A STUDY OF NITROGEN AVAILABILITY
IN CROPPED AND VIRGIN SOILS

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By

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Nitrogen availability in the soil may be affected by many factors. Soil nitrogen is continually undergoing physical and chemical change. It is closely associated with the organic matter of the soil. Organic matter is one of the most important constituents of a fertile soil. When cultivated crops are grown, the loss of soil organic matter is greater than the quantity added by returning the crop residue. Many experiments have been conducted in which various types of raw organic materials have been applied to soils to maintain good tilth and supply nitrogen for succeeding crops. The carbon-nitrogen ratio will influence the rate of decomposition of organic matter to produce available nitrogen because of the nitrogen and energy requirements of the microorganisms which are responsible for most of the decomposition. All of the plant residues do not decompose at the same rate but vary due to such factors as rate of oxidation and hydrolysis of relatively insoluble organic compounds to soluble organic matter and simple proteins. Some constituents such as sugar, starch, cellulose, pentosans, and simple proteins are attacked rapidly while lignin or ligno-protein compounds decompose more slowly and play important roles in the formation of soil humus.

Organic matter with a wide carbon-nitrogen ratio must be given sufficient time to decay before a succeeding crop is planted or a reduced yield will be obtained on soils which cannot supply enough available nitrogen for the optimum growth of the crop. Material high in carbon and low in nitrogen often decomposes rapidly, and the soil organisms, which do the work of decomposition, take up the available nitrate from the soil for their body metabolism.

The main objective of this study was to determine whether the nitrogen left after cropping for several years is as readily available as it was when the soil was in a virgin condition.

II. REVIEW OF THE LITERATURE

Bray (13) points out that available forms of nitrogen in soils, such as nitrate and ammonia vary considerably in amount not only from season to season but from week to week and day to day. There is little significance as an indication of the amount that will become available to crops during the growing period. Nitrate measurements made during the spring before crops start to feed heavily probably have the most significance.

Daniel and Langham (21) found there was considerable difference in total nitrogen between cropped and virgin soils. Their study, table 1, was conducted in the panhandle of Oklahoma.

Table 1 Nitrogen differences found among cropped, virgin and drifted soils.

Kind of soil	No. of samples analyzed	Organic matter		Nitrogen	
		Soil per cent	Difference per cent	Soil per cent	Difference per cent
Virgin Surface	61	2.33		0.100	
Cropped Surface	61	1.91	-18.0	0.085	-15.0
Drifted Soils	61	1.76	-24.5	0.072	-28.0

Gainey (27) studied total nitrogen as a factor influencing nitrate accumulation in soils. He found that when the nitrogen content and the nitrate-accumulating abilities of a large number of soils are determined and the data obtained are grouped on a basis of nitrogen content of the soils and averaged, an almost perfect direct relationship may appear to exist between the total nitrogen content and the nitrate-accumulating ability. If the original data are used as a basis of calculating the coefficient of correlation, the relationship between two factors may be very slight.

As a result of continuous cultivation, losses, not only of total humus but also of the nitrogen content of humus, have been observed repeatedly (4,5). This is especially true of soils receiving applications of lime (59), which led to the general conclusion that lime hastens the rate of decomposition of humus; this loss of organic matter is partly offset by the production of larger crops due to the use of lime with the result that larger quantities of plant residues reach the soil and are converted into humus.

Observations made by Waksman (59) led him to conclude that humus does not decompose in the soil as a whole, but that certain constituents of the humus decompose more readily than others. One may even be tempted to consider the existence of unstable and stable forms of humus as was done by certain pedologists. The term "stable humus" (59) might be used to designate that type of humus which has undergone extensive decomposition, similar to that which has taken place in well-decomposed composts or cultivated mineral soils. It is characterized by an almost complete disappearance of the cellulose and hemicelluloses; by a considerable increase in the percentage of the lignin-like complexes, especially the proteins; and by a narrowing of the carbon-nitrogen ratio to about 10 to 1 or less. The term unstable humus might be applied to those forms of humus which still undergo rapid decomposition when placed under favorable conditions, as by correcting the reaction, by proper aeration (drainage), by a more favorable temperature, or by the addition of mineral nutrients or available nitrogen essential for the activities of microorganisms. The difference between stable and unstable humus is more of degree than of kind; the second type of humus has either been less decomposed under the particular conditions or has undergone a special type of decomposition.

