J. GARST

THE RATE OF OXIDATION OF SOIL ORGANIC MATTER

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by

Jonathan Garst

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This thesis has two aims; the first, a general review of the literature on soil organic matter; the second, a special problem in an attempt to differentiate between supposedly active and supposedly inactive humus.

There is probably less positively known about soil organic matter than about any other subject of equal importance in the economy of man's existence. In fact, the very importance of soil organic matter in crop production has often been undervalued. The pendulum of opinion swings from one extreme to the other and the theory that organic matter was a direct plant food gave way to the idea that the inorganic elements were all important. Tobacco stalks were burned to make it easier to distribute nitrate, straw was burned in the stack, and corn stalks in windows, nor have these practices entirely ceased. The lack of humus began to be felt some time ago and in answer to it bulletins on diversified farming, live stock, and green manures have poured forth. Let us hope that we shall also see an increase in the scientific investigations of soil organic matter in answer to the needs of those who wish to advise the farmer.

There is one fact, though it be a lonely one, on which all investigators agree, and it is that soil organic matter is a complex of different chemical compounds. Nor

is this surprising when it is considered that it is derived from plants and animals containing innumerable different substances. There are two ways of dealing with a mass made up of a great number of individuals; first, the mass as a whole may be studied as if it were homegeneous even though there are differences in the individuals (the science of economics is based on this method of studying mankind) second, the mass may be separated and each individual studied.

This latter method - the identification and study of the separate organic compounds - will probably be the ultimate means of the scientific investigation of humus, but it is a matter of extreme difficulty and will probably require a long time.

The first efforts of any consequence along this line were made by Mulder in about 1810. He divided the organic matter of the soil into four different acidswhich together with their salts, formed humus. The acids with the proposed formulæ are as follows: (1)

Ulmic - - - - - - - - $C_{40}H_{28}O_{12} + H_2O$

Humic - - - - - - - - $C_{40}H_{24}O_{12} + 3\ H_2O$

Apocrenic - - - - - - $C_{24}H_{24}O_{12} + H_2O$

Crenic - - - - - - - - $C_{24}H_{24}O_{12} + 3\ H_2O$

The ulmic acid and ulmin were the brown substances found in the earlier decomposition of peat. The humic acid and humin were the black organic compounds and the apocrenic

(1) McMurtree American Fert. April, 1908.

and crenic acids the products of further decay. This classification was accepted for many years and is referred to even in recent literature. Many investigators tried to verify Mulder's formulæ, but every one got different results. Other students either avoided the subject or in expressing an opinion of the complexity of humus spoke in terms which implied it was impossible to separate out the individual compounds.

So far as the writer knows, no studies were made to find the fertilizing significance of the different acids, nor could anyone explain the constant presence of nitrogen in the compounds.

However, as has been said, this classification stood and there was little effort to apply the practices of organic chemistry and isolate true compounds. In 1906 S. Suzuki[1] of Japan isolated some known compounds from humus more recently Schreiner and Shorey (2) have worked on the true composition of organic matter and have isolated thirty-five different known organic compounds. They consist of:

13 organic acids
9 organic basic compounds
3 carbohydrates
2 aldehydes
2 alcohols
1 hydrocarbon, glyceride, ester, sulphur compound, phosphorus compound, and an acid hydrid.

1) Bulletin of Col. of Agric. Tokyo, Imp. Uni. Vol VII,#4, p. 528.
2) Bulletin #88, Bur. of Soils.

These determinations were, however, entirely qualitative and the main emphasis has been laid on the compounds found which were toxic to plants.

Other work has been done with the nitrogen compounds of the soil. Jodidi (1) found that only about 1% of the nitrogen was in the form of nitrates and ammonia and that 99% was in organic compounds. Of the 99% he found from 26% to 33% in the form of amido nitrogen and considerable quantities of monoamino and diamino acids. Dojarenko (2) found that in black soil from one-half to two-thirds of the nitrogen exists as amido acids and the rest mainly as amides, while Chardet (3) found acid amides to equal 49% of the total nitrogen in peat, 52% in swamp soil, 66% in garden soil, and 68% in compost.

As far as the study of the individual compounds of the soil organic matter goes, there really is not much yet known, which can be used in determining agricultural practices. The study of organic matter as a mass shows more immediate results.

