SITE-SPECIFIC SUBSOILING: BENEFITS FOR COASTAL PLAIN SOILS

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ABSTRACT

The negative impacts of soil compaction on crop yields can often be alleviated by subsoiling. However, this subsoiling operation is often conducted at unnecessarily deep depths where it wastes energy and disturbs surface residue necessary for erosion control and soil quality. A corn (*Zea mays* L.)-cotton (*Gossypium hirsutum* L.) rotation experiment was conducted for four years on a Coastal Plain soil with a hardpan in east-central Alabama to evaluate the potential for site-specific subsoiling (tilling just deep enough to eliminate the hardpan layer) to improve crop yields and conserve energy. Both crops showed benefits of subsoiling as compared to the no-subsoiling treatment. Site-specific subsoiling produced yields equivalent to deep subsoiling treatment while not excessively disturbing surface soil and residues.

INTRODUCTION

The depth and degree of soil compaction has been found to vary greatly throughout Southern U.S. fields. Subsoiling at a uniform depth has been found to be particularly effective in reducing the effect of compaction on crop yields (Campbell *et al.*, 1974). However, subsoiling at a depth deeper than necessary wastes subsoiling energy and unnecessarily disturbs excessive amounts of soil and crop residue. Also, subsoiling at a depth shallower than necessary wastes subsoiling energy without eliminating the compacted soil condition.

Adjusting the depth of subsoiling to match the hardpan depth throughout a field, i.e., site-specific subsoiling, was investigated as a potential method for soil compaction management. Measurements of the hardpan depth taken in the Southeastern U.S. indicate that between 25 and 75% of subsoiling energy could be saved if some form of site-specific subsoiling could be developed and used (Fulton *et al.*, 1996; Raper, 1999). Also, some data indicate that subsoiling deeper than necessary may reduce yields (Raper *et al.*, 2000). Therefore, this study was initiated to evaluate whether the concept of site-specific subsoiling was viable.

METHODS AND MATERIALS

A 20-ac field from the Alabama Agricultural Experiment Station's E.V. Smith Research and Education Center in east-central Alabama, USA was used for this experiment. The coastal plain field was comprised of a Toccoa fine sandy loam (coarse-loamy, mixed, active, nonacid, thermic Typic Udifluvents) that had excessive soil strength and required annual subsoiling. A complete set of soil cone penetrometer measurements (ASAE, 1999a; ASAE, 1999b) were obtained with the Multiple-Probe Soil Measurement System (Raper *et al.*, 1999) on an approximate 300-ft grid. Cone index measurements were analyzed to determine depth to the hardpan over the entire field.

The depth of the hardpan that was responsible for restricting root growth was found to range from 6-18 in. over the entire field. This range in depth of compaction was split into three distinct hardpan depth ranges of 6-10 in, 10-14 in, and 14-18 in, with four replications within the field. Three subsoiling treatments were imposed across each of the hardpan depth ranges in the spring of 2000, 2001, 2002, and 2003:

1. no-subsoiling (zero-depth subsoiling)
2. site-specific subsoiling (10-in, 14-in, or 18-in depth subsoiling)
3. deep subsoiling (18-in depth subsoiling)

As an example, for the plots with the shallowest hardpan (the 6-10 in hardpan depth), a 10-in subsoiling depth was selected for the site-specific subsoiling depth. Therefore, three subsoiling treatments were applied in these shallow hardpan areas; (1) no-subsoiling, (2) site-specific subsoiling (with a depth of 10 in), and (3) deep subsoiling. A John Deere (JD) 955 Row Crop Ripper equipped with 2.75-in wide LASERRIP™ Ripper Points was used for all subsoiling operations (Mention of trade names or commercial products in this article does not imply recommendation by USDA or Auburn University.) This subsoiler was supplied as part of a Cooperative Research and Development Agreement with Deere & Co (Moline, IL). Modifications were made to this implement to allow for a subsoiling depth of 10-18 in and to incorporate heavy residue handling attachments supplied by Yetter (Colchester, IL). This subsoiler was manually adjusted for each subsoiling depth by moving the coulters and the residue handling attachments. All subsoiling treatments were conducted as part of a conservation tillage system with limited tillage. The only field operations consisted of rolling the cover crop down, subsoiling, planting, harvesting, intermittent herbicide application as necessary, harvesting, and cover crop seeding.

The field was split (Field 1 and Field 2) to allow for a corn-cotton rotation. Cotton was planted in 40-in rows with 4-row equipment while corn was planted in 30-in rows with 6-row equipment. Plot size was either 4 rows x 100 ft for cotton or 6 rows x 100 ft for corn. Half of each plot was seeded to a cover crop and the other half was left bare. Prior to planting cotton, the cover crop was rye (*Secale cereale* L.). Prior to planting corn, the cover crop was crimson clover (*Trifolium incarnatum* L.).

