

A STUDY OF SOIL ORGANIC MATTER MAINTENANCE
IN A KIRKLAND SILT LOAM AND BETHANY-NORGE COMPOSITE

By

ROYCE RAY LEWIS

Bachelor of Science
Oklahoma Agricultural and Mechanical College
Stillwater, Oklahoma
1954

Submitted to the faculty of the Graduate School of
the Oklahoma Agricultural and Mechanical College
in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
August, 1955

A STUDY OF SOIL ORGANIC MATTER MAINTENANCE
IN A KIRKLAND SILT LOAM AND BETHANY-NORGE COMPOSITE

Thesis Approved:

L. W. Reed

Thesis Adviser

Henton Gray

Robert Macdonald

Dean of the Graduate School

ACKNOWLEDGMENT

The writer desires to express his sincere appreciation to Dr. Lester W. Reed for his constant supervision throughout the course of this study, and for his advice and helpful criticism. The writer wishes also to thank Dr. H. F. Murphy for supplying the field plot data. The writer is also indebted to the Agronomy Department for furnishing the funds which made this work possible.

TABLE OF CONTENTS

Chapter	Page
I. INTRODUCTION	1
II. REVIEW OF LITERATURE	2
III. MATERIAL AND METHODS	8
IV. RESULTS AND DISCUSSION	11
V. SUMMARY AND CONCLUSIONS	25
VI. LITERATURE CITED	27
VITA	30
TYPIST PAGE	31

LIST OF TABLES

Table	Page
I. Plot E 5100 Total Forage and Grain Produced by All Crops from 1949-1954	12
II. Plot E 5100 Yield in Pounds per Acre 1949-1954.	13
III. Plot E 5100 Chemical Analysis	15-19
IV. Plot 2100 Average of 18 years 1936-1954, Rotation of 4 Years Alfalfa, 8 Years Wheat	21
V. Plot 2100 Chemical Analysis	22

I. INTRODUCTION

Soil organic matter is of primary importance in maintaining high yields of grain and forage crops. The level of organic matter in our agronomic soils has been decreasing at an alarming rate since these soils were put under cultivation. The maintenance of soil organic matter is of major concern to all those associated with agriculture.

The characteristics of soils are such that they contain within their profiles a vast population of microorganisms which are capable of decomposing tons of plant and animal residues each year. The decay of organic matter is not harmful, but rather it is beneficial; because the decay of soil organic matter liberates nitrogen, phosphorus, sulfur, carbon dioxide, numerous other elements and compounds that are needed for plant growth.

Under natural soil conditions, an equilibrium exists between the formation of organic matter and its decomposition. Cultivation disturbs this natural equilibrium because less organic matter is usually returned to the soil and decomposition processes are speeded up by tillage operations. The amount of organic matter retained in a soil is an inherited characteristic of that particular type of soil. Additions of organic and inorganic fertilizers tend to increase crop production, which may or may not increase the organic matter content of soils. This study is an effort to determine the type of fertilizer and management practice that will help maintain organic matter.

II. REVIEW OF LITERATURE

The nitrogenous material of soil is predominantly organic in nature. The inorganic forms of nitrogen account for only 1 to 3 per cent of the total soil nitrogen. It has definitely been established that a considerable portion of the nitrogen in soil organic matter is proteinaceous in character. Attempts to isolate intact proteins from soil have not been successful. A quantitative determination of the products of soil protein hydrolyzates has been used to estimate proteinaceous material in soil organic matter. The protein hydrolyzates of soil organic matter have been divided into the following classes: (A) ammonia and amide nitrogen, (B) basic (diamino), (C) nonbasic (monamino), (D) and humin nitrogen. On this basis, it has been estimated that (4)* one-third of the total nitrogen in a mineral soil and (20) three-fourths of the total nitrogen in a muck soil is protein.

Bremner and Shaw (8) estimated that 5 to 10 per cent of the total nitrogen in an organic and mineral soil was amino-sugars. Bremner (7) estimated that less than 10 per cent of the total nitrogen in soil was in the form of nucleic acid. He regarded this figure as a maximal estimate. Dodd et al. (10) found free amino acids in all of the organic soils they examined. The results obtained suggest that there may be a seasonal difference in the total number and concentration of free amino acids. It would be interesting to know if these free amino acids are actually precursors to soil ammonia or if they are the results of microbial autolysis.

* Figures in parentheses refer to "Literature Cited."

The availability of organic nitrogen in soil has been a subject of much concern and speculation. Harper (16) concluded that there was no correlation between soil nitrates and total nitrogen. Johnson (19) found that cropped soils produced more nitrates in a 33-day period than a virgin soil which contained a higher percentage of nitrogen. Lathrop (21) concluded that new proteins were formed, during decomposition of dried blood, that were resistant to microbial enzyme activity.

It has been shown by Broadbent (9) that the addition of green plant residues, high in available energy, accelerated the rate of decay of the native soil organic matter. Hallan et al. (15) confirmed Broadbent's results. Allison (2) believed, however, that the priming action of green manure on native soil organic matter was of minor agronomic importance.

At the present time there are two theories which account for the resistance of organic matter to microbial enzymes. One is the lignin-protein or lignin-ammonia theory and the other is the formation of a complex between organic matter and clay colloids. Waksman and Iyer (37) concluded that proteins form a complex with lignin and are resistant to rapid decay. Mattson et al. (23) obtained results which showed that lignin fixed ammonia nitrogen into a chemically stable form when it undergoes autoxidation. They concluded that such fixation occurs in the soil. They showed that nitrogen fixed in heterocyclic compounds was resistant to hydrolysis by strong acids. Bremner (7) found that lignin and nitrous acid in contact at room temperature for a few hours resulted in a chemical reaction in which nitrogen was fixed, and only 20 to 30 per cent of the nitrogen fixed could be recovered by prolonged hydrolysis with hydrochloric acid. The extent of these reactions in soil has not been shown. However, it is known that a certain portion of the soil nitrogen is resistant to

hydrolysis in boiling concentrated hydrochloric acid for 30 hours at temperatures of over 100° C. (25).

A complex between organic materials and clay colloids has been shown (26). X-ray data of Ensminger and Gieseck (11) show that organic nitrogen compounds are adsorbed within the expanding lattice structure of montmorillonite clay. They concluded that proteins were partly adsorbed as cations. They (12) also found that proteins adsorbed by montmorillonite type clays were resistant to hydrolysis by enzymes. Kaolinite, a clay mineral that does not have an expanding lattice and has a low base exchange capacity, had no significant effect retarding the hydrolysis of proteins by enzymes. Talibudeen (35) pointed out that proteins can be adsorbed as two monolayers within the interlamellar space of clay minerals. The proteins adsorbed by soil colloids were also resistant to prolonged hydrolysis of one-normal HCl.

