THE EFFECT OF DIFFERENT WHEATLAND SOIL MANAGEMENT PRACTICES ON BULK DENSITY, AGGREGATE STABILITY AND ORGANIC MATTER

By

SERI TANCHANDRPHONGS

Bachelor of Science

Kasetsart University

Bangkok, Thailand

1964

Submitted to the faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
July, 1967

Thesis
1967
T162e
cop. 2

OKLAHOMA
STATE UNIVERSITY
LIBRARY

JAN 18 1968

THE EFFECT OF DIFFERENT WHEATLAND SOIL MANAGEMENT

PRACTICES ON BULK DENSITY, AGGREGATE

STABILITY AND ORGANIC MATTER

James M. Davidson

Thesis Adviser

Lester W. Reed

Billy B. Tucker

D. D. Durham

Dean of the Graduate College

660209

ACKNOWLEDGMENTS

The author wishes to express sincere gratitude to Dr. James M. Davidson, principal adviser, for his instruction and kindness while the author has been attending Oklahoma State University, and for his help in preparation of this thesis. Appreciation is also extended to the other members of his committee, Dr. Lester W. Reed and Dr. Billy B. Tucker.

Special gratitude is due Dr. Robert D. Morrison for his advice and consultation in statistical analysis.

Thanks are due to Mr. Loyd R. Stone for his assistance in collecting the sample.

TABLE OF CONTENTS

Chapter Page

I. INTRODUCTION 1

II. LITERATURE REVIEW 3

III. MATERIALS AND METHODS 8

IV. RESULTS AND DISCUSSION 12

V. SUMMARY AND CONCLUSIONS 30

LITERATURE CITED 31

APPENDIX 33

LIST OF TABLES

Table		Page
I.	Previous Management of Plots Used in Study.	9
II.	Average Organic Matter for Grant Silt Loam at 7.6 to 15.2 cm. Depth After Different Practices.	19
III.	Average Organic Matter for Grant Silt Loam at 15.2 to 22.9 cm. Depth After Different Practices.	19
IV.	Average Organic Matter for Grant Silt Loam at 22.9 to 30.5 cm. Depth After Different Practices.	20
V.	Average Organic Matter for Grant Silt Loam at 30.5 to 38.1 cm. Depth After Different Practices.	20
VI.	Average Aggregate Stability Larger Than 2 mm. But Less Than 8 mm. for Grant Silt Loam at 7.6 to 15.2 cm. Depth After Different Practices	21
VII.	Average Aggregate Stability Larger Than 2 mm. But Less Than 8 mm. for Grant Silt Loam at 15.2 to 22.9 cm. Depth After Different Practices	21
VIII.	Average Aggregate Stability Larger Than 2 mm. But Less Than 8 mm. for Grant Silt Loam at 22.9 to 30.5 cm. Depth After Different Practices	22
IX.	Average Aggregate Stability Larger Than 2 mm. But Less Than 8 mm. for Grant Silt Loam at 30.5 to 38.1 cm. Depth After Different Practices	22
X.	Average Aggregate Stability Smaller than 2 mm. But Larger Than 0.2 mm. for Grant Silt Loam at 7.6 to 15.2 cm. Depth After Different Practices.	23
XI.	Average Aggregate Stability Smaller Than 2 mm. But Larger Than 0.2 mm. for Grant Silt Loam at 15.2 to 22.9 cm. Depth After Different Practices.	23
XII.	Average Aggregate Stability Smaller Than 2 mm. But Larger Than 0.2 mm. for Grant Silt Loam at 22.9 to 30.5 cm. Depth After Different Practices.	24

Table | Page

XIII. Average Aggregate Stability Smaller Than 2 mm. But Larger Than 0.2 mm. for Grant Silt Loam at 30.5 to 38.1 cm. Depth After Different Practices 24

XIV. Average Bulk Density for Grant Silt Loam at 7.6 to 15.2 cm. Depth After Different Practices. 28

XV. Average Bulk Density for Grant Silt Loam at 15.2 to 22.9 cm. Depth After Different Practices. 28

XVI. Average Bulk Density for Grant Silt Loam at 22.9 to 30.5 cm. Depth After Different Practices. 29

XVII. Analysis of Variance of Organic Matter Content for Grant Silt Loam at 7.6 to 15.2 cm. Depth. 34

XVIII. Analysis of Variance of Organic Matter Content for Grant Silt Loam at 15.2 to 22.9 cm. Depth 35

XIX. Analysis of Variance of Organic Matter Content for Grant Silt Loam at 22.9 to 30.5 cm. Depth 36

XX. Analysis of Variance of Organic Matter Content for Grant Silt Loam at 30.5 to 38.1 cm. Depth 37

XXI. Analysis of Variance of Aggregate Stability Larger Than 2 mm. But Less Than 8 mm. for Grant Silt Loam at 7.6 to 15.2 cm. Depth 38

XXII. Analysis of Variance of Aggregate Stability Larger Than 2 mm. But Less Than 8 mm. for Grant Silt Loam at 15.2 to 22.9 cm. Depth. 39

XXIII. Analysis of Variance of Aggregate Stability Larger Than 2 mm. But Less Than 8 mm. for Grant Silt Loam at 22.9 to 30.5 cm. Depth. 40

XXIV. Analysis of Variance of Aggregate Stability Larger Than 2 mm. But Less Than 8 mm. for Grant Silt Loam at 30.5 to 38.1 cm. Depth. 41

XXV. Analysis of Variance of Aggregate Stability Smaller Than 2 mm. But Larger Than 0.2 mm. for Grant Silt Loam at 7.6 to 15.2 cm. Depth 42

XXVI. Analysis of Variance of Aggregate Stability Smaller Than 2 mm. But Larger Than 0.2 mm. for Grant Silt Loam at 15.2 to 22.9 cm. Depth. 43

XXVII. Analysis of Variance of Aggregate Stability Smaller Than 2 mm. But Larger Than 0.2 mm. for Grant Silt Loam at 22.9 to 30.5 cm. Depth. 44

Table		Page

XXVIII. Analysis of Variance of Aggregate Stability Smaller Than 2 mm. But Larger Than 0.2 mm. for Grant Silt Loam at 30.5 to 38.1 cm. Depth 45

XXIX. Analysis of Variance of Bulk Density for Grant Silt Loam at 7.6 to 15.2 cm. Depth. 46

XXX. Analysis of Variance of Bulk Density for Grant Silt Loam at 15.2 to 22.9 cm. Depth 47

XXXI. Analysis of Variance of Bulk Density for Grant Silt Loam at 22.9 to 30.5 cm. Depth 48

LIST OF FIGURES

Figure Page

1. Average Organic Matter Content at Four Soil Depths Under Different Practices 16

2. Average Aggregate Stability Larger Than 2 mm. But Less Than 8 mm. at Four Soil Depths Under Different Practices. . . 17

3. Average Aggregate Stability Smaller Than 2 mm. But Larger Than 0.2 mm. at Four Soil Depths Under Different Practices. . 18

4. Average Soil Bulk Density at Three Soil Depths Under Different Practices 27

CHAPTER I

INTRODUCTION

"Whatever else may be said about agriculture, the land is first and basic for all purposes of man" (20). This vital fact has been recognized by people of all ages. The periods of prosperity and advances in civilization coincided with periods of proper use and management of land, and the same holds true today.

Our greatest natural resource, the soil, must produce more food and fiber each year. Because of this burden, crop and tillage practices must become more intensive in order to meet the challenge. Frequently, the pressure for production results in a degradation of the physical and chemical properties in the soil, a most distressing fact is that these soils present the fewest management problems. Any soil not in production now, but used for agricultural purposes in the future, will require stricter management practices than many of our present soils; therefore, to meet the needs of future generations it will be necessary to produce not only more food and fiber, but to improve agricultural procedures involving the soil and its manipulation.

Soils vary from site-to-site in physical and chemical properties. These changes are noted from one location of a field to another. Specific soil management practices may be used to improve or destroy some of these physical and chemical soil properties. Changes and problems with soil structure, infiltration, soil compaction, erosion, nutrient

..., etc. uptake appear, mostly under poor soil management practices. These soil properties reduce the maximum yield for many crop varieties available. Crop varieties are available to improve the yield; but soil properties must improve or at least remain at their present status for optimum yields.

Crop and management practices are the principal ways available to control and improvement of soil conditions. Several methods are frequently practiced; crop rotation, stubble mulch, zone tillage and addition of organic materials. The use of these methods depends upon the management practices, the crop, and the location. However, some procedures are applicable to all situations.

More information is necessary regarding the importance of management and cropping practices on the chemical and physical properties of soil. There is, at present, a deficiency of information on the influence of management practices on wheatland soil.

