The chemical nature of the organic nitrogen in the soil: influence of various factors on decomposition of soil organic matter

S. L. Jodidi
Iowa State College

Follow this and additional works at: http://lib.dr.iastate.edu/researchbulletin

Part of the Agriculture Commons, Agronomy and Crop Sciences Commons, and the Soil Science Commons

Recommended Citation

Available at: http://lib.dr.iastate.edu/researchbulletin/vol1/iss3/1

This Article is brought to you for free and open access by Iowa State University Digital Repository. It has been accepted for inclusion in Research Bulletin by an authorized editor of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
The Chemical Nature of the Organic Nitrogen in the Soil

Influence of Various Factors on Decomposition of Soil Organic Matter

BY S. L. JODIDI

Agronomy Section

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS

AMES, IOWA
STATE BOARD OF EDUCATION

Hon. A. B. Funk, Spirit Lake.
Hon. George T. Baker, Davenport.
Hon. Charles R. Brenton, Dallas Center.
Hon. E. P. Schoentgen, Council Bluffs.
Hon. Parker K. Holbrook, Onawa.
Hon. D. D. Murphy, Elkader.
Hon. Roger Leavitt, Cedar Falls.

OFFICERS

Hon. J. H. Trewin, Cedar Rapids ...................... President
Hon. D. A. Emery, Ottumwa ......................... Secretary

FINANCE COMMITTEE

Hon. W. R. Boyd, President, Cedar Rapids.
Hon. Thos. Lambert, Sabula.
Hon. D. A. Emery, Secretary, Ottumwa.

STATION STAFF

E. W. Stanton, B. Sc., M. Sc., L. L. D., Acting President.
W. J. Kennedy, B. S. A., Animal Husbandman and Vice-Director.
S. A. Beach, M. S. A., Horticulturist.
H. E. Summers, B. S., Entomologist.
A. W. Dox, B. S., A. M., Ph. D., Chemist.
M. Mortensen, B. S. A., Dairying.
J. B. Davidson, B. S. in M. E., Agricultural Engineering.
H. D. Hughes, M. S., Farm Crops.
G. B. MacDonald, B. S. F., Forester.
R. E. Buchanan, M. S., Ph. D., Bacteriologist.
Laurenz Greene, B. S., M. S. A., Experimentalist in Horticulture.
S. L. Jodidi, B. S., Ph. D., Experimentalist in Soils.
H. H. Kildee, B. S. A., Assistant in Dairy Cattle.
L. C. Burnett, M. S. A., Assistant in Farm Crops.
M. L. King, B. M. E., Experimentalist in Agricultural Engineering.
John M. Evvard, M. S., Experimentalist in Animal Husbandry.
A. A. Wells, B. S., M. S., Assistant in Soils.
B. W. Hammer, B. S. A., Dairy Bacteriology.
R. L. Webster, A. B., Assistant in Entomology.
Charlotte M. King, Assistant in Botany.
Harriette Kellogg, Assistant in Botany.
F. E. Colburn, Photographer.
Fred W. Beckman, Ph. B., Bulletin Editor.
THE CHEMICAL NATURE OF THE ORGANIC NITROGEN IN THE SOIL

(Second Part—First Part appeared as Research Bulletin No. 1.)

By S. L. JODIDI.

INTRODUCTION.

It was shown in previous publications that the acid-soluble organic nitrogen in Iowa soils as well as in Michigan peat soils is composed chiefly of acid amides, monamino acids and diamino acids. Following those publications, and also before, other papers appeared, dealing with the isolation of organic nitrogenous compounds from soils. Thus Schreiner and Shorey succeeded in isolating from various soils, in addition to a number of non-nitrogenous bodies, the diamino acids, arginine\(^2\) and histidine, as well as the pyrimidine\(^3\) derivative, cystosine and the purine\(^3\) bases, xanthine and hypoxanthine. Prior to that Shorey extracted from Hawaiian soils a compound which he was able to identify as a pyridine derivative, picoline\(^4\) carboxylic acid, and which he was inclined to believe, existed in the form of a lime salt in the soil. Among the decomposition products of Michigan peat the two monamino acids, leucine\(^5\) and isoleucine, were isolated and identified by Robinson who also quantitatively determined the amino\(^6\) nitrogen in the peat by Van Slyke’s nitrous acid method.

It is true that the above researches add materially to our knowledge concerning the nature of the organic compounds in soils, but the actual chemical nature of the organic matter will not be fully understood until all of its individual organic compounds have been discovered, isolated and identified, and the way they are linked together has been found out. That makes it desirable, if not imperative, to throw more light upon this paramount question. Especially is it important to know the character of the organic nitrogen in soils, for that is of fundamental value to agriculture, since it is intimately connected with the momentous biological processes of ammonification, nitrification and denitrification.

---

3 Ibid., 8, 385 (1910); Bul. 74, Bureau of Soils, U. S. Dept. Agr.
It was for this reason that it was decided to investigate a number of soil plots as to the nature of the organic nitrogen in them.

The plots examined, S, T and V, formed a part of the Iowa Agricultural Experiment Station field which is situated on the Wisconsin Drift. The plots had an area of one-tenth of an acre each and were treated as follows:

In 1906 they received a heavy application of manure, in 1907, 1908 and 1909, none. They grew corn in 1905 and 1906, oats and clover in 1907, corn in 1908 and 1909.

The soil samples were taken in the fall of 1909 and represented composite samples of twenty-four borings taken from each plot to a depth of seven inches. On being air-dried they were passed through a half millimeter sieve.

While the percentage of moisture, ammonia and nitric acid was determined in both the air-dry and moist soil samples, all other determinations and observations reported in this bulletin were made with the air-dried soils only. The oven-dried soil, however, was taken as a basis for the calculation of all the tables given in this publication.

**METHODS APPLIED IN THIS INVESTIGATION.**

It was soon ascertained that the proportion of ammoniacal and nitric nitrogen in the plots under consideration was quite insignificant and attention was therefore directed towards the organic nitrogen.

The separation of the organic nitrogenous compounds into acid amides, diamino acids and monamino acids was performed according to the Hausmann-Osborne method, namely by distilling the evaporated acid extract of the soil with magnesia which gave in the form of ammonia all the nitrogen corresponding to the amides present in the soil. The residue on distillation of the soil extract with magnesia was thoroughly extracted with water and concentrated to 100cc. to which sulphuric acid and enough phosphotungstic acid was added to throw down the diamino acids present in the extract.

Ordinarily for every 0.15 gr. nitrogen contained in the soil extract five grams of sulphuric acid and thirty cc. of a solution containing five grams of sulphuric acid and twenty grams of phosphotungstic acid per 100cc. were applied. In all cases more of the phosphotungstic acid was added to the filtrate from the phosphotungstes to make sure that diamino acids were completely precipitated.

The Kjeldahlization of the washed phosphotungstic acid precipitate gave the amount of the diamino nitrogen. The per-
centage of the monamino nitrogen was obtained by subtracting
the sum of ammoniacal, amido, and diamino nitrogen from
100.

The results secured by this method are recorded in Table I.
The data given in Table I need some explanation. In a
former investigation it was demonstrated that with the Haus-
mann-Osborne method the ammonia obtained by distilling the
evaporated extract of the soil with magnesia was actually pure
ammonia which the acid amides split off, but that the phosho-
tungstic acid precipitate and the filtrate from that precipitate
did not represent diamino and monamino acids only.

**TABLE I.—AMOUNT OF NITROGEN IN THE VARIOUS COM-
PONDS.**

<table>
<thead>
<tr>
<th>Plot</th>
<th>Gram</th>
<th>Per cent. of oven dried soil</th>
<th>Percent of total soil Nitrogen</th>
<th>Percent of Nitrogen in Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total nitrogen in solution (obtained by boiling with hydrochloric acid)</td>
<td>0.16069</td>
<td>0.1844</td>
<td>87.37</td>
<td>100.00</td>
</tr>
<tr>
<td>Ammoniacal nitrogen</td>
<td>0.00081</td>
<td>0.0009</td>
<td>0.44</td>
<td>0.50</td>
</tr>
<tr>
<td>Nitrogen of acid amides</td>
<td>0.05397</td>
<td>0.0619</td>
<td>29.35</td>
<td>33.59</td>
</tr>
<tr>
<td>Nitrogen of diamino acids</td>
<td>0.02773</td>
<td>0.0318</td>
<td>15.08</td>
<td>17.26</td>
</tr>
<tr>
<td>Nitrogen of monamino acids (difference from 100)</td>
<td>0.07818</td>
<td>0.0897</td>
<td>42.51</td>
<td>48.65</td>
</tr>
<tr>
<td>T</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total nitrogen in solution (obtained by boiling hydrochloric acid)</td>
<td>0.20247</td>
<td>0.2199</td>
<td>92.41</td>
<td>100.00</td>
</tr>
<tr>
<td>Ammoniacal nitrogen</td>
<td>0.00099</td>
<td>0.0011</td>
<td>0.45</td>
<td>0.49</td>
</tr>
<tr>
<td>Nitrogen of acid amides</td>
<td>0.06789</td>
<td>0.0737</td>
<td>30.99</td>
<td>33.53</td>
</tr>
<tr>
<td>Nitrogen of diamino acids</td>
<td>0.04029</td>
<td>0.0438</td>
<td>18.39</td>
<td>19.90</td>
</tr>
<tr>
<td>Nitrogen of monamino acids (difference from 100)</td>
<td>0.09330</td>
<td>0.1013</td>
<td>42.58</td>
<td>46.08</td>
</tr>
<tr>
<td>V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total nitrogen in solution (obtained by boiling with hydrochloric acid)</td>
<td>0.12675</td>
<td>0.2216</td>
<td>88.98</td>
<td>100.00</td>
</tr>
<tr>
<td>Ammoniacal nitrogen</td>
<td>0.00062</td>
<td>0.0011</td>
<td>0.43</td>
<td>0.49</td>
</tr>
<tr>
<td>Nitrogen of acid amides</td>
<td>0.04207</td>
<td>0.0735</td>
<td>29.53</td>
<td>33.19</td>
</tr>
<tr>
<td>Nitrogen of diamino acids</td>
<td>0.01797</td>
<td>0.0314</td>
<td>12.61</td>
<td>14.18</td>
</tr>
<tr>
<td>Nitrogen of monamino acids (difference from 100)</td>
<td>0.06698</td>
<td>0.1155</td>
<td>46.40</td>
<td>52.14</td>
</tr>
</tbody>
</table>

To find out just how much of the diamino and monamino
nitrogen given in Table I actually belonged to diamino and mon-

*Jour. Am. Chem. Soc., 33, 1241 (1911).*
amino acids, the solutions in question were subjected to analysis by the formol-titration method.

DETAILS OF THE FORMALDEHYDE TITRATION METHOD.

A few cautions may not be amiss in connection with the use of this method. In order to avoid mistakes it is necessary to use for titration enough of the amino acids: the more of them employed for the formol-titration, the more accurate are the results. Further, it is of advantage to start the formol-titration of the soil extract supposed to contain amino acids, not in the alkaline, but in the acid state; i.e., the soil extract to be formol-titrated is slightly acidified with hydrochloric acid so as to require, say, from one to three cc. of 1/5 barium hydroxide. With these precautions and under observation of conditions outlined elsewhere, the formaldehyde titration method gives accurate quantitative results practically for all monamino acids. This is also true of the diamino acids in case one of them only is contained in the sample to be titrated. If several diamino acids are present, then the calculation of the formol-titrimetrical results is more complicated.

The operations in question are conveniently carried out as follows: The soil extract containing amino acids, upon examination of the optical activity in the polariscope, is made up to a definite volume, say, to 60cc. of which 15cc. are Kjeldahlized to ascertain the total nitrogen present in the sample, 15cc. are titrated in the ordinary way to determine the percentage of acidity of the substance, and two portions of 15cc. each are formol-titrated to find the increase of acidity due to the reaction with neutralized formaldehyde. These three operations furnish all the data necessary for the calculation of the percentage of diamino or monamino acids present in the substance under examination.

For the sake of convenience the method of separation of the organic nitrogenous compounds into the various groups is schematically presented as follows:

---

Bloch. Zeitschr. 7, 45 (1907); 7, 407 (1908); Zeitschr. physiol. Chem. 60, (1909); 64, 121 (1910).

Research Bul. 1, Iowa Agr. Expt. Sta., page 35, etc.
Digest soil with boiling hydrochloric acid.

INSOLUBLE RESIDUE.
Contains nitrogenous bodies of practically unknown constitution.

ACID FILTRATE.
Evaporate and distill with magnesia.

DISTILLATE.
Contains ammonia.

ALKALINE RESIDUE.
Extract with hot water and treat with phosphotungstic acid.

PRECIPITATE.
Contains diamino acids. Use a small portion for precipitation reactions, and the principal portion for optical observations. The latter to be used also for formol-titration.

FILTRATE.
Represents monamino acids. Remove inorganic salts by crystallization and use final mother liquor for optical observations. Same to be used for formol-titration.

In connection with the scheme just given it should be borne in mind that the distillate obtained by distilling the evaporated acid filtrate with magnesia contains the ammonia originally present as such in the soil, as well as the ammonia split off from the acid amides by boiling with acid. Further, the precipitate containing diamino acids and the filtrate representing monamino acids are freed from phosphotungstic acid by means of barium hydroxide the excess of which is removed with CO₂. The filtrate from barium carbonate is then treated as given in the scheme. Both the precipitate and filtrate may contain also nitrogenous compounds other than diamino and monamino acids.

SEPARATION OF THE MONAMINO ACIDS FROM INORGANIC SALTS.