Pinck and Allison (28) compared the carbon dioxide produced during the incubation of a protein-montmorillonite complex, a protein-montmorillonite mixture and a protein-sand mixture. They found that approximately 3 per cent of protein-complex, 18 per cent of the protein-mixture and 64 per cent of the protein-sand mixture were decomposed during a ten day incubation period. In a similar experiment Pinck and Allison (29) showed that two monolayers of protein were less resistant to proteolytic enzymes than a single monolayer within the interlamellar space. They found that montmorillonite could adsorb 8 per cent of its weight in the form of protein and that the adsorbed protein was resistant to enzymatic hydrolysis. Goring et al. (14) demonstrated that nucleoproteins were adsorbed between the lattice structure of clay colloids. The adsorption was linearly related to the cation exchange capacity of the clay colloids. It would seem that these data should explain why some of the heavier tex-

tured soils are higher in organic matter than the lighter textured soils. Allison (1) pointed out that aeration in heavy textured soils was adequate for microbial activity and that the type of clay colloid was an important factor in organic matter retention.

Numerous methods have been used to fractionate soil organic matter. One of the earlier and most widely used methods was the extraction of organic matter with sodium hydroxide. The following names have been used for the various fractions: humin for the fraction insoluble in alkali; humic acid for that fraction soluble in alkali but insoluble in acid; and fulvic acid for that fraction soluble in both alkali and acid (32). Sowden et al. (34) compared the properties of humate fractions separated from Group I and Group II colloids obtained by Tiulin's (36) method of fractionation and found that they were very similar in nitrogen distribution and amino acid composition. Waksman (37) used the proximate analyses to determine the change of plant constituents as they were decomposed. The treatment used for the extraction of each fraction was considered to have little effect on any of the subsequent fractions. This method presents a general picture of the changes which occur during decomposition.

Uronic acids in soils have been estimated by the Lefevre-Tollens ((13) as reviewed by Fuller et al.) procedure on the assumption that only uronic acids are quantitatively decarboxylated when boiled with 12 per cent hydrochloric acid. Bremner (6) states that "there is no direct evidence to justify faith in figures obtained by the application of the Lefevre-Tollens method to soils." However, it does give some basis for comparison of the differences between different types of organic matter.

Moodie (24) considers the hypiodite method a valuable tool in detecting differences in soil organic matter. Hypiodite is a semi-specific oxidant which is believed to attack the phenolic-hydroxyl group of lignin. At the present time this is considered an empirical procedure. However, Moodie did find a difference between an arid and a podzol soil. The arid soils were characterized by low activity organic matter which decreased with depth, while the podzol soils were characterized by a high activity which increased with depth. He concluded that lignin in the soils of arid regions was more completely oxidized than the lignin of podsol soils because of the higher base status of the acid soils.

Fractionation of the nitrogen in organic matter has received considerable attention. The percent of the total nitrogen hydrolyzed with hydrochloric acid depends on the strength, volume and length of hydrolyzing time. Morrow (25) hydrolyzed an average of 72.19 per cent of the total nitrogen using 20 per cent hydrochloric acid at a volume of 2 parts acid to 1 part soil for 48 hours. He studied soil of different types and found that the nitrogen hydrolyzates were very similar. Jodidi (18) used 32 per cent hydrochloric acid to hydrolyze the soil nitrogen. He found an average of 75.77 per cent of the total nitrogen was hydrolyzed when refluxed for 15 hours. There was very little correlation between the amount of nitrogen fractionated and the different types of organic residues added to the soil. Potter et al. (30) used 22 per cent hydrochloric acid to hydrolyze soil nitrogen. They found an average of 74.41 per cent of the total nitrogen was hydrolyzed and concluded that there was no difference in the nitrogen fractions under different treatments of soils of the same type. Waksman et al. (39)

found 22.5 to 33.5 per cent of the total nitrogen in soil was made soluble when it was boiled for 5 hours in 2 per cent hydrochloric acid. Bremner (5) found that 69 to 87 per cent of the total nitrogen in soil was brought into solution when hydrolyzed with 6N hydrochloric acid for 12 hours. Rendig (31) found that there was a maximum of nitrogen hydrolyzed in 3N hydrochloric acids when autoclaved at 15 pounds pressure for 10 hours. His results showed that the various forms of amide, basic, nonbasic and humin nitrogen were very similar in a virgin forest and a virgin prairie soil. A cropped soil contained a higher percentage of nitrogen, that was not extracted by hydrolysis, than an uncropped soil. The nitrogen which was insoluble in hydrochloric acid was believed to be in the form of heterocyclic nitrogen compounds (4, 20, 23).

Mattingly (22) studied the effect of acid concentration and time of hydrolysis on the amount of nitrogen dissolved from sewage sludge and composts. The changes in the percentage of total nitrogen as amino and amide nitrogen was greatest during the first few weeks of composting. The percentage of the insoluble organic nitrogen appeared to be almost independent, after three months of decomposition, of the initial source of nitrogen used in composting.

III. MATERIAL AND METHODS

The objective of this study was to determine the differences in soil organic matter content under a livestock and grain type of farming. The soil used in this study was taken from the E5100 experimental plots from the agronomy farm west of Stillwater, Oklahoma.

In 1916 the 5100 series were divided into plots 17.5 feet by 248.9 feet (0.1 acre) plots with a 7 foot alley between them. From 1916 to 1928, inclusive, the plots received regular designated rates of fertilizer. Beginning in 1929 the plots received no fertilizer until 1948. In the fall of 1948 the series were split into two parts, namely E 5100 and W 5100, making each plot 0.05 acre in size. Beginning in the fall of 1948 to the present time, the following treatments were used: Manure was applied at the rate of 5 tons per acre prior to the planting of oats. Rock phosphate was applied at the rate of 500 pounds per acre prior to the planting of oats. Gypsum was applied at the rate of 150 pounds per acre prior to the planting of oats. Superphosphate was applied at the rate of 150 pounds per acre at the planting of oats and cotton. Potassium chloride was applied at the rate of 100 pounds per acre at the planting of oats and cotton. Lime was applied at the rate of 2 tons per acre, but has not been applied regularly as there were signs of minor element deficiency and toxicity due to the increase in pH. Nitrogen was supplied as ammonium nitrate at the rate of 100 pounds per acre as a top dressing on oats. Residues from the crop grown were turned under. Beginning in 1948 the following crop rotation has been grown: cotton, oats, sweet clover and darso.

