SOME EFFECTS OF SIX ANNUAL TILLAGE TREATMENTS ON CERTAIN PHYSICAL AND CHEMICAL PROPERTIES OF A MEMPHIS SILT LOAM SOIL AFTER FOUR YEARS IN COTTON PRODUCTION

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ABSTRACT

The purpose of this study was to measure certain physical and chemical characteristics at different depths in the profile of a Memphis silt loam soil. These characteristics were considered in detecting potential "traffic pans." The experiment included six tillage treatments. The effectiveness of the six tillage treatments in the mixing of lime and fertilizer was also evaluated.

The experiment was conducted at the Milan Field Station for five years (1968-1972). A randomized complete block design was used. The six treatments were break 6 inches, break 9 inches, break 12 inches, offset disc 6 inches, chisel 14-16 inches and bedding 6 inches. Cotton was grown each year and yields collected from all plots. Rainfall data was available in Climatological Data, U. S. Department of Commerce.

Core samples and bulk samples were obtained in the spring of 1972 from the tilled zones and immediately below the tilled zones of each treatment. Bulk density, large and small pore space, pH, available phosphorus and potassium were determined on all zones sampled.

There were no significant differences in bulk density among the treatments or depths and no distinguishable "traffic pan." A compacted layer was detected using a soil sampling probe in the break 6 inch and offset disc 6 inch treatments. Some one-inch cores were taken in the most compact layers of these treatments and their bulk densities were somewhat higher than the bulk densities of three-inch cores taken from

the same treatment. It was concluded that the densest layers were masked to some extent in the three-inch cores.

There were differences in the mixing of lime and fertilizer among treatments, but the differences did not show up in yield response.

No significant differences in yield among treatments were observed in any of the years studied.

The rainfall data was considered for each year. None of the growing seasons studied had serious deficiencies in rainfall.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Considerable interest in deep tillage and deep placement of fertilizer has developed during the past two decades. This concern has increased recently due to greater use of bigger and heavier equipment in the mechanization of crop production. Such production practices often result in undesirable conditions in the soil profile.

This study was designed to determine some of the physical and chemical properties of a Memphis silt loam soil, where the soil had been prepared by six different tillage methods: break 6 inches; break 9 inches; break 12 inches; chisel 14 to 16 inches; offset disc 6 inches; and bedding 6 inches.

Bulk density, large pore space, and small pore space were determined to detect possible compacted zones that might produce mechanical impedance to rooting. Available phosphorus, available potassium and pH were determined at different levels in the soil profile so the effectiveness of different tillage treatments in mixing lime and fertilizer could be evaluated. Also, consideration was given to the possibility of the different tillage methods developing or alleviating dense compacted layers.

Cotton yields from the plots of each treatment were collected for five years, 1968-1972. The rainfall data for the Milan Field Station were compiled and considered when evaluating yield response to the various treatments.

CHAPTER II

LITERATURE REVIEW

The study of induced compacted conditions in the soil, where the restrictive layer is the result of an applied compacting force from a tillage implement or a power unit, has led to the use of terms such as "traffic pan," "plow pan" and "induced hardpan." These "pans" most often occur in medium textured (loam, sandy loam and silt loam) soils. The zone of highest bulk density and lowest permeability is most commonly found just below the zone disturbed by normal tillage operations, and may be similar in texture and chemical properties to the material immediately above and below it.

Bulk density may be higher and permeability lower in the middles than in the rows of intertilled crop fields (10). The pattern of alternating strips of high and low bulk density may persist through several seasons.

When one attempts to dig a hole in dry soil, the induced compacted layer is recognizable by the resistance offered. If soil is moist, however, the zone of induced compaction may be difficult to recognize in the field. Bulk density, pore size distribution, permeability or hydraulic conductivity of undisturbed soil cores and penetrability are among the quantitative measurements that have been used to identify induced compaction.

Critical limits, which can be generally used to identify serious compaction for the above listed measurements, cannot be precisely established due to wide variations in soil and crop characteristics. Within a given soil type, however, plant growth may be closely related to bulk density of the compacted zone (4).

Instances are fairly common where the downward penetration of roots is abruptly terminated at a soil layer of high bulk density and low porosity. The results of several investigators (23) indicate that the root growth tends to be restricted in fine textured soils when the bulk density gets much above 1.4 g per cm^3 while in coarser textured soils root growth may not be noticeably restricted at bulk densities less than about 1.6 g per cm^3.

Viehmeyer and Hendrickson (27) found that roots of the sunflower plant failed to penetrate an Aiken clay soil compacted to bulk density of 1.46 g per cm^3. Higher bulk densities were required to prevent root penetration in silty and sandy soils. Scarsbrook (23) indicated that bulk densities as low as 1.35 g per cm^3 seriously restricted the penetration of sugar cane roots in several silt loam soils in the Louisiana delta.

Compact soil layers or horizons may be unfavorable to root growth because of lack of moisture or oxygen. Mechanical impedance can also be a critical factor for lack of root penetration.

Slow penetrability by water limiting the amount of water stored in the soil is an inevitable consequence of close packing of soil particles. Likewise, movement of oxygen or other gases through the soil mass will be slower where density is high and porosity low. Thus, the conditions that make for mechanical resistance to penetration of a soil zone by roots are unavoidably, and perhaps inseparably, associated with undesirable moisture and aeration characteristics (19).

In some cases, compacted soil layers have been found to remain dry, even when the soil above the compacted layer is saturated with water. In such cases, both waterlogged conditions just above the pan, and lack of water within the pan may contribute to the restriction of root growth (19).

The exact cause of root impedance or restriction cannot be pinpointed. In most cases compaction may exert detrimental effects on crops through the interaction of several factors. However, most of these factors become more favorable if the compact layer is loosened. Consequently, subsoil tillage studies constitute the bulk of the applied research for the correction of soil compaction.

Results of deep tillage experiments reported to date indicate that the responses are variable and are dependent on certain physical and chemical properties of the soil as well as the amount and distribution of rainfall. Raney et al. (20) found that deep breaking a well-drained Mississippi River alluvial soil containing a traffic pan resulted in sizable yield increases of cotton in years of below normal rainfall. In a year with a normal moisture supply no increase in yield was obtained by deep breaking. Robertson et al. (21), working with acid soils of North and West Florida, observed that the response to subsoiling and deep placement of fertilizer was related to the presence of traffic pans, the fertility of the subsoil, and the time and duration of moisture stress periods. They found that responses to subsoiling and deep fertilizer placement were larger if the moisture stress periods occurred in the first part of the growing season.

Woodruff and Smith (28) found that subsoiling alone did not improve root development of sweet clover on an acid claypan soil in Missouri, but that applying lime to the shattered subsoil resulted in a greatly improved root system. The necessity of applying lime and plant nutrients to acid subsoils before alfalfa root development improved was observed by Engelbert and Truog (8) in Wisconsin. Kohnke and Bertrand (13) found in the majority of their experiments in Indiana that subsoil fertilization resulted in increased corn yields when compared with subsoiling alone.

Patrick et al. (18) in experiments conducted for several years on four soil types obtained greater root development in the subsoil and increased yield from deep tillage and deep fertilizer placement on soils that possessed traffic pans. This was particularly evident in years of below-average rainfall, when the increased root development in the subsoil caused by deep placement of fertilizer or deep tillage enabled the crop to better withstand dry periods.