An Agleader Technology, Inc. (Ames, IA) yield monitor was used to obtain corn yields. Yield data obtained from the middle 4-row section for each plot were averaged to determine a mean value for each plot. A cotton yield monitor from Agriplan (Stow, MA) was used to obtain cotton yield data for each of the plots. Yield data obtained from the middle 2-row section of each plot were averaged to determine a mean value for each plot.

A split plot arrangement of treatments with four replications was imposed in three field locations for each of the three hardpan depths, 6-10 in, 10-14 in, and 14-18 in. Main plots were cover crop and subplots were subsoiling treatments. Data were analyzed with an appropriate ANOVA model using SAS (Cary, NC). A significance level of $P \leq 0.1$ was chosen to separate treatment effects.

RESULTS AND DISCUSSION

Discussions will be limited to main and two-way treatment effects, although some slight three-way interactions were noted.

Corn Yield

Corn yield averaged across replications, depth of hardpan, and cover crop for years 2000-2003 showed yields varied significantly from 94 bu/ac in 2000 and 2003 to 124 bu/ac in 2002 (Figure 1;

P≤0.03). An interaction occurred between cover crop and depth of hardpan for corn yield (Figure 2; *P≤0.08*). In both the shallow (10-in) and deep (18-in) hardpan depth plots, the effect of the cover crop was to slightly decrease corn yields while in the 14-in hardpan depth plots, the cover crop caused slightly increased corn yields.

Subsoiling treatment was found to have a significant effect on corn yield (Figure 3; *P≤0.01*). Deep (18-in) subsoiling resulted in the highest yields (116 bu/ac) although yields were similar to site-specific subsoiling yields (110 bu/ac). Both deep and site-specific subsoiling resulted in greater yields than the no-subsoiling treatment (92 bu/ac). An interaction also occurred between the depth of hardpan and subsoiling treatment (Figure 4; *P≤0.02*) with reduced yields for each of the three subsoiling treatments in the deep (18-in) hardpan depth plots. A general trend seemed to exist where no-subsoiling yielded the least in all three hardpan depth plots. Another trend that all plots exhibited was that site-specific subsoiling yielded similar to deep subsoiling.

Cotton Yield

Seed cotton yield averaged across replications, depth of hardpan, and cover crop for years 2000-2003 showed yields varied significantly from 1776 lb/ac in 2002 to 2248 lb/ac in 2003 (Figure 5; *P≤0.01*). A year by cover crop interaction existed for cotton yield, with cover crops contributing to higher yields in only the first year of the experiment, 2000 (Figure 6; *P≤0.01*).

Subsoiling treatment was also found to have a significant effect on seed cotton yield (Figure 7; *P≤0.01*). Site-specific subsoiling (2030 lb/ac) and deep subsoiling (2151 lb/ac) both resulted in yields which were greater than no-subsoiling (1838 lb/ac), due to yield-limiting soil compaction inherent in this coastal plain soil.

A year by subsoiling treatment interaction also occurred (Figure 8; *P≤0.01*) with the 2000 season resulting in an anomaly; higher yields resulted for the no-subsoiling treatment than for the other two subsoiling treatments in 2000. In each succeeding year, highest yields were found with deep subsoiling (18-in) and site-specific subsoiling compared to the no-subsoiling treatment. A greatly reduced amount of rainfall occurred during the critical period for cotton production from mid-June to mid-July of 2000. Increased evaporation was probably present with the subsoiling treatments, thereby reducing yields from all plots except the no-subsoiling treatments.

Another interaction was found between the depth of hardpan and subsoiling treatment (Figure 9; *P≤0.04*). Similar trends were found for cotton yields and corn yields with slightly reduced yields being found for the deep hardpan (18-in) depths. Within this field, the overall productivity of soils with shallower hardpans tends to be greater than those containing deep hardpans. This is evidenced by noting that the yields from the no-subsoiling treatments declined as depth of hardpan increased.

CONCLUSIONS

1. Site-specific subsoiling produced corn and seed cotton yields similar to those produced by uniform deep subsoiling which were both greater than no-subsoiling treatment yields.
2. A trend existed that suggested cover crops contributed to slightly decreased corn and cotton yields for this soil type.
3. The depth to the hardpan was found to interact with subsoiling treatment. At the shallow hardpan depth, subsoiling didn't increase yields substantially over the no-subsoiling treatment. At the two deeper hardpan depths, subsoiling tended to produce a greater benefit.

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Figure 1. Corn yield averaged over replications, depth of hardpan, subsoiling treatments, and cover crop for years 2000-2003.

