INFLUENCE OF RESIDUE MANAGEMENT AND NITROGEN APPLICATION ON NITRATE ACCUMULATION IN THE SOIL PROFILE

By

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INFLUENCE OF RESIDUE MANAGEMENT AND NITROGEN

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IN THE SOIL PROFILE

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CHAPTER I

INTRODUCTION

Organic matter of most wheatland soils in Oklahoma has dropped to such a low level that it is unable to supply sufficient amounts of nitrogen for both high yields and high quality wheat. If Oklahoma farmers are to remain competitive in wheat production, high yields of a high quality product must be produced.

Due to wind and water erosion hazards that plague the wheat producing area and a desire to produce high yields of good quality wheat, several new cultural practices are being used. The effect of these practices for reducing soil erosion is evident, but the effects upon nitrogen supplying power of the soil and fertility level of the soil is not known. It is necessary to know the effect of these cultural practices on nitrogen availability in making fertilizer recommendations to Oklahoma wheat farmers.

The amount of nitrogen available in the soil very largely determines quality and yield of wheat. In this study an attempt will be made to determine the influence of cultural and tillage practices on the nitrogen status of soils. This thesis involves three studies:

1. Influence of Residue Management and Nitrogen Applications on Nitrate Accumulations in the Soil Profile.
2. Influence of Long Term Tillage and Fertilization Procedures on Soil Profile Nitrates and Other Nitrogen Fractions.

3. Influence of Wheat Straw on Nitrate Nitrogen Immobilization in Laboratory Equilibrium Studies.

CHAPTER II

LITERATURE REVIEW

Influence of Residue Management and Nitrogen Applications on Nitrate Accumulations in the Soil Profile

Research work on soil fertility, carried out by Harper (11)[1] in the 1940's with wheat producing soils of different sections of Oklahoma, showed that in Central Oklahoma nitrate nitrogen was higher in plowed plots than in subtilled plots at planting time. Generally, the same was true in Western Oklahoma except that depths below 0-2 inches were usually higher in nitrate nitrogen than the 0-2 inch layer. In Western Oklahoma, only a few instances were noted where subtilled plots were higher in nitrate nitrogen than plowed plots.

Dawson (4), working with crop residues on Maryland soils, reported results of using wheat straw residue with different methods of tillage. He reported a greater accumulation of nitrate nitrogen in the plowed plots than in the disked or mulched plots. This accumulation was greatest for the three sampling dates of June 1, August 31 and October 10.

A possible reason for the high nitrate accumulation on plowed soils was suggested by Halvorson (9), after working with Minnesota soils.

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[1]Figures in parenthesis refer to Literature Cited, Pages 63 and 64.

In general, soils with higher carbon-nitrogen ratios had the lowest nitrate producing capacity. This situation could possibly be brought about by large amounts of wheat straw or other high carbon-nitrogen ratio materials present. These materials require large amount of nitrate nitrogen for the decomposition processes. Greene (8) suggests that a similar possibility is true on wheat-producing soils of Oklahoma.

Gamble et al. (7), working with Virginia soils, reported that a decreased availability of plant food had been observed for some stubble mulch practices. They also stated that slightly lower amounts of nitrate nitrogen were formed from mulched soils than from turnplowed soils.

Salter et al. (17), reporting on some early studies in Ohio in which continuous wheat culture began in 1894, found the total pounds of nitrogen in the soil in 1913 was 1675 pounds per acre as compared with 1315 pounds in 1925. No nitrogen was added to this treatment, indicating that continuous wheat tends to decrease the amount of nitrogen in the soil.

McCalla (15), working on wheat-producing soils of Nebraska, reported that, from a large number of soil samples taken in the spring of the year to a depth of 6 feet from plots of different management treatments, generally the nitrate content of those fields plowed will be 7 to 10 percent higher than those that are stubble mulched. In the top 1/2 inch of soil he found 23.6 pounds nitrate nitrogen per acre for stubble mulched plots as compared with 32.8 pounds where the residue was plowed under. For the years 1939, 1941 and 1942 residue plowed under treatments yielded 152.6 pounds of nitrate nitrogen per acre as compared with 112.4 pounds for subtilled plots.

Dodge and Jones (5), working at the Kansas Agriculture Experiment Station, reported that almost without exception in Kansas soils there had been an overall loss of nitrogen on continuous wheat production regardless of the treatment of fertilizer applied from 1915 to 1935, but from 1935 to 1945 it seemed that an equilibrium had been reached. Nitrogen applications were rather low, averaging 14.6 pounds nitrogen per acre annually during later years of the experiments.

Harper (10) reported nitrate content of an Oklahoma soil after two years of plowing and subtilled treatments to be 10.3 and 10.7 pounds per acre, respectively, in the 0 to 6 inch area.

Greene (8) studied the nitrate accumulation on a Grant silt loam at Cherokee, Oklahoma, and found that the nitrate accumulation was greater from clean tilled treatments than from stubble mulched plots. He found this to be true for both the 1961-1962 and 1962-1963 crops. He also found that the accumulation was greater on the treatments of higher previous nitrogen treatments. A buildup of nitrates was found to begin at approximately 40 pounds nitrogen per acre in the clean tilled treatments and at about 80 pounds nitrogen per acre in the stubble mulched treatments.

Michalyna and Hedlin (16) reported research carried out on Red River and Fort Garry soil associations in Manitoba, Canada. In their research they found nitrate nitrogen to be higher in the plots where fallowing had been carried out and decreased as an additional crop was harvested. In May, 1957, on the first year wheat after fallow, they found 24.5 pounds of nitrate nitrogen per acre in the check plot as compared with 19.9 pounds per acre in the plot receiving 45 pounds of 11-48-0. On second year wheat following fallow, they found 12.6 pounds of nitrate nitrogen per acre on check plots as compared with 13.9 pounds of nitrate nitrogen per acre on plots fertilized with 160 pounds of 27-14-0. They also reported a sharp increase of nitrate nitrogen on plots fallowed from May, 1957, to October, 1957. The average for May was 8.8 pounds of nitrate nitrogen per acre and increased to 40 pounds of nitrate nitrogen per acre in October, 1957. They also reported the average pounds of nitrate nitrogen per acre for second and third year wheat following fallow which was 9.3 pounds and 7.5 pounds of nitrate nitrogen per acre for check plots and plots treated with 160 pounds of 27-14-0, respectively. These nitrate nitrogen findings were all in the 0 to 24 inch profile.

Influence of Residue Management and Fertilizer Applications on Yield of Winter Wheat

Harper (11) reported that yields of wheat in 1943 were higher on subtilled soil than on plowed soil in Western Oklahoma but the opposite was true in Eastern Oklahoma. This was before the time that Western Oklahoma soils became so depleted in nitrogen.

From 1943 through 1947, Harper also reported that grain yields began a gradual decline on the subtilled soils of Western Oklahoma. In Blaine County the average yield for moldboard plots was 15 bushels per acre and on the subtilled plots 14.4 bushels per acre.

Dawson (4) reported yields of wheat under mulched and plowed treatments to be 17 and 16.3 bushels per acre, respectively, on a

Maryland soil. These yields were for the 3-year average of 1943-1945. No significant decrease in yield was obtained as a result of the mulched treatment. There was a decrease in yield for each treatment from year to year, which was probably caused by a depression of the nutrient level of the soil by growing the same crop three years in succession without the addition of fertilizer.

McCalla (15) reported wheat yields on Nebraska soils to be 28.1 bushels per acre on plots with residue plowed under and 26.7 on plots with residue on surface and subtilled. This report was for the period 1939-1944 on a Sharpsburg silty clay loam. During dry years or in areas with lower rainfall, the mulched plots outyielded plowed plots in some instances.

Massee et al. (14), working in the Upper Snake River dry farming area in Utah, reported that yields of wheat were greater where stubble was left standing as compared to stubble removed. This study was for 1946 through 1958. Twenty-five and three-tenths bushels per acre were produced on plots with stubble left standing and 24.8 where straw was removed. The greatest increases in yields were in favor of residue plots occurring during years that the moisture was limited.

Harper (10) reported, on a comparison of 4 tillages over a 17-year period, that yields were significantly higher at 5 percent level on plowed areas than on the other tillage areas. These areas were all in a rotation with sweet clover. The tillage methods used were moldboard plow, basin list, one-way disk, and sweep. From 1941 through 1951 there was no difference, but beginning in 1952 differences in favor of moldboard plowing occurred. The average yields for plowed and sweep areas were 19.8 and 19 bushels per acre, respectively. The same general trend held true for straw yields.

Cox et al.,[2] working on Grant Silt Loam 1-3 percent slope at Cherokee, Oklahoma, in 1962 reported that 40 pounds of nitrogen applied to continuous wheat increased yields an average of 6.4 bushels per acre and 5.8 bushels per acre on continuous wheat plots which were stubble mulched and 6.9 bushels per acre on continuous wheat plots which were clean tilled. The practice of adding nitrogen has increased yields on stubble mulched plots for 5 years and on clean tilled plots for 4 years. Continuous wheat, stubble mulched plots yielded an average of 19.3 bushels per acre as compared with 20.5 bushels per acre for clean tilled, continuous wheat. These averages are without the addition of nitrogen. This difference of 1.2 bushels per acre in favor of clean tilled is not significant.

Cox et al.[3] reported that 40 pounds of nitrogen gave an average increase in wheat yields of 9 bushels per acre. Continuous wheat, stubble mulched plots with 40 pounds nitrogen yielded 12.2 bushels per acre as compared with 17.9 bushels per acre on clean tilled plots or an average increase of 5.7 bushels per acre. Continuous wheat plots with no nitrogen added yielded an average of 17.5 bushels as compared with 24.2 bushels per acre for clean tillage without nitrogen. With applied nitrogen there was no significant difference of yield of wheat between stubble mulching and clean tillage.

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[2]Annual Report, number 8, 1962. Wheatland Conservation Experiment Station, Cherokee, Oklahoma.

[3]Annual Report, number 10, 1963. Wheatland Conservation Experiment Station, Cherokee, Oklahoma.

Tucker et al. (19) reported that the stubble mulching practice reduced yields as compared with clean tillage. Twenty pounds of nitrogen applied to stubble mulched plots and clean tilled plots gave yields of 26 and 30.1 bushels per acre, respectively. When 40 pounds of nitrogen was added, 23.4 and 27.8 bushels per acre were produced in favor of clean tillage. These same general differences occurred with 80 and 160 pounds of nitrogen per acre applied.

Influence of Residue Management and Fertilizer Application on Organic Matter Accumulation in the Soil Profile

Coover et al. (2), working with Pullman silt loam soil at Amarillo, Texas, used different tillage methods to study the reaction of soil organic matter content. Originally, in 1942, the organic matter was 2.45 percent. On one-wayed plots, organic matter had dropped to 2.10 percent and to 2.15 percent on subtilled plots by 1949. Neither of these treatments retarded the organic matter loss, but subtilled treatments seemed to maintain the organic matter slightly better than the one-wayed treatments.

Allison (1) reported that nitrogen added to crops tends to maintain soil organic matter at a higher level than if nitrogen was not added. This is due to the fact that nitrogen's being added produces more crop residues which in turn is available for decomposition. This work substantiates the premise that addition of nitrogen not only increases yields but also helps maintain the organic matter content of the soil.

Massee et al. (13) studied organic matter losses on some Southeastern Idaho soils by using different cultural practices. They reported that on moldboarded treatments 7.96 percent of the organic matter was lost as compared with 1.33 percent on the one-wayed treatments and 7.74 percent on the sweep treatments. One-way disk treatments with 4000 pounds of residue per acre lost only 0.66 percent of its organic matter.

Fenster et al. (6), in their promotion of stubble mulch farming in Nebraska, pointed out that the decline of organic matter tends to be reduced by stubble mulching and protein content of wheat grain may be slightly lower.

In the upper Snake River dry farming area, Massee et al. (14) reported that the organic matter decreased under the tillage treatments except where 4000 pounds of straw was added. With this amount of straw being added the percent of organic matter was maintained at the original level.

CHAPTER III

INFLUENCE OF RESIDUE MANAGEMENT AND FERTILIZER APPLICATIONS ON NITRATE ACCUMULATIONS IN THE SOIL PROFILE

Materials and Methods

This experiment was initiated in the fall of 1960 at the Wheatland Conservation Experiment Station, Cherokee, Oklahoma, with the first data being collected from the 1961 harvest. The experiment was located on Pond Creek silt loam, which is a "key" wheatland soil in North Central Oklahoma.

Two tillage treatments were employed: clean tillage and stubble mulching. Primary tillage on the clean tilled plot was with a moldboard plow, the residue being completely turned under. Stubble mulched plots were tilled with sweeps and a mulch treader, leaving approximately 2000 pounds of wheat straw residue on the surface of the soil at seeding time. Tillage was performed only as often as necessary to control weeds and manage crop residues.

Seeding was done with a John Deere L. Z. A. hoe type grain drill with 20 pounds of P_2O_5 being applied at seeding with the seed on all treatments. Concho[1] C. I. 12517 wheat was the variety seeded in this experiment.

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[1] C. I. refers to Cereal Investigations, A. R. S., U.S.D.A.

Nitrogen treatment rates in pounds per acre were 0, 20, 40, 80, 160. Nitrogen application was carried out in early spring by top dressing prilled ammonia nitrate with a grain drill.

Harvesting was performed by combining one swath width of the combine (8') from the center of the plot. The grain obtained from this harvest was weighed and the yield calculated. A pint sample of grain was saved from each plot to make nitrogen determinations.

Soil sampling for determining soil nitrate nitrogen was obtained with a Veihmeyer soil sampling tube. These samples were obtained for two dates for each of two crop years. For the 1962 crop year, soil samples were taken in November, 1961 (1)[2] and February, 1962 (2). For the 1963 crop year, soil samples were taken in October, 1962 (3), and February, 1963 (4). Soil samples were taken at depths of 0-6 inches, 6-12 inches, and 12-24 inches. Nitrate determinations were made for each soil increment and the total 24 inch profile nitrates were calculated by totaling the amount found in each increment. The phenoldisulfonic acid method, as outlined by Jackson (12), was used for determining nitrates.

Plots for this study were arranged in a split-split plot design with tillage being the main plot, nitrogen application being sub plots and date being the sub-sub plots. Plot size for individual plots was 20 feet by 100 feet or approximately 0.04 of an acre. Data from this study was analyzed by analysis of variance method to determine differences of significance.

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[2]Figures in parenthesis after dates refer to sampling number.

RESULTS AND DISCUSSION

Nitrate Nitrogen Accumulation Comparisons Between Stubble Mulch and Clean Tillage as Influenced by Residue Management and Nitrogen Applications

Stubble Mulching

Without exception, total nitrate nitrogen was found to be higher in the 24 inch profile where nitrogen fertilizer applications had previously been applied. Only one nitrogen application had been made at dates 1 and 2, whereas two nitrogen applications had been made (spring, 1961, and spring, 1962) on plots sampled at sampling dates 3 and 4. A rather small amount of residual nitrate nitrogen was found for the 20-pound and 40-pound per acre nitrogen treatment, but where 80 and 160 pounds of nitrogen per acre had been applied larger amounts of nitrate nitrogen were found (Figure 1). In some instances a decrease was noted from the 20 pounds per acre nitrogen treatment to the 40 pounds per acre nitrogen treatment, but in no case did the decrease fall as low as the check treatment. Perhaps, this was due to increased yield for the 40-pound nitrogen treatment, removing larger amounts of nitrogen from the soil. In October, 1962, the 80-pound per acre nitrogen treatment contained 35.9 pounds of nitrate nitrogen per acre and the 160-pound per acre nitrogen treatment contained 111.1 pounds of nitrate nitrogen per acre. In February, 1963, the 80-pound per acre nitrogen treatment contained 24.6 pounds nitrate nitrogen per acre and the 160-pound per acre nitrogen treatment contained 33.6 pounds of nitrate nitrogen per acre, which represents the smallest amount noted for any 160-pound per acre nitrogen treatment.

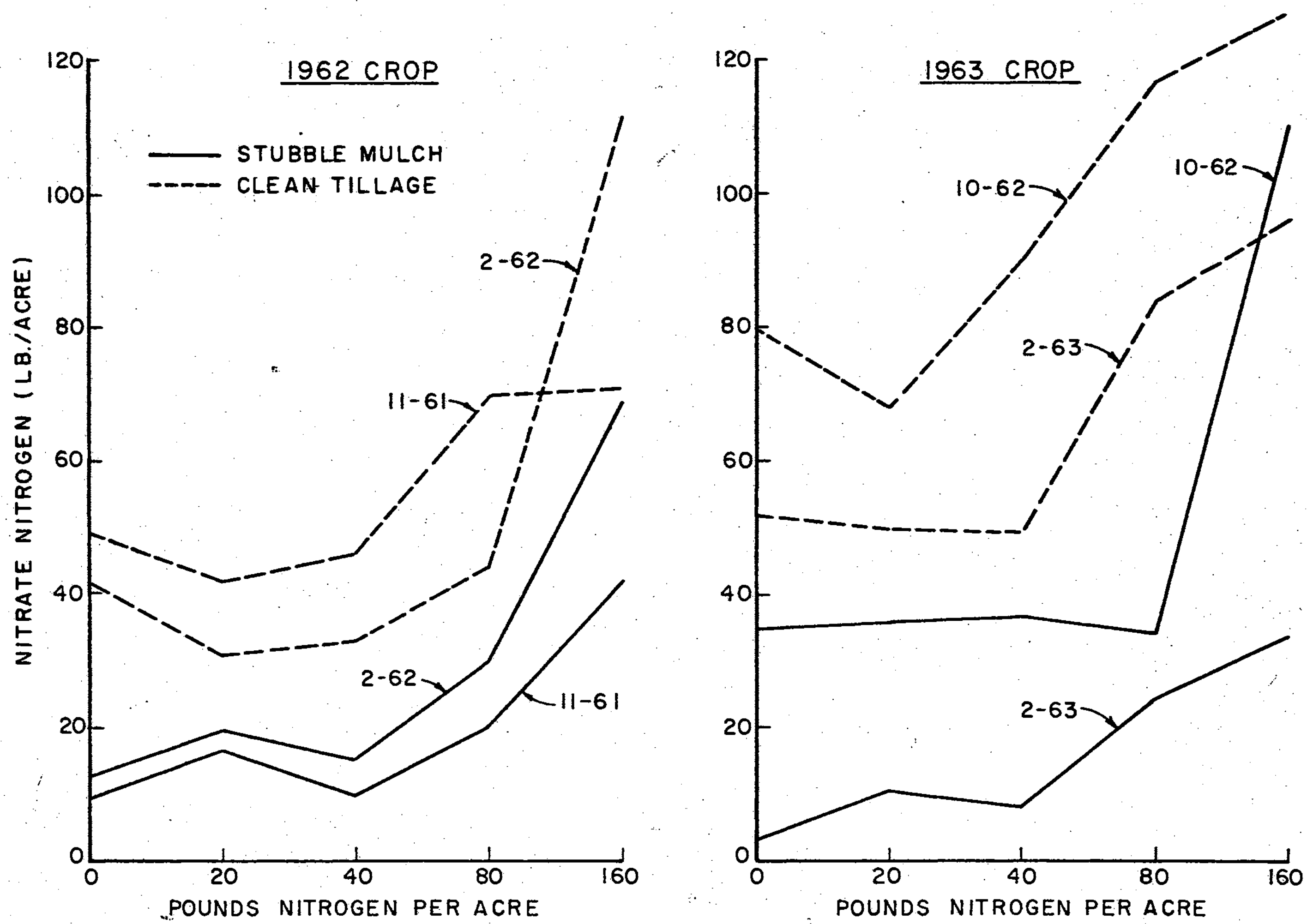

Figure 1. Nitrate Nitrogen Concentrations as Influenced by Residue Management and Nitrogen Application for 1962 and 1963 Crops. (24" Profile)

Clean Tillage

Without exception, nitrate nitrogen accumulation in the 24-inch profile was lower for the 20-pound per acre nitrogen treatment than for the check treatment (Figure 1). With exception of one date out of four, the 40-pound per acre nitrogen treatment was also lower than the check treatment in total pounds of nitrate nitrogen accumulated. This possibly is caused by accelerated biological activity due to the residue's being distributed in the soil mass. This accelerated activity requires a larger amount of nitrogen, which explains the presence of a smaller amount of nitrate in the soil. Eighty pounds per acre was the lowest treatment of nitrogen in which an increased accumulation of nitrate nitrogen was noted for stubble mulched and clean tilled plots. The nitrate nitrogen accumulation for the 160-pound per acre nitrogen treatment was only slightly higher than the 80-pound per acre nitrogen treatment except for the February, 1962, date. The profile nitrates from the 80-pound per acre nitrogen treatment compared with the 40-pound per acre nitrogen treatment was rather large except for the February, 1962, sampling date. There was no reasonable explanation for the nitrate nitrogen accumulation not to increase more from 40 to 80 pounds per acre nitrogen than it did. The decrease in accumulation from the check treatment to the 20-pound per acre nitrogen treatment ranged from 1 to 15 pounds of nitrate nitrogen per acre. The increase in accumulation from the 20-40-pound per acre nitrogen treatment was 5 to 20 pounds of nitrate nitrogen per acre.

