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Papers.

INFLUENCE OF MANURES AND MICRO-ORGANISMS ON H-ION CONCENTRATION IN THE SOIL.

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According to theories expounded by Professors LORENZ and LARMOR, the constitution of chemical atoms is that of a positive centre, surrounded by a considerable number of electrons, the algebraic sum of the electric charges of the atom being zero. It has been suggested that these electrons gravitate round the centre and constitute a system similar to a collection of planets gravitating round a star. Cannot what has been said of the atom be said of the molecule ? In the case of a molecule of benzene, for example, do we not conceive a system of many centripetal forces whose resultant is zero ? Any such striking analogy between the planetary system and the molecular microcosm is perhaps equally applicable to the difficulties of study of these two extremes.

General chemistry and especially analytical chemistry have rendered inestimable services to society far exceeding any anticipations formed when these sciences were still in their infancy. For some years the study of solutions, thanks to Arrhenius' theory of electrolytic dissociation of molecules, has given rise to a new branch of chemistry which consists in measuring the H-ion concentration of these solutions. This new branch of science has undergone great extensions in Germany, Denmark and especially in America.

In the New World, where practical realisation of discoveries and inventions is effected much more quickly than elsewhere, the determination of Hydrogen ion concentration constitutes a very convenient and very precise means either for preparing media of microbe culture, or for controlling or estimating various industrial solutions.

Hydrionometry can also give valuable indications to agriculture. An account will here be given of the result of research, the agrochemical deductions drawn from them, and of a new hydrionometric method.

A number of works exist in English on this subject, but there is little in French, either original or translated. Leaving the literature aside, some considerations of a theoretical and technical kind may be reviewed.

A. — THEORETICAL CONSIDERATIONS.

According to Arrhenius' theory, salts in aqueous solution are more or less completely dissociated into ions. Acids are salts of hydrogen and bases are salts of hydroxyl.

A solution of a weak acid HA, contains " active " H and A ions, and " potential " ions contained in the non-dissociated mass H A. The state of equilibrium between H and A on one side and H A on the other is expressed by the equation

$$\frac{(H^+)\ (A^-)}{(H\ A)} = Ka \qquad (1)$$

where Ka is the constant of dissociation and indicates the strength of an acid; (H^+), (A^-), (HA) indicate simply the concentrations of the ions H, A, and of H A during equilibrium. If this acid is titrated by a base, the equilibrium is constantly broken and re-established, until the H ions are completely exhausted as shown by the indicator. While acidimetry has the object of measuring the " normality ", that is to say the total amount of the " active " and " potential " H of an acid, hydrionometry on the other hand only measures the " intensity " of an acid, that is to say the " active " H ions of the solution. Hence we must distinguish between the factor of " quantity " of an acid and that of the " intensity " of the same acid.

Every solution, whether acid, neutral or alkaline, contains H and O H ions; the reaction is neutral if $(H^+) = 10^{-7}$ at 22° C. in gramme ions per litre, acid if $(H^+) > 10^{-7}$ at 22° C. in gramme ions per litre, alkaline if $(H^+) < 10^{-7}$ at 22° C. in ions gramme per litre.

Water though very slightly dissociated contains about one gramme molecule of H and O H ions per ten million litres.

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In pure water $(H^+) = (O\,H^-)$ which enables us to write

$$\frac{(H^+)^2}{(H\,.\,OH)} = Ke \qquad (2)$$

$(H\,.\,O\,H)$ being practically constant,

$$(H^+)^2 = Ke.\,(H\,.\,OH) = K_w, \text{ and}$$
$$(H^+) = \sqrt{K_w} = 1.006 \times 10^{-7} \text{ or } 10^{-7}$$

whence $K_w = 10^{-14} = (H^+)\,.\,(OH^-)$.

If in a base $(OH^-) = \frac{N}{100}$ that is to say 10^{-2}, (H^+) will equal :

$$(H^+) = \frac{10^{-14}}{10^{-2}} = 10^{-12}\,N.$$

Chemists seldom exceed dilutions $\frac{N}{100}$ of acids or bases, every interval included between 10^{-2} and 10^{-12} escapes acidimetry and alkalimetry.