Soils kept in grass (pasture) usually show an increase of both humus and total nitrogen. Sievers (54) found that as a result of thirty years cultivation, unlimed soils contained 1.279 per cent organic carbon and 0.104 per cent nitrogen and had a carbon nitrogen ratio of 12.34 to 1.

Temperature, precipitation and evaporation influence the nature and abundance of the surface vegetation of the soil, as well as the mechanism and rapidity of the decomposition of the plant remains, thus determining the rate of accumulation of humus, its abundance and its chemical composition. Waksman (59) points out that the accumulation of humus in soils can take place only under those conditions where decomposition of the organic matter is less than its addition; when decomposition equals addition, no accumulation is possible.

Waksman (59) cited a demonstration by Mohr that no organic matter accumulates in well-drained and porous soils, i. e., well-aerated soils, when the average temperature is 25 degrees C. or higher, as is the case of most tropical lowlands. He suggested that this is due to the fact that the higher temperatures are nearer to the optimum for the activities of the humus-destroying microorganisms than they are for the growth of higher plants which furnish the raw material for the accumulation of humus in soil.

Waksman (59) points out that in poorly drained and boggy soils, the lower organisms, fungi and bacteria for example, suffer more from the lack of oxygen than do certain of the higher plants. Certain trees and grasses are fully as luxuriant in the marshes and bogs as on high ground. Since this abundant organic material is decomposed slowly, peat and other forms of humus accumulate. The high temperatures of the tropics lead to very rapid decomposition of the organic matter except in the water-logged soils of the lowlands.

As to the effect of rainfall, it was shown that when the temperature is constant, the nitrogen and humus content of the soil increase logarithmically with increasing precipitation. In high altitudes where the annual temperature is below 0 degrees centigrade, the activities of microorganisms are considerably delayed, and even with a sparse vegetation, the content of humus in the soil may reach 20 to 30 per cent, as is the case in alpine soils (59).

Harper (3) made a study of ammonia, nitrate, total nitrogen content, and acidity of several soils. The results of this study are given in table 2. From this experiment he concluded that the ammonia content was not affected by the crop grown on the soil. The soil ammonia was not correlated with the total nitrogen or acidity. The nitrate content varied with the crop grown. It was low in soils growing small grain and higher in the case of soils growing legumes and corn.

Allison and Sterling (2) found practically no correlation between total nitrogen and nitrate formed after different periods of incubation. Gainey (27) made a study in Kansas of the total nitrogen content of soils as compared with the nitrate nitrogen formed, and he concluded that a very close and direct relationship exists between the total nitrogen content of a soil and its ability to accumulate nitrogen as nitrates.

Table 2 A study of ammonia, nitrate, total nitrogen content and acidity of several field soils growing various crops.

Sample number	Soil Type	Crop	Acidity	Total nitrogen 6 2/3 in. of soil lbs.	Nitrate p.p.m.	Ammonia p.p.m.
1	Webster silt loam	Oats	not acid	7,870	1.0	8.2
2	Floyd silt loam	Onions	strong	6,460	153.6	20.6
3	Tama silt loam	Corn	medium	4,680	16.8	12.2
4	Grundy silt loam	do	strong	4,660	28.0	9.3
5	Marshall silt loam	Alfalfa	slight	3,430	8.6	6.7
6	Putnam silt loam	Oats	medium	2,700	8.0	7.9
7	Marion silt loam	Corn	medium +	2,680	24.4	16.8

Not only the total humus but the chemical nature of the humus, as shown by the carbon-nitrogen ratio, is considerably influenced by fertilizer treatment. This was demonstrated (59) for the soils in the longtime field experiments at Rothamsted. To establish the influence of soil treatment, other chemical characteristics of soil humus, such as an analysis of its nitrogen distribution, can be used. It has been shown (59), for example, that by fallowing a soil for thirteen years, without the addition of fertilizer, the total humus and total nitrogen were reduced by 43 per cent. The reduction of the nitrogen was largely at the expense of the di-amino form; the amide nitrogen decreased only slightly. When the same soil received stable manure annually, there was an increase in amide nitrogen above the uncultivated soil. This increase was found even when the increase in total humus and total nitrogen was not quite sufficient to replace the loss due to cultivation.

