SUBSOILING: TILLAGE AND ENERGY IMPLICATIONS

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Tillage pans were identified and characterized in four Coastal Plain soil series occurring throughout the Southeastern United States (5). Depth to the pan was 11 to 15 cm, pan thickness was 13 to 14 cm, and root growth within the pan was severely restricted.

Deep tillage and deep placement of lime, fertilizer, and nematicides have been tested on various crops at several locations with inconsistent results (1, 2, 3, 6, 9, 10, 11, 12). Subsoiling under the row increased seed cotton yields 41% but bedding, deep placement of lime, and addition on a nematicide had no influence on yield (1). Subsoiling increased soybean yields in 7 of 16 experiments, whereas, a nematicide increased yields in 10 of 16 tests (6). However, the combined treatment of subsoiling, plus a nematicide, increased yields significantly in 13 of 16 experiments (6). Subsoiling, in New Jersey, with and without deep placement of lime and fertilizer on a Collington sandy loam soil, did not produce significant yield increases of several vegetables (2). However, residual effects of subsoiling significantly increased water movement into this soil for 3 years after the last deep tillage operation.

In-row subsoiling before planting produced highest soybean yields in North Florida (7). Depth of rooting of corn was increased with subsoiling (8). Response to subsoiling on sandy soils appears to be related more to increased nutrient availability than to availability of water. Yield response to subsoiling has been most consistent where under-the-row subsoiling was practiced.

Energy requirements for subsoiling are quite high and considerable savings could be achieved if the subsoiling operation was not necessary every growing season. However, under normal tillage operations the soil is recompacted each year and subsoiling is required on an annual basis for maximum crop yields. There is a possibility that recompaction of the soil following subsoiling could be minimized under minimum tillage production of crops. Avoiding travel over crop rows from the previous season with tillage implements and tractor wheels should reduce soil compaction. This can be accomplished with minimum tillage operations where succeeding crops are planted directly in stubble rows of the previous crop.

This report contains test results from experiments designed to measure the effect of soil-moisture content on resistance to soil penetration and the effects of a disc-harrow and a tractor wheel on soil compaction. Power requirements for subsoiling at different levels of soil penetrometer resistance were also estimated.

METHODS

Eight tillage and compaction treatments were applied to three soil types during the winter of 1979-80. The soils were Orangeburg loamy fine sand, Norfolk loamy

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fine sand, and Troup sand. All treatments were harrowed with an offset disc-harrow before tillage and compaction treatments were applied. Treatments were as follows: 1) no treatment, 2) subsoiled only, 3) subsoiled followed by one trip with the offset harrow, 4) subsoiled followed by two trips with the harrow, 5) subsoiled followed by four trips with the harrow, 6) subsoiled followed by one trip with the tractor tire directly over the subsoiled furrow, 7) subsoiled followed by two trips with the tractor tire as in no. 6, and 8) subsoiled followed by four trips with the tractor tire as in no. 6.

Resistance to penetration was measured with a recording penetrometer to a depth of two feet (60 cm). Four measurements were taken each time per treatment and averaged. Soil-moisture content was measured with a neutron moisture probe when penetrometer measurements were made.

Penetrometer measurements were taken to correspond to different levels of soil-moisture content.

Power requirements were estimated from the following equation:

$$HP = PR \times 14.5 \times A \times 3 \text{ mph} \times \frac{5280}{3600} \times \frac{1}{550}$$

where HP = horsepower
PR = penetrometer resistance in bars
A = area of chisel point in square inches
mph = miles per hour

These estimates may be slightly high since the angle of the chisel point with respect to direction of travel was not considered.

RESULTS AND DISCUSSION

Soil moisture content has a significant effect on resistance to penetration of the soil profile. The traffic pan is located in the top foot (30 cm) in most coastal plain soils with a long history of cultivation. Therefore, the moisture content in the upper part of the soil profile will have a pronounced effect on penetrometer resistance. Penetrometer resistance (PR) was reduced from 36 to 18 bars in the top 30 cm of a Norfolk soil when the moisture content increased from 17.4% to 20.6% (Fig. 1). This corresponds to a power requirement change of 25 HP per chisel or 100 HP for a four row subsoiler (Table 1). The change in moisture content corresponds to 0.18% per bar of chanqe in PR. Similar results were observed in the Trour, soil except the moisture change was much less, corresponding to .09% per bar change' in PR (Fig. 2).