The E 5100 series are located on a soil classified as Kirkland¹ silt loam with slopes of 0-2 per cent. The plot treatments were not randomized when the experimental plan was inaugurated. There is a slope gradient across the entire series of plots, which is a definite handicap in interpreting a non-randomized experiment.

The 2100 series are located on a transitional soil zone of Norge and Bethany silt loam¹ with slopes of 0-3 per cent. A rotation of 4 years of alfalfa and 8 years of wheat has been grown on these plots. Manure was applied at the rate of 8 tons per acre prior to seeding the land to alfalfa. Rock phosphate was applied at the rate of 1600 pounds per acre with the manure prior to seeding the land to alfalfa. Superphosphate was broadcast at the rate of 100 pounds per acre each year the land was in alfalfa. No fertilizer was applied on the wheat.

The soil samples were taken in August, 1954, at three depths, 0-6, 6-12 and 12-18 inches. Each sample was a composite of ten locations taken in the center of the field plots. The soil samples were taken to the laboratory, air dried, processed and stored in glass jars. The soil was diluted 2.5 times with distilled water. The pH determinations were made after stirring the solutions twice during a 30-minute period. Base Exchange capacity was determined essentially by the method of Peech et al. (27). The exchangeable bases in the leachate were determined with a Beckman Quartz Flame Spectrophotometer model D U with an accessory photomultiplier. The following wavelengths were used with each respective

¹Personal communication or unpublished data supplied by E. M. Galloway.

ion: 424 millimicron calcium, 774 millimicron potassium, 371 millimicron magnesium, 591.9 millimicron sodium. Corrections were made for the interference of calcium on magnesium and magnesium on sodium. Organic carbon determinations were made by using a modification of the wet combustion procedure by Schollenberger (33). Acid soluble phosphorus was determined essentially by the method of Harper (17).

Determination of organic-and ammonia-nitrogen was made by the conventional Kjeldahl method. Acid soluble nitrogen (31) was determined by placing 100 grams of soil in a 250 ml. Erlenmeyer flask and adding 80 ml. of 3N HCl. Each flask was stoppered with a glass wool plug to help prevent contamination and autoclaved for 10 hours at 15 pounds pressure. The residue was filtered on a Buchner funnel and washed with 200 ml. of 1N HCl. The nitrogen hydrolyzed in the filtrate was determined by the Kjeldahl method. The ammonia formed was distilled into boric acid and titrated with sulfuric acid.

Mechanical analysis was determined essentially by the method of Bouyoucos (3).

Duplicate analyses were made on all determinations with the exception of mechanical analysis.

IV. RESULTS AND DISCUSSION

The E 5100 plot treatments represented three types of soil management practices viz. a livestock, grain or cash crop and an inorganic fertilizer system. Plots 2-7 represent a livestock system, plots 8-13 represent a grain system and plots 14-19 represent an inorganic fertilizer system. Plots 20-28 have various combinations of organic and inorganic fertilizers. It was hoped that a fertilizer treatment could be found that would return the highest yields in both grain and forage subject to climatic and edaphic limitations.

The E 5100 plots are on a slope of approximately 1 to 2 per cent, and the slope gradient is from plot 2 to plot 28. The yields of the checks show the results of sheet erosion on this slowly permeable claypan soil with slopes of 1 to 2 per cent. In general the crop yields were increased considerably on those plots that received the eroded soil and organic matter from plots farther up the slope. Yields of plots 2-7 show that some erosion has taken place. Plot number 6, which received 5 tons of manure, 150 pounds of superphosphate and 2 tons of lime per acre, yielded only 150 pounds per acre more forage and grain than check plot number 7 during a five-year period. The yields that are associated with the treatments may not give a valid picture of the relations that would exist under different circumstances as shown in Table I.

Generally the plots that received phosphate, either in the form of rock phosphate or superphosphate, gave higher yields than the plots that received no phosphate as shown in Tables I and II. Plots that received rock phosphate were higher in acid soluble phosphorus than those plots

TABLE I
PLOT E 5100
TOTAL FORAGE AND GRAIN PRODUCED BY ALL CROPS FROM 1949-1954

Plot No.	Treatment	Yield lbs./acre
2	Manure	7,920
3	Manure, lime	9,077
4	Check	7,528
5	Manure, Lime, Rock Phosphate	9,987
6	Manure, Lime, Superphosphate	10,282
7	Check	10,092
8	Residue	8,451
9	Residue, Lime	8,464
10	Check	9,100
11	Residue, Lime, Rock Phosphate	10,009
12	Residue, Lime, Superphosphate	10,305
13	Check	7,881
14	Nitrogen	9,012
15	Nitrogen, Lime	10,660
16	Check	9,492
17	Nitrogen, Lime, Rock Phosphate	12,125
18	Nitrogen, Lime, Superphosphate	12,268
19	Check	8,607
20	Nitrogen, Lime, Potassium	10,149
21	Nitrogen, Lime, Potassium, Rock Phosphate	13,320
22	Check	9,753
23	Lime	11,500
24	Gypsum	8,305
25	Check	11,641
26	Manure, Gypsum	12,016
27	Manure, Gypsum, Rock Phosphate	13,378
28	Check	11,722

TABLE II
 PLOT E 5100
 YIELD IN POUNDS PER ACRE 1949-1954

Plot No.	Cotton ¹		Oats ²		Sweet Clover		Darso		
	lint & seed		grain	straw	hay	seed	stalks	grain	forage
2 M	964		345	455	480			813	3100
3 M L	968		430	610	700			920	3440
4 Ck	944		335	465	280			880	2880
5 M L RP	1112		562	706	1020			867	3440
6 M L SP	1081		582	633	1160			1240	3280
7 Ck	1096		626	654	960			960	3420
8 Res	979		387	393	168	832		973	2960
9 Res L	908		396	424	292	948		987	2780
10 Ck	860		346	594	264	996		1240	3000
11 Res L RP	1071		498	492	424	1476		1147	2840
12 Res L SP	972		405	515	616	1544		1160	3200
13 Ck	880		404	386	238	422		1200	2680
14 N	886		481	519	282	958		1320	2680
15 N L	954		563	717	496	1384		1173	3140
16 Ck	914		444	491	436	1184		1173	3000
17 N L RP	992		788	992	720	1920		1040	2900
18 N L SP	894		771	909	792	2228		1200	2800
19 Ck	807		336	404	422	1118		1213	2760
20 N L K	838		569	601	532	1268		1253	3080
21 N L K RP	1014		727	903	812	2728		1533	2960
22 Ck	946		394	386	606	1394		1400	2900
23 L	1070		461	489	720	1840		1640	3260
24 G	1174		505	435	540	1480		1720	3380
25 Ck	1214		622	598	548	1452		1733	3040
26 M G	1205		713	747	648	1212		1640	3180
27 M G RP	1205		793	937	790	2030		1707	2980
28 Ck	984		783	927	350	1250		1627	3080

¹Average of 1949 and 1953 yields

²Average of 1950 and 1954 yields

that received superphosphate. The plots that did not receive phosphorus fertilizers contained more acid soluble phosphorus in the 12-18 inch layer than in the 0-6 or 6-12 inch depth as shown in Table III.