The objective of this study was to evaluate and compare the effect of different wheatland crop and management practices on bulk density, aggregate stability and organic matter content.

CHAPTER II

LITERATURE REVIEW

It is recognized that tillage practices that leave a residue on the soil surface, protect the soil from the beating action of raindrops, and reduce evaporation, surface water run-off and soil erosion. This surface residue practice is important for the conservation of soil and water. Although, large differences have been noted for different tillage practices (13). Generally, soils with favorable physical condition are not markedly changed by any one tillage practice. This is true, however, so long as the practice is not abusive. On heavier and more poorly drained soils or on soils with poor physical condition, the effect of various tillage and/or cropping practice should be considered as a possible method of improvement or maintenance.

A crop practice has considerable bearing on the soil bulk density. Pinson (19) found that the bulk density of a continuously cropped Norge Loam was significantly different from the virgin soil at the 5 to 8 inch soil depth. The continuously cropped soil had a higher bulk density at the 5 to 8 inch depth than the 3 inch layer above or below. Bradfield (3) found that many fine-grained soils under continuous cultivation tended to become compacted. This was particularly noted where the soil had been cropped for a prolonged period without a grass or legume rotation. Bulk densities of the soil also varied with the method of tillage as well as with the crop grown. Hobbs *et al*. (11)

found that deep tillage lowered the soil bulk density and improved the permeability of the compacted layer. Locke, et al. (15) found that bulk density of the spring shallow-plowed soil was least, and the fall deep-plowed was intermediate. They also show that alternately cropped and fallowed soil produced a higher bulk density. According to McCalla and Army (16), there is only a small difference in soil bulk density due to tillage in the Great Plains. Taylor, et al. (23) in a detailed study of the chemical and physical properties of 17 Southern Great Plains soils which exhibited root restriction pans were unable to distinguish the origin or cause of the pan.

A number of factors seem to influence the size, distribution, and aggregate stability of a soil. Feng and Browning (9) state that the ease with which excessive water can be drained from a soil in the field is related to the presence in the soil of stable aggregates. It has been speculated that the effective capacity for holding available water for plants is higher in a well-granulated soil than in soils with poor granulation and with low aggregate stability. Workers have also found that the soil water content and temperature of the soil and stage of plant development, seedbed preparation and cultivation are all factors responsible for the dynamic phenomenon of soil aggregation (13, 16).

Beale, et al. (1) found that the percent of water-stable aggregates greater than 0.2 mm. were approximately the same with plow or mulch tillage 1 year after the start of a cover crop tillage practice. During the next 2 years, the aggregation of mulch tilled plots of vetch and rye increased considerably and was greater than the aggregation of the plowed vetch and rye plots. Stephenson and Schuster (22) have reported that the percentage of water-stable aggregates can be increased by mulching with plant residues. According to Chepil (4), the decomposing vegetative matter (wheat straw or green alfalfa), when mixed with the soil, increased the proportion of water-stable aggregates and slightly decreased erodibility of the soil by wind.

Metzger and Hide (17) report that a soil from corn and grain sorghum under field and greenhouse conditions showed as good an aggregation as sorghum. When oats succeeded these two crops in the field, however, soil samples revealed a greater degree of dispersion from oats following sorghum than when corn was the preceding crop. Sweetclover left the soil better aggregated after one year's growth than soybeans, while alfalfa and sweetclover gave similar results.

Rynasiewicz (21) found that the average aggregation for a Bridgehampton very sandy loam under six different crop rotations, and permanent sod, was in the following order: onions, 2 years mangels < onions, 2 years buckwheat < onions, 2 years corn < onions, 2 years redtop < corn-potatoes - 3 years leguminous hay = corn-potatoes - 3 years nonleguminous hay < permanent sod.

Elson and Lutz (7) found that on Cecil soils a crop rotation resulted in better aggregation with less erosion than continuous cotton. Also, the inclusion of lespedeza in the rotation on two plots resulted in greater aggregation than a continuous sod of shallow-rooted grass. Wilson, et al. (25) also found that aggregates formed under rotation meadows and rotation corn were less stable than aggregates formed under continuous bluegrass.

Johnson, et al. (13) states that the size distribution of aggregates has been influenced materially by the cropping system, with the greatest number of larger sized aggregates in bluegrass, clover, oats, rotation corn and continuous corn, respectively. Red clover in the rotation was shown to maintain a loose, granular structure, whereas continuous corn left the soil cloddy and difficult to manage.

Soil aggregates in a cultivated Indian soil (18) showed that the aggregates between 3 and 0.25 mm. were the most active and effective in developing good tilth. Finer aggregates contained more clay, organic matter, and total nitrogen. Under field conditions, they found a higher water content in the smaller aggregates.

Under natural conditions there exists an equilibrium between the addition of organic matter by vegetation and its decomposition by microorganisms. Cultivation of soils usually results in a decrease in nitrogen content from that in the virgin state by speeding up microbial decomposition and by subjecting the land to greater losses of nitrogen by erosion and leaching (8).

Numerous studies have been made regarding the effect of cropping on both rate of decline and final nitrogen content of soils in the dryland wheatgrowing regions. Harper (10) reported that 11 Oklahoma Panhandle soils had lost 14.8 per cent of their nitrogen after 15 years of cropping.

Bracken and Greaves (2) surveyed the nitrogen losses on farms in two areas of Utah. A study of 9 dry farms in Cache Valley, northern Utah, showed the first foot of virgin land to be 15.9 per cent higher in nitrogen than adjacent wheat land. Twelve farms in Juab Valley, central Utah, were found to be 14.5 per cent lower in nitrogen than virgin soils. Beale, et al. (1) found that the organic matter content of a vetch and rye mulch-tilled soil increased significantly. The organic matter content of the vetch and rye mulch-tilled soil was signi-

tly greater than that of either the fallow or clean-tilled o
lean-tilled without a crop. The organic matter content of lean-tilled soil with and without crop did not change materially.

n (19) studied the effect of cropping systems and cultural practices on soil compaction in Nebraska. He found that the organic matter content decreased about 1/4 in the surface of a continuously cropped soil.

McCalla and Army (16) stated that when a mulch or protective material is used on the surface, the destructive forces of falling water drops acting on the structure of the soil are reduced. Consequently, infiltration of water into the soil is maintained at a higher rate.

In the drier regions of the Great Plains, small grains cannot grow in rotation with other crops because of lack of water. Therefore, this experiment will be an attempt to find the better method of soil management using residue of wheat. The influence of cropping and soil management practices on bulk density, aggregation, porosity, permeability and organic matter content were studied.

CHAPTER III

MATERIALS AND METHODS

All soil samples for this experiment were taken from the Wheatland Conservation Experiment Station, Cherokee, Oklahoma. The plots on which the studies were conducted are arbitrarily designated the "A" plots (6). The plots varied in size, shape and a 1-3% land slope.

The length of the "A" plots with the slope was interval of 6 contour spaces at 1 foot. The width of the slope, however, was such that the average length of the contour was equal to, or slightly greater than, the length of the slope within the plot. The soil type of the "A" plot is a Grant silt loam with a slope of 1-3% and is classified as Class II land (6).

The soil management practices were started in the Fall of 1955. The alfalfa-wheat rotation study was started in the Spring of 1955, but because of poor stand was replanted and all plots date from the Spring of 1956. Plot samples were treated from 1955-1966 or 11 years as shown in Table I.

Collection of the Samples

Soil samples were taken at four random locations within every plot. At each location samples were collected at the 7.6-15.2, 15.2-22.9, 22.9-30.5 and 30.5-38.1 cm. depths. Each treatment was replicated and each replicate was sampled as described above.

Undisturbed and disturbed samples were used to measure the effect of cropping and management practices on bulk density, aggregate stability and organic matter content. Undisturbed core samples for bulk density were collected at only the first three soil depths.

TABLE I

PREVIOUS MANAGEMENT OF PLOTS USED IN STUDY

Cropping System	Treatment
A. Continuous Wheat	
Clean tilled	No nitrogen 40 lbs. nitrogen annually*
Stubble mulched	No nitrogen 40 lbs. nitrogen annually*
B. Alfalfa-Wheat Rotation	
Clean tilled	Wheat-1 Wheat-3
Stubble mulched	Wheat-1 Wheat-3

* Ammonium nitrate.
Wheat-1 First-year wheat following alfalfa.
Wheat-3 Third-year wheat following alfalfa.