The monamino acids present in the extracts from the various soil samples investigated were separated from the inorganic salts by crystallization. Usually the mother liquor was filtered off with suction from the first crop of crystals which consisted mainly of barium chloride. They were washed with 96 per cent alco-
hol. The separated mother liquor, on being mixed with the wash alcohol, yielded within half an hour or so practically the remainder of the inorganic salts which were composed of barium chloride and of the chlorides of potassium and sodium. The liquor was now again separated by suction from the second crop of the inorganic salts which, too, were treated with 96 per cent alcohol. A further evaporation of the second mother liquor or-

<table>
<thead>
<tr>
<th>DIAMINO ACIDS</th>
<th>MONAMINO ACIDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactions</td>
<td>Reaction with Formaldehyde</td>
</tr>
<tr>
<td>The diamino acids extracted from the various plots (S, T, V), displayed the following reactions:</td>
<td>The monamino acids extracted from the soils examined, on being mixed with hydrochloric acid, showed in the 2 dm. tube the rotation $\alpha = +0.61^\circ$ (Ventzke).</td>
</tr>
<tr>
<td>1. Phosphotungstic acid gave a heavy white precipitate.</td>
<td>[ \text{Rotation} ]</td>
</tr>
<tr>
<td>2. Phosphomolybdic acid gave a yellow precipitate.</td>
<td>[ \text{Rotation} ]</td>
</tr>
<tr>
<td>3. Mercuric chloride gave a grayish white flocculent precipitate.</td>
<td>[ \text{Rotation} ]</td>
</tr>
<tr>
<td>4. Silver nitrate gave a grayish or yellowish white precipitate, soluble in excess of ammonia.</td>
<td>[ \text{Rotation} ]</td>
</tr>
<tr>
<td>5. Picric acid either failed to give a precipitate or the precipitate obtained after some time was quite insignificant.</td>
<td>[ \text{Rotation} ]</td>
</tr>
<tr>
<td>6. The aqueous solution of the diamino acids was strongly alkaline.</td>
<td>[ \text{Rotation} ]</td>
</tr>
<tr>
<td>7. Addition of neutralized formaldehyde to the alkaline solution caused it to turn acid pointing to the presence of carboxyl and amino groups.</td>
<td>[ \text{Rotation} ]</td>
</tr>
</tbody>
</table>

**TABLE II.**

<table>
<thead>
<tr>
<th>DIAMINO ACIDS</th>
<th>MONAMINO ACIDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactions</td>
<td>Reaction with Formaldehyde</td>
</tr>
<tr>
<td>The diamino acids extracted from the various plots (S, T, V), displayed the following reactions:</td>
<td>The monamino acids extracted from the soils examined, on being mixed with hydrochloric acid, showed in the 2 dm. tube the rotation $\alpha = +0.61^\circ$ (Ventzke).</td>
</tr>
<tr>
<td>1. Phosphotungstic acid gave a heavy white precipitate.</td>
<td>[ \text{Rotation} ]</td>
</tr>
<tr>
<td>2. Phosphomolybdic acid gave a yellow precipitate.</td>
<td>[ \text{Rotation} ]</td>
</tr>
<tr>
<td>3. Mercuric chloride gave a grayish white flocculent precipitate.</td>
<td>[ \text{Rotation} ]</td>
</tr>
<tr>
<td>4. Silver nitrate gave a grayish or yellowish white precipitate, soluble in excess of ammonia.</td>
<td>[ \text{Rotation} ]</td>
</tr>
<tr>
<td>5. Picric acid either failed to give a precipitate or the precipitate obtained after some time was quite insignificant.</td>
<td>[ \text{Rotation} ]</td>
</tr>
<tr>
<td>6. The aqueous solution of the diamino acids was strongly alkaline.</td>
<td>[ \text{Rotation} ]</td>
</tr>
<tr>
<td>7. Addition of neutralized formaldehyde to the alkaline solution caused it to turn acid pointing to the presence of carboxyl and amino groups.</td>
<td>[ \text{Rotation} ]</td>
</tr>
</tbody>
</table>
ordinarily furnished but an insignificant amount of inorganic salts which were treated in the above manner. The final mother liquors of the various soils obtained in the manner described contained practically nothing but organic compounds. They showed acid reaction immediately upon the addition of neutralized formaldehyde, hence they contained the NH₂ and COOH group. They showed optical activity, consequently they contained an asymmetric C-atom and had the NH₂ group very likely in the α position.

In Table II are presented the facts which go to show that the substances designated in Table I as diamino and monamino acids actually display reactions and possess properties which are characteristic of those compounds.

The determinations of the rotatory power of the soil extracts as presented in Table II have but a qualitative value. No effort was made to determine the specific rotatory power because of the probable presence of several amino acids in each of the soil extracts examined. We had in view only the object to find out whether the solutions, supposed to contain diamino or monamino acids, were optically active or inactive.

As shown in another investigation,¹¹ not all of the nitrogen obtained by the Hausmann-Osborne method as nitrogen of diamino and monamino acids actually represents diamino and monamino nitrogen, but a portion of that nitrogen belongs to classes other than amino acids. To find out just what proportion of that nitrogen is really made up of diamino and monamino acids, the soil extracts from the plots, S, T, V were subjected to formaldehyde titration with the results given in Table III.

### TABLE III.

<table>
<thead>
<tr>
<th>Plot</th>
<th>DIAMINO ACIDS.</th>
<th>MONAMINO ACIDS.</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.</td>
<td>The soil extract containing diamino acids was made up to 60cc. of which 15cc. were titrated in the usual way and required 0.2cc. n/5 barium hydroxide, and two portions of 15cc. each were formol-titrated and required on the average 0.6cc. n/5 barium hydroxide. This means that the increase of the acidity caused by the presence of diamino acids is corresponding to 0.4cc. n/5 barium hydroxide. Unfortunately, 15cc. of the soil extract oxidized according to Kjeldahl were lost so that the actual percentage of the diamino acids could not be calculated.</td>
<td>Sixty cc. of the soil extract containing monamino acids were treated as follows: 15cc. were Kjeldahlized and the ammonia obtained required 10.02cc. n/10 H₂SO₄ corresponding to 0.01407 gram nitrogen: 15cc. were titrated and required 2.2cc. n/5 barium hydroxide; two portions of 15cc. each were formol-titrated and required on the average 5.61cc. n/5 barium hydroxide. This means that 3.41cc. n/5 barium hydroxide equivalent to 0.00957 gr. nitrogen, or 65.02 per cent of what is given in Table I as nitrogen of monamino acids actually represent monamino nitrogen. The other 31.98 per cent belong to classes other than monamino acids.</td>
</tr>
</tbody>
</table>

¹¹*Jour, Am. Chem. Soc., 33, 1239 (1911).*
TABLE III (Continued)

<table>
<thead>
<tr>
<th>Plot</th>
<th>DIAMINO ACIDS.</th>
<th>MONAMINO ACIDS.</th>
</tr>
</thead>
<tbody>
<tr>
<td>T.</td>
<td>The soil extract containing diamino acids was made up to 60cc. The Kjeldahlization of 15cc. showed that they contain 0.006 gr. nitrogen; 15cc. titrated in the ordinary way required 1.47cc. ( \frac{\text{n}}{5} ) barium hydroxide; two portions of 15cc. each formol-titrated required 2.04cc. ( \frac{\text{n}}{5} ) barium hydroxide. This means that the 60cc. substance through formaldehyde increased in acidity the amount of which is equivalent to 2.28cc. ( \frac{\text{n}}{5} ) barium hydroxide or 1.01280 gr. nitrogen (53.3%) of lysine alone were present, or 0.01921 gr. nitrogen (80.0%), if histidine alone were present; or 0.02561 gr. nitrogen (106.7%), if arginine only were present. While these figures do not give the actual percentage of each one of the diamino acids, they do show that the total percentage of the diamino acids is quite considerable. In other words, a large portion of what is given in Table I as nitrogen of diamino acids actually represents diamino nitrogen.</td>
<td>The formol-titrations of 60cc. substance, with 0.05520 gr. nitrogen, showed that 82.03% of what is given in Table I as nitrogen of monamino acids, actually represents monamino nitrogen, the rest consisting of nitrogenous compounds other than monamino acids.</td>
</tr>
</tbody>
</table>

V. Sixty cc. of the soil extract were analyzed with this result: The titration of 15cc. of this solution required 3.35cc. \( \frac{\text{n}}{5} \) barium hydroxide; the formol-titrations of two portions of 15cc. each required on the average 3.02cc. \( \frac{\text{n}}{5} \) barium hydroxide. Hence, the increase of acidity through formaldehyde is equal to 0.67cc. \( \frac{\text{n}}{5} \) barium hydroxide. The Kjeldahl determination of 15cc. of this solution was unfortunately lost by accident, which rendered the calculation of the actual percentage of diamino nitrogen impossible. The substance containing monamino acids was analyzed with the following result: 15cc. were Kjeldahlized and found to contain 0.0097 gr. nitrogen. 15cc. titrated in the ordinary way required 3.55cc. \( \frac{\text{n}}{5} \) barium hydroxide; two portions of 15cc. formol-titrated required on the average 6.52cc. \( \frac{\text{n}}{5} \) barium hydroxide. This means that the increase of acidity due to the reaction with formaldehyde was equivalent to 2.97cc. \( \frac{\text{n}}{5} \) barium hydroxide= 0.00834 gr. nitrogen. Or 0.00834 x \( \frac{100}{0.00070} \approx 85.98 \) per cent of what is recorded in Table I as nitrogen of monamino acids actually represent monamino nitrogen. |

While the data before us to a certain degree modify the results reported in previous publications, especially as far as the percentage of diamino and monamino acids is concerned, yet this modification does not go far enough to shift the ratio of the acid amides to the diamino and monamino acids. Here, as in our
earlier investigations, the percentage of monamino acids is predominant; next in proportion follow the acid amides, and finally the diamino acids. The percentage of the ammoniacal nitrogen is insignificant.

In comparing the results, it is to be borne in mind that whereas in laboratory or pot experiments it is easy to get good average samples, it is quite different with field or plot experiments. In the first place it is not an easy task to obtain one or several tons of manure, hay or straw as a uniform and homogeneous mass. Nor is it possible to distribute such organic materials absolutely evenly throughout the plots. Likewise, it is very difficult, if at all possible, to get a truly average soil sample from a plot of the size of one-tenth of an acre. It is for these reasons that samples from the same plot, and still more from different plots, though treated with the same organic materials, may in some measure differ from each other. This may account for some differences in the results reported, yet on the whole the data secured in the above experiments confirm the results reported in the former publications.

CONCLUSIONS.

The data at hand permit of the following conclusions:

1. The principal portion of the acid-soluble organic nitrogen contained in the soils herein investigated is made up of acid amides, monamino acids and diamino acids.

2. The larger part of the phosphotungstic acid precipitate obtained by the Hausmann-Osborne method in the manner described in this publication and recorded in Table I as nitrogen of diamino acids, actually represents diamino nitrogen, the smaller part belonging to classes other than diamino acids.

3. In the case of the filtrate from the phosphotungstic acid precipitate presented in Table I as nitrogen of monamino acids, it was found that from 68.02 to 85.98 per cent of that filtrate in fact represented monamino nitrogen, the remainder, from 31.98 to 14.02 per cent, consisting of nitrogenous compounds other than monamino acids. The above conclusions refer to that portion of the organic nitrogen which could be extracted by boiling with hydrochloric acid.

In conclusion 10, on p. 46 of Research Bul. 1, Iowa Agr. Expt. Sta., the word "acid-soluble" was omitted by the printers. It should correctly read as follows: "Since we have found that the acid-soluble organic nitrogenous compounds in Iowa soils as well as in Michigan peat soils are made up chiefly of acid amides and amino acids, despite a considerable variety of the sources of the organic nitrogen, it seems fairly safe to state that the bulk of the acid-soluble organic nitrogen in the majority of soils, if not in all, consists very likely of acid amides and amino acids."
The fact that soil organic matter is the result of decomposed or still decaying vegetable and animal tissues, not infrequently of very different nature, prompted an examination of a considerable number of plots treated with different organic materials under a variety of conditions. The plots chosen for this investigation formed part of the experiment station field which is located on the Wisconsin Drift. The plots, A, B, C, D, F, G, I, K, L, M, had an area of one-twentieth of an acre each and the plots O, P, R, S, T and V, one-tenth of an acre each. Their treatment can best be seen from the following tabulation:

### TREATMENT PER ACRE

<table>
<thead>
<tr>
<th>Plot</th>
<th>1907</th>
<th>1908</th>
<th>1909</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>No Treatment</td>
<td>No Treatment</td>
<td>No Treatment</td>
</tr>
<tr>
<td>B</td>
<td>Two tons of Peat</td>
<td>Two tons of Peat</td>
<td>Two tons of Peat</td>
</tr>
<tr>
<td>C</td>
<td>No Treatment</td>
<td>No Treatment</td>
<td>No Treatment</td>
</tr>
<tr>
<td>D</td>
<td>No Treatment</td>
<td>No Treatment</td>
<td>No Treatment</td>
</tr>
<tr>
<td>F</td>
<td>Two tons of Timothy</td>
<td>Two tons of Timothy</td>
<td>Two tons of Timothy</td>
</tr>
<tr>
<td>G</td>
<td>No Treatment</td>
<td>No Treatment</td>
<td>No Treatment</td>
</tr>
<tr>
<td>I</td>
<td>One ton of Clover Hay</td>
<td>One ton of Clover Hay</td>
<td>One ton of Clover Hay</td>
</tr>
<tr>
<td>K</td>
<td>Four tons of Clover Hay</td>
<td>Four tons of Clover Hay</td>
<td>Four tons of Clover Hay</td>
</tr>
<tr>
<td>L</td>
<td>One ton of Manure</td>
<td>One ton of Manure</td>
<td>One ton of Manure</td>
</tr>
<tr>
<td>M</td>
<td>Two tons of Manure</td>
<td>Two tons of Manure</td>
<td>Two tons of Manure</td>
</tr>
<tr>
<td>O</td>
<td>No Treatment</td>
<td>No Treatment</td>
<td>No Treatment</td>
</tr>
<tr>
<td>P</td>
<td>No Treatment</td>
<td>No Treatment</td>
<td>No Treatment</td>
</tr>
<tr>
<td>R</td>
<td>No Treatment</td>
<td>No Treatment</td>
<td>No Treatment</td>
</tr>
<tr>
<td>S</td>
<td>No Treatment</td>
<td>No Treatment</td>
<td>No Treatment</td>
</tr>
<tr>
<td>T</td>
<td>No Treatment</td>
<td>No Treatment</td>
<td>No Treatment</td>
</tr>
<tr>
<td>V</td>
<td>No Treatment</td>
<td>No Treatment</td>
<td>No Treatment</td>
</tr>
</tbody>
</table>
Each of the soil samples examined represents a composite of twelve or twenty-four borings taken from each plot to the depth of seven inches. For analytical purposes the samples were air dried, ground in a ball mill and finally passed through a sieve having 400 perforations to the square inch. The amount of soil which did not pass through the sieve was negligible. For the sake of convenience the analytical data are given in the form of tables.
<table>
<thead>
<tr>
<th>PLOT</th>
<th>Wet soil used</th>
<th>Water Found</th>
<th>Air dry soil used</th>
<th>Water Found</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grams</td>
<td>Gram</td>
<td>Percent</td>
<td>Average</td>
</tr>
<tr>
<td>A</td>
<td>2.5307</td>
<td>0.4030</td>
<td>15.92</td>
<td>16.00</td>
</tr>
<tr>
<td>B</td>
<td>2.6626</td>
<td>0.4604</td>
<td>16.08</td>
<td>16.04</td>
</tr>
<tr>
<td>C</td>
<td>3.7181</td>
<td>0.7281</td>
<td>19.58</td>
<td>18.64</td>
</tr>
<tr>
<td>D</td>
<td>3.4747</td>
<td>0.5981</td>
<td>19.80</td>
<td>19.28</td>
</tr>
<tr>
<td>E</td>
<td>3.2467</td>
<td>0.5662</td>
<td>17.44</td>
<td>17.70</td>
</tr>
<tr>
<td>F</td>
<td>2.8626</td>
<td>0.4604</td>
<td>16.08</td>
<td>16.04</td>
</tr>
<tr>
<td>G</td>
<td>3.7181</td>
<td>0.7281</td>
<td>19.58</td>
<td>18.64</td>
</tr>
<tr>
<td>H</td>
<td>3.4747</td>
<td>0.5981</td>
<td>19.80</td>
<td>19.28</td>
</tr>
<tr>
<td>I</td>
<td>3.2467</td>
<td>0.5662</td>
<td>17.44</td>
<td>17.70</td>
</tr>
</tbody>
</table>

With the exception of A and P, all the plots which grew crops in 1909, when the soil samples were taken, individually show a lower percentage of moisture than the fallowed plots. On the average the soils of the fallowed plots had about three per cent more moisture than those of the cropped plots. This confirms the observations already reported in the first paper of this series, that fallowing is one of the means for the accumulation of moisture in the soil.

The estimation of the specific gravity as well as of the total nitrogen in the various plots will be found in the table following.

The knowledge of the specific gravity of the soils allows us with reasonable accuracy to estimate the nitrogen in the soil extracts by simply making them up to a definite volume and Kjeldahlizing an aliquot of it, which is then recalculated to the total volume of the liquid.

The ammoniacal and nitric nitrogen was determined, as was also the moisture of the soils, in both the wet and air-dry samples. While the percentages of ammoniacal and nitric nitrogen make it possible to find the proportion of the organic nitrogen by subtracting their sum from the total soil nitrogen, they are of further interest in that they represent the immediately available nitrogenous plant food and show at the same time what is going on in the plots in the way of ammonification and nitrification. The data in question are recorded in Tables III, IV, V and VI.
### Table III.

**Ammoniacal Nitrogen in the Wet Soil Samples of the Various Plots.**

<table>
<thead>
<tr>
<th>Plot</th>
<th>Wet soil used Grams</th>
<th>Ammoniacal Nitrogen found Gram</th>
<th>Per cent of oven-dry soil</th>
<th>Per cent of total soil Nitrogen</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>50.0</td>
<td>0.0003510</td>
<td>0.000836</td>
<td>0.209</td>
<td>0.167</td>
</tr>
<tr>
<td>B</td>
<td>50.0</td>
<td>0.0002106</td>
<td>0.000501</td>
<td>0.125</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>50.0</td>
<td>0.000510</td>
<td>0.000863</td>
<td>0.323</td>
<td>0.277</td>
</tr>
<tr>
<td>D</td>
<td>50.0</td>
<td>0.0002106</td>
<td>0.000512</td>
<td>0.239</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>50.0</td>
<td>0.0002106</td>
<td>0.000502</td>
<td>0.187</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>50.0</td>
<td>0.0002106</td>
<td>0.000502</td>
<td>0.187</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>50.0</td>
<td>0.0002808</td>
<td>0.000663</td>
<td>0.270</td>
<td>0.270</td>
</tr>
<tr>
<td>H</td>
<td>50.0</td>
<td>0.0002808</td>
<td>0.000663</td>
<td>0.270</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>50.0</td>
<td>0.0002808</td>
<td>0.000663</td>
<td>0.270</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>50.0</td>
<td>0.0002808</td>
<td>0.000663</td>
<td>0.270</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>50.0</td>
<td>0.0002808</td>
<td>0.000663</td>
<td>0.270</td>
<td>0.153</td>
</tr>
<tr>
<td>L</td>
<td>50.0</td>
<td>0.0002106</td>
<td>0.000494</td>
<td>0.230</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>50.0</td>
<td>0.0002106</td>
<td>0.000494</td>
<td>0.222</td>
<td>0.229</td>
</tr>
<tr>
<td>N</td>
<td>50.0</td>
<td>0.0002106</td>
<td>0.000494</td>
<td>0.222</td>
<td>0.577</td>
</tr>
<tr>
<td>O</td>
<td>50.0</td>
<td>0.0002106</td>
<td>0.000494</td>
<td>0.222</td>
<td>0.577</td>
</tr>
<tr>
<td>P</td>
<td>50.0</td>
<td>0.0002106</td>
<td>0.000494</td>
<td>0.222</td>
<td>0.223</td>
</tr>
<tr>
<td>Q</td>
<td>50.0</td>
<td>0.0002106</td>
<td>0.000494</td>
<td>0.223</td>
<td>0.223</td>
</tr>
<tr>
<td>R</td>
<td>50.0</td>
<td>0.0002106</td>
<td>0.000494</td>
<td>0.223</td>
<td>0.223</td>
</tr>
<tr>
<td>S</td>
<td>50.0</td>
<td>0.0002106</td>
<td>0.000494</td>
<td>0.223</td>
<td>0.223</td>
</tr>
<tr>
<td>T</td>
<td>50.0</td>
<td>0.0002106</td>
<td>0.000494</td>
<td>0.223</td>
<td>0.223</td>
</tr>
<tr>
<td>U</td>
<td>50.0</td>
<td>0.0002106</td>
<td>0.000494</td>
<td>0.223</td>
<td>0.223</td>
</tr>
<tr>
<td>V</td>
<td>50.0</td>
<td>0.0002106</td>
<td>0.000494</td>
<td>0.223</td>
<td>0.223</td>
</tr>
</tbody>
</table>

As can be seen from the figures just presented, the amount of ammoniacal nitrogen which was estimated by distillation with magnesia is very small throughout all the plots. This is also true of the air-dry soil samples recorded in Table IV.

While the percentage of ammoniacal nitrogen in both the wet and air-dry soil samples is on the whole insignificant, a closer examination of the figures contained in Tables III and IV shows that, without a single exception, the ammonia in the wet soils is somewhat lower than in the corresponding air-dry soils. This is at first sight striking when we take into consideration that both tables were calculated to the same (dry) basis and that the wet as well as the air-dry soils represent identical samples, with the
TABLE IV.

AMMONIACAL NITROGEN IN THE AIR-DRY SOIL SAMPLES OF THE VARIOUS PLOTS.

<table>
<thead>
<tr>
<th>Plot</th>
<th>air-dry soil used Grams</th>
<th>Ammoniacal Nitrogen Found</th>
<th>Average</th>
<th>Per cent of total soil Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grams</td>
<td>Per cent of oven-dry soil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>50.0</td>
<td>0.0003791</td>
<td>0.000796</td>
<td>0.000649</td>
</tr>
<tr>
<td>F</td>
<td>50.0</td>
<td>0.0003791</td>
<td>0.000792</td>
<td>0.000792</td>
</tr>
<tr>
<td>G</td>
<td>50.0</td>
<td>0.0005195</td>
<td>0.001081</td>
<td>0.001227</td>
</tr>
<tr>
<td>I</td>
<td>50.0</td>
<td>0.0005195</td>
<td>0.001072</td>
<td>0.001072</td>
</tr>
<tr>
<td>K</td>
<td>50.0</td>
<td>0.0005195</td>
<td>0.001070</td>
<td>0.001070</td>
</tr>
<tr>
<td>L</td>
<td>50.0</td>
<td>0.0008083</td>
<td>0.001653</td>
<td>0.001508</td>
</tr>
<tr>
<td>M</td>
<td>50.0</td>
<td>0.0006599</td>
<td>0.001363</td>
<td>0.000856</td>
</tr>
<tr>
<td>O</td>
<td>50.0</td>
<td>0.0003791</td>
<td>0.000929</td>
<td>0.000782</td>
</tr>
<tr>
<td>P</td>
<td>50.0</td>
<td>0.0003791</td>
<td>0.000782</td>
<td>0.000782</td>
</tr>
<tr>
<td>R</td>
<td>50.0</td>
<td>0.0005195</td>
<td>0.001077</td>
<td>0.001077</td>
</tr>
<tr>
<td>S</td>
<td>50.0</td>
<td>0.0005195</td>
<td>0.001077</td>
<td>0.001077</td>
</tr>
<tr>
<td>T</td>
<td>50.0</td>
<td>0.0005195</td>
<td>0.001077</td>
<td>0.001077</td>
</tr>
<tr>
<td>V</td>
<td>50.0</td>
<td>0.0005195</td>
<td>0.001078</td>
<td>0.001078</td>
</tr>
</tbody>
</table>

difference, of course, that the samples recorded in Table IV were air-dried prior to estimating the ammonia in them, and with the further difference that the ammonia determinations of the air-dry soils were made first. The estimation of ammonia in the wet soils was carried out after they had been allowed to remain in sealed jars for about one year. This accounts for the differences noticed, as there can be no doubt but that a part of the ammonia in the wet soils must have changed to nitrates as a consequence of which the amount of nitrates in the wet samples must be higher than in the air-dry samples. This was found to be actually the case as the examination of Tables V and VI shows.

In connection with Table V these explanations should be made. Ordinarily about 1000 grams of soil were used for the estimation of the nitrates. This quantity was either increased or decreased depending on the amount of soil available for this es-
# TABLE V.

**NITRIC NITROGEN IN THE WET SOIL SAMPLES OF THE VARIOUS PLOTS.**

<table>
<thead>
<tr>
<th>Plot</th>
<th>Wet Soil used Grams</th>
<th>Of Extract Used c.c.</th>
<th>Corresponding oven-dried soil Grams</th>
<th>Gram</th>
<th>Per cent of oven-dried Soil</th>
<th>Average</th>
<th>Per cent of total soil Nitrogen</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>500</td>
<td>255</td>
<td>119.700</td>
<td>0.00770</td>
<td>0.00643</td>
<td>0.00627</td>
<td>1.61</td>
<td>1.57</td>
</tr>
<tr>
<td>B</td>
<td>700</td>
<td>425</td>
<td>172.890</td>
<td>0.00732</td>
<td>0.00612</td>
<td>0.00617</td>
<td>2.24</td>
<td>2.23</td>
</tr>
<tr>
<td>C</td>
<td>700</td>
<td>425</td>
<td>172.890</td>
<td>0.01446</td>
<td>0.00836</td>
<td>0.00832</td>
<td>2.22</td>
<td>2.20</td>
</tr>
<tr>
<td>D</td>
<td>900</td>
<td>533</td>
<td>219.303</td>
<td>0.01366</td>
<td>0.00894</td>
<td>0.00895</td>
<td>2.73</td>
<td>2.72</td>
</tr>
<tr>
<td>E</td>
<td>900</td>
<td>525</td>
<td>220.264</td>
<td>0.01309</td>
<td>0.00958</td>
<td>0.00976</td>
<td>2.53</td>
<td>2.52</td>
</tr>
<tr>
<td>F</td>
<td>900</td>
<td>527</td>
<td>220.264</td>
<td>0.01872</td>
<td>0.00854</td>
<td>0.00852</td>
<td>2.61</td>
<td>2.60</td>
</tr>
<tr>
<td>G</td>
<td>1200</td>
<td>800</td>
<td>338.440</td>
<td>0.01897</td>
<td>0.00865</td>
<td>0.00862</td>
<td>2.69</td>
<td>2.68</td>
</tr>
<tr>
<td>H</td>
<td>1100</td>
<td>725</td>
<td>310.628</td>
<td>0.01815</td>
<td>0.00824</td>
<td>0.00821</td>
<td>3.07</td>
<td>3.06</td>
</tr>
<tr>
<td>I</td>
<td>1100</td>
<td>725</td>
<td>310.628</td>
<td>0.01809</td>
<td>0.00821</td>
<td>0.00820</td>
<td>3.06</td>
<td>3.05</td>
</tr>
<tr>
<td>J</td>
<td>1100</td>
<td>725</td>
<td>310.628</td>
<td>0.02583</td>
<td>0.00764</td>
<td>0.00763</td>
<td>3.11</td>
<td>3.10</td>
</tr>
<tr>
<td>K</td>
<td>1100</td>
<td>725</td>
<td>310.628</td>
<td>0.02588</td>
<td>0.00768</td>
<td>0.00767</td>
<td>3.12</td>
<td>3.11</td>
</tr>
<tr>
<td>L</td>
<td>1100</td>
<td>725</td>
<td>310.628</td>
<td>0.01997</td>
<td>0.00643</td>
<td>0.00641</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>M</td>
<td>1000</td>
<td>625</td>
<td>260.906</td>
<td>0.02016</td>
<td>0.00649</td>
<td>0.00646</td>
<td>3.03</td>
<td>3.02</td>
</tr>
<tr>
<td>N</td>
<td>1000</td>
<td>625</td>
<td>260.906</td>
<td>0.02235</td>
<td>0.00806</td>
<td>0.00804</td>
<td>3.62</td>
<td>3.61</td>
</tr>
<tr>
<td>O</td>
<td>1000</td>
<td>625</td>
<td>260.906</td>
<td>0.02260</td>
<td>0.00815</td>
<td>0.00813</td>
<td>3.65</td>
<td>3.64</td>
</tr>
<tr>
<td>P</td>
<td>1000</td>
<td>625</td>
<td>260.906</td>
<td>0.02241</td>
<td>0.00767</td>
<td>0.00766</td>
<td>3.32</td>
<td>3.31</td>
</tr>
<tr>
<td>Q</td>
<td>1100</td>
<td>625</td>
<td>260.906</td>
<td>0.02285</td>
<td>0.00748</td>
<td>0.00746</td>
<td>3.24</td>
<td>3.23</td>
</tr>
<tr>
<td>R</td>
<td>1100</td>
<td>625</td>
<td>260.906</td>
<td>0.02016</td>
<td>0.00773</td>
<td>0.00772</td>
<td>3.50</td>
<td>3.49</td>
</tr>
<tr>
<td>S</td>
<td>1100</td>
<td>625</td>
<td>260.906</td>
<td>0.02009</td>
<td>0.00770</td>
<td>0.00769</td>
<td>3.48</td>
<td>3.47</td>
</tr>
<tr>
<td>T</td>
<td>1000</td>
<td>625</td>
<td>260.906</td>
<td>0.01283</td>
<td>0.00422</td>
<td>0.00421</td>
<td>2.72</td>
<td>2.70</td>
</tr>
<tr>
<td>U</td>
<td>1000</td>
<td>625</td>
<td>260.906</td>
<td>0.01308</td>
<td>0.00438</td>
<td>0.00437</td>
<td>2.03</td>
<td>2.02</td>
</tr>
<tr>
<td>V</td>
<td>1100</td>
<td>625</td>
<td>260.906</td>
<td>0.01578</td>
<td>0.00587</td>
<td>0.00586</td>
<td>2.69</td>
<td>2.68</td>
</tr>
<tr>
<td>W</td>
<td>1100</td>
<td>625</td>
<td>260.906</td>
<td>0.01621</td>
<td>0.00603</td>
<td>0.00602</td>
<td>2.76</td>
<td>2.75</td>
</tr>
<tr>
<td>X</td>
<td>1100</td>
<td>625</td>
<td>260.906</td>
<td>0.01928</td>
<td>0.00590</td>
<td>0.00589</td>
<td>2.72</td>
<td>2.71</td>
</tr>
<tr>
<td>Y</td>
<td>1100</td>
<td>625</td>
<td>260.906</td>
<td>0.01928</td>
<td>0.00590</td>
<td>0.00589</td>
<td>2.72</td>
<td>2.71</td>
</tr>
<tr>
<td>Z</td>
<td>1100</td>
<td>625</td>
<td>260.906</td>
<td>0.01928</td>
<td>0.00590</td>
<td>0.00589</td>
<td>2.72</td>
<td>2.71</td>
</tr>
</tbody>
</table>
### TABLE VI.
NITRIC NITROGEN IN THE AIR-DRY SOIL SAMPLES OF THE VARIOUS PLOTS.