From an energy viewpoint the most desirable moisture content for subsoiling is at field capacity or when the soil first becomes dry enough for tillage following rainfall. It may be desirable to subsoil when the soil *is* dry in order to shatter the tillage pan as much as possible but the increased yield response may not offset the added cost of energy. A decrease in moisture content in the Norfolk soil of 3% below field capacity would about double the power requirement for subsoiling. A decrease of only 1% moisture below field capacity would double the power requirement for subsoiling in the Troup soil. Furthermore, substantial yield increases have been observed in corn and soybeans as a result of subsoiling when soil moisture content was near field capacity (7, 8).

Soil compaction has been attributed mainly to the use of a disc-harrow, by many people. However, four trips over a subsoil crevice with an offset disc-harrow recompacted the soil to a PR value of less than 5 bars (Fig. 3). The graph shows the depth of subsoiling at about 14 inches (35 cm) and the depth of the harrow at about 6 inches (15 cm). One trip over a subsoiled crevice with a tractor tire caused greater recompaction of the soil than 4 trips with a harrow (Fig. 4). Four trips over the crevice with a tractor tire recompacted the soil to resistance levels of over 15 bars as measured with the recording penetrometer. There is a high probability that tractor tires will pass over the subsoil crevice three or four times during a single year where conventional tillage is used. This is why most growers have planters attached directly behind the subsoiler chisel in order to avoid recompaction of the soil between the subsoiling and planting operation. Minimum tillage provides a way to avoid recompaction of soil in the subsoil slit between crops since the ,location of the rows from the previous crop are visible during the planting operation. Therefore, the tractor operator can run the tractor wheels between rows and plant directly over the subsoiler slit made for the previous crop. Perhaps as a result of this practice the subsoiling operation would only be necessary every other year. Thus, a significant savings of energy would be accomplished.

LITERATURE CITED

1. Boswell, F. C., D. A. Ashley, O. L. Brooks, G. W. Bird, T. D. Canerday, J. G. Futral, R. S. Hussey, C. E. Perry, R. W. Ronadori and J. S. Schepers. 1977. Influence of subsoiling, liming, a nematicide, and soil bedding on cotton yield in 'stunt' areas of Georgia. Agri. Exp. Sta. Univ. of Ga. Res. Bul. 204.

2. Brill, G. D., R. B. Alderfer, and W. J. Hanna. 1965. Effects of subsoiling and deep placement of fertilizer on a coastal plain soil and vegetables. Agron. J. 57:201-204.

3. Jamison, V. C., and P. F. Thornton, 1960. Results of deep fertilization and subsoiling on a claypan soil. Agron. J. 52:193-195.

4. Kashirad, A., C. E. Hurton, J. G. A. Fiskell, and V. W. Carlisle. 1966. Tillage pan identification and root growth. Soil and Crop Sci. Soc. Fla. Proc. 26: 41–52.

5. Kashirad, A., J. G. A. Fiskell, V. W. Carlisle, and C. E. Hutton. 1967. Tillage pan characterization of selected Coastal Plain soils. Soil Sci. Soc. Am. Proc. 31:534-541.

6. Parker, M. G., N. A. Minton, O. L. Brooks, and C. E. Perry. 1976. Soy–bean response to subsoiling and a nematicide. Agri. Exp. Sta. Univ. of Ga. Res. Bul. 181.

7. Rhoads, F. M. 1978. Response of soybeans to subsoiling in North Florida. Soil and Crop Sci. Soc. of Fla. Proc. 37:151-154.

8. Rhoads, F. M., and R. S. Mansell. 1978. Effect of water stress and sub-soiling on soil-water depletion and grain yield of corn on a sand. Southern Branch Amer. Soc. Agron. (Abstracts).

9. Robertson, W. K., J. G. A. Fiskell, C. E. Hutton, L. G. Thompson, R. W. Lipscomb, and H. W. Lundy. 1957. Results from subsoiling and deep fertilization of corn for 2 years. Soil Sci. Soc. Am. Proc. 21:340-346.