In 1893 Snyder at the Minnesota Experiment Station began to study the reason for the decline in the yields of wheat on the prairies of that state. He found that the main difference between the virgin soils which yielded well and the cropped soils which were decreasing in production was in the amount of humus present. (4) In the

(1) Iowa Research Bulletin No. 3, 1911.
(2) Landw. Vers. Sta - 56, 1902 - No. 4, p. 311 - Exp. Sta. Rec. Vol. XIV, p. 20.
(3) Rev - Gén. Chim. 17 - (1914) Vol. 9 - p. 137, Exp. Sta. Rec. Vol. XXXI, p. 515.
(4) Bul. 53, Minnesota Exp. Station.

virgin soils he found 3.75% humus and in a soil which had been cropped twenty-two years 2.50% humus by the Grandeau method. This decrease in organic matter was accompanied by an increase in the volume weight or compactness of the soil which accounted for the difficulty of working the old soils. There was also a decrease in the average water content from 16.48% to 12.14%. The humic phosphoric acid decreased from .06% in the virgin soil to .03% in the cultivated soils. His results showed that five pounds of nitrogen were lost through waste to every pound used by the crops.

In Bulletin 53 Snyder reports some experiments on the production of humus and the formation of humates. He mixed a soil from the bottom of a twenty foot excavation with different fertilizers, allowed them to stand for one year, and analyzed the Grandeau humus formed.

His results were as follows:

COMPOSITION OF GRANDEAU HUMUS FORMED IN ONE YEAR

	Cow Manure	Green Clover	Meat Scraps	Wheat Flour	Oat Straw	Saw Dust	Sugar
C:	41.95	54.22	48.77	51.62	54.34	49.28	57.84
H:	6.26	3.40	4.30	3.82	2.48	3.33	3.04
N:	6.16	8.24	10.96	5.02	2.50	0.32	0.08
O:	45.63	34.14	35.95	40.14	40.72	47.07	39.04

This table shows that the humus formed from different materials varies greatly, especially the nitrogen

content. He made no quantitative estimate of the amounts of humus produced by different amounts of fertilizers nor did the writer find any data anywhere on this subject. These experiments also showed that in the formation of humus, phosphorus was taken from the inorganic matter of the soil to form the so-called humates. A Petit, (1) on the other hand, maintained that the fixation of phosphoric acid by humus was so small as to be negligible.

Jodidi (2) started some experiments which might have a more direct bearing on farm practices than those of Snyder. The experiments were run in the field where all the biological and chemical factors are at work under natural conditions. The experiments were made to determine the rate of decomposition of the soil organic matter as indicated by the carbon dioxide content of the soil air. He made daily determinations of the per cent of carbon dioxide and the oxygen in the soil air over a series of plots on the Iowa Experiment Station. His results follow:

Increase of moisture and temperature increases the oxidation of the organic matter.

RELATION OF MOISTURE AND TEMPERATURE TO CARBON DIOXIDE PROD

	April	May	June	July	August
Precipitation	2.25in:	1.55 in:	2.36in:	1.42in:	3.02 in.
Soil Temperature	13.82°	16.34°	22.95°	25.77°	24.57
CO_2 content of Soil Air	0.191%	0.182%	0.29%	0.256%	0.344%

(1) A. Petit. Exp. Sta. Rec. XXV
(2) Iowa Research Bulletin No. 3.(313)

RELATION OF CULTIVATION TO CO_2 PRODUCTION

Plot	May 23	May 24	May 26	May 27	
B	0.1	0.05	0.4	0.3	
C	0.1	0.1	0.9	0.7	Plots cultivated on May 23 and harrowed
D	0.1	0.1	0.2	0.4	
E	0.2	0.1		0.3	

These results explain the rapid decrease in humus due to cultivation. The increase in oxidation from the increased moisture content does not seem to agree with the fact that the soils in humid regions have higher humus content than those of arid regions. It may be, however, that the moisture increases the growth of humus forming material faster than it does the decomposition of the humus.

