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The effect of controlled traffic on cotton yield and soil condition on three West Tennessee soils

Jon S. Jablonski

To the Graduate Council:

I am submitting herewith a thesis written by Jon S. Jablonski entitled "The effect of controlled traffic on cotton yield and soil condition on three West Tennessee soils." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Biosystems Engineering.

James A. Mullins, Major Professor

We have read this thesis and recommend its acceptance:

J. I. Sewell, D. H. Luttrell, W. L. Parks

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

August 15, 1975

To the Graduate Council:

I am submitting herewith a thesis written by Jon S. Jablonski entitled "The Effect of Controlled Traffic on Cotton Yield and Soil Condition on Three West Tennessee Soils." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Engineering.

James A. Mullins

James A. Mullins, Major Professor

We have read this thesis
and recommend its acceptance:

John D. Sewell

Houston Luttrell

W L Parks

Accepted for the Council:

Hilton A. Smith

Vice Chancellor
Graduate Studies and Research

A

THE EFFECT OF CONTROLLED TRAFFIC ON COTTON YIELD AND SOIL CONDITION ON THREE WEST TENNESSEE SOILS

A Thesis

Presented for the

Master of Science

Degree

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Jon S. Jablonski

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ABSTRACT

The purpose of this investigation was to study the effects of a controlled traffic pattern on the physical condition of soil and the cotton yield. Three types of seedbed preparation were used: conventional, bedded, and none. Three types of equipment--two-row, four-row, and six-row--were used; the traffic from this equipment was controlled such that the traffic remained on permanent wheel paths through the field.

The controlled traffic pattern caused no severe adverse soil physical conditions. Also, yields from the bedded plots tended to exceed those from the conventional plots suggesting the possibility of reducing the number of pre-planting trips through the field.

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CHAPTER I

INTRODUCTION

Background

Tennessee farmers in 34 West and Middle Tennessee counties annually grow between 170,000 and 180,000 hectares (420,000-450,000 acres) of cotton. In 1973, the value of the cotton crop was approximately $100 million or roughly 7 percent of the gross income of Tennessee farmers (1). Production costs for the crop were approximately $470 per hectare ($190 per acre). Of this $470, approximately 14 percent was energy and equipment costs (2).

To increase net income the farmer realizes from the crop, two things might be done. First, a practice which increases the yield with little additional cost would increase the income. Second, a practice in which energy costs are lowered either by more efficient equipment or fewer equipment trips across the field would increase the net income although the gross income might be reduced slightly.

With larger equipment being used in field work for cotton production, soil compaction has become a recognized problem. Accompanying the resulting increase in soil strength which tends to inhibit root growth after resistances to penetration of 2070 kilopascals (300 psi) have been reached (3) is the lower availability of soil air and water (4).

Saveson et al. (5) showed that subsoiling to remove the effects of compaction resulted in a $125 per hectare ($50 per acre) increase in cotton income. This increase was for years when moisture stress was such that the compacted areas interfered with the recharge of deep soil moisture. If this compaction could be prevented by use of controlled tillage practices, an additional $25 per hectare ($10 per acre) subsoiling cost could be saved.

Objective

A study having the objective of reducing the number of trips through the field thus reducing the equipment, fuel, and labor costs was conducted at The University of Tennessee Milan Field Station in 1973 and 1974. The purpose of the study was to investigate the effects of a controlled traffic pattern on yield, bulk density, pore space, moisture content, and infiltration rate. Alabama studies (5) have shown that using special wide equipment such that the seedbed received no traffic during the season has increased yields by as much as 37 percent. However, special equipment is required or existing equipment must be extensively modified. Using existing two-, four-, and six-row equipment and controlling the traffic pattern to achieve the same end result was attempted in this study.

CHAPTER II

REVIEW OF LITERATURE

Tillage Studies

The primary objective of tillage is weed control and the modification of the soil's physical properties to improve the air, water, and heat relationships and to reduce the impedance to root penetration (6). Cooper (7) defines tillage as the operation, practice, or art and science of tilling land or the improvement of land for agricultural purposes.

Tillage for agricultural purposes takes several forms. Primary tillage is that which is done to prepare the seedbed for planting. After the crop is planted, tillage is done for weed control and for altering the surface soil to aid in water infiltration. Agricultural equipment is usually designed for the overall efficiency of technical operations, but it is not necessarily designed for the overall efficiency of crop production (8). With larger and heavier equipment being designed for field use in tillage and harvesting, resulting compaction of the soil is being magnified compared to that of a few years ago.

Compaction results from the increasing size and weight of equipment and the repetition of traffic in row cropping practices (6). The effect of compaction on the plant is to hamper root growth and, subsequently, plant development. United States' soil scientists generally recognize that compaction required to end root growth is 2070 kilopascals (300 psi) resistance to a cone penetrometer (3). If this compacted region results from a shallow clay pan or plow sole, subsoiling can fracture this region and increase yields at least for one year. Grissom et al. (9) showed that on well drained soils which had no hardpan or subsoil restrictions, and on "buckshot" soils, deep tillage had no effect on yield. However, on soils that did have subsoil restrictions, yields have been more than doubled the first year after subsoiling. Of this yield increase, about one-half of the beneficial effect on a silt loam was carried over into the next year's crop.

Mullins et al. (10) have shown, in a five-year study on a Collins silt loam and a Memphis silt loam in West Tennessee, no significant differences among yields from plots in which deep tillage, up to 0.4 m (16 in), was compared with offset discing to 0.4 m in depth and with bedding 0.4 m.

In addition to the method of deep tillage of plots, zone tillage may be used to reduce this compaction problem and reduce draft. In zone tillage, tillage is performed only in a 0.3- to 0.4-m (12- to 16-in) zone out of the 1.02-m (40-in) row spacing (11). A practice similar to zone tillage, precision tillage, is also used. Precision tillage consists of subsoiling directly under the plant row before planting.

Using precision tillage, Carter and Tavernetti (12) have found that yields were independent of the initial level of compaction. This implies that yield increases due to precision tillage were proportional to the initial soil strengths. On coarse-textured soils, Carter and Tavernetti found yield increases from 5 percent to 200 percent. On finer textured soils, increases ranged from zero to 6 percent.

Gill and Trouse (8) state that conventional seedbed preparation provides a good seedbed but a less than desirable rootbed because of compaction. Since 75 percent of the compaction occurs on the first pass of the machine over the seedbed (13), a logical approach to controlling compaction would be to manage tillage such that the soil in the vicinity of the plant receives no traffic--not just a reduction in traffic.

From results of previous work in controlled traffic, the basic reasons for this approach follow:

1. Obtain a yield increase;
2. Eliminate or reduce tillage operations such as deep tillage;
3. Reduce power requirement in tillage;
4. Improve mechanical stability on permanent wheel paths for cultivation machinery;
5. Increase water storage;
6. Reduce water runoff; and
7. Increase plant population (8).

Gill and Trouse (8), in their work in Alabama, have determined that controlling the traffic after a compacted condition has developed will not increase yields. To experience yield increases, first a good loose condition of the soil must be achieved, and this condition must be preserved by controlled traffic. In the Alabama study, the cotton was planted on 1.02-m (40-in) centers with tractor paths fixed on 3.05-m (120-in) centers. On deep tilled, non-trafficked plots, the yield was 1.25 bale per hectare (0.5 bale per acre) higher than in the trafficked plots. The bulk density in the trafficked area was 1.8 g/cc; and in the non-trafficked area it was 1.48 g/cc.

In addition to the deep tillage and controlled traffic work, wide-bed cultural practices have been investigated where the rows are 1.02 m (40 in) apart on 2.50-m (98.4-in) beds which are wider than the conventional 2.03-m (80-in) beds. This practice reduced cost in two ways:

1. Reducing length of row per unit area, and
2. Reducing primary tillage (14).

The result of no traffic on the wide bed was a reduction in compaction which gave excellent soil tilth. The theoretical field efficiency using the wide-bed practice was increased 23 percent over the conventional (14). Other practices such as the wide-bed, narrow-row system present a problem in that no reliable harvester is available for the narrow rows.