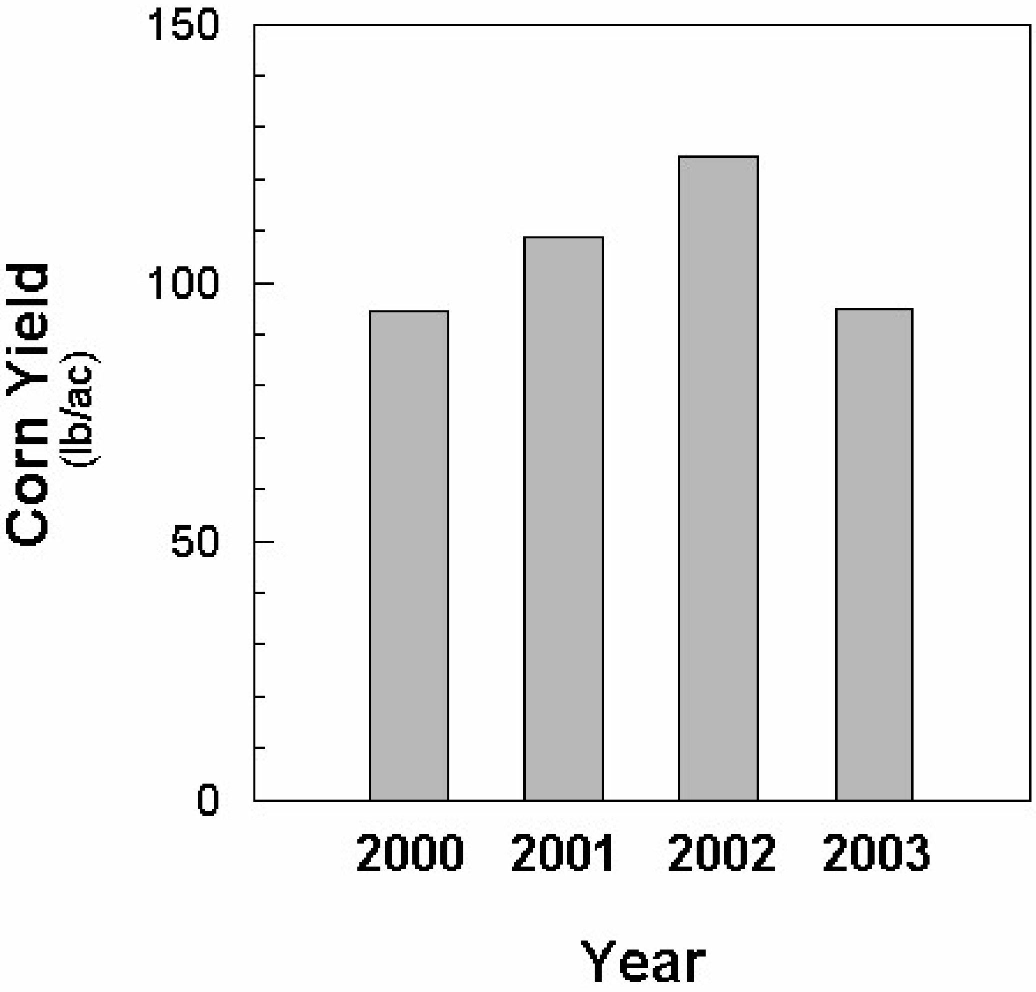

Figure 2. Corn yield averaged over replications, years, and subsoiling treatments showing the effect of cover crops in the three different hardpan depth zones.