Statistically, there were highly significant differences in the amount of nitrate nitrogen present in the soil profile as a result of nitrogen application (Table IV). The larger amount of nitrate nitrogen was found in treatments in excess of 40 pounds of nitrogen per acre (Figure 1 and Tables I and II).

Nitrate Nitrogen Accumulation Comparisons Between Stubble Mulch and Clean Tillage as Influenced by Residue Management and Nitrogen Applications

Without exception, accumulations of nitrate nitrogen per acre in the 24-inch profile was greater on the clean tilled plots than on the stubble mulched plots (Figure 1).

The greater accumulation of nitrate nitrogen in each of the clean tilled treatments is an indication of the increased amount of nitrogen required for the stubble mulching practice. The increased amount of residue requires a larger amount of nitrogen to satisfy the decomposition activities of soil organisms.

The accmulations of nitrate nitrogen vary widely for several of the nitrogen treatments. The 160-pound per acre nitrogen treatment gave the greatest variation, which was 33.6 pounds per acre in February, 1963, to 111.1 pounds nitrate nitrogen per acre in October, 1962.

Statistically, there are highly significant differences in the amount of nitrate nitrogen present in the soil profile as a result of tillage practices (Table IV). The larger amount of nitrate nitrogen was found in the clean tilled treatments (Figure 1 and Tables I and II).

TABLE I

DEPTHS OF NITRATE NITROGEN ACCUMULATIONS AS INFLUENCED BY NITROGEN APPLICATIONS AND DATE OF SAMPLING ON STUBBLE MULCHED PLOTS

		DATES			
Nitrogen Treatments (lbs. per acre)	Depth (inches)	11-61	2-62	10-62	2-63
		Nitrate Nitrogen (ppm)			
0	0-6	0.5	1.6	7.0	0.5
	6-12	2.2	1.3	5.3	0.4
	12-24	1.1	1.8	2.5	0.4
20	0-6	1.2	1.7	7.7	1.1
	6-12	2.7	2.7	5.7	1.6
	12-24	2.3	2.7	2.3	1.4
40	0-6	1.2	1.4	6.6	0.8
	6-12	1.7	2.2	5.7	1.6
	12-24	1.1	2.1	3.1	0.8
80	0-6	1.9	2.7	7.6	2.4
	6-12	4.1	3.0	4.8	4.1
	12-24	2.1	4.6	2.7	2.6
160	0-6	2.6	3.2	13.2	2.6
	6-12	6.6	7.0	11.5	5.2
	12-24	5.9	11.7	15.4	5.4

TABLE II

DEPTHS OF NITROGEN ACCUMULATIONS AS INFLUENCED BY NITROGEN APPLICATIONS AND DATE OF SAMPLING ON CLEAN TILLED PLOTS

		DATES			
Nitrogen Treatment (lbs. per acre)	Depth (inches)	11-61	2-62	10-62	2-63
		Nitrate Nitrogen (ppm)			
0	0-6	2.7	5.7	14.7	5.3
	6-12	7.0	5.8	14.5	9.0
	12-24	7.0	4.7	5.5	5.9
20	0-6	1.4	2.7	12.5	3.7
	6-12	6.0	3.0	12.4	9.5
	12-24	6.8	3.4	4.6	6.0
40	0-6	1.8	2.2	16.0	4.6
	6-12	6.6	4.1	15.9	7.6
	12-24	7.3	4.9	6.5	5.7
80	0-6	3.2	3.4	17.8	6.4
	6-12	8.2	4.6	17.8	15.6
	12-24	11.8	6.9	11.6	10.0
160	0-6	1.9	4.2	19.8	4.0
	6-12	7.4	7.0	19.7	17.1
	12-24	13.1	22.4	12.2	13.6

Depth of Nitrate Nitrogen Accumulations As a Result of Residue Management and Nitrogen Applications

Nitrate nitrogen concentrations were influenced by date, depth and nitrogen treatment.

Generally, there was no difference in the accumulation of nitrate nitrogen for the first two dates (1962 crop year samples) for the 6-12 inch and 12-24 inch soil depths for both clean tilled and stubble mulched plots (Tables I and II). The nitrate nitrogen accumulation was generally lower in the 0-6 inch soil depth than the deeper depths.

Soil samples taken in October, 1962, generally yielded a larger accumulation of nitrate nitrogen in the 0-6 inch depths with the 6-12 inch and 12-24 inch horizons having less nitrate nitrogen accumulations (Tables I and II).

Nitrate nitrogen accumulations for the February, 1963 dates were greater in the 6-12 inch and 12-24 inch horizons with the 0-6 inch horizon generally having a lower concentration (Tables I and II).

Statistically, the differences in nitrate nitrogen accumulations found at the three depths are highly significant (Table IV). The smallest amount of nitrate nitrogen is generally found in the upper part (0-6 inch) of the profile while the greater amounts are found in the lower areas of the profile (Tables I and II).

Yield Response as Influenced by Residue Management and Nitrogen Application

Although, the primary objective of this study was concerned with soil nitrate accumulation as a function of applied nitrogen fertilizer and residue management, some discussion of yield response is pertinent.

Maximum yields for 1961, 1962, and 1963 were reached with 40 pounds of nitrogen per acre on stubble mulched plots and with 20 pounds of nitrogen per acre on clean tilled plots (Figure 2). The stubble mulched plots with 20 pounds of nitrogen per acre treatments increased yields over the check treatment and the 40-pound per acre nitrogen treatment gave an increase over the 20-pound per acre nitrogen treatment, except in 1962, which was a low yield year for all treatments. Also, on stubble mulched plots a decrease in yield was noted from the 40 pound per acre nitrogen treatment to the 80-pound per acre nitrogen treatment, except in 1963, which gave a slight increase. For the 40-pound per acre nitrogen treatment to the 160-pound per acre nitrogen treatment, the yields essentially leveled off and remained unchanged. On the clean tilled plots the maximum yields were reached with a 20-pound per acre nitrogen treatment.

In both the stubble mulched and clean tilled plots, the yield response for each year levels off at the 40-pound per acre nitrogen treatment and very slight variations are noted up to the 160-pound per acre nitrogen treatment.

Yield of Grain Nitrogen As Influenced by Residue Management and Nitrogen Applications

Total pounds of nitrogen removed per acre in the grain was calculated by multiplying the percent nitrogen in the grain times the grain yield in pounds.

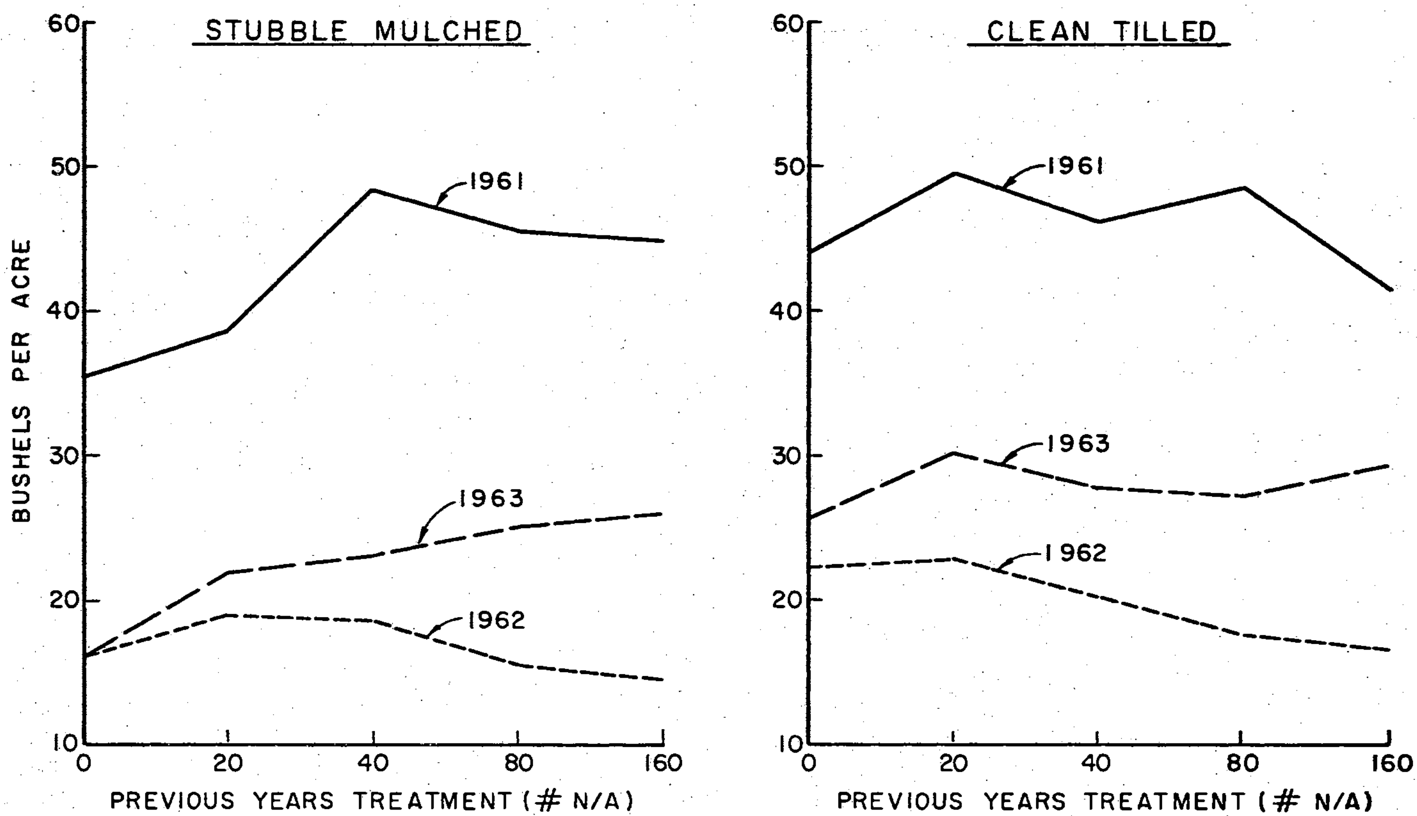

Figure 2. Yields of Wheat Grain as Influenced by Nitrogen Treatments and Residue Management Practices at Cherokee for Crop Years 1961, 1962 and 1963.

The greatest increase in grain nitrogen per acre for all years was noted on stubble mulched plots between the 20-pound per acre nitrogen treatment and the 40-pound per acre nitrogen treatment (Figure 3). The second largest increase, also on stubble mulched plots, was between the 0 nitrogen treatment and the 20-pound per acre nitrogen treatment. This increase corresponded with the greatest increase in grain yield (Figure 2). Beyond the 40-pound per acre nitrogen treatment, a gradual increase in yield of grain nitrogen was noted over the lower nitrogen treatments. Yield of grain nitrogen increased more rapidly on the stubble mulched plots than on the clean tilled plots. On the stubble mulched plots in 1961, grain nitrogen yield increased from 28.6 pounds per acre for the 0 nitrogen treatment to 64.6 pounds per acre for the 160-pound per acre nitrogen treatment (Table III). This represented the largest increase in grain nitrogen for all treatments and years. The smallest increase in grain nitrogen due to soil nitrogen treatments was recorded for the 1962 crop when the increase from 0 to 160 pounds nitrogen treatments went from 22 to 33 pounds of nitrogen per acre for stubble mulched plots and from 35 to 36 pounds of nitrogen per acre for clean tilled plots (Table III).

Increases were observed on clean tilled plots, but they were not as striking as on the stubble mulched plots. The greatest increase for the clean tilled plots was from 38.9 pounds nitrogen per acre on 0 nitrogen treatment to 60.2 on the 160-pound per acre nitrogen treatment (Table III). Each increased rate of nitrogen applied gave an increase of grain nitrogen for the clean tilled plots except 1962 when drought conditions caused lower yields of wheat.

TABLE III

YIELD OF GRAIN NITROGEN AS INFLUENCED BY NITROGEN APPLICATION, RESIDUE MANAGEMENT AND YEAR

Nitrogen Treatment (lbs. per acre)	1961	1962	1963	Average
		DATE		
		Pounds per acre		
Stubble Mulched				
0	28.65	22.03	19.92	23.53
20	32.83	25.45	29.21	29.16
40	49.08	32.55	34.49	38.71
80	49.29	30.45	46.93	42.22
160	64.61	33.10	53.42	50.38
Clean Tilled				
0	38.90	35.01	36.42	36.78
20	42.14	36.32	46.24	41.57
40	44.38	38.62	49.84	44.28
80	56.05	36.48	53.82	48.78
160	60.23	36.18	58.53	51.65

TABLE IV

STATISTICAL ANALYSIS SUMMARY OF INFLUENCE OF RESIDUE MANAGEMENT AND NITROGEN APPLICATION ON SUBSEQUENT NITRATE NITROGEN IN THE SOIL

	Average Over Reps	Average Over Dates	Average Over Depth	Average Over Tillage	Average Over Years	Average Overall
Year	**	**	**	**	NS	**
Tillage	**	**	**	NS	**	*[1]
Tillage x Year	**	**	**	NS	NS	**
Treatment	**	**	**	**	**	**[2]
Tillage x Treatment	NS	NS	NS	NS	NS	NS[3]
Depth	NS	**	NS	**	**	**
Tillage x Depth	NS	**	NS	NS	**	**
Treatment x Depth	NS	**	NS	**	**	**
Tillage x Treatment x Depth	NS	NS	NS	NS	NS	NS
Date	**	NS	**	**	**	**
Tillage x Date	NS	NS	NS	NS	NS	NS
Treatment x Date	NS	NS	NS	NS	NS	NS
Depth x Date	NS	NS	NS	**	**	**
Tillage x Treatment x Date	NS	NS	NS	NS	NS	NS
Tillage x Depth x Date	NS	NS	NS	NS	NS	NS
Treatment x Depth x Date	NS	NS	NS	NS	NS	NS
Tillage x Treatment x Depth x Date	NS	NS	NS	NS	NS	NS
Replications	NS	NS	NS	**	NS	NS

[1]* means significant at 5% level

[2]** means significant at 1% level (highly significant)

[3]NS means not significant below the 5% level

Table IV (Continued)

	Average Over Reps	Average Over Dates	Average Over Depth	Average Over Tillage	Average Over Years	Average Overall
Replications x Tillage	NS	NS	NS	NS	NS	NS
Treatment x Year	NS	NS	NS	NS	NS	NS
Depth x Years	NS	**	NS	**	NS	**
Tillage x Treatment x Years	NS	NS	NS	NS	NS	NS
Tillage x Depth x Year	NS	**	NS	NS	NS	**
Treatment x Depth x Year	NS	NS	NS	NS	NS	NS
Tillage x Treatment x Depth x Year	NS	NS	NS	NS	NS	NS
Tillage x Date x Years	NS	NS	NS	NS	NS	NS
Treatment x Date x Years	NS	NS	NS	NS	NS	**
Tillage x Treatment x Date x Years	NS	NS	NS	NS	NS	NS
Treatment x Replications	NS	NS	NS	**	NS	NS
Date x Years	NS	NS	**	**	NS	**
Depth x Date x Year	NS	NS	NS	**	NS	**
Treatment x Depth x Date x Year	NS	NS	NS	NS	NS	NS
Tillage x Depth x Date x Year	NS	NS	NS	NS	NS	**