<table>
<thead>
<tr>
<th>Plot</th>
<th>Air dry soil used Grams</th>
<th>Of Extract Used</th>
<th>Nitric oxide ( \text{NO} ) found</th>
<th>Nitric Nitrogen found [Calculated from ( \text{NO} )]</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>c.c.</td>
<td>Corresponding oven-dried soil Grams</td>
<td>Volume c.c.</td>
<td>Temperature °C</td>
</tr>
<tr>
<td>A</td>
<td>500</td>
<td>236</td>
<td>111.4</td>
<td>2.2</td>
<td>23</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>250</td>
<td>111.4</td>
<td>2.2</td>
<td>23</td>
</tr>
<tr>
<td>C</td>
<td>900</td>
<td>450</td>
<td>213.2</td>
<td>0.8</td>
<td>23</td>
</tr>
<tr>
<td>F</td>
<td>1500</td>
<td>800</td>
<td>232.0</td>
<td>19.5</td>
<td>23</td>
</tr>
<tr>
<td>G</td>
<td>1400</td>
<td>700</td>
<td>336.5</td>
<td>12.4</td>
<td>23</td>
</tr>
<tr>
<td>I</td>
<td>1400</td>
<td>800</td>
<td>387.9</td>
<td>10.0</td>
<td>22</td>
</tr>
<tr>
<td>K</td>
<td>1300</td>
<td>800</td>
<td>388.6</td>
<td>9.8</td>
<td>23</td>
</tr>
<tr>
<td>L</td>
<td>1100</td>
<td>500</td>
<td>242.0</td>
<td>6.9</td>
<td>23</td>
</tr>
<tr>
<td>M</td>
<td>1100</td>
<td>650</td>
<td>314.5</td>
<td>10.8</td>
<td>23</td>
</tr>
<tr>
<td>O</td>
<td>1100</td>
<td>650</td>
<td>314.5</td>
<td>10.8</td>
<td>23</td>
</tr>
<tr>
<td>P</td>
<td>1400</td>
<td>880</td>
<td>424.6</td>
<td>0.7</td>
<td>21</td>
</tr>
<tr>
<td>R</td>
<td>1500</td>
<td>900</td>
<td>459.9</td>
<td>0.8</td>
<td>23</td>
</tr>
<tr>
<td>S</td>
<td>1500</td>
<td>900</td>
<td>437.4</td>
<td>1.3</td>
<td>22</td>
</tr>
<tr>
<td>T</td>
<td>1400</td>
<td>800</td>
<td>387.4</td>
<td>1.3</td>
<td>21</td>
</tr>
<tr>
<td>V</td>
<td>1400</td>
<td>850</td>
<td>409.7</td>
<td>2.8</td>
<td>24</td>
</tr>
</tbody>
</table>

*Not estimated.
†Determination lost.
timation. The accurately weighed soil was mixed with double the amount of water, including the moisture already in the soil, and during two days was regularly shaken each hour. The soil was then allowed to settle, the supernatant liquid filtered into a graduated cylinder and divided into two halves. The amount of oven-dried soil corresponding to the volume of the liquid used was then calculated. It is recorded in the fourth column. The nitric acid of the extract was decomposed with ferrous chloride, in the presence of hydrochloric acid, to nitric oxide the volume of which, on reduction to 0°C and 760 mm. bar. pressure, was calculated to nitrogen in grams which will be found in the eighth column. The other data need no explanation.

The determination of the nitrates in the air-dry soils is contained in Table VI.

An examination of the data in Table V and VI reveals the fact that the percentage of nitrates in the wet soils is considerably higher than in the air-dry ones. Recalling that the reverse was true as far as the proportion of ammonia in the wet and air-dry soils is concerned, it is but logical to conclude that the ammonia in the wet soils was transformed into nitrates. It should be borne in mind, however, that the soils under examination contain, in addition to ammonia and nitrates, also organic nitrogen, and it must be due to this factor that the increase of nitrates in the wet soils is larger than the decrease of ammonia in them. This has logically to be attributed to the fact that during the six or eight weeks which elapsed between the nitrate determinations in the air-dry soils on the one hand and in the wet soils on the other, not only the ammonia present as such in the wet soils, but also the ammonia which is constantly split off from the organic nitrogenous compounds, is gradually transformed into nitrates.

At any rate, the total percentage of ammonia and nitrates is small throughout all the plots, being a few thousandths of one per cent calculated to the oven-dried soil as a basis, or from about 0.4 to 1.4 per cent of the total soil nitrogen, recalling that the amount of ammoniacal and nitric nitrogen actually present in the soils is represented by the air-dry samples. This means that about 99 per cent of the total nitrogen is present in the soils in the shape of organic compounds. Their separation into amides, diamino and monamino acids was performed by the method used in Part I of this bulletin. The results are presented in Table VII.

As far as the data given in Table VII are concerned, it should be remembered that the phosphotungstic acid precipitate designated in the table as nitrogen of diamino acids, and the filtrate
## TABLE VII.

AMOUNT OF NITROGEN IN THE VARIOUS COMPOUNDS.

<table>
<thead>
<tr>
<th>Plot</th>
<th>Gram</th>
<th>Per cent of oven-dried soil</th>
<th>Per cent of total soil Nitrogen</th>
<th>Per cent of Nitrogen in solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total nitrogen in solution (obtained by boiling with hydrochloric acid)</td>
<td>0.14778</td>
<td>0.3415</td>
<td>85.36</td>
</tr>
<tr>
<td></td>
<td>Ammoniacal nitrogen.</td>
<td>0.00030</td>
<td>0.0007</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Nitrogen of acid amides</td>
<td>0.04167</td>
<td>0.0963</td>
<td>24.07</td>
</tr>
<tr>
<td></td>
<td>Nitrogen of amino acids (difference from 100)</td>
<td>0.10581</td>
<td>0.2445</td>
<td>61.12</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total nitrogen in solution (obtained by boiling with hydrochloric acid)</td>
<td>0.08050</td>
<td>0.2936</td>
<td>75.92</td>
</tr>
<tr>
<td></td>
<td>Ammoniacal nitrogen.</td>
<td>0.00104</td>
<td>0.0038</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>Nitrogen of acid amides</td>
<td>0.02363</td>
<td>0.0862</td>
<td>23.17</td>
</tr>
<tr>
<td></td>
<td>Nitrogen of diamino acids</td>
<td>0.00778</td>
<td>0.0284</td>
<td>7.63</td>
</tr>
<tr>
<td></td>
<td>Nitrogen of monamino acids (difference from 100)</td>
<td>0.04805</td>
<td>0.1752</td>
<td>47.11</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total nitrogen in solution (obtained by boiling with hydrochloric acid)</td>
<td>0.11472</td>
<td>0.3027</td>
<td>83.15</td>
</tr>
<tr>
<td></td>
<td>Ammoniacal nitrogen.</td>
<td>0.00034</td>
<td>0.0009</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>Nitrogen of acid amides</td>
<td>0.03189</td>
<td>0.0841</td>
<td>23.12</td>
</tr>
<tr>
<td></td>
<td>Nitrogen of amino acids (difference from 100)</td>
<td>0.08249</td>
<td>0.2177</td>
<td>59.79</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total nitrogen in solution (obtained by boiling with hydrochloric acid)</td>
<td>0.25696</td>
<td>0.2654</td>
<td>83.19</td>
</tr>
<tr>
<td></td>
<td>Ammoniacal nitrogen.</td>
<td>0.00062</td>
<td>0.0006</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>Nitrogen of acid amides</td>
<td>0.07015</td>
<td>0.0724</td>
<td>22.71</td>
</tr>
<tr>
<td></td>
<td>Nitrogen of amino acids (difference from 100)</td>
<td>0.18619</td>
<td>0.1923</td>
<td>60.28</td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total nitrogen in solution (obtained by boiling with hydrochloric acid)</td>
<td>0.22715</td>
<td>0.2462</td>
<td>91.88</td>
</tr>
<tr>
<td></td>
<td>Ammoniacal nitrogen.</td>
<td>0.00074</td>
<td>0.0008</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Nitrogen of acid amides</td>
<td>0.06474</td>
<td>0.0702</td>
<td>26.19</td>
</tr>
<tr>
<td></td>
<td>Nitrogen of amino acids (difference from 100)</td>
<td>0.16167</td>
<td>0.1753</td>
<td>65.39</td>
</tr>
<tr>
<td>K</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total nitrogen in solution (obtained by boiling with hydrochloric acid)</td>
<td>0.30817</td>
<td>0.2977</td>
<td>93.56</td>
</tr>
<tr>
<td></td>
<td>Ammoniacal nitrogen.</td>
<td>0.00110</td>
<td>0.0011</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>Nitrogen of acid amides</td>
<td>0.05619</td>
<td>0.0561</td>
<td>25.26</td>
</tr>
<tr>
<td></td>
<td>Nitrogen of amino acids (difference from 100)</td>
<td>0.15088</td>
<td>0.1505</td>
<td>67.81</td>
</tr>
</tbody>
</table>
from that precipitate designated as nitrogen of monamino acids, do not exclusively represent diamino and monamino acids. Likewise, what is recorded in the table as nitrogen of amino acids, which was obtained by subtracting the sum of ammoniacal and amido nitrogen from the total nitrogen in solution, does not represent amino acids only. In addition to diamino and monamino acids, the phosphotungstic acid precipitate and the filtrate from this precipitate may contain also nitrogenous compounds not belonging to the amino acid class. This has been demonstrated in Part I of this bulletin as well as in a previous\(^2\) investigation.

The fact that the phosphotungstic acid precipitate and the filtrate thereof, in the case of the plots recorded in Table VII, actually contain diamino and monamino acids has been ascer-
tained by a number of tests of which those made with the soil extracts of the plots O and R may be given here. Thus, the phosphotungstates obtained from these two plots having been freed from phosphotungstic acid, yielded solutions which displayed the following reactions:

1. Phosphotungstic acid gave a heavy, white precipitate.
2. Phosphomolybdic acid gave a yellow precipitate.
3. Silver nitrate gave a grayish-white precipitate, soluble in excess of ammonia.
4. Mercuric chloride gave a grayish-white flocculent precipitate.
5. The aqueous solution was strongly alkaline.
6. Addition of neutralized formaldehyde to the alkaline solution brought about an acid reaction.

The filtrates from the phosphotungstates, obtained from the two plots under consideration, displayed optical activity. Thus, the observation of the aqueous solution obtained from plot O and freed from inorganic salts by crystallization, showed in the 2 dm. tube the rotation $\alpha = -0.27^\circ$. When acidulated with 5cc. of conc. hydrochloric acid the same solution rotated $\alpha = +0.15^\circ$.

In the case of plot R the corresponding aqueous solution obtained from about 150 grams of soil rotated in the 2 dm. tube as follows: $\alpha = -0.67^\circ$. On having been mixed with 10cc. of conc. hydrochloric acid the same solution showed the rotation $\alpha = +0.47^\circ$. The contents of the polariscope tubes of plots O and R having been freed from the bulk of hydrochloric acid by evaporation showed, upon addition to them of formaldehyde, increased acidity corresponding to several cc. of $\frac{1}{3}$ barium hydroxide, etc.