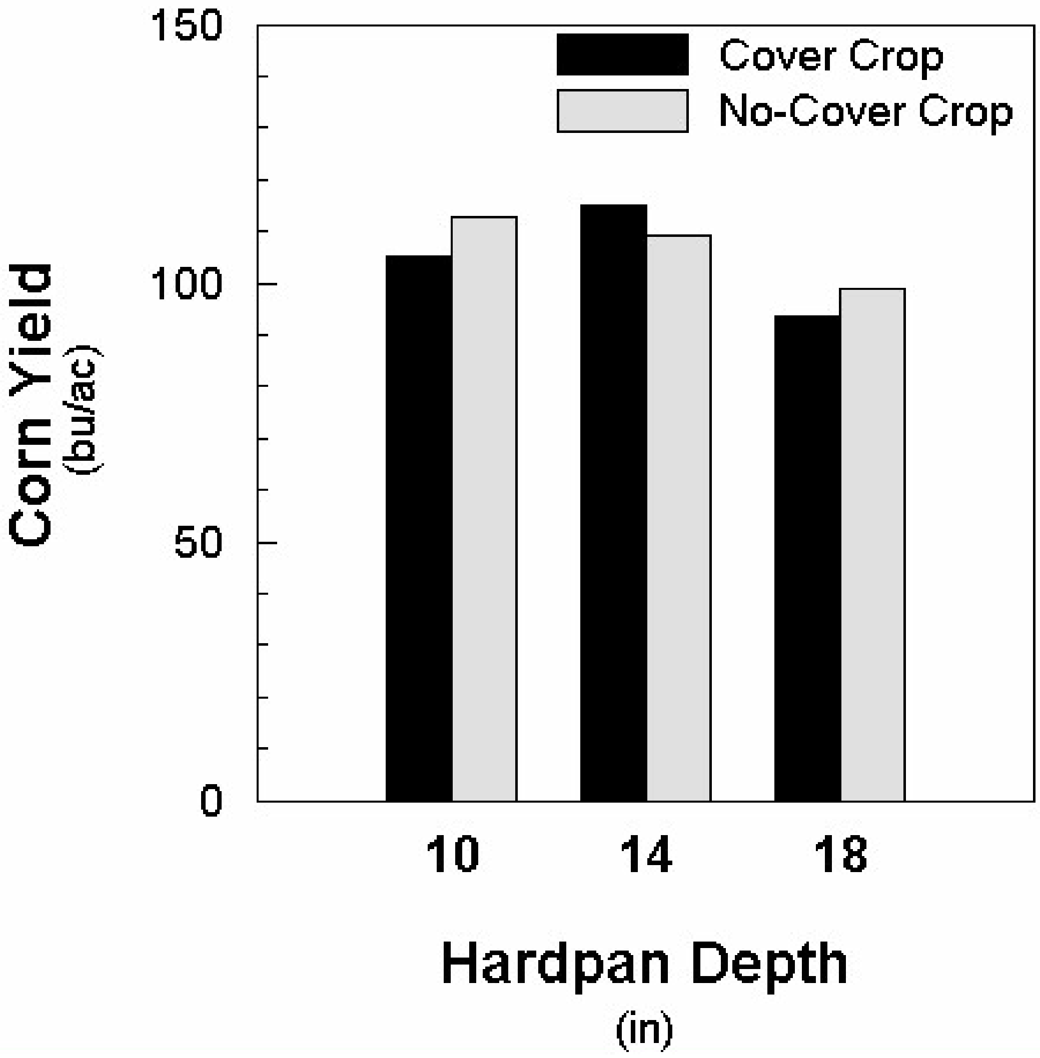

Figure 3. Corn yield averaged over replications, years, depth of hardpan, and cover crops showing the effect of the three different subsoiling treatments.

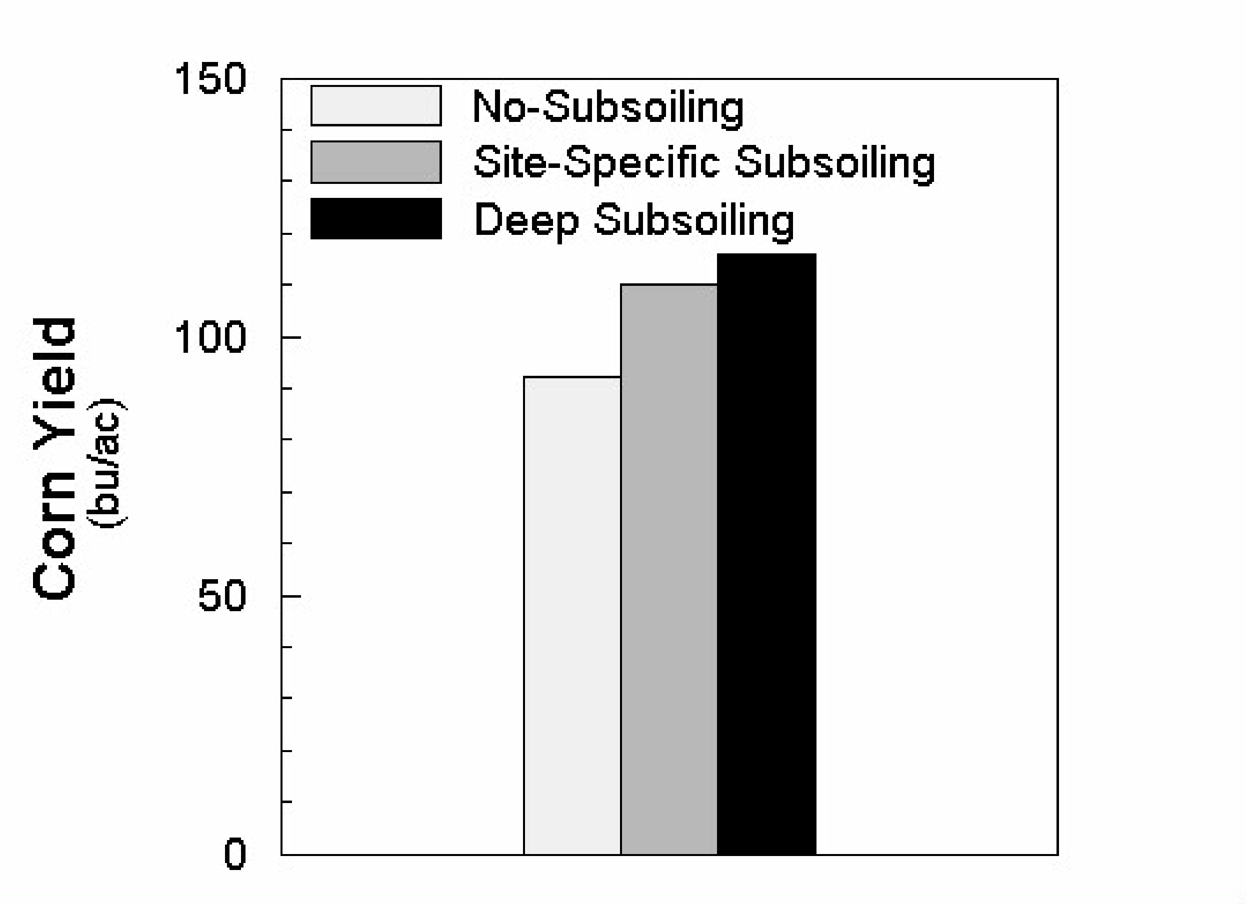

Figure 4. Corn yield averaged over replications, years, and cover crops showing the effect of the three subsoiling treatments in the three different hardpan depth zones.