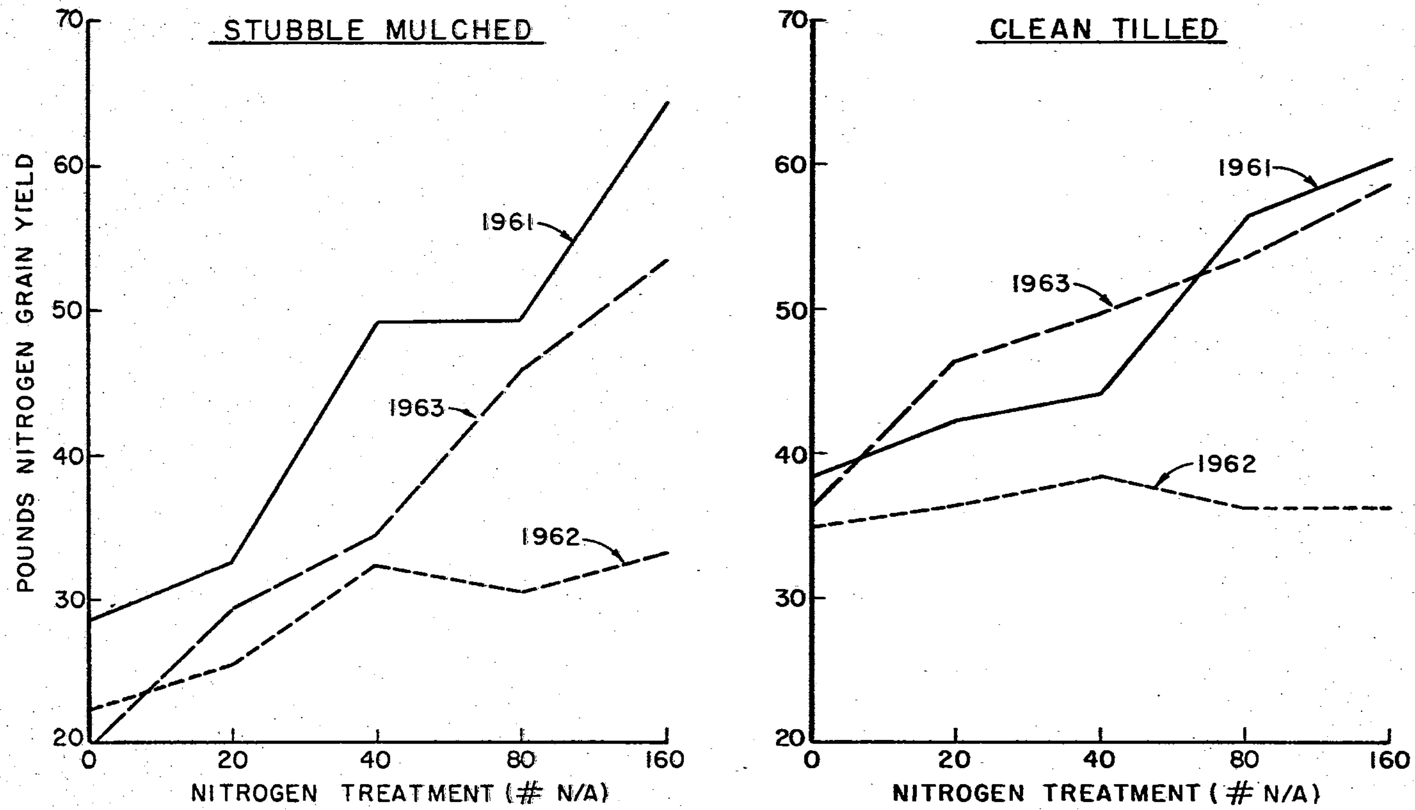

Figure 3. Grain Nitrogen Yield of Wheat as Influenced by Residue Management and Nitrogen Application at Cherokee for 1961, 1962 and 1963 Crops.

Percent Nitrogen in Wheat Grain as Influenced by Residue Management and Nitrogen Application

Grain nitrogen percentage generally increased with increasing rates of nitrogen application (Figure 4). A decrease was observed in only two instances. In both cases, the decrease was between 0 nitrogen treatment and 20-pound per acre nitrogen treatment and in both cases an increase in grain yield was noted (Figure 2). The increased grain yield is possibly the reason for the decrease in percent nitrogen in the grain.

On both clean tilled and stubble mulched plots, the percent grain nitrogen in 1961 was the lowest of the three years observed (Figure 4). This is due to the highest grain yields being recorded that year (Figure 2). The higher yields cause a dilution effect of the nitrogen that is present, therefore, lowering the percent grain nitrogen.

Grain yields were lower in 1962 than in 1961 and in 1963 for all treatments, whereas percent grain nitrogen and grain nitrogen yields were higher in 1962 than in the other years (Figures 3 and 4).

It can be noted when comparing grain nitrogen percentage on stubble mulched and clean tilled plots that there was very little difference due to tillage procedures (Figure 4).

SUMMARY

Nitrate nitrogen accumulations were: (1) found to be higher on the clean tilled plots than on the stubble mulched plots; (2) generally found to be higher on the first sampling date (October or November) than on the second sampling date (February); (3) generally not noted until

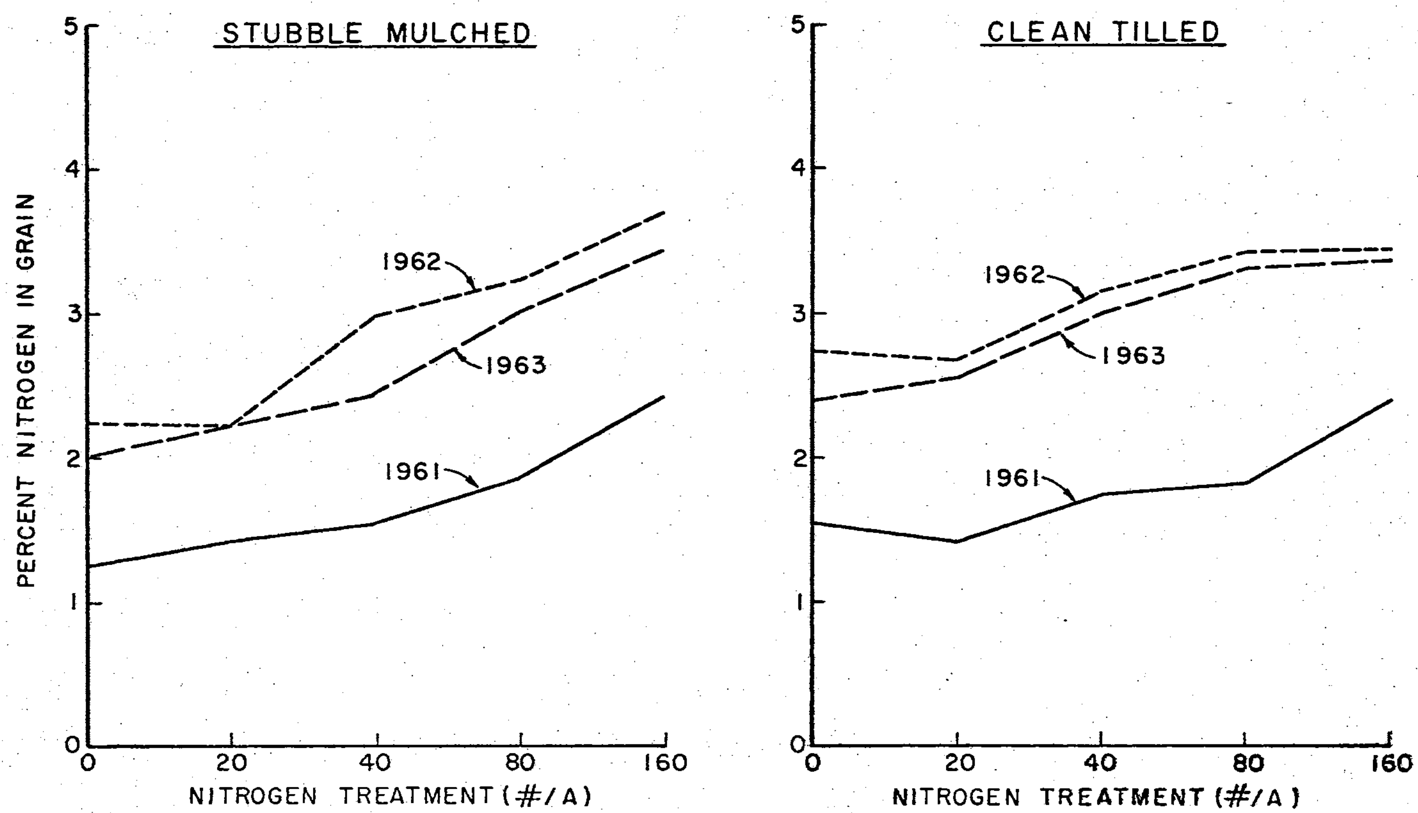

Figure 4. Percent Nitrogen in Grain as Influenced by Residue Management and Nitrogen Application at Cherokee for 1961, 1962 and 1963 Crops.

nitrogen applications of 80 and 160 pounds per acre were made. The 1963 crop year plots contained higher concentrations of nitrate nitrogen than the 1962 crop year plots. One more application of nitrogen had been made on the plots for the 1963 season than in the 1962 season, and this is possibly the reason for the higher nitrate concentrations in the 1963 season; (4) not found to be concentrated in any one horizon throughout. Generally, with the exception of one date (October, 1962), the 0-6 inch horizons were lower in nitrate nitrogen accumulations than the 6-12 inch and 12-24 inch horizons. The October, 1962 samples generally had a higher accumulation of nitrate nitrogen in the 0-6 inch horizon. A possible reason for this horizon to have a greater accumulation of nitrate nitrogen is the lower rainfall in the summer months of 1962.

For an average of the three years observed, the peak yield was at the 40-pound per acre nitrogen treatment on stubble mulched plots, whereas on clean tilled plots the peak yield was at the 20-pound per acre nitrogen treatment. Beyond the 40-pound per acre nitrogen treatment the yields decreased, whereas the percent grain nitrogen as well as the total grain nitrogen increased. The increase in percent grain nitrogen is greater than the decrease in yield of grain per acre and produces this effect.

The percent grain nitrogen increased each year on both clean tilled and stubble mulched plots beyond the 40-pound per acre nitrogen treatment, regardless of whether the grain yield increased or decreased. Very little difference in percentage grain nitrogen was observed due to the two residue management practices.

Yield of grain nitrogen increased each year regardless of residue management practice with each increase in nitrogen application. Grain nitrogen increased regardless of the decrease in grain yields with some treatments.

CHAPTER IV

THE EFFECT OF TILLAGE, RESIDUE MANAGEMENT, AND NITROGEN FERTILIZATION ON SOIL NITROGEN FRACTIONS

Materials and Methods

A soil fertility and management experiment established on wheat in 1957 was used for this study. This experiment was conducted on the Wheatland Conservation Experiment Station, Cherokee, Oklahoma.

The soil on which this study was located is a Grant Silt Loam with a 1-3 percent slope. This soil is a "key" wheatland soil for North Central Oklahoma.

Soil samples for analysis were obtained by using a Veihmeyre soil sampling tube. Soil samples were obtained on two dates, date (1)[1] was October, 1962, and date (2) was January, 1963. Soil samples for date (1) were taken at 6-inch increments to 18 inches deep and date (2) samples were taken at 6-inch increments to 24 inches.

Plot sizes in this experiment ranged from 0.5 to 1.5 acres. Plot arrangement was made at random, placing plots on the proper slope and soil series so that all plots would be located on soil as near the same as possible. Data obtained were analyzed statistically by analysis

[1]Figures in parentheses refer to sampling number

of variance. Each treatment was replicated four times by disregarding plow pan treatments.

A complete description of the field plot design was reported by Daniel et al. (3).

Soil samples for analysis were taken from the following treatments:

1. Continuous wheat without nitrogen.
2. Continuous wheat plus 40 pounds of nitrogen each year.
3. Second year wheat following 3 years of alfalfa.

From each of these three treatments there were two residue management treatments:

1. Stubble mulched
2. Clean tilled

Stubble mulched plots were tilled with sweeps and a mulch treader, leaving approximately 2000 pounds of wheat straw per acre on the surface at seeding time.

Clean tilled plots were plowed with a moldboard plow, as the initial tillage method. Subsequent tillage tools consisted of a one-way, disk plow and spring tooth harrow as needed to control weeds and break the crusts after rains. On the clean tilled plots most of the residue was buried beneath the surface and fairly well decomposed prior to planting time.

Seeding was done with a L. A. A. John Deere hoe type grain drill with 20 pounds of P_2O_5 being applied with the seed at planting time.

Nitrogen on the continuous wheat treatments was top dressed in early spring using ammonium nitrate prills.

Varieties of wheat seeded were Concho for years 1958 through 1962 and Kaw for 1963.

Grain yields were determined by harvesting the entire plot with a combine. The grain from the plots was weighed and calculated in bushels per acre. A pint sample was retained for nitrogen determination. The yield of grain nitrogen was calculated by multiplying the percent of nitrogen in the grain times the yield of grain. Percent nitrogen in the grain was determined by the Kjeldahl method as outlined by Jackson (12). The analyses made on each soil sample were:

1. Total nitrogen
2. Nitrate nitrogen
3. Nitrate nitrogen after 14 days of incubation
4. Ammonia nitrogen
5. Percent organic matter

Total nitrogen was determined by the Kjeldahl method as outlined by Jackson (12).

Nitrate nitrogen before and after incubation was determined by the phenoldisulphonic acid method as outlined by Jackson (12).

Ammonia nitrogen was determined by acid-base titration of distilled ammonia as outlined by Jackson (12).

Percent organic matter was determined by the wet combustion method using potassium dichromate as the oxidizing agent as outlined by Schollenberger and Dreibelbis (18).

Results and Discussion

Total Soil Nitrogen as Influenced by Residue Management and Nitrogen Application

Very small differences in total pounds of soil nitrogen per acre were detected regardless of residue practice or nitrogen application. However, samples collected in January, 1963, were higher in nitrogen than those collected in October, 1962 (Figure 5). The increase in the January sampling cannot be explained and is not consistent with information obtained by Greene (8).

Percent Organic Matter of the Soil as Influenced by Residue Management and Nitrogen Applications

The percent of organic matter was found to be higher on continuous wheat receiving an annual application of 40 pounds of nitrogen than on continuous wheat treatments without nitrogen's being applied (Figure 6). This is rather consistent throughout the data and is statistically significant at the 5 percent level.

Generally, regardless of the residue management used and the date that samples were taken, the percent of organic matter is higher on the continuous wheat plus 40 pounds nitrogen than on the continuous wheat treatment without nitrogen (Table V). The largest difference of 0.08 percent was found in October, 1962, between clean tilled treatments of continuous wheat and continuous wheat plus 40 pounds of nitrogen application (Figure 6). The smallest difference between continuous wheat plus 40 pounds nitrogen and continuous wheat was in January, 1963, with a difference of only 0.02 percent on the stubble mulched treatment (Figure 6).

Organic matter was not influenced by type of residue management under continuous wheat.

Organic matter content of the soil decreased with increasing soil depth particularly below the 12 inch depth. The decrease was evident

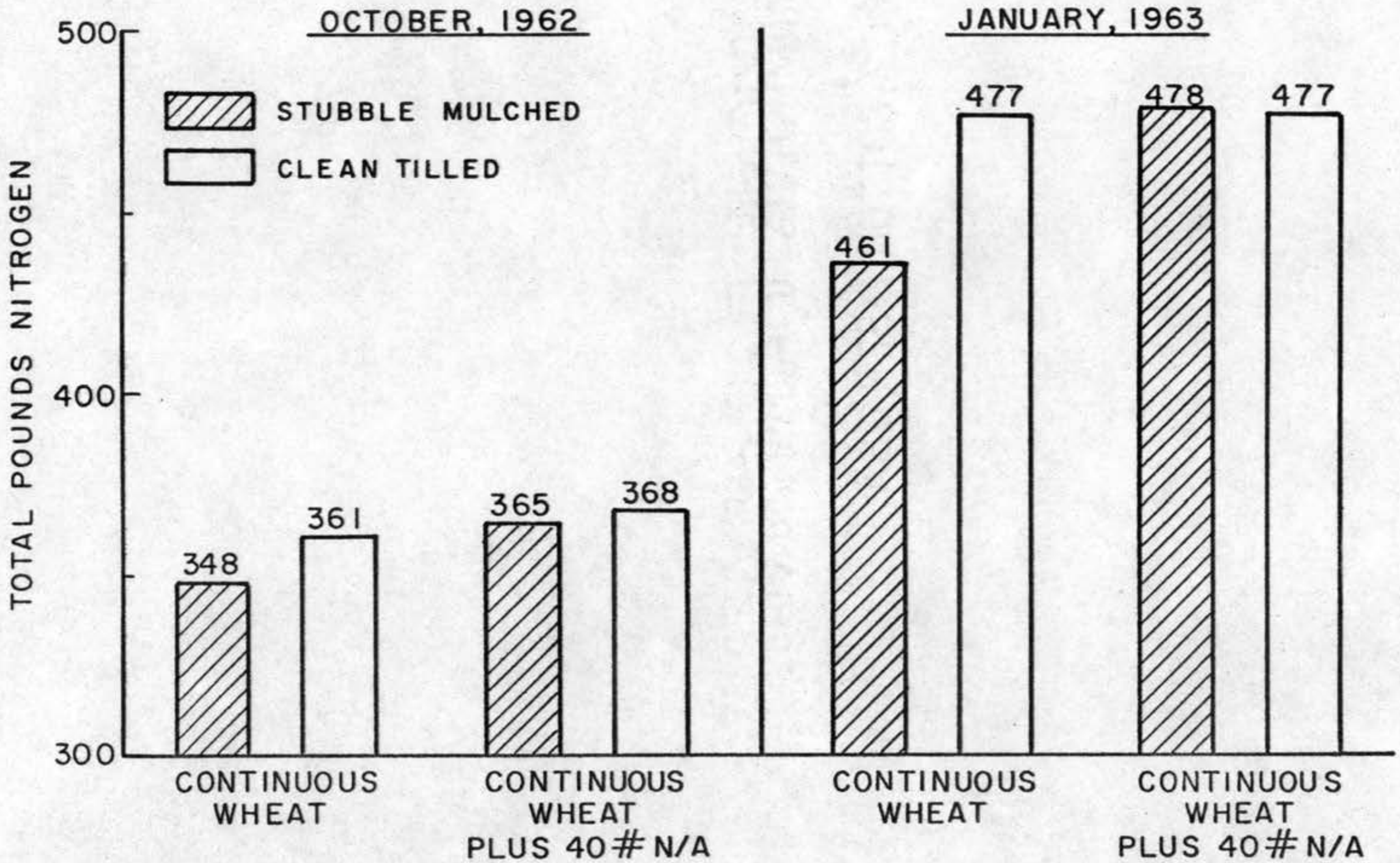

Figure 5. Total Pounds Nitrogen Per Acre in the Soil as Influenced by Residue Management and Nitrogen Application.