CONCLUSIONS.

1. The amount of ammoniacal nitrogen in all of the plots examined is insignificant, ranging from 0.000649 to 0.001508 per cent of the oven-dried soil, or from 0.203 to 0.653 per cent of the total soil nitrogen. Likewise, the proportion of nitric nitrogen is small, namely from 0.00005 to 0.00269 per cent of the oven-dried soil, or from 0.02 to 1.00 per cent calculated upon the total soil nitrogen. This leaves about 99 per cent of the total soil nitrogen in the form of organic compounds.
2. The proportion of amido nitrogen is quite considerable, ranging from 26.99 to 33.83 per cent calculated upon the nitrogen obtained in solution by boiling with hydrochloric acid.
3. Among the nitrogenous compounds, contained in the rest of the acid-soluble nitrogen, the monamino acids and diamino acids were found to be present in considerable quantities.
INFLUENCE OF VARIOUS FACTORS ON
DECOMPOSITION OF SOIL ORGANIC
MATTER

By S. L. JODIDI and A. A. WELLS.

One of the chief objects of humus investigations is to find
out the chemical composition of soil humus, which will undoubtedly
require a number of years of hard labor by competent re-
searchers. Agriculture will in the meantime have to look for
methods which, in a general way indicate the behavior of soil
humus as affected by physical, chemical or bacteriological factors.
To such methods belong those showing the degree of chemical
changes taking place in the soil organic matter under certain condi-
tions. To be sure, such changes while chemical in nature, are
not brought about by purely chemical means. They represent
rather chemical-physiological phenomena in which the activities
of certain micro-organisms are involved, the life functions of
which, broadly speaking, are subject to similar physical and
chemical laws as those of the higher plants. In both cases mois-
ture, temperature, light, air and chemical factors play a very
prominent part.

In order to get an idea as to the changes which may occur in
the soil, we must first of all realize what elements are contained
in soil humus. Since it represents the transition stage between
the dead vegetable matter from which it is principally derived,
and its final decomposition phase so to speak, i.e., the ash, we
should logically expect to find in the soil organic matter the ten
well-known elements, which are essential for plant life, though
in different proportions. This being the case, it is at once evi-
dent that, theoretically, the changes taking place with any one
of these elements may give us some idea as to what is going on
with the whole of the soil humus. Further contemplation, how-
ever, will show us that there are only two elements whose oxida-
tion can serve as a measure of the changes taking place in soil
humus. The requirements which an element must answer to be
suitable for the purpose indicated are these: It must occur in the
humus in a considerable proportion and it must at the same time
be easily determinable in the least possible time. Neither the inorganic elements, potassium, calcium, magnesium and iron, nor the metalloids, sulphur and phosphorus, fully possess those qualities. The elements, hydrogen and oxygen, usually oxidized in the soil to water, are also to be eliminated from consideration for similar reasons. There remain, then, but two elements, namely, carbon and nitrogen, whose rate of oxidation can serve as a measure of the oxidation of humus.

Whereas the changes taking place with nitrogen undoubtedly throw considerable light upon the behavior of humus as a whole, it should be remembered that measuring the nitrogen requires too much time inasmuch as it involves several determinations, namely, of ammonia (liberated as such from humus) and of nitrites and nitrates, the oxidation products of the former. This renders the simultaneous examination of a number of plots not quite feasible. Carbon, on the other hand, oxidizes under the ordinary methods of soil cultivation to but one form, namely, carbon dioxide, which can easily and accurately be measured, even under field conditions. In addition the fact should also be borne in mind that carbon makes up a very considerable part of humus, namely more than fifty per cent of it. The above considerations point to carbon as the very element whose oxidation can best serve as a measure to determine the rate of oxidation of the humus.

Before presenting the data in question it may not be out of place, for reasons outlined below, to give here the analyses showing the total percentage of humus and of total and available phosphoric acid, as well as of carbon dioxide contained in the form of carbonates in each of the plots examined.

As already mentioned, decomposition of soil organic matter is no longer considered as a chemical phenomenon. Viewed in the light of modern researches, it is rightly looked upon as a biological process in which various species of micro-organisms are concerned. It is further well known that the activities of certain bacteria can materially be affected by the presence of acids, alkalies and salts. Thus, nitrification is aided by the presence of basic substances such as carbonate of lime, which are necessary for the neutralization of the nitric acid formed. Likewise, the presence of some inorganic salts, e. g., phosphates, in certain proportions will stimulate or retard the activities of certain micro-organisms. It is for these reasons that determinations of carbon dioxide of the carbonates present in the soils, as well as of total and available phosphoric acid, were made with a view of
TABLE I.

<table>
<thead>
<tr>
<th>PLOT</th>
<th>Humus Per cent.</th>
<th>Total Phosphoric acid per cent</th>
<th>More active forms of phosphoric acid, ct. P$_2$O$_5$</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.54</td>
<td>0.110</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>4.02</td>
<td>0.107</td>
<td>0.027</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>4.62</td>
<td>0.100</td>
<td>0.032</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>3.79</td>
<td>0.105</td>
<td>0.029</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>3.67</td>
<td>0.110</td>
<td>0.036</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>3.27</td>
<td>0.107</td>
<td>0.028</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>3.04</td>
<td>0.100</td>
<td>0.028</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>2.87</td>
<td>0.105</td>
<td>0.009</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>2.73</td>
<td>0.099</td>
<td>0.009</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>2.74</td>
<td>0.120</td>
<td>0.011</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>2.46</td>
<td>0.126</td>
<td>0.010</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>2.66</td>
<td>0.094</td>
<td>0.009</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>2.65</td>
<td>0.106</td>
<td>0.011</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>2.85</td>
<td>0.079</td>
<td>0.008</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>2.27</td>
<td>0.100</td>
<td>0.034</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>3.20</td>
<td>0.100</td>
<td>0.034</td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>3.35</td>
<td>0.111</td>
<td>0.034</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>2.70</td>
<td>0.112</td>
<td>0.013</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>2.42</td>
<td>0.115</td>
<td>0.027</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>2.99</td>
<td>0.115</td>
<td>0.027</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>3.44</td>
<td>0.109</td>
<td>0.026</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>3.27</td>
<td>0.109</td>
<td>0.026</td>
<td></td>
</tr>
</tbody>
</table>

The total phosphoric acid as well as the more active forms of it were not determined in some of the plots because the soil samples in question were not large enough for making all of the analyses.

determining their influence upon the behavior of humus in the particular plots under examination.

While humus, as well as the total and more active forms of phosphoric acid in the soils, were determined according to the official methods (see Table I), the estimation of carbonates present in the soils was carried out, after the somewhat modified method of Mulder, Stolba and Kolbe.¹

THE METHODS AND APPARATUS EMPLOYED.

Some details of this method can best be seen from the accompanying prints. N in Figure 1 represents a boiling flask in which the soil under examination is to be decomposed with acid. The accurately weighed tubes, E and F', are filled with soda-lime for the absorption of carbon dioxide evolved from the acid-treated soil and contain in their upper shanks some calcium chloride to prevent loss of vapor. All the other tubes serve simply for their protection, namely, tube A contains calcium chloride in the lower part only; the tubes B and D are also filled with calcium chloride, while C contains pumice stone covered with water-free copper.

¹Annal. (Liebig), 119, 129; Zeitschr. f. analyt. Chem. 2, 49; 2, 341.
sulphate. The four tubes named are designed to free the evolved carbon dioxide from vapor and hydrochloric acid, while the tube G, the left and right shanks of which are filled with calcium chloride and soda-lime, respectively, serves to protect tube F.
from outside vapor. The decomposition of the weighed soil in question takes place in the flask N by means of hydrochloric acid or any other suitable acid, which is introduced into N through the funnel i by opening the pinch cock K. The carbon dioxide evolved passes through the system of tubes, being absorbed in E and F, and is regulated by the cock Q which allows the water to run from the aspirator R with the desired speed. The bubbles passing through the tube II, which contains some water in its lower part, enable one to observe the speed with which the carbon dioxide is evolved. As soon as the acid is no longer able to evolve carbon dioxide from the soil at room temperature, the funnel i is removed and the apparatus is connected with the tube T (see Fig. 2), which is filled with soda-lime and is connected
with the flask F containing potassium hydroxide. The flask N is now heated just long enough to bring its contents to the boiling point, while a continuous and uniform outflow of water from the aspirator R is maintained which causes all of the carbon dioxide contained in the system to be absorbed by the tubes E and F. Ordinarily the absorption of carbon dioxide is completed in about ten minutes. The increase in weight of these two tubes after the decomposition of the soil over that before the experiment expresses the exact amount of carbon dioxide present in the soil in the shape of carbonates.

It may be mentioned here that the determination of carbon dioxide in the carbonates was first tried with Geissler’s apparatus. However, the results secured with that apparatus were so unsatisfactory that it was decided to make the carbon dioxide estimations with the apparatus just described. Again, the evolution of carbon dioxide from the carbonates was tried with dilute hydrochloric, nitric and phosphoric acid. While the data secured with hydrochloric acid were accurate, as were also those with phosphoric acid, the results obtained with nitric acid, because of the evolution of red fumes, were generally too high, for which reason only the estimations made with hydrochloric and phosphoric acid were included in the average. The figures obtained are recorded in Table II. A discussion of the results found will be given at the end of this bulletin.

**TABLE II.**

<table>
<thead>
<tr>
<th>PLOT</th>
<th>Air-dry soil Grams</th>
<th>Corresponding oven-dry soil Grams</th>
<th>Acid Used</th>
<th>Carbon dioxide [CO₂] found</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gram</td>
</tr>
<tr>
<td>A</td>
<td>4.0000</td>
<td>3.775</td>
<td>HCl</td>
<td>0.0025</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.437</td>
<td>HCl</td>
<td>0.0052</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.437</td>
<td>HNO₃</td>
<td>0.0221</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.437</td>
<td>H₃PO₄</td>
<td>0.0128</td>
</tr>
<tr>
<td>B</td>
<td>10.0000</td>
<td>9.489</td>
<td>HCl</td>
<td>0.0064</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.489</td>
<td>HCl</td>
<td>0.0065</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.489</td>
<td>HCl</td>
<td>0.0033</td>
</tr>
<tr>
<td>C</td>
<td>10.0000</td>
<td>9.489</td>
<td>HNO₃</td>
<td>0.0308</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.489</td>
<td>HCl</td>
<td>0.0064</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.489</td>
<td>HCl</td>
<td>0.0074</td>
</tr>
<tr>
<td>D</td>
<td>10.0000</td>
<td>9.524</td>
<td>HCl</td>
<td>0.0037</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.524</td>
<td>HCl</td>
<td>0.0031</td>
</tr>
<tr>
<td>E</td>
<td>10.0000</td>
<td>9.548</td>
<td>HCl</td>
<td>0.0053</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.548</td>
<td>HCl</td>
<td>0.0040</td>
</tr>
</tbody>
</table>
TABLE II. (Continued.)

<table>
<thead>
<tr>
<th>PLOT</th>
<th>Air-dry soil Grams</th>
<th>Corresponding oven-dry soil Grams</th>
<th>Acid Used</th>
<th>Carbon dioxide [CO₂] found</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gram</td>
<td>Percent</td>
</tr>
<tr>
<td>F</td>
<td>10.0000</td>
<td>9.576</td>
<td>HCl</td>
<td>0.0016</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.576</td>
<td>HCl</td>
<td>0.0038</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.576</td>
<td>HCl</td>
<td>0.0041</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.576</td>
<td>HCl</td>
<td>0.0041</td>
</tr>
<tr>
<td>G</td>
<td>10.0000</td>
<td>9.613</td>
<td>HCl</td>
<td>0.0042</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.013</td>
<td>HCl</td>
<td>0.0029</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.613</td>
<td>HCl</td>
<td>0.0031</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.611</td>
<td>H₂PO₄</td>
<td>0.0034</td>
</tr>
<tr>
<td>H</td>
<td>10.0000</td>
<td>9.688</td>
<td>HCl</td>
<td>0.0050</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.688</td>
<td>HCl</td>
<td>0.0029</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.688</td>
<td>HCl</td>
<td>0.0029</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.688</td>
<td>HCl</td>
<td>0.0029</td>
</tr>
<tr>
<td>I</td>
<td>10.0000</td>
<td>9.697</td>
<td>HCl</td>
<td>0.0054</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.697</td>
<td>HCl</td>
<td>0.0040</td>
</tr>
<tr>
<td>J</td>
<td>10.0000</td>
<td>9.698</td>
<td>HCl</td>
<td>0.0030</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.698</td>
<td>HCl</td>
<td>0.0031</td>
</tr>
<tr>
<td>K</td>
<td>10.0000</td>
<td>9.714</td>
<td>HCl</td>
<td>0.0036</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.714</td>
<td>HCl</td>
<td>0.0024</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.714</td>
<td>HCl</td>
<td>0.0045</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.682</td>
<td>HCl</td>
<td>0.0030</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.682</td>
<td>HCl</td>
<td>0.0036</td>
</tr>
<tr>
<td>L</td>
<td>10.0000</td>
<td>9.676</td>
<td>HCl</td>
<td>0.0025</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.676</td>
<td>HCl</td>
<td>0.0027</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.676</td>
<td>HCl</td>
<td>0.0027</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.676</td>
<td>H₂PO₄</td>
<td>0.0037</td>
</tr>
<tr>
<td>M</td>
<td>10.0000</td>
<td>9.666</td>
<td>HCl</td>
<td>0.0036</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.666</td>
<td>HCl</td>
<td>0.0024</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.669</td>
<td>HCl</td>
<td>0.0035</td>
</tr>
<tr>
<td>N</td>
<td>10.0000</td>
<td>9.689</td>
<td>HCl</td>
<td>0.0043</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.689</td>
<td>HCl</td>
<td>0.0025</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.649</td>
<td>HCl</td>
<td>0.0021</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.680</td>
<td>HCl</td>
<td>0.0016</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.680</td>
<td>HCl</td>
<td>0.0028</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.680</td>
<td>HCl</td>
<td>0.0033</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.687</td>
<td>HCl</td>
<td>0.0029</td>
</tr>
<tr>
<td>R</td>
<td>10.0000</td>
<td>9.687</td>
<td>HCl</td>
<td>0.0037</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.719</td>
<td>HCl</td>
<td>0.0022</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.719</td>
<td>HCl</td>
<td>0.0024</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.719</td>
<td>HCl</td>
<td>0.0024</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.719</td>
<td>HCl</td>
<td>0.0024</td>
</tr>
<tr>
<td>T</td>
<td>10.0000</td>
<td>9.647</td>
<td>HCl</td>
<td>0.0018</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.647</td>
<td>HCl</td>
<td>0.0014</td>
</tr>
<tr>
<td>U</td>
<td>10.0000</td>
<td>9.663</td>
<td>HCl</td>
<td>0.0010</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.663</td>
<td>HCl</td>
<td>0.0021</td>
</tr>
<tr>
<td>V</td>
<td>10.0000</td>
<td>9.640</td>
<td>HCl</td>
<td>0.0027</td>
</tr>
<tr>
<td></td>
<td>10.0000</td>
<td>9.640</td>
<td>HCl</td>
<td>0.0034</td>
</tr>
</tbody>
</table>

The idea of ascertaining the influence of physical factors, like moisture, temperature, air, light, as well as of certain chemical substances upon the decomposition of the organic matter in the
soil is not new. Kostytseff, Schloesing, Wollny, Deherain, Soyka, Warington, and Boussingault experimented along those lines. While some of them tried to find out the rate of oxidation of the organic matter by determining the amount of carbon dioxide evolved under the influence of certain factors, the others did it by estimating the proportions of ammonia, nitrites and nitrates produced. The observations of the investigators named have this in common: they represent chiefly laboratory experiments in which small amounts of soil mixed with other materials were put into tubes, cylinders or other vessels and the rate of decomposition stated. Other experimenters, too, worked along similar lines though some field observations were also made.