In controlled traffic practices, an increase in yield is not always the deciding factor related to the desirability of the practice. Lower costs due to reduced draft requirements or fewer trips through the field without cuts in yield are also important. Using controlled traffic on a Norfolk sandy loam, Dumas et al. (15) achieved cotton yields which were 14 percent higher than those from plots with tractor traffic only and 21 percent higher than from plots with tractor and sprayer traffic. Williford et al. (14) reported no cotton yield differences on a Dubbs silt loam between the wide-bed and other treatments which included a conventional, random traffic check.

Root Growth

Controlling the traffic and therefore controlling compaction affects the crop yield. Studies of the effects of soil compaction on root growth have been made. Taylor and Gardner (16) and Barley (17) concur that soil strength is a valid criterion for root penetration only when no voids are present to provide paths for root penetration. When the soil is compacted to a level such that insufficient voids are present for root penetration, the soil strength becomes the limiting factor. If a critical bulk density were to be considered as the limiting factor, the moisture at the time of root penetration would need to be considered as well. Camp and Land (18) and Taylor and Gardner (16) showed that the effects of bulk density on soil strength, as measured with a cone penetrometer, increase as soil moisture increases.

Soil Moisture

The increase in bulk density of the compacted soil also affects the soil moisture relationship. Hill and Sumner (19) report that for sands, clays, and clay loams the capacity to retain soil moisture at some matric potential increases as the bulk density increases; and for sandy loams and sandy clay loams, the capacity to hold moisture at low matric potentials decreases due to an increase in bulk density. Jamison (20) reports that for most soils, moderate compaction will give an increase in available moisture capacity. One must look at these soil moisture--bulk density--root growth relationships relative to the limiting factors and determine the best tillage practice while considering these limiting factors.

CHAPTER III

PROCEDURE

Experimental Procedure

For this controlled traffic study, equipment which is readily available to the farmer was used. No modification of existing equipment was necessary for the experimental procedure. Three methods of seedbed preparation were used: conventional, bedded, and none. For the conventional and bedded plots, three types of equipment were used: two-row, four-row, and six-row. For the stubble planted plots, two-row and four-row equipment was used. A summary of the treatments is given in Table 1.

After planting was completed, all tillage traffic for weed control and water infiltration was limited and controlled such that the same middles received all traffic. Fertilizer was applied with a four-wheel tractor and a four-row applicator. This added traffic to middles other than the controlled traffic middles in the two- and six-row plots. At harvest all plots were picked with a two-row picker in 1973 and a one-row picker in 1974. After harvest the stubble was mowed with a two-row rotary mower. Prior to the 1974 cultivation season, all middles with the exception of the outside middles on the four- and six-row conventional plots had received at least one traffic pass. In the following season, plots were planted on the same rows with the same planting methods. Traffic was kept in the same middles as the previous season.

TABLE 1. Summary of treatments.

Number	Treatment
1	Conventional seedbed preparation, 2-row equipment
2	Conventional seedbed preparation, 4-row equipment
3	Conventional seedbed preparation, 6-row equipment
4	Seedbed bedded, 2-row equipment
5	Seedbed bedded, 4-row equipment
6	Seedbed bedded, 6-row equipment
7	No seedbed preparation, 2-row equipment
8	No seedbed preparation, 4-row equipment

The experimental plots were arranged as split plots with one block missing, that of the six-row, stubble planted plots. The experiment was replicated three times on a Memphis-Loring silt loam, three times on a Collins silt loam, and twice on a Grenada silt loam.

Memphis soil is a deep, well drained, upland soil. Collins soil is a deep, moderately well drained, alluvial soil on first bottoms. Grenada soil is a moderately well drained, upland soil with a fragipan having depths varying with degree of erosion. Samples of the soils were analyzed for their physical characteristics in the winter of 1974, and the results of this analysis can be seen in Table 31, Appendix E.

Records were kept of all traffic over the plots. As an indication of the effect of the controlled traffic on the crop, yields were taken for individual rows. These were then combined to form treatment yields. In addition to the yields, plant heights were measured two times during the season, and a stand count was made one time during the season. At the end of the season, tap roots were dug and measured as a further indicator of crop response.

Within each type of seedbed preparation, four types of traffic middles were represented. The middle receiving the highest amount of traffic was the traffic middle in the two-row plots. This middle received double traffic during each field operation and is referred to hereafter as the high-traffic middle. The middle receiving the second highest amount of traffic was the traffic middle on the four- and six-row plots. This middle received single traffic during each field operation and is referred to hereafter as the medium-traffic middle. The middle receiving the third highest amount of traffic was the middle between the two traffic middles on all plots. This middle received the front wheel of the high-clearance sprayer. This middle is called the low-traffic middle. Finally, the middle receiving the least amount of traffic was the outside middle on the four- and six-row plots. This middle received no traffic and is called the no-traffic middle.

For the response of the soil condition on the Memphis soil to the controlled traffic, infiltration rates using a double-ring infiltrometer (Appendix A) were collected for each type of traffic middle within each type of seedbed preparation before cultivation traffic occurred and after all cultivation traffic had ended for the season. Pore space measurements and bulk densities (Appendix B) were taken for two zones, zero to 0.076 m (zero to 3 in) and 0.15 to 0.23 m (6 to 9 in), for each type of traffic middle within each type of seedbed preparation on the Memphis soil before cultivation traffic began and after all traffic including rotary mower traffic had ended for the season. For the Collins and Grenada soils, bulk density measurements were taken for each type of traffic middle within each type of seedbed preparation after cultivation had ended for the season. Soil moisture data were taken using a neutron moisture gauge surface probe (Appendix C) for all soils at selected times throughout the season for each type of traffic middle within each experimental unit.

1973 Procedure

In 1973, all plots were plowed 0.3 m (12 in) deep, and traffic on all two- and four-row plots was controlled in the same middles as were used during the following season. Six-row plots were cultivated with four-row equipment in 1973 because six-row equipment had not been obtained.

All plots were cultivated on June 15, July 9, and July 27. Only the two-row plots were trafficked by the high-clearance sprayer on July 10. All plots were trafficked with the high-clearance sprayer on July 19, July 27, August 7, August 21, and August 27. In 1973, the plots were picked with a two-row picker, and stalks were cut with a two-row rotary mower. All plots were prepared conventionally in 1973. Data from the 1973 crop are not included in the analyses of Chapter IV.

1974 Procedure

On April 4, 1974, all fields were fertilized at the rate of 448 kg per hectare (400 lbs per acre) of 15-15-15 fertilizer. Also on April 4, the conventional plots were broken 0.20 m (8 in) deep using a four-bottom, 0.4-m (16-in) plow, and the two- and four-row bedded plots were bedded. On May 8, after the six-row equipment was received, the six-row plots were bedded.

On May 9, Roundup was applied on the stubble planted plots at the rate of 1.12 kg active ingredient per hectare (1 lb per acre). On May 17, the beds were "knocked off," and the conventional plots were run over with a "bed knocker" before planting on the same day. Two-row beds were "knocked off" using a six-row "bed knocker"; four-row beds were "knocked off" using a four-row "bed knocker"; and six-row beds were "knocked off" using a six-row "bed knocker." With regard to the rows which were harvested for the yield, traffic was restricted to the controlled traffic middle for this operation. All plots were planted in the two-, four-, and six-row patterns previously described. After planting, all plots were sprayed by a tricycle, high-clearance sprayer with Cotoran at the rate of 1.12 kg active ingredient per hectare (1 lb per acre) in 196 liters of water per hectare (17.5 gallons per acre). On June 4, all plots were sprayed with Bidrin at 0.11 liters active ingredient per hectare (1.5 ounces per acre) in 56 liters of water per hectare (6 gallons per acre). When the two-row, tricycle, high-clearance sprayer was used for insect or weed control, the same middles used for cultivation were trafficked by the rear wheels. The middle between these two middles received the traffic from the front wheel of the high-clearance sprayer.

All treatments, including the stubble planted, were cultivated on June 18, July 9, and July 17, for the Collins and Grenada plots. The Memphis plots were cultivated July 1, July 9, and July 17. Sprayer traffic for insect control occurred on July 25, July 30, August 6, August 21, and August 26. A one-row picker was used to harvest all treatments on November 21 and 22. The number of trips each row received between planting and layby is given in Table 2. After each cultivation, escape weeds were hand chopped to reduce the weed stress as completely as possible.