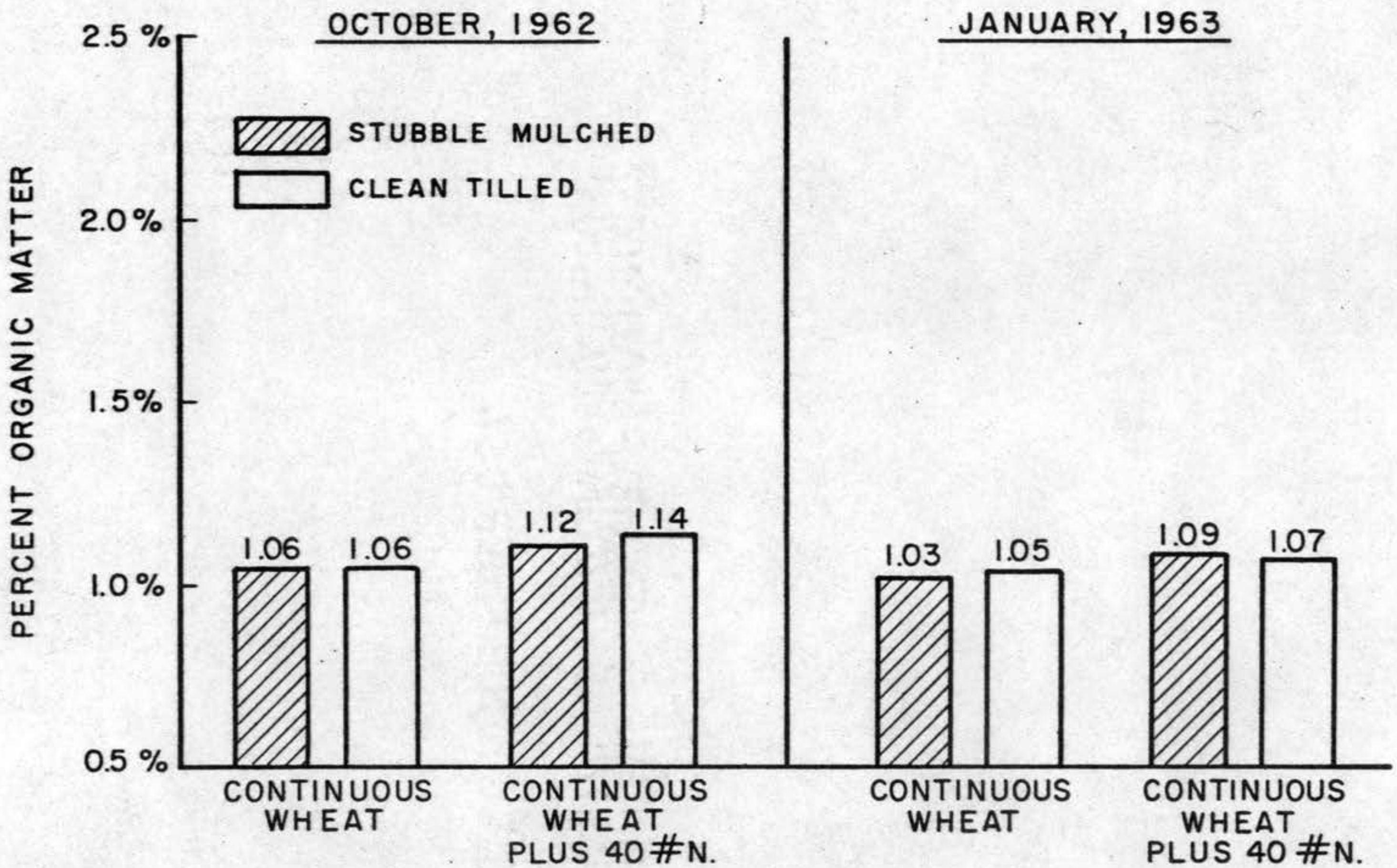

Figure 6. Percent Organic Matter in the Soil as Influenced by Residue Management and Nitrogen Applications.

TABLE V

PERCENT ORGANIC MATTER IN THE SOIL AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATIONS

	10-62 Wheat + 40		10-62 Continuous Wheat	
	S. M.	C. T.	S. M.	C. T.
0-6	1.07	1.23	1.07	1.09
6-12	1.10	1.17	1.12	1.11
12-18	.91	1.04	.98	.91

	1-63		1-63	
0-6	1.31	1.06	1.12	1.18
6-12	1.17	1.18	1.10	1.11
12-18	1.00	1.09	1.23	1.02
18-24	.88	.70	.88	.90

regardless of tillage procedure (Tables V and VIII). The decrease in organic matter was more consistent on the plots which had not been deep plowed in order to disrupt the plow pan.

Statistically, there were significant differences of the percent of organic matter as a result of several sources of variation. Among these sources were replications, depth, treatment and tillage (Table VIII).

Nitrate Nitrogen in the Soil as Influenced by Tillage Procedures, Residue Management and Nitrogen Applications

The greatest accumulation of nitrate nitrogen was from the clean tilled treatments regardless of the date of sampling or the addition of nitrogen on continuous wheat treatments (Figures 7, 8 and 9, and Table VI). The differences in amount of nitrate nitrogen present ranged from 37 pounds additional nitrate nitrogen on continuous wheat receiving 40 pounds per acre of fertilizer nitrogen for date (2) and 23 pounds for date (1) down to 18 pounds nitrate nitrogen for date (1) and 11 pounds nitrate nitrogen for date (2) on continuous wheat treatments.

Greater amounts of nitrate nitrogen were found in October, 1962, than in January, 1963 (Figure 9). This suggests that considerable amounts of nitrate nitrogen had been used by the wheat plant by January, 1963, or that during the summer of 1962 there was not sufficient rainfall to leach the nitrates; therefore, an accumulation occurred in the fall. This agrees with previous work by Greene (8), in which rather large amounts of nitrate nitrogen accumulated during

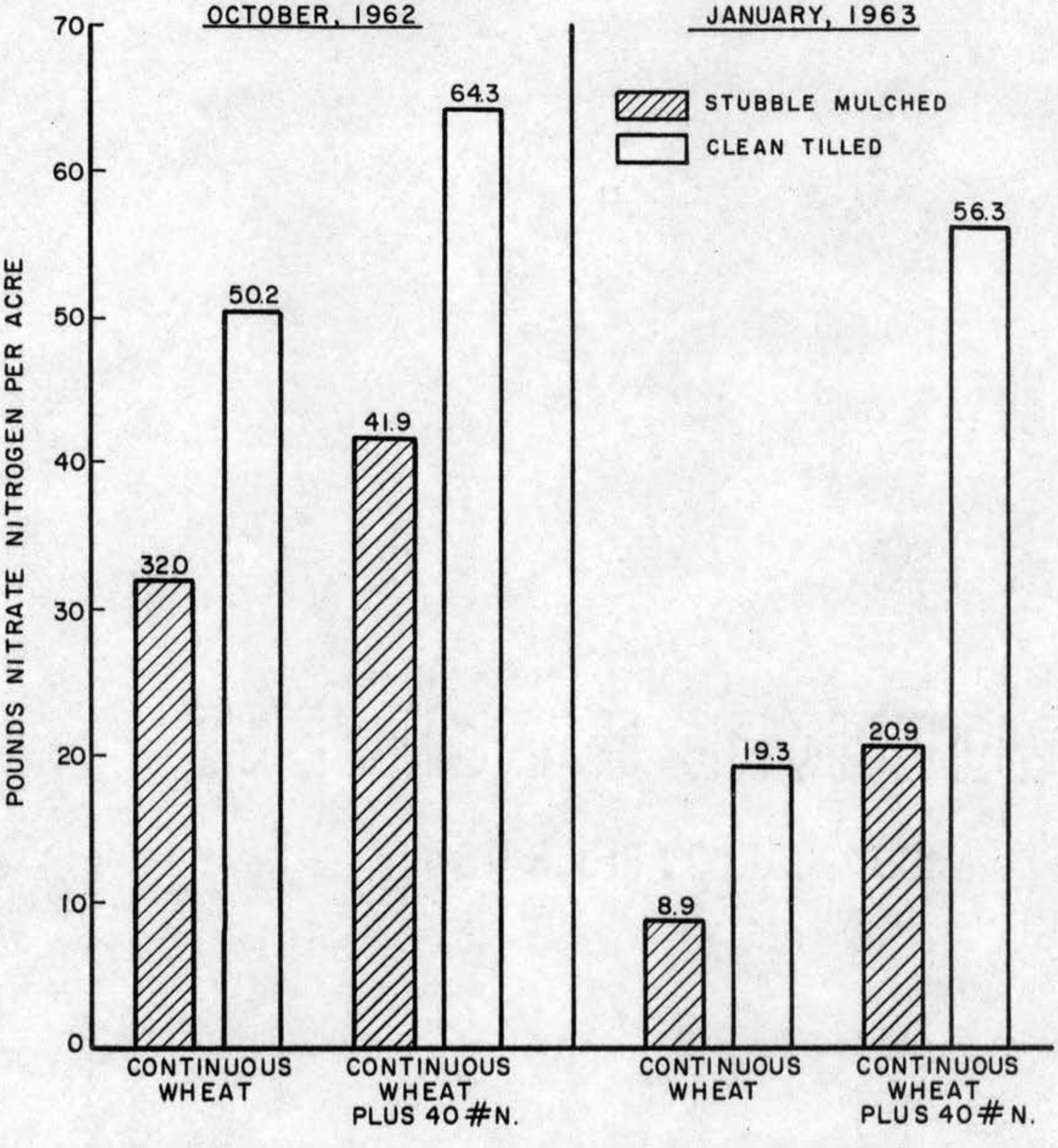

Figure 7. Nitrate Nitrogen in the Soil as Influenced by Residue Management and Nitrogen Application.

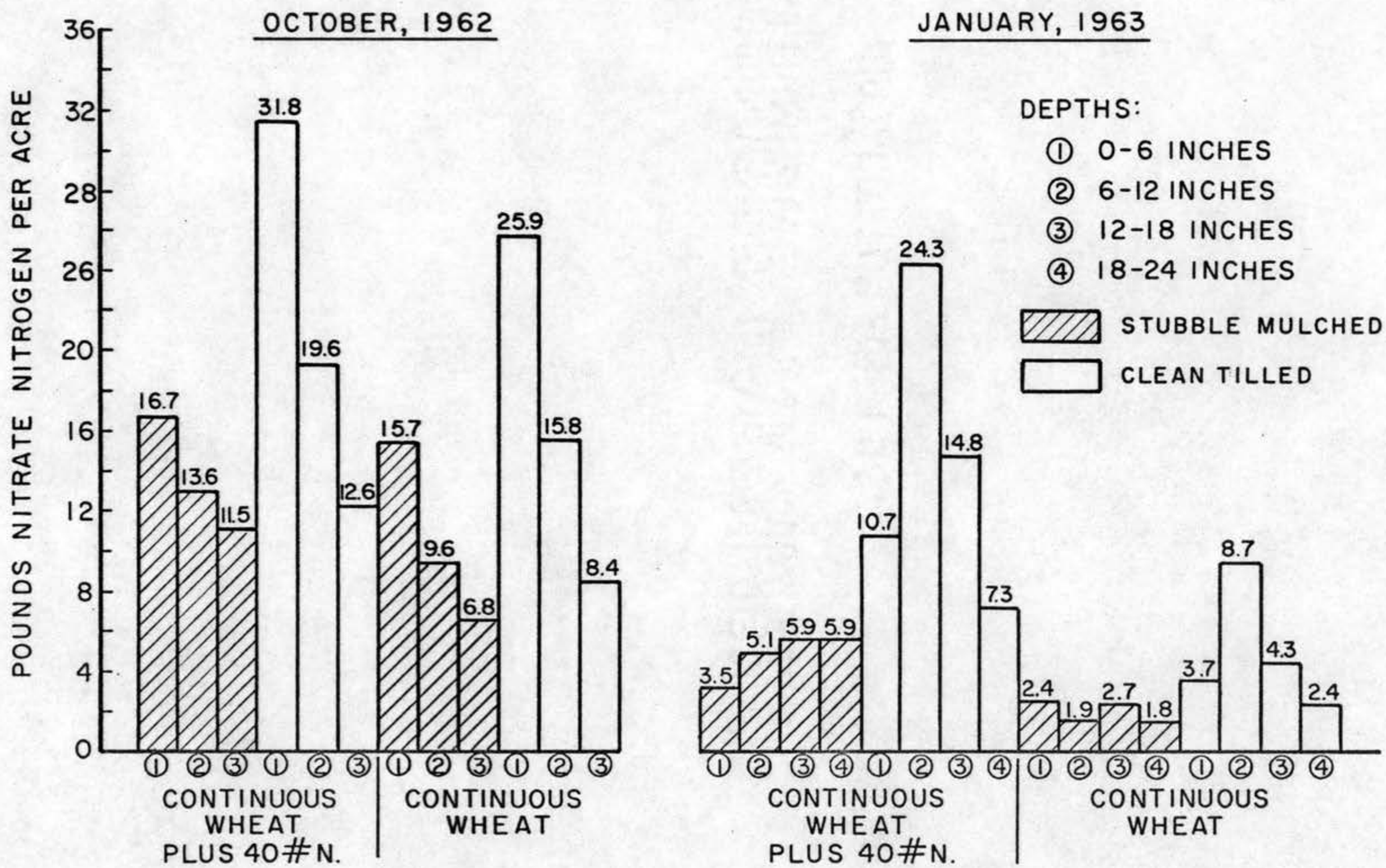

Figure 8. Nitrate Nitrogen as Influenced by Residue Management and Nitrogen Applications.

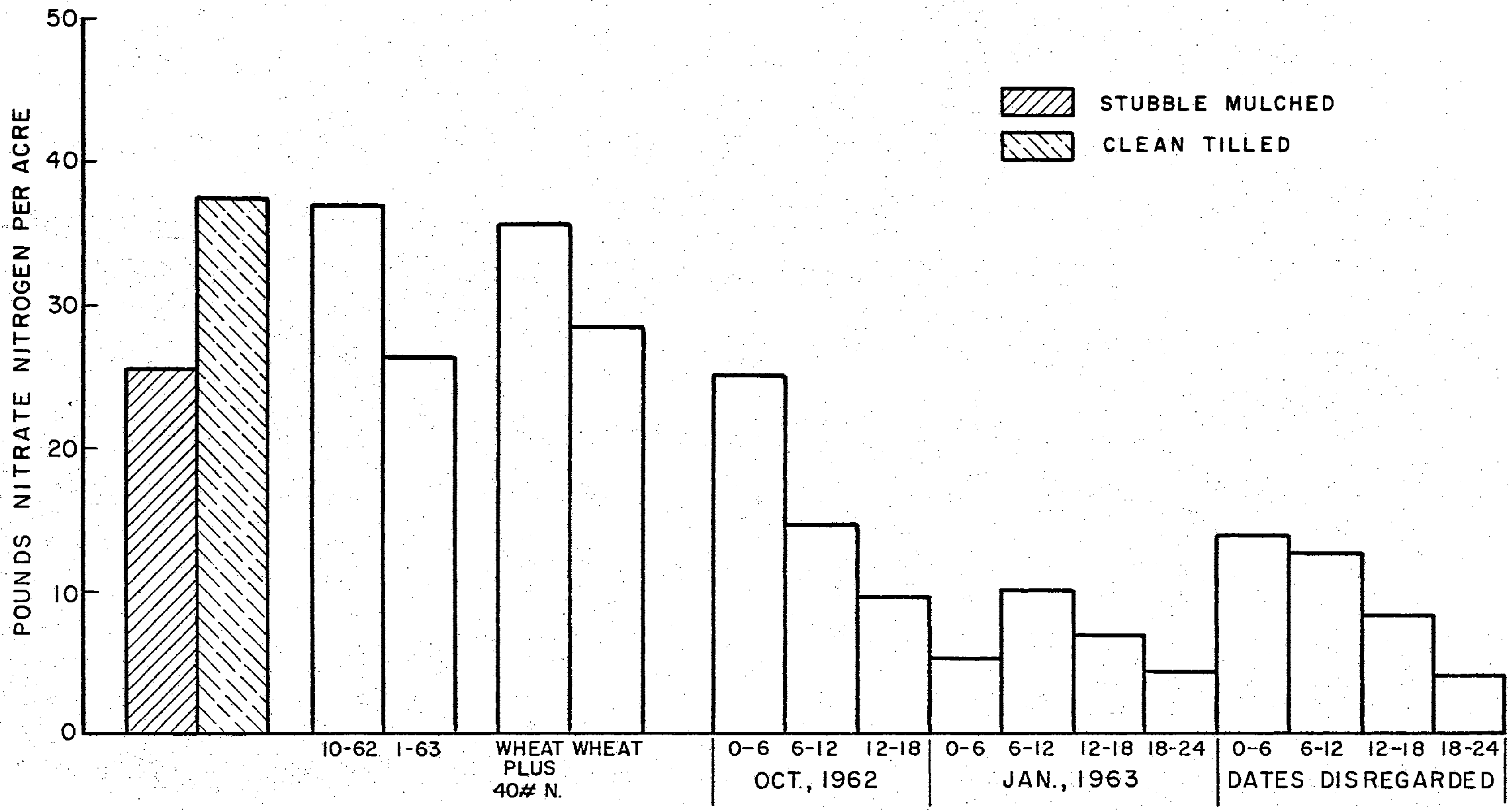

Figure 9. Nitrate Nitrogen as Influenced by Residue Management and Nitrogen Applications.

TABLE VI

NITRATE CONTENT OF SOIL AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATIONS

(Pounds Nitrate Nitrogen Per Acre)

	10-62		1-63	
	Continuous Wheat + 40 lbs. Nitrogen		Continuous Wheat + 40 lbs. Nitrogen	
	S.M.	C.T.	S.M.	C.T.
0-6	16.7	31.8	3.5	10.7
6-12	13.6	19.6	5.1	24.3
12-18	11.5	12.6	5.9	14.8
18-24			5.9	7.3
	Continuous Wheat		Continuous Wheat	
0-6	15.7	25.9	2.4	3.7
6-12	9.6	15.8	1.9	8.7
12-18	6.8	8.4	2.7	4.3
18-24			1.8	2.4

the fallow season but were rapidly utilized by the growing wheat seedlings.

Nitrate nitrogen was found in greater concentration in 0-6 inch depth than any other 6 inch depth for October, 1962. Generally the reverse was true for the January, 1963. The 0-6 inch depth had less nitrate nitrogen than the other 6 inch depths excluding the 18-24 inch depth (Table VI and Figures 8 and 9).

As shown graphically in Figure 9, nitrogen accumulation decreased with depth on the fallowed soil. When plants start growing, nitrates were extracted in greater amounts from shallow depths. This tends to equalize nitrate concentrations throughout the profile.

Almost twice as much nitrate nitrogen was found in clean tilled treatments as in stubble mulch treatments where tillage alone was considered (Figure 9). This would suggest that approximately half of the nitrates available for plant use under clean tillage will be involved in decomposition and unavailable for plant use under stubble mulching. Nitrate nitrogen found in clean tilled treatments was 48 pounds per acre as compared with 26 pounds per acre for stubble mulched treatments.

