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IN-THE-ROW SUBSOILING OF TOBACCO

Lloyd Murdock, George Everette, Ted Howard
Bill Green and Richard Barnhisel

Tobacco is probably more adversely affected by soil compaction than the other crops grown in Kentucky. This is due to the characteristics of the plant and the unusual cultural practices under which it is grown.

Soil compaction increases soil density while reducing pore space and root penetration. The reduced pore space reduces the aeration of the soil, which reduces tobacco growth especially during wet periods. The effects of soil compaction on tobacco are due to both impedance of root growth and lack of aeration.

The traditional cultural methods of preparing tobacco land for transplanting in many cases leads to excessive trafficking of the field. This can increase the density of the soil and result in compacted layers. Since wet soils are lubricated and can be easily molded they are more susceptible to compaction. Farmers often feel forced to prepare the soil when it is "too wet" because tobacco plants have grown too large and must be transplanted. Consequently, it is not unusual for tobacco fields to be at least partially prepared when the soil is too wet.

All of these factors can increase the compaction of the soil. Even if a field has no compaction prior to soil preparation, it is possible to establish severe compaction layers during soil preparation.

In order to determine the effect of soil compaction and in-the-row subsoiling during transplanting in tobacco production, a series of experiments were carried out.

METHODS AND MATERIALS

A variable depth subsoiling shank made from a 3/4 X 3 inch steel bar and a 1 inch wide shoe was mounted on a one-row tobacco setter. The shank was aligned directly in the row and preceded the transplanting operation. The depth of the shank was adjusted to locate the show of the subsoiler 1 to 2 inches below the compacted layer.

The experiment was carried out on 5 different farms over a 4-year period. The compaction in the fields ranged from severe to slight before transplanting.

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Sites and Treatment

Site 1 - 1977
Location - Calloway County, Lassiter farm
Soil - Loring silt loam, 2% slope
Crop - Kentucky 14 burley tobacco
Compaction - Moderate pan at 10 inches and about 2 inches thick
Randomized block design with 2 replications

Site 2 - 1977
Location - Graves County, Nicholson farm
Soil - Vicksburg silt loam, 0-2% slope
Crop - Ky 171 dark tobacco
Compaction - Moderate plow pan at 10 inches about 2 inches thick
Randomized block design with 2 replications

Site 3 - 1978
Location - Graves County, Ronnie Newsom farm
Soil - Grenada silt loam, 2-4% slope
Crop - Ky 171 dark tobacco
Compaction - Moderate pan at 9 inches and about 2 inches thick
Randomized block design with 3 replications

Site 4 - 1978
Location - Calloway County, Lassiter farm
Soil - Loring silt loam, 2% slope
Crop - Kentucky 14 burley tobacco
Compaction - Severe pan at 8-9 inches and about 2-3 inches thick
One replication comparison

Site 5 - 1978
Location - Calloway County, Shelton farm
Soil - Grenada silt loam, 2% slope
Crop - MSB 21 X Ky 10 burley tobacco
Compaction - Slight pan at 6-7 inches and about 1-2 inches thick
Randomized block design with 4 replications

Site 6 - 1979
Location - Princeton Research and Education Center
Soil - Tilsit silt loam, 1% slope
Crop - Ky 14, Ky 15, and Ky 17 burley tobaccos
Compaction - Slight to moderate pan at 6-7 inches about 1-2 inches thick
Subsoiling - In-the-row and conventionally subsoiled
Randomized block design with 6 replications

Site 7 - 1979
Location - Calloway County, Lassiter farm
Soil - Loring silt loam, 2% slope
Crop - Ky 15 burley tobacco
Compaction - Moderate pan at 6 inches and 4 inches thick
Randomized block design with 4 replications

Site 8 - 1980
Location - Princeton Research and Education Center
Soil - Tilsit silt loam, 1% slope
Crop - Ky 160 dark tobacco
Compaction - Slight to moderate pan at 8 inches about 2-3 inches thick
Randomized block design with 6 replications
Plant height and root depths were measured on some of the experiments at different times of plant development. Plant survival and yields were measured on all trials.

RESULTS AND DISCUSSION

This research indicates that when a compacted layer in the upper part of the root zone exists, stands, root growth, height and yields can be adversely affected.