Under normal moisture conditions in 1950 in the Delta Section of Mississippi, research workers (19) found no significant increase in cotton yields where deep breaking had been compared to conventional middle busting on a Bosket fine sandy loam soil having a well-defined induced hardpan. However, the deep tillage did significantly increase stand, stalk size, pore space and reduce bulk density. All effects of deep tillage on the physical properties of the soil disappeared when cotton was returned to the same area in 1951. In years of less favorable moisture, deep tillage (up to 12 inches in depth) of Dubbs fine sandy loams having a compacted layer, beginning 5 to 6 inches deep, and extending 10 to 11 inches deep, gave seed cotton yield increases in the order of 200 to 400 pounds in 1952, 1300 to 1600 pounds in 1953 and 1000 to 1300 pounds in 1954.

Saveson et al. (22) obtained yield increases of approximately two-thirds bale of cotton per acre from deep breaking a Commerce silt loam at the Northeast Louisiana Experiment Station, St. Joseph, in 1954 and 1956. Both 1954 and 1956 growing seasons were dry. These workers found no increases in cotton yield from deep tillage in 1955, a year without a serious deficiency of water during the growing season.

Taylor et al. (26) found that the apparent critical bulk density--at which no roots grew through the soil mass--was lower in years when substantial drought periods occurred than during years when soil moisture was available. This phenomen suggested that the magnitude of soil bulk density effects upon root penetration depended upon the soil moisture content. They further concluded that soil strength--not soil bulk density--was the critical impedance factor controlling root penetration in the sandy soils of the Southern Great Plains.

Soil bulk density is not a direct measure of mechanical impedance of plant roots and shoots because it is not a direct measure of the size of pores and the rigidity of the soil (3).

Meredith et al. (16), indicated that artificial soil compaction resulted in increased bulk density and decreased noncapillary porosity and water permeability. Root penetration decreased as soil compaction was increased. Meredith and coworkers, through field observations, found that the effects of compaction were usually less permanent in a clay loam or clay than in a medium-textured soil. When fine sand and silt particles are compacted, the swelling and shrinking forces which accompany hydration and dehydration are not great enough to loosen soil mass. Thus the packing effect of traffic on soils low in clay and high in fine sand and silt accumulates over the years. On the other hand, soil compaction is not as accumulative in a soil containing significant amounts of 2:1 type clay since the swelling and shrinking forces tend to loosen the soil after it has been artificially compacted.

Taylor et al. (25) indicated that it was soil strength, and not soil bulk density nor any other physical factor of soil, that actually controlled the penetration of cotton taproots through cores of Amarillo fine sandy loam soil at 1/2 to 2/3 bar soil moisture tension. When soil strength (as measured with a soil penetrometer*) was greater than 30 bars, no roots penetrated the cores. When the strength was less than 30 bars, the percentage of roots that penetrated the soil was inversely proportional to soil strength.

*"Static penetrometer" - Model 719-40, John Chatellon and Sons, 85 Cliff St., New York.

Several investigators, to date, have concluded that soil strength (being a function of soil bulk density and moisture content) is the critical factor in root impedance. Other researchers indicate that soil porosity or the percent noncapillary pore space is an important factor for root entrance and proliferation.

Tackett and Pearson (24), in studying cotton root penetration of compacted soil cores, found that mechanical impedance was more detrimental than low oxygen for root growth in the subsoils at bulk densities above 1.5 g per cm^3. At lower densities root growth was depressed at oxygen levels below 10 percent, and there was a strong interaction of oxygen and bulk density.

Farnsworth and Baver (9) noted significant increases in the growth of sugar beets when the noncapillary porosity of a Brookston clay was maintained at a level of 6 percent or above and suggested that aeration of the soil is likely to become a limiting factor in plant growth if the air capacity is below 9 percent. These researchers also indicated that spring plowing raised the noncapillary porosity from 4 percent to 16 percent by volume.

Larson (14) showed that many cornbelt soils, when loosened with a moldboard plow, had reductions in bulk density generally from 1.4 g per cm^3 to 1.0 g per cm^3 and total porosity increased from 47 percent to 62 percent with the increase primarily in noncapillary pore space or aeration porosity.

In work done by Bertrand and Kohnke (2), corn roots did not penetrate a silty clay loam subsoil which had a bulk density of 1.5 g per cm^3 and 5.4 percent noncapillary pores, however when the soil was loosened to a bulk density of 1.2 g per cm^3 and aeration porosity of 14.6 percent corn roots grew profusely. These workers showed that a compact soil having a bulk density of 1.5 g per cm^3, aeration porosity of 5.4 percent, and 38.1 percent capillary pore space when loosened by moldboard plowing had a bulk density of 1.2 g per cm^3, 14.6 percent aeration porosity, and 40.5 percent capillary pore space.

Jamison and Domby (12) in their study of the root development and nutrient uptake of cotton in Commerce silt loam concluded that a combination of factors affecting air-water relationships and root extension were responsible for the so-called "hotspot" problem areas that occurred in fields of Commerce silt loam in the lower Mississippi River Delta areas.

In summarizing deep tillage experiments to date, it appears that tillage treatments which reduce soil density and shatter induced pans may result in greater rooting depth, available water supply, and crop yields in certain years when moisture deficits occur in the early part of the growing season. It was also noted that the duration of beneficial effects of deep tillage were most often limited to one season.

CHAPTER III

METHODS AND MATERIALS

The tillage experiment from which the samples of this study were taken was started in 1968. The experimental design was a randomized complete block and had four replications. The treatments were established and repeated on the same plots each year so that a cumulative effect could be realized.

As previously mentioned, the six tillage methods evaluated were: break 6 inches; break 9 inches; break 12 inches; chisel 14 to 16 inches; offset disc 6 inches; and bedding 6 inches. The purpose of the experiment was to determine the effect of these six methods of land preparation upon the yield of cotton and soil characteristics.

After four years of the experiment (in the spring of 1972 before the ground was prepared for the next growing season) core samples and bulk samples were taken at various depths in the profile of each treatment. This is the time in the tillage cycle when the soils would be most compact. Three-inch core samples (three inches in diameter and three inches long) were obtained from the tilled zone and immediately below the tilled zone on each plot. Bulk samples were collected with a soil probe from the same positions in the profile as the core samples.

From physical inspection with the soil probe (that is the resistance it gave when pushed through the soil) a dense or compacted layer of soil could be detected most readily in the break 6 inch and offset disc 6 inch treatments. In these treatments one-inch cores were taken from a zone immediately below the tilled zone where the most dense layer of soil occurred. The one-inch cores were obtained for bulk density and pore space determinations to be compared with the bulk density and pore space of the three-inch cores of the same treatments. This comparison was made to see if the most dense layer was masked in the three-inch cores.

After the core and bulk samples were collected in the field, laboratory determinations were made for bulk density, large pore space, small pore space, pH, available phosphorus and available potassium.

In the laboratory a vacuum desiccator was used to saturate the core samples. After saturation the samples were weighed and placed on a tension table with tension produced by a 50 cm water column. After 24 hours, the samples were weighed and then oven dried and weighed again. Then the empty aluminum cylinder was weighed. Bulk density was determined by:

$$\text{Bulk Density} = \frac{\text{Weight of oven dry soil and cylinder - weight of cylinder}}{\text{Cylinder volume}}$$

Large pore space was determined by:

$$\text{Percent Large Pore Space} = \frac{\text{Weight of saturated core - weight of core after 50 cm tension}}{\text{Cylinder volume}}$$

Small pore space was determined by:

$$\text{Percent Small Pore Space} = \frac{\text{Weight of core after 50 cm tension - weight of oven dry core}}{\text{Cylinder volume}}$$

Available phosphorus, available potassium and pH were determined on bulk samples at the State Soil Testing Laboratory in Nashville.

The yields of cotton from each plot were collected each year by workers at the Milan Field Station. Climatological data for the station were also used.