Statistically, there were significant differences of nitrate nitrogen present as a result of depth and treatment, date, tillage and some interactions (Table VIII).

Nitrate Nitrogen in Soil After Incubation as Influenced by Residue Management and Nitrogen Applications

Nitrate nitrogen present in the soil after incubation was greater than that found in soils before incubation in the 0-6 inch or the 6-12 inch depths (Table VII and Figure 10). Nitrate nitrogen was found to

TABLE VII

NITRATE NITROGEN IN THE SOIL BEFORE AND AFTER INCUBATION OF THE SOIL AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATIONS

(Pounds Per Acre)

	OCTOBER 1962				JANUARY 1963			
	Before SM	After SM	Before CT	After CT	Before SM	After SM	Before CT	After CT
Continuous Wheat + 40 Pounds Nitrogen								
0-6	16.8	69.9	31.9	61.8	3.4	115.7	10.8	50.1
6-12	13.6	22.5	19.7	45.3	5.2	63.0	23.4	44.0
12-18	11.5	5.7	12.7	6.7	6.0	48.3	14.7	5.9
18-24					6.0	11.3	7.4	5.1
Continuous Wheat								
0-6	15.7	56.2	25.9	44.6	2.4	43.7	3.7	52.8
6-12	9.7	25.3	15.8	22.6	2.0	29.0	8.8	32.2
12-18	6.9	11.0	8.5	2.4	2.7	11.2	4.3	8.6
18-24					1.8	5.4	2.5	18.1

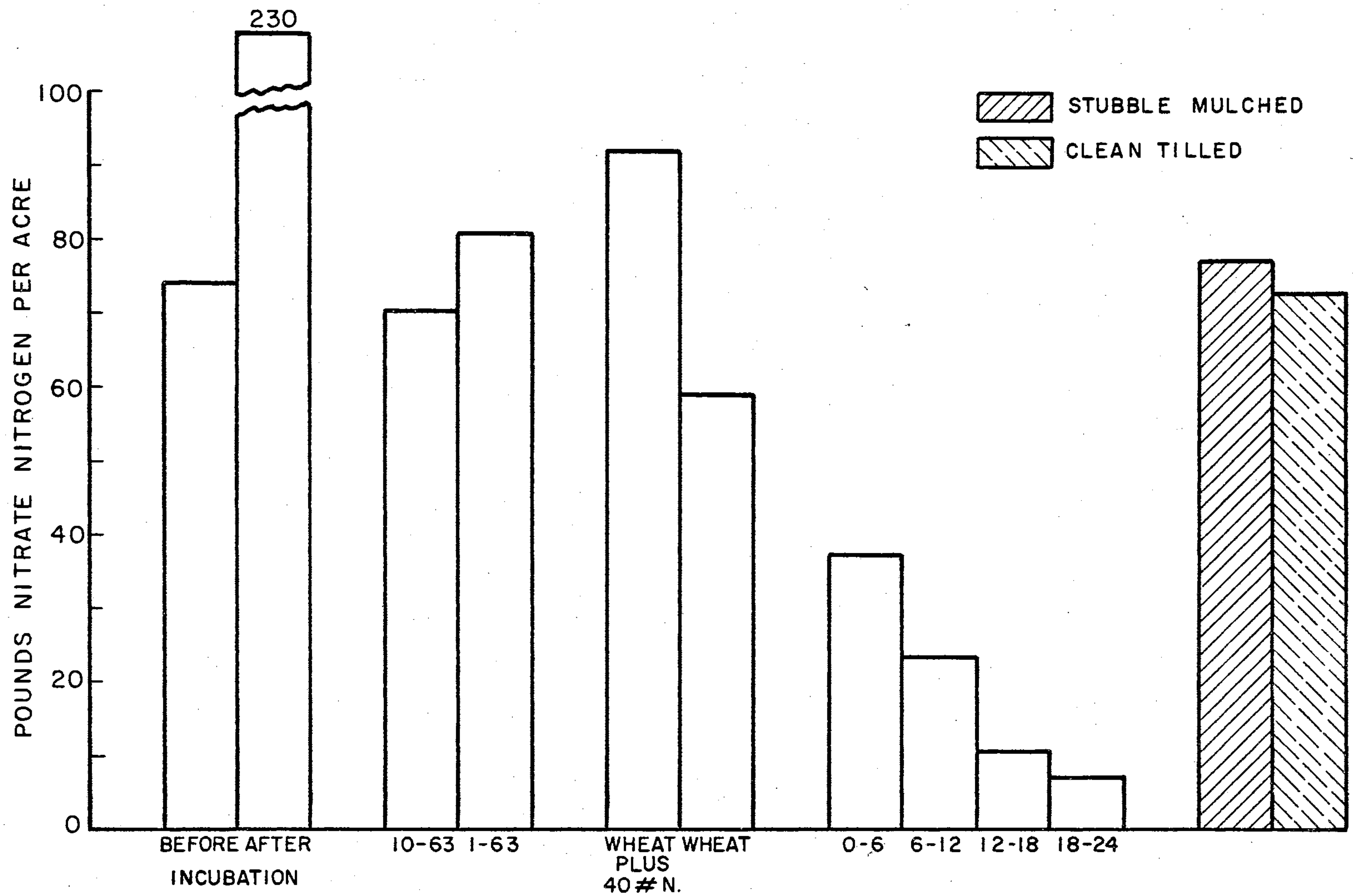

Figure 10. Nitrate Nitrogen as Influenced by Residue Management, Nitrogen Application and Incubation.

be more than three times greater in the same soil after incubation than before incubation. Disregarding all treatments except incubation, it was found that before incubation there was 74 pounds of nitrate nitrogen per acre present as compared with 230 pounds after incubation (Figure 10).

Nitrate nitrogen per acre was higher from samples collected in January, 1963, than for those collected in October, 1962. This was the reverse found on unincubated soils (Figure 10). The difference was only 10.6 pounds of nitrate nitrogen after incubation in favor of January, 1963, as compared with 21 pounds per acre in favor of October, 1962, before incubation (Figures 9 and 10).

Stubble mulched treatments yielded 77.9 pounds of nitrate nitrogen per acre as compared with 73.7 pounds for clean tilled treatments. This was also a reversal of nitrate present as a result of treatment comparing incubated and nonincubated samples (Figure 10).

Continuous wheat plus 40 pounds of nitrogen yielded a greater amount of nitrate nitrogen (92 pounds per acre) than did the no nitrogen treatments, (59 pounds per acre). This difference was greater than the difference in amount of nitrate nitrogen present before incubation of only 17 pounds per acre.

Nitrate nitrogen present after incubation was greatest in the 0-6 inch depth and was progressively less at greater depths (Figure 10). This was the same condition found before incubation, except the differences found from depth to depth were greater after incubation. The decreased nitrate concentration with depth probably is due to a decrease in organic matter with depth.

The higher incubated nitrate nitrogen on stubble mulched plots as compared with clean tillage indicates that nitrate nitrogen measurements directly out of the field are better indicators of nitrogen needs than on incubated samples. It is a well-known fact that the nitrogen requirements for wheat grown under stubble mulching is higher than that grown on clean-tilled land. Nitrate nitrogen measurements on field samples verify these observations, whereas nitrate nitrogen measurements on incubated samples would lead to reverse conclusions. However, over a period of several seasons, the measurements on incubated samples may reflect the true nitrogen supplying-power of the soil.

Statistically, there were significant differences of nitrate nitrogen present after incubation as a result of primarily depth and treatment (Table VIII).

Ammonia Nitrogen In the Soil as Influenced by Residue Management and Nitrogen Application

Ammonia nitrogen present in the soil was not influenced by residue management or nitrogen applications (Figure 11). This was considerably different from the influences found in the case of nitrate nitrogen and total nitrogen in the soil.

There was a slight difference in ammonia nitrogen present in the soil for October, 1962, and January, 1963. October, 1962, soil samples had 105 pounds of ammonia nitrogen as compared with 112 pounds for January, 1963 (Figure 11). This is a difference of only 7 pounds per acre, which probably is not significant.

Ammonia nitrogen present at the different depths of soil varied but slightly. The greatest amount appeared in 0-6 inch depth with a

TABLE VIII

ANALYSIS OF VARIANCE ON INFLUENCE OF RESIDUE MANAGEMENT AND NITROGEN APPLICATIONS UPON SOME OF THE NITROGEN FRACTIONS OF THE SOIL
TOTAL POUNDS NITROGEN PER ACRE

(VARIABLE 1)

	Tillage Combined	Reps Combined	Depth Combined	Treatment Combined	Dates Combined	Plow Pan Combined
Replications	NS	NS[3]	NS	NS	NS	NS
Depth	*[1]	NS	NS	**[2]	**	**
Depth x Replications	NS	NS	NS	NS	NS	NS
Treatment	NS	NS	NS	NS	NS	NS
Depth x Treatment	NS	*	NS	NS	NS	NS
Date	NS	*	NS	NS	NS	NS
Depth x Date	NS	NS	NS	NS	NS	NS
Treatment x Date	NS	NS	NS	NS	NS	NS
Depth x Treatment x Date	NS	NS	NS	NS	NS	NS
Plow Pan	NS	NS	NS	NS	NS	NS
Depth x Plow Pan	NS	NS	NS	NS	NS	NS
Treatment x Plow Pan	NS	NS	NS	NS	NS	NS
Date x Plow Pan	NS	NS	NS	NS	NS	NS
Depth x Treatment x Plow Pan	NS	NS	NS	NS	NS	NS
Depth x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Treatment x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Depth x Treatment x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage	NS	NS	NS	NS	NS	NS
Plow Pan x Tillage	NS	NS	NS	NS	NS	NS
Tillage x Depth	NS	NS	NS	NS	NS	NS
Tillage x Treatment	NS	NS	NS	NS	NS	NS
Tillage x Depth x Treatment	NS	NS	NS	NS	NS	NS
Tillage x Date	NS	NS	NS	NS	NS	NS
Tillage x Depth x Date	NS	*	NS	NS	NS	NS
Tillage x Treatment x Date	NS	NS	NS	NS	NS	NS
Tillage x Depth x Treatment x Date	NS	NS	NS	NS	NS	NS
Tillage x Treatment x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Treatment x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Replications	NS	NS	NS	*	*	*
Tillage x Depth x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Depth x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Depth x Treatment x Plow Pan	NS	NS	NS	NS	NS	NS

[1]* means significant at 5 percent level

[2]** means significant at 1 percent level (highly significant)

[3]NS means not significant below the 5 percent level

TABLE VIII (Continued)

TOTAL POUNDS NITRATE NITROGEN PER ACRE

(VARIABLE 2)

	Tillage Combined	Reps Combined	Depth Combined	Treatment Combined	Dates Combined	Plow Pan Combined
Replications	NS	NS	NS	NS	NS	NS
Depth	**	**	NS	**	**	**
Depth x Replications	NS	NS	NS	NS	NS	NS
Treatment	**	**	*	NS	**	**
Depth x Treatment	NS	NS	NS	NS	NS	NS
Date	**	**	**	**	NS	**
Depth x Date	**	**	NS	**	NS	**
Treatment x Date	*	*	NS	NS	NS	NS
Depth x Treatment x Date	NS	NS	NS	NS	NS	NS
Plow Pan	**	**	*	**	*	NS
Depth x Plow Pan	NS	NS	NS	NS	NS	NS
Treatment x Plow Pan	NS	NS	NS	NS	NS	NS
Date x Plow Pan	NS	NS	NS	NS	NS	NS
Depth x Treatment x Plow Pan	NS	NS	NS	NS	NS	NS
Depth x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Treatment x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Depth x Treatment x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage	NS	**	**	**	**	**
Plow Pan x Tillage	NS	*	*	*	*	NS
Tillage x Depth	NS	*	NS	**	*	**
Tillage x Treatment	NS	*	NS	NS	**	**
Tillage x Depth x Treatment	NS	NS	NS	NS	NS	NS
Tillage x Date	NS	NS	NS	NS	NS	NS
Tillage x Depth x Date	NS	**	NS	*	NS	*
Tillage x Treatment x Date	NS	**	NS	NS	NS	NS
Tillage x Depth x Treatment x Date	NS	NS	NS	NS	NS	NS
Tillage x Treatment x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Treatment x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Replications	NS	NS	NS	NS	NS	NS
Tillage x Depth x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Depth x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Depth x Treatment x Plow Pan	NS	NS	NS	NS	NS	NS

TABLE VIII (Continued)

PERCENT ORGANIC MATTER

(VARIABLE 3)

	Tillage Combined	Reps Combined	Depth Combined	Treatment Combined	Dates Combined	Plow Pan Combined
Replications	NS	NS	NS	**	**	**
Depth	NS	**	NS	**	**	**
Depth x Replications	NS	NS	NS	NS	NS	NS
Treatment	NS	*	*	NS	*	*
Depth x Treatment	NS	NS	NS	NS	NS	NS
Date	NS	*	NS	NS	NS	NS
Depth x Date	NS	NS	NS	NS	NS	NS
Treatment x Date	NS	NS	NS	NS	NS	NS
Depth x Treatment x Date	NS	NS	NS	NS	NS	NS
Plow Pan	NS	NS	NS	NS	NS	NS
Depth x Plow Pan	NS	NS	NS	NS	NS	NS
Treatment x Plow Pan	NS	NS	NS	NS	NS	NS
Date x Plow Pan	NS	NS	NS	NS	NS	NS
Depth x Treatment x Plow Pan	NS	NS	NS	NS	NS	NS
Depth x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Treatment x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Depth x Treatment x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage	*	NS	NS	*	*	*
Plow Pan x Tillage	NS	NS	NS	NS	NS	NS
Tillage x Depth	NS	NS	NS	*	*	*
Tillage x Treatment	NS	NS	NS	NS	NS	NS
Tillage x Depth x Treatment	NS	NS	NS	NS	NS	NS
Tillage x Date	NS	NS	NS	NS	NS	NS
Tillage x Depth x Date	NS	NS	NS	NS	NS	NS
Tillage x Treatment x Date	NS	NS	NS	NS	NS	NS
Tillage x Depth x Treatment x Date	NS	NS	NS	NS	NS	NS
Tillage x Treatment x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Treatment x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Replications	NS	NS	*	**	**	**
Tillage x Depth x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Depth x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Depth x Treatment x Plow Pan	NS	NS	NS	NS	NS	NS

TABLE VIII (Continued)

TOTAL POUNDS NITRATE NITROGEN AFTER INCUBATION

(VARIABLE 4)

	Tillage Combined	Reps Combined	Depth Combined	Treatment Combined	Dates Combined	Plow Pan Combined
Replications	NS	NS	NS	NS	NS	NS
Depth	**	**	NS	*	*	*
Depth x Replications	NS	NS	NS	NS	NS	NS
Treatment	*	**	NS	NS	*	*
Depth x Treatment	NS	NS	NS	NS	NS	NS
Date	NS	**	NS	NS	NS	NS
Depth x Date	NS	NS	NS	NS	NS	NS
Treatment x Date	NS	*	NS	NS	NS	NS
Depth x Treatment x Date	NS	NS	NS	NS	NS	NS
Plow Pan	NS	NS	*	NS	NS	NS
Depth x Plow Pan	NS	NS	NS	NS	NS	NS
Treatment x Plow Pan	NS	NS	NS	NS	NS	NS
Date x Plow Pan	NS	NS	NS	NS	NS	NS
Depth x Treatment x Plow Pan	NS	NS	NS	NS	NS	NS
Depth x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Treatment x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Depth x Treatment x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage	NS	NS	NS	NS	NS	NS
Plow Pan x Tillage	NS	NS	NS	NS	NS	NS
Tillage x Depth	NS	NS	NS	NS	NS	NS
Tillage x Treatment	NS	*	NS	NS	NS	NS
Tillage x Depth x Treatment	NS	NS	NS	NS	NS	NS
Tillage x Date	NS	**	NS	NS	NS	NS
Tillage x Depth x Date	NS	NS	NS	NS	NS	NS
Tillage x Treatment x Date	NS	**	NS	NS	NS	NS
Tillage x Depth x Treatment x Date	NS	NS	NS	NS	NS	NS
Tillage x Treatment x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Treatment x Date x Plow Pan	NS	NS	*	NS	NS	NS
Tillage x Replications	NS	NS	NS	NS	NS	NS
Tillage x Depth x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Depth x Date x Plow Pan	NS	NS	NS	NS	NS	NS
Tillage x Depth x Treatment x Plow Pan	NS	NS	NS	NS	NS	NS

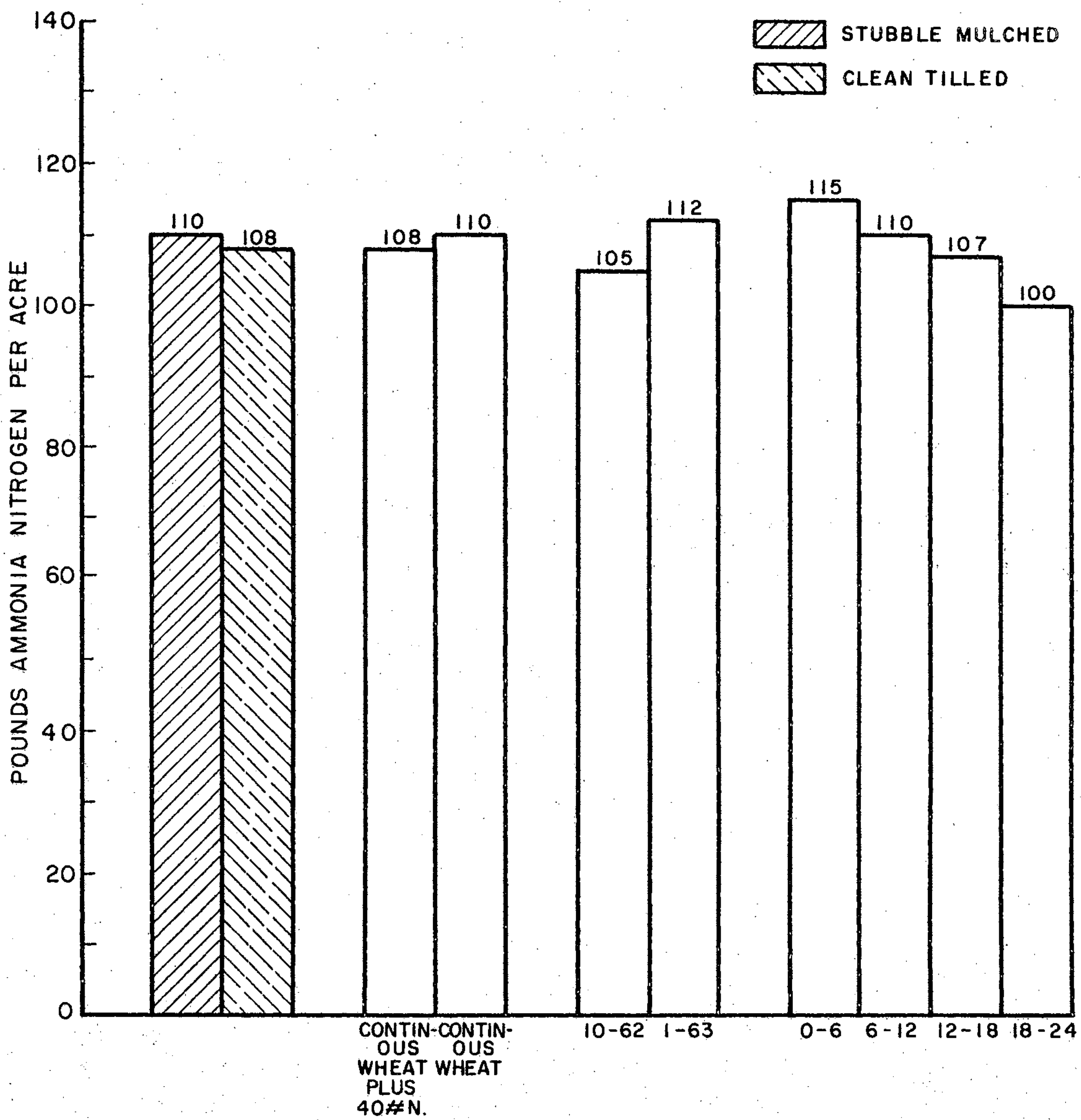

Figure 11. Ammonia Nitrogen in the Soil as Influenced by Residue Management and Nitrogen Application.

slight decrease present with each succeeding 6 inch depth (Figure 11). There was a difference of only 15 pounds of ammonia nitrogen difference between the 0-6 inch depth of 115 pounds to the 18-24 inch depth with 100 pounds. These differences are small and probably not significant. An analysis of variance was not computed for this variable.