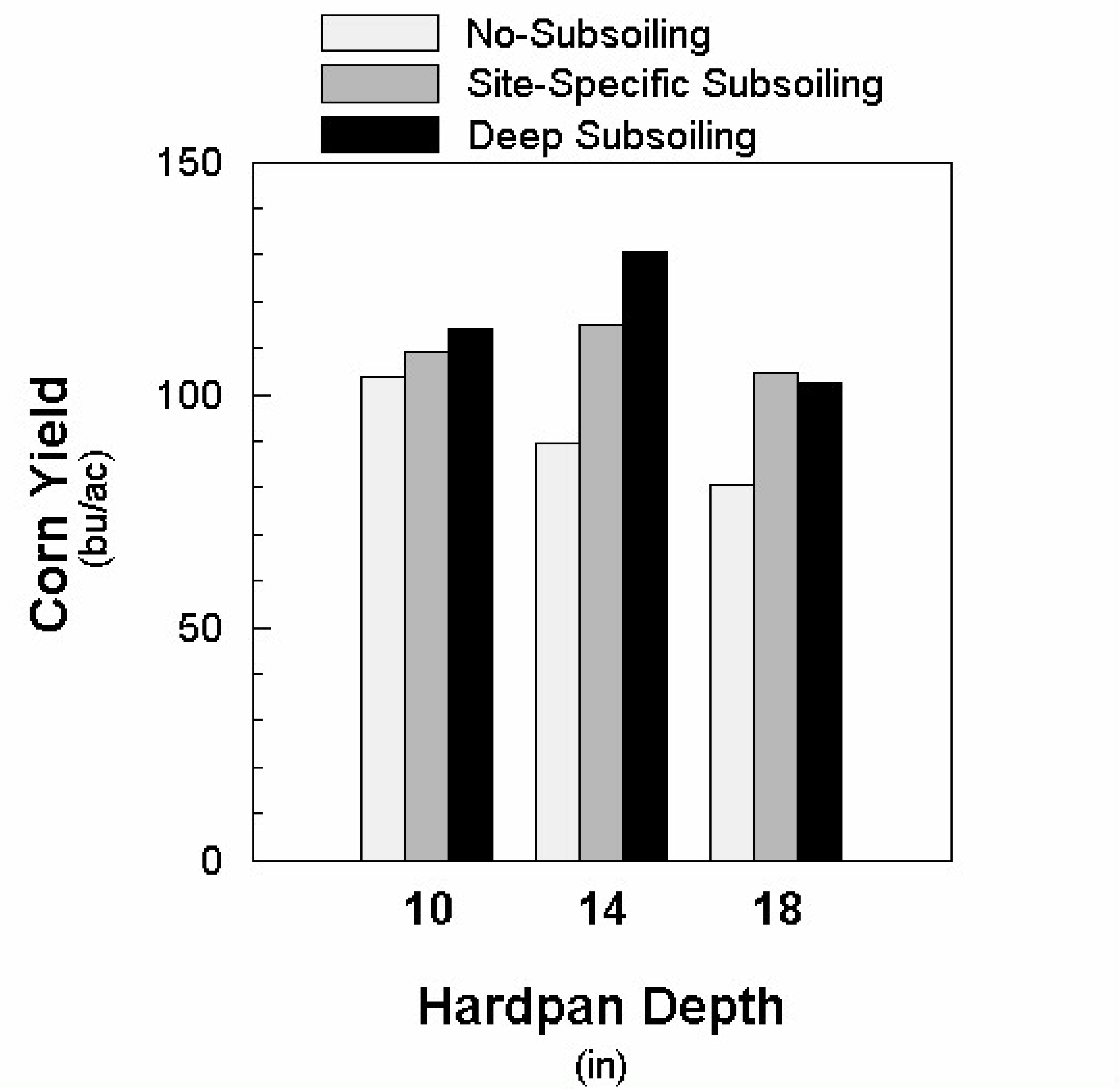

Figure 5. Cotton yield averaged over replications, depth of hardpan, subsoiling treatments, and cover crop for years 2000-2003.