All plots were fertilized uniformly at the rates shown in Table I during the five crop years. The pH of the plots ranged from 5.7 to 5.8 in 1968 before tillage and fertilization, and two tons of lime per acre was applied.

TABLE I

FERTILIZATION RATES EACH YEAR OF THE FIVE YEAR EXPERIMENT

Year	N	P_2O_5	K_2O	B	Lime
	pounds/acre				
1968	80	50	50	--	4000
1969	100	60	60	--	--
1970	80	40	40	--	--
1971	80	60	60	.5	--
1972	80	40	40	.5	--

CHAPTER IV

RESULTS AND DISCUSSION

I. PHYSICAL CHARACTERISTICS

Bulk density determinations were made from three-inch core samples for the tilled and the undisturbed zones of the soil profile in each treatment. These data are shown in Table II. The bulk densities of the zones were compared to detect a potential compacted layer ("traffic pan"), there were no significant differences in the zones (depths) of the treatments; however, the bulk densities appeared great enough to cause root impedance as suggested by Tackett and others (23,24,27). Comparisons of the bulk densities found in each treatment were made to establish any difference in the effectiveness of the different tillage methods and there were no differences apparent. There were no significant differences in bulk densities among the treatments or depths. The bulk densities ranged from 1.45 g per cm^3 to 1.48 g per cm^3 in the tilled zones and from 1.42 g per cm^3 to 1.49 g per cm^3 in the untilled zones.

The same comparisons among treatments and depths were made in evaluating large (noncapillary) and small (capillary) pore space and no significant differences were found as shown in Table II.

The aeration porosity (large pore space) values in this experiment ranged from 2.3 percent to 3.9 percent for the untilled zones and 2.3 percent to 5.3 percent for the tilled zones. These values are

TABLE II

SOME PHYSICAL CHARACTERISTICS AT TWO AND THREE DEPTHS IN SIX TILLAGE TREATMENTS ON A MEMPHIS SILT LOAM SOIL

Treatment	Depth[a]	Mean Values of Four Replications		
		Bulk Density[b]	Percent Large Pore Space[c]	Percent Small Pore Space
Break 6"	D_1	1.45	5.3	37.0
	D_2	1.49	3.2	30.3
Break 9"	D_1	1.47	2.5	37.9
	D_2	1.47	3.9	37.9
Break 12"	D_1	1.48	2.8	37.2
	D_2	1.47	4.2	38.6
	D_3	1.44	2.3	41.1
Chisel 14"-16"	D_1	1.46	3.6	38.0
	D_2	1.48	3.6	38.1
	D_3	1.42	3.2	39.8
Offset disc 6"	D_1	1.47	2.3	38.0
	D_2	1.46	3.9	38.0
Bedding 6"	D_1	1.46	2.7	39.0
	D_2	1.48	3.0	37.6
LSD (.05)		N.S.	N.S.	N.S.

[a]In the deeper tilled (Break 12" and Chisel 14"-16") treatments, two samples (D_1 and D_2) were taken in the tilled zone and D_3 was taken in the undisturbed zone.

[b]These bulk density values were for the three-inch core samples, in g/cm^3.

[c]Large pore space = aeration porosity = noncapillary pore space.

characteristic of a compact soil and are approaching critical points for suppressing plant growth as indicated by Baver and others (2,9,14,21).

The small pore space values ranged from 30.3 percent to 41.1 percent in the untilled zones and from 37.0 percent to 39.8 percent in the tilled zones. These values are low for a soil with tilth sufficient for good plant growth when compared to the values found by Bertrand and Kohnke (2).

Bertrand, Farnsworth and others (2,9,14,24,27) found that bulk density, large pore space and small pore space values similar to those for the tilled as well as the untilled zones are characteristic of compact soils with tilth insufficient for good plant growth.

Larson and other researchers (2,9,14) have indicated that normal moldboard plowing reduces the bulk density to the 1.0-1.2 g per cm^3 range and increases aeration porosity to the 15-20 percent range. The relatively high bulk density and low aeration porosity of the tilled zones in all treatments certainly indicate the need for adequate tillage in the preparation of a seedbed. These bulk density and pore space figures also indicate that the beneficial effects of tillage on aeration porosity and bulk density do not last more than one season which agrees with the findings of Raney (16).

There were no significant differences found in any of the three physical characteristics evaluated, as is indicated in Table II. Therefore, no distinct compacted layer could be detected by differences in bulk density values in the untilled zone of any treatment, but the actual bulk density and aeration porosity values were indicative of a compact soil and show the need for adequate seedbed preparation to reduce soil density and increase the aeration porosity of the soil.

As previously mentioned, one-inch cores were taken from the undisturbed, compacted layer in the break 6 inch and offset disc 6 inch treatments. As shown in Table III, the bulk density of the most compact layer (characterized by the one-inch cores) was masked to some extent in the three-inch cores. From physical inspection with a soil probe, a dense layer could be detected more readily in these two shallow tilled treatments than in the other four treatments. The most compact portion was apparently less than one inch thick.

II. CHEMICAL CHARACTERISTICS

The effectiveness of the different tillage treatments in mixing lime and fertilizer through the soil profile was evaluated. Soil test values which relate to lime and fertilizer mixing in the tilled layer of soil are shown in Table IV. Significant differences in levels of pH, available phosphorus and available potassium were apparent.

The data in Table IV would seem to indicate that the movement of added nutrients to the undisturbed zones of soil was less effective in the break 6 inch and break 9 inch treatments than it was in the offset disc 6 inch and bedding 6 inch treatments. The pH, available phosphorus and available potassium levels of the untilled zones of the bedding 6 inch treatment were significantly higher than the pH, available phosphorus and available potassium levels of the untilled zones of the break 6 inch treatment and break 9 inch treatment.

TABLE III

BULK DENSITIES OF ONE-INCH AND THREE-INCH CORE SAMPLES FROM THE COMPACTED LAYERS IN TWO TREATMENTS

Treatment	Mean Bulk Densities in g/cm^3	
	One-Inch Core	Three-Inch Core
Break 6"	1.53	1.49
Offset disc 6"	1.52	1.46

TABLE IV

SOME CHEMICAL PROPERTIES AT TWO AND THREE DEPTHS IN SIX TILLAGE TREATMENTS ON A MEMPHIS SILT LOAM SOIL

Treatment	Depth[a]	Mean Values of Four Replications		
		pH	Phosphorus[b]	Potassium[c]
Break 6"	D_1	6.7	30	258
	D_2	5.8	15	130
Break 9"	D_1	6.8	27	235
	D_2	5.9	14	138
Break 12"	D_1	6.4	22	193
	D_2	6.3	23	170
	D_3	6.0	19	155
Chisel 14"-16"	D_1	6.6	40	218
	D_2	6.4	18	120
	D_3	5.4	11	113
Offset Disc 6"	D_1	6.9	51	325
	D_2	6.2	20	145
Bedding 6"	D_1	6.9	54	365
	D_2	6.7	29	215
LSD (.05)		0.4	13	83

[a]In the deeper tilled (Break 12" and Chisel 14"-16") treatments, two samples (D_1 and D_2) were taken in the tilled zone and D_3 was taken in the undisturbed zone.

[b]Available phosphorus in pounds per acre.

[c]Available potassium in pounds per acre.

There were generally higher levels of lime (indicated by pH), phosphorus and potassium in the offset disc 6 inch and bedding 6 inch treatments than in the break 6 inch and break 9 inch treatments; indicating more mixing and dilution in the latter two treatments--assuming levels of application were uniform. In the two deeper tilled treatments, the break 12 inch treatment resulted in deeper mixing of added nutrients than did the chisel 14-16 inch treatment where there was a higher concentration of nutrients in the D_1 sampling depth.