The soil cores were taken with a steel cylindrical sampler equipped with a driving assembly and cutting edge similar to that described by Van Doren and Klingebiel (24). The dimensions of the aluminum ring were 7.6 x 7.6 cm. Each sample was placed in paraffin-coated one pint ice cream cartons in the field for transporting to the laboratory. Disturbed soil samples were collected at each location for soil aggregate stability and organic matter analysis. The disturbed samples were collected in 7.6 cm. increments from 7.6-38.1 cm. These samples were obtained at the same time the undisturbed samples were collected.

Laboratory Analysis of Soil Samples

The undisturbed core samples were trimmed in the field to 7.6×7.6 cm. and oven dried and weighed in the laboratory. Each sample was placed in a beaker and put in an oven at 105° C for 24 hours. The samples were removed from the oven and weighed as soon as they were cool. Bulk density was determined by the following relation:

$$\text{Bulk density} = \frac{\text{Weight of soil (oven dry)}}{\text{Volume of soil}}$$

The water-stable aggregate analyses were made using the wet-sieve method described by Kemper and Chepil (14). The samples had been previously air-dried at room temperature for storage and sieved through an 8 mm. (2½ mesh) screen. Aggregates and clods larger than 8 mm. were pulled apart until their subunits were small enough to go through the sieve. This sample was then sieved again for particles larger than 2 mm. so that the aggregates remaining were less than 8 mm. but greater than 2 mm.

A 30 gram sample of the less than 8 mm. but greater than 2 mm. aggregates from each location was wet under vacuum in a desicator with deaired water. The wet sample was then transferred to a mechanical sieving machine which raised and lowered the nest of sieve in a water bath at 40 rpm for 15 minutes. Two separate sieve sizes were used with hole widths of 2 mm. and 0.2 mm., respectively. The oven-dry weight of material on each sieve was measured and recorded for statistical analysis.

Organic matter content of the soil sample was measured by means of the modified Schollenberger procedures (12). These procedures are indicated as follows:

1. Weigh 0.5 gm., 20 mesh air-dried soil sample into a 300 ml. tall pyrex beaker.

2. Add 10 mm. of .4 N $K_2Cr_2O_7$ to all samples.

3. Taking each sample separately, add 15 ml. conc. H_2SO_4.

4. Place on ring stand and heat slowly until temperature of 165° C (remove at 162° C).

5. Remove beaker and let all beakers cool.

6. Add 100 ml. distilled water to each beaker.

7. Add 2 drops of Orthophenanthroline (color indicator) to all samples.

8. Titrate excess dichromate with .2 N Ferrous Ammonium Sulfate to red end point (use light box to improved end point).

The results were obtained and used to calculate the per cent organic matter.

The statistical analysis consisted of an analysis of variance with a factorial design. All the data was run by an IBM 7040 digital computer. The level of significance for the various treatments were determined by the F-test value.

CHAPTER IV

RESULTS AND DISCUSSION

Effect of Different Wheatland Cropping Practices on Organic Matter

The comparison of organic matter content with depth under the two tillage methods, stubble mulching and clean tillage, is shown in Figure 1. Stubble mulching resulted in a higher organic matter level than that of the clean tillage (Table II to V). The higher organic matter content of the stubble mulch soil may, in effect, not be an increase but a less rapid decline in organic matter. The less rapid decline and/or build-up in organic matter with stubble mulching is probably the result of the residues decomposing at a reduced rate. This reduced decomposition rate for stubble mulching is caused by not mixing or manipulating the soil to an appreciable depth thus providing less aeration. Results reported by Beale, et al. (1) illustrate an increase in organic matter in a mulch-tilled soil. With a cover crop, organic matter and nitrogen content increased significantly in a 4-year period in the same study. Organic matter and nitrogen of the clean tilled soil without a cover crop did not increase.

An analysis of variance of organic matter content at different depths and tillage practices, Tables XVII, XVIII, XIX and XX, shows the 15.2 to 22.9 and 22.9 to 30.5 cm. soil depths significantly different at the 1% level. Stubble mulching shows a higher organic matter content than clean tillage (Tables III and IV).

The organic matter content in the alfalfa-wheat rotation was significantly higher than the continuous wheat program at the 5% level for the 15.2 to 22.9 and 22.9 to 30.5 cm. depths.

The 40 pounds of annual nitrogen and no nitrogen treatments were significantly different at the 5% level for the 15.2 to 22.9 cm. depth.

Several interactions between the tillage method and cropping systems existed. An interaction between tillage method and rotation was significant at the 5% level for the 15.2 to 22.9 and 22.9 to 30.5 cm. soil depths. The interaction between tillage method and nitrogen treatments at the 22.9 to 30.5 cm. depth was significant at the 5% level. Also, an interaction between tillage method and year of wheat following alfalfa was illustrated in the 15.2 to 22.9 cm. depth and was significant at the 5% level.

Effect of Different Wheatland Cropping Practices on Aggregate Stability

The size distribution of water-stable soil aggregates is an important soil physical property because the size of the aggregates determines their susceptibility to movement by wind and water. Also, size is important in determining the dimensions of the pore space in cultivated soils. The size of the pores, in turn, affects the movement and distribution of water and air in the soil, which are major factors affecting plant growth. Any determination of aggregate-size distribution is also, in one sense, a determination of aggregate stability.

The average wet aggregate stability is affected by different practices both for larger than 2 mm. but less than 8 mm. and smaller than 2 mm. but greater than 0.2 mm. These results are shown in Figures

2 and 3, respectively. For both aggregate-size classes, aggregation increased with depth, with only aggregates larger than 2 mm. but less than 8 mm. under stubble mulching lower at the 15.2 to 22.9 cm. soil depth. This may be due to the high percentage of sand in this region. Aggregation under stubble mulching is greater in all cases than under clean tillage (Tables VI to XIII).

An analysis of variance between aggregates larger than 2 mm. but less than 8 mm. and tillage method, Tables XXI, XXII, XXIII and XXIV, shows the 7.6 to 15.2, 15.2 to 22.9 and 22.9 to 20.5 cm. depth significantly different at the 1% level. The difference between a continuous wheat and alfalfa-wheat rotation was significant at the 5% level at the 7.6 to 15.2 and 15.2 to 22.9 cm. soil depths and significant at the 1% level at the 22.9 to 30.5 cm. depth. Also, the difference between first-year wheat following alfalfa and third-year wheat following alfalfa was significant at the 1% level for the 7.6 to 15.2 and 15.2 to 22.9 cm. depths. It should be noted that the addition of nitrogen fertilizer did not affect the per cent of aggregates.

An interaction between the year of wheat following alfalfa and tillage method existed at the 15.2 to 22.9 cm. depth and was significant at the 1% level. This same interaction was present for the organic matter content.

An analysis of variance between aggregates smaller than 2 mm. but greater than 0.2 mm. and tillage method, Tables XXV, XXVI, XXVII and XXVIII, shows the 7.6 to 15.2, 15.2 to 22.9 and 22.9 to 30.5 cm. depth significantly different at the 1% level and at the 5% level for the 30.5 to 38.1 cm. depth. The cropping systems did not produce any significant difference and there were no interactions.

The comparison of average aggregate stability, Figures 2 and 3, with average organic matter content, Figure 1, and bulk density, Figure 4, show strong correlation to each other. As the organic matter content increased, the aggregate stability increased and, in turn, a decrease in bulk density was noted. An increase in aggregation is normally associated with a decrease in run-off and erosion and also an increase in infiltration.