Yield Response as Influenced by Residue Management, Tillage Procedures and Nitrogen Application

Although the primary objective of this study was concerned with the nitrogen fractions of the soil, the grain yields were subjected to statistical analysis. Statistically, there were significant differences primarily with treatment, tillage and an interaction of treatment and tillage (Table IX).

SUMMARY

Differences in total nitrogen amounts were very small regardless of residue management or addition of 40 pounds of nitrogen per acre.

Organic matter was found to be slightly higher on treatments which had received 40 pounds of nitrogen per acre. Organic matter content was found to be higher in the 0-12 inch depths than in lower levels.

Clean tilled treatments contained more nitrate nitrogen per acre than did the stubble mulched treatments. Residue management influenced nitrate nitrogen content to a greater extent than did date of sampling or addition of nitrogen.

Nitrate nitrogen was found to be higher in soils after incubation from the 0-6 and 6-12 inch depths. Stubble mulched treatments contained higher amounts of nitrate nitrogen after incubation which is a reversal from before incubation. Nitrate nitrogen was also found to be higher on treatments receiving 40 pounds of nitrogen per acre per year after incubation.

Ammonia nitrogen content of the soil stayed constant. Residue management, date or depth of sampling, or nitrogen application had no influence on amount of ammonia nitrogen present.

TABLE IX

SUMMARY OF SIGNIFICANCE FOR YIELD OF WHEAT GRAIN
FOR YEARS 1957-1963

	1957	1958	1959	1960	1961	1962	1963
Replications	NS[1]	NS	NS	NS	NS	NS	NS
Tillage	NS	NS	*[2]	*	*	NS	NS
Tillage x Replications	NS	NS	NS	NS	NS	NS	NS
Treatment	NS	NS	*	*	*	*	*
Tillage x Treatment	NS	NS	NS	*	*	NS	NS
Plow Pan	NS	NS	NS	NS	NS	*	NS
Tillage x Plow Pan	NS	NS	NS	NS	NS	NS	*
Treatment x Plow Pan	*	NS	NS	NS	NS	NS	NS
Treatment x Tillage x Plow Pan	NS	NS	NS	NS	NS	*	NS

[1]NS means not significant below the 5% level

[2] * means significant at 5% level

CHAPTER V

NITRATE NITROGEN ACCUMULATION IN INCUBATED SOILS AS INFLUENCED BY RESIDUE AND NITROGEN APPLICATION

Materials and Methods

This experiment was designed as a split-split plot experimental design with nitrogen treatments being main plots, residue treatments being sub plots and days of incubation being sub-sub plots.

The main plot treatments are 0 nitrogen and 400 pounds nitrogen per acre. The nitrogen material used was ammonium nitrate which was dissolved in distilled water and mixed with the soil as a solution.

The nitrogen solution was used to bring the soil moisture to 1/2 atmospheres of tension. Soils which received no nitrogen solution were brought to 1/2 atmospheres of tension with distilled water. Moisture was maintained at that level in all samples by adding water as frequently as it was determined by weighing that moisture was leaving the media.

The sub-plot treatments, rates of residue, were 0, 2400 pounds and 12,000 pounds per acre. Residue used was very finely ground wheat straw. This material was added in proper amounts by weight to each sample of soil.

The sub-sub plot treatments were 5 dates of 4-day intervals. At each of the 5 dates a complete set of treatments, replicated 3 times, were taken from incubation and frozen until all samples had incubated the proper length of time.

Nitrate determinations were made on all soils at the end of the 20-day period. Nitrate nitrogen was determined by the phenoldesulfonic acid method as outlined by Jackson (12).

Incubation of soil took place in a controlled temperature room of 25° centigrade. Soil was contained in a plastic food container for incubation with a small hole partially plugged with cotton to allow a small amount of air passage.

Soil for this experiment was taken from the Wheatland Conservation Experiment Station, Cherokee, Oklahoma. This soil was a Grant silt loam, 1 to 3 percent slope. Soil used for this study came from the 0 to 6 inch depth.

Results and Discussion

This study was designed to ascertain the relationship between added residue and nitrogen immobilization in the soil selected.

The addition of 2400 pounds of residue with no added nitrogen essentially resulted in no change in nitrate nitrogen under incubation (Figures 12 and 13). This would indicate that there was approximately enough nitrogen present in the soil to decompose the residue and have 35 to 40 pounds of nitrate nitrogen available for plant use.

An increase in amount of nitrate nitrogen was recorded for each succeeding date, where there was no added residue and on soils where 2400 pounds of residue per acre and 400 pounds of nitrogen per acre were added (Figure 13). This increase in the case of soils with the

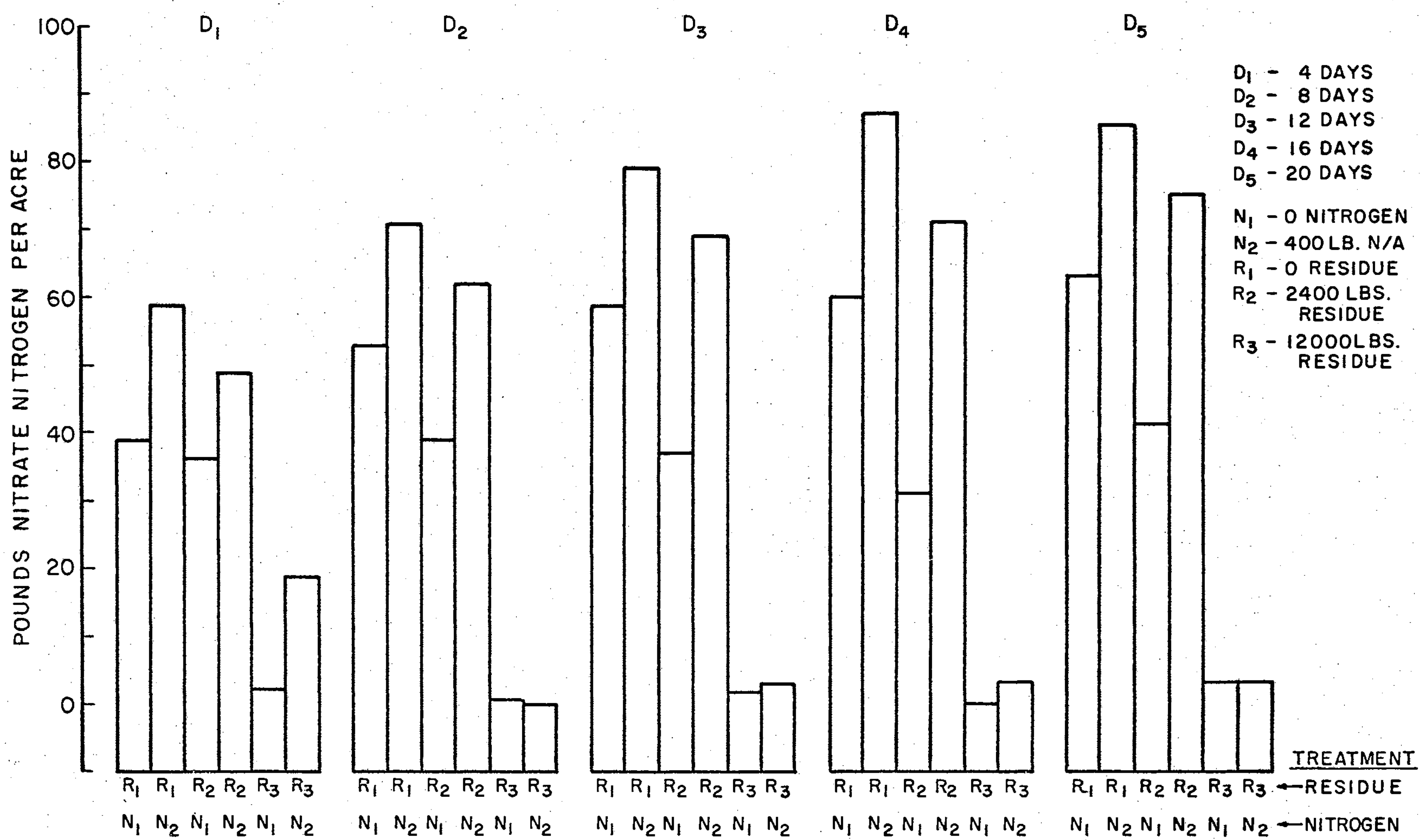

Figure 12. Nitrate Nitrogen Produced Under Incubation as Influenced by Residue Rates and Nitrogen Applications on Grant Silt Loam Soil.

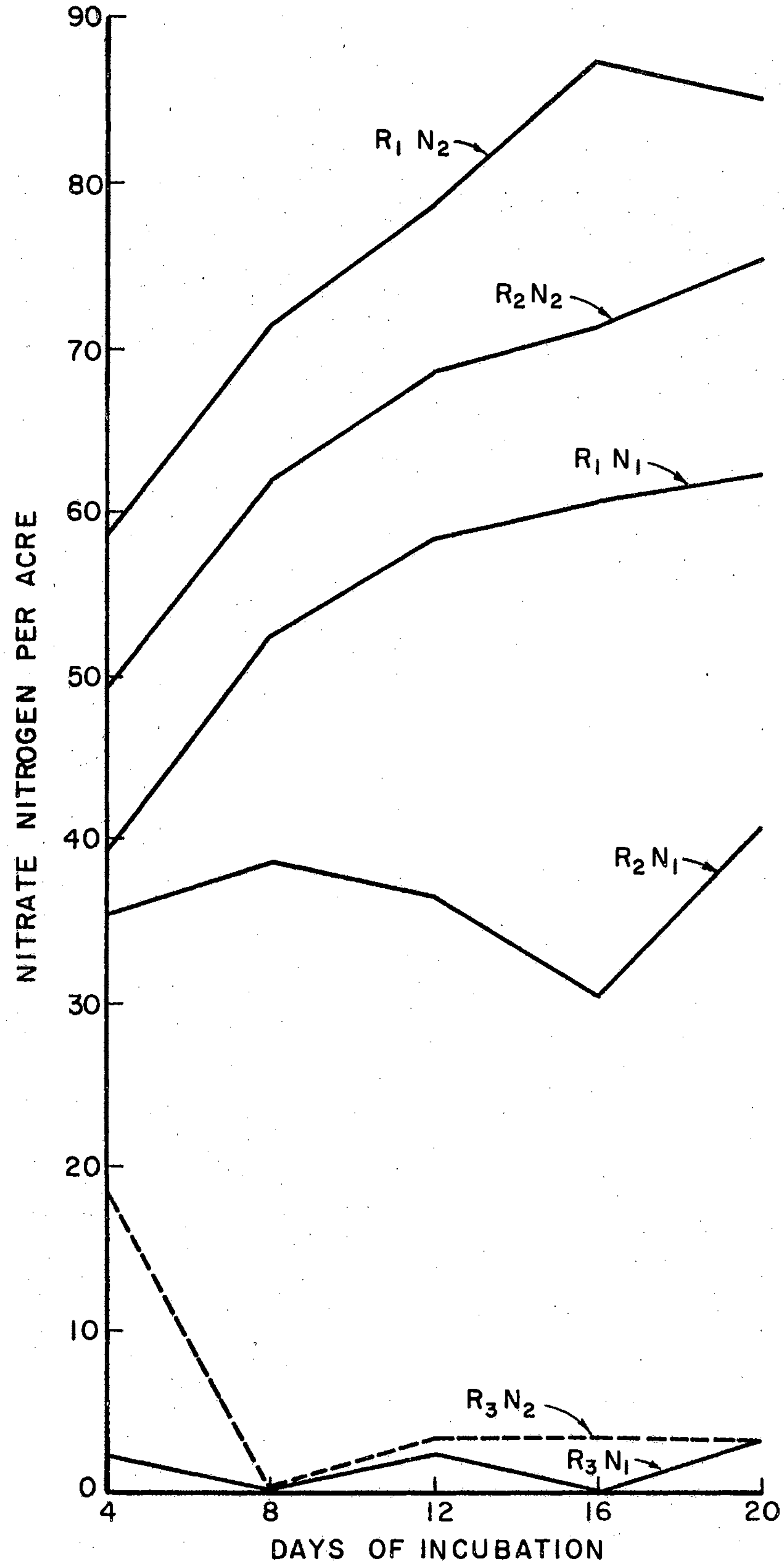

Figure 13. Nitrate Nitrogen in Incubated Soil as Influenced by Residue Rates and Nitrogen Applications on Grant Silt Loam Soil.

added nitrogen is believed to be from the conversion of ammonia nitrogen to nitrate nitrogen.

Where residue rates of 12,000 pounds were used, nitrate nitrogen was completely immobilized (Figure 13). This would suggest that between 2400 and 12,000 pounds of residue will completely immobilize all the nitrate nitrogen produced by the soil leaving little nitrogen for plant growth.

With this proof of nitrate immobilization occurring with high rates of residue some refinement within the rates need to be carried out. This additional information would help in making prediction of how much nitrogen fertilizer would have to be added to a certain soil with a given amount of residue in order to furnish sufficient nitrate nitrogen to overcome the immobilization. This refinement could possibly be accomplished by adding to a soil certain amounts of residue, 500, 1000, 1500, 2000 and 2500 pounds, and at the end of 12 to 20 days of incubation determine nitrate nitrogen. This would indicate the nitrogen supply of the soil. From this information recommendations could be made of how much nitrogen per acre should be added to have a desired amount of nitrogen available for plants.

SUMMARY

It was determined that immobilization of soil nitrogen of Grant Silt Loam was complete with the addition of 12,000 pounds of residue per acre. The addition of 400 pound of nitrogen per acre and incubation at 25° C. up to 20 days had little or no effect on the immobilization.

Nitrate nitrogen increased with increased incubation time with and without added nitrogen when no residue was added to the sample.

An increase of nitrate nitrogen was also recorded with 2400 pounds of residue and 400 pounds of nitrogen per acre.

Nitrate nitrogen remained about stable with 2400 pounds of residue and no nitrogen during sampling periods.

The limits established in this study for nitrogen mobilization is a point from which it may be possible to work out further refinements. It is possible that this procedure may be perfected for determining the nitrogen supplying power of wheatland soils. Also, it may be possible to develop a procedure of this type to help ascertain nitrogen needs based upon residue at seeding time or the previous straw crop.

CONCLUSION

Nitrate nitrogen accumulations were higher on the clean tilled plots than on stubble mulched plots and accumulations within the profile were not noted until rates exceeded 80 pounds per acre. Nitrates generally accumulated in the surface soil (above 18 inches) and did not readily leach below that depth.

Nitrate nitrogen accumulations in the 24-inch soil profile at seeding of winter wheat appears to be a better indicator of nitrogen supplying power of the soil for subsequent crop production than nitrifiable nitrogen upon incubation.

Organic matter measured slightly higher on continuous wheat plots that had received annual applications of 40 pounds of nitrogen per acre for 7 years as compared with continuous wheat plots without nitrogen. Nitrifiable nitrogen was much greater on stubble mulched plots than on clean tilled plots indicating nitrogen immobilization by undecomposed residue.

The addition of wheat straw to soil samples being incubated for nitrifiable nitrogen shows promise as a method to determine the nitrogen supplying power of the soil as well as determining the influence of wheat straw on nitrogen requirement of the subsequent wheat crop.

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APPENDICES

APPENDIX A

3-A <u>Pond Creek silt loam</u>, 0-1 percent slopes

This unit comprises brown and grayish-brown soils with moderate development which occurs on nearly dead flat upland areas. B2 horizons are non-calcareous and may range in texture from clay loam to silty clay loam. This horizon is less reddish, heavier and has stronger, more blockly structure than 2-B, Grant silt loam. Small areas of Grant silt loam occur in this unit. The Pond Creek soils are well drained but the permeability is slower than in the more permeable Grant soils.

Representative profile of Pond Creek silt loam (cultivated) S62-OKLA-2-4 (4), was described 300' east of center of Section 16.

A1	0-18"	Dark brown (10YR 3/3) silt loam, brown (10YR 4/3) dry; weak fine and medium plates crushes easy granule; friable; pH 6.5 (Hillige); plowed boundary.
B1	18-26"	Dark brown (7.5YR 3/4) light silty clay loam, brown (7.5YR 4/4) dry; compound, moderate medium prismatic and subangular blocky; friable; pH 6.8; clear boundary.
B2t	26-48"	Dark brown (7.5YR 4/4) silty clay loam; brown (7.5YR 5/4) dry; moderate medium cubical blocky; firm; ped faces have dark, continuous clay films; a very few, small gravels observed; pH 7.0; gradual boundary.
B3	48-54"	Color as above; silty clay loam; weak medium and coarse blocky; friable; pH 7.8 non-calcareous.