Results secured on a small scale in the laboratory may not necessarily hold good for field conditions. It was, therefore, deemed advisable to carry out similar experiments directly in the field and all the more so since we had at our command a number of plots under a variety of conditions. The fact that not less than twenty-two plots were to be under observation rendered determinations of ammonia, nitrites and nitrates practically infeasible, and it was decided to measure the rate of oxidations taking place in the soil by the amount of carbon dioxide evolved. It is evident that the greater the decomposition of the organic matter in the soil, the richer in carbon dioxide will be the soil atmosphere and vice versa.

THE FIELD APPARATUS.

The arrangements for the daily observations, the results of which are presented in the following pages, were made as follows: In the first place each of the twenty-two plots under experiment was provided with an iron tube twelve inches long and with an inner diameter of \( \frac{5}{8} \) of an inch. At one end the tube was drawn out to a point. The periphery of the lower two inches of the tube was provided with twelve small holes of one-eighth of an inch diameter. Into the upper part of the tube was put a rubber stopper, a one-eighth inch glass tube, thirteen inches long, passing through stopper and all made air tight. This tube stood out above the iron tube some three inches and reached with its lower end the periphery holes of the iron tube. In order to prevent completely the outside air from coming into the tube, the space below the rubber stopper between the glass and iron tube was in part filled out with paraffin which together with the rubber stopper held both tubes always in the same position.

---

142

\(^3\) Comptes rendus., 77, 1873, p. 203; ibid., 77, 1873, p. 353.
\(^5\) Am. agron., 13, No. 6, 1887, p. 241.
\(^6\) Zeitschr. Biol., 14, 1878.
\(^7\) Landw. Versuchsstat., 24, 161 (1879).
\(^8\) Comptes rendus, 86, 22.
For drawing a portion of the soil atmosphere into the tube just described, its pointed end was forced into the soil of each plot to a depth of seven inches, the upper end of the glass tube being connected by means of rubber tubing, with the Orsat apparatus. The whole arrangement can be seen from the photographs (see Figures 3 and 4) and needs no further description. By means of the pressure bottle the soil atmosphere is drawn into the Orsat apparatus, the first 100cc. being discarded in order to force the air out of the apparatus, and the next 100cc being used for analysis. By alternately raising and lowering the pressure bottle the soil atmosphere is a number of times brought into contact with the right bulb of the apparatus containing a solution of potassium hydroxide which absorbs the carbon dioxide of the atmosphere. The decrease in volume of the soil atmosphere analyzed expresses the proportion of carbon dioxide in it. Likewise the estimation of oxygen is made by bringing the atmosphere, freed from carbon dioxide, into contact with the left bulb containing an alkaline solution of pyragallol which absorbs the oxygen. Since the burette of the apparatus has a capacity of 100cc. and is graduated into cubic centimeters with divisions allowing to record one-tenth of one cc., it is evident that the readings express directly the percentage of carbon dioxide or oxygen in the soil atmosphere.

In addition to carbon dioxide and oxygen determinations which were made once a day, the temperature of the air as well as of the soil in the various plots to a depth of six inches was regularly observed. The temperature of the soil was recorded only once a day at the time the carbon dioxide and oxygen estimations were run, while the temperature of the air was recorded three times every day, namely, at 8 a.m., 1 p.m. and 5 p.m.

In connection with the analytical data secured we must not omit to mention here that each one of the figures given in the tables for April, May, June, July and August represents the average of the observations for a whole month, with the essential restriction, however, that, as a rule, observations were not made on rainy days or on such days which immediately followed a heavy rain, because of the muddy condition of the plots which rendered observations very inconvenient. Pressing work in the laboratory, too, sometimes prevented the field observations in question. It is for these reasons that conclusions from the results presented in the following tables will have to be made cautiously.

**THE INFLUENCE OF MOISTURE AND TEMPERATURE.**

In reviewing the data before us we can clearly see the influence of moisture and temperature upon the decomposition of soil organic matter. Thus, in June, both the soil temperature
<table>
<thead>
<tr>
<th>PLOT</th>
<th>Temperature of air °C</th>
<th>Temperature of soil °C</th>
<th>Precipitation in inches</th>
<th>Per cent of CO₂</th>
<th>Per cent of O₂</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>21.1</td>
<td>11.9</td>
<td>2.25</td>
<td>0.500</td>
<td>21.10</td>
<td>Maximum and minimum air temperature was 18.7° and 4.2°C respectively.</td>
</tr>
<tr>
<td>B</td>
<td>19.1</td>
<td>13.1</td>
<td>2.25</td>
<td>0.260</td>
<td>21.20</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>19.1</td>
<td>13.5</td>
<td>2.25</td>
<td>0.220</td>
<td>21.10</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>19.1</td>
<td>13.3</td>
<td>2.25</td>
<td>0.125</td>
<td>20.85</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>19.1</td>
<td>13.3</td>
<td>2.25</td>
<td>0.125</td>
<td>21.05</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>19.1</td>
<td>13.2</td>
<td>2.25</td>
<td>0.125</td>
<td>20.97</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>19.1</td>
<td>13.2</td>
<td>2.25</td>
<td>0.100</td>
<td>20.87</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>19.1</td>
<td>14.0</td>
<td>2.25</td>
<td>0.125</td>
<td>20.95</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>19.1</td>
<td>15.2</td>
<td>2.25</td>
<td>0.150</td>
<td>21.03</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>19.1</td>
<td>14.3</td>
<td>2.25</td>
<td>0.225</td>
<td>21.20</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>19.1</td>
<td>15.0</td>
<td>2.25</td>
<td>0.225</td>
<td>21.13</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>19.1</td>
<td>14.5</td>
<td>2.25</td>
<td>0.225</td>
<td>21.00</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>19.1</td>
<td>15.1</td>
<td>2.25</td>
<td>0.175</td>
<td>20.85</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>19.1</td>
<td>16.4</td>
<td>2.25</td>
<td>0.167</td>
<td>21.00</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>19.1</td>
<td>16.0</td>
<td>2.25</td>
<td>0.133</td>
<td>21.20</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>19.1</td>
<td>15.5</td>
<td>2.25</td>
<td>0.167</td>
<td>21.17</td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>21.1</td>
<td>16.1</td>
<td>2.25</td>
<td>0.100</td>
<td>21.00</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>21.6</td>
<td>14.1</td>
<td>2.25</td>
<td>0.300</td>
<td>20.50</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>21.6</td>
<td>11.6</td>
<td>2.25</td>
<td>0.200</td>
<td>20.50</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>21.6</td>
<td>11.2</td>
<td>2.25</td>
<td>0.150</td>
<td>20.60</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>21.6</td>
<td>12.0</td>
<td>2.25</td>
<td>0.250</td>
<td>20.70</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>21.6</td>
<td>11.6</td>
<td>2.25</td>
<td>0.150</td>
<td>20.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>19.85</td>
<td>13.82</td>
<td>2.25</td>
<td>0.191</td>
<td>20.93</td>
</tr>
</tbody>
</table>

<p>| A      |      |      |      |      |      | Maximum and minimum air temperature was 20.3° and 5.8°C respectively. |
| B      | 18.80 | 14.64 | 1.55 | 0.14 | 20.27 |
| C      | 18.80 | 14.84 | 1.55 | 0.30 | 20.50 |
| D      | 18.80 | 14.54 | 1.55 | 0.16 | 20.46 |
| E      | 18.54 | 14.50 | 1.55 | 0.19 | 20.55 |
| F      | 18.54 | 14.51 | 1.55 | 0.21 | 20.49 |
| G      | 18.54 | 14.70 | 1.55 | 0.16 | 20.60 |
| H      | 18.54 | 14.86 | 1.55 | 0.15 | 20.54 |
| I      | 18.54 | 15.45 | 1.55 | 0.19 | 20.60 |
| J      | 18.54 | 15.68 | 1.55 | 0.14 | 20.52 |
| K      | 18.54 | 16.20 | 1.55 | 0.25 | 20.58 |
| L      | 18.54 | 17.05 | 1.55 | 0.25 | 20.75 |
| M      | 18.54 | 17.29 | 1.55 | 0.19 | 20.55 |
| N      | 18.54 | 17.20 | 1.55 | 0.21 | 20.58 |
| O      | 17.80 | 17.94 | 1.55 | 0.16 | 20.63 |
| P      | 17.80 | 17.90 | 1.55 | 0.17 | 20.64 |
| Q      |      |      |      |      |      |         |
| R      | 17.80 | 17.89 | 1.55 | 0.16 | 20.69 |
| S      | 17.80 | 17.70 | 1.55 | 0.13 | 20.70 |
| T      | 17.80 | 17.99 | 1.55 | 0.19 | 20.77 |
| U      | 17.80 | 18.01 | 1.55 | 0.17 | 20.81 |
| V      | 17.80 | 17.93 | 1.55 | 0.13 | 20.70 |
|      | Average | 18.32 | 16.34 | 1.55 | 0.182 | 20.60 |</p>
<table>
<thead>
<tr>
<th>PLOT</th>
<th>Temperature of Air °C</th>
<th>Temperature of soil °C</th>
<th>Precipitation in inches</th>
<th>Per cent of CO₂</th>
<th>Percent of O₂</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>31.8</td>
<td>22.50</td>
<td>2.36</td>
<td>0.10</td>
<td>19.90</td>
<td>Maximum and minimum air temperature was 27.7° and 12.5°C respectively.</td>
</tr>
<tr>
<td>B</td>
<td>28.1</td>
<td>22.20</td>
<td>2.36</td>
<td>0.04</td>
<td>19.93</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>28.1</td>
<td>22.50</td>
<td>2.36</td>
<td>0.82</td>
<td>19.36</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>28.1</td>
<td>22.60</td>
<td>2.36</td>
<td>0.20</td>
<td>20.38</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>25.6</td>
<td>21.80</td>
<td>2.36</td>
<td>0.14</td>
<td>20.49</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>25.7</td>
<td>21.00</td>
<td>2.36</td>
<td>0.11</td>
<td>20.53</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>25.7</td>
<td>20.97</td>
<td>2.36</td>
<td>0.12</td>
<td>20.63</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>25.7</td>
<td>20.88</td>
<td>2.36</td>
<td>0.44</td>
<td>20.26</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>25.7</td>
<td>21.44</td>
<td>2.36</td>
<td>0.18</td>
<td>20.56</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>25.7</td>
<td>21.86</td>
<td>2.36</td>
<td>0.20</td>
<td>20.61</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>25.7</td>
<td>21.68</td>
<td>2.36</td>
<td>0.40</td>
<td>20.35</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>27.4</td>
<td>23.33</td>
<td>2.36</td>
<td>0.40</td>
<td>20.53</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>27.4</td>
<td>23.62</td>
<td>2.36</td>
<td>0.32</td>
<td>20.52</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>27.4</td>
<td>24.05</td>
<td>2.36</td>
<td>0.46</td>
<td>20.34</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>27.4</td>
<td>24.50</td>
<td>2.36</td>
<td>0.27</td>
<td>20.38</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>27.4</td>
<td>23.75</td>
<td>2.36</td>
<td>0.18</td>
<td>20.54</td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>27.4</td>
<td>24.42</td>
<td>2.36</td>
<td>0.71</td>
<td>20.15</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>27.4</td>
<td>24.81</td>
<td>2.36</td>
<td>0.22</td>
<td>20.54</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>27.4</td>
<td>24.67</td>
<td>2.36</td>
<td>0.32</td>
<td>20.60</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>27.4</td>
<td>24.07</td>
<td>2.36</td>
<td>0.26</td>
<td>20.64</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>27.4</td>
<td>24.03</td>
<td>2.36</td>
<td>0.29</td>
<td>20.49</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>27.4</td>
<td>24.22</td>
<td>2.36</td>
<td>0.40</td>
<td>20.49</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>27.15</td>
<td>22.95</td>
<td>2.36</td>
<td>0.299</td>
<td>20.37</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PLOT</th>
<th>Temperature of Air °C</th>
<th>Temperature of soil °C</th>
<th>Precipitation in inches</th>
<th>Per cent of CO₂</th>
<th>Percent of O₂</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>27.08</td>
<td>21.92</td>
<td>1.42</td>
<td>0.12</td>
<td>20.30</td>
<td>Maximum and minimum air temperature was 31.2° and 14.9°C respectively.</td>
</tr>
<tr>
<td>B</td>
<td>27.08</td>
<td>24.35</td>
<td>1.42</td>
<td>0.12</td>
<td>20.36</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>27.08</td>
<td>24.52</td>
<td>1.42</td>
<td>0.17</td>
<td>20.00</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>27.08</td>
<td>24.75</td>
<td>1.42</td>
<td>0.40</td>
<td>19.90</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>26.40</td>
<td>24.70</td>
<td>1.42</td>
<td>0.20</td>
<td>20.25</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>26.40</td>
<td>24.48</td>
<td>1.42</td>
<td>0.28</td>
<td>20.30</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>26.40</td>
<td>24.40</td>
<td>1.42</td>
<td>0.38</td>
<td>20.33</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>26.40</td>
<td>24.34</td>
<td>1.42</td>
<td>0.18</td>
<td>20.57</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>26.40</td>
<td>24.38</td>
<td>1.42</td>
<td>0.26</td>
<td>20.53</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>26.40</td>
<td>24.64</td>
<td>1.42</td>
<td>0.20</td>
<td>20.42</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>26.40</td>
<td>24.86</td>
<td>1.42</td>
<td>0.22</td>
<td>20.42</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>27.00</td>
<td>25.32</td>
<td>1.42</td>
<td>0.28</td>
<td>20.46</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>27.00</td>
<td>25.94</td>
<td>1.42</td>
<td>0.20</td>
<td>20.47</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>27.00</td>
<td>26.32</td>
<td>1.42</td>
<td>0.24</td>
<td>20.75</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>27.00</td>
<td>28.16</td>
<td>1.42</td>
<td>0.24</td>
<td>20.43</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>27.00</td>
<td>27.86</td>
<td>1.42</td>
<td>0.22</td>
<td>20.47</td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>27.00</td>
<td>25.26</td>
<td>1.42</td>
<td>0.36</td>
<td>20.53</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>27.00</td>
<td>28.72</td>
<td>1.42</td>
<td>0.20</td>
<td>20.30</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>27.00</td>
<td>28.50</td>
<td>1.42</td>
<td>0.40</td>
<td>20.33</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>27.00</td>
<td>27.74</td>
<td>1.42</td>
<td>0.38</td>
<td>20.53</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>27.00</td>
<td>27.90</td>
<td>1.42</td>
<td>0.20</td>
<td>20.60</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>27.00</td>
<td>27.72</td>
<td>1.42</td>
<td>0.38</td>
<td>20.40</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>26.82</td>
<td>25.77</td>
<td>1.42</td>
<td>0.256</td>
<td>20.39</td>
<td></td>
</tr>
</tbody>
</table>
### AUGUST.