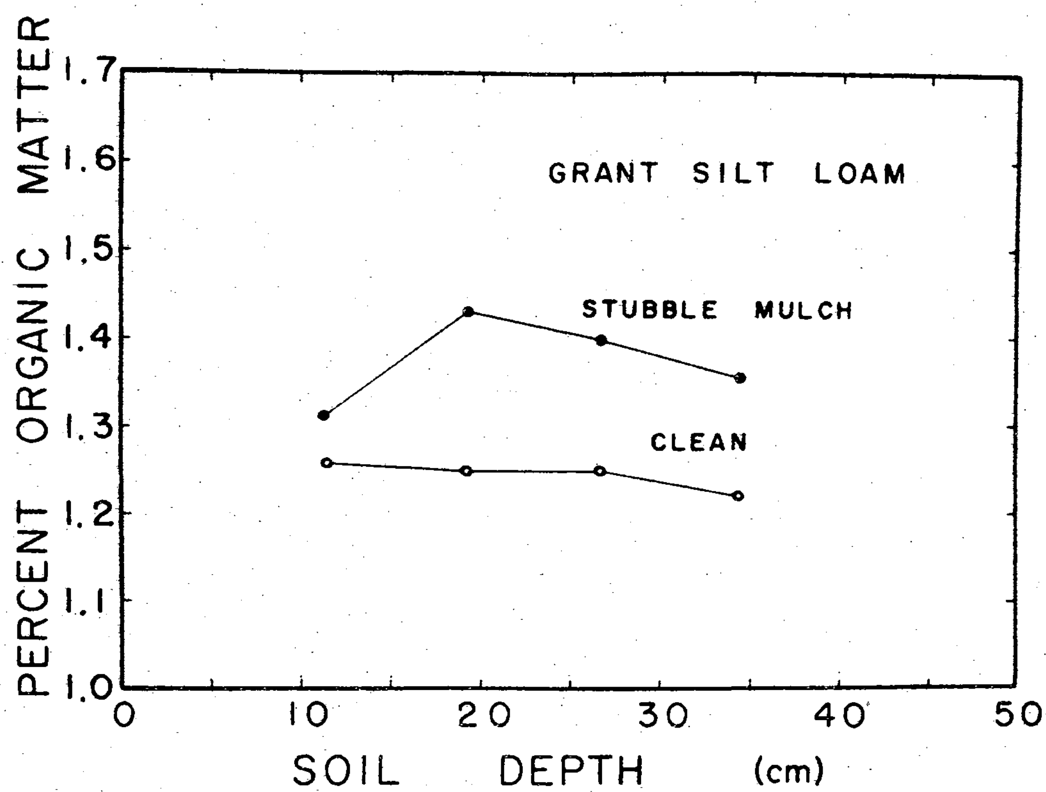

Figure 1. Average Organic Matter Content at Four Soil Depths Under Different Practices

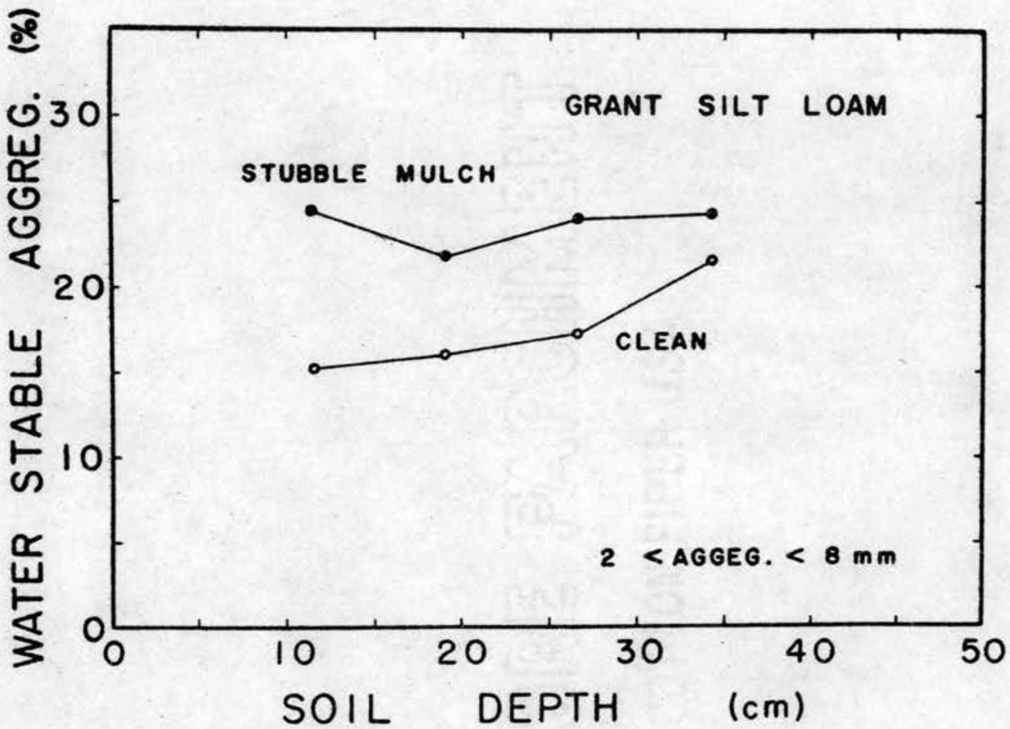

Figure 2. Average Aggregate Stability Larger Than 2 mm. But Less Than 8 mm. at Four Soil Depths Under Diferent Practices

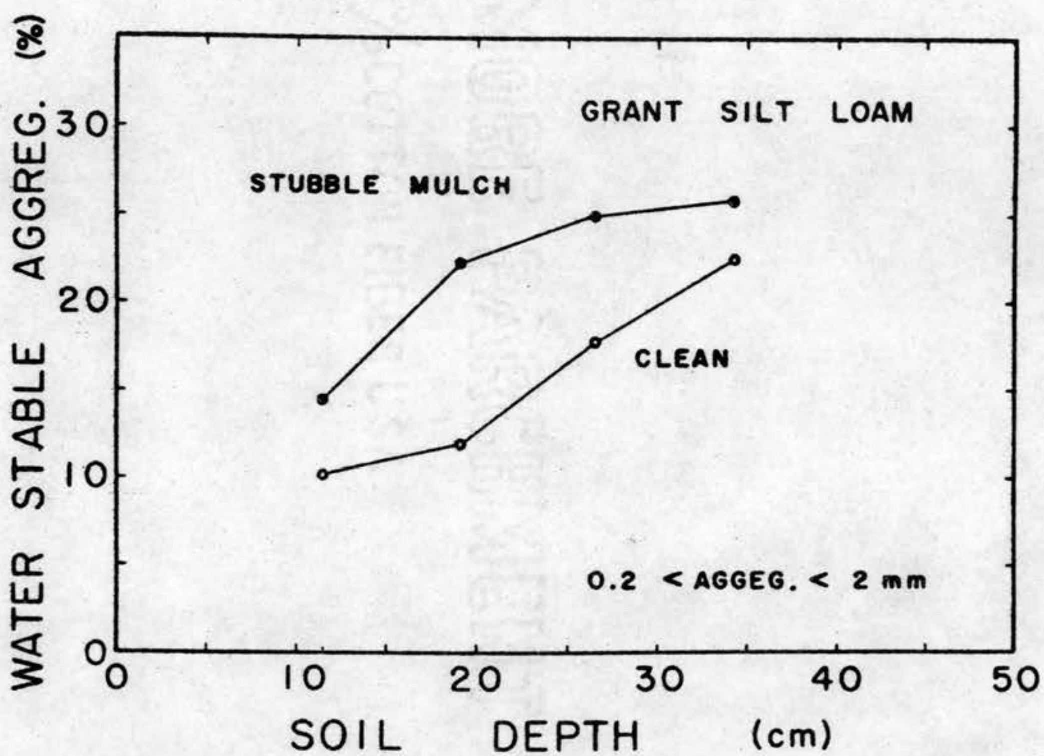

Figure 3. Average Aggregate Stability Smaller Than 2 mm. But Larger Than 0.2 mm. at Four Soil Depths Under Different Practices

TABLE II

AVERAGE ORGANIC MATTER FOR GRANT SILT LOAM AT 7.6 TO 15.2 cm. DEPTH AFTER DIFFERENT PRACTICES

Tillage Method	Continuous Wheat			Alfalfa-Wheat Rotation			
	No Nitrogen	Nitrogen	Average	W-1	W-3	Average	Average
Clean Tilled	1.20	1.34	1.27	1.29	1.22	1.25	1.26
Stubble Mulch	1.11	1.34	1.22	1.26	1.41	1.33	1.28
Average	1.15	1.34	1.25	1.27	1.31	1.29	1.27

TABLE III

AVERAGE ORGANIC MATTER FOR GRANT SILT LOAM AT 15.2 TO 22.9 cm. DEPTH AFTER DIFFERENT PRACTICES

Tillage Method	Continuous Wheat			Alfalfa-Wheat Rotation			
	No Nitrogen	Nitrogen	Average	W-1	W-3	Average	Average
Clean Tilled	1.17	1.32	1.24	1.29	1.24	1.26	1.25
Stubble Mulch	1.24	1.43	1.33	1.42	1.66	1.54	1.44
Average	1.20	1.37	1.29	1.35	1.45	1.40	1.34

TABLE IV

AVERAGE ORGANIC MATTER FOR GRANT SILT LOAM AT 22.9 TO 30.5 cm. DEPTH AFTER DIFFERENT PRACTICES

Tillage Method	Continuous Wheat			Alfalfa-Wheat Rotation			
	No Nitrogen	Nitrogen	Average	W-1	W-3	Average	Average
Clean Tilled	1.32	1.19	1.25	1.25	1.24	1.24	1.25
Stubble Mulch	1.18	1.41	1.29	1.47	1.58	1.53	1.41
Average	1.25	1.30	1.27	1.36	1.41	1.39	1.33