In the break 12 inch treatment, there were no significant differences among depths in pH, available phosphorus or available potassium, indicating a uniform mixture of nutrients down through the soil profile and a more uniform plant growth media. This was not true for any other treatment.

Table V shows the soil test values of the topsoil (0-6 inches) and the subsoil (6-12 inches) before fertilization and tillage each year. It is easy to distinguish that two tons of lime per acre were added to the plots in 1968 as there was a rise in pH between 1968 and 1969. The plots had a high fertility status from 1969 through 1971 but the excess rain in the fall of 1971 apparently caused considerable leaching, as the soil test values of 1972 would indicate.

III. YIELDS

The theory that better distribution of increments of lime and fertilizer down through the soil profile in conjunction with better physical conditions found in the deeper tilled treatments would result

TABLE V

SOIL TEST VALUES BEFORE FERTILIZATION, AVERAGE FOR ALL PLOTS

Treatment	Analysis	Soil Depth in.	1968	1969	1970	1971	1972
Break 6"	pH	0-6	5.8	6.8	6.4	6.7	5.9
		6-12	5.2	5.8	6.1	5.7	5.8
	P	0-6	21	26	26	25	27
		6-12	10	17	19	13	18
	K	0-6	165	195	203	170	160
		6-12	103	135	175	100	110
Break 9"	pH	0-6	5.7	6.8	6.5	6.6	5.9
		6-12	5.5	6.1	5.7	6.3	5.5
	P	0-6	25	26	23	24	25
		6-12	16	19	13	20	18
	K	0-6	165	190	180	185	158
		6-12	125	143	145	130	128
Break 12"	pH	0-6	5.6	6.7	6.1	6.3	5.8
		6-12	5.3	6.0	6.1	5.9	5.7
	P	0-6	20	24	20	18	20
		6-12	16	18	19	19	21
	K	0-6	163	168	188	158	148
		6-12	130	140	170	138	133
Chisel 14"-16"	pH	0-6	5.8	6.6	6.7	6.8	6.0
		6-12	5.8	5.9	6.0	6.0	5.7
	P	0-6	24	28	32	35	36
		6-12	11	11	12	14	11
	K	0-6	165	175	188	185	163
		6-12	110	118	125	103	88
Offset disc 6"	pH	0-6	5.7	6.7	6.6	6.6	6.0
		6-12	5.3	5.8	5.6	5.4	5.5
	P	0-6	24	39	35	32	37
		6-12	12	15	13	9	12
	K	0-6	170	223	203	190	198
		6-12	110	130	155	105	93
Bedding 6"	pH	0-6	5.8	6.7	6.5	6.8	5.9
		6-12	5.4	5.7	5.6	6.0	5.6
	P	0-6	20	40	31	35	35
		6-12	13	13	12	13	13
	K	0-6	183	255	245	303	213
		6-12	113	135	150	125	108

in better rooting and more proliferation was not apparent in the yield data in Table VI. No significant differences in yield among treatments in any one year nor when the years were combined were observed.

Apparently no years were dry enough--when soil strength was great enough to limit rooting in the shallow tilled treatments or when a great deficit of available water occurred in the shallow tilled treatments--to affect the yields of cotton.

Significant differences of yield among years were observed but this is only indicative of variations in growing seasons (which include variations of temperature, amount and timeliness of rainfall, etc.).

IV. RAINFALL

The lack of differences of yield among treatments could be attributed to the adequacy of rainfall in each of the growing seasons from 1968 through 1972. Yield response to deep tillage would be expected in years when there was a deficiency of rainfall, particularly in the first part of the growing season as indicated by other workers (21). No serious moisture deficiencies occurred in any year of the five year experiment.

The rainfall data for the growing seasons of years 1968 through 1972 are shown in Figures 1 through 5, respectively.

In 1968 the rainfall in June was a little below normal but the rainfall in April and May was above normal and the cotton had sufficient time and moisture for rooting before the dry periods in July and August.

TABLE VI

SEED COTTON YIELDS FROM SIX TILLAGE TREATMENTS ON A MEMPHIS SILT LOAM SOIL, 1968-1972

Treatment	1968	1969	1970	1971	1972	5-Year Avg.
	pounds/acre					
Break 6"	2049[a]	1954	2777	2942	2484	2441
Break 9"	2121	2005	2830	2613	2593	2432
Break 12"	2068	1957	3028	2566	2676	2459
Chisel 14"-16"	1968	1942	3045	2873	2711	2506
Offset Disc 6"	2001	1812	2782	2621	2604	2364
Bedding 6"	2162	1943	2984	2875	2602	2513
LSD (.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Year Means[b]	2062	1936	2908	2748	2612	

[a]Yields are averages of four replications.

[b]Years - LSD (.05) = 326.

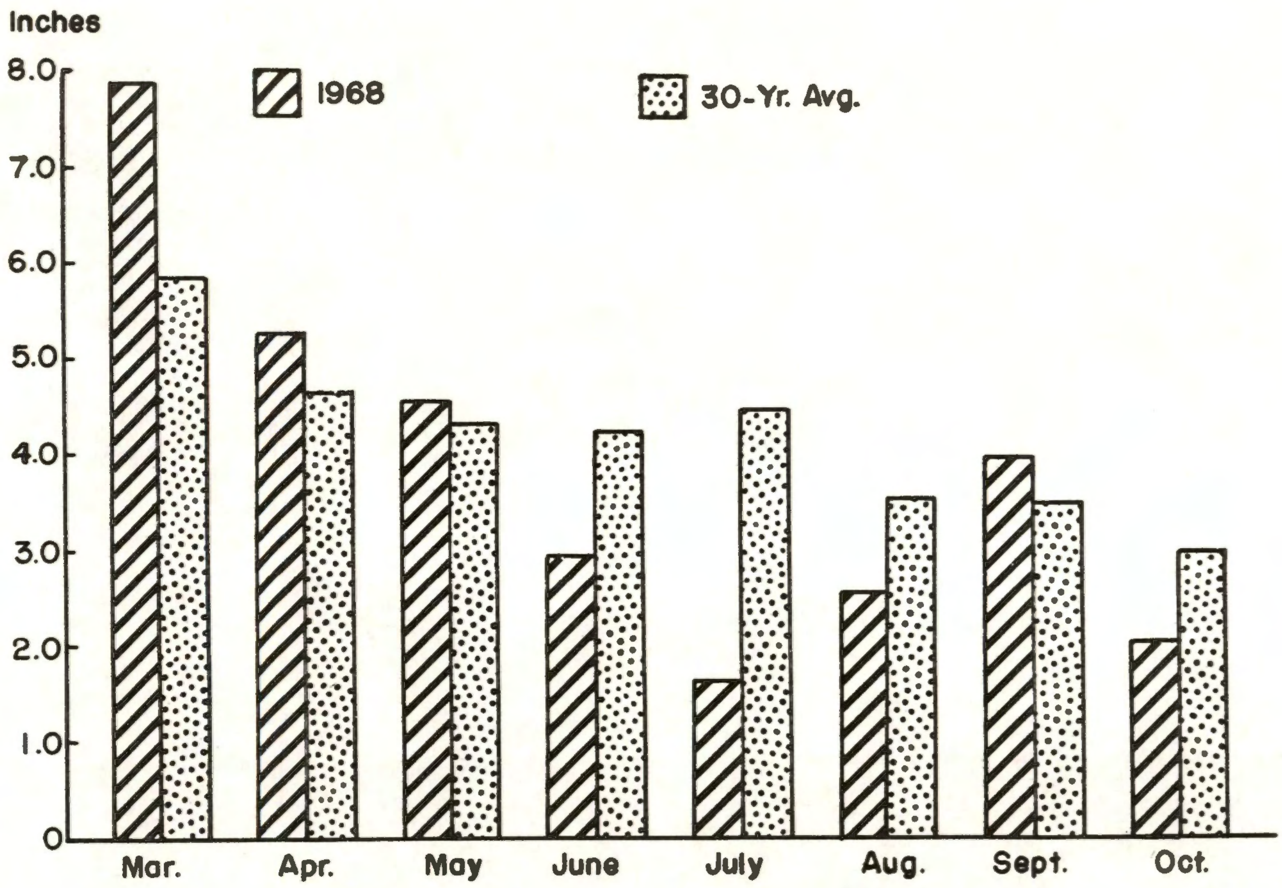

Figure 1. Growing season rainfall - Milan Field Station, 1968.