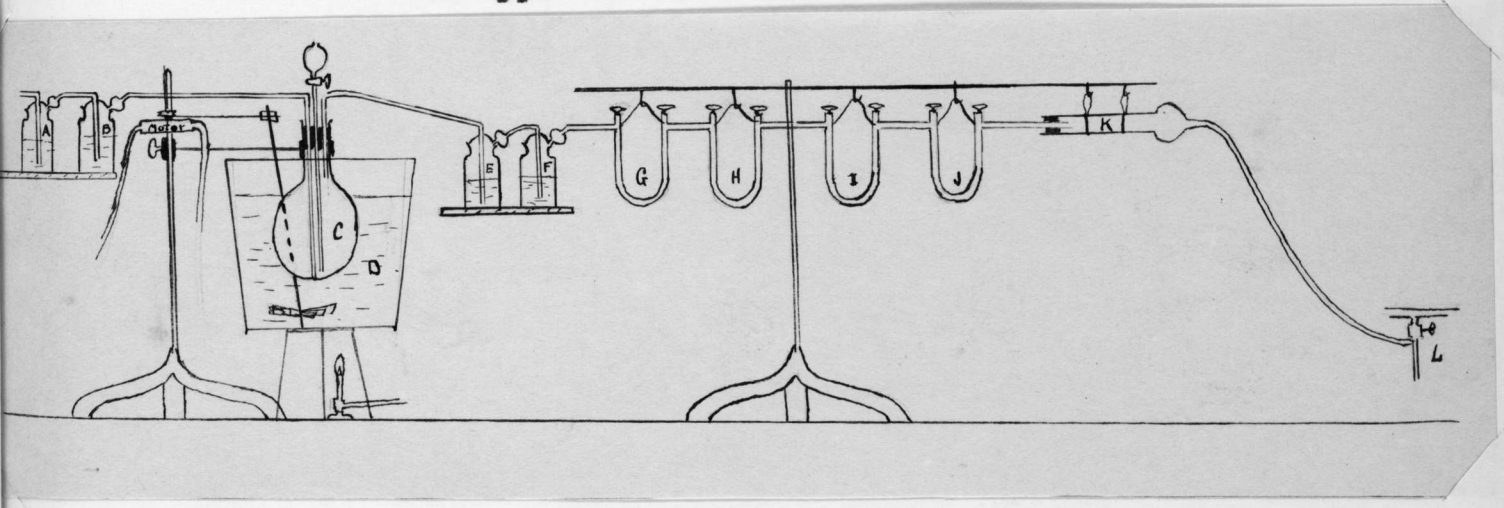
There was not sufficient data to show much difference in the rate of oxidation due to the chemical nature of the humus. One plot, however, which had been fertilized with peat, was third in humus content but last or twenty-second in the carbon dioxide content of the soil air. This would seem to show that the peat carbon was in an inert state.

On the whole, a review of the literature on organic matter simply emphasizes the fact that there is little positively known about what we are disposed to call humus. We know something of its physical characteristics, a little about its chemical composition, but we can not explain its

action nor even its formation. As yet, in fact, there is no satisfactory quantitative determination for humus.

The special problem of this thesis was an attempt to determine what might be called an availability test of soil carbon. It is generally supposed that the humus in virgin soils is more active than that of cropped soils, or, in other words, that it is more readily oxidized by soil organisms and by chemical action. To test this, it was decided to try and differentiate between the rate at which the organic matter of virgin and the organic matter of the same soil when cropped would be oxidized by hydrogen peroxide.

The apparatus used was as follows:



The soil was placed in flask C, a water pump was attached at L and a current of air drawn through the apparatus It passed first through the KOH bottles, A and B, which removed any CO_2 that it might contain. In this way the apparatus was filled with carbon dioxide free air and then hydrogen peroxide was poured on the soil through the separatory funnel. The air current passing through this

solution carried with it all the carbon dioxide that resulted from the action of the hydrogen peroxide on the soil. The wash bottles, E and F contained sulphuric acid which removed the water carried from C. The carbon dioxide was collected from the dry air by the soda lime tube G. The fixation of carbon dioxide by soda lime gives off water and in order to keep the loss of this from spoiling the results, the tube H was filled with pumice stone and sulphuric acid. Tubes G and H were weighed together and the increase in both of them represented the weight of the carbon dioxide liberated by the hydrogen peroxide. Tubes I and J were similar to G and H and were weighed in order to make sure that no carbon dioxide passed through the first set. Tube K was simply a guard tube containing soda lime. The pail D was filled with water in order to hold the flask C at a constant temperature. The water was agitated by a small fan wheel.

No data was available regarding the action of the hydrogen peroxide on soil organic matter. Some preliminary tests were made with some aged hydrogen peroxide which tested 1.41%. 200 cc. of this were used on ten grams of soil and the resultant carbon dioxide given off, while showing the differences in the two soils, was so small as to be valueless for calculations.