TABLE V

AVERAGE ORGANIC MATTER FOR GRANT SILT LOAM AT 30.5 TO 38.1 cm. DEPTH AFTER DIFFERENT PRACTICES

Tillage Method	Continuous Wheat			Alfalfa-Wheat Rotation			
	No Nitrogen	Nitrogen	Average	W-1	W-3	Average	Average
Clean Tilled	1.26	1.22	1.24	1.19	1.25	1.22	1.23
Stubble Mulch	1.18	1.34	1.26	1.38	1.42	1.40	1.33
Average	1.22	1.28	1.25	1.28	1.34	1.31	1.28

TABLE VI

AVERAGE AGGREGATE STABILITY LARGER THAN 2 mm. BUT LESS THAN 8 mm. FOR GRANT SILT LOAM AT 7.6 TO 15.2 cm. DEPTH AFTER DIFFERENT PRACTICES

Tillage Method	Continuous Wheat			Alfalfa-Wheat Rotation			Average
	No Nitrogen	Nitrogen	Average	W-1	W-3	Average	
Clean Tilled	2.62	4.41	3.52	4.49	6.91	5.70	4.61
Stubble Mulch	5.38	8.07	6.73	4.77	11.54	8.15	7.44
Average	4.00	6.24	5.12	4.63	9.23	6.93	6.03

TABLE VII

AVERAGE AGGREGATE STABILITY LARGER THAN 2 mm. BUT LESS THAN 8 mm. FOR GRANT SILT LOAM AT 15.2 TO 22.9 cm. DEPTH AFTER DIFFERENT PRACTICES

Tillage Method	Continuous Wheat			Alfalfa-Wheat Rotation			Average
	No Nitrogen	Nitrogen	Average	W-1	W-3	Average	
Clean Tilled	3.78	3.89	3.84	5.74	5.87	5.81	4.82
Stubble Mulch	6.67	5.21	5.94	3.22	11.13	7.17	6.56
Average	5.23	4.55	4.89	4.48	8.50	6.49	5.69

TABLE VIII

AVERAGE AGGREGATE STABILITY LARGER THAN 2 mm. BUT LESS THAN 8 mm. FOR GRANT SILT LOAM AT 22.9 TO 30.5 cm. DEPTH AFTER DIFFERENT PRACTICES

Tillage Method	Continuous Wheat			Alfalfa-Wheat Rotation			
	No Nitrogen	Nitrogen	Average	W-1	W-3	Average	Average
Clean Tilled	4.16	4.72	4.44	5.93	5.94	5.94	5.19
Stubble Mulch	6.37	5.46	5.91	7.20	9.70	8.45	7.18
Average	5.26	5.09	5.18	6.57	7.82	7.19	6.19

TABLE IX

AVERAGE AGGREGATE STABILITY LARGER THAN 2 mm. BUT LESS THAN 8 mm. FOR GRANT SILT LOAM AT 30.5 TO 38.1 cm. DEPTH AFTER DIFFERENT PRACTICES

Tillage Method	Continuous Wheat			Alfalfa-Wheat Rotation			
	No Nitrogen	Nitrogen	Average	W-1	W-3	Average	Average
Clean Tilled	4.99	6.03	5.51	8.05	5.13	6.59	6.05
Stubble Mulch	8.05	6.04	7.05	8.81	8.32	8.56	7.81
Average	6.52	6.03	6.28	8.43	6.72	7.58	6.93

TABLE X

AVERAGE AGGREGATE STABILITY SMALLER THAN 2 mm. BUT LARGER THAN 0.2 mm. FOR GRANT SILT LOAM AT 7.6 TO 15.2 cm. DEPTH AFTER DIFFERENT PRACTICES

Tillage Method	Continuous Wheat			Alfalfa-Wheat Rotation			
	No Nitrogen	Nitrogen	Average	W-1	W-3	Average	Average
Clean Tilled	3.08	3.24	3.16	3.18	2.70	2.94	3.05
Stubble Mulch	4.59	5.08	4.83	4.46	4.42	4.44	4.64
Average	3.84	4.16	4.00	3.82	3.56	3.69	3.84

TABLE XI

AVERAGE AGGREGATE STABILITY SMALLER THAN 2 mm. BUT LARGER THAN 0.2 mm. FOR GRANT SILT LOAM AT 15.2 TO 22.9 cm. DEPTH AFTER DIFFERENT PRACTICES

Tillage Method	Continuous Wheat			Alfalfa-Wheat Rotation			
	No Nitrogen	Nitrogen	Average	W-1	W-3	Average	Average
Clean Tilled	3.88	3.66	3.77	3.62	3.05	3.33	3.55
Stubble Mulch	6.70	6.68	6.69	5.85	7.20	6.52	6.61
Average	5.29	5.17	5.23	4.74	5.12	4.93	5.08

TABLE XII

AVERAGE AGGREGATE STABILITY SMALLER THAN 2 mm. BUT LARGER THAN 0.2 mm. FOR GRANT SILT LOAM AT 22.9 TO 30.5 cm. DEPTH AFTER DIFFERENT PRACTICES

Tillage Method	Continuous Wheat			Alfalfa-Wheat Rotation			
	No Nitrogen	Nitrogen	Average	W-1	W-3	Average	Average
Clean Tilled	4.90	5.84	5.37	5.72	4.91	5.32	5.35
Stubble Mulch	7.25	7.11	7.18	8.23	7.28	7.76	7.47
Average	6.07	6.47	6.27	6.97	6.10	6.54	6.41

TABLE XIII

AVERAGE AGGREGATE STABILITY SMALLER THAN 2 mm. BUT LARGER THAN 0.2 mm. FOR GRANT SILT LOAM AT 30.5 TO 38.1 cm. DEPTH AFTER DIFFERENT PRACTICES

Tillage Method	Continuous Wheat			Alfalfa-Wheat Rotation			
	No Nitrogen	Nitrogen	Average	W-1	W-3	Average	Average
Clean Tilled	6.52	7.41	6.97	7.13	6.10	6.61	6.79
Stubble Mulch	7.38	8.03	7.71	8.54	7.15	7.84	7.77
Average	6.95	7.72	7.34	7.83	6.62	7.23	7.28

Effect of Different Wheatland Cropping Practices on Bulk Density

Soil bulk density is the ratio of the dry soil mass to the bulk or macroscopic volume of soil particles plus pore space. It is not an invariant quantity for a given soil, but varies with structural conditions of the soil. It is frequently related to soil compaction and is used as a measure of soil structure.

The average density of the Grant silt loam at various soil depths after 11 years of clean tillage and stubble mulching is shown in Figure 4. The bulk density decreased with depth for both practices. Stubble mulching shows a slightly sharper decrease than clean tillage. A comparison, Tables XIV, XV and XVI, shows clean tillage having a slightly higher bulk density than stubble mulching.

An analysis of variance between bulk density at each depth, Tables XXIX, XXX and XXXI, and tillage practice shows only the 22.9 to 30.5 cm. soil depth significantly different at the 5% level. At this same depth, the difference between first-year wheat following alfalfa and third-year wheat following alfalfa is also significant at the 5% level. There is no significance among cropping systems.

Curtis and Post (5) have found a relation between bulk density and organic matter and have used this relation to estimate the bulk density of a stony forested soil. They found that when bulk density decreased, the amount of organic matter increased. The graph of bulk density, Figure 4, and organic matter content, Figure 1, show a relationship similar to that obtained by Curtis and Post. It is also in agreement with the aggregate stability (Figures 2 and 3) results.

The development of compaction zone will restrict the rate of the infiltration of water and thereby increases the opportunity for surface run-off and soil erosion. In addition, they are detrimental to plant root development and crop production. Such a zone appears to be present at the 22.9 to 30.5 cm. depth under clean tillage.