Plots that received ammonium nitrate produced slightly higher crop yields than plots that received either residues or manure. There was no appreciable difference in the crop yield of plots receiving manure or residues as shown in Table II. The plots that received manure and nitrogen fertilizers were slightly higher in total nitrogen (0-18 inches) than plots receiving residues. There was no apparent relation between total nitrogen and crop yields.

There was a slight difference in the organic matter content of plots receiving manure, residues and nitrogen. The plots receiving manure and nitrogen were higher in organic matter than the plots that received residues as shown in Table III. The organic matter content was lower in the 12-18 inch depth than in the other levels studied, with the exception of the last three plots. The surface soil of plots 26, 27 and 28 are composed, at least to some extent, of soil material eroded from the other plots up the slope.

There was no relation between quantity of nitrogen hydrolyzed in 3N HCl and total nitrogen in the soil, and there was no relation between acid soluble nitrogen and crop yield as shown in Table III. There was a considerable difference between the percent nitrogen hydrolyzed at different depths. Less nitrogen was hydrolyzed at deeper soil depths, which may be directly related to the percentage of clay and base exchange capacity.

Wilkerson and Gray (40) estimated that 35 per cent of the clay fraction, in the B horizon of a Kirkland soil, was montmorillonite and 25 per

TABLE III PLOT E 5100 CHEMICAL ANALYSIS

Plot	Depth inches	Total N ₁ /	Soluble N ₂ /	Sand %	Silt %	Clay %	O.M. %	Base Exch. ₃ /	Ca. me. ₃ /	K. me. ₃ /	Mg. me. ₃ /	Na. me. ₃ /	P. ppm. ₄ /	pH
2 M	6	76.8	53.4	24	51	25	2.06	12.1	5.94	.300	3.64	.80	4.6	6.6
	12	69.9	44.8	26	39	35	1.97	26.3	9.88	.461	7.37	1.07	3.5	6.4
	18	64.1	40.0	24	35	41	1.81	27.5	12.30	.397	7.90	1.16	8.6	6.8
	5/	211.8	46.2											
3 M L	6	68.0	60.7	36	45	19	1.99	11.0	6.50	.320	3.72	.81	4.3	6.4
	12	75.8	43.7	27	38	35	2.42	27.8	11.12	.416	6.80	1.02	4.6	6.3
	18	62.4	38.4	24	33	43	1.51	28.1	11.85	.397	7.84	1.20	8.3	6.7
		206.2	47.7											
4 Ck	6	65.1	58.7	36	45	19	1.70	11.6	6.12	.274	3.40	.68	2.5	6.1
	12	73.8	43.9	26	38	36	2.61	28.3	10.25	.390	6.95	1.18	5.4	6.4
	18	57.4	40.5	24	33	43	1.44	28.5	12.20	.410	8.10	1.34	9.5	6.8
		196.3	46.9											
5 M L RP	6	68.0	64.4	36	45	19	1.94	13.1	7.25	.307	3.48	.88	58.0	6.3
	12	75.8	43.6	26	35	39	1.87	30.3	11.38	.460	7.39	1.18	5.5	6.4
	18	62.3	41.1	22	33	45	1.58	29.1	12.30	.397	7.99	1.27	8.0	6.7
		206.1	49.7											
6 M L SP	6	71.5	58.1	37	42	21	1.95	12.0	8.00	.309	3.43	.84	8.6	6.4
	12	71.9	45.2	27	37	36	2.31	27.6	10.88	.405	6.85	.98	5.5	6.4
	18	62.2	43.0	25	34	41	1.69	28.5	12.52	.410	8.03	1.18	7.2	6.7
		215.6	46.8											
7 CK	6	79.8	52.9	33	46	21	1.97	12.8	7.88	.313	3.74	.85	4.6	6.2
	12	74.8	43.5	28	39	33	1.79	24.3	9.75	.416	5.77	.94	5.4	6.3
	18	64.1	41.2	25	43	42	1.82	27.7	11.62	.326	6.72	1.14	7.3	6.7
		218.7	46.3											

1/ Milligrams per 100 grams. 2/ Per cent of total nitrogen. 3/ Milliequivalents per 100 grams.
4/ Parts per million. 5/ Milligrams per 300 grams.

TABLE III Continued PLOT E 5100 CHEMICAL ANALYSIS

Plot	Depth inches	Total N ₁ / ₂	Soluble N ₂ / ₂	Sand %	Silt %	Clay %	O.M. %	Base Exch. ₃ / ₃	Ca. me. ₃ / ₃	K. me. ₃ / ₃	Mg. me. ₃ / ₃	Na. me. ₃ / ₃	P. ppm. ₄ / ₄	pH
8 Res	6	70.0	55.4	38	43	19	1.72	9.7	6.69	.313	3.48	.65	3.2	5.9
	12	71.9	43.4	28	35	37	1.79	22.6	10.25	.405	7.15	1.21	5.2	6.3
	18	<u>58.3</u>	<u>43.7</u>	34	35	51	1.40	27.1	11.39	.320	6.54	1.12	10.4	6.7
	5/ 200.2		<u>47.7</u>											
9 Res L	6	70.9	53.0	34	43	23	1.83	12.9	7.38	.390	3.71	.78	4.0	6.2
	12	70.0	43.3	26	35	39	1.81	24.7	11.88	.422	7.87	1.42	5.5	6.2
	18	<u>57.4</u>	<u>40.8</u>	26	31	43	1.29	27.3	11.62	.326	6.64	1.16	8.8	6.8
	198.3		<u>46.0</u>											
10 Ck	6	69.0	53.7	36	41	23	1.66	12.6	7.12	.294	3.68	.77	3.0	6.1
	12	67.0	43.9	26	33	41	1.63	25.2	11.75	.454	7.70	1.46	6.5	6.3
	18	<u>55.4</u>	<u>41.2</u>	26	31	43	1.26	27.1	11.87	.320	6.45	1.37	9.4	6.8
	191.4		<u>46.6</u>											
11 Res L RP	6	72.8	52.2	36	43	21	1.89	13.8	8.00	.326	3.48	.80	24.1	6.2
	12	71.9	42.6	27	34	39	1.69	25.8	11.75	.429	7.42	.98	8.0	6.4
	18	<u>58.3</u>	<u>41.6</u>	26	31	43	1.57	26.6	12.00	.326	6.54	1.25	10.7	6.7
	203.0		<u>45.7</u>											
12 Res L SP	6	72.8	52.5	36	41	23	1.87	12.6	7.75	.326	3.44	.83	8.2	6.2
	12	70.0	48.3	26	33	41	1.63	24.7	12.00	.396	7.68	1.26	6.6	6.4
	18	<u>54.4</u>	<u>39.5</u>	27	32	41	1.33	26.7	11.75	.370	6.16	1.08	10.1	6.8
	197.2		<u>47.4</u>											
13 Ck	6	70.0	51.4	36	43	21	1.86	14.3	7.06	.274	3.44	.86	3.8	6.0
	12	70.9	43.7	27	32	41	2.14	25.9	11.38	.429	7.20	1.26	7.4	6.4
	18	<u>54.4</u>	<u>42.1</u>	27	32	41	1.39	26.8	11.50	.370	6.32	1.33	9.7	6.8
	195.3		<u>46.0</u>											