Soils in a good state of fertility gave the following ratios (59): Soluble humus divided by total nitrogen equals 3.5, and the total humus divided by the soluble humus equals 5.0. It should be emphasized that it is the nature of the humus in the soil, rather than the total concentration, that is primarily concerned with soil productivity.

It is reported (59) that the continued loss of organic matter through cultivation makes the soil puddle more and more easily. It was found that with a good supply of organic matter the soil could be plowed with 27 per cent moisture, but with very low organic matter the soil puddled under tractor wheels at 17 per cent moisture.

Stewart (57) of Illinois states that in general the carbon-nitrogen ratio of the soil tends to become narrower with the aging of the organic material. He found the ratio in the old soils, the gray silt loam, to be 10.4 to 1; in brown silt loam 12.1 to 1; and in black clay loam, 11.7 to 1.

Russell(48) shows from his work on Broadwalk plots that it is only by an increase in carbon that nitrogen can be increased in soil. The reverse is also true that, without nitrogen, carbon will not be held. Therefore in humid sections the carbon-nitrogen ratio tends to become narrower. Energetic decay processes cause a more rapid loss of carbon than of nitrogen. In semi-humid sections, those with a rainfall-evaporation ratio of less than 1, conditions are less favorable for plant growth and for decomposition. The result is that carbonaceous materials do not disappear as rapidly as do nitrogeneous compounds. This tends to widen the carbon-nitrogen ratio.

Slater (49) pointed out that the factors which most affect the carbon-nitrogen ratio are those of climate, temperature and rainfall. In regions with a wide rainfall-evaporation ratio and a high temperature there are conditions favorable for luxuriant vegetative growth, but at the same time these also favor rapid decomposition processes. Thus, although more organic material may enter into a soil, because of rapid decay it is difficult to keep it.

A number of efforts have been made to associate the carbon-nitrogen ratio with the fertility and nitrogen availability of the soil. Brown and Allison (14) state,

> The determination of the carbon-nitrogen ratio in soils is now coming to be considered of much importance in fertility studies. It shows the rate at which decomposition processes are going on in the soil. Experience (48) has shown that, if the ratio narrowed beyond a point of about 10 to 1, crop yields may be reduced evidently because of an insufficient production of available nitrogen, phosphorus, and potassium. On the other hand, if the ratio were 12 to 1 or above, bacterial activities apparently occur to a satisfactory extent, and sufficient amounts of soluble plant-food are produced for good crop growth.

From data presented by Russell (48) it appears that if there is any correlation between productivity and the ratio of carbon to nitrogen, fertile soils have the narrower ratio.

Several workers, notably Alway and McLean (4), Blair and McLean (11) and Sievers and Holtz (55), have pointed out that in soil under cultivation the carbon-nitrogen ratio becomes narrower. Stirring the soil appears to produce a much greater loss of carbon than of nitrogen. When soils are first brought under cultivation, there is a rapid loss of organic matter, but as the amount of nitrogen becomes less, the rate of loss slows down and narrower ratio remains fairly stable.

Waynick and Sharp (59) have presented data showing the amount of variation found in the total carbon and total nitrogen of California soils.

The samples selected were taken for their apparent uniformity, and yet the nitrogen fluctuation was as much as 0.977 to 0.210, and the carbon ran from 1.383 to 0.179. As many as 100 samples were taken from a plot of a little over an acre. Since these great variations occurred on small areas which appeared to be uniform, these authors discredit any significance that might be given to the association of the carbon-nitrogen ratio with soil fertility. Read (45) has corroborated the work of Waynick and Sharp by the study of samples collected from many experiment stations. His analytical results were compared with the actual yields as reported by the various stations, although it seems to be impossible to relate the ratio of carbon to nitrogen in soils.

Doryland (22) has probably carried out the most extensive work to show that soil microorganisms may become competitors to crops for the supply of available plant nutrients. He has shown that these competitors are not necessarily "detrimental" organisms but may be some of the most vigorous ammonifiers. He points out that the most favorable conditions for the consumption of ammonia or nitrates is an application of energy material, such as carbohydrates or straw. This use of nitrogen by the organisms is simply a normal metabolic process. For the construction of their body tissues they require a certain amount of nitrogen for each unit of carbon consumed. When a substance having a wide energy-nitrogen ratio is added to the soil, there is an abundance of energy material but very little nitrogen, and the organisms make use of the available nitrogen from the soil in their growth processes. Since the soil organisms are more advantageously situated with respect to this nitrogen, the plant suffers.