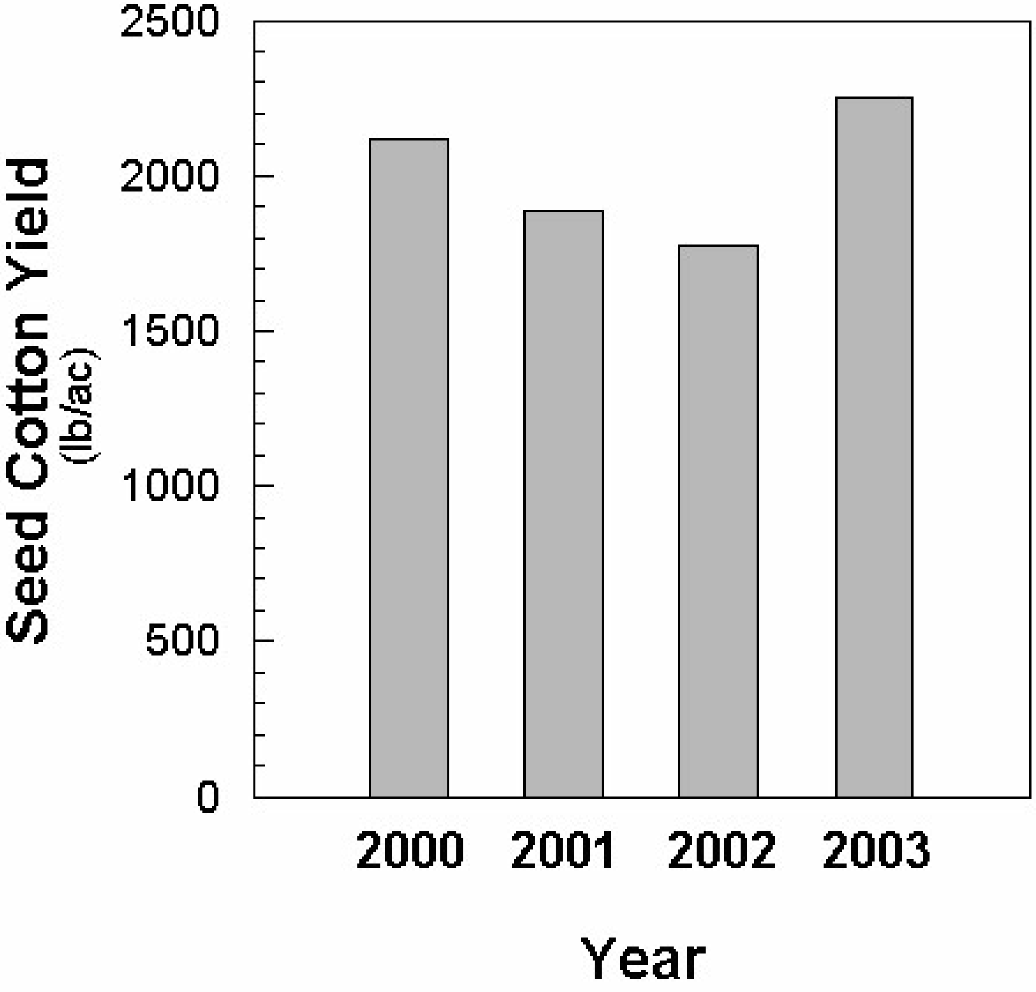

Figure 6. Cotton yield averaged over replications, subsoiling treatments, and hardpan depth zones showing effect of cover crops across years.