10. Robertson, W. K., C. E. Hutton, and L. G. Thompson. 1958. Response of corn in a superphosphate placement experiment. Soil Sci. Soc. Am. Proc. 22:431-434.

11. Robertson, W. K., and C. E. Hutton. 1959. Fertilizer placement studies on farm crops. Soil and Crop Sci. Soc. of Fla. Proc. 19:190-196.

12. Stibbe, E., and U. Kafkaki. 1973. Influence of tillage depths and P-fertilizer application rates on the yields of annual cropped winter-grown wheat. Agron. J. 65:617-620.

Figure Captions

Figure 1. Effect of soil moisture content on penetrometer resistance in a Norfolk soil. Average per cent moisture by volume is shown for 0 to 30 cm and 30 to 60 cm for two separate observations.

Figure 2. Effect of soil moisture content on penetrometer resistance in a Troup soil. Average per cent moisture by volume is shown for 0 to 30 cm and 30 to 60 cm for two separate observations.

Figure 3. Penetrometer resistance before subsoiling and in the subsoiler crevice before and after four trips with a disc harrow.

Figure 4. Effect of a tractor tire on recompaction of soil in the subsoiler crevice.

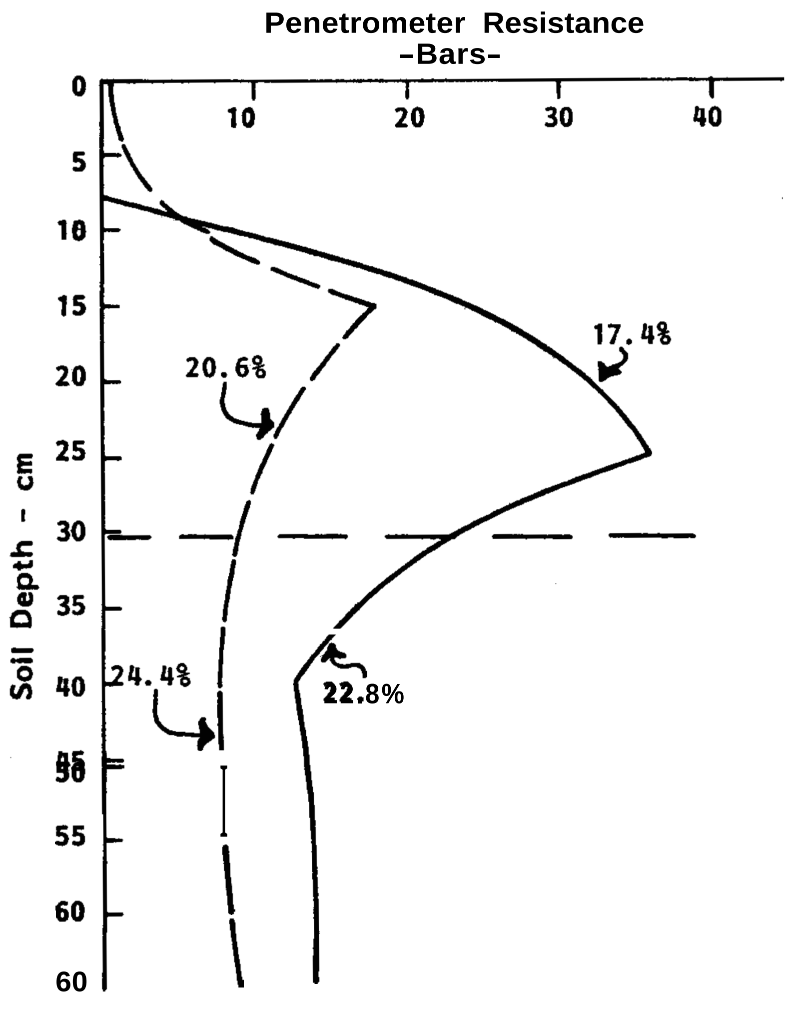

Figure 1. Effect of soil moisture content on penetrometer resistance in a Norfolk soil. Average per cent moisture by volume is shown for 0 tp 30 cm and 30 to 60 cm for two separate observations.