TABLE I DECOMPOSITION OF ORGANIC MATTER WITH 1.41% H_2O_2 at 39°C.

Soil	Wgt. of sample	cc. of H_2O_2	Time	Original wgt. of CO_2 tubes	Final wgt. of CO_2 tubes	Gain
A	10 gms	200	1st 30 min.	168.6045	168.6098	.0053
			2nd 30 min.	174.3790	174.3824	.0034
B	10 gms	200	1st 30 min.	174.3824	174.3864	.0040
			2nd 30 min.	139.3110	139.3096	°).0014
A	10 gms	200	1st 30 min.	174.3864	174.3934	.0070

°) Loss in weight.

Some new hydrogen peroxide was obtained which tested 3.23% and 200 cc. of this were used on ten gram samples of soil at room temperature with the following results:

TABLE II. DECOMPOSITION OF ORGANIC MATTER WITH 3.23% H_2O_2 at 24.5°C

Soil	Wgt. of sample	cc. of H_2O_2	Time	Original weight of CO_2 tubes	Final weight of CO_2 tubes	Gain
A	10 gms	200	1st 30 min	174.4008	174.4130	.0128
			2nd " "	139.3154	139.3172	.0018
B	10 gms	200	1st " "	139.3172	139.3258	.0086
			2nd " "	174.4130	174.4160	.0030

This showed an increase over the results obtained with the 1.41% hydrogen peroxide, but the results were still too small to be of value.

The action of the hydrogen peroxide might be increased in several ways: In the first place, the increase in strength showed increased action, but it seemed undesirable to use stronger than 3% solution, since that is the standard commercial strength. Another way to increase the action would be by raising the temperature at which the action was to take place. This was tried by holding the temperature of the thermostat at 55°C with the following results:

TABLE III. DECOMPOSITION OF ORGANIC MATTER WITH 3.23% H_2O_2 at 55°C.

Soil	Wgt. of samp.	cc. of H_2O_2	Time	Original weight of CO_2 tubes	Final weight of CO_2 tubes	Gain	Wgt. of Carbon	% of total Carbon
			30 m.	174.4160	174.4409	.0249)		
A	10 gr:	200	30 m.	139.3258	139.3524	.0266)	.0144	4.64
			30 m.	174.4474	174.4612	.0138)		
B	10 g.	200	30 m.	139.3876	139.4018	.0132)	.0072	6.07
			30 m.	139.4046	139.4392	.0346)		
			30 m.	174.4618	174.4936	.0318)	.0181	5.83
			30 m.	139.4392	139.4677	.0285		
			30 m.	174.4936	174.5212	.0276		
A	10 g.	200	30 m.	139.4677	139.4930	.0253		
			30 m.	174.5212	174.5622	°.0410		
			30 m.	139.8362	139.8605	.0243		
			30 m.	174.9076	174.9360	.0284		
			160 m.	139.8605	139.9828	.1223		
			30 m.	174.9360	174.9540	.0180		

°) Evidently incorrect.

The CO_2 weighings obtained by this method were large enough to use in calculations, but the rate at which the carbon dioxide was given off remained almost constant for several hours. For example, in the first half hour- .0346 gms. of carbon dioxide were given off and in the twelfth half hour

.0180 grams of carbon dioxide. Now, the problem undertaken was to differentiate between two different humuses by the rate at which they were oxidized by hydrogen peroxide, but if the oxidation were to go on constantly and diminish gradually then the rate could only be determined by the time allowed for the reaction. This could hardly be used with exactness on different soils because, if the time rate were all that determined the length of the reaction, the structure of the soil and the differences in the agitation would have a marked influence on the rate found. This could easily vitiate results so as to show no relation to the chemical activity of the humus. For example, a chemically active humus in a clay which the hydrogen peroxide could not readily penetrate would not give off as much carbon dioxide in a half hour as a less active humus in a porous sand. It would be very much better to have the arbitrary stopping place at the end of a chemical reaction. If, for instance, there were two elements of the soil humus, X and Y, X being rapidly oxidized by H_2O_2 and Y only slowly, the action on X could be allowed to go on to completion and then the CO_2 tested. This would still be an arbitrary determination, because the carbon dioxide given off would represent not only all from X but also some from Y. However, it would be much preferable to a time limitation of action, because it takes into consideration all the differences in rate due to structure of the soil and other factors.