In practice (H^+) is expressed as a function of

$$\log\frac{1}{H^+} = \log\frac{1}{Ka} + \log\frac{\alpha}{1-\alpha} = pH,$$

a formula derived by the algebraic development of equation (1) and where α indicates the percentage of dissociation of (H A). The notation pH was introduced by SORENSEN and represents the common logarithm $\frac{1}{(H^+)}$.

pH varies inversely with the H ion concentration.

(H^+)	pH
10^{-0}	0
10^{-1}	1
10^{-2}	2
= =	=
= =	=
10^{-13}	13
10^{-14}	14

The buffer action. — This is the resistance offered by a solution to change of its pH by addition or loss of an acid or a base. This resistance varies with the solution as well as with the base or acid added to it.

Determination of pH. — Two principal methods are distinguished, namely, the electrometric method and the colorimetric method. The former gives accurate results, but it is more difficult to effect.

The colorimetric method, slightly less exact than the former (maximum error pH 0.2), can however fully satisfy ordinary requirements, that is, of course, if the necessary precision is observed. It is based on the fact that each indicator has its own zone of change comprised between pH 0 and pH 14. This zone of change, relatively narrow, is characteristic for each indicator. Thus phenolphthalein changes at p H 8.3 and gives a salt completely dissociated at pH 10.0, owing to its neutralisation. The zone of change of this weak acid (phenolphthalein) is therefore comprised between 8.3 and 10.0.

An indicator is a weak acid or base and consequently feebly ionised. Its neutralisation gives rise to a neutral salt which is then strongly dissociated and radiates two kinds of light: that which results from absorption is coloured and comes from the interior of the solution, the other, on the contrary, is reflected by the surface of the solution and is generally white light (OSTWALD). The shades of a colorimetric scale are due to relatively small differences in the wave lengths of the reflected light.

Measurement by titration only makes use of the extreme colours of the zone, while hydrionometry, by means of type solutions whose p H is previously determined, fixes and utilises the intermediate stages.

B. — TECHNICAL CONSIDERATIONS.

Type solutions. — The greatest precautions must be taken in their preparation. This is how CLARK and LUB's type solutions should be prepared :—

Phthalate $\frac{M}{5}$. Dry at 115° C. $KHC_8H_4O_4$ $\frac{M}{5}$. 40.836 gr. per l.

KCl $\frac{M}{5}$. Recrystallise 3 or 4 times and dry the crystals for two days at 120° C.

KH_2PO_4 $\frac{M}{5}$. Recrystallise at least 3 times in distilled water and dry at 115° C. to constant weight.

H_3BO_3 $\frac{M}{5}$. Recrystallise several times in distilled water and dry in a dessicator with $CaCl_2$.

Na OH $\frac{M}{5}$. Boil distilled water in an Erlenmeyer vessel to drive off the CO_2, cool, add sufficient ethylic ether to form a layer 4 or 5 cm. thick and throw in carefully some metallic Na cut up into small pieces. The Na O H which is formed at the expense of traces of water contained in the ether, passes slowly through the layer of ether and is thus kept from carbonisation. Siphon and dilute quickly to $\frac{M}{5}$.

HCl $\frac{M}{5}$. Distill HCl to 20 % and dilute the distillate to $\frac{M}{5}$.

The tables below show how by mixing these solutions it is possible to obtain a whole series of standards.

$$\frac{M}{5}\,KHC_8H_4O_4 + \frac{M}{5}\,NaOH \text{ (at 20° C.)}$$

pH = 4.0	50 c.c.	$\frac{M}{5}$	$KHC_8H_4O_4$ +	0.40	cc.	$\frac{M}{5}$ NaOH	— Dilute	to 200 c.c.
4.2	»	»	»	3.70	»	»	»	»
4.4	»	»	»	5.70	»	»	»	»
4.6	»	»	»	12.15	»	»	»	»
4.8	»	»	»	17.20	»	»	»	»
5.0	»	»	»	23.85	»	»	»	»
5.2	»	»	»	29.95	»	»	»	»
5.4	»	»	»	35.45	»	»	»	»
5.6	»	»	»	39.85	»	»	»	»
5.8	»	»	»	43.00	»	»	»	»
6.0	»	»	»	45.45	»	»	»	»
6.2	»	»	»	47.00	»	»	»	»