<table>
<thead>
<tr>
<th>PLOT</th>
<th>Temperature of air °C</th>
<th>Temperature of soil °C</th>
<th>Precipitation in inches</th>
<th>Per cent of CO₂</th>
<th>Per cent of O₂</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.17</td>
<td>20.03</td>
<td>Maximum and minimum air temperature was 29.5° and 15.5°C respectively.</td>
</tr>
<tr>
<td>B</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.34</td>
<td>20.18</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.68</td>
<td>19.93</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.39</td>
<td>20.10</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.40</td>
<td>20.18</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.27</td>
<td>20.23</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.34</td>
<td>20.29</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.37</td>
<td>20.23</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.17</td>
<td>20.40</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.31</td>
<td>20.29</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.27</td>
<td>20.33</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.29</td>
<td>20.23</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.42</td>
<td>20.40</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.41</td>
<td>20.43</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.27</td>
<td>20.27</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.24</td>
<td>20.44</td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.36</td>
<td>20.43</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>26.4</td>
<td>22.04</td>
<td>3.02</td>
<td>0.38</td>
<td>20.34</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>26.2</td>
<td>22.04</td>
<td>3.02</td>
<td>0.30</td>
<td>20.31</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>26.2</td>
<td>22.04</td>
<td>3.02</td>
<td>0.42</td>
<td>20.42</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>26.2</td>
<td>22.04</td>
<td>3.02</td>
<td>0.35</td>
<td>20.51</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>26.2</td>
<td>22.04</td>
<td>3.02</td>
<td>0.42</td>
<td>20.50</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>26.39</td>
<td>24.57</td>
<td>3.02</td>
<td>0.344</td>
<td>20.30</td>
<td></td>
</tr>
</tbody>
</table>

(22.95°) and the amount of precipitation (2.36 inches) were higher than in April (13.82° and 2.25 inches), or in May (16.34° and 1.55 inches). This caused the organic matter to decompose more rapidly as a consequence of which the soil atmosphere was richer in carbon dioxide during June (0.299%) as compared with April (0.191%) and May (0.182%). Again, August with the largest quantity of precipitation (3.02 inches) and with a temperature but 1.2° lower than in July, the hottest month of the season, shows a soil atmosphere richest in carbon dioxide (0.344%).

The influence of temperature alone can be seen by a comparison of April and June with practically the same amount of rainfall (2.25 and 2.36 inches respectively) but with different temperature (13.82° and 22.95° respectively). In conformity with the higher temperature the soil atmosphere was richer in carbon dioxide during June (0.299%) than during April (0.191%). We arrive at the same conclusion by comparing May and July with about the same amount of rainfall (1.55 and 1.42 inches respectively) but with different soil temperatures
TOTAL AVERAGES FOR SEASON.
(April, May, June, July, August, 1910.)

<table>
<thead>
<tr>
<th>PLOT</th>
<th>Temperature of Air °C</th>
<th>Temperature of soil °C</th>
<th>Precipitation in inches</th>
<th>Per cent of CO₂</th>
<th>Percent of O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>26.59</td>
<td>19.59</td>
<td>10.60</td>
<td>0.220</td>
<td>20.33</td>
</tr>
<tr>
<td>B</td>
<td>23.90</td>
<td>19.63</td>
<td>10.60</td>
<td>0.180</td>
<td>20.38</td>
</tr>
<tr>
<td>C</td>
<td>23.90</td>
<td>19.84</td>
<td>10.60</td>
<td>0.440</td>
<td>20.18</td>
</tr>
<tr>
<td>D</td>
<td>23.90</td>
<td>19.80</td>
<td>10.60</td>
<td>0.255</td>
<td>20.34</td>
</tr>
<tr>
<td>E</td>
<td>23.21</td>
<td>19.63</td>
<td>10.60</td>
<td>0.211</td>
<td>20.51</td>
</tr>
<tr>
<td>F</td>
<td>23.23</td>
<td>19.41</td>
<td>10.60</td>
<td>0.199</td>
<td>20.50</td>
</tr>
<tr>
<td>G</td>
<td>23.23</td>
<td>19.44</td>
<td>10.60</td>
<td>0.220</td>
<td>20.54</td>
</tr>
<tr>
<td>H</td>
<td>23.23</td>
<td>19.55</td>
<td>10.60</td>
<td>0.253</td>
<td>20.51</td>
</tr>
<tr>
<td>I</td>
<td>23.23</td>
<td>20.10</td>
<td>10.60</td>
<td>0.190</td>
<td>20.65</td>
</tr>
<tr>
<td>J</td>
<td>23.23</td>
<td>20.10</td>
<td>10.60</td>
<td>0.215</td>
<td>20.62</td>
</tr>
<tr>
<td>K</td>
<td>23.23</td>
<td>20.38</td>
<td>10.60</td>
<td>0.275</td>
<td>20.56</td>
</tr>
<tr>
<td>L</td>
<td>23.69</td>
<td>21.05</td>
<td>10.60</td>
<td>0.189</td>
<td>20.59</td>
</tr>
<tr>
<td>M</td>
<td>23.69</td>
<td>21.61</td>
<td>10.60</td>
<td>0.261</td>
<td>20.56</td>
</tr>
<tr>
<td>N</td>
<td>23.69</td>
<td>21.46</td>
<td>10.60</td>
<td>0.297</td>
<td>20.62</td>
</tr>
<tr>
<td>O</td>
<td>23.54</td>
<td>22.37</td>
<td>10.60</td>
<td>0.215</td>
<td>20.58</td>
</tr>
<tr>
<td>P</td>
<td>23.54</td>
<td>22.08</td>
<td>10.60</td>
<td>0.195</td>
<td>20.65</td>
</tr>
<tr>
<td>Q</td>
<td>25.50</td>
<td>22.40</td>
<td>10.60</td>
<td>0.332</td>
<td>20.53</td>
</tr>
<tr>
<td>R</td>
<td>24.12</td>
<td>22.39</td>
<td>10.60</td>
<td>0.252</td>
<td>20.47</td>
</tr>
<tr>
<td>S</td>
<td>24.00</td>
<td>21.68</td>
<td>10.60</td>
<td>0.270</td>
<td>20.49</td>
</tr>
<tr>
<td>T</td>
<td>24.00</td>
<td>21.32</td>
<td>10.60</td>
<td>0.280</td>
<td>20.59</td>
</tr>
<tr>
<td>U</td>
<td>24.00</td>
<td>21.47</td>
<td>10.60</td>
<td>0.252</td>
<td>20.62</td>
</tr>
<tr>
<td>V</td>
<td>24.00</td>
<td>21.17</td>
<td>10.60</td>
<td>0.296</td>
<td>20.52</td>
</tr>
<tr>
<td>Average</td>
<td>23.85</td>
<td>20.75</td>
<td>10.60</td>
<td>0.252</td>
<td>20.51</td>
</tr>
</tbody>
</table>

(16.34° and 25.77° respectively). As a consequence of the higher temperature in July, the soil atmosphere was richer in carbon dioxide (0.256%) than in May (0.182%).

The influence of precipitation alone follows from the tables for July and August with very little difference in soil temperature (25.77° and 24.57° respectively), but with considerable difference in rainfall (1.42 and 3.02 inches respectively). The smaller rainfall in July shows a smaller percentage of carbon dioxide (0.256%) in the soil atmosphere than in August (0.344%). This conclusion is still further substantiated by the individual tables for August 13th, 16th, 17th, 18th, 19th and 20th, with but inconsiderable differences in soil temperature (23.62°, 25.05°, 23.75°, 22.12°, 22.52° and 24.27° respectively). With 0.29 per cent of carbon dioxide in the soil atmosphere on August 13th, it rose to 0.99 per cent of carbon dioxide because of a heavy rainfall of one inch on August 15th. The influence of the heavy rainfall was felt for several days, though owing to inconsiderable or lack of rainfall in the following days the proportion of car-
<table>
<thead>
<tr>
<th>PLOT</th>
<th>Temperature of soil</th>
<th>Precipitation in inches</th>
<th>Per cent of CO₂</th>
<th>Temperature of soil</th>
<th>Precipitation in inches</th>
<th>Per cent of CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>*</td>
<td>0.13</td>
<td>*</td>
<td>23.0</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>B</td>
<td>*</td>
<td>0.13</td>
<td>*</td>
<td>24.0</td>
<td>0.0</td>
<td>1.7</td>
</tr>
<tr>
<td>C</td>
<td>*</td>
<td>0.13</td>
<td>*</td>
<td>23.8</td>
<td>0.0</td>
<td>0.3</td>
</tr>
<tr>
<td>D</td>
<td>*</td>
<td>0.13</td>
<td>*</td>
<td>23.5</td>
<td>0.0</td>
<td>1.5</td>
</tr>
<tr>
<td>E</td>
<td>24.2</td>
<td>0.13</td>
<td>0.3</td>
<td>23.9</td>
<td>0.0</td>
<td>0.7</td>
</tr>
<tr>
<td>F</td>
<td>24.0</td>
<td>0.13</td>
<td>0.2</td>
<td>23.7</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>G</td>
<td>23.7</td>
<td>0.13</td>
<td>0.2</td>
<td>24.0</td>
<td>0.0</td>
<td>1.2</td>
</tr>
<tr>
<td>H</td>
<td>23.6</td>
<td>0.13</td>
<td>0.6</td>
<td>24.4</td>
<td>0.0</td>
<td>1.2</td>
</tr>
<tr>
<td>I</td>
<td>23.8</td>
<td>0.13</td>
<td>0.1</td>
<td>24.1</td>
<td>0.0</td>
<td>0.6</td>
</tr>
<tr>
<td>J</td>
<td>23.5</td>
<td>0.13</td>
<td>0.2</td>
<td>24.1</td>
<td>0.0</td>
<td>0.9</td>
</tr>
<tr>
<td>K</td>
<td>23.6</td>
<td>0.13</td>
<td>0.2</td>
<td>23.5</td>
<td>0.0</td>
<td>1.3</td>
</tr>
<tr>
<td>L</td>
<td>24.1</td>
<td>0.13</td>
<td>0.4</td>
<td>25.0</td>
<td>0.0</td>
<td>1.1</td>
</tr>
<tr>
<td>M</td>
<td>24.6</td>
<td>0.13</td>
<td>0.4</td>
<td>27.0</td>
<td>0.0</td>
<td>1.4</td>
</tr>
<tr>
<td>N</td>
<td>24.5</td>
<td>0.13</td>
<td>0.4</td>
<td>27.1</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>O</td>
<td>22.9</td>
<td>0.13</td>
<td>0.2</td>
<td>25.8</td>
<td>0.0</td>
<td>0.9</td>
</tr>
<tr>
<td>P</td>
<td>23.0</td>
<td>0.13</td>
<td>0.3</td>
<td>27.0</td>
<td>0.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Q</td>
<td>22.0</td>
<td>0.13</td>
<td>0.2</td>
<td>25.9</td>
<td>0.0</td>
<td>0.8</td>
</tr>
<tr>
<td>R</td>
<td>24.2</td>
<td>0.13</td>
<td>0.4</td>
<td>26.6</td>
<td>0.0</td>
<td>1.1</td>
</tr>
<tr>
<td>S</td>
<td>23.7</td>
<td>0.13</td>
<td>0.4</td>
<td>27.2</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>T</td>
<td>23.2</td>
<td>0.13</td>
<td>0.4</td>
<td>26.5</td>
<td>0.0</td>
<td>1.1</td>
</tr>
<tr>
<td>U</td>
<td>24.0</td>
<td>0.13</td>
<td>0.2</td>
<td>27.1</td>
<td>0.0</td>
<td>1.2</td>
</tr>
<tr>
<td>V</td>
<td>22.6</td>
<td>0.13</td>
<td>0.2</td>
<td>25.5</td>
<td>0.0</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Average: 23.62 (0.13), 0.29 (Per cent of CO₂: 0.99)

*Observations prevented by rain.