Effect of In-Row Subsoiling on Early Tobacco Growth

Early measurements on plant and root growth were taken at only sites 1, 2, and 7. Plant height was measured 25 to 30 days after transplanting on sites 1 and 2 and 65 days after transplanting on site 7. As indicated by the height measurements (Table 1) and visual observations on most of the other experiments, early growth can be enhanced with in-the-row subsoiling. The difference in height in Table 1 is about 10%.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant Height</th>
<th>Root Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Site 1</td>
<td>Site 2</td>
</tr>
<tr>
<td>Conventional</td>
<td>4.19</td>
<td>4.40</td>
</tr>
<tr>
<td>In-Row Subsoiled</td>
<td>4.33</td>
<td>5.25</td>
</tr>
</tbody>
</table>

Treatments followed by the same letter are not significantly different at the 5 percent level.

The average rooting depth was also increased with in-row subsoiling (average 26%). Evidently moderately compacted soil is dense enough to reduce root growth.

The height difference that was noted in the early growth stage persisted into the later stages of growth (about 12% on site 7) and was visually perceptible in the field. This visual difference in growth was evident in 4 of the 7 experiments throughout the growing season.
The differences in root growth also persisted through to this stage of development. Although, the depth of the primary roots in this experiment (site 7) was not as great with either treatment as one would expect.

Field Stands

The final stands were greater with the in-row subsoiling treatment in 4 of the 6 locations (Table 2). The greatest increase in stand was +10% (site 2) and the least was -3% (site 7). The average overall increase was 3.8% and was about the same for both dark and burley tobacco. This indicates that the conditions for survival may be somewhat more favorable when in-row subsoiling is used, but not in all cases.

<table>
<thead>
<tr>
<th>Site</th>
<th>Population (Plants/ac)* In-Row Subsoiling</th>
<th>Leaf Yield (lbs/ac) In-Row Subsoiling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conventional</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2626</td>
<td>3333</td>
</tr>
<tr>
<td>2</td>
<td>3380</td>
<td>3733</td>
</tr>
<tr>
<td>3</td>
<td>3383</td>
<td>3282</td>
</tr>
<tr>
<td>4</td>
<td>6970</td>
<td>7245</td>
</tr>
<tr>
<td>5</td>
<td>6622</td>
<td>7103</td>
</tr>
<tr>
<td>6</td>
<td>5933</td>
<td>6533</td>
</tr>
<tr>
<td>7</td>
<td>8483</td>
<td>8230</td>
</tr>
<tr>
<td>Average</td>
<td>5795</td>
<td>6021</td>
</tr>
</tbody>
</table>

* Surviving plants at harvest

** Treatments followed by the same letter are not significantly different at the 5 percent level.

Yields

Including all replications, there were 22 total measurements made. In-row subsoiling increased the yield in 17 of these measurements. As can be seen from the average yields at each location (Table 2), in-row subsoiling increased yields at all locations. The increases can be categorized by the amount of compaction found in the field.
The field classified as severe compaction (site 4) resulted in a 40% increase due to in-row subsoiling. Sites 1, 2, 3, and 7 were classified as having layers of moderate compaction and the yield increases averaged 20%. Site 6 was classified as having slight to moderate compaction and in-row subsoiling resulted in a 7% increase in yield. Site 5 only showed a 1% increase in yield and was only classified as slightly compacted. The overall average yield increase for in-row subsoiling across all sites was 18%.

The increase in yield was due to both a higher survival rate and an increased yield per plant. However, the proportional contributions from these two sources varied from location to location. In sites 2 and 4, both survival and yield per plant were greater with in-row subsoiling. At sites 3 and 7, the yield increase for in-row subsoiling was due entirely to a greater yield per plant, while in treatments 1, 5, 6 the yield increases are due entirely to a greater survival rate.

**Conventional Subsoiling**

If a compaction layer exists in the soil then subsoiling the field with a conventional subsoiling tool before seedbed preparation should be sufficient to disrupt this compacted layer. However, the traffic during preparation can consolidate the soil. Therefore, in-row subsoiling at planting may be more effective than the conventional method of subsoiling. These two methods were compared (Table 3, site 6) and the in-row subsoiling method was more effective in this trial. Although conventional subsoiling was ineffective in this case, one would usually expect some benefit if a severe traffic pan existed in the soil.

<table>
<thead>
<tr>
<th><strong>TABLE 3. EFFECT OF CONVENTIONAL AND IN-ROW SUBSOILING ON DRY AND WET SOIL</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Treatment</strong></td>
</tr>
<tr>
<td>Not Subsoiled</td>
</tr>
<tr>
<td>Conventionally Subsoiled</td>
</tr>
<tr>
<td>In-Row Subsoiled</td>
</tr>
</tbody>
</table>

1 Treatments followed by the same letter are not significantly different at the 5 percent level.

**Subsoiling Wet Soil**

It is important that subsoiling be accomplished when the soil is dry enough to shatter the soil. If the soil is too wet, then the subsoiling shank cuts through the soil like a knife instead of lifting and shattering the compacted zone. In 1980 an in-row subsoiling trial was carried out on soil that was determined to be too wet for subsoiling. As can be seen in Table 3 (site 8), the in-row subsoiling treatment reduced the yields. An air pocket approximately 1 inch wide and about 6 inches deep was found in the root zone below the plant which prevented normal root growth and resulted in a yield reduction.
Effect of Disking and Depth of Subsoiling

In an effort to determine if excessive repeated traffic during soil preparation has an effect on soil structure and crop yield, three extra trips with a disk were made in the trial at site 7. The soil was at a desirable moisture content for tillage. The extra trips reduced yields for every treatment (Table 4). The average yield reduction was 12%.