1/ Milligrams per 100 grams. 2/ Per cent of total nitrogen. 3/ Milliequivalents per 100 grams.
 4/ Parts per million. 5/ Milligrams per 300 grams.

TABLE III Continued PLOT E 5100 CHEMICAL ANALYSIS

Plot	Depth inches	Total N ₁ /	Soluble N ₂ /	Sand %	Silt %	Clay %	O.M. %	Base Exch. ₃ /	Ca. me. ₃ /	K. me. ₃ /	Mg. me. ₃ /	Na. me. ₃ /	P. ppm. ₄ /	pH
14 N	6	73.8	54.2	36	41	23	1.94	16.1	6.87	.321	3.50	.73	3.0	5.8
	12	71.9	44.4	26	34	40	1.80	27.1	10.75	.435	6.84	1.16	6.0	6.2
	18	<u>54.4</u>	<u>41.6</u>	26	31	43	1.62	27.6	11.87	.359	6.78	1.32	10.0	6.6
	5/	210.1	45.0											
15 N L	6	75.8	53.0	30	47	23	2.00	13.6	8.37	.313	3.78	.73	4.5	6.1
	12	71.2	45.5	23	32	45	1.72	27.7	12.95	.448	7.40	1.08	6.5	6.3
	18	<u>56.4</u>	<u>41.5</u>	22	32	46	1.35	27.7	12.00	.370	6.96	1.21	9.5	6.7
		213.4	45.0											
16 Ck	6	75.8	51.2	33	44	23	2.21	14.6	7.00	.300	3.64	.73	3.5	6.2
	12	75.8	49.3	22	32	46	1.61	28.3	12.00	.588	8.07	1.25	4.1	6.3
	18	<u>67.0</u>	<u>42.5</u>	23	31	46	1.56	30.1	12.20	.384	7.45	1.21	10.0	6.6
		218.6	47.9											
17 N L RP	6	78.7	52.0	32	44	24	1.85	13.3	7.62	.336	3.66	.77	30.5	6.1
	12	70.9	44.4	26	32	42	1.69	25.4	11.78	.403	6.60	1.10	3.7	6.4
	18	<u>62.3</u>	<u>38.6</u>	26	29	45	1.48	25.9	11.75	.397	7.14	1.42	9.7	6.7
		211.9	45.5											
18 N L SP	6	70.9	54.7	34	45	21	1.74	13.0	7.25	.337	3.28	.86	10.8	6.1
	12	69.9	43.2	26	35	39	1.70	23.5	11.37	.435	5.80	1.32	5.1	6.5
	18	<u>64.1</u>	<u>39.9</u>	20	33	48	1.46	29.2	12.40	.397	7.60	1.68	11.8	6.7
		214.9	44.0											
19 Ck	6	71.0	50.8	33	42	25	1.76	17.3	5.38	.352	3.62	.83	3.2	6.0
	12	68.5	43.5	24	30	46	1.79	26.6	12.70	.492	8.15	1.68	8.0	6.4
	18	<u>59.3</u>	<u>39.0</u>	24	30	46	1.24	29.4	12.20	.397	8.00	1.84	11.1	6.8
		198.8	44.8											

1/ Milligrams per 100 grams. 2/ Per cent of total nitrogen. 3/ Milliequivalents per 100 grams.
4/ Parts per million. 5/ Milligrams per 300 grams.

TABLE III Continued PLOT E 5100 CHEMICAL ANALYSIS

Plot	Depth inches	Total N _{1/}	Soluble N _{2/}	Sand %	Silt %	Clay %	O.M. %	Base Exch. _{3/}	Ca. me. _{3/}	K. me. _{3/}	Mg. me. _{3/}	Na. me. _{3/}	P. ppm. _{4/}	pH
20 N L K	6	69.0	53.9	35	43	22	1.72	13.5	6.88	.356	3.50	.84	3.1	6.2
	12	68.0	44.4	23	33	44	1.50	26.9	11.75	.422	8.19	1.84	6.0	6.5
	18	60.3	41.1	23	31	46	1.47	29.2	12.40	.390	7.30	1.78	10.1	6.9
	5/	197.3	46.7											
21 N L K RP	6	68.0	56.4	39	40	21	1.47	12.1	7.62	.312	3.12	.63	51.3	6.3
	12	71.9	44.6	29	30	41	1.70	25.4	11.00	.423	7.50	1.40	5.7	6.3
	18	63.1	40.0	27	31	42	1.42	26.6	11.11	.346	6.78	1.37	10.7	6.8
		213.0	44.9											
22 CK	6	66.1	57.7	41	40	19	1.73	12.2	6.50	.287	2.96	.69	4.6	6.1
	12	74.8	46.6	31	37	32	1.94	20.3	9.50	.326	5.60	1.18	3.3	6.1
	18	66.0	39.9	25	30	45	1.65	28.9	11.62	.264	7.36	1.57	6.4	6.6
		216.9	45.8											
23 L	6	67.2	58.8	36	45	19	1.67	11.5	6.88	.295	2.82	.62	4.6	6.1
	12	84.5	44.7	32	34	34	2.02	24.8	10.12	.448	6.10	.94	4.2	6.1
	18	63.2	41.8	25	33	42	1.58	28.2	11.62	.364	6.96	1.04	9.4	6.5
		214.9	48.3											
24 G	6	70.0	59.5	36	45	19	1.69	11.7	6.88	.274	2.60	.62	4.2	6.0
	12	85.0	50.1	31	42	27	2.32	25.8	7.98	.384	4.28	.73	3.1	5.9
	18	70.9	42.2	28	31	41	1.46	26.7	11.62	.371	6.00	.52	6.6	6.2
		225.9	50.9											
25 CK	6	66.1	59.8	37	43	20	1.77	10.8	5.78	.268	2.62	.62	4.4	5.7
	12	82.6	53.1	35	41	24	2.18	16.5	7.74	.240	2.98	.21	5.5	5.8
	18	75.8	46.2	27	37	36	1.69	22.8	9.62	.314	4.79	.52	5.4	6.2
		224.5	52.7											

1/ Milligrams per 100 grams. 2/ Per cent of total nitrogen. 3/ Milliequivalents per 100 grams.
4/ Parts per million. 5/ Milligrams per 300 grams.