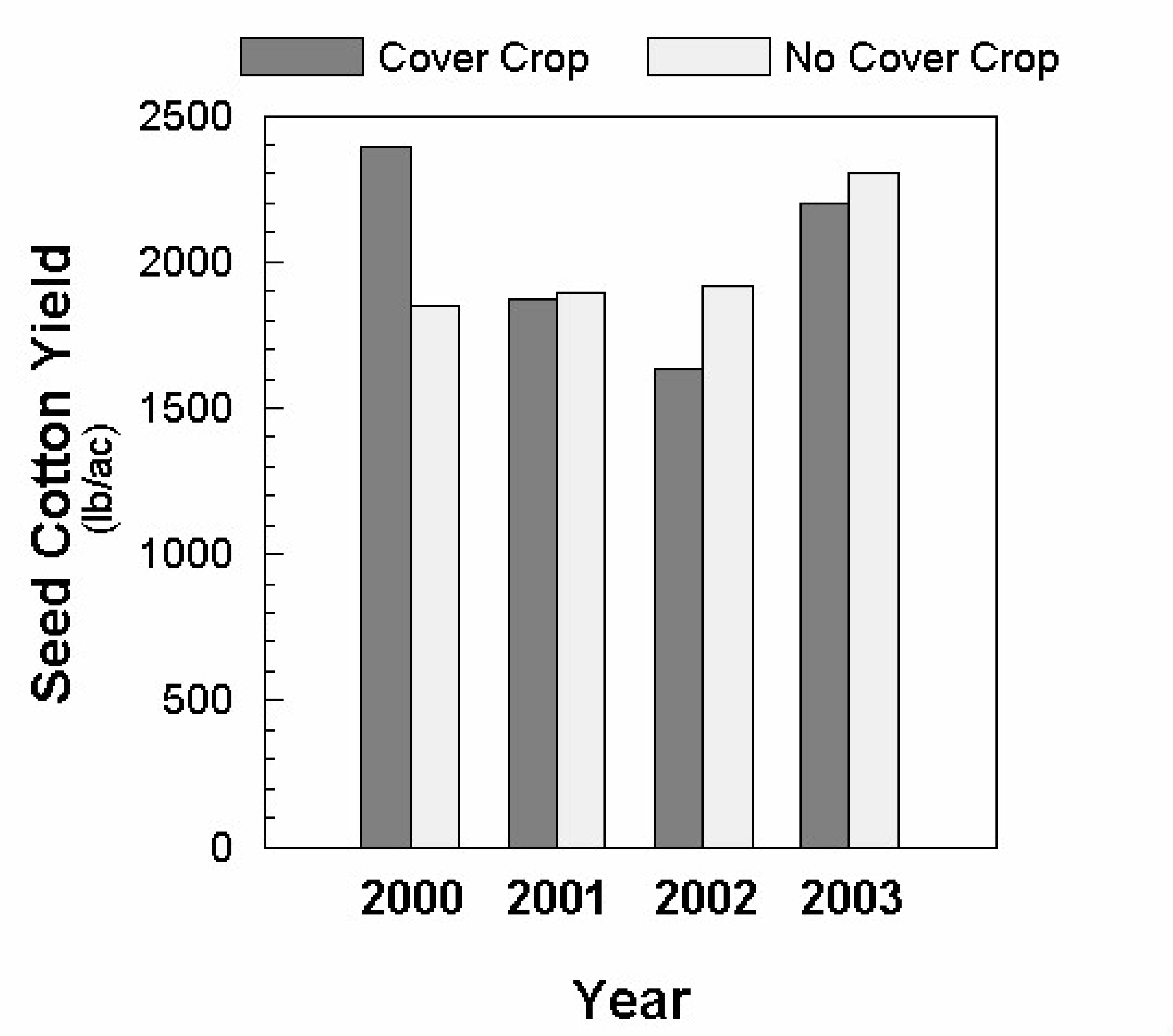

Figure 7. Cotton yield averaged over replications, years, depth of hardpan, and cover crops showing the effect of the three different subsoiling treatments.