The effect of depth of in-row subsoiling on yields were also checked in this trial. The compacted layer was approximately 4 inches thick and the bottom of the layer was 10 inches deep. When the subsoiler was run at 13 inches in depth there was a very slight yield advantage compared to subsoiling at 10 inches. Evidently, subsoiling at or just below the compacted layer is sufficient.

Subsoiling Effect on Soil Strength

For subsoiling to be effective, it must loosen the soil to allow unrestricted root penetration. As the soil strength increases, then the root growth may be reduced. In order to determine how effective in-row subsoiling is in altering soil strength, penetrometer measurements were made after the 1979 tobacco crop was harvested (Table 4). In-row subsoiling at a 13 inch depth greatly lowered the soil strength in the row to the 12 inch depth.

---

<table>
<thead>
<tr>
<th>Treatment</th>
<th>6 Diskings</th>
<th>9 Diskings</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>2457</td>
<td>2274</td>
<td>2366</td>
</tr>
<tr>
<td>Subsoiled 10&quot;</td>
<td>2748</td>
<td>2467</td>
<td>2608</td>
</tr>
<tr>
<td>Subsoiled 13&quot;</td>
<td>2997</td>
<td>2466</td>
<td>2732</td>
</tr>
<tr>
<td>Average</td>
<td>2743</td>
<td>2402</td>
<td></td>
</tr>
</tbody>
</table>

Penetrometer Resistance ---- lbs/Sq. inch ----

<table>
<thead>
<tr>
<th>In-The-Row Measurements</th>
<th>0-6 inch depth</th>
<th>6-12 inch depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>100</td>
<td>141</td>
</tr>
<tr>
<td>In-Row Subsoiled</td>
<td>33</td>
<td>78</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Between-The-Row Measurements</th>
<th>0-6 inch depth</th>
<th>6-12 inch depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>185</td>
<td>179</td>
</tr>
<tr>
<td>In-Row Subsoiled</td>
<td>144</td>
<td>155</td>
</tr>
</tbody>
</table>

1 Moderate compaction existed over 2/3 of the area. It began 6 inches below the soil surface and was about 4 inches thick.
The season long persistence of this large difference in soil strength is probably due to the fact that there was no further traffic after the combined subsoiling and transplanting operation.

The measurements made between the rows indicate that the in-row subsoiling loosened the soil between the rows to the point that it was still measurable at the end of season.

Figure 1 shows a detailed soil strength profile of the in-row subsoiling effect made at location 4. This location had severe compaction which resulted in sharp differences in soil strength. The area affected by the subsoiling shank was V-shaped and was about twice as wide as it was deep. For tobacco set in 40 inch rows, it would mean that only about 30% of the area would be affected by the subsoiling operation.

SUMMARY AND CONCLUSIONS

In-row subsoiling appears to be an effective method for reducing soil compaction in tobacco production. This technique removes compaction that may have been established during soil preparation and prevents reconsolidation because it is accomplished after transplanting and traffic after this is usually light and infrequent. In every trial where in-row subsoiling was used properly, yields were increased. The average yield increase across all sites was 18%. The amount of increase was related to the amount of compaction that existed at transplanting. The yield increased by 40% on the severely compacted site and by only 1% on the slightly compacted site. On many of the sites, in-row subsoiling resulted in a higher plant survival and a more rapid plant growth and root development. In-row subsoiling disturbed and loosened the soil under the row. The disturbed area is V-shaped and the upper part of the disturbed area is about 20 inches wide when subsoiled at 12 inches deep. Subsoiling wet soil results in an air pocket in the soil causing reduced survival, root development and yields. In-row subsoiling is a simple inexpensive process that can insure a favorable rooting environment at time of transplanting.
Figure 1. Effect of In-Row Subsoiling at 12 Inches of Depth on Penetrometer Measurements Taken Various Distances from the Row.

Distance from Row (Inches)

0-100 psi*

100-300 psi

300+ psi

Depth of Soil (Inches)

*Subsoiling depth

*Pounds per square inch