Infiltration rates were taken between June 17 and June 27, and between August 28 and September 16 on the Memphis plots. Soil cores for pore space and bulk density measurements were taken only on the Memphis plots. These cores were taken on June 19, 1974, and March 5, 1975. Bulk density cores were obtained for the Grenada and Collins plots on August 23 and September 5, respectively.

TABLE 2. Summary of 1974 traffic patterns from planting to layby.

Traffic Pattern	Trips Through the Middle After Planting Tractor Trips	 Sprayer Trips
High-traffic (Traffic middles on two-row plots)	6	14
Medium-traffic (Traffic middles on four-row and six-row plots)	3	7
Low-traffic (Center middles on all plots)	0	7
No-traffic (Outside middles on four-row and six-row plots)	0	0

Plant heights were measured on the middle two rows of all plots on June 26 and August 20. Stand counts were made on June 10. Soil moisture data for the plots planted on the Memphis soil were taken on June 13, July 3, and July 19. Soil moisture data for plots on the Collins soil were taken June 24 and July 12. Soil moisture data for plots on the Grenada soil were taken June 18 and July 15.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

The statistical analyses of the data were performed using the Statistical Analysis System which is a statistical package maintained by North Carolina State University and available through The University of Tennessee Computing Center. Two types of analyses were used. Because of the missing blocks in the split plot arrangement, a regression analysis was used for the data in which the type of equipment was a treatment. For the other analyses in which the types of seedbed preparation were split into different traffic patterns, no blocks were missing, thus the analysis of variance for a split plot arrangement was used. The data for each soil were analyzed separately and will be examined separately. All treatments were prepared conventionally in 1973. Only the 1974 data were analyzed.

Memphis Soil

The most important variable examined was seed cotton yield since this represents income to the farmer. For cotton grown on the Memphis soil, the analysis of variance for yield (Table 21, Appendix D) indicates a significant ($p < 0.05$) interaction between seedbed preparation and equipment. An examination of Table 3 shows that the four-row bedded plots had the highest yields. Statistically ($p < 0.05$), yields from the two-row bedded and the four-row conventional plots were not

TABLE 3. Seed cotton yield from Memphis soil for 1974 season.

Treatment	Yield (Kilograms of seed cotton per hectare)			
	Rep 1	Rep 2	Rep 3	Mean
Conventional 2-row	1764	1789	1630	1728 bcd*
Conventional 4-row	1526	2247	2031	1935 abc
Conventional 6-row	1355	1604	1751	1570 cde
Bedded 2-row	1892	2124	2234	2083 ab
Bedded 4-row	2357	2466	1924	2249 a
Bedded 6-row	1184	972	1130	1095 f
Stubble Planted 2-row	1075	1349	1282	1235 ef
Stubble Planted 4-row	946	1313	1692	1319 def

*Means followed by the same letter are not significantly different at the 0.05 level of probability.

different from the yields of the four-row bedded plots. The lowest yields were in the six-row bedded plots and the stubble planted plots.

The 1974 growing season was relatively wet receiving in a four-month period from May 17 to September 13 approximately 0.66 m (26.3 in) of rain. In a wet season, cotton grown on beds tends to yield better than cotton planted in furrows. Therefore, the high yields for the two- and four-row bedded plots were to be expected. However, the yields of the six-row bedded plots were unexpected. With one-third of the rows receiving no traffic on either side of the drill, and the other two-thirds of the rows receiving the same traffic as the four-row beds, yields equal to or greater than the yields from the four-row bedded plots were expected. Note on page 12 that a month passed between the time when the four-row plots were bedded and the six-row plots were bedded which allowed only nine days between bedding and planting of the six-row plots rather than the six-weeks between bedding and planting for the two- and four-row beds. This additional month which the six-row beds lacked, coupled with the fact that only 0.084 m (3.3 in) of rain fell, gave the two- and four-row beds time to settle and become an integral part of the soil mass.

This extra time enabled the two- and four-row beds to produce a somewhat better stand relative to the six-row beds as can be seen in Table 4. Also from Table 4, the plant height for the six-row beds was significantly ($p < 0.05$) lower than those for the two- and four-row beds for the measurements made June 26, 1974.

TABLE 4. Summary of cotton stand counts and plant heights for Memphis soil.

Seedbed Preparation	Equipment	Stand Count (plants/18.3 m) 6/10/74	Plant Height (meters) 6/26/74	Plant Height (meters) 8/20/74
Conventional	2-row	278 b*	0.21 ab	1.00 a
Conventional	4-row	273 b	0.20 ab	0.99 a
Conventional	6-row	285 ab	0.19 ab	1.02 a
Bedded	2-row	283 ab	0.25 a	0.94 ab
Bedded	4-row	245 b	0.23 a	0.95 ab
Bedded	6-row	190 c	0.13 b	0.88 b
Stubble Planted	2-row	295 ab	0.14 b	0.72 c
Stubble Planted	4-row	336 a	0.13 b	0.75 c

*Means followed by the same letter are not significantly different at the 0.05 level of probability.

As a further indication of the poor performance of the six-row beds, Table 5 shows that the outside rows on the six-row beds on the Memphis soil which received no traffic on either side of the drill, referred in the table as NT-NT row type, were the lowest yielding rows in the field.

Field observations indicated that the six-row beds and the stubble planted plots had experienced a stunting of growth and some yellowing such as might be expected from a nitrogen deficiency. This condition was so pronounced that the six-row bedded and stubble planted plots could be readily identified in the field by observation. For these crops, the fertilizer was applied on the surface of the field. The six-row bedded plots lay idle for 34 days before they were bedded and the fertilizer mixed into the soil. During these 34 days, 0.28 m (11 in) of rain fell including one 0.13-m (5.3-in) rain just two weeks after fertilization. Approximately 39 percent of the nitrogen was applied in the form of diammonium phosphate with the remaining 61 percent in the form of urea. Since diammonium phosphate and urea are not as quickly taken into the soil as other forms of nitrogen may be, this nitrogen could possibly have been washed from the surface of the soil especially by the 0.13-m rain.

The taproot lengths samples showed no significant difference between lengths among the various treatments (Table 6). This would indicate that no subsoil restriction differences existed among the treatments on the Memphis soil.

An examination of the effect of the traffic on soil conditions showed the small pore space differed significantly ($p < 0.05$) among the various traffic middles (Table 26, Appendix D). Middles which received

TABLE 5. Summary of 1974 cotton yields by row type.

Seedbed Preparation	Row Type	Yield by Row (kg/hectare) Memphis	Collins	Grenada
Conventional 2-row	DT-HB*	1726 abc	1460 a	1701 a
Conventional 4-, 6-row	ST-HB**	1693 abc	1254 a	1543 a
Conventional 4-, 6-row	ST-NT***	1797 ab	1268 a	1671 a
Conventional 6-row	NT-NT****	1590 abc	1199 a	1311 a
Bedded 2-row	DT-HB	2082 a	1307 a	1851 a
Bedded 4-, 6-row	ST-HB	1742 abc	1622 a	1491 a
Bedded 4-, 6-row	ST-NT	1549 abc	1445 a	1515 a
Bedded 6-row	NT-NT	1195 c	939 a	1226 a
Stubble Planted 2-row	DT-HB	1234 c	870 a	1113 a
Stubble Planted 4-row	ST-HB	1386 bc	809 a	1104 a
Stubble Planted 4-row	ST-NT	1248 bc	1000 a	1348 a

*This row has double traffic on one side and front wheel of high-clearance sprayer traffic on the other side.

**This row has single traffic on one side and front wheel of high-clearance sprayer on the other side.

***This row has single traffic on one side and no traffic on the other side.

****This row has no traffic on either side.

TABLE 6. Cotton taproot lengths in Memphis soil.

Seedbed Preparation	Equipment	Taproot Length (meters) Rep 1	Rep 2	Rep 3	Mean
Conventional	2-row*	0.26	0.24	0.25	0.25 a#
Conventional	4-row**	0.23	0.22	0.21	0.22 a
Conventional	6-row**	0.25	0.23	0.23	0.24 a
Conventional	6-row (NT)***	0.22	0.21	0.22	0.21 a
Bedded	2-row	0.20	0.21	0.24	0.22 a
Bedded	4-row	0.24	0.21	0.21	0.22 a
Bedded	6-row	0.17	0.26	0.24	0.22 a
Bedded	6-row (NT)	0.18	0.24	0.24	0.22 a
Stubble Planted	2-row	0.21	0.22	0.20	0.21 a
Stubble Planted	4-row	0.24	0.21	0.21	0.22 a

*Double traffic occurred in one middle adjacent to the rows from which the taproots were sampled.