$KH_2PO_4 + NaOH$

pH = 5.8	50	c.c.	$\frac{M}{5}$ KH_2PO_4 +	3.72	c.c.	$\frac{M}{5}$ NaO H	Dilute to	200 c.c.
6.0	»	»	»	5.70	»	»	»	»
6.2	»	»	»	8.60	»	»	»	»
6.4	»	»	»	12.60	»	»	»	»
6.6	»	»	»	17.80	»	»	»	»
6.8	»	»	»	23.65	»	»	»	»
7.0	»	»	»	29.63	»	»	»	»
7.2	»	»	»	35.00	»	»	»	»
7.4	»	»	»	39.50	»	»	»	»
7.6	»	»	»	42.80	»	»	»	»
7.8	»	»	»	45.20	»	»	»	»
8.0	»	»	»	46.80	»	»	»	»

$H_3BO_3 + HCE + NaOH$

pH = 7.8	50 c.c.	$\frac{M}{5}$ H_3BO_3	$\frac{M}{5}$ KCl	2.61	c.c.	$\frac{M}{5}$ NaOH	— Dilute to	200 c.c.
8.0	»	»	»	3.97	»	»	»	»
8.2	»	»	»	5.90	»	»	»	»
8.4	»	»	»	8.50	»	»	»	»
8.6	»	»	»	12.00	»	»	»	»
8.8	»	»	»	16.30	»	»	»	»
9.0	»	»	»	21.30	»	»	»	»
9.2	»	»	»	26.70	»	»	»	»
9.4	»	»	»	32.00	»	»	»	»
9.6	»	»	»	36.85	»	»	»	»
9.8	»	»	»	40.90	»	»	»	»
10.0	»	»	»	43.90	»	»	»	»

CLARK and LUB's indicators.

Zones of change		Concentrations
3.4 – 4.6	Bromphenol blue	0.04 %
4.4 – 6.0	Methyl red	0.02 %
6.0 – 7.6	Bromothymol blue	0.04 %
6.4 – 7.0	Bromocresol purple	0.04 %
6.6 – 8.2	Phenol red	0.04 %
7.2 – 8.8	Cresol red	0.04 %
8.2 – 9.8	Thymol blue	0.04 %

Test tubes. — In order that the results may be as precise as possible, tubes of white glass should be used of uniform thickness and diameter, otherwise there is risk of comparing the solutions under conditions of varying thickness which would be a cause of error. With this object we have instituted a practical and precise " solenometrical " (1) process. The apparatus required consists of a

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(1) From the Greek solene = tube.

graduated test tube of 100 c.c. and a drop measure. The test tube is filled to 80 c.c. and the tube to be examined is plunged into it so that the bottom of the tube is level with the 50 mark of the test tube.

The level of the water then reaches a certain height above the 90 mark. The tube withdrawn takes away a little water which is restored by means of the drop measure.

Out of 300 tubes tested about 30 caused the water to rise to the 95 mark and 20 to the 94 mark.

It is evident how much the tubes differ one from another. The test tube to contain the earth filtrate should be of the same capacity as the scale tubes.

Filtration. — The theoretical and practical details will be found in all books on analytical chemistry.

The filtration of clay soils is not always very easy. The fine particles of colloidal clay easily pass through ordinary filter paper. Filtration on a double filter or by decanting only aggravates this difficulty. We have always obtained very clear filtrates by rapid agitation of 10 gr. of soil with 50 c.c. of distilled water, then pouring the whole quickly, but adroitly, on to a folded filter paper.

In this way the pores of the paper rapidly contract. The particles which are deposited on the filter paper itself also play an appreciable part in clarifying the filtrate. The first filtrates will be turbid, and should be collected in a vessel specially prepared. A dozen filtrations can thus be accomplished in 20 minutes.