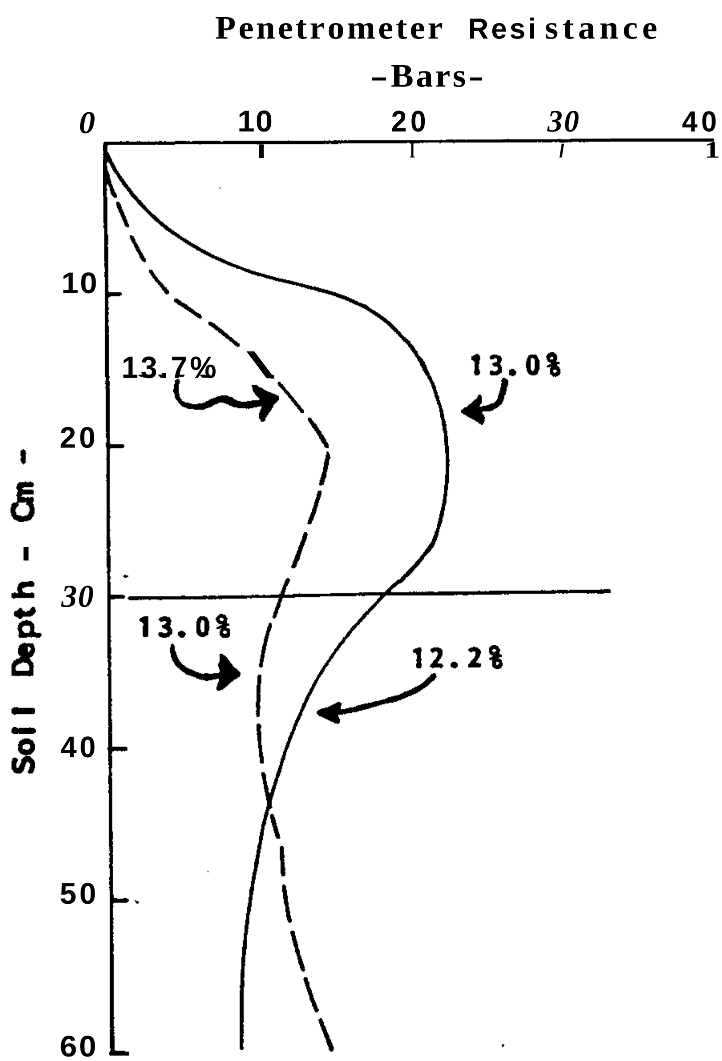

Figure 2. Effect of soil moisture content on penetrometer resistance in a Troup **soil.** Average per cent moisture by volume is shown for 0 to 30 cm and 30 to 60 cm for two separate observations.