TABLE III Continued PLOT E 5100 CHEMICAL ANALYSIS

Plot	Depth Inches	Total N <u>1/</u>	Soluble N <u>2/</u>	Sand %	Silt %	Clay %	O.M. %	Base Exch. <u>3/</u>	Ca. me. <u>3/</u>	K. me. <u>3/</u>	Mg. me. <u>3/</u>	Na. me. <u>3/</u>	P. ppm. <u>4/</u>	pH
26 MG	6	74.8	56.6	38	41	21	1.84	11.2	6.15	.268	2.72	.63	4.7	5.7
	12	84.5	53.8	34	41	25	2.08	12.0	7.50	.326	2.90	.54	4.0	5.5
	18	74.8	47.7	28	37	35	2.19	21.1	9.75	.282	4.25	.48	4.3	6.0
	<u>5/</u>	<u>234.1</u>	<u>52.8</u>											
27 M G RP	6	75.8	60.9	34	47	19	1.75	11.7	7.50	.338	2.48	.62	30.5	5.7
	12	83.6	53.7	32	45	23	2.01	14.8	7.87	.246	2.59	.46	6.5	5.7
	18	80.6	47.4	32	39	29	2.19	16.7	9.06	.222	3.20	.22	7.2	6.0
		<u>240.0</u>	<u>53.9</u>											
28 CK	6	70.9	59.6	32	48	20	1.93	10.9	5.58	.281	2.54	.58	6.1	5.6
	12	77.7	55.6	32	47	21	2.16	14.4	7.10	.246	2.45	.41	2.8	5.5
	18	90.4	52.1	31	41	28	2.18	16.3	7.44	.160	3.04	.33	4.6	5.9
		<u>239.0</u>	<u>55.5</u>											

1/ Milligrams per 100 grams. 2/ Per cent of total nitrogen. 3/ Milliequivalents per 100 grams.
4/ Parts per million. 5/ Milligrams per 300 grams.

cent was illite. From the work of Ensminger and Gieseking (11,12), Talibudeen (35), Allison (1) and numerous other workers, it may be concluded that the reason for the decrease in nitrogen hydrolyzed at lower depths was due to the protective action of montmorillonitic clays on protein. Moodie (24) has shown that soils in arid regions have organic matter that is more completely oxidized in the B horizons than in the A horizons. This interpretation may explain the differences in the type of organic matter at the lower depths.

Mattson (23) has shown that the oxidized lignin could fix labile nitrogen into compounds which were resistant to hydrolysis in acid. The extent and mechanism of the reaction between organic matter and clay minerals or the fixation of nitrogen by lignin in soils is not known at the present time. It is possible that both reactions were responsible for the resistance of soil nitrogen to acid hydrolysis as shown in Table III.

Plots receiving lime were slightly higher in exchangeable calcium and crop yields than those plots that received no lime. There was little difference in exchangeable calcium in the 6-12 and 12-18 inch depth. There was more exchangeable potassium at the 6-12 inch depth than the other depths. Also there was slightly more exchangeable potassium in the 12-18 than in the 0-6 inch depth as shown in Table III.

The Kirkland soil is high in exchangeable magnesium as shown in Table III. The amount of exchangeable magnesium was greatest in the 6-12 and 12-18 inch depth. Generally the exchangeable sodium was greatest at the 12-18 inch depth. The soil pH increased with depth. There was no appreciable difference in the pH between the plots with the exception of plots 25, 26, 27 and 28. These plots were more acid at all three depths than the other plots as shown in Table III.

TABLE IV
 PLOT 2100
 AVERAGE OF 18 YEARS 1936-1954
 ROTATION OF 4 YEARS ALFALFA, 8 YEARS WHEAT

Plot No.	Treatment	Wheat		Alfalfa
		grain Bu./acre	straw Lb./acre	hay Lb./acre
1	Ck	8.9	786	508
2	M ¹	12.86	1305	1495
3	M RP ²	16.3	1810	1869
4	Ck	10.8	1084	804
5	M	13.0	1277	1367
6	M SP ³	19.3	2043	1646

¹Manure applied at the rate of 8 tons per acre in the preparation of the land for alfalfa.

²Rock phosphate applied at the rate of 1600 pounds per acre with manure in the preparation of the land for alfalfa.

³Superphosphate applied at the rate of 100 pounds per acre with manure in the preparation of the land for alfalfa and 100 pounds per acre broadcast annually early in the spring for the other 3 years the land is in alfalfa.

TABLE V PLOT 2100 CHEMICAL ANALYSIS

Plot	Depth Inches	Total N ₁ /	Soluble N ₂ /	Sand %	Silt %	Clay %	O.M. %	Base Exch. ₃ /	Ca. me. ₃ /	K. me. ₃ /	Mg. me. ₃ /	Na. me. ₃ /	P. ppm. ₄ /	pH
1 Ck	6	87.4	54.8	44	35	21	1.76	10.2	5.25	.345	2.78	.56	2.0	5.5
	12	82.6	47.2	34	33	33	1.82	21.9	9.00	.308	4.52	.52	0.0	5.9
	18	60.2	42.1	35	27	38	1.18	22.4	9.15	.222	5.34	.47	4.3	6.3
	5/	230.2	48.7											
2 M	6	93.3	53.3	47	34	19	2.04	10.6	6.00	.422	2.42	.47	3.5	5.2
	12	94.2	47.7	39	32	29	2.28	18.6	8.97	.313	4.15	.52	3.5	5.7
	18	69.9	41.1	41	20	39	1.68	22.5	9.75	.285	5.03	.42	3.7	6.2
		257.4	48.0											
3 M RP	6	89.4	57.1	43	36	21	2.23	11.2	6.15	.256	2.44	.52	383.7	5.5
	12	87.4	51.4	37	22	31	1.98	20.2	8.62	.269	4.86	.51	5.4	6.1
	18	68.0	48.1	33	28	39	1.52	23.3	9.87	.227	5.03	.42	7.4	6.4
		244.8	52.2											
4 Ck	6	81.6	57.6	43	36	21	1.92	10.7	5.25	.293	2.16	.54	2.8	5.4
	12	86.4	51.4	40	27	33	1.87	18.6	9.38	.214	3.93	.46	2.8	5.9
	18	65.1	47.6	35	26	39	1.48	23.5	10.00	.237	4.96	.35	4.0	6.2
		233.1	52.5											
5 M	6	89.4	61.7	46	32	22	1.91	10.6	6.15	.338	2.50	.54	2.7	5.5
	12	83.9	52.6	33	38	29	1.95	16.5	8.12	.220	3.26	.46	2.9	6.0
	18	69.0	45.4	25	36	39	1.51	21.8	9.87	.250	4.45	.40	3.8	6.7
		242.3	53.9											
6 M SP	6	93.3	57.0	42	34	24	2.00	11.4	6.15	.249	2.38	.58	29.9	5.4
	12	92.3	50.9	34	35	31	1.99	19.7	9.50	.224	3.46	.41	3.0	6.0
	18	66.0	48.4	34	27	39	1.40	21.2	10.40	.245	4.05	.41	3.2	6.1
		251.6	52.5											

