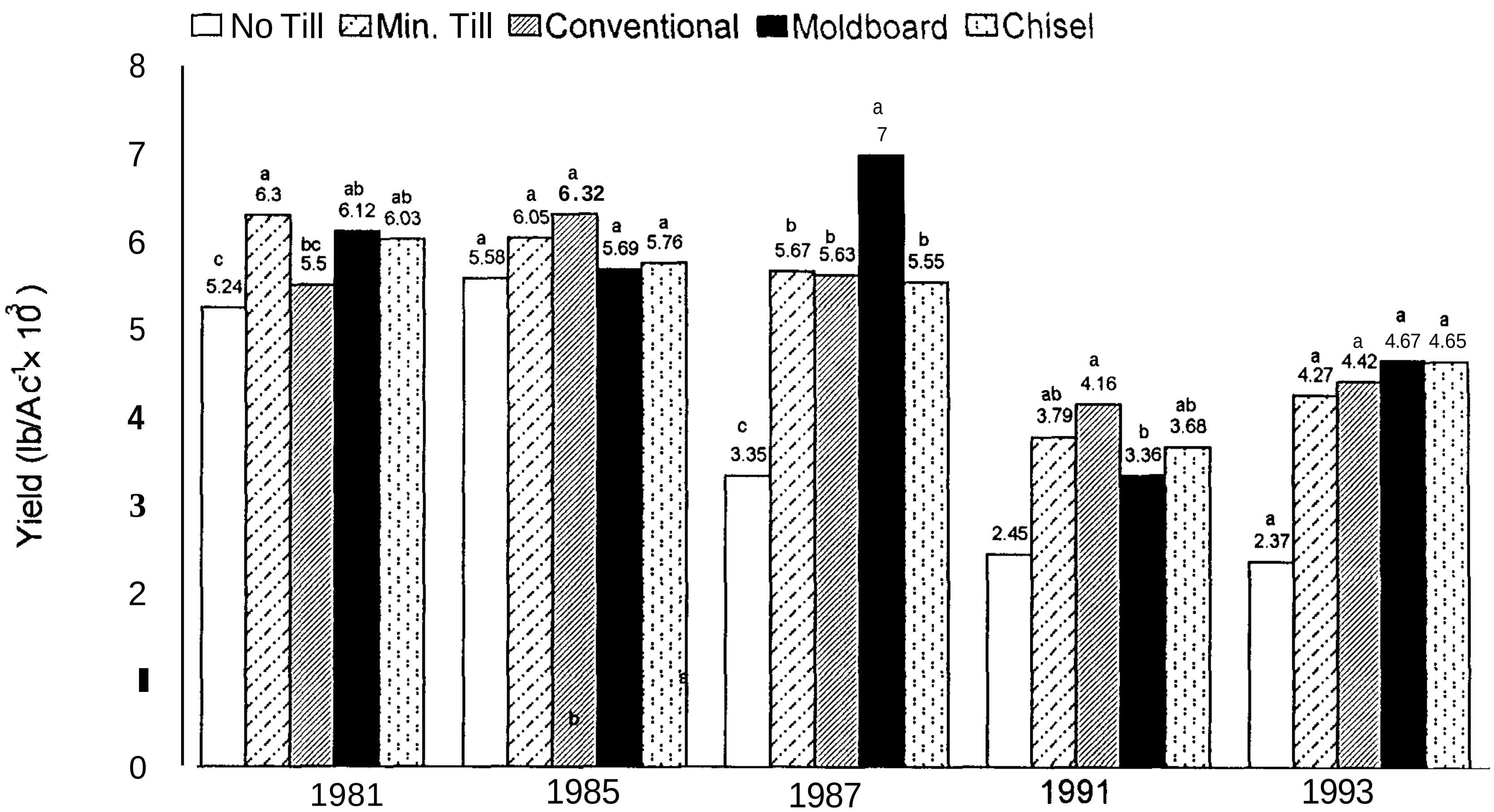

Figure 4. Effect of long-term tillage systems on grain yields with precipitation 150 percent of average. Moldboard and chisel plow at 12-inch depth. Values followed by the same letter within seasons are not significant at 0.05.