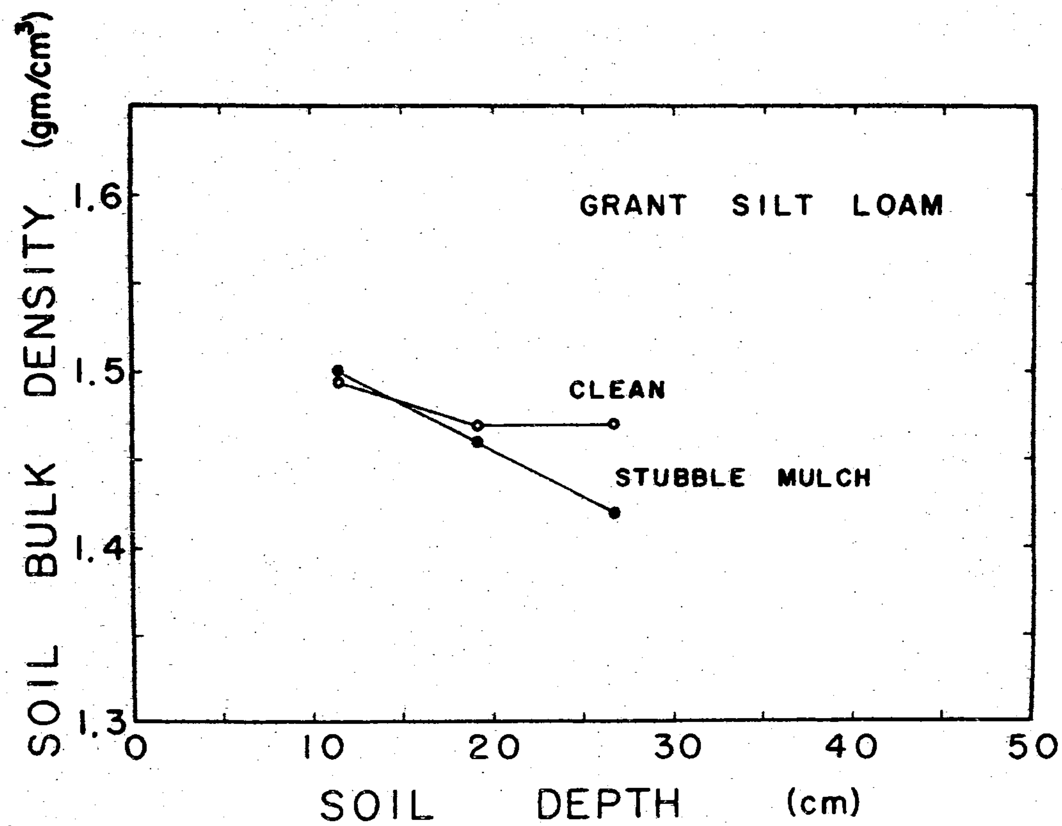

Figure 4. Average Soil Bulk Density at Three Soil Depths Under Different Practices

TABLE XIV

AVERAGE BULK DENSITY FOR GRANT SILT LOAM AT 7.6 TO 15.2 cm. DEPTH AFTER DIFFERENT PRACTICES

Tillage Method	Continuous Wheat			Alfalfa-Wheat Rotation			
	No Nitrogen	Nitrogen	Average	W-1	W-3	Average	Average
Clean Tilled	1.496	1.518	1.507	1.505	1.442	1.473	1.490
Stubble Mulch	1.508	1.504	1.506	1.537	1.461	1.499	1.503
Average	1.502	1.511	1.507	1.521	1.452	1.486	1.496

TABLE XV

AVERAGE BULK DENSITY FOR GRANT SILT LOAM AT 15.2 TO 22.9 cm. DEPTH AFTER DIFFERENT PRACTICES

Tillage Method	Continuous Wheat			Alfalfa-Wheat Rotation			
	No Nitrogen	Nitrogen	Average	W-1	W-3	Average	Average
Clean Tilled	1.462	1.515	1.488	1.467	1.441	1.454	1.471
Stubble Mulch	1.502	1.463	1.482	1.495	1.414	1.455	1.468
Average	1.482	1.489	1.485	1.481	1.428	1.454	1.469

TABLE XVI

AVERAGE BULK DENSITY FOR GRANT SILT LOAM AT 22.9 TO 30.5 cm. DEPTH UNDER DIFFERENT PRACTICES

Tillage Method	Continuous Wheat			Alfalfa-Wheat Rotation			
	No Nitrogen	Nitrogen	Average	W-1	W-3	Average	Average
Clean Tilled	1.489	1.492	1.490	1.517	1.394	1.455	1.473
Stubble Mulch	1.455	1.408	1.431	1.419	1.409	1.414	1.423
Average	1.472	1.450	1.461	1.468	1.401	1.435	1.448

CHAPTER V

SUMMARY AND CONCLUSIONS

The effect of different wheatland soil management practices on bulk density, aggregate stability and organic matter content in the Grant silt loam soil on the Wheatland Conservation Experiment Station, Cherokee, Oklahoma, may be summarized as follows:

1. The amount of organic matter present in a Grant silt loam after 11 years of different soil management practices showed that stubble mulched plots contained a higher organic matter content than clean tilled.

2. The organic matter content was closely related to the aggregate stability and bulk density.

3. Aggregation under stubble mulching was greater than under clean tillage.

4. Soil bulk density under clean tillage was slightly higher than under stubble mulching.

5. The 40 pounds of annual nitrogen was found to significantly influence the amount of organic matter under different practice at specific soil depths.

6. The alfalfa-wheat rotation was found to influence the amount of organic matter and aggregate-stability formation more than continuous wheat.

LITERATURE CITED

1. Beale, O. W., G. B. Nutt and T. C. Peele. 1955. The Effects of Mulch Tillage on Run-Off, Erosion, Soil Properties and Crop Yields. Soil Sci. Soc. Amer. Proc. 19: 244-247.

2. Bracken, A. F. and J. E. Greaves. 1941. Losses of Nitrogen and Organic Matter from Dry-Farm Soils. Soil Sci. 51: 1-15.

3. Bradfield, R. 1937. Soil Conservation from the Standpoint of Soil Physics. Jour. of Amer. Soc. Agron. 29: 85-92.

4. Chepil, W. S. 1955. Factors that Influence Clod Structure and Erodibility of Soil by Wind: V. Organic Matter at Various Stages of Decomposition. Soil Sci. 80: 413-421.

5. Curtis, R. O. and B. W. Post. 1964. Estimate Bulk Density from Organic Matter Content in Some Vermont Forest Soils. Soil Sci. Soc. Amer. Proc. 28: 285-286.

6. Daniel, H. A., M. B. Cox, B. B. Tucker and F. G. Viets, Jr. 1957. Design of Plots Conforming to the Land of Evaluating Moisture Conservation Practices. Soil Sci. Soc. Amer. Proc. 21: 347-350.

7. Elson, J. and J. F. Lutz. 1940. Factors Affecting Aggregation of Cecil Soils and Effect of Aggregation on Run-Off and Erosion. Soil Sci. 50: 265-275.

8. Ensminger, L. E. and A. W. Pearson. 1950. Soil Nitrogen. Advances in Agron. 2: 81-111.

9. Feng, C. E. and G. M. Browning. 1946. Aggregate Stability in Relation to Pore Size Distribution. Soil Sci. Soc. Amer. Proc. 11: 67-73.

10. Harper, J. H. 1945. Soil as a Factor in the Future of Great Plains Agriculture. Soil Sci. Soc. Amer. Proc. 10: 16-22.

11. Hobbs, J. A. 1961. Deep Tillage Effects on Soils and Crops. Agron. Jour. 53: 313-316.

12. Jackson, M. L. 1965. Soil Chemical Analysis. Prentice-Hall, Inc. N. J. 498 p.

13. Johnson, J. R., G. M. Browning and M. B. Russell. 1942. The Effect of Cropping Practices on Aggregation, Organic Matter Content, and Loss of Soil and Water in the Marshall Silt Loam. Soil Sci. Soc. Amer. Proc. 7: 105-108.

14. Kemper, W. D. and W. S. Chepil. 1965. Method of Soil Analysis. Part 1, Physical and Mineralogical Properties, Including Statistics of Measurement and Sampling. Amer. Soc. of Agron. Monograph. No. 9: 506-510.

15. Locke, L. F., J. V. Eck, B. A. Stewart and H. J. Haas. 1960. Plowpan Investigations at the Great Plains Field Stations. Woodward, Oklahoma; Mandan, North Dakota. USDA Production Res. Report 40.

16. McCalla, T. M. and T. J. Army. 1961. Stubble Mulch Farming. Advances in Agron. 13: 125-196.

17. Metzger, W. H. and J. C. Hide. 1938. Effect of Certain Crops and Soil Treatment on Soil Aggregation and the Distribution of Organic Carbon in Relation to Aggregate Size. Jour. Amer. Soc. Agron. 30: 833-843.

18. Nighawan, S. D. and L. R. Dhingra. 1947. Some Characteristics of Soil Aggregates in Cultivated Soil of Punjab, India. Soil Sci. Soc. Amer. Proc. 12: 39-43.

19. Pinson, D. I. 1956. The Effect of Cropping Systems and Cultural Practices on Soil Compaction on a Norge Loam. Unpublished M.S. Thesis, Oklahoma State University, Stillwater.