**Single traffic occurred in one middle adjacent to the rows from which the taproots were sampled.

***No traffic occurred adjacent to the row from which the taproots were sampled.

#Means followed by the same letter are not significantly different at the 0.05 level of probability.

no traffic had the least amount of small pore space, 38.1 percent, compared with the small pore space in the high-, medium-, and low-traffic middles of 40.0 percent, 39.8 percent, and 39.5 percent, respectively. Between sampling times, no significant differences were detected indicating that any change in the small pore space occurred prior to the first measurement. The succeeding traffic and the winter which occurred between measurements had no effect on the small pore space.

The analysis for the large pore space (Table 27, Appendix D) indicates a significant ($p < 0.05$) effect due to a time * seedbed preparation interaction. From Table 7, the large pore space for samples taken June 19, 1974, decreased from the conventional plots to the bedded plots to the stubble planted plots. Since the conventional plots were in fact the only plots which had the traffic controlled completely in that they were broken each year, this trend seems reasonable. For the samples taken on March 5, 1975, a reverse trend was detected with the stubble planted plots having the greater large pore space.

An analysis of the bulk density (Table 28, Appendix D) indicates a significant effect due to a time*seedbed preparation interaction and a depth*time*seedbed preparation interaction. No significant differences in bulk densities due to the traffic pattern (Table 28, Appendix D) were detected. Method of seedbed preparation had a greater effect than the traffic on the bulk density on the Memphis soil. Table 8 indicates a trend for the samples taken June 19, 1974, to have a greater bulk density than those taken March 5, 1975. Also, for the samples taken at the various depths for all seedbed preparations except the stubble

TABLE 7. Large pore space in Memphis soil.

Seedbed Preparation	Time of Sampling	Percent Large Pores#
Conventional	June 19, 1974	6.43 cd*
Bedded	June 19, 1974	5.13 d
Stubble Planted	June 19, 1974	4.49 d
Conventional	March 5, 1974	8.44 bc
Bedded	March 5, 1975	9.27 ab
Stubble Planted	March 5, 1975	11.55 a

#Each reported value is the average of 24 measurements.

*Means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE 8. Average bulk density in Memphis soil.

Seedbed Preparation	Time of Sampling	Depth of Sampling	Bulk Density[#] (g/cc)
Conventional	June 19, 1974	zero to 0.076 m	1.49 bcde*
Conventional	June 19, 1974	0.15 to 0.23 m	1.54 ab
Bedded	June 19, 1974	zero to 0.076 m	1.51 bc
Bedded	June 19, 1974	0.15 to 0.23 m	1.54 ab
Stubble Planted	June 19, 1974	zero to 0.076 m	1.59 a
Stubble Planted	June 19, 1974	0.15 to 0.23 m	1.50 bcd
Conventional	March 5, 1975	zero to 0.076 m	1.45 cde
Conventional	March 5, 1975	0.15 to 0.23 m	1.47 cde
Bedded	March 5, 1975	zero to 0.076 m	1.46 cde
Bedded	March 5, 1975	0.15 to 0.23 m	1.44 de
Stubble Planted	March 5, 1975	zero to 0.076 m	1.37 f
Stubble Planted	March 5, 1975	0.15 to 0.23 m	1.43 e

[#]Each reported value is the average of 12 measurements.

*Means followed by the same letter are not significantly different at the 0.05 level of probability.

planted plots, no significant ($p < 0.05$) difference was found between the depths. However, for the stubble planted plots the difference between the depths for each time was significant. The trend in bulk densities for those samples taken March 5, 1975, was reversed to that for those samples taken June 19, 1974.

Samples taken from the stubble planted plots on June 19, 1974, showed a greater bulk density in the surface 0.076 m (3 in) as shown in Table 8. Samples taken on March 5, 1975, showed a lower bulk density in the surface 0.076 m. No cultivation for weed control occurred prior to the samples taken on June 19, but the plots had received three spray operations in addition to the previous season's traffic. Notice (page 13) that between June 19 and March 5, the plots were cultivated three times and a winter had passed. Since work at the National Tillage Machinery Laboratory shows that 75 percent of compaction occurs on the first pass over the field (13), possibly no change had taken place between June 19 and harvest. Assuming that this is true and that soil moisture in the surface 0.076 m would tend to be more responsive to quick temperature changes of short duration, the winter action of thawing and freezing apparently had a more pronounced effect on the surface soil than on the 0.15- to 0.23-m soil. This seems very plausible since the intervening winter was mild with few long periods of sub-freezing weather.

The analysis of soil moisture measurements taken in 1974 shows a significant ($p < 0.05$) effect due to the time of sampling and due to traffic (Table 24, Appendix D). A difference due to time is reasonable since rainfall, and thus soil moisture conditions, will vary during the season. An examination of Table 9 shows that moisture contents in the high-traffic and no-traffic middles were significantly ($p < 0.05$) higher than the low-traffic middles. The small pore measurements (page 23) showed the high-traffic middles with the largest amount of small pores. The high-traffic rows had higher moisture than the low-traffic rows. A conclusion that this additional moisture is available to the plant would probably be correct since the small pore space was higher in the high-traffic middles and the available water is found in the small pore space. Since the amount of small pore space is similar in the low- and no-traffic middles, the additional moisture in the no-traffic middles is probably more readily available to the plant. Table 10 gives a summary of moisture data taken in 1974.

An analysis of the infiltration rates was not attempted because 11 of 72 values were missing. These 11 values were missing due to an obvious error in sampling technique. This error was probably caused by draining into an old root canal or incorrect placement of the rings into the soil. However, trends in the data, Table 11, were detected and are reported. In the high-traffic middles, 50 percent of the rows had increased infiltration rates at the end of the cultivation season, while 50 percent showed decreased rates. For the medium- and low-traffic middles, 87 percent and 67 percent of the middles, respectively, exhibited decreased infiltration rates. On the no-traffic middles, 55 percent of the middles had increased in infiltration rates. Thus, the effect of traffic was to tend to decrease the infiltration in those middles receiving traffic. However, this tendency was not marked.

TABLE 9. Soil moisture in Memphis soil by type of traffic middle.

Type of Middle	6/14/74		7/3/74		7/19/74		Mean
	Trips*	Moisture** (kg/m^3)	Trips	Moisture (kg/m^3)	Trips	Moisture (kg/m^3)	
High-traffic	4	247	6	132	10	125	168 a#
Medium-traffic	2	253	3	121	5	116	163 ab
Low-traffic	2	241	2	114	2	108	154 b
No-traffic	0	250	0	117	0	134	167 a

*Trips refers to the number of trips, after planting, over the middle prior to the moisture measurement.

**The value is the average of nine measurements.

#Means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE 10. Soil moisture in Memphis soil by type of traffic middle within each type of seedbed preparation.

		6/14/74		7/3/74		7/19/74		
Seedbed Preparation	Middle Type	Trips*	Moisture** (kg/m^3)	Trips	Moisture (kg/m^3)	Trips	Moisture (kg/m^3)	Mean
Conventional	High-traffic	4	232	6	126	10	132	163 a#
Conventional	Medium-traffic	2	242	3	134	5	96	157 a
Conventional	Low-traffic	2	218	2	117	2	100	145 a
Conventional	No-traffic	0	226	0	107	0	112	148 a
Bedded	High-traffic	4	249	6	122	10	112	161 a
Bedded	Medium-traffic	2	256	3	112	5	126	165 a
Bedded	Low-traffic	2	243	2	102	2	110	152 a
Bedded	No-traffic	0	259	0	117	0	144	173 a
Stubble Planted	High-traffic	4	261	6	148	10	132	180 a
Stubble Planted	Medium-traffic	2	273	3	113	5	127	171 a
Stubble Planted	Low-traffic	2	271	2	127	2	117	172 a
Stubble Planted	No-traffic	0	281	0	136	0	150	189 a

*Trips refers to the number of trips, after planting, over the middle prior to the moisture measurement.