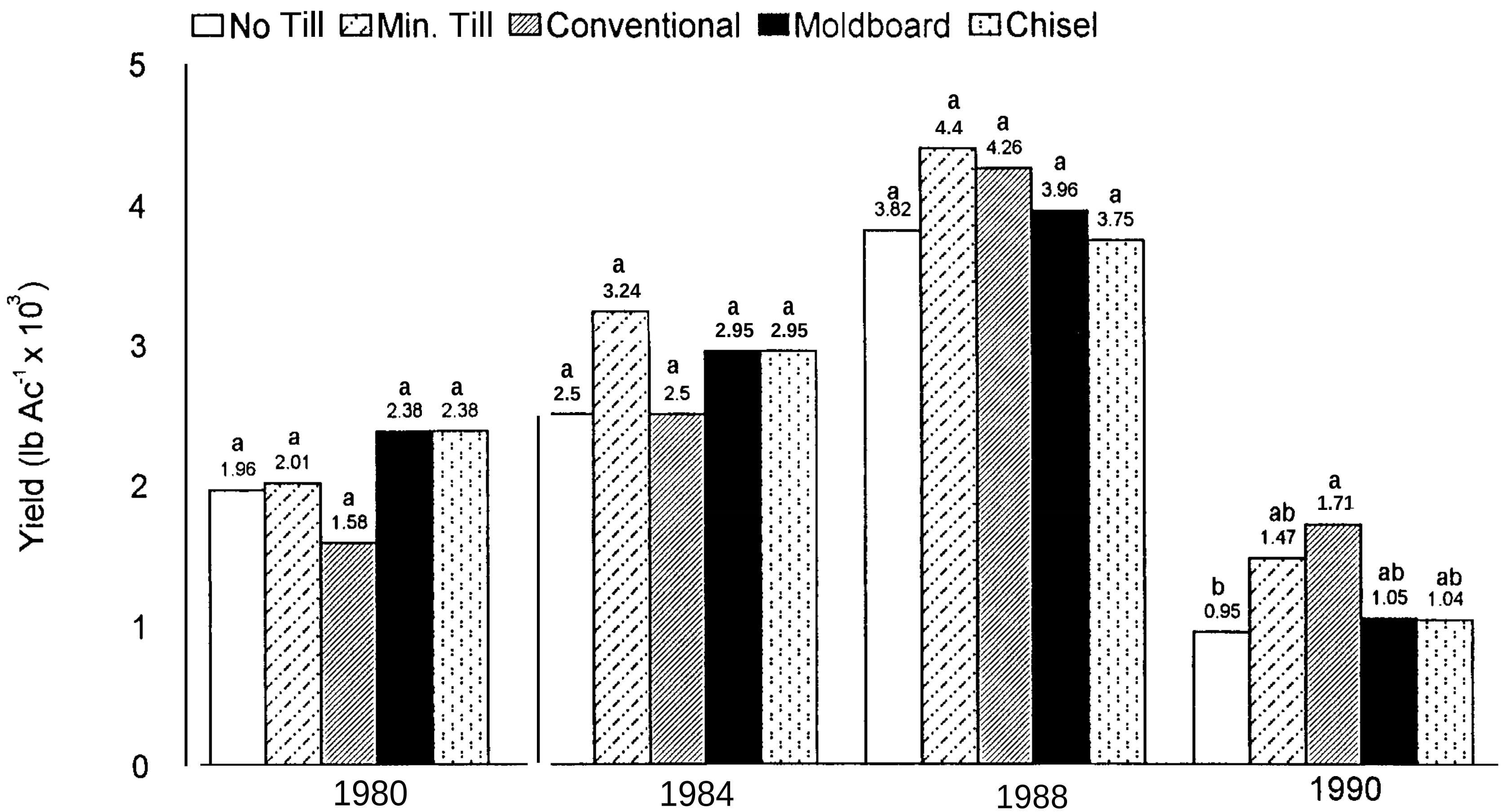

Figure 5. Effect of long-term tillage systems on grain yields with precipitation less than 50 percent of average. Moldboard and chisel plow at 12-inch depth. Values followed by same letter within seasons are not significant at 0.05.