<u>Range in Characteristics:</u>

Surface soil depths vary from 14 to 20 inches. B2 horizons encompass clay loams and silty clay loams and vary from dark brown and brown to dark reddish brown. Several profiles had a few gravels in the B and/or C horizon.

APPENDIX B

2-B Grant silt loam, 1-3 percent slopes

This unit occurs on gentle slopes and is the representative unit of the farm. It differs from Albion in lacking the gravelly substrata within auger depths (48") and from 3-B in having lighter textured, redder and prismatic, rather than blocky B2 horizons. However, small inclusions of these two soils may occur in this extensive mapping unit. It is well drained.

Representative profile of Grant silt loam (cultivated) S62-OKLA-2-2(4), was described 700' south and 700' east of center of Section 16.

A1	0-15"	Dark brown (7.5YR 3/3) silt loam, brown (7.5YR 4/3) dry; weak fine and medium granular; tends to crust or "set up" when dry; friable; pH 6.5; plowed boundary.
A3	15-22"	Dark brown (7.5YR 3/4) heavy loam, brown (7.5YR 4/4) dry; moderate medium granular; friable; pH 7.2; gradual boundary.
B2t	22-34"	Dark reddish brown (5YR 3/4) light clay loam, reddish brown (5YR 4/4) dry; moderate medium prismatic; weak shine on peds; friable; slightly sticky; pH 7.2; gradual boundary.
C	34-54"	Yellowish red (5YR 4/6) light clay loam, yellowish red (5YR 5/6) dry; weakly granular; friable; pH 7.5, non-calcareous.

Range in Characteristics:

Surface (A1) depths vary from 8 to 22 inches; depth to B2, from 16 to 32 inches. Texture of B2 varies from heavy loam to medium clay loam, being heavier on the flatter slopes. A sprinkling of small gravels may occur throughout some profiles but are more commonly found in the deeper subtrata. Some areas have small threads and nodules of lime in the lower substrata.

APPENDIX C

RAINFALL DATA FOR WHEATLAND CONSERVATION EXPERIMENT STATION CHEROKEE, OKLAHOMA (inches)

1961	July	1.72	1962	July	4.57
	August	2.61		August	2.35
	September	3.10		September	3.32
	October	2.17		October	.99
	November	2.58		November	1.02
	December	1.14		December	.73
1962	January	1.12	1963	January	.38
	February	.20		February	.08
	March	.47		March	1.31
	April	2.46		April	2.18
	May	1.97		May	2.07
	June	5.66		June	8.58
TOTAL		25.20			25.56

APPENDIX D

ANALYSIS OF VARIANCE OF NITRATE NITROGEN TO RESIDUE MANAGEMENT, NITROGEN APPLICATION, DATE OF SAMPLING, AND DEPTH OF SAMPLING

Overall Average

Source of Variation	Degree Freedom	Mean Square
Total	479	
Replications	3	120.34
Tillage	1	2647.98*
Replications x Tillage (Error a)	3	106.87
Treatment	4	480.24**
Treatment x Tillage	4	28.71
Error b	24	46.49
Depth	2	142.22**
Depth x Tillage	2	74.90**
Depth x Treatment	8	64.25**
Depth x Tillage x Treatment	8	5.78
Error c	60	13.01
Date	1	655.20**
Date x Tillage	1	22.20
Date x Treatment	4	3.16
Date x Depth	2	138.44**
Date x Tillage x Treatment	4	29.95
Date x Tillage x Depth	2	12.26
Date x Treatment x Depth	8	11.52
Date x Tillage x Treatment x Depth	8	11.87
Error d	90	12.71

Overall Average (Continued)

Source of Variation	Degree Freedom	Mean Square
Year	1	1249.37**
Year x Tillage	1	333.00**
Year x Treatment	4	10.59
Year x Depth	2	388.98**
Year x Date	1	771.15**
Year x Tillage x Treatment	4	12.88
Year x Tillage x Depth	2	151.17**
Year x Treatment x Depth	8	10.61
Year x Tillage x Date	1	5.17
Year x Depth x Date	2	196.86**
Year x Treatment x Date	4	53.80**
Year x Date x Depth x Treatment	8	12.43
Year x Date x Depth x Tillage	2	85.22**
Year x Date x Treatment x Tillage	4	2.75
Year x Tillage x Treatment x Depth	8	15.18
Year x Tillage x Treatment x Depth x Date	8	1.66
Error e	180	15.36

AVERAGE OVER REPLICATIONS

Source of Variation	Degree Freedom	Mean Square
Total	119	
Year	1	1249.36**
Tillage	1	2647.98**
Tillage x Year	1	333.00**
Treatment	4	480.24**
Tillage x Treatment	4	28.71
Error a	8	11.73
Depth	2	142.22
Tillage x Depth	2	74.46
Treatment x Depth	8	64.26
Tillage x Treatment x Depth	8	5.78
Error b		
Date	1	655.20**
Tillage x Date	1	22.10
Treatment x Date	4	3.16
Depth x Date	2	138.44
Tillage x Treatment x Date	4	29.94
Tillage x Depth x Date	2	12.25
Treatment x Depth x Date	8	10.26
Tillage x Treatment x Depth x Date	8	11.85
Error c	30	55.98

AVERAGE OVER DATES

Source of Variation	Degree Freedom	Mean Square
Total	239	
Replications	3	120.34
Tillage	1	2647.98**
Replications x Tillage	3	106.87
Treatment	4	480.24**
Tillage x Treatment	4	28.71
Error a	24	46.49
Depth	2	142.22**
Tillage x Depth	2	74.90**
Treatment x Depth	8	64.25**
Tillage x Treatment x Depth	8	5.78
Error b	60	13.01
Years	1	1249.37**
Tillage x Years	1	333.00**
Treatment x Years	4	10.59
Depth x Years	2	388.98**
Tillage x Treatment x Years	4	12.88
Tillage x Depth x Years	2	151.17**
Treatment x Depth x Years	8	10.61
Tillage x Treatment x Depth x Years	8	15.18
Error c	90	19.60

AVERAGE OVER DEPTH

Source of Variation	Degree Freedom	Mean Square
Total	159	
Replications	3	120.33
Tillage	1	2647.98**
Tillage x Replications	3	106.86
Treatment	4	480.24**
Tillage x Treatment	4	28.71
Error a	24	46.49
Date	1	655.19**
Tillage x Date	1	22.11
Treatment x Date	4	3.16
Tillage x Treatment x Date	4	29.94
Error b	30	26.27
Years	1	1249.39**
Tillage x Years	1	333.01**
Treatment x Years	4	10.59
Date x Years	1	771.15**
Tillage x Treatment x Years	4	12.88
Tillage x Date x Years	4	53.80
Tillage x Treatment x Date x Years	4	2.73
Error c	60	26.27

AVERAGE OVER TILLAGE

Source of Variation	Degree Freedom	Mean Square
Total	239	
Replications	3	120.34**
Treatment	4	480.24**
Treatment x Replications	12	39.52**
Depth	2	142.22**
Treatment x Depth	8	64.25**
Error a	30	11.85
Date	1	655.20**
Treatment x Date	4	3.16
Depth x Date	2	138.44**
Treatment x Depth x Date	8	11.52
Error b	45	15.79
Years	1	1249.37**
Treatment x Years	4	10.59
Depth x Years	2	388.98**
Date x Years	1	771.15**
Treatment x Depth x Years	8	10.61
Treatment x Date x Years	4	53.80
Depth x Date x Years	2	196.87**
Treatment x Depth x Date x Years	8	12.43
Error c	90	15.35

AVERAGE OVER YEARS

Source of Variation	Degree Freedom	Mean Square
Total	239	
Replications	3	120.34
Tillage	1	2647.98**
Tillage x Replications	3	106.87
Treatment	4	480.24**
Tillage x Treatment	4	28.71
Error a	24	46.49
Depth	2	142.22**
Tillage x Depth	2	74.90**
Treatment x Depth	8	64.25**
Tillage x Treatment x Depth	8	5.78
Error b	60	13.01
Date	1	327.60**
Tillage x Date	1	22.10
Treatment x Date	4	3.16
Depth x Date	2	138.44**
Tillage x Treatment x Date	4	29.95
Tillage x Depth x Date	2	12.26
Treatment x Depth x Date	8	11.52
Tillage x Treatment x Depth x Date	8	11.87
Error c	90	12.71

APPENDIX E

ANALYSIS OF VARIANCE OF TOTAL NITROGEN IN THE SOIL AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION

AVERAGE OVER TILLAGE

Source of Variance	Degree Freedom	Mean Square
Total	47	
Replications	1	60.17
Depth	2	3003.58*
Depth x Replications	2	68.08
Treatment	1	216.00
Depth x Treatment	2	608.38
Error a	3	145.08
Date	1	204.17
Depth x Date	2	48.04
Treatment x Date	1	24.00
Depth x Treatment x Date	2	21.13
Error b	6	61.25
Plow Pan	1	66.67
Depth x Plow Pan	2	437.54
Treatment x Plow Pan	1	.17
Date x Plow Pan	1	66.67
Depth x Treatment x Plow Pan	2	86.29
Depth x Date x Plow Pan	2	14.29
Treatment x Date x Plow Pan	1	28.17
Depth x Treatment x Date x Plow Pan	2	104.54
Error c	12	131.25

AVERAGE OVER REPLICATIONS

Source of Variance	Degree Freedom	Mean Square
Total	47	
Plow Pan	1	66.67
Tillage	1	66.67
Plow Pan x Tillage	1	140.17
Depth	2	1501.79
Tillage x Depth	2	73.29
Error a	4	230.29
Treatment	1	216.00
Tillage x Treatment	1	73.50
Depth x Treatment	2	608.38*
Tillage x Depth x Treatment	2	41.38
Error b	6	116.33
Date	1	204.17*
Tillage x Date	1	24.00
Depth x Date	2	48.04
Treatment x Date	1	24.00
Tillage x Depth x Date	2	207.37*
Tillage x Treatment x Date	1	.17
Depth x Treatment x Date	2	21.13
Tillage x Depth x Treatment x Date	2	23.29
Error c	12	34.33

AVERAGE OVER DEPTH

Source of Variance	Degree Freedom	Mean Square
Total	31	
Replications	1	
Tillage	1	66.66
Tillage x Replications	1	560.68
Treatment	1	216.02
Tillage x Treatment	1	73.50
Error a	2	86.41
Date	1	204.16
Tillage x Date	1	24.00
Treatment x Date	1	24.00
Tillage x Treatment x Date	1	.17
Error b	4	127.46
Plow Pan	1	66.66
Tillage x Plow Pan	1	140.18
Treatment x Plow Pan	1	.17
Date x Plow Pan	1	66.67
Tillage x Treatment x Plow Pan	1	416.66
Tillage x Date x Plow Pan	1	28.17
Treatment x Date x Plow Pan	1	28.17
Tillage x Treatment x Date x Plow Pan	1	6.01
Error c	8	112.92

AVERAGE OVER TREATMENT

Source of Variance	Degree Freedom	Mean Square
Total	47	
Replications	1	60.17
Tillage	1	66.67
Tillage x Replications	1	560.67*
Depth	2	1501.79**
Tillage x Depth	2	73.29
Error a	4	32.04
Date	1	204.17
Tillage x Date	1	24.00
Depth x Date	2	48.04
Tillage x Depth x Date	2	207.37
Error b	6	95.83
Plow Pan	1	66.67
Tillage x Plow Pan	1	140.17
Depth x Plow Pan	2	437.54
Date x Plow Pan	1	66.67
Tillage x Depth x Plow Pan	2	23.04
Tillage x Date x Plow Pan	1	28.16
Depth x Date x Plow Pan	2	14.29
Tillage x Depth x Date x Plow Pan	2	5.29
Error c	12	134.50

AVERAGE OVER DATES

Source of Variance	Degree Freedom	Mean Square
Total	47	
Replications	1	60.17
Tillage	1	66.67
Tillage x Replications	1	560.67*
Depth	2	1501.79**
Tillage x Depth	2	73.29
Error a	4	32.04
Treatment	1	216.00
Tillage x Treatment	1	73.50
Depth x Treatment	2	608.38
Tillage x Depth x Treatment	2	41.38
Error b	6	142.17
Plow Pan	1	66.67
Tillage x Plow Pan	1	140.17
Depth x Plow Pan	2	437.54
Treatment x Plow Pan	1	.17
Tillage x Depth x Plow Pan	2	23.04
Tillage x Treatment x Plow Pan	1	416.67
Depth x Treatment x Plow Pan	2	86.29
Tillage x Depth x Treatment x Plow Pan	2	54.29
Error c	12	169.17

AVERAGE OVER PLOW PAN

Source of Variation	Degree Freedom	Mean Square
Total	47	
Replications	1	60.17
Tillage	1	66.67
Tillage x Replications	1	560.67*
Depth	2	1501.79**
Tillage x Depth	2	73.29
Error a	4	32.04
Treatment	1	216.00
Tillage x Treatment	1	73.50
Depth x Treatment	2	608.38
Tillage x Depth x Treatment	2	41.38
Error b	6	142.17
Date	1	204.17
Tillage x Date	1	24.00
Depth x Date	2	48.04
Treatment x Date	1	24.00
Tillage x Depth x Date	2	207.37
Tillage x Treatment x Date	1	.17
Depth x Treatment x Date	2	21.13
Tillage x Depth x Treatment x Date	2	23.29
Error c	12	106.00

APPENDIX F

ANALYSIS OF VARIANCE OF TOTAL NITRATE NITROGEN IN THE SOIL AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION

AVERAGE OVER REPLICATIONS

Source of Variance	Degree Freedom	Mean Square
Total	47	
Plow Pan	1	339.00**
Tillage	1	1184.42**
Plow Pan x Tillage	1	213.61*
Depth	2	249.40**
Tillage x Depth	2	86.34*
Error a	4	11.31
Treatment	1	661.50**
Tillage x Treatment	1	139.20*
Depth x Treatment	2	14.44
Tillage x Depth x Treatment	2	3.35
Error b	6	18.74
Date	1	1706.91**
Tillage x Date	1	2.28
Depth x Date	2	496.99**
Treatment x Date	1	41.61*
Tillage x Depth x Date	2	123.38**
Tillage x Treatment x Date	1	67.33**
Depth x Treatment x Date	2	10.11
Tillage x Depth x Treatment x Date	2	13.41
Error c	12	6.22

AVERAGE OVER TILLAGE

Source of Variance	Degree Freedom	Mean Square
Total	47	
Replications	1	29.48
Depth	2	249.40**
Depth x Replications	2	1.36
Treatment	1	661.50**
Depth x Treatment	2	14.44
Error a	3	5.74
Date	1	1706.91**
Depth x Date	2	498.99**
Treatment x Date	1	41.61*
Depth x Treatment x Date	2	10.11
Error b	6	4.17
Plow Pan	1	339.00**
Depth x Plow Pan	2	11.17
Treatment x Plow Pan	1	24.40
Date x Plow Pan	1	3.08
Depth x Treatment x Plow Pan	2	4.15
Depth x Date x Plow Pan	2	4.48
Treatment x Date x Plow Pan	1	6.61
Depth x Treatment x Date x Plow Pan	2	1.90
Error c	12	11.96

AVERAGE OVER DEPTH

Source of Variance	Degree Freedom	Mean Square
Total	31	
Replications	1	29.48
Tillage	1	1184.42**
Tillage x Replications	1	7.26
Treatment	1	661.47*
Tillage x Treatment	1	139.21
Error a	2	9.37
Date	1	1706.97**
Tillage x Date	1	2.29
Treatment x Date	1	41.60
Tillage x Treatment x Date	1	67.34
Error b	4	42.81
Plow Pan	1	338.99*
Tillage x Plow Pan	1	213.63*
Treatment x Plow Pan	1	24.40
Date x Plow Pan	1	3.08
Tillage x Treatment x Plow Pan	1	79.20
Tillage x Date x Plow Pan	1	4.86
Treatment x Date x Plow Pan	1	6.62
Tillage x Treatment x Date x Plow Pan	1	8.64
Error c	8	35.26

AVERAGE OVER TREATMENT

Source of Variance	Degree Freedom	Mean Square
Total	47	
Replications	1	29.48
Tillage	1	1184.42**
Tillage x Replications	1	7.26
Depth	2	249.40**
Tillage x Depth	2	86.34**
Error a	4	4.09
Date	1	1706.91**
Tillage x Date	1	2.28
Depth x Date	2	498.99**
Tillage x Depth x Date	2	123.38*
Error b	6	21.33
Plow Pan	1	339.00**
Tillage x Plow Pan	1	213.61*
Depth x Plow Pan	2	11.17
Date x Plow Pan	1	3.08
Tillage x Depth x Plow Pan	2	11.46
Tillage x Date x Plow Pan	1	4.86
Depth x Date x Plow Pan	2	4.48
Tillage x Depth x Date x Plow Pan	2	15.46
Error c	12	27.81

AVERAGE OVER DATES

Source of Variance	Degree Freedom	Mean Square
Total	47	
Replications	1	29.48
Tillage	1	1184.42**
Tillage x Replications	1	7.26
Depth	2	249.40**
Tillage x Depth	2	86.34*
Error a	4	8.19
Treatment	1	661.50**
Tillage x Treatment	1	139.20**
Depth x Treatment	2	14.44
Tillage x Depth x Treatment	2	3.35
Error b	6	4.38
Plow Pan	1	339.00*
Tillage x Plow Pan	1	213.61*
Depth x Plow Pan	2	11.17
Treatment x Plow Pan	1	24.40
Tillage x Depth x Plow Pan	2	11.45
Tillage x Treatment x Plow Pan	1	79.21
Depth x Treatment x Plow Pan	2	4.15
Tillage x Depth x Treatment x Plow Pan	2	.27
Error c	12	20.67

AVERAGE OVER PLOW PAN

Source of Variance	Degree Freedom	Mean Square
Total	47	
Replications	1	29.48
Tillage	1	1184.42**
Tillage x Replications	1	7.26
Depth	2	249.40**
Tillage x Depth	2	86.34**
Error a	4	4.09
Treatment	1	661.50**
Tillage x Treatment	1	139.20**
Depth x Treatment	2	14.44
Tillage x Depth x Treatment	2	3.35
Error b	6	4.38
Date	1	1706.91**
Tillage x Date	1	2.28
Depth x Date	2	498.99**
Treatment x Date	1	41.61
Tillage x Depth x Date	2	123.38*
Tillage x Treatment x Date	1	67.33
Depth x Treatment x Date	2	10.11
Tillage x Depth x Treatment x Date	2	13.41
Error c	12	17.54