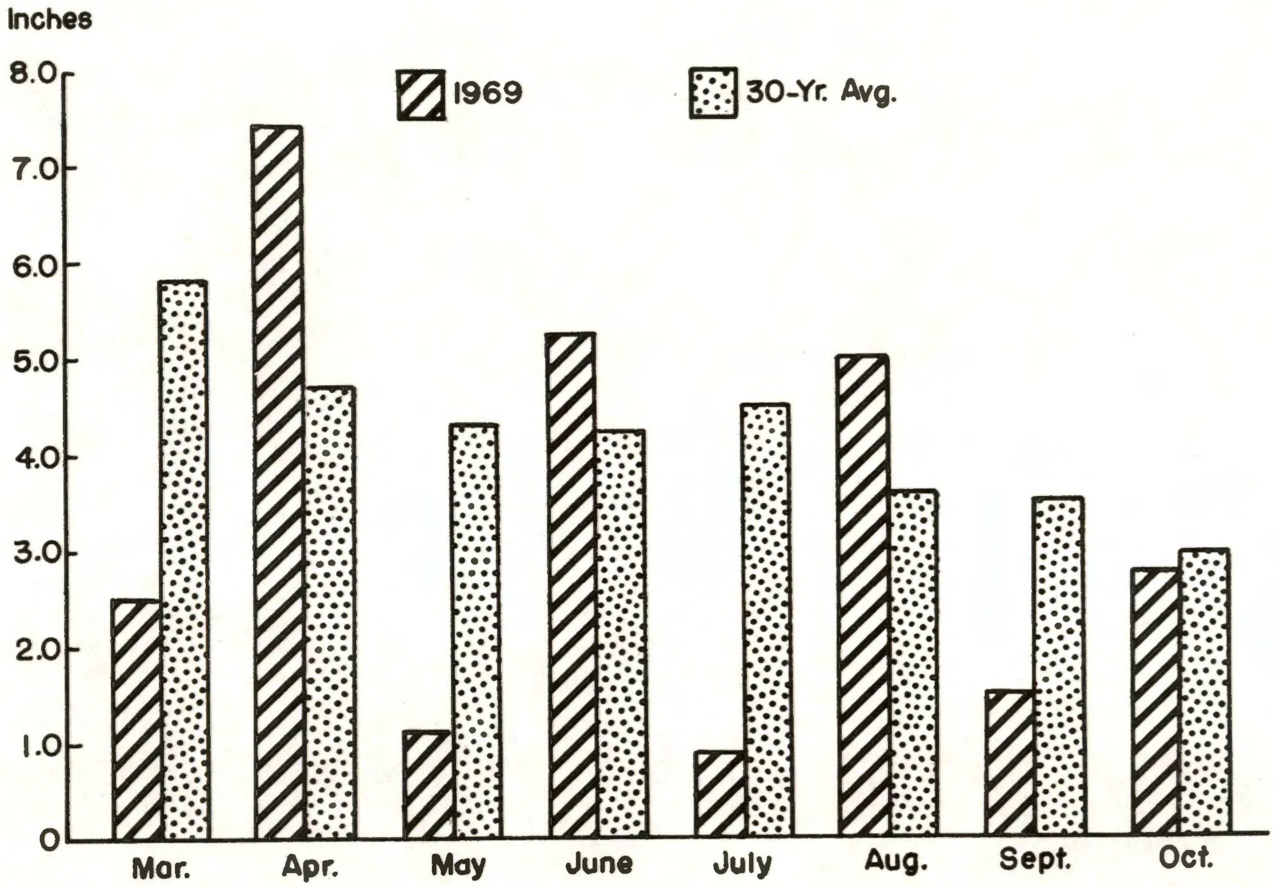

Figure 2. Growing season rainfall - Milan Field Station, 1969.

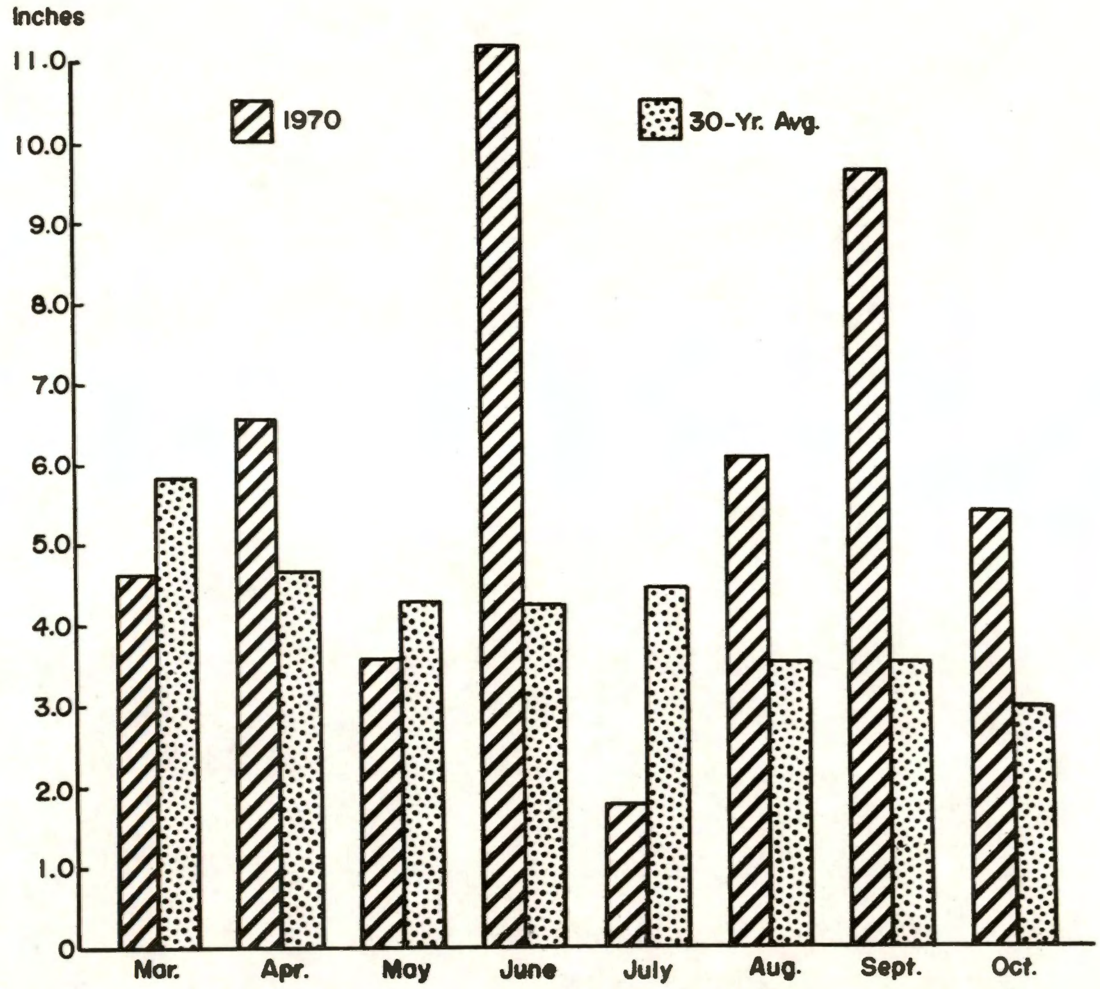

Figure 3. Growing season rainfall - Milan Field Station, 1970.