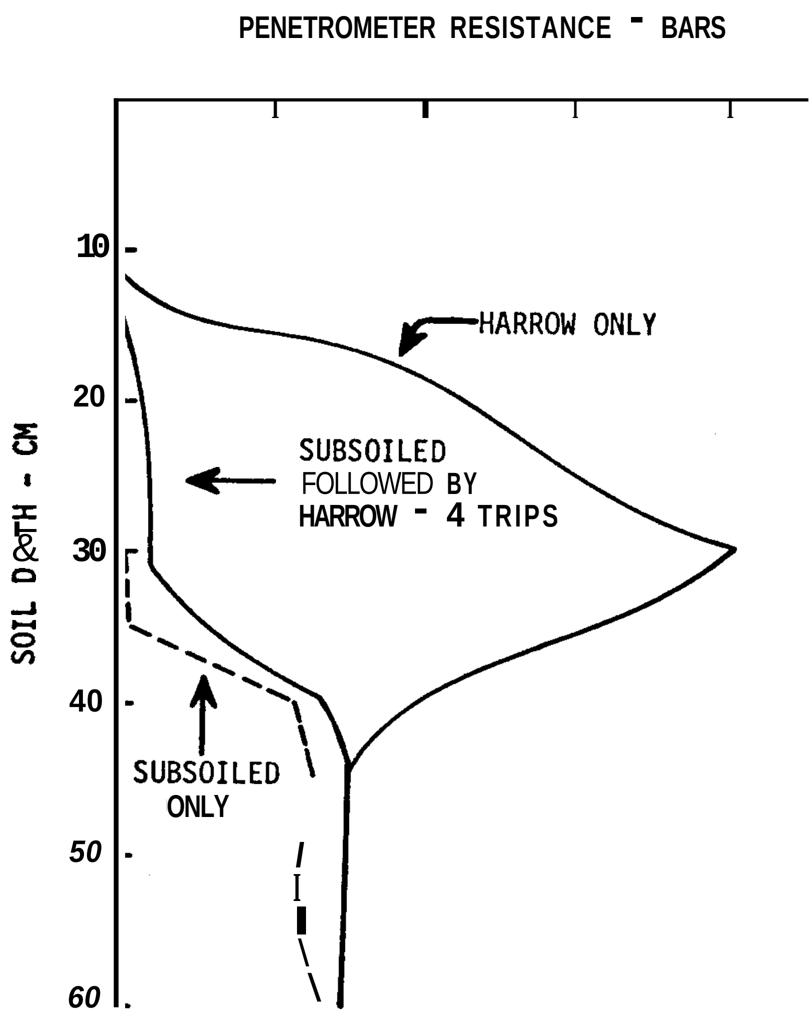

Figure 3. Penetrometer resistance before subsoiling and in the subsoiler crevice before and after four trips with a disc harrow.

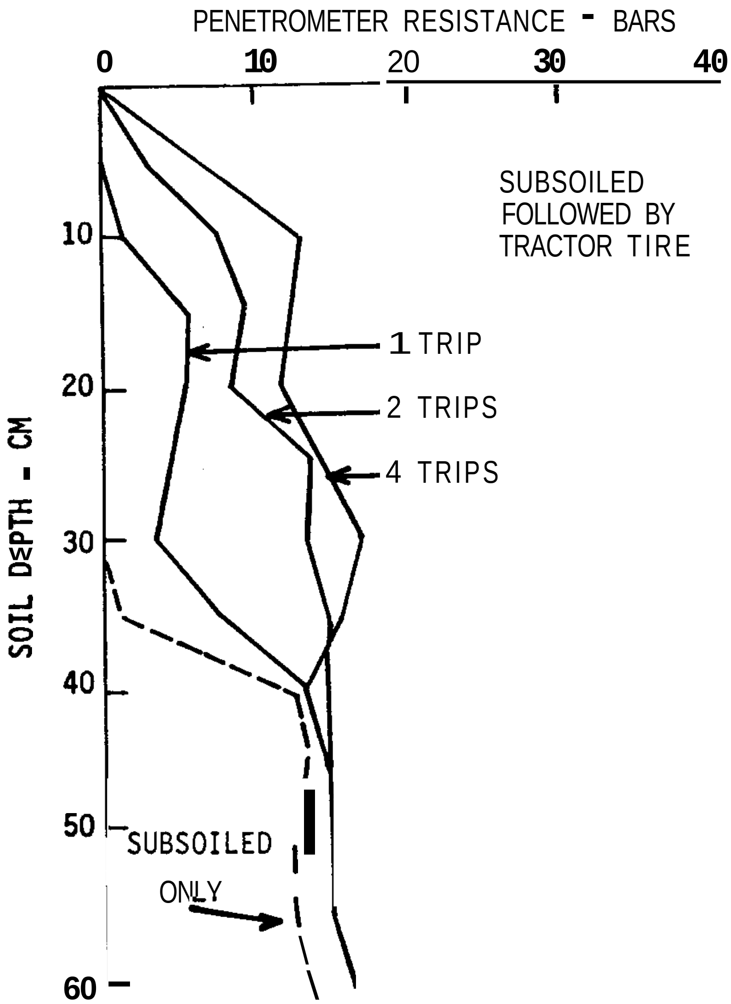

Figure 4. Effect of a tractor tire on recompaction of soil in the subsoiler crevice.

Table 1. Power required to pull a single subsoil chisel through the soil with various levels of resistance to penetration at a speed of 3 miles per hour. Chisel point dimensions 2 inches by 6 inches.

Penetrometer Resistance (bars)	Horsepower per chisel
5	7
10	14
20	28
30	42
40	56