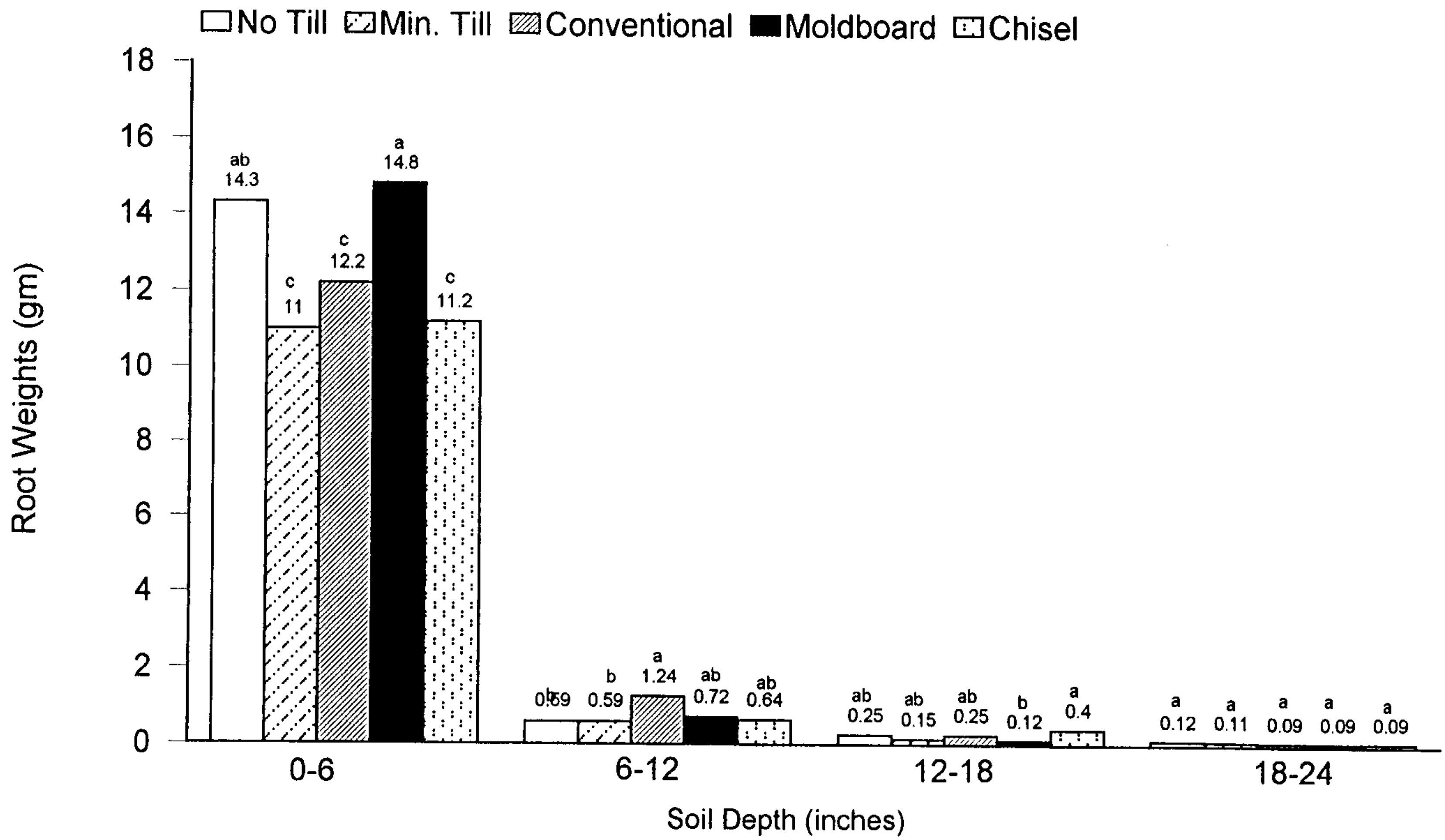

Figure 6. Plant root weights as affected by tillage systems at various soil depths.