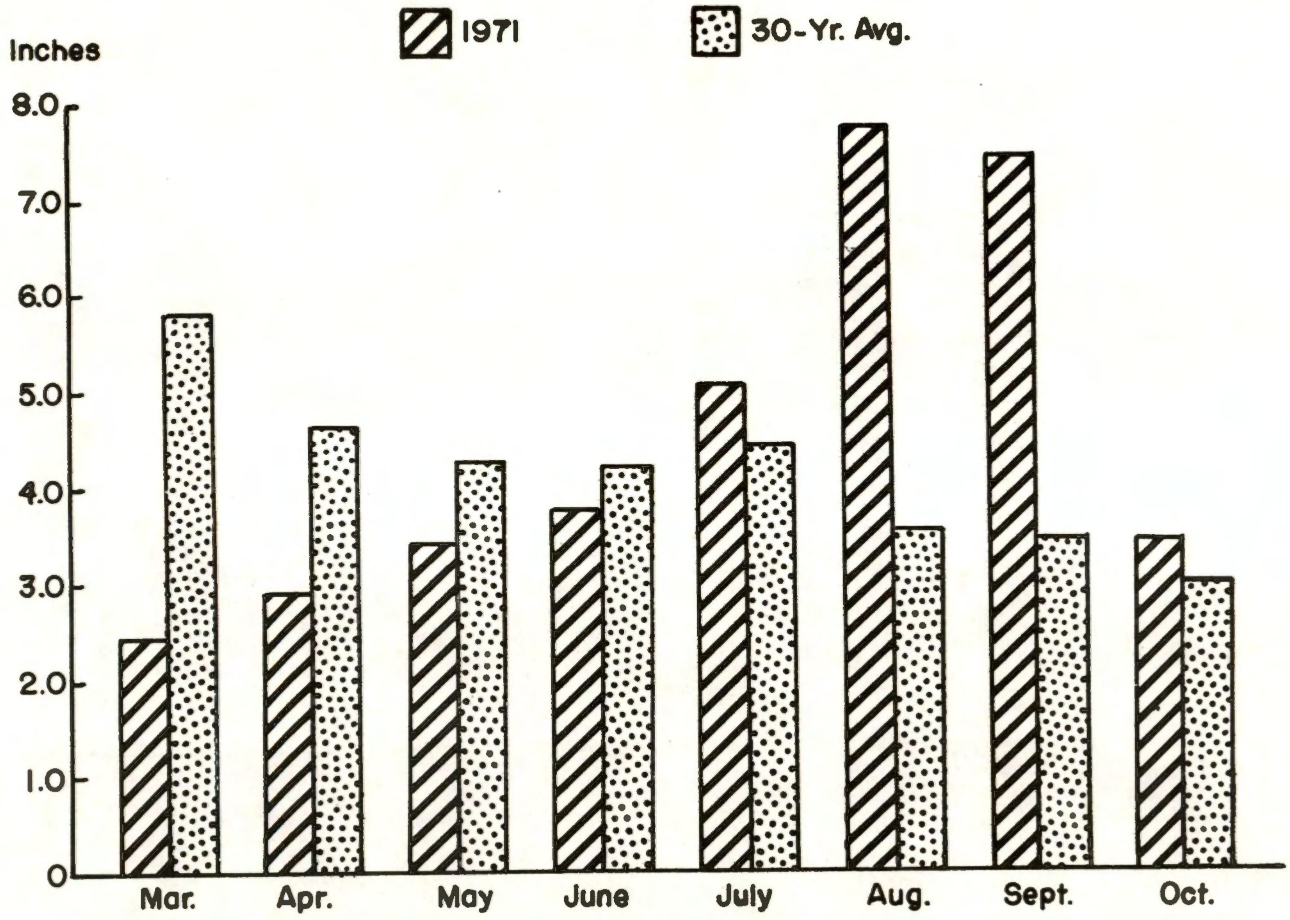

Figure 4. Growing season rainfall - Milan Field Station, 1971.

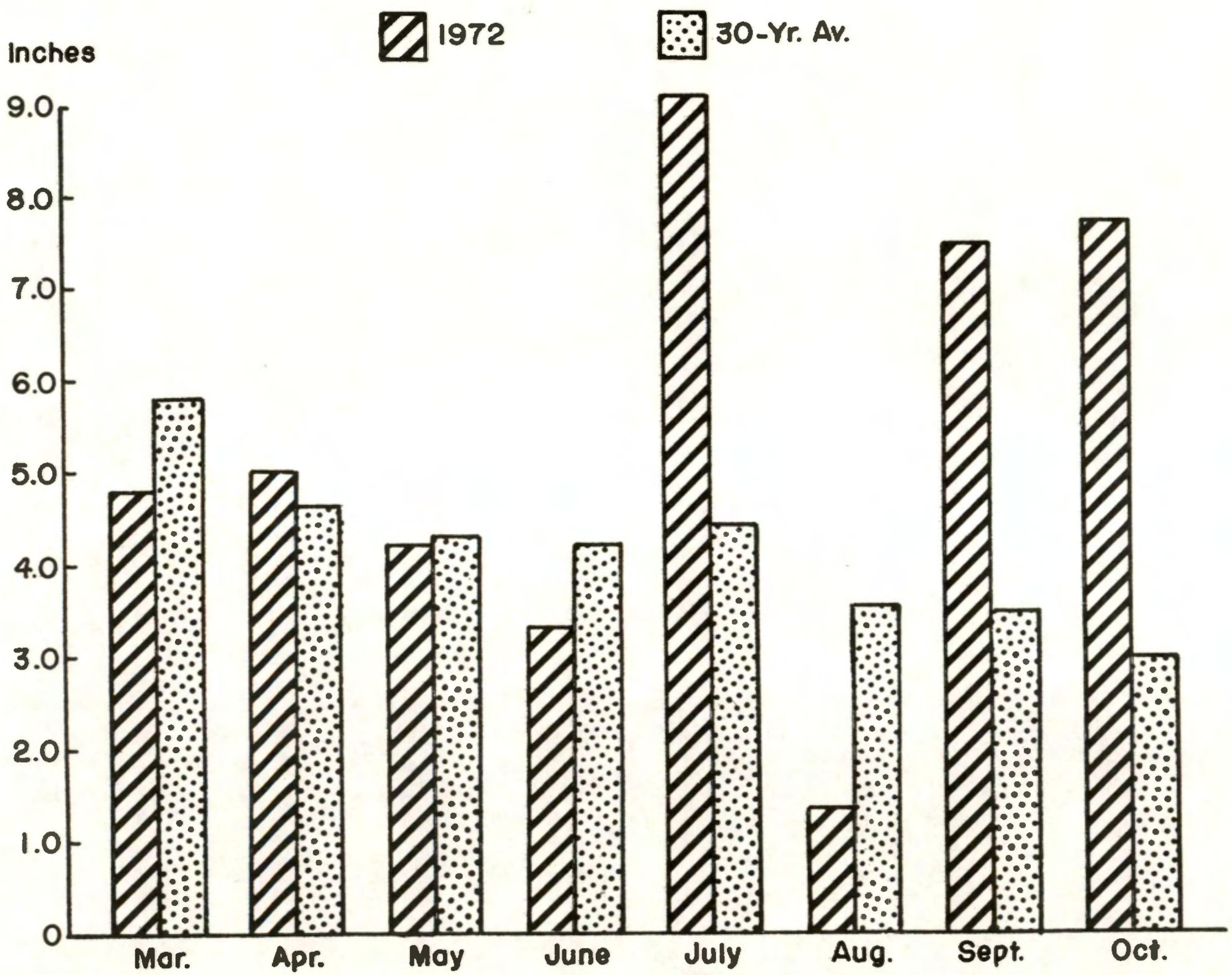

Figure 5. Growing season rainfall - Milan Field Station, 1972.