**The value reported is the average of three replications.

#Means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE 11. Infiltration rates for various traffic middles on Memphis soil in 1974 season.

		Infiltration Rates (m/hr)					
		Rep I		Rep II		Rep III	
Seedbed Preparation	Middle Type	June	Sept.	June	Sept.	June	Sept.
Conventional	High-traffic	0.006	0.008	-	-	0.002	0.005
Conventional	Medium-traffic	0.003	0.002	0.000	0.004	0.003	0.000
Conventional	Low-traffic	0.008	0.012	0.013	0.005	0.002	-
Conventional	No-traffic	-	-	0.008	0.026	-	-
Bedded	High-traffic	0.003	0.003	0.000	0.002	0.003	0.002
Bedded	Medium-traffic	0.005	0.003	0.008	0.005	0.002	0.000
Bedded	Low-traffic	0.014	0.008	0.002	0.006	0.005	0.000
Bedded	No-traffic	0.005	0.009	0.000	0.010	0.024	0.017
Stubble Planted	High-traffic	0.008	0.006	0.000	0.005	0.003	0.000
Stubble Planted	Medium-traffic	-	0.005	0.007	-	0.002	0.001
Stubble Planted	Low-traffic	0.010	0.004	-	-	0.007	0.003
Stubble Planted	No-traffic	0.004	0.002	0.010	0.006	0.005	0.008

Collins Soil

For the plots grown on the Collins soil, the analysis of variance for yield (Table 21, Appendix D) shows a significant ($p < 0.05$) effect due to seedbed preparation and a highly significant ($p < 0.01$) effect due to equipment. An examination of Table 12 shows that the four-row bedded plots produced more cotton than either the conventional or stubble planted plots. Since bedded plots are usually considered to produce better in wet seasons, this trend is reasonable. Notice, however, that the six-row plots showed low yields for both the conventional and bedded plots. A similar condition of stunting and yellowing was observed on the Collins soil as on the Memphis soil.

An examination of Table 5, page 21, and the row-by-row yields shows that, although differences among the yields from the various rows were not significant, the outside rows of the six-row conventional plots tended to yield less than the middle rows. These outside rows which received no traffic on either side had been expected to give better yields due to low compaction, especially in the conventional plots.

The stand count (Table 13) for the six-row bedded and conventional plots on the Collins soil was among the better stand counts with no significance between the six-row conventional plots and the plots with the highest stand counts. The plant heights (Table 13) and taproot lengths (Table 14) for six-row plots were among the greatest. From Table 15, no significant difference in soil moisture was detected among the various treatments. These observations tend to contradict the trend in yields.

TABLE 12. Seed cotton yield from Collins soil for the 1974 season.

Treatment	Yield (Kilograms of seed cotton per hectare)			
	Rep 1	Rep 2	Rep 3	Mean
Conventional 2-row	1795	1209	1386	1463 b*
Conventional 4-row	1270	1184	1763	1406 b
Conventional 6-row	1169	1399	945	1168 b
Bedded 2-row	1392	1533	1001	1309 b
Bedded 4-row	1782	1880	2454	2039 a
Bedded 6-row	1050	1018	976	1015 b
Stubble Planted 2-row	750	683	1188	874 b
Stubble Planted 4-row	1086	703	982	924 b

*Means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE 13. Summary of cotton stand counts and plant heights for Collins soil.

Seedbed Preparation	Equipment	Stand Count (plants/18.3 m) 6/10/74	Plant Height (meters) 6/26/74	8/20/74
Conventional	2-row	216 bc*	0.20 a	1.10 a
Conventional	4-row	213 bc	0.18 a	1.12 a
Conventional	6-row	273 ab	0.21 a	1.14 a
Bedded	2-row	174 c	0.17 ab	0.95 b
Bedded	4-row	213 bc	0.20 ab	1.04 b
Bedded	6-row	227 bc	0.18 ab	0.96 b
Stubble Planted	2-row	174 c	0.13 b	0.87 c
Stubble Planted	4-row	299 a	0.13 b	0.83 c

*Means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE 14. Cotton taproot lengths in Collins soil.

Seedbed Preparation	Equipment	Taproot Length (meters)			
		Rep 1	Rep 2	Rep 3	Mean
Conventional	2-row*	0.23	0.16	0.21	0.20 a#
Conventional	4-row**	0.22	0.21	0.19	0.21 a
Conventional	6-row**	0.19	0.20	0.21	0.20 a
Conventional	6-row (NT)##	0.21	0.22	0.21	0.21 a
Bedded	2-row	0.16	0.19	0.20	0.18 ab
Bedded	4-row	0.16	0.15	0.15	0.15 b
Bedded	6-row	0.19	0.21	0.20	0.20 a
Bedded	6-row (NT)	0.20	0.25	0.21	0.22 a
Stubble Planted	2-row	0.18	0.18	0.20	0.18 ab
Stubble Planted	4-row	0.18	0.17	0.22	0.19 ab

*Double traffic occurred in one middle adjacent to the rows from which the taproots were sampled.

**Single traffic occurred in one middle adjacent to the rows from which the taproots were sampled.

##No traffic occurred adjacent to the row from which the taproots were sampled.

#Means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE 15. Soil moisture in Collins soil by type of traffic middle within each type of seedbed preparation.

Seedbed Preparation	Middle Type	6/24/74 Trips*	6/24/74 Moisture** (kg/m^3)	7/12/74 Trips	7/12/74 Moisture (kg/m^3)	Mean
Conventional	High-traffic	6	187	8	188	188 a#
Conventional	Medium-traffic	3	193	4	182	188 a
Conventional	Low-traffic	2	171	2	174	172 a
Conventional	No-traffic	0	189	0	180	184 a
Bedded	High-traffic	6	206	8	169	188 a
Bedded	Medium-traffic	3	192	4	190	191 a
Bedded	Low-traffic	2	207	2	197	202 a
Bedded	No-traffic	0	190	0	204	197 a
Stubble Planted	High-traffic	6	218	8	210	214 a
Stubble Planted	Medium-traffic	3	202	4	176	189 a
Stubble Planted	Low-traffic	2	199	2	190	194 a
Stubble Planted	No-traffic	0	199	0	193	196 a

*Trips refers to the number of trips over the middle prior to the moisture measurement.

**The value reported is the average of three replications.

#Means followed by the same letter are not significantly different at the 0.05 level of probability.

The year 1974 was the first summer that six-row equipment was used at the Milan Field Station. The men who cultivated the plots were not as skilled with the six-row equipment as they were with the two- and four-row equipment. During cultivation, the equipment tended to stray and plow down some plants. This was not reflected in the stand count since the stand count was made prior to cultivation.

Taproot lengths (Table 14) for the plants on the stubble planted plots were not different from the lengths of taproots from the other plots. Evidently, subsoil restrictions did not cause the lower yields, especially since differences in bulk densities were not significant (Table 16). The poor yield of the stubble planted treatments probably was caused by factors other than physical soil conditions. A probable nitrogen deficiency is suspected.

When the stubble planted plots were planted on the Collins soil, some weed growth was present on the surface. Although a herbicide was used, weed stress remained on the crop. Weeds present were: mare's tail, wild geranium, wild barley, wild mustard, evening primrose, and fescue. Of these weeds, fescue was the greatest problem. Some difficulty was encountered in the attempt to cultivate the stubble planted plots. This difficulty was in not being able to cultivate the plots without damaging the cotton plants. Dead stubble would collect on the sweeps thus damaging the plants; also plants in clumps of sod would be pulled up as the cultivator passed over the plots. Attempts were made to reduce this stress by hand chopping the weeds. Before all weeds could be removed, the damage apparently had been done and low yields resulted.

TABLE 16. Bulk densities after layby for the Collins and Grenada soils.

Type of Middle	Depth	Bulk Density (g/cc)*	
		Collins Soil	Grenada Soil
High-traffic	zero to 0.076 m	1.60 a**	1.62 a
High-traffic	0.15 to 0.23 m	1.59 a	1.54 b
Medium-traffic	zero to 0.076 m	1.58 a	1.52 b
Medium-traffic	0.15 to 0.23 m	1.56 a	1.51 b
Low-traffic	zero to 0.076 m	1.57 a	1.53 b
Low-traffic	0.15 to 0.23 m	1.62 a	1.51 b
No-traffic	zero to 0.076 m	1.52 a	1.45 c
No-traffic	0.15 to 0.23 m	1.58 a	1.54 b

*Each value is an average of three replications.