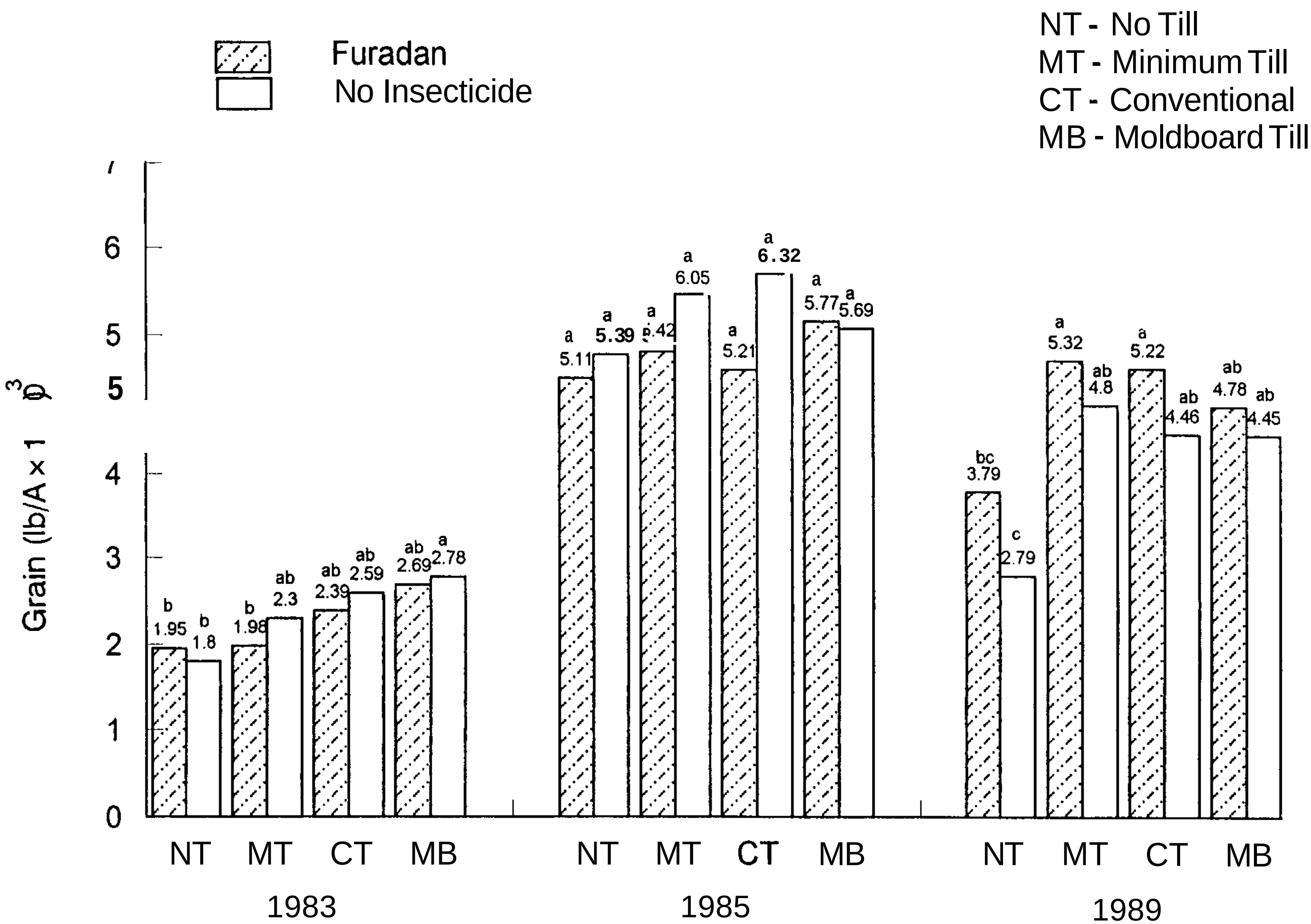

Figure 7. Influence of tillage systems and soil insecticide on grain yields of corn (T-3). Values followed by the same letter within season are not significant at 0.05 level.