In summarizing, as brought out by Waksman (59), the processes carried on by the soil microorganisms result, with materials having a wide carbon-nitrogen ratio, in the use of available soil nitrates, the loss of considerable carbon, and a narrowing of the ratio. If, however, the added substance has a narrow ratio, this favors the synthesizing of more cell protoplasm because of the abundance of nitrogen, with the result that less carbon will be lost, and, at the same time, nitrogen will be liberated as available nitrates. The result will be a widening of the ratio of carbon to nitrogen. A soil having a ratio wider than normal is not in a condition to support plant growth, since the activities of the soil organisms will result in nitrogen starvation. When a soil shows a constant ratio, this indicates that there is a proper balance of nitrogen and carbon to meet the needs of the metabolic processes of the soil flora. Some energy material will be utilized, and at the same time some nitrogen will be liberated as ammonia. The addition of fresh organic materials having a carbon-nitrogen ratio of 10.1 will result in stimulating the growth of the organisms, the liberation of some CO_2 and the formation of an equivalent amount of ammonia. Salter (49) found that with a given carbon-nitrogen ratio the microorganic processes taking place in the soil are similar, regardless of the organic materials added.

In the case of cacao soils, good soils were found to have a carbon-nitrogen ratio ranging from 7.0 to 8.3, whereas poor soils had a ratio of 5.7 to 6.8.

III. EXPERIMENTAL PROCEDURE

Six important soil types for this study were collected from eastern, northern and western Oklahoma. In each case a virgin and a cropped soil were selected from the same vicinity. About 200 pounds of the surface 6 inches was obtained from each area. Each soil was screened to remove the large roots and other crop residue and was mixed thoroughly. Representative samples were taken for nitrogen and moisture determination.

Table 3 Moisture and nitrogen found in these virgin and cropped soils.

Soil Type	Where Found	Cropped		Virgin	
		per cent moisture	per cent nitrogen	per cent moisture	per cent nitrogen
Albion silt loam	Noble Co.	3.47	0.112	8.10	0.178
Bates very fine sandy loam	Mayes Co.	8.81	0.113	12.78	0.201
Kirkland silt loam	Noble Co.	4.87	0.098	11.20	0.154
Parsons silt loam	Mayes Co.	5.35	0.095	12.32	0.228
Norge very fine sandy loam	Payne Co.	3.55	0.083	8.52	0.185
St. Paul fine sandy loam	Woodward Co.	2.49	0.065	4.48	0.119
Average		4.76	0.094	9.57	0.178

The information concerning the nitrogen and moisture content of these soils, as indicated in table 3, is necessary in order to set up the nitrogen availability experiment as measured by the growth of rye grass. In this experiment it is desirable to have all factors affecting plant growth at an optimum except the nitrogen. It is desirable to have the amount of total nitrogen in each pot constant, which is accomplished by mixing nitrogen-free sand with each of the soils except the cropped St. Paul. Mixing the correct proportion of soil and sand insures that the mixture in each pot will contain the same per cent nitrogen as the cropped St. Paul fine sandy loam which is 0.065 per cent nitrogen.

The amount of moisture used in this experiment was 20 per cent for the soil and 12 per cent for the sand. Each soil was made up in triplicate making a total of 36 pots. Mixed with the soil in each pot were 2 grams of KCl and 5 grams of superphosphate so that nitrogen was likely to be the only factor of plant growth measured. Since there were not enough pots of the same size, two different sizes had to be used. This, and the fact that some soils had smaller volume per unit of weight, made it advisable to put sand in the bottom of some pots so that the soil mixture would come within an inch of the top of the pot. A pound and a half of sand was then put on top of the soil sand mixture to decrease evaporation. Forty perennial rye grass seeds were planted in each pot, and these were later thinned to 30 plants per pot. The temperature in the greenhouse, where the pots were placed, ranged from 80 to 90 degrees as tropical plants were also in the same house. The pots were shifted twice weekly so that each received the same amount of sunshine. The pots were weighed once or twice per week and the proper amount of water added. Table 4 indicates the amount of the