**Means followed by the same letter are not significantly different at the 0.05 level of probability.

Grenada Soil

For plots grown on Grenada soil, differences in yields were not significant. Similar to the plots on the other soils, the trend was for the six-row plots to yield somewhat poorer than the two- and four-row plots (Table 17). For the plots on the Grenada soil, little difference was detected between the conventional and bedded plots, although the crop on these two plots tended to yield better than the crop which was stubble planted. Row-by-row yields (Table 5, page 21) also showed no significance among rows.

From Tables 18 and 19, no significance in stand count or taproot length was found which agrees with the yield. For the plant height measurements taken June 26, 1974, the plants on the conventional and bedded plots were taller than the plants on the stubble planted plots (Table 18). Some yellowing of plants on the stubble planted plots as well as the six-row bedded plots was evident. Although this was not so bad as on the other two soils, a similar condition existed. Since this condition was present in all three fields, credence is given to the theory that a nitrogen deficiency existed.

Table 16 shows significant ($p < 0.05$) effects in the bulk density measurements due to the depth*traffic interaction. This had not influenced the yield, but the surface 0.076 m of the high-traffic rows was the most compacted and the surface 0.076 m of the no-traffic rows was the least compacted. The effect of traffic was most noticeable on the surface of the highest trafficked rows. On rows which received no cultivation and sprayer traffic, the surface 0.076 m bulk density was

TABLE 17. Seed cotton yield from Grenada soil for 1974 season.

Treatment	Yield (Kilograms of seed cotton per hectare) Rep 1	Rep 2	Mean
Conventional 2-row	1734	1673	1704 a*
Conventional 4-row	1666	1753	1710 a
Conventional 6-row	1362	1521	1442 a
Bedded 2-row	1935	1746	1840 a
Bedded 4-row	1746	1656	1701 a
Bedded 6-row	1250	1314	1282 a
Stubble Planted 2-row	1233	995	1114 a
Stubble Planted 4-row	1306	1148	1227 a

*Means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE 18. Summary of cotton stand counts and plant heights for Grenada soil.

Seedbed Preparation	Equipment	Stand Count (plants/18.3 m) 6/10/74	Plant Height (meters) 6/26/74	8/20/74
Conventional	2-row	251 a*	0.23 ab	0.94 a
Conventional	4-row	271 a	0.22 ab	0.91 ab
Conventional	6-row	324 a	0.22 ab	0.93 a
Bedded	2-row	265 a	0.26 a	0.87 b
Bedded	4-row	229 a	0.19 bc	0.77 c
Bedded	6-row	270 a	0.20 abc	0.76 c
Stubble Planted	2-row	289 a	0.15 cd	0.72 cd
Stubble Planted	4-row	242 a	0.13 d	0.67 d

*Means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE 19. Cotton taproot lengths in Grenada soil.

Seedbed Preparation	Equipment	Taproot Length@ (meters)		
		Rep 1	Rep 2	Mean
Conventional	2-row*	0.22	0.21	0.22a#
Conventional	4-row**	0.22	0.23	0.22a
Conventional	6-row**	0.23	0.19	0.21a
Conventional	6-row (NT)##	0.22	0.19	0.21a
Bedded	2-row	0.18	0.19	0.19a
Bedded	4-row	0.20	0.19	0.20a
Bedded	6-row	0.21	0.19	0.20a
Bedded	6-row (NT)	0.18	0.17	0.17a
Stubble Planted	2-row	0.18	0.18	0.18a
Stubble Planted	4-row	0.19	0.17	0.18a

*Double traffic occurred in one middle adjacent to the rows from which the taproots were sampled.

**Single traffic occurred in one middle adjacent to the rows from which the taproots were sampled.

##No traffic occurred adjacent to the rows from which the taproots were sampled.

#Means followed by the same letter are not significantly different at the 0.05 level of probability.

@The length reported is the average of 10 measurements in each replication.

lower indicating that the surface soil responded to cultivation with no traffic to recompact the surface.

No moisture differences among the various trafficked rows were observed (Table 20) indicating that the moisture level was not affected by the controlled traffic pattern.

TABLE 20. Soil moisture in Grenada soil by type of traffic middle within each type of seedbed preparation.

Seedbed Preparation	Middle Type	6/18/74 Trips*	6/18/74 Moisture** (kg/m^3)	7/15/74 Trips	7/15/74 Moisture (kg/m^3)	Mean
Conventional	High-traffic	4	195	8	108	152 a#
Conventional	Medium-traffic	2	188	4	133	160 a
Conventional	Low-traffic	2	204	2	118	161 a
Conventional	No-traffic	0	200	0	105	152 a
Bedded	High-traffic	4	225	8	141	183 a
Bedded	Medium-traffic	2	214	4	136	175 a
Bedded	Low-traffic	2	224	2	115	170 a
Bedded	No-traffic	0	227	0	125	176 a
Stubble Planted	High-traffic	4	235	8	126	180 a
Stubble Planted	Medium-traffic	2	222	4	148	185 a
Stubble Planted	Low-traffic	2	229	2	114	172 a
Stubble Planted	No-traffic	0	208	0	119	164 a

*Trips refers to the number of trips over the middle prior to the moisture measurement.

**The value reported is the average of two replications.

#Means followed by the same letter are not significantly different at the 0.05 level of probability.

CHAPTER V

CONCLUSIONS

The analysis of data obtained in 1974 indicated that, for a Memphis and a Collins soil with no natural subsoil restrictions, cotton grown on four-row beds on which the traffic was controlled produced the best yields. These yields were 82 percent higher than yields from the two-row, stubble planted plot on the Memphis soil and were 133 percent higher than the two-row, stubble planted plot on the Collins soil.

For the Grenada soil with a fragipan, no significance among the treatments was observed; however, the bedded and conventional plots tended to yield better than the stubble planted plots.

Top yields were obtained from bedded plots in 1974. This fact suggests that top yields can be obtained while reducing the number of equipment trips through the field. One trip is saved for the bedded plots over the conventional plots during the pre-planting treatments. This trip saves labor as well as the energy to power the equipment.

In a wet season such as 1974, no soil moisture stress due to the controlled traffic pattern was detected.

For the plots grown on the Memphis soil, some improvement in large pore space and bulk density occurred over the winter. This indicates that damage done to the soil from the controlled traffic lanes may be reduced or eliminated over the winter months for this West Tennessee soil.

No significant differences in bulk densities due to traffic patterns were detected in the Grenada soil. In Memphis soil differences due to time and depth interactions with seedbed preparation were found. In West Tennessee soils with no natural subsoil restrictions, the traffic patterns had no effect on the bulk densities.

Prospects for Future Work

If the yields from a stubble planted system could be increased to the same degree as for the conventional and bedded plots, at least one additional trip through the field could be eliminated. In addition to raising the yields to a respectable level, the prospects for obtaining a good stand season after season must be improved.

A stubble planting system which creates a more adequate seedbed would probably be a solution. A vibratory tillage tool might perform well under such circumstances.

Other problems facing a good stubble planting system are: adequate weed control, weed and crop residue management, fertilizer placement, and reducing compaction due to the cultivators.

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APPENDICES

APPENDIX A

TECHNIQUE FOR OBTAINING INFILTRATION RATES

Equipment

Equipment required includes: 0.30-m diameter X 0.20-m high, hollow, steel cylinder; 0.50-m diameter X 0.20-m high, hollow, steel cylinder; piece of burlap; driving plate; hammer; carpenter's level; and constant-head water supply.

Procedure

Drive the 0.30-m diameter cylinder into the soil vertically checking with a carpenter's level as needed. Do not drive the cylinder into the soil irregularly, so that one side, and then the other, goes down. This procedure produces a poor bond between the cylinder and the soil. Drive the cylinder into the soil to a depth of approximately 0.10 m.

Around the measuring cylinder, place a buffer cylinder having a diameter of at least 0.20 m greater than the measuring cylinder. Drive the buffer cylinder into the soil to a depth of 0.05 to 0.10 m. Strict vertical movement is not necessary for this buffer cylinder.