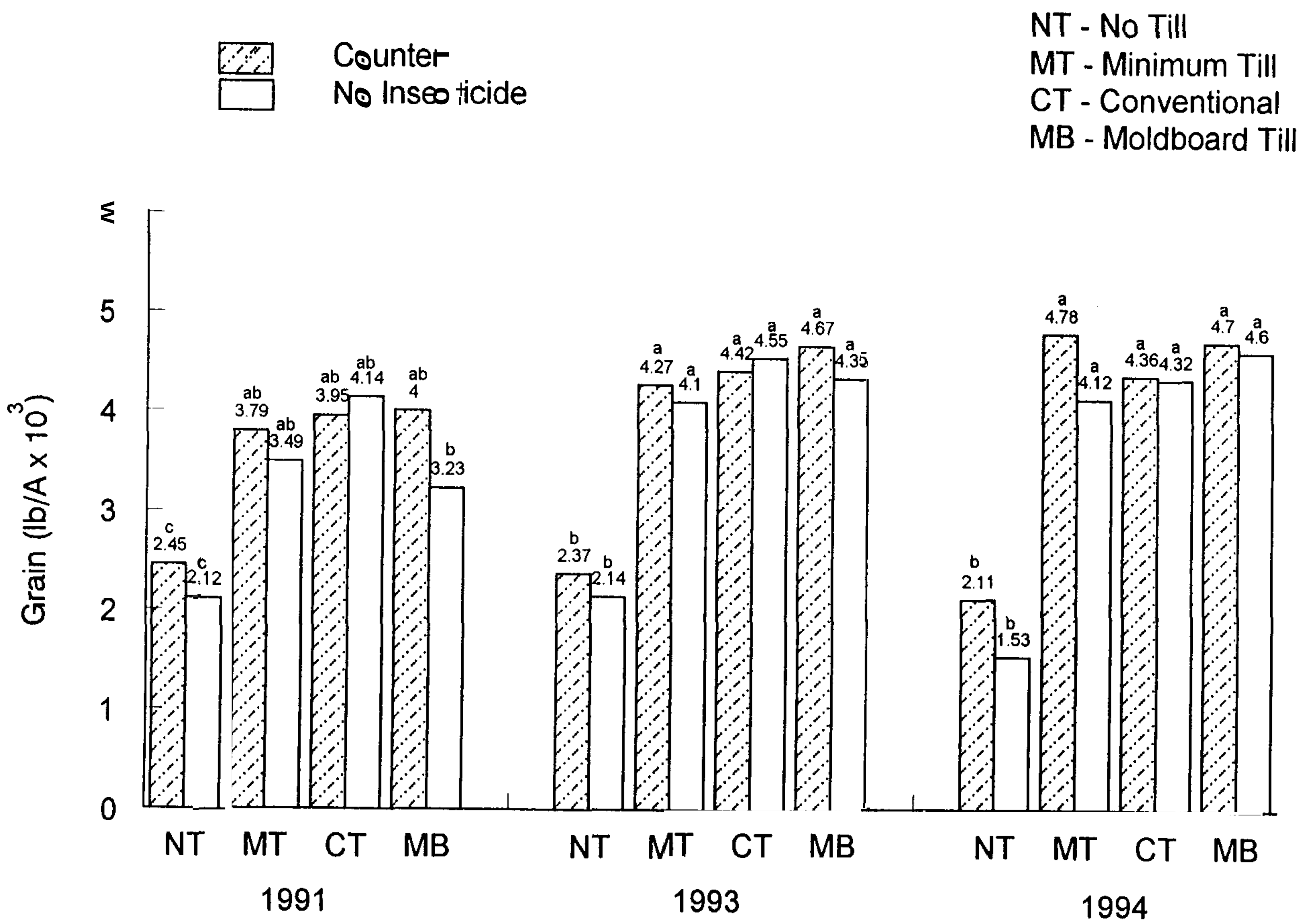

Figure 8. Influence of tillage systems and soil insecticide on grain yields of corn (T-3). Values followed by the same letter within season are not significant at 0.05 level.