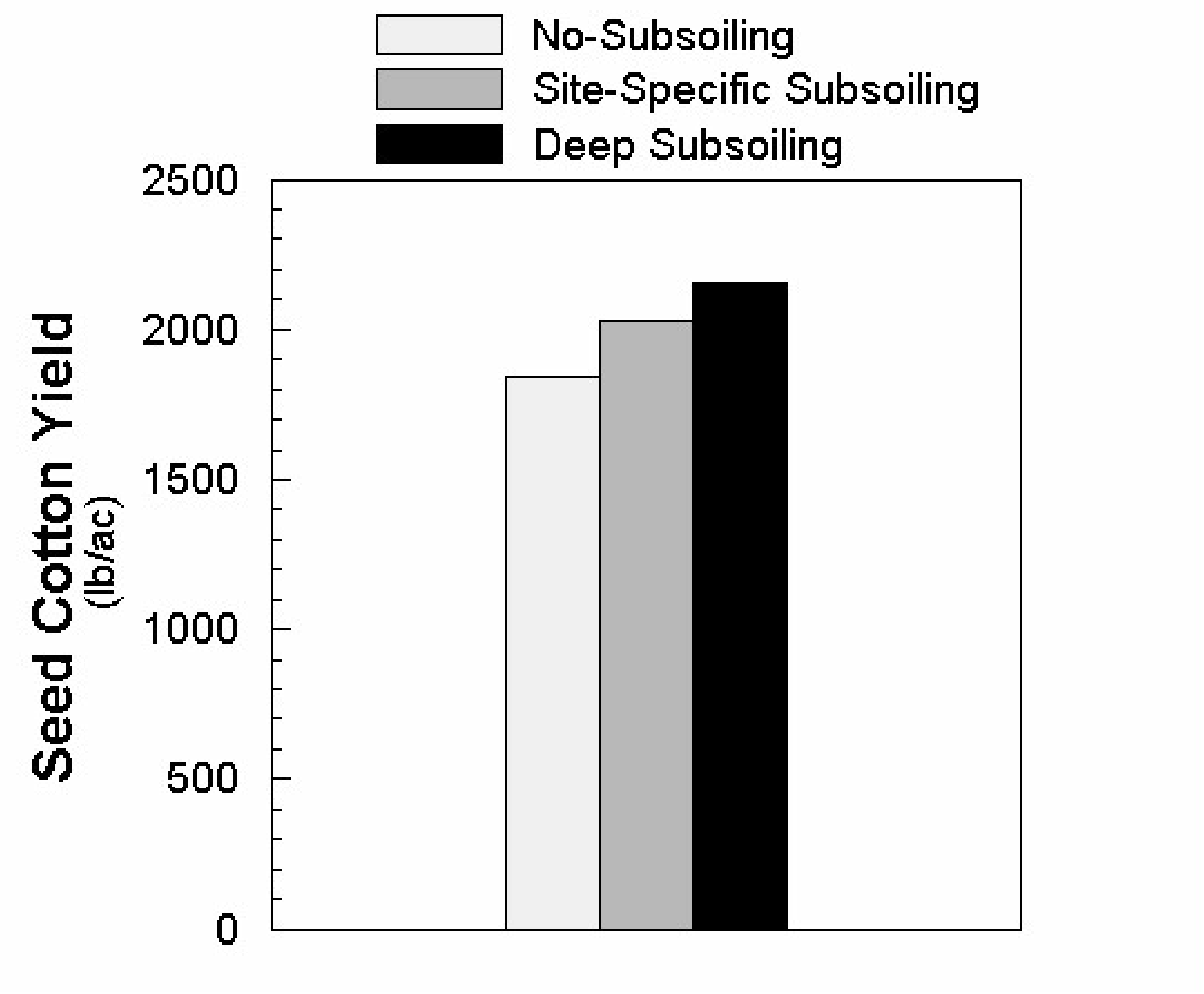

Figure 8. Cotton yield averaged over replications, and cover crops showing the effect of the three subsoiling treatments in the three different hardpan depth zones.

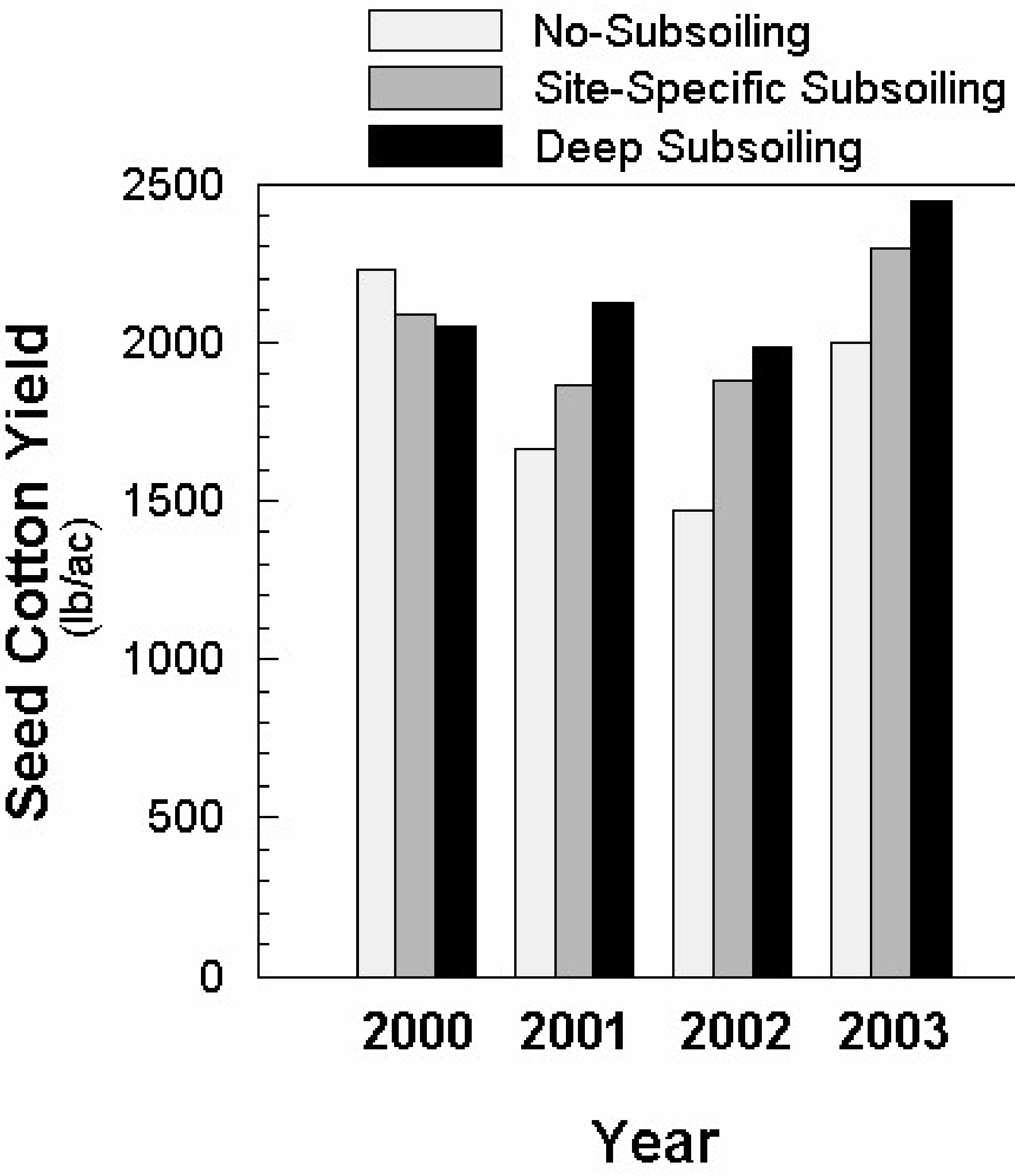

Figure 9. Cotton yield averaged over replications, years, and cover crops showing the effect of the three subsoiling treatments in the three different hardpan depth zones.