Place burlap or other puddling protection device on the soil within the central cylinder. Fill buffer cylinder to a depth of 0.08 m and maintain this approximate depth throughout the period of observation. Fill measuring cylinder to the desired depth, and using the constant head water supply, maintain the water at this level throughout the test period. Remove the puddling protection device. Read water level from the constant-head water supply at 0, 1, 2, 10, 20, 30, 60, 120, and 180 minutes after starting test. Calculate the infiltration rate (21).

APPENDIX B

METHOD FOR OBTAINING PORE SPACE AND BULK DENSITY DATA

Equipment

Equipment required consists of: 0.076-m core sampler; 0.076-m cores; 0.076-m rings; rubber bands; 0.15-m diameter pieces of muslin; knife; vacuum style desiccator; tension table; water; and shovel.

Procedure

Determine the location in the field from which the samples will be collected. Drive the core sampler into the surface 0.076 m of soil and obtain the surface core. After the surface core has been obtained, dig to a depth of 0.15 m and level the soil. Drive the core sampler into the soil and obtain the 0.15- to 0.23-m core sample.

Remove the samples from the field to the laboratory. Trim the cores so that the ends are flush. Place muslin around one end of each core and anchor this with a rubber band. Connect a ring to the other end of each core with a rubber band. Place the prepared cores into the desiccator and fill with water to a depth just over the top of the cores. The rings will prevent flooding of the cores from the top. Connect the vacuum and let cores soak for 24 hours under vacuum. Remove cores from the desiccator and sponge them dry. Weigh. This is weight number 1. Place cores on tension table for 24 hours. Remove. Weigh. This is weight number 2. Remove rubber bands, rings, and cloths. Weigh. This is weight number 3. Dry the core samples at 105°C for 24 hours.

Remove from oven. Weigh each core plus the soil. This is weight number 4. Weigh each empty core. This is weight number 5.

Calculations

$$\text{Large pore space} = \frac{\text{wt. \#1} - \text{wt. \#2}}{347.5} \text{ X } 100 \text{ percent}$$

$$\text{Small pore space} = \frac{\text{wt. \#2} - \text{wt. \#3} - \text{wt. \#4}}{347.5} \text{ X } 100 \text{ percent}$$

$$\text{Bulk density} = \frac{\text{wt. \#4} - \text{wt. \#5}}{347.5} \text{ grams/cc}$$

All weights are in grams.

APPENDIX C

METHOD FOR OBTAINING MOISTURE MEASUREMENTS

Equipment

Equipment required consists of: Nuclear-Chicago Model 5901 Density-Moisture surface probe; model 5920 d/M gauge scaler; and a shovel.

Procedure

Select a location in the middle where the sample will be taken. Clear the surface of any loose vegetation and trash. Place the probe in contact with the soil surface. Turn on gauge scaler and take a count for one minute. Place probe perpendicular to the first position. Obtain a second count for one minute. Average these two counts for a count rate. Express this count rate in terms of kilograms of water per cubic meter using the conversion chart supplied with the probe. This moisture content is an integrated moisture in the top 0.15 to 0.25 m of soil.

APPENDIX D

ANALYSIS OF VARIANCE TABLES

The summary analysis of variance tables for the data analyzed are given in Tables 21 to 30.

TABLE 21. Summary analysis of variance for treatment yield.

Source	df	Estimate of Variance	F Value
MEMPHIS SOIL			
Rep	2	140,756.90	
Seedbed prep	2	464,288.62	10.993*
Error A	4	42,236.20	
Equip	2	478,448.22	7.630**
Equip*Seedbed prep	3	252,396.38	4.025*
Error B	19	62,702,84	
COLLINS SOIL			
Rep	2	59,718.06	
Seedbed prep	2	893,823.41	9.985*
Error A	4	89,520.80	
Equip	2	840,332.27	8,156**
Equip*Seedbed prep	3	268,927.24	2.610
Error B	19	103,030.04	
GRENADA SOIL			
Rep	1	47,259.78	
Seedbed prep	2	55,754.57	2.177
Error A	2	25,606.25	
Equip	2	20,518.87	0.760
Equip*Seedbed prep	3	29,707.62	1.100
Error B	11	27,006.00	

*Significant at the 0.05 level of probability.

**Significant at the 0.01 level of probability.

TABLE 22. Summary analysis of variance for row yield.

Source	df	Estimate of Variance	F Value
MEMPHIS SOIL			
Rep	2	549,150.58	
Seedbed prep	2	49,113.79	0.1945
Error A	4	252,501.78	
Row	3	100,737.18	0.5811
Row*Seedbed prep	5	419,409.33	2.4193*
Error B	91	173,357.51	
COLLINS SOIL			
Rep	2	151,811.79	
Seedbed prep	2	344,101.38	2.8744
Error A	4	119,710.46	
Row	3	75,454.87	0.4626
Row*Seedbed prep	5	280,899.99	1.7223
Error B	91	163,099.51	
GRENADA SOIL			
Rep	1	62,182.84	
Seedbed prep	2	10,212.75	0.1047
Error A	2	97,536.76	
Row	3	112,231.40	1.2856
Row*Seedbed prep	5	113,818.04	1.3038
Error B	58	87,298.80	

*Significant at the 0.05 level of probability.

TABLE 23. Summary analysis of variance for cotton stand count.

Source	df	Estimate of Variance	F Value
MEMPHIS SOIL			
Rep	2	3,689.976	
Seedbed prep	2	5,100.298	0.9827
Error A	4	5,190.206	
Equip	2	181.630	
Equip*Seedbed prep	3	6,265.406	7.0372**
Error B	19	890.329	
COLLINS SOIL			
Rep	2	1,763.369	
Seedbed prep	2	2,701.206	0.9026
Error A	4	2,992.500	
Equip	2	10,087.857	9.1104**
Equip*Seedbed prep	3	5,736.313	5.1805**
Error B	19	1,107.287	
GRENADA SOIL			
Rep	1	152.004	
Seedbed prep	2	3,984.821	7.5740
Error A	2	526.123	
Equip	2	2,620.369	3.4699
Equip*Seedbed prep	3	2,432.062	3.2205
Error B	11	755.178	

**Significant at the 0.01 level of probability.

TABLE 24. Summary analysis of variance for soil moisture.

Source	df	Estimate of Variance	F Value
MEMPHIS SOIL			
Time	2	377,457.10	34.032**
Error A	6	11,091.34	
Seedbed prep	2	9,501.00	3,025
Time*Seedbed prep	4	2,278.97	0.726
Error B	12	3,141.00	
Traf	3	2,843.87	3.449*
Traf*Time	6	796.83	0.966
Traf*Seedbed prep	6	842.45	1.022
Traf*Time*Seedbed prep	12	526.22	0.691
Error C	189	824.66	
COLLINS SOIL			
Time	1	2,369.03	0.299
Error A	4	7,925.67	
Seedbed prep	2	3,021.09	1.176
Time*Seedbed prep	2	198.28	0.077
Error B	8	2,569.76	
Traf	3	395.99	0.519
Traf*Time	3	365.41	0.479
Traf*Seedbed prep	6	1,252.15	1.641
Traf*Time*Seedbed prep	6	673.45	0.883
Error C	126	762.76	
GRENADA SOIL			
Time	1	185,436.12	210.396*
Error A	2	881.36	
Seedbed prep	2	4,201.96	1.715
Time*Seedbed prep	2	575.69	0.235
Error B	4	2,449.53	
Traf	3	355.03	0.525
Traf*Time	3	1,243.02	1.839
Traf*Seedbed prep	6	401.32	0.594
Traf*Time*Seedbed prep	6	198.04	0.293
Error C	78	675.91	

*Significant at the 0.05 level of probability.

**Significant at the 0.01 level of probability.

TABLE 25. Summary analysis of variance for cotton plant height.