20. Robert, Edd. Land Judging. Norman: University of Oklahoma Press, 1955.

21. Rynasiewicz, J. 1945. Soil Aggregation and Onion Yields. Soil Sci. 60: 387-395.

22. Stephenson, R. E. and C. E. Schuster. 1945. Effect of Mulches on Soil Properties. Soil Sci. 59: 219-230.

23. Taylor, H. M., A. C. Mothers and F. B. Lotspeich. 1964. Pans in the Southern Great Plains Soils. I. Why Root-Restricting Pans Occur. Agron. Jour. 56: 328-332.

24. Van Doren, C. A. and A. A. Klingebiel. 1949. Permeability Studies on Some Illinois Soils. Soil Sci. Soc. Amer. Proc. 14: 51-55.

25. Wilson, H. A., R. Gish, and G. M. Browning. 1949. Cropping Systems and Season as Factors Affecting Aggregate Stability. Soil Sci. Soc. Amer. Proc. 12: 36-38.

APPENDIX

TABLE XVII

ANALYSIS OF VARIANCE OF ORGANIC MATTER CONTENT FOR GRANT SILT LOAM AT 7.6 TO 15.2 cm. DEPTH

Source of variation	d.f.	S.S.	M.S.	F
Total	63	2.3387	-	-
Treatment combination	7	0.4972	-	-
Tillage	1	0.0038	0.0038	-
Treatment (3)		0.3133	-	-
Cont. Wheat vs. Alfalfa W. rotation (A)	1	0.0328	0.0328	-
No Nitrogen vs. Nitrogen (B)	1	0.2664	0.2664	-
W-1 vs. W-3 (C)	1	0.0140	0.0140	-
Tillage x Treatment (3)		0.1801	-	-
Tillage x A	1	0.0681	0.0681	-
Tillage x B	1	0.0162	0.0162	-
Tillage x C	1	0.0957	0.0957	-
Error (a)	8	0.6290	0.6290	-
Samples	48	1.2124	-	-

TABLE XVIII

ANALYSIS OF VARIANCE OF ORGANIC MATTER CONTENT FOR GRANT SILT LOAM AT 15.2 TO 22.9 cm. DEPTH

Source of variation	d.f.	S.S.	M.S.	F
Total	63	3.4995	-	-
Treatment combination	7	1.3477	-	-
Tillage	1	0.5383	0.5383	24.15**
Treatment (3)		0.5047	-	-
Cont. Wheat vs. Alfalfa W. rotation (A)	1	0.1993	0.1993	8.94*
No Nitrogen vs. Nitrogen (B)	1	0.2381	0.2381	10.68*
W-1 vs. W-3 (C)	1	0.0674	0.0674	-
Tillage x Treatment		0.3046	-	-
Tillage x A	1	0.1324	0.1324	5.93*
Tillage x B	1	0.0055	0.0055	-
Tillage x C	1	0.1667	0.1667	7.48*
Error (a)	8	0.1783	0.0222	-
Samples	48	1.9732	-	-

*Significantly different at the 5% level.

**Significantly different at the 1% level.

TABLE XIX

ANALYSIS OF VARIANCE OF ORGANIC MATTER CONTENT FOR GRANT SILT LOAM AT 22.9 TO 30.5 cm. DEPTH

Source of variation	d.f.	S.S.	M.S.	F
Total	63	2.7905	-	-
Treatment combination	7	1.1704	-	-
Tillage	1	0.3985	0.3985	11.93**
Treatment (3)		0.2538	-	-
Cont. Wheat vs. Alfalfa W. rotation (A)	1	0.2061	0.2061	6.16*
No Nitrogen vs. Nitrogen (B)	1	0.0254	0.0254	-
W-1 vs. W-3 (C)	1	0.0226	0.0226	-
Tillage x Treatment (3)		0.5181	-	-
Tillage x A	1	0.2316	0.2316	6.92*
Tillage x B	1	0.2520	0.2520	7.53*
Tillage x C	1	0.0344	0.0344	-
Error (a)	8	0.2677	0.0334	-
Samples	48	1.3525	-	-

*Significantly different at the 5% level.

**Significantly different at the 1% level.

TABLE XX

ANALYSIS OF VARIANCE OF ORGANIC MATTER CONTENT FOR GRANT SILT LOAM AT 30.5 TO 38.1 cm. DEPTH

Source of variation	d.f.	S.S.	M.S.	F
Total	63	2.3147	-	-
Treatment combination	7	0.4705	-	-
Tillage	1	0.1620	0.1620	-
Treatments (3)		0.1119	-	-
Cont. Wheat vs. Alfalfa W. rotation (A)	1	0.0613	0.0613	-
No Nitrogen vs. Nitrogen (B)	1	0.0277	0.0277	-
W-1 vs. W-3 (C)	1	0.0231	0.0231	-
Tillage x Treatment (3)		0.1965	-	-
Tillage x A	1	0.1139	0.1139	-
Tillage x B	1	0.0820	0.0820	-
Tillage x C	1	0.0006	0.0006	-
Error (a)	8	0.5123	0.0640	-
Samples	48	1.3319	-	-

TABLE XXI

ANALYSIS OF VARIANCE OF AGGREGATE STABILITY LARGER THAN 2 mm. BUT LESS THAN 8 mm. FOR GRANT SILT LOAM AT 7.6 TO 15.2 cm. DEPTH

Source of variation	d.f.	S.S.	M.S.	F
Total	63	638.8516	-	-
Treatment combination	7	431.1355	-	-
Tillage	1	128.2273	128.2273	14.14**
Treatments (3)		261.2257	-	-
Cont. Wheat vs. Alfalfa W. rotation(A)	1	52.2187	52.2187	5.76*
No nitrogen vs. Nitrogen (B)	1	40.1408	40.1408	-
W-1 vs. W-3 (C)	1	168.8663	168.8663	18.62**
Tillage x Treatment (3)		41.6825	-	-
Tillage x A	1	2.2990	2.2990	-
Tillage x B	1	1.6471	1.6471	-
Tillage x C	1	37.7363	37.7363	-
Error (a)	8	72.5718	9.0715	-
Samples	48	135.1443	-	-

*Significantly different at the 5% level.

**Significantly different at the 1% level.

TABLE XXII

ANALYSIS OF VARIANCE OF AGGREGATE STABILITY LARGER THAN 2 mm. BUT LESS THAN 8 mm. FOR GRANT SILT LOAM AT 15.2 TO 22.9 cm. DEPTH

Source of variation	d.f.	S.S.	M.S.	F
Total	63	555.4460	-	-
Treatment combination	7	350.7373	-	-
Tillage	1	48.1463	48.1463	11.57**
Treatments (3)		174.1665	-	-
Cont. Wheat vs. Alfalfa W. rotation(A)	1	41.1042	41.1042	9.88*
No Nitrogen vs. Nitrogen (B)	1	3.6585	3.6585	-
W-1 vs. W-3 (C)	1	129.4038	129.4038	31.10**
Tillage x Treatment (3)		128.4246	-	-
Tillage x A	1	2.1646	2.1646	-
Tillage x B	1	5.0086	5.0086	-
Tillage x C	1	121.2514	121.2514	29.14**
Error (a)	8	33.2873	4.1609	-
Samples	48	171.4214	-	-

*Significantly different at the 5% level.

**Significantly different at the 1% level.

TABLE XXIII

ANALYSIS OF VARIANCE OF AGGREGATE STABILITY LARGER THAN 2 mm. BUT LESS THAN 8 mm. FOR GRANT SILT LOAM AT 22.9 TO 30.5 cm. DEPTH

Source of variation	d.f.	S.S.	M.S.	F.
Total	63	400.1238	-	-
Treatment combination	7	162.6359	-	-
Tillage	1	63.8002	63.8002	13.37**
Treatments (3)		77.9573	-	-
Cont. Wheat vs. Alfalfa W. rotation(A)	1	65.1653	65.1653	13.66**
No Nitrogen vs. Nitrogen (B)	1	0.2295	0.2295	-
W-1 vs. W-3 (C)	1	12.5626	12.5626	-
Tillage x Treatment (3)		21.0784	-	-
Tillage x A	1	4.3264	4.3264	-
Tillage x B	1	4.3145	4.3145	-
Tillage x C	1	12.4376	12.4376	-
Error (a)	8	38.1760	4.7720	-
Samples	48	199.1119	-	-

**Significantly different at the 1% level.

TABLE XXIV

ANALYSIS OF VARIANCE OF AGGREGATE STABILITY LARGER THAN 2 mm. BUT LESS THAN 8 mm. FOR GRANT SILT LOAM AT 30.5 TO 38.1 cm. DEPTH