Table 4 The weight of ingredients used in the greenhouse experiment to determine the availability of nitrogen for plant growth

Soil	CROPPED						VIRGIN					
	Wt. of Soil		Wt. of Sand		Wt. of Water		Wt. of Soil		Wt. of Sand		Wt. of Water	
	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.
Albion silt loam	14	6	17	6	5	6	9	8	23	8	4	11
Bates very fine sandy loam	15	2	17	13	4	11	9		24		4	04
Kirkland silt loam	16	11	15	11	5	11	3		21	11	4	07
Norge very fine sandy loam	19	5	13		7	10	26	8	19	5	6	08
Parsons silt loam	18	7	15		7	6	8		25		6	04
St. Paul fine sandy loam	25		7		6	1	12	8	19	7	5	01

Five grams of super phosphate and two grams of KCl were mixed with the soil and sand of each pot.

One pound and 7 ounces of sand was placed on top of each pot and enough sand was placed in the bottom so the soil mixture was within an inch of the top of the pot.

different ingredients used in this experiment. It was anticipated that the grass would be cut several times, weighed, and total nitrogen determined on it. On both the soil and grass, total nitrogen was determined on an oven dry basis.

A second experiment concerned nitrate formation in soils after 33 days incubation. This experiment was also run in triplicate with the total nitrogen equal in each beaker and moisture brought to an optimum each week. This experiment was conducted with the ingredients as indicated in table 5. The temperature was held constant at 80 degrees F. during the incubation.

At the end of the incubation period the soil was dried and nitrate nitrogen was determined by the phenoldisulfonic colorimetric method (31) measuring the intensity of color with an electrophotometer and comparing the results obtained with a standard nitrate curve.

It was felt that a determination of the carbon-nitrogen ratio might shed further light on this problem of nitrogen availability in virgin and cropped soils, so this determination was made, and the results are indicated in table 6. It was found that there had been a narrowing of the carbon-nitrogen ratio due to cultivation, and there had been considerable loss in both nitrogen and carbon in the cropped soils as compared with the virgin soils.

Table 5 The weight in grams of the ingredients used in the incubation for nitrate determination.

Soil Type	CROPPED Weight of Soil	Weight of Sand	Weight Water	VIRGIN Weight of Soil	Weight of Sand	Weight Water
Albion silt loam	114.34	85.65	31.15	68.88	131.12	27.35
Bates very fine sandy loam	104.40	95.60	30.50	58.98	141.02	26.24
Kirkland silt loam	128.51	71.49	31.65	81.04	118.96	27.80
Norge very fine sandy loam	152.10	47.90	34.00	66.00	134.00	27.51
Parsons silt loam	131.44	68.56	32.90	52.43	147.57	25.63
St. Paul fine sandy loam	200.00	0.00	37.90	98.44	101.57	29.90

Two tenths of a gram of $CaCO_3$ and .05 grams of superphosphate was thoroughly mixed with the soil and sand mixture of each beaker. Twelve grams of sand were placed on top of each beaker to prevent rapid evaporation.

Table 6 Carbon and nitrogen found in cropped and virgin soils.

Soil Type	CROPPED Total Nitrogen	Carbon	C:N Ratio	VIRGIN Total Nitrogen	Carbon	C:N Ratio
Albion silt loam	0.112%	0.975%	7.23	0.179%	1.550%	8.66
Bates very fine sandy loam	0.113	0.823	7.32	0.201	2.113	10.51
Kirkland silt loam	0.098	0.849	8.66	0.154	1.670	10.93
Parsons silt loam	0.095	0.974	11.70	0.228	2.779	12.19
Norge very fine sandy loam	0.083	0.323	7.23	0.185	2.237	12.12
St. Paul fine sandy loam	0.065	0.624	9.26	0.119	1.398	11.75