In 1969 shortages of rain occurred in May and July, but the surplusses of April, June and August probably maintained sufficient available water throughout the growing season. The growing season of 1970 had generally above normal rainfall. In 1971 there was not a serious moisture deficiency although below normal rainfall occurred in March, April, May and June. The growing season of 1972 also produced sufficient moisture with July having excessive rainfall.

6 offset Disc 1"

CHAPTER V

SUMMARY AND CONCLUSIONS

Six tillage treatments (break 6 inches, break 9 inches, break 12 inches, chisel 14 to 16 inches, and bedding 6 inches) were evaluated on a Memphis silt loam soil in their effectiveness in producing or alleviating compacted layers of soil and in the mixing of additions of lime and fertilizer.

No differences in bulk density, large pore space, or small pore space could be detected between the tilled and untilled zones of soil nor among treatments. There wasn't a distinct "traffic pan" in any of the treatments.

Soil compaction has occurred in the tilled as well as the untilled zones. There apparently has been little if any cumulative compaction in the untilled zones of these treatments. However, the data in Table II, page 15, show a need for tillage to reduce the bulk density and increase the air capacity of the seedbed, which would agree with the findings of Larson and others (2,9,14).

Differences in the apparent effectiveness of mixing added nutrients occurred among the tillage treatments, as was previously mentioned. The break 12 inch treatment resulted in a thorough mixing of lime and fertilizer which would be the most conducive plant-root environment. The superior chemical and physical status of the break 12 inch treatment, as well as differences among the other treatments, had no effect on the yielding ability of cotton in the years studied.

No significant differences in yields of cotton existed among the tillage treatments studied. This was probably due to the fact that there were no "dry years" where serious moisture deficiencies occurred. In theory, when "dry periods" occur, particularly in the first part of the growing season, the soil strength of compacted layers below the tilled zone ("traffic pan") will be great enough to restrict rooting depth and consequently reduce the volume of soil from which the plant can draw water and nutrients. It is doubtful that this phenomenon occurred in these experiments as the treatments had no effect on the yields of cotton in the years studied.

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BIBLIOGRAPHY

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APPENDIX

APPENDIX

TABLE A-I

BULK DENSITIES OF THREE-INCH CORES AT TWO AND THREE DEPTHS IN SIX TILLAGE TREATMENTS ON A MEMPHIS SILT LOAM SOIL AT THE MILAN FIELD STATION, 1972

Treatment	Depth	Bulk Densities in g/cm^3				$\bar{x}$
		R_1	R_2	R_3	R_4	
Break 6"	D_1	1.47	1.49	1.52	1.32	1.45
	D_2	1.46	1.54	1.54	1.41	1.49
Break 9"	D_1	1.47	1.48	1.43	1.49	1.47
	D_2	1.49	1.50	1.51	1.39	1.47
Break 12"	D_1	1.46	1.54	1.52	1.40	1.48
	D_2	1.43	1.51	1.47	1.46	1.47
	D_3	1.44	1.51	1.41	1.40	1.44
Chisel 14"-16"	D_1	1.50	1.40	1.48	1.48	1.46
	D_2	1.46	1.55	1.53	1.37	1.48
	D_3	1.44	1.51	1.36	1.36	1.42
Offset Disc 6"	D_1	1.50	1.45	1.49	1.44	1.47
	D_2	1.41	1.50	1.46	1.46	1.46
Bedding 6"	D_1	1.46	1.45	1.47	1.46	1.46
	D_2	1.49	1.49	1.52	1.44	1.48
LSD (.05)						N.S.

TABLE A-II

BULK DENSITIES OF ONE-INCH CORES OF THE COMPACTED LAYERS IN TWO TREATMENTS AT THE MILAN FIELD STATION, 1972

Treatment	Samples	Bulk Densities in g/cm^3			$\bar{x}$
		R_1	R_2	R_3	
Offset Disc 6"	A	1.57	1.54	1.53	
	B	1.56	1.53	1.50	1.52
	C	1.53	1.52	1.44	
Break 6"	A	1.56	1.47	1.54	
	B	1.53	1.54	1.54	1.53
	C	1.47	1.54	1.59	

TABLE A-III

PERCENT LARGE PORE SPACE AT TWO AND THREE DEPTHS IN SIX TILLAGE TREATMENTS ON A MEMPHIS SILT LOAM SOIL AT THE MILAN FIELD STATION, 1972

Treatment	Depth	R_1	R_2	R_3	R_4	$\bar{x}$
Break 6"	D_1	3.1	3.7	4.2	10.0	5.3
	D_2	4.2	2.1	1.6	4.8	3.2
Break 9"	D_1	3.3	2.7	2.6	1.2	2.5
	D_2	2.6	1.1	2.4	9.8	3.9
Break 12"	D_1	2.8	1.6	2.0	4.7	2.8
	D_2	4.3	1.8	2.6	8.0	4.2
	D_3	2.2	2.3	2.1	2.6	2.3
Chisel 14"-16"	D_1	2.3	2.8	2.6	6.6	3.6
	D_2	3.3	0.8	2.0	8.3	3.6
	D_3	5.1	1.5	3.2	2.9	3.2
Offset disc 6"	D_1	2.4	1.2	2.0	3.4	2.3
	D_2	6.7	1.7	3.4	3.7	3.9
Bedding 6"	D_1	5.3	2.5	2.8	0.3	2.7
	D_2	2.9	2.8	2.5	3.9	3.0
LSD (.05)						N.S.

TABLE A-IV

PERCENT SMALL PORE SPACE AT TWO AND THREE DEPTHS IN SIX TILLAGE TREATMENTS ON A MEMPHIS SILT LOAM SOIL AT THE MILAN FIELD STATION, 1972

Treatment	Depth	R_1	R_2	R_3	R_4	$\bar{x}$
Break 6"	D_1	37.7	36.3	36.3	37.8	37.0
	D_2	39.2	38.8	37.7	37.4	38.3
Break 9"	D_1	37.7	36.2	39.4	38.1	37.9
	D_2	37.4	37.8	36.5	39.8	37.9
Break 12"	D_1	37.5	37.3	37.5	36.4	37.2
	D_2	40.6	37.5	37.3	38.7	38.6
	D_3	42.7	37.4	41.7	42.5	41.1
Chisel 14"-16"	D_1	37.6	37.9	38.4	38.0	38.0
	D_2	37.7	37.2	39.1	38.3	38.1
	D_3	38.3	38.2	41.7	41.2	39.8
Offset disc 6"	D_1	37.4	38.7	38.0	37.7	38.0
	D_2	39.1	37.5	37.3	38.3	38.0
Bedding 6"	D_1	38.2	39.2	39.0	39.7	39.0
	D_2	37.9	37.0	38.6	36.9	37.6
LSD (.05)						N.S.