APPENDIX G

ANALYSIS OF VARIANCE OF PERCENT ORGANIC MATTER IN THE SOIL AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION

AVERAGE OVER PLOW PAN

Source of Variance	Degree Freedom	Mean Square
Total	47	
Replications	1	.07**
Tillage	1	.01*
Tillage x Replications	1	.14**
Depth	2	.31**
Tillage x Depth	2	.01*
Error a	4	.00
Treatment	1	.16*
Tillage x Treatment	1	.00
Depth x Treatment	2	.06
Tillage x Depth x Treatment	2	.02
Error b	6	.02
Date	1	.03
Tillage x Date	1	.00
Depth x Date	2	.00
Treatment x Date	1	.00
Tillage x Depth x Date	2	.00
Tillage x Treatment x Date	1	.00
Depth x Treatment x Date	2	.00
Tillage x Depth x Treatment x Date	2	.00
Error c	12	.01

AVERAGE OVER TILLAGES

Source of Variance	Degree Freedom	Mean Square
Total	47	
Replications	1	.07
Depth	2	.31*
Depth x Replications	2	.00
Treatment	1	.16
Depth x Treatment	2	.06
Error a	3	.03
Date	1	.03
Depth x Date	2	.00
Treatment x Date	1	.00
Depth x Treatment x Date	2	.00
Error b	6	.01
Plow Pan	1	.01
Depth x Plow Pan	2	.01
Treatment x Plow Pan	1	.00
Date x Plow Pan	1	.00
Depth x Treatment x Plow Pan	2	.00
Depth x Date x Plow Pan	2	.00
Treatment x Date x Plow Pan	1	.00
Depth x Treatment x Date x Plow Pan	2	.00
Error c	12	.02

AVERAGE OVER REPLICATIONS

Source of Variance	Degree Freedom	Mean Square
Total	47	
Plow Pan	1	.01
Tillage	1	.01
Tillage x Plow Pan	1	.04
Depth	2	.31**
Tillage x Depth	2	.01
Error a	4	.01
Treatment	1	.16*
Tillage x Treatment	1	.00
Depth x Treatment	2	.06
Tillage x Depth x Treatment	2	.02
Error b	6	.02
Date	1	.03*
Tillage x Date	1	.00
Depth x Date	2	.00
Treatment x Date	1	.00
Tillage x Depth x Date	2	.00
Tillage x Treatment x Date	1	.00
Depth x Treatment x Date	2	.00
Tillage x Depth x Treatment x Date	2	.00
Error c	12	.00

AVERAGE OVER DEPTH

Source of Variance	Degree Freedom	Mean Square
Total	31	
Replications	1	.07
Tillage	1	.01
Tillage x Replications	1	.14*
Treatment	1	.16*
Tillage x Treatment	1	.00
Error a	2	.00
Date	1	.03
Tillage x Date	1	.00
Treatment x Date	1	.00
Tillage x Treatment x Date	1	.00
Error b	4	.00
Plow Pan	1	.01
Tillage x Plow Pan	1	.04
Treatment x Plow Pan	1	.00
Date x Plow Pan	1	.00
Tillage x Treatment x Plow Pan	1	.10
Tillage x Date x Plow Pan	1	.01
Treatment x Date x Plow Pan	1	.00
Tillage x Treatment x Date x Plow Pan	1	.01
Error c	8	.32

AVERAGE OVER TREATMENT

Source of Variance	Degree Freedom	Mean Square
Total	47	
Replications	1	.07**
Tillage	1	.01*
Tillage x Replications	1	.14**
Depth	2	.31**
Tillage x Depth	2	.01*
Error a	4	.00
Date	1	.03
Tillage x Date	1	.00
Depth x Date	2	.00
Tillage x Depth x Date	2	.00
Error b	6	.02
Plow Pan	1	.01
Tillage x Plow Pan	1	.04
Depth x Plow Pan	2	.01
Date x Plow Pan	1	.00
Tillage x Depth x Plow Pan	2	.01
Tillage x Date x Plow Pan	1	.01
Depth x Date x Plow Pan	2	.00
Tillage x Depth x Date x Plow Pan	2	.00
Error c	12	.03

AVERAGE OVER DATES

Source of Variance	Degree Freedom	Mean Square
Total	47	
Replications	1	.07**
Tillage	1	.01*
Tillage x Replications	1	.14**
Depth	2	.31**
Tillage x Depth	2	.01*
Error a	4	.00
Treatment	1	.16*
Tillage x Treatment	1	.00
Depth x Treatment	2	.06
Tillage x Depth x Treatment	2	.02
Error b	6	.02
Plow Pan	1	.01
Tillage x Plow Pan	1	.04
Depth x Plow Pan	2	.01
Treatment x Plow Pan	1	.00
Tillage x Depth x Plow Pan	2	.01
Tillage x Treatment x Plow Pan	1	.11
Depth x Treatment x Plow Pan	2	.00
Tillage x Depth x Treatment x Plow Pan	2	.01
Error c	12	.08

APPENDIX H

ANALYSIS OF VARIANCE FOR TOTAL NITROGEN IN THE SOIL AFTER INCUBATION AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION

AVERAGE OVER PLOW PAN

Source of Variance	Degree Freedom	Mean Square
Total	47	
Replications	1	710.68
Tillage	1	2583.38
Tillage x Replications	1	345.04
Depth	2	19523.18*
Tillage x Depth	2	852.80
Error a	4	1510.81
Treatment	1	6626.72*
Tillage x Treatment	1	1600.66
Depth x Treatment	2	556.28
Tillage x Depth x Treatment	2	695.23
Error b	6	1026.56
Date	1	2847.08
Tillage x Date	1	2020.34
Depth x Date	2	73.84
Treatment x Date	1	1660.02
Tillage x Depth x Date	2	.30
Tillage x Treatment x Date	1	5115.84*
Depth x Treatment x Date	2	21.63
Tillage x Depth x Treatment x Date	2	146.70
Error c	12	914.57

AVERAGE OVER TILLAGES

Source of Variance	Degree Freedom	Mean Square
Total	47	
Replications	1	710.68
Depth	2	19523.18**
Depth x Replications	2	1187.66
Treatment	1	6626.72*
Depth x Treatment	2	556.28
Error a	3	576.53
Date	1	2847.08
Depth x Date	2	73.84
Treatment x Date	1	1660.02
Depth x Treatment x Date	2	21.63
Error b	6	910.93
Plow Pan	1	866.40
Depth x Plow Pan	2	235.94
Treatment x Plow Pan	1	413.34
Date x Plow Pan	1	.08
Depth x Treatment x Plow Pan	2	251.52
Depth x Date x Plow Pan	2	105.90
Treatment x Date x Plow Pan	1	100.86
Depth x Treatment x Date x Plow Pan	2	258.38
Error c	12	293.44

AVERAGE OVER REPLICATIONS

Source of Variance	Degree Freedom	Mean Square
Total	47	
Plow Pan	1	866.40
Tillage	1	2583.38
Tillage x Depth	1	155.04
Depth	2	19523.18**
Tillage x Depth	2	852.80
Error a	4	336.97
Treatment	1	6626.72**
Tillage x Treatment	1	1600.66*
Depth x Treatment	2	556.28
Tillage x Depth x Treatment	2	695.23
Error b	6	255.99
Date	1	2847.08**
Tillage x Date	1	2020.34**
Depth x Date	2	73.84
Treatment x Date	1	1660.02*
Tillage x Depth x Date	2	.30
Tillage x Treatment x Date	1	5115.84**
Depth x Treatment x Date	2	21.63
Tillage x Depth x Treatment x Date	2	146.70
Error c	12	214.57

AVERAGE OVER DEPTH

Source of Variance	Degree Freedom	Mean Square
Total	31	
Replications	1	710.70
Tillage	1	2583.33
Tillage x Replications	1	345.06
Treatment	1	6626.73
Tillage x Treatment	1	1600.71
Error a	2	1450.05
Date	1	2846.97
Tillage x Date	1	2020.32
Treatment x Date	1	1660.02
Tillage x Treatment x Date	1	5115.75
Error b	4	941.32
Plow Pan	1	866.40*
Tillage x Plow Pan	1	155.04
Treatment x Plow Pan	1	413.37
Date x Plow Pan	1	.06
Tillage x Treatment x Plow Pan	1	181.47
Tillage x Date x Plow Pan	1	231.87
Treatment x Date x Plow Pan	1	100.83
Tillage x Treatment x Date x Plow Pan	1	927.54*
Error c	8	139.95

AVERAGE OVER TREATMENT

Source of Variance	Degree Freedom	Mean Square
Total	47	
Replications	1	710.68
Tillage	1	2583.38
Tillage x Replications	1	345.04
Depth	2	19523.18*
Tillage x Depth	2	852.80
Error a	4	1510.81
Date	1	2847.08
Tillage x Date	1	2020.34
Depth x Date	2	73.84
Tillage x Depth x Date	2	.30
Error b	6	1160.12
Plow Pan	1	866.40
Tillage x Plow Pan	1	155.04
Depth x Plow Pan	2	235.94
Date x Plow Pan	1	.08
Tillage x Depth x Plow Pan	2	438.01
Tillage x Date x Plow Pan	1	231.88
Depth x Date x Plow Pan	2	105.90
Tillage x Depth x Date x Plow Pan	2	57.83
Error c	12	184.44

AVERAGE OVER DATES

Source of Variance	Degree Freedom	Mean Square
Total	47	
Replications	1	710.68
Tillage	1	2583.38
Tillage x Replications	1	345.04
Depth	2	19523.18*
Tillage x Depth	2	852.80
Error a	4	1510.81
Treatment	1	6626.72*
Tillage x Treatment	1	1600.66
Depth x Treatment	2	556.28
Tillage x Depth x Treatment	2	695.23
Error b	6	1026.56
Plow Pan	1	866.40
Tillage x Plow Pan	1	155.04
Depth x Plow Pan	2	235.94
Treatment x Plow Pan	1	413.34
Tillage x Depth x Plow Pan	2	438.01
Tillage x Treatment x Plow Pan	1	181.52
Depth x Treatment x Plow Pan	2	251.52
Tillage x Depth x Treatment x Plow Pan	2	219.03
Error c	12	324.03

APPENDIX I

ANALYSIS OF VARIANCE OF YIELD OF WHEAT GRAIN, YEARS COMBINED (1957-1963), AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION

Source of Variation	Degree Freedom	Mean Square
Total	279	
Replications	1	.60
Tillage	1	682.66*
Replications x Tillage	1	4.47
Treatment	4	612.93*
Tillage x Treatment	4	91.33
Error a	8	42.53
Plow Pan	1	90.97*
Tillage x Plow Pan	1	40.73
Treatment x Plow Pan	4	7.94
Tillage x Treatment x Plow Pan	4	16.94
Error b	10	11.54
Years	6	4566.15**
Tillage x Years	6	88.91**
Treatment x Years	24	130.68*
Plow Pan x Years	6	9.94
Tillage x Treatment x Years	24	27.31*
Tillage x Plow Pan x Years	6	23.19
Treatment x Plow Pan x Years	24	17.68
Tillage x Treatment x Plow Pan x Years	24	10.28
Error c	120	10.98

ANALYSIS OF VARIANCE OF YIELD OF WHEAT GRAIN AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION 1957

Source of Variation	Degree Freedom	Mean Square
Total	39	
Replications	1	.87
Tillage	1	24.18
Tillage x Replications	1	.06
Treatment	4	19.93
Tillage x Treatment	4	1.04
Error a	8	7.78
Plow Pan	1	.06
Tillage x Plow Pan	1	.24
Treatment x Plow Pan	4	7.94**
Treatment x Tillage x Plow Pan	4	1.07
Error b	10	1.15

ANALYSIS OF VARIANCE OF YIELD OF WHEAT GRAIN AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION 1958

Source of Variance	Degree Freedom	Mean Square
Total	39	
Replications	1	.55
Tillage	1	4.58
Tillage x Replications	1	.49
Treatment	4	6.26
Tillage x Treatment	4	3.48
Error a	8	2.11
Plow Pan	1	.34
Tillage x Plow Pan	1	.21
Treatment x Plow Pan	4	.32
Tillage x Treatment x Plow Pan	4	1.38
Error b	10	1.01

ANALYSIS OF VARIANCE OF YIELD OF WHEAT GRAIN AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION 1959

Source of Variance	Degree Freedom	Mean Square
Total	39	
Replications	1	34.04
Tillage	1	188.79*
Replications x Tillage	1	9.31
Treatment	4	349.64**
Tillage x Treatment	4	8.88
Error a	8	16.17
Plow Pan	1	52.21
Tillage x Plow Pan	1	29.07
Treatment x Plow Pan	4	22.28
Tillage x Treatment x Plow Pan	4	36.68
Error b	10	26.98

ANALYSIS OF VARIANCE OF YIELD OF WHEAT GRAIN AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION 1960

Source of Variance	Degree Freedom	Mean Square
Total	39	
Replications	1	.12
Tillage	1	842.24**
Tillage x Replications	1	2.30
Treatment	4	238.96*
Tillage x Treatment	4	93.30*
Error a	8	10.59
Plow Pan	1	2.40
Tillage x Plow Pan	1	20.73
Treatment x Plow Pan	4	27.47*
Tillage x Treatment x Plow Pan	4	4.76
Error b	10	4.82

ANALYSIS OF VARIANCE OF YIELD OF WHEAT GRAIN AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION 1961

Source of Variance	Degree Freedom	Mean Square
Total	39	
Replications	1	.78
Tillage	1	8.09*
Tillage x Replications	1	
Treatment	4	16.89*
Tillage x Treatment	4	6.23*
Error a	8	1.27
Plow Pan	1	.37
Tillage x Plow Pan	1	.20
Treatment x Plow Pan	4	2.91
Tillage x Treatment x Plow Pan	4	.29
Error b	10	1.14

ANALYSIS OF VARIANCE OF YIELD OF WHEAT GRAIN AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION 1962

Source of Variance	Degree Freedom	Mean Square
Total	39	
Replications	1	.38
Tillage	1	28.06
Tillage x Replications	1	4.03
Treatment	4	119.15**
Error a	8	7.04
Plow Pan	1	23.87*
Tillage x Plow Pan	1	2.55
Treatment x Plow Pan	4	6.32
Tillage x Treatment x Plow Pan	4	14.35*
Error b	10	3.60

ANALYSIS OF VARIANCE OF YIELD OR WHEAT GRAIN AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION 1963

Source of Variance	Degree Freedom	Mean Square
Total	39	
Replications	1	5.95
Tillage	1	.01
Tillage x Replications	1	2.50
Treatment	4	43.79*
Tillage x Treatment	4	4.34
Error a	8	2.83
Plow Pan	1	6.50
Tillage x Plow Pan	1	12.32*
Treatment x Plow Pan	4	1.77
Tillage x Treatment x Plow Pan	4	5.10
Error b	10	2.15

APPENDIX J

ANALYSIS OF VARIANCE OF PERCENT NITROGEN IN WHEAT GRAIN AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION, YEARS COMBINED (1961-1963)

Source of Variance	Degree Freedom	Mean Square
Total	119	
Replications	1	.00
Tillage	1	1.34*
Replications x Tillage	1	.00
Treatment	4	4.67*
Tillage x Treatment	4	.23
Error a	8	.07
Plow Pan	1	.20*
Tillage x Plow Pan	1	.05
Treatment x Plow Pan	4	.30*
Tillage x Treatment x Plow Pan	4	.05
Error b	10	.03
Years	2	7.27**
Tillage x Years	2	.07
Treatment x Years	8	.64*
Plow Pan x Years	2	.01
Tillage x Treatment x Years	2	.01
Treatment x Plow Pan x Years	8	.18*
Tillage x Treatment x Plow Pan x Years	8	.09
Error c	40	.05

ANALYSIS OF VARIANCE OF PERCENT NITROGEN IN WHEAT GRAIN AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION 1961

Source of Variance	Degree Freedom	Mean Square
Total	39	.00
Replications	1	.28
Tillage	1	2.42*
Tillage x Replications	1	
Treatment	4	6.05**
Tillage x Treatment	4	1.12
Error a	8	.36
Plow Pan	1	1.09
Tillage x Plow Pan	1	.00
Treatment x Plow Pan	4	.64
Tillage x Treatment x Plow Pan	4	.12
Error b	10	.27

ANALYSIS OF VARIANCE OF PERCENT NITROGEN IN WHEAT GRAIN AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION 1962

Source of Variance	Degree Freedom	Mean Square
Total	39	.10
Replications	1	.36
Tillage	1	29.58*
Tillage x Replications	1	5.63
Treatment	4	323.16**
Tillage x Treatment	4	5.43
Error a	8	1.36
Plow Pan	1	10.00
Tillage x Plow Pan	1	3.85
Treatment x Plow Pan	4	10.30
Tillage x Treatment x Plow Pan	4	2.09
Error b	10	5.89

ANALYSIS OF VARIANCE OF PERCENT NITROGEN IN WHEAT GRAIN AS INFLUENCED BY RESIDUE MANAGEMENT AND NITROGEN APPLICATION 1963

Source of Variance	Degree Freedom	Mean Square
Total	39	.01
Replications	1	.21
Tillage	1	9.36*
Tillage x Replications	1	1.06
Treatment	4	21.03*
Tillage x Treatment	4	1.57
Error a	8	.79
Plow Pan	1	.14
Tillage x Plow Pan	1	.30
Treatment x Plow Pan	4	2.18
Tillage x Treatment x Plow Pan	4	1.86
Error b	10	.96

APPENDIX K

SOIL TEST VALUES FOR SOILS ON WHICH WHEAT EXPERIMENTS WERE CONDUCTED

Grant Silt Loam

Organic Matter (%)	1.39
Nitrogen (%)	0.0765
Phosphorus (Pounds per acre, available)*	160.0
Potassium (Pounds per acre exchangeable)	700.0
pH	5.7

*Extracted with nitrogen acetic acid

VITA

Billy Bert Webb

Candidate for the Degree of

Master of Science

Thesis: INFLUENCE OF RESIDUE MANAGEMENT AND NITROGEN APPLICATION ON NITRATE ACCUMULATION IN THE SOIL PROFILE

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Personal Data: Born March 13, 1930, at Custer, Oklahoma, son of Ted and Jessie Webb.

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Experience: Reared on a farm at Custer, Oklahoma; worked on family farm during summers of college years; farmed in partnership on my family farm for 4 years after college graduation; spent 4 years with Oklahoma State University, 1956-1960 in Ethiopia as Experiment Station Superintendent; research work in Agronomy Department, Oklahoma State University, 1960-1963, working in soil fertility; Superintendent of Irrigation Research Station, Altus, Oklahoma 1963-1966.

Member: Agronomy Club, Alpha Zeta, American Society of Agronomy.

Date of Final Examination: March, 1966.