IV. EXPERIMENTAL RESULTS

1. Availability of nitrogen for plant growth as measured by greenhouse experiments.

It would seem to be of considerable importance to know whether the nitrogen left in the soil after several years cropping is as readily available for plant growth as it was under virgin conditions, or whether the more soluble nitrogen is used up first, leaving nitrogen, which is relatively unavailable to plants. Consequently, this phase of the experiment was set up with the same amount of nitrogen in each pot, but half of the pots contain nitrogen from virgin soils and half from cropped soils. An attempt was made to keep all other factors for plant growth at an optimum. This was made particularly difficult because of the three attacks of red spiders which moved in from an adjoining experiment. The large amounts of parathion and other insect sprays may have had some effect on the rye grass plants. Just before the time that the first cutting should have been made on the grass, a very devastating hail knocked all of the glass out of the greenhouse, and the following two nights the temperature was at a minimum of about 28 degrees F. The sudden change in temperature from 85 degrees plus the falling hailstones and glass caused much of the grass to die back to the roots, and some plants were killed. With no top on the greenhouse, it was not possible to keep some of the soils from becoming water-logged when it rained. Excess water was immediately poured off after each rain so that the soils might dry to an optimum moisture content as soon as possible.

It is felt that further experiments need be conducted on this subject so these soils and this set up are being saved for that purpose.

Table 7 presents the information gained from this experiment concerning the availability of nitrogen in cropped and virgin soils as determined by the growth of rye grass in greenhouse tests.

Table 7 Availability of nitrogen for plant growth from cropped and virgin soils as measured by the forage obtained.

	Soil Type	FIRST CUTTING			SECOND CUTTING		
		Green Wt. Grass Grams	Dry Wt. Grass Grams	Per cent Nitrogen in Grass	Green Wt. Grass Grams	Dry Wt. Grass Grams	Per cent Nitrogen in Grass
1.	Albion silt loam, Cropped	11.20	5.030	.96	2.01	1.00	*
2.		13.62	6.129	.89	1.25	.80	
3.		11.25	5.060	1.01	1.95	1.20	
4.	Albian silt loam, Virgin	10.25	5.060	.99	1.85	1.00	
5.		10.72	4.820	.98	2.25	1.30	
6.		15.32	6.894	.96	1.50	1.00	
7.	Bates v.f.s.l., Cropped	18.70	8.390	.99	3.65	1.54	
8.		15.50	6.900	.98	2.17	1.40	
9.		13.15	5.940	.94	2.15	1.50	
10.	Bates v.f.s.l., Virgin	21.35	9.600	1.09	3.45	1.60	
11.		14.16	6.400	1.05	7.25	3.15	.138
12.		19.75	8.800	.96	5.13	2.65	.155
13.	Kirkland silt loam, Cropped	5.60	3.320	1.03	3.00	1.85	
14.		12.92	5.850	.99	4.25	2.41	.158
15.		12.37	5.530	.91	1.70	.50	
16.	Kirkland silt loam, Virgin	18.81	8.460	1.09	4.15	1.92	
17.		13.05	5.910	1.06	3.27	1.90	
18.		13.02	5.910	1.05	8.95	3.61	.155

Table 7 continued

Soil Type	FIRST CUTTING Green Wt. Grass Grams	Dry Wt. Grass Grams	Per Cent Nitrogen in Grass	SECOND CUTTING Green Wt. Grass Grams	Dry Wt. Grass Grams	Per cent Nitrogen in Grass
19. Norge v.f.s.l., Cropped	63.40	24.35	.96	14.95	5.05	.185
20.	114.80	35.59	.93	39.30	14.80	.167
21.	28.65	11.75	.96	8.30	4.20	.172
22. Norge v.f.s.l., Virgin	45.00	18.52	.90	8.20	3.65	.154
23.	34.35	14.77	.96	4.67	2.48	.162
24.	32.60	14.02	1.02	14.25	5.95	.148
25. Parsons silt loam, Cropped	16.50	7.42	.89	3.65	1.80	
26.	41.90	17.39	1.09	12.50	4.10	.172
27.	76.75	29.17	.99	22.88	7.40	.176
28. Parsons silt loam, Virgin	25.20	11.09	1.04	7.65	2.00	.155
29.	37.80	15.50	1.17	6.60	2.60	.172
30.	61.60	23.69	1.12	18.65	5.65	.167
31. St. Paul f.s.l., Cropped	24.70	10.87	.86	3.05	1.50	
32.	10.05	5.57	.86	5.16	3.00	.151
33.	10.45	5.66	.91	7.08	3.80	.121
34. St. Paul f.s.l., Virgin	18.00	8.06	.90	8.87	4.00	.155
35.	21.90	9.70	.85	3.80	1.60	
36.	16.42	7.39	.87	10.10	4.80	.129

Due to hail, freezing, waterlogging, and red spiders and insect spray no very well founded conclusions can be reached on this portion of the experiment. This work is being continued.