Source of variation	d.f.	S.S.	M.S.	F
Total	63	455.5385	-	-
Treatment combination	7	132.6145	-	-
Tillage	1	49.4033	49.4033	-
Treatments (3)		52.2626	-	-
Cont. Wheat vs. Alfalfa W. rotation (A)	1	27.0269	27.0269	-
No Nitrogen vs. Nitrogen (B)	1	1.8769	1.8769	-
W-1 vs. W-3 (C)	1	23.3586	23.3586	-
Tillage x Treatment (3)		30.9486	-	-
Tillage x A	1	0.7678	0.7678	-
Tillage x B	1	18.4680	18.4680	-
Tillage x C	1	11.7128	11.7128	-
Error (a)	8	134.7615	16.8452	-
Samples	48	189.1625	-	-

TABLE XXV

ANALYSIS OF VARIANCE OF AGGREGATE STABILITY SMALLER THAN 2 mm. BUT LARGER THAN 0.2 mm. FOR GRANT SILT LOAM AT 7.6 TO 15.2 cm. DEPTH

Source of variation	d.f.	S.S.	M.S.	F.
Total	63	78.8845	-	-
Treatment combination	7	43.7809	-	-
Tillage	1	40.1798	40.1798	28.97**
Treatments (3)		2.8930	-	-
Cont. Wheat vs. Alfalfa W. rotation(A)	1	1.5098	1.5098	-
No Nitrogen vs. Nitrogen (B)	1	0.8450	0.8450	-
W-1 vs. W-3 (C)	1	0.5382	0.5382	-
Tillage x Treatment		0.7082	-	-
Tillage x A	1	0.1131	0.1131	-
Tillage x B	1	0.2145	0.2145	-
Tillage x C	1	0.3806	0.3806	-
Error (a)	8	11.0948	1.3869	-
Samples	48	24.0087	-	-

**Significantly different at the 1% level.

TABLE XXVI

ANALYSIS OF VARIANCE OF AGGREGATE STABILITY SMALLER THAN 2 mm. BUT LARGER THAN 0.2 mm. FOR GRANT SILT LOAM AT 15.2 to 22.9 cm. DEPTH

Source of variation	d.f.	S.S.	M.S.	F
Total	63	224.8825	-	-
Treatment combination	7	159.5348	-	-
Tillage	1	149.0231	149.0231	69.37**
Treatments (3)		2.7718	-	-
Cont. Wheat vs. Alfalfa W. rotation(A)	1	1.4580	1.4580	-
No Nitrogen vs. Nitrogen (B)	1	0.1164	1.1164	-
W-1 vs. W-3 (C)	1	1.1974	1.1974	-
Tillage x Treatment (3)		7.7399	-	-
Tillage x A	1	0.2916	0.2916	-
Tillage x B	1	0.0851	0.0851	-
Tillage x C	1	7.3632	7.3632	-
Error (a)	8	17.1848	2.1481	-
Samples	48	48.1631	-	-

**Significantly different at the 1% level.

TABLE XXVII

ANALYSIS OF VARIANCE OF AGGREGATE STABILITY SMALLER THAN 2 mm. BUT LARGER THAN 0.2 mm. FOR GRANT SILT LOAM AT 22.9 TO 30.5 cm. DEPTH

Source of variation	d.f.	S.S.	M.S.	F
Total	63	202.0484	-	-
Treatment combination	7	84.4787	-	-
Tillage	1	72.0164	72.0164	30.14**
Treatments (3)		8.4989	-	-
Cont. Wheat vs. Alfalfa W. rotation(A)	1	1.1262	1.1262	-
No Nitrogen vs. Nitrogen (B)	1	1.3001	1.3001	-
W-1 vs. W-3 (C)	1	6.0726	6.0726	-
Tillage x Treatment (3)		3.9633	-	-
Tillage x A	1	1.5971	1.5971	-
Tillage x B	1	2.3166	2.3166	-
Tillage x C	1	0.0496	0.0496	-
Error (a)	8	19.0838	2.3855	-
Samples	48	102.8859	-	-

**Significantly different at the 1% level.

TABLE XXVIII

ANALYSIS OF VARIANCE OF AGGREGATE STABILITY SMALLER THAN 2 mm. BUT LARGER THAN 0.2 mm. FOR GRANT SILT LOAM AT 30.5 TO 38.1 cm. DEPTH

Source of variation	d.f.	S.S.	M.S.	F
Total	63	132.9988	-	-
Treatment combination	7	33.4144	-	-
Tillage	1	15.5039	15.5039	6.32*
Treatments (3)		16.5948	-	-
Cont. Wheat vs. Alfalfa W. rotation(A)	1	0.1849	0.1849	-
No Nitrogen vs. Nitrogen (B)	1	4.6971	4.6971	-
W-1 vs. W-3 (C)	1	11.7128	11.7128	-
Tillage x Treatment (3)		1.3157	-	-
Tillage x A	1	0.9555	0.9555	-
Tillage x B	1	0.1152	0.1152	-
Tillage x C	1	0.2450	0.2450	-
Error (a)	8	19.6154	2.4519	-
Samples	48	79.9689	-	-

*Significantly different at the 5% level.

TABLE XXIX

ANALYSIS OF VARIANCE OF BULK DENSITY FOR GRANT SILT LOAM AT 7.6 TO 15.2 cm. DEPTH

Source of variation	d.f.	S.S.	M.S.	F
Total	63	0.3005	-	-
Treatment combination	7	0.0546	-	-
Tillage	1	0.0024	0.0024	-
Treatments (3)		0.0457	-	-
Cont. Wheat vs. Alfalfa W. rotation (A)	1	0.0068	0.0068	-
No Nitrogen vs. Nitrogen (B)	1	0.0007	0.0007	-
W-1 vs. W-3 (C)	1	0.0382	0.0382	-
Tillage x Treatment (3)		0.0045	-	-
Tillage x A	1	0.0029	0.0029	-
Tillage x B	1	0.0013	0.0013	-
Tillage x C	1	0.0003	0.0003	-
Error (a)	8	0.0575	0.0072	-
Samples	48	0.1904	-	-

TABLE XXX

ANALYSIS OF VARIANCE OF BULK DENSITY FOR GRANT SILT LOAM AT 15.2 TO 22.9 cm. DEPTH

Source of variation	d.f.	S.S.	M.S.	F
Total	63	0.3296	-	-
Treatment combination	7	0.0618	-	-
Tillage	1	0.0001	0.0001	-
Treatments (3)		0.0386	-	-
Cont. Wheat vs. Alfalfa W. rotation (A)	1	0.0154	0.0154	-
No Nitrogen vs. Nitrogen (B)	1	0.0004	0.0004	-
W-1 vs. W-3 (C)	1	0.0229	0.0229	-
Tillage x Treatment (3)		0.0230	-	-
Tillage x A	1	0.0002	0.0002	-
Tillage x B	1	0.0168	0.0168	-
Tillage x C	1	0.0060	0.0060	-
Error (a)	8	0.0379	0.0047	-
Samples	48	0.2299	-	-

TABLE XXXI

ANALYSIS OF VARIANCE OF BULK DENSITY FOR GRANT SILT LOAM AT 22.9 TO 30.5 cm. DEPTH

Source of variation	d.f.	S.S.	M.S.	F
Total	63	0.3579	-	-
Treatment combination	7	0.1219	-	-
Tillage	1	0.0400	0.0400	7.62*
Treatments (3)		0.0504	-	-
Cont. Wheat vs. Alfalfa W. rotation (A)	1	0.0107	0.0107	-
No Nitrogen vs. Nitrogen (B)	1	0.0039	0.0039	-
W-1 vs. W-3 (C)	1	0.0358	0.0358	6.80*
Tillage x Treatment (3)		0.0315	-	-
Tillage x A	1	0.0012	0.0012	-
Tillage x B	1	0.0050	0.0050	-
Tillage x C	1	0.0253	0.0253	-
Error (a)	8	0.0420	0.0053	-
Samples	48	0.1940	-	-

*Significantly different at the 5% level.

VITA

Seri Tanchandrphongs

Candidate for the Degree of

Master of Science

Thesis: THE EFFECT OF DIFFERENT WHEATLAND SOIL MANAGEMENT PRACTICES ON BULK DENSITY, AGGREGATE STABILITY AND ORGANIC MATTER

Major Field: Agronomy

Biographical:

Personal Data: Born at Prae, Thailand, February 13, 1938, the son of Kiat and Vilai Tanchandrphongs.

Ecucation: Attended elementary school at Charoen Raj School, Prae, Thailand, and graduated from high school at the Assumption College, Bangkok, Thailand in 1959. Attended Kasetsart University, Bangkok, Thailand in June, 1959 and received the B. S. degree with a major in Field Crops in June, 1964. Attended Graduate School at Oklahoma State University in January, 1966. Completed requirements for the Master of Science degree in July, 1967.