TABLE A-V

pH AT TWO AND THREE DEPTHS IN SIX TILLAGE TREATMENTS ON A MEMPHIS SILT LOAM SOIL AT THE MILAN FIELD STATION, 1972

Treatment	Depth	R_1	R_2	R_3	R_4	$\bar{x}$
Break 6"	D_1	6.5	6.8	6.9	6.6	6.7
	D_2	5.9	5.5	6.0	5.6	5.8
Break 9"	D_1	6.7	6.6	6.9	7.1	6.8
	D_2	5.6	6.5	5.4	6.1	5.9
Break 12"	D_1	5.9	6.3	6.7	6.6	6.4
	D_2	5.7	5.8	6.9	6.7	6.3
	D_3	5.3	5.6	6.5	6.7	6.0
Chisel 14"-16"	D_1	5.7	6.7	7.2	6.9	6.6
	D_2	6.2	5.9	6.9	6.5	6.4
	D_3	5.3	5.2	5.6	5.6	5.4
Offset disc 6"	D_1	6.8	6.7	6.8	7.2	6.9
	D_2	6.5	5.8	6.7	5.9	6.2
Bedding 6"	D_1	7.2	6.7	7.0	6.9	6.9
	D_2	6.8	6.4	6.8	6.9	6.7
LSD (.05)						0.4

TABLE A-VI

AVAILABLE PHOSPHORUS AT TWO AND THREE DEPTHS IN SIX TILLAGE TREATMENTS ON A MEMPHIS SILT LOAM SOIL AT THE MILAN FIELD STATION, 1972

Treatment	Depth	R_1	R_2	R_3	R_4	$\bar{x}$
		---------pounds/acre----------				
Break 6"	D_1	26	35	35	23	30
	D_2	30	13	13	6	15
Break 9"	D_1	30	25	30	22	27
	D_2	24	11	15	7	14
Break 12"	D_1	16	16	30	26	22
	D_2	17	19	30	26	23
	D_3	13	15	20	26	19
Chisel 14"-16"	D_1	18	35	65	40	40
	D_2	13	11	25	23	18
	D_3	12	10	13	10	11
Offset disc 6"	D_1	40	40	70	55	51
	D_2	14	16	35	13	20
Bedding 6"	D_1	35	60	45	75	54
	D_2	22	30	35	30	29
LSD (.05)						12

TABLE A-VII

AVAILABLE POTASSIUM AT TWO AND THREE DEPTHS IN SIX TILLAGE TREATMENTS ON A MEMPHIS SILT LOAM SOIL AT THE MILAN FIELD STATION, 1972

Treatment	Depth	R_1	R_2	R_3	R_4	$\bar{x}$
		---------pounds/acre----------				
Break 6"	D_1	210	260	300	260	258
	D_2	120	140	120	140	130
Break 9"	D_1	240	260	260	180	235
	D_2	180	120	120	130	138
Break 12"	D_1	180	150	180	260	193
	D_2	190	140	160	190	170
	D_3	160	120	150	190	155
Chisel 14"-16"	D_1	150	240	230	250	218
	D_2	110	120	100	150	120
	D_3	100	100	130	120	113
Offset disc 6"	D_1	320	290	420	270	325
	D_2	140	100	230	110	145
Bedding 6"	D_1	320	460	360	320	365
	D_2	150	260	260	190	215
LSD (.05)						83

TABLE A-VIII

SEED COTTON YIELDS FROM DEPTH OF PLOW LAYER EXPERIMENT, MILAN FIELD STATION, 1968

Treatment	Replications 1	2	3	4	Avg.
Break 6"	3452	2406	2150	2390	2600
Break 9"	2907	2836	2167	2303	2553
Break 12"	2586	2956	1747	2265	2389
Chisel 14"-16"	2820	3277	2395	2216	2677
Offset disc 6"	2286	2521	1927	3016	2438
Bedding 6"	2417	2134	2461	2232	2311
LSD (.05)					N.S.

TABLE A-IX

SEED COTTON YIELDS FROM DEPTH OF PLOW LAYER EXPERIMENT, MILAN FIELD STATION, 1969

Treatment	Replications 1	2	3	4	Avg.
Break 6"	2017	1989	2235	3335	2394
Break 9"	2371	2087	2365	3335	2540
Break 12"	2469	1837	2196	2033	2134
Chisel 14"-16"	2300	1967	2153	3243	2416
Offset disc 6"	2158	1946	2207	1717	2007
Bedding 6"	2153	1973	2136	2038	2075
LSD (.05)					N.S.

TABLE A-X

SEED COTTON YIELDS FROM DEPTH OF PLOW LAYER EXPERIMENT, MILAN FIELD STATION, 1970

Treatment	Replications				Avg.
	1	2	3	4	
Break 6"	2965	2883	2954	2305	2777
Break 9"	2643	2976	2883	2818	2830
Break 12"	3063	3052	3112	2883	3028
Chisel 14"-16"	3346	2720	3041	3074	3045
Offset disc 6"	2839	2943	2485	2861	2782
Bedding 6"	3308	2801	2883	2943	2984
LSD (.05)					N.S.

TABLE A-XI

SEED COTTON YIELDS FROM DEPTH OF PLOW LAYER EXPERIMENT, MILAN FIELD STATION, 1971

Treatment	Replications 1	2	3	4	Avg.
Break 6"	3128	3068	2812	2758	2942
Break 9"	2752	3041	2202	2458	2613
Break 12"	2485	2725	2790	2262	2566
Chisel 14"-16"	2842	3008	2940	2703	2873
Offset disc 6"	2943	2018	2896	2627	2621
Bedding 6"	3325	2850	2688	2638	2875
LSD (.05)					N.S.

TABLE A-XII

SEED COTTON YIELDS FROM DEPTH OF PLOW LAYER EXPERIMENT, MILAN FIELD STATION, 1972

Treatment	Replications				Avg.
	1	2	3	4	
Break 6"	2681	2562	2284	2409	2484
Break 9"	2055	2572	2790	2954	2593
Break 12"	2812	2605	2649	2638	2676
Chisel 14"-16"	2730	2534	2921	2660	2711
Offset disc 6"	2556	2393	2583	2883	2604
Bedding 6"	2741	2327	2709	2632	2602
LSD (.05)					N.S.

TABLE A-XIII

RAINFALL AT MILAN FIELD STATION, 1968-1972

Year	Total	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1968	47.49	4.10	1.85	7.84	5.23	4.55	2.95	1.61	2.52	3.92	2.02	7.02	3.88
1969	46.99	5.26	3.18	2.46	7.41	1.09	5.24	0.85	4.99	1.48	2.73	4.56	7.74
1970	63.75	0.91	4.58	4.60	6.54	3.59	12.23	1.79	6.02	9.59	5.36	2.12	6.42
1971	52.34	1.61	6.84	2.45	2.99	3.47	3.78	5.05	7.76	7.48	3.45	2.20	5.26
1972	--	5.40	2.78	4.81	5.03	4.23	3.31	9.09	1.34	7.44	7.72	--	--
Normal	53.37	6.38	4.65	5.81	4.65	4.29	4.22	4.45	3.51	3.45	2.96	4.37	4.60

VITA

Stephen Mooring Parks was born on September 8, 1948, in Lake County, Tennessee, and attended public schools there. Following high school, he attended the University of Tennessee at Martin for two quarters and then David Lipscomb College in Nashville for four quarters. He then completed a Bachelor of Science degree in Agricultural Mechanization at the University of Tennessee at Knoxville, and started to work on a Master of Science degree in Plant and Soil Science.