1/ Milligrams per 100 grams. 2/ Per cent of total nitrogen. 3/ Milliequivalents per 100 grams.
4/ Parts per million. 5/ Milligrams per 300 grams.

On the 2100 plots manure increased the average yield of wheat approximately 3 bushels per acre as shown in Table IV. Manure and rock phosphate increased the yields approximately 3 bushels per acre over manure alone. Manure and superphosphate increased the yields approximately 3 bushels per acre over manure and rock phosphate. The application of manure and rock phosphate resulted in over 0.5 tons per acre more alfalfa than the checks. Alfalfa gave a better response to rock phosphate than to superphosphate.

There was a large amount of acid soluble phosphorus in the plots receiving rock phosphate as shown in Table V. This increase was noted even at the 12-18 inch depth. The plot that received superphosphate was also higher in acid soluble phosphorus than the plots that received no phosphorus; however, the 6-12 and 12-18 inch depths showed no increase in acid soluble phosphorus.

Plots receiving manure were appreciably higher in total nitrogen than the checks, although there was no direct relationship between total nitrogen and the crop yields. There was no apparent correlation between acid soluble nitrogen and total nitrogen and crop yields as shown in Table IV. Acid soluble nitrogen decreased with depth; this was probably inversely related to the percentage of clay and base-exchange capacity. There was a slight increase in the organic matter content on those plots which received manure; however, the organic matter content decreased with increase in depth.

The exchangeable calcium and magnesium increased with increase in depth as shown in Table V. The exchangeable potassium was greatest in the 0-6 inch depth and decreased with an increase in depth. Exchangeable sodium decreased with increase in depth. The top 6 inches

of soil were moderately acid on all the plots. The pH was highest at the 12-18 inch depth.

There was a slight difference in the acid soluble nitrogen between the transitional Bethany-Norge soil and Kirkland silt loam. The 2100 plots contained an average of approximately 1.1 per cent more acid soluble nitrogen in the 0-6 inch depth, 3.0 per cent in the 6-12 inch depth and 2.7 per cent in the 12-18 inch depth than the 5100 plots. There was no appreciable difference in the organic matter content in the profile in the two soils, but there was a considerable difference in the percentage of clay, especially at the 6-12 inch depth.

V. SUMMARY AND CONCLUSIONS

A study of soil organic matter maintenance under different management practices was made. The management practices studied included a livestock, grain or cash crop, and an inorganic fertilizer system on a Kirkland silt loam. The plots were not randomized which is a disadvantage in the evaluation of field studies. The data show that sheet erosion was probably taking place on the Kirkland soil, which raised the yields of the check plots and caused the treatments to be biased.

The plots on the Kirkland silt loam that received ammonium nitrate and manure were slightly higher in organic matter and nitrogen than plots receiving residues. An average of 55.8, 47.2, and 42.0 per cent of the total nitrogen was hydrolyzed in 3N HCl at the respective depths 0-6, 6-12 and 12-18 inches. The percentage of nitrogen hydrolyzed was independent of the treatments and crop yields. The percentage of nitrogen hydrolyzed was related to either a different type of organic matter or per cent of clay minerals occurring in the soil profile. Both of these factors were probably acting together.

The Kirkland soil gave a response to phosphate fertilizers. There was a residual effect of limestone as shown by the slight increase in exchangeable calcium and crop yields. The amount of exchangeable magnesium was high in the Kirkland soil. There was no noticeable crop response from the application of potassium or gypsum.

The Bethany-Norge composite, which was a rotation study of wheat and alfalfa, showed a crop response to manure and phosphate fertilizer treatments. Wheat gave a greater response to superphosphate than to

rock phosphate, while alfalfa responded better to rock phosphate than to superphosphate. Manure and superphosphate increased the wheat yields approximately 10 bushels per acre over the checks. The applications of manure increased the organic matter and nitrogen content in the soil profile. There was no relation between acid soluble nitrogen and soil treatments or crop yields. The percentage of acid soluble nitrogen decreased with an increase in depth, 56.9, 50.2 and 45.3 per cent of the total nitrogen was hydrolyzed in the 0-6, 6-12 and 12-18 inch depths. The decrease in acid soluble nitrogen at the lower depths was probably related to a difference in the type of organic matter and an increase in clay content.

VI. LITERATURE CITED

1. Allison, F. E., Sherman, M. S., and Pinck, L. A. Maintenance soil organic matter: I inorganic soil colloids as a factor in retention of carbon in humus formation. *Soil Sci.*, 68:463-478. 1949.
2. _____. Maintenance of soil organic matter: III influence of green manures on the release of native soil carbon. *Soil Sci.*, 71:67-75. 1951.
3. Bouyoucos, G. J. Direction for making mechanical analysis of soils by the hydrometer method. *Soil Sci.*, 42:225-229. 1936.
4. Bremner, J. M. Studies on soil organic matter: I the chemical nature of soil organic nitrogen. *Jour. Agri. Sci.*, 37:183-193. 1949.
5. _____. The amino acid composition of the protein material in soil. *Jour. Biochem.*, 47:538-542. 1950.
6. _____. Review of recent work on soil organic matter. *Jour. Soil Sci.*, 2:67-82. 1951.
7. _____. The nature of soil nitrogen complexes. *Jour. Sci. Food Agr.*, 3:497-500. 1952.
8. Bremner, J. M. and Shaw, K. Studies on the estimation and decomposition of amino sugars in soil. *Jour. Agri. Sci.*, 44:152-159. 1954.
9. Broadbent, F. E., and Bartholomew, W. V. The effect of quantity of plant material add to soils on its rate of decomposition. *Soil Sci. Soc. Amer. Proc.*, 13:271-274. 1948.
10. Dodd, C. C., Fowden, L., and Pearsall, W. H. An investigation of the free amino acids in organic soil types using paper partition chromatography. *Jour. Soil Sci.*, 4:69-71. 1953.
11. Ensminger, L. E. and Giesecking, J. E. The absorption of proteins by montmorillonite clays and its effect on base exchange capacity. *Soil Sci.*, 51:125-132. 1941.
12. _____, and _____. Resistance of clay-absorbed proteins to proteolytic hydrolysis. *Soil Sci.*, 53:205-209. 1942.
13. Fuller, W. H., Bartholomew, W. V., and Norman, A. G. Some factors involved in the decarboxylation rate of uronic groups of soil organic matter and pectin. *Soil Sci.*, 64:143-156. 1947.