Source	df	Estimate of Variance	F Value
MEMPHIS SOIL			
Time	1	2,333.021	44.9067**
Error A	4	52.064	
Seedbed prep	2	59.662	4,7238*
Time*Seedbed prep	2	24.126	1.9102
Error B	8	12.630	
Equip	2	6.536	2.1145
Equip*Time	2	1.169	0.3782
Equip*Seedbed prep	3	9.643	3.1197*
Equip*Time*Seedbed prep	3	0.228	0.0738
Error C	38	3.091	
COLLINS SOIL			
Time	1	2,852.083	987.1409**
Error A	4	2.889	
Seedbed prep	2	113.103	26.8589**
Time*Seedbed prep	2	55.357	13.1458
Error B	8	4.211	
Equip	2	11.123	2.2759
Equip*Time	2	3.452	0.7063
Equip*Seedbed prep	3	9.2227	1.8880
Equip*Time*Seedbed prep	3	3.785	0.7743
Error C	38	4.887	
GRENADA SOIL			
Time	1	1,156.003	142.2681**
Error A	2	8.126	
Seedbed prep	2	33.223	4.8374
Time*Seedbed prep	2	25.830	3.7609
Error B	4	6.868	
Equip	2	12.860	13.2039**
Equip*Time	2	1.080	1.1085
Equip*Seedbed prep	3	5.253	5.3936**
Equip*Time*Seedbed prep	3	0.198	0.2029
Error C	22	0.974	

*Significant at the 0.05 level of probability.

**Significant at the 0.01 level of probability.

TABLE 26. Summary analysis of variance for small pore space for Memphis soil.

Source	df	Estimate of Variance	F Value
Time	1	2.428	0.1787
Error A	4	13.589	
Seedbed prep	2	14.439	0.9589
Time*Seedbed prep	2	5.063	0.3363
Error B	8	15.058	
Traf	3	27.610	3.6051*
Traf*Time	3	3.973	0.5188
Traf*Seedbed prep	6	11.979	1.5641
Time*Traf*Seedbed prep	6	10.796	1.4096
Error C	36	7.769	
Dep	1	35.244	2.9771
Dep*Time	1	23.056	1.9476
Dep*Seedbed prep	2	26.023	2.1982
Dep*Traf	3	10.636	0.8984
Dep*Time*Seedbed prep	2	22.886	1.9332
Dep*Time*Traf	3	7.238	0.6114
Dep*Traf*Seedbed prep	6	13.846	1.1695
Dep*Time*Traf*Seedbed prep	6	10.692	0.9032
Error D	40	11.838	

*Significant at the 0.05 level of probability.

TABLE 27. Summary analysis of variance for large pore space for Memphis soil.

Source	df	Estimate of Variance	F Value
Time	1	710.698	17.8403*
Error A	4	39.837	0.5287
Seedbed prep	2	7.573	0.5287
Time*Seedbed prep	2	76.461	5.3380*
Error B	8	14.324	
Traf	3	30.337	1.7474
Traf*Time	3	21.057	1.2128
Traf*Seedbed prep	6	12.530	0.7217
Time*Traf*Seedbed prep	6	21.604	1.2444
Error C	36	17.362	
Dep	1	24.640	2.8586
Dep*Time	1	7.034	0.8161
Dep*Seedbed prep	2	13.040	1.5128
Dep*Traf	3	8.297	0.9625
Dep*Time*Seedbed prep	2	17.363	2.0143
Dep*Time*Traf	3	3.379	0.3920
Dep*Traf*Seedbed prep	6	18.999	2.2041
Dep*Traf*Time*Seedbed prep	6	3.067	0.3558
Error D	40	8.620	

*Significant at the 0.05 level of probability.

TABLE 28. Summary analysis of variance for bulk density for Memphis soil.

Source	df	Estimate of Variance	F Value
Time	1	0.3117	5.3366
Error A	4	0.0584	
Seedbed prep	2	0.0026	0.6934
Time*Seedbed prep	2	0.0277	7.2825*
Error B	8	0.0038	
Traf	3	0.0284	2.7632
Traf*Time	3	0.0090	1.2676
Traf*Seedbed prep	6	0.0177	1.7176
Time*Traf*Seedbed prep	6	0.0071	0.6882
Error C	36	0.0103	
Dep	1	0.0032	0.6488
Dep*Time	1	0.0030	0.6112
Dep*Seedbed prep	2	0.0094	1.9014
Dep*Traf	3	0.0070	1.4064
Dep*Time*Seedbed prep	2	0.0374	7.5581*
Dep*Time*Traf	3	0.0023	0.4611
Dep*Traf*Seedbed prep	6	0.0059	1.1853
Dep*Traf*Time*Seedbed prep	6	0.0055	0.4583
Error D	40	0.0120	

*Significant at the 0.05 level of probability.

TABLE 29. Summary analysis of variance for cotton taproot length.

Source	df	Estimate of Variance	F Value
MEMPHIS SOIL			
Rep	2	0.0611	
Seedbed prep	2	0.5867	0.2956
Error A	4	1.9847	
Equip	3	0.3272	0.5299
Equip*Seedbed prep	4	0.9642	1.5614
Error B	23	0.6175	
COLLINS SOIL			
Rep	2	1.1904	
Seedbed prep	2	3.2673	2.5498
Error A	4	1.2814	
Equip	3	2.9830	4.2825*
Equip*Seedbed prep	4	1.4140	2.0307
Error B	23	0.6966	
GRENADA SOIL			
Rep	1	1.0038	
Seedbed prep	2	2.6327	10.9091
Error A	2	0.2413	
Equip	3	0.4579	1.0090
Equip*Seedbed prep	4	0.2101	0.4630
Error B	13	0.4538	

*Significant at the 0.05 level of probability.

TABLE 30. Summary analysis of variance for bulk density on the Collins and Grenada soils for 1974 season after layby.

Source	df	Estimate of Variance	F Value
COLLINS SOIL			
Rep	2	0.034563	
Seedbed prep	2	0.006198	0.0684
Error A	4	0.090679	
Traf	3	0.020531	0.2525
Traf*Seedbed prep	6	0.119795	1.4732
Error B	18	0.081318	
Dep	1	0.005932	0.0830
Dep*Seedbed prep	2	0.082367	1.1532
Dep*Traf	3	0.077365	1.0831
Dep*Traf*Seedbed prep	6	0.055278	0.7739
Error C	24	0.071427	
GRENADA SOIL			
Rep	1	0.000713	
Seedbed prep	2	0.020462	13.5260
Error A	2	0.001513	
Traf	3	0.015844	7.1375**
Traf*Seedbed prep	6	0.005182	2.3342
Error B	9	0.002220	
Dep	1	0.000248	0.1298
Dep*Seedbed prep	2	0.008082	4.2344*
Dep*Traf	3	0.015274	8.0031**
Dep*Traf*Seedbed prep	6	0.003704	1.9408
Error C	12	0.001909	

*Significant at the 0.05 level of probability.

**Significant at the 0.01 level of probability.

APPENDIX E

SOIL ANALYSIS

The results of the soil analyses are given in Table 31.

TABLE 31. Results of soil analyses made during winter quarter of 1974.

Soil	Depth	Org. Matter %	Spec. Grav. %	Clay %	Silt %	Coarse Silt %	Sand %	Percent Moisture Content at 1/3 Bar	2 Bar	5 Bar	15 Bar
Memphis	0–0.15 m	1.22	2.75	30.4	26.0	36.5	7.1	20.6	11.0	7.8	5.7
Memphis	0.2–0.35 m	1.00	2.62	24.4	58.5	13.6	3.5	28.2	17.3	14.6	9.1
Collins	0–0.15 m	1.13	2.54	18.4	34.4	24.9	22.3	18.2	6.9	5.4	3.4
Collins	0.2–0.35 m	0.25	2.52	23.1	49.7	15.2	12.0	27.6	14.8	11.5	8.1
Grenada	0–0.15 m	1.01	2.58	26.6	24.4	43.5	5.6	21.3	11.4	9.1	6.2
Grenada	0.2–0.35 m	0.82	2.65	16.1	47.2	30.5	6.1	20.8	11.1	9.0	5.8

VITA

Jon S. Jablonski was born in Harrisburg, Pennsylvania, on May 15, 1951. His family moved to Washington College, Tennessee, in October, 1953. He graduated from Washington College Academy in May, 1969, and entered The University of Tennessee in the following September. He received his Bachelor of Science in Metallurgical Engineering in June, 1973. In June, 1973, he accepted a graduate research assistantship in Agricultural Engineering.

He is a member of Tau Beta Pi, Phi Kappa Phi, and Gamma Sigma Delta honoraries.

He is married to the former Lynda Carroll Potts of Nashville, Tennessee.