*Sample too small for nitrogen analysis.

Table 8 A study of nitrate formation after 33 days incubation in a soil and sand mixture where total nitrogen is constant

Soil	Location	PARTS PER MILLION OF NO_3 Cropped I	II	III	Av.	Virgin I	II	III	Av.
Albion silt loam	Noble County	13.07	12.67	12.80	12.83	10.06	11.66	10.65	10.75
Bates very fine sandy loam	Mayes County	12.35	11.67	11.21	11.75	10.47	9.82	10.35	10.22
Kirkland silt loam	Noble County	12.76	12.41	14.89	13.35	12.14	10.09	12.79	11.67
Parsons silt loam	Mayes County	11.24	11.71	12.80	11.92	10.65	10.06	10.35	10.35
Norge very fine sandy loam	Payne County	12.19	10.35	8.53	10.35	8.58	8.64	9.17	8.81
St. Paul fine sandy loam	Woodward County	12.89	11.95	13.56	12.80	10.65	11.36	11.83	11.28

The cropped soils consistently produced a little more nitrate nitrogen than did the virgin soils.

2. <u>A study of nitrate formed after 33 days incubation</u>.

As indicated in table 8, there was more nitrate formed in the cropped soils than in the virgin soils. This would lead one to conclude that there will be more nitrogen available for plant growth in the humus of the cropped soils rather than the virgin soils.

This finding does not seem to agree with the work of Crowther (20) who found that the removal of soluble humus by alkaline extraction from both a garden and a field soil reduced the productiveness over a series of crops in pot experiments. However, he also found that the field soil showed an initial but temporary increase in productiveness.

Many farmers report that they get poor yields the first year that virgin soil is put into cultivation.

V. DISCUSSION

Some factors affecting soil nitrogen and nitrogen availability were studied. The data showed that cropped soils had a little narrower carbon-nitrogen ratio than the virgin soils, and these narrower ratios were accompanied by an increase in nitrate accumulation. This would seem to indicate that more plant growth would be had from the nitrogen of the cropped soils, but this was not definitely proved because of the adverse conditions under which the greenhouse experiment was conducted with rye grass. Time did not allow this portion of the experiment to be started over after the hail, but the set up is to remain intact so that a more reliable plant experiment can be conducted.

An analysis of the cropped and virgin soils, collected just across the road from each other, brought out several results well worth considering. There was found to be slightly over twice as much moisture in the virgin as there was in the cropped soils. Over most of Oklahoma, moisture is likely to be a limiting factor to plant growth a good portion of the time. This brings out one of the values of conserving our dwindling supply of organic matter.

It was found that cropping had reduced the total supply of nitrogen 46.85 per cent, and the supply of carbon was reduced 55.9 per cent. These losses point out a problem which our farmers are facing now, and a problem which will become more acute as time passes. If, as some writers (20,22, 59) point out, the more soluble part of the humus goes first, leaving humus which becomes increasingly stable and unavailable as a source of plant food, then the problem may be even more serious. More work needs to be done on soil nitrogen and its availability under Oklahoma conditions.

SUMMARY

Six different soils were selected from different areas of Oklahoma with two requirements being considered; namely, that a virgin and a cropped soil be found side by side, and that the soil be quite extensive in the county in which it was found. A number of experiments were run on these soils in order to determine the relationship of the nitrogen between the cropped and virgin soils.

Carbon and nitrogen were found to be much higher in the virgin soils than they were in the cropped soils. The carbon-nitrogen ratio was narrower for the cropped soils. Without nitrogen in the soil, carbon will not be held. The narrower carbon-nitrogen ratio was found to correspond with the greatest nitrate accumulation.

After 33 days incubation more nitrate was found in the cropped than in the virgin soils. Virgin soils, under field conditions, contained twice as much moisture as did the cropped soils. The grass from the virgin soil pots contained slightly more nitrogen than the grass from the cropped soil pots. The deeper series of pots gave more room for root development than did the shallower pots, and as a result, they produced more forage. The first year a virgin soil is cultivated, it was found to produce less nitrate than a cultivated soil. The soils which were highest in nitrogen under field conditions soaked up water more readily than those low in nitrogen.

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