14. Goring, C. A. I., and Bartholomew, W. V. Adsorption of mononucleotides, nucleic acids and nucleoproteins by clays. *Soil Sci.*, 74:149-164. 1952.
15. Hallam, M. J., and Bartholomew, W. V. Influence of rate of plant residue addition in accelerating the decomposition of soil organic matter. *Soil Sci. Soc. Amer. Proc.*, 17:365-368. 1953.
16. Harper, H. J. The ammonia content of soil and its relation to total nitrogen, nitrates and soil reaction. *Jour. Agri. Res.*, 31:549-553. 1939.
17. _____. Tentative methods for the analysis of soil and plant material. Soil Laboratory. Oklahoma A. and M. College.
18. Jodidi, S. L. The chemical nature of the organic nitrogen in soil. *Iowa Agri. Exp. Sta. Res. Bul.*, 1:112-154. 1911.
19. Johnson, F. F. A study of nitrogen availability in cropped and virgin soils. M. S. Thesis. Oklahoma A. and M. College. 1950.
20. Kojima, R. T. Soil organic nitrogen; nature of the organic nitrogen in a muck soil from Geneva, New York. *Soil Sci.*, 64:157-165. 1947.
21. Lathrop, E. C. Protein decomposition in soils. *Soil Sci.*, 1:509-532. 1916.
22. Mattingly, G. E. G. Studies on composts prepared from waste materials; the fraction of organic nitrogen. *Jour. Sci. Food Agri.*, 5:353-364. 1954.
23. Mattson, S., and Koutler-Anderson, E. The acid-base condition in vegetation, litter and humus: III ammonia fixation and humus nitrogen. *Annals Agri. Sweden*, 11:107-137. 1943.
24. Moodie, C. D. Hypiodite method for studying the nature of soil organic matter: II application to the organic matter and organic fractions of different soils. *Soil Sci.*, 71:51-65. 1951.
25. Morrow, C. A., and Gortner, R. A. The organic matter of soil; a study of the nitrogen distributions in different soil types. *Soil Sci.*, 3:297-331. 1917.
26. Myers, H. E. Physicochemical reaction between organic and inorganic soil colloids as related to aggregate formation. *Soil Sci.*, 44:331-357. 1937.
27. Peech, M., and English, L. Rapid microchemical soil tests. *Soil Sci.*, 57:167-195. 1944.

28. Pinesk, L. A., and Allison, F. E. Resistance of a protein-montmorillonite complex to decomposition by soil microorganisms. *Science*, 114:130-131. 1951.
29. Pinesk, L. A., Dyal, R. S., and Allison, F. E. Protein-montmorillonite complexes, their preparation and the effects of soil microorganisms on their decomposition. *Soil Sci.*, 78:109-119. 1954.
30. Potter, R. S., and Snyder, R. S. Amino acid nitrogen in soil and the chemical groups of amino acids in the hydrolyzed soil and their humic acid. *Jour. Amer. Chem. Soc.*, 37:2219-2227. 1915.
31. Rendig, V. V. Fractionation of soil nitrogen and factors effecting distribution. *Soil Sci.*, 71:255-267. 1951.
32. Russell, E. J. Soil conditions and plant growth. Eighth Edition, Longmans, Green and Co. 1950.
33. Schollenberger, C. J. Determinations of soil organic matter. *Soil Sci.*, 31:483-486. 1930.
34. Sowden, F. J., Parker, D. I., and Atkinson, H. J. Comparison of organic matter fractions from three soil types. *Sci. Agri.*, 32:127-134. 1952.
35. Talibudeen, O. Interlamella absorption of protein monolayers on pure montmorillonite clay. *Nature*, 166:236. 1950.
36. Tyulin, A. th. The composition and structure of soil organo-mineral gels and soil fertility. *Soil Sci.*, 45:343-357. 1938.
37. Waksman, S. A. Humus. The Williams and Wilkins Co. 1936.
38. Waksman, S. A., and Iyer, K. R. N. Contribution to our knowledge of the chemical nature and origin of humus. *Soil Sci.*, 34:43-69, 71-77. 1932.
39. Waksman, S. A., and Stevens, K. R. A critical study of the methods for determining the nature and abundance of soil organic matter. *Soil Sci.*, 30:97-116. 1930.
40. Wilkerson, G. E., and Gray, F. A clay mineralogical study of certain reddish prairie soil of Oklahoma with an estimation of the montmorillonite and illite content. *Soil Sci. Soc. Amer. Proc.*, 18:264-268. 1954.

VITA

Royce Ray Lewis
candidate for the degree of
Master of Science

Thesis: A STUDY OF SOIL ORGANIC MATTER MAINTENANCE IN A KIRKLAND
AND BETHANY-NORGE COMPOSITE

Major: Soils

Biographical and Other items:

Born: January 2, 1931, Texas County, Oklahoma

Undergraduate Study: Panhandle A. and M. College, Goodwell,
Oklahoma, 1949-1952; O. A. M. C., 1952-1954

Graduate Study: O. A. M. C., 1954-1955

Experiences: Reared on a farm in Beaver County, Oklahoma.
Department clerk for Beech Aircraft, 1952. Farmed
during summers.

Member of Masonic Club, Agronomy Club and Alpha Zeta.

Date of Final Examination: August, 1955.

THESIS TITLE: A STUDY OF SOIL ORGANIC MATTER MAINTENANCE
IN A KIRKLAND AND BETHANY-NORGE COMPOSITE

AUTHOR: Royce Ray Lewis

THESIS ADVISER: Dr. Lester W. Reed

The content and form have been checked and approved by the author and thesis adviser. The Graduate School Office assumes no responsibility for errors either in form or content. The copies are sent to the bindery just as they are approved by the author and faculty adviser.

TYPIST: Grace E. Hudson