---

**August 17**

<table>
<thead>
<tr>
<th>PLOT</th>
<th>Temperature of soil</th>
<th>Precipitation in inches</th>
<th>Per cent of CO₂</th>
<th>Temperature of soil</th>
<th>Precipitation in inches</th>
<th>Per cent of CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>23.1</td>
<td>0.3</td>
<td>0.3</td>
<td>21.5</td>
<td>0.0</td>
<td>0.6</td>
</tr>
<tr>
<td>B</td>
<td>24.0</td>
<td>0.3</td>
<td>0.6</td>
<td>22.0</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>C</td>
<td>24.0</td>
<td>0.3</td>
<td>0.3</td>
<td>21.6</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>D</td>
<td>23.9</td>
<td>0.3</td>
<td>1.2</td>
<td>21.8</td>
<td>0.0</td>
<td>1.1</td>
</tr>
<tr>
<td>E</td>
<td>24.1</td>
<td>0.3</td>
<td>0.4</td>
<td>21.5</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>F</td>
<td>23.4</td>
<td>0.3</td>
<td>0.5</td>
<td>21.2</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>G</td>
<td>0.3</td>
<td>0.5</td>
<td></td>
<td>21.2</td>
<td>0.0</td>
<td>0.6</td>
</tr>
<tr>
<td>H</td>
<td>21.2</td>
<td></td>
<td></td>
<td>21.2</td>
<td>0.0</td>
<td>0.9</td>
</tr>
<tr>
<td>I</td>
<td>21.5</td>
<td></td>
<td></td>
<td>21.5</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>J</td>
<td>21.5</td>
<td></td>
<td></td>
<td>21.5</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>K</td>
<td>21.5</td>
<td></td>
<td></td>
<td>21.5</td>
<td>0.0</td>
<td>0.3</td>
</tr>
<tr>
<td>L</td>
<td>22.5</td>
<td></td>
<td></td>
<td>22.5</td>
<td>0.0</td>
<td>0.6</td>
</tr>
<tr>
<td>M</td>
<td>22.8</td>
<td></td>
<td></td>
<td>22.8</td>
<td>0.0</td>
<td>0.6</td>
</tr>
<tr>
<td>N</td>
<td>23.0</td>
<td></td>
<td></td>
<td>23.0</td>
<td>0.0</td>
<td>0.4</td>
</tr>
<tr>
<td>O</td>
<td>22.5</td>
<td></td>
<td></td>
<td>22.5</td>
<td>0.0</td>
<td>0.3</td>
</tr>
<tr>
<td>P</td>
<td>21.5</td>
<td></td>
<td></td>
<td>21.5</td>
<td>0.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Q</td>
<td>22.5</td>
<td></td>
<td></td>
<td>22.5</td>
<td>0.0</td>
<td>0.8</td>
</tr>
<tr>
<td>R</td>
<td>23.8</td>
<td></td>
<td></td>
<td>23.8</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>S</td>
<td>23.5</td>
<td></td>
<td></td>
<td>23.5</td>
<td>0.0</td>
<td>0.6</td>
</tr>
<tr>
<td>T</td>
<td>23.2</td>
<td></td>
<td></td>
<td>23.2</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>U</td>
<td>22.4</td>
<td></td>
<td></td>
<td>22.4</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>V</td>
<td>23.75</td>
<td>0.3</td>
<td>0.54</td>
<td>22.12</td>
<td>0.0</td>
<td>0.51</td>
</tr>
</tbody>
</table>

---

*Further observations prevented by rain.*
Carbon dioxide gradually fell from 0.99 per cent (August 16th) to 0.54% (August 17th), 0.51% (August 18th), 0.36% (August 19th) and 0.35% (August 20th).

No observations were made during August 14 and 15. Precipitation of August 14 and 15 was equal to 0.12 and 1.00 inch respectively.

It is interesting to note that the average percentage of oxygen in the soil atmosphere for all the plots and for the whole season was 20.51%. Adding to this 0.252—the average percentage of carbon dioxide for the season—we get about 20.8%, which is approximately the percentage of oxygen in the air. This is easily explained by a consideration of the fact that in the oxidation process of humus carbon to carbon dioxide, one volume of oxygen is used for the production of one volume of carbon dioxide as expressed in the following equation: $C + O_2 = CO_2$. Hence, all other things being equal, the soil atmosphere differs from the air in that it is poorer in oxygen and correspondingly richer in carbon dioxide. In other words, the total percentage of carbon dioxide and oxygen in the soil atmosphere is about the same as in the air.

<table>
<thead>
<tr>
<th>PLOT</th>
<th>Temperature of soil</th>
<th>Precipitation in inches</th>
<th>Per cent of CO$_2$</th>
<th>Temperature of soil</th>
<th>Precipitation in inches</th>
<th>Per cent of CO$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>21.0</td>
<td>0.0</td>
<td>0.4</td>
<td>22.0</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>B</td>
<td>21.8</td>
<td>0.0</td>
<td>0.2</td>
<td>23.4</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>C</td>
<td>21.8</td>
<td>0.0</td>
<td>0.1</td>
<td>24.0</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>D</td>
<td>21.6</td>
<td>0.0</td>
<td>0.6</td>
<td>23.5</td>
<td>0.0</td>
<td>0.7</td>
</tr>
<tr>
<td>E</td>
<td>21.6</td>
<td>0.0</td>
<td>0.1</td>
<td>24.0</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>F</td>
<td>21.5</td>
<td>0.0</td>
<td>0.4</td>
<td>24.0</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>G</td>
<td>21.4</td>
<td>0.0</td>
<td>0.3</td>
<td>23.7</td>
<td>0.0</td>
<td>0.4</td>
</tr>
<tr>
<td>H</td>
<td>21.5</td>
<td>0.0</td>
<td>0.4</td>
<td>23.0</td>
<td>0.0</td>
<td>0.8</td>
</tr>
<tr>
<td>I</td>
<td>21.8</td>
<td>0.0</td>
<td>0.2</td>
<td>24.0</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>J</td>
<td>21.9</td>
<td>0.0</td>
<td>0.3</td>
<td>23.0</td>
<td>0.0</td>
<td>0.3</td>
</tr>
<tr>
<td>K</td>
<td>21.8</td>
<td>0.0</td>
<td>0.3</td>
<td>24.2</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>L</td>
<td>23.1</td>
<td>0.0</td>
<td>0.5</td>
<td>24.2</td>
<td>0.0</td>
<td>0.4</td>
</tr>
<tr>
<td>M</td>
<td>24.1</td>
<td>0.0</td>
<td>0.6</td>
<td>24.3</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>N</td>
<td>24.1</td>
<td>0.0</td>
<td>0.3</td>
<td>25.1</td>
<td>0.0</td>
<td>0.7</td>
</tr>
<tr>
<td>O</td>
<td>23.3</td>
<td>0.0</td>
<td>0.3</td>
<td>23.1</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>P</td>
<td>23.6</td>
<td>0.0</td>
<td>0.5</td>
<td>25.1</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Q</td>
<td>22.1</td>
<td>0.0</td>
<td>0.7</td>
<td>24.2</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>R</td>
<td>22.1</td>
<td>0.0</td>
<td>0.0</td>
<td>24.7</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>S</td>
<td>24.8</td>
<td>0.0</td>
<td>0.3</td>
<td>27.7</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>T</td>
<td>23.3</td>
<td>0.0</td>
<td>0.5</td>
<td>25.8</td>
<td>0.0</td>
<td>0.6</td>
</tr>
<tr>
<td>U</td>
<td>24.4</td>
<td>0.0</td>
<td>0.3</td>
<td>26.4</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>V</td>
<td>22.5</td>
<td>0.0</td>
<td>0.3</td>
<td>24.5</td>
<td>0.0</td>
<td>0.3</td>
</tr>
<tr>
<td>Average</td>
<td>22.52</td>
<td>0.0</td>
<td>0.36</td>
<td>24.27</td>
<td>0.0</td>
<td>0.35</td>
</tr>
</tbody>
</table>
IMPORTANCE OF INCREASED CARBON DIOXIDE IN SOIL.

A higher percentage of carbon dioxide in the soil atmosphere, pointing to a more rapid decomposition of soil humus, is agriculturally an important indication, inasmuch as carbon dioxide represents plant food. True, the air contains enough carbon dioxide to feed all plants. The fact, however, should not be forgotten that the increase in mass of any plant is, everything being equal, proportional to the period of its growth. Since, however, the space of time for the growth of most of the cultivated plants is limited, the importance of an abundance of carbon dioxide in the soil atmosphere is quite evident. While the proportion of carbon dioxide throughout all the plots examined was small, owing to inconsiderable rainfall in the summer of 1910, we find, however, that the average proportion for the whole season and all the plots was 0.252 per cent of carbon dioxide, which is more than six times the percentage of carbon dioxide present in the air. Besides, a higher proportion of carbon dioxide in the soil atmosphere is an indication that not merely carbon, but that other elements contained in the humus, are also being decomposed which means a new supply of ammonia, nitrates, phosphoric acid, etc.

A further examination of the data in hand shows that the production of carbon dioxide, through decomposition of humus, is on the whole fairly uniform in all the plots, being for the whole season lowest in plot B (0.180% CO₂) and highest in plot C (0.440% CO₂). It is of interest to note that the least decomposition took place in plot B, which was treated annually with peat, showing the inert character of the latter. The rather uniform and in but small degree varying decomposition of soil humus has as a consequence the constant production of plant food throughout the growing season. This is a great advantage as compared with commercial fertilizers, such as nitrate of soda, which being at once soluble and available are not infrequently leached out of the soil in considerable quantities, while the plants find ample time to take up the food resulting from the gradual decay of humus materials.

In addition to the influence of moisture and temperature upon the decomposition of soil organic matter it was intended to find out the behavior of the organic matter as affected by tillage of the soil. For lack of time, however, this question could not be investigated as thoroughly as it undoubtedly deserves. A few observations only, given in Table III, will be given any space here. Thus, the percentage of carbon dioxide in the soil atmosphere of the plots B, C, D, E and F, was on May 20th, 23rd and 24th quite small, ranging (with the exception of but one case) from 0.05 to 0.1 per cent. The cultivation of the plots on
TABLE III.

<table>
<thead>
<tr>
<th>Plot</th>
<th>May 20 CO₂ percent</th>
<th>May 23 CO₂ percent</th>
<th>May 24 CO₂ percent</th>
<th>May 26 CO₂ percent</th>
<th>May 27 CO₂ percent</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>0.1</td>
<td>0.05</td>
<td>0.05</td>
<td>0.4</td>
<td>0.3</td>
<td>The plots were cultivated on May 23 and May 25.</td>
</tr>
<tr>
<td>C</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.9</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
<td>0.3</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

May 23d and their harrowing on May 25th were followed by an increase of carbon dioxide in the soil atmosphere, being on May 26th 0.4, 0.9 and 0.2 per cent in the case of plots B, C, D, and on May 27th 0.3, 0.7, 0.4, 0.3 and 0.2 per cent in the case of the above named plots. The more rapid decay of humus as affected by cultivation and harrowing is easy to understand when we consider that tillage operations render possible the free access to the soil of air, and hence of oxygen, which oxidizes the organic matter.

INFLUENCE OF CHEMICAL FACTORS ON DECOMPOSITION OF HUMUS.

Turning to the influence of chemical factors upon decomposition of soil humus and comparing the results secured for total and available phosphoric acid (Table I) as well as for carbon dioxide of carbonates (Table II) present in the soils on the one hand, and for carbon dioxide found in the soil atmosphere on the other, we fail to find a very definite relation between the figures in question. It would seem that while it is easy to show the influence of certain chemicals upon the decay of soil organic matter in the laboratory, it is not so simple a matter to demonstrate it under field conditions. In the case of the plots examined it may be due in part to the fact that all the plots contain fairly uniform and sufficient amounts of the chemicals under consideration. Another, perhaps better, explanation which suggests itself, is that the influence of the chemicals being not as significant as that of physical factors, like temperature and moisture, may perhaps in some measure be masked by the latter.

A few figures, however, seem to indicate that there is a certain relation between the percentage of humus in the plots and the proportion of carbon dioxide in the corresponding soil atmospheres. Thus, plot C, with the highest percentage of humus, (4.62%), shows a soil atmosphere richest in carbon dioxide (0.440%). Likewise, the plots Q and V, with considerable humus, percentage (3.35%, 3.27% respectively) show a high proportion of carbon dioxide in their atmospheres (0.382%, 0.296%).
respectively). Plot B, though with a high humus content, (4.02%) shows a soil atmosphere poorest in carbon dioxide (0.180%) which is perhaps due to the inert character of the peat which that plot annually received. That the mentioned relation is not evident in other plots may be due to other chemical factors which for lack of time have not been touched upon in this paper and which may play a certain part in the decay of soil organic matter. It is hoped that a thorough inquiry into this important question, as well as into others indicated above, will be taken up as soon as possible.

CONCLUSIONS.

1. Increase of moisture and temperature (as well as tillage operations) was followed by a more rapid decomposition of the organic matter in all of the plots herein investigated.

2. While owing to a variety of conditions obtaining in the plots there is a difference in the rapidity with which the organic matter in them decomposes, it is especially marked in the case of plot B, which though with a high humus content shows the lowest percentage of carbon dioxide in the soil atmosphere. It seems fairly reasonable to ascribe it in part to the inert nature of the peat with which it was annually treated.