Unfortunately, however, there does not seem to be any types of humus corresponding to X and Y, but another scheme

was hit upon which somewhat answers these requirements.

Ferrous sulphate greatly increases the action of hydrogen peroxide by decomposing it into water and oxygen. This increased oxidizing power of the hydrogen peroxide gives a greater quantity of carbon dioxide, which is an advantage. Furthermore, different amounts of ferrous sulphate decomposes the hydrogen peroxide with different rapidity, so that it is possible by adding different amounts of ferrous sulphate to decompose the water in different and fairly constant lengths of time. Again, if the $FeSO_4$ be ground with the soil, the rate with which it decomposes the H_2O_2 will be subject to the same influences of structure of soil and other factors, as the rate with which the H_2O_2 acts on the organic matter of the soil.

Theoretically, the greatest action of the H_2O_2 on a soil mixed with ferrous sulphate in one half hour would be found when there was just sufficient ferrous sulphate present to complete the decomposition of the hydrogen peroxide in one half hour. The amount of crystalline ferrous sulphate which would oxidize 100 cc. of 3% hydrogen peroxide was found to be 1.66 grams. The increase in the action caused by the ferrous sulphate made it possible to reduce the sample to 5 grams and the cc. of hydrogen peroxide from 200 to 100, and to run the determination at room temperature.

The decomposition of the hydrogen peroxide was found to be faster in the presence of the soil, so that with 1.66 grams of ferrous sulphate the action was completed before the

end of one half hour. A series of determinations were then run to find what amount of ferrous sulphate gave the highest results. 0.833 gram or one half the calculated amount gave the greatest oxidation on soil A.

TABLE IV. DECOMPOSITION OF ORGANIC MATTER WITH 3.39% H_2O_2 at Room Temperature (20-24°) with $FeSO_4$

Soil	Wgt of sample	cc of H_2O_2	Gms of FeSO4	Time mins.	Original weight of CO_2 tubes	Final weight of CO_2 tubes	Gain	Net Gain CO_2	Carbon oxidized
A	5	100	1.666	30	178.8166	178.9593	.1427	.0567	.01546
A	5	100	1.666	30	(178.9593 (145.4160	179.1036) 145.4164)	.1443	.0583	.01592
	0	100	1.666	30	(179.1036 (145.4164	179.1854) 145.4163)	.0818		
A	5	100	0.833	30	(179.1854 (145.4163	179.3727) 145.4182)	.1892	.1032	.02813
A	5	100	3.33	30	(179.3727 (145.4182	149.4780) 145.4199)	.1070	.0210	.005724
	0	100	1.66	15	(179.4780 (145.4182	179.5432) 145.4218)	.0686		
B	5	100	1.66	30	(179.5396 (145.4198	179.6500) 145.4210)	.1116	.0256	.00698
B	5	100	0.833	30	(179.6500 (145.4210	179.7645) 145.4247)	.1182	.0322	.00878
B	5	100	3.33	30	(179.7645 (145.4247	179.8642) 145.4268)	.1018	.0158	.00431
	0	100	1.66	30	(177.5248 (145.4268	177.6132) 145.4294)	.0916		
B	5	100	1.66	30	(177.6138 (145.4294	177.7154) 145.4290)	.1016	.0156	.00425
B	5	100	3.33		(177.7154 (145.4290	177.8050) 145.4320)	.0924	.0064	.001745
B	5	100	1.66	30	(177.8073 (145.4341	177.9185) 145.4340)	.1112	.0252	

TABLE IV. CONTINUED:

Soil	Wgt of samp.	cc. of H_2O_2	Gms of $FeSO_4$	Time: mins.	Original weight of CO_2 tubes:	Final weight of CO_2 tubes	Gain	Net gain CO_2	Carbon oxidiz.
B	5	100	3.33	30	(177.9185 (145.4340	178.0022) 145.4365)	.0862	.0002	
B	5	100	0.833	30	(178.0022 (145.4365	178.1134) 145.4368)	.1112	.0252	.006865
A	5	100	0.833	30	(178.1134 (145.4368	178.3036) 145.4370)	.1902	.1042	.0284
	0	100	0.833	30	(178.5228 (145.4442	178.6106) 145.4472)	.0908		
A	5	100	3.33	30	(178.6106 (145.4472	178.7138) 145.4488)	.1048	.0188	.005123
A	5	100	0.5	30	(178.7138 (145.4488	178.8470 145.4515)	.1359	.0499	.01361
B	5	100	3.33	15 15	(178.8470 (145.4515 178.9270	178.9270) 145.4546) 178.9312)	.0885	.0233	.00636
	0	100	0	30	(179.0344 (145.4594	179.0640) 145.4590)	.0296		
			1.66	30	(179.0640 (145.4590	179.0968) 145.4598)	.0336		
	0	100	1.66	30	(179.0900 (145.4582	179.1578) 145.4604)	.0700		
831:	5g.	100	1.66	30	(179.1578 (145.4604	179.2716) 145.4610)	.1144	.0492	.0134
830:	5g.	100	1.66	30	(179.2716 (145.4610	179.3626) 145.4634)	.0934	.0282	.0077
831:	5g.	100	1.66	30	(179.3626 (145.4634	179.4672) 145.4668)	.1080	.0428	.01168
830:	5g	100	1.66	30	(179.4692 145.4668	149.5550) 145.4706)	.0896	.0244	.00666
831	5g	100	0.833	30	(176.7998	176.9345	.1347	.0695	.08890
830:	5g	100	0.833	30	147.6210	147.6962	.0752	.0100	.00273

TABLE IV. CONTINUED:

Soil	Wgt of samp.	cc. of H_2O_2	Gms of $FeSO_4$	Time	Original weight of CO_2 tubes	Final weight of CO_2 tubes	Gain	Net gain CO	Carbon oxidized
831	5	100	0.833	30	185.6124	185.7546	.1422	.0770	.0210
830	5	100	0.833	30	146.1386	146.2310	.0924	.0272	.00742
	0	100	0.833	30	185.5500	185.6124	.0624		
	0	100	0.833	30	146.0774	146.1386	.0512		
A	5	100	0.5	30	185.7546	185.8332	.0787	.0135	.00368
B	5	100	0.5	30	146.2310	146.2734	.0424	0	
B	5	100	1.66	30	146.2734	146.3536	.0802	.0150	.00409
B	5	100	0.5	30	185.8332	185.8760	.0428	0	
B	5	100	1.00	30	186.2585	186.3860	.1275	.0383	.0104
A	5	100	1.00	30	150.5580	150.7447	.1867	.0975	.0266
A	5	100	1.00	30	186.3860	186.5666	.1806	.0914	.0249
B	5	100	1.00	30	150.7447	150.8706	.1259	.0367	.0100
831	5	100	1.00	30	186.5666	186.7508	.1842	.0950	.0259
830	5	100	1.00	30	150.8706	150.9936	.1232	.0340	.00927
830	5	100	1.00	30	186.7508	186.8892	.1284	.0392	.0107
831	5	100	1.00	30	150.9936	151.1762	.1826	.0934	.0254
	0	100	1.00	30	151.1762	151.2670	.0908		
	0	100	1.00	30	186.8892	186.9768	.0876		
832	5	100	1.00	30	182.2894	182.4324	.1434	.0542	.01477
833	5	100	1.00	30	148.7096	148.9880	.2784	.1892	.0516
833	5	100	1.00	30	182.4328	182.6714	.2386	.1694	.04620
832	5	100	1.00	30	148.9880	149.1176	.1296	.0404	.01102

We now had a method which would oxidize a significant amount of carbon dioxide from the soil organic matter and gave results that check fairly well. The duplicates were not as close as could be wished for, and, very probably, to get accurate results, the temperature of the reaction will have to be controlled by some thermostat arrangement, such as was used in the first part of the experiment, but which was later discarded. However, in the limited time left, it seemed best to proceed and run a few determinations on some different set of virgin and cropped soils rather than to continue on the perfection of a method. The results obtained, however, were not very accurate, and are not advanced as proving anything at all, but merely indicate a possible direction for future work.

The soils tested were:-

A:- a virgin soil from Milton Twp. Rock Co. Wisconsin. It is a Miami silt loam, acid in reaction. Contains 3.10% total carbon.

B:- a cropped soil corresponding to A. It is more acid than A in reaction. Contains 1.21% carbon.

830:- soil from Evansville Union Twp. - surface, 8".

History: cropped 60 years; 25 years wheat of 25 bu.; 5 years timothy and clover at 2 tons; 30 years tobacco yielding 1300 lbs. to 1400 lbs. Manured 30 times with 10 loads and clay loam and clay subsoil.

Analysis:- P_2O_5 - .14%; CO_2 - 0.037%; T Carbon - 1.24%
N - .15%; Organic matter - 2.14%.

Soil No. 831:- equivelant virgin soil.

Sample from Road fence.

Analysis:-

Total P_2O_5 - 0.15%; CO_2 - 0.056%.
Total C - 2.52%
Total N - 0.25%; Organic matter -4.35%.

Soil No. 832:- sampled July, 1907.

Sec. 10 Union Twp.

History:-

Cropped 32 years; 20 years of tobacco, 1500 lbs; 9 crops corn, 50 bu.; 1 crop rye; 1 crop wheat; 1 crop clover; manured 12-13 times. Dark clay loam - clay subsoil.

Analysis:-

Total P_2O_5 - 0.14%; CO_2 - 0.045%.
Total N -- 0.15%; Organic matter - 2.8%.
Total Carbon -1.62%.

Soil No. 833:- virgin sample of 832 - wood lot.

Analysis:-

P_2O_5 - 0.31%; CO_2 - 0.156%.
Total N- 0.35%; Organic matter - 9.00%.
Total Carbon - 5.22%.

The results of the determinations are shown in the following table:-

TABLE V. COMPA RATIVE AMOUNTS OF SOIL CARBON OXIDIZED

In a 5 gr. Sample of Soil, with 1 gr of $FeSO_4$ and

	Soil "A"		Soil "B"		Soil "831"	
Amount of $FeSO_4$	Carbon oxidized	% of total carbon	Carbon oxidized	% of total carbon	Carbon oxidized	% of total carbon
	.0059	3.74	.00195	3.16		
3.33 gr	.0053	3.41	.0002	0.33		
			.00085	1.41		
	.0156	10.06	.0068	11.33	.01168	7.53
	.0183	11.80	.0044		.0134	8.64
1.66 gr			.0070	11.66		
			.0064	10.66		
	.0266	17.16	.0104	17.33	.0259	20.07
1.00 gr	.0249	16.06	.0100	16.66	.0254	18.57
	.0281	18.12	.00878	14.63	.0189	12.14
.833 gr	.0284	18.32	.00686	11.43	.0210	13.56

100 cc. of 3% H_2O_2 at Room Temperature for 30 minutes

Soil "830"		Soil "833"		Soil "832"	
Carbon oxidized	% of total carbon	Carbon oxidized	% of total carbon	Carbon oxidized	% of total carbon
.0067	11.16				
.0077	12.83				
.0107	17.62	.0516	19.85	.0147	18.10
.0093	15.32	.0462	17.77	.0110	13.54
.0027	4.55				
.0074	10.70				

There can not be said to be any appreciable difference in the rate of oxidation of the organic carbon in any of the samples. On the whole, the amounts of carbon dioxide obtained seem to check remarkably close to the total carbon determinations. These results may be disproven and possibly there is little use in drawing conclusions, but this explanation suggests itself.

These soils are all upland, arable soils of nearly the same type and structure. The places from which they come are close enough to have the same climate and probably as virgin soils they had approximately the same vegetation. Under such conditions, the humus in all of them would be very nearly the same. This explains the similarity between the different sets.

The apparent equal activity of the virgin and cropped soil humus needs further explanation. There is reason to believe that the humus in soils is the result of very long accumulation and that in such a long period of years only that organic matter remains which is stable under the conditions in which it accumulates. A thing which tends to prove this is the fact that the soils of the Cache Valley, Utah, which originally had no sod, and were practically in the same state as when cultivated, did not lose their organic matter when cultivated. In other words, the humus which has accumulated in conditions similar to cultivated conditions, does not decrease because of cultivation.

It follows, then, that the organic matter in these virgin soils is nearly all reduced down to below a certain stage of resistance at which it will not be oxidized under its virgin conditions. Besides this, if we admit that the humus is the result of ages of accumulation, then there can only be a little added each year or the organic matter in forms between dead tissue and stable humus is comparatively small.

When these soils were brought under cultivation, the organic matter was, then, practically all at the same stage of resistance to oxidation and all had an equal start in being oxidized. The fact was that the humus which remains was not due to chemical difference but to mechanical inhibition. This would only explain equal rate of oxidation for soils of the same type. This experiment did not include soils of different types.

On the whole, this thesis has mainly been an attempt to work out a method, and the best that can be hoped for it, is that it may indicate the general direction which will have to be followed in attempting to differentiate between different kinds of soil organic matter.

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