C. — RESULTS.

1. *Action of manures on the pH of the soil.* — For this research thoroughly prepared ground has been available: the experimental plots of Prof. JOURNÉE of the Gembloux Agricultural Institute. We took a first sample from them during very cold weather, a factor unfavourable to bacterial activity. Although these plots are of the same geological formation and are subject to the same surrounding influence, the different distribution of manures in the various plots has resulted in a special ionic character for each plot where for more than 10 years the same kind of manure and the same doses have been applied for the production of the same crop.

TABLE I. — *Species grown*: — *Kidney bean.*

Plots		pH
1.	Without manuring	7.45
2.	With 100 k. Na NO_3 500 k. Superphosphate	7.00
3.	With 100 k. $NaNO_3$ 300 k. K_2SO_4	7.30
4.	With 500 k. Superphosphate 500 k. K_2SO_4	7.20
5.	With 100 k. $NaNO_3$ 500 k. Superphosphate 300 k. K_2SO_4	7.15

2. *Effect of aërobic micro-organisms on the pH of the soil.* — As might be expected the influence of manures on the (H^+) of the soil is therefore certain. Will it not also modify the bacterial condition? Biogenic factors are necessary to the higher plants in the same manner as to bacteria, and it is known experimentally at the present time that manures have an influence on these lower organisms. We shall see that the latter in turn influence the pH.

The same samples of soil subjected to a temperature of 26° C. for 48 hours, with a constant relative humidity, altered pH in very sensible proportion.

TABLE II.

Plots	Initial pH	Final pH	Difference	Yield per *are*
1. Complete manuring	7.15	6,60	0.55	25.833 Kgs
2. Without nitrogen	7.20	6,50	0.70	30.833 »
3. Without P_2O_5	7.30	6.90	0,40	24.166 »
4. Without K_2O	7.00	6.90	0.10	15.833 »
5. Without manure	7.45	7.10	0.35	23.333 »

(The species grown was the Kidney bean. The last column shows the yields per *are* of the ligneous matter of the Kidney bean).

What is most striking is the parallelism of variation of the yields and that of pH, the numerical importance of which for each plot measures the bacterial activity of the latter. The yield of a soil therefore depends on its richness in aërobic micro-organisms.

The soil is not merely a mixture of humus and mineral substances, but also pre-eminently a living medium.

The relative acidification of all the plots should also be noted, due, no doubt, to respiratory loss by the aërobic micro-organisms.

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The taking of another sample on a very sunny warm day has given the following results :—

TABLE III.

Kidney bean

Plots		Initial pH	Final pH	Yield per *are*
1.	Complete manuring	6.6	6.50	25.833 Kgs
2.	Without nitrogen	6.5	6.25	30.833 »
3.	Without P_2O_5	6.8	6.80	24.166 »
4.	Without K_2O	7.0	6.90	15.833 »
5.	Without manure	7.1	6.60	23.333 »

TABLE IV.

Potatoes.

1.	Complete manuring		6.6 (Initial pH)
2.	Without nitrogen	500 k. Superphosphate 300 k. K_2SO_4	6.5
3.	Without P_2O_5	400 k. $NaNO_3$ 300 k. K_2SO_4	6.8
4.	Without K_2O	400 k. $NaNO_3$ 500 k. Superphosphate	6.9
5.	Without manure		7.25

Here the influence of solar heat on the pH of the soil by the agency of micro-organisms is manifest, giving results practically identical with those which have been obtained with artificial heating in the course of our experiments, an identity which shows the practical importance of the laboratory work done.

The figures of final pH in Table III were obtained after incubation of 60 hours under a temperature of 32° C. The new variations are smaller, but in the same sense as those of Table II.

The relative smallness of these variations is due to the difference of temperature on the days on which the samples were taken.

The acidifying action of the aërobic organisms is again confirmed.

The plot without nitrogen was most acidified, which agrees with PLUMMER's results. (The $NaNO_3$ indirectly basifies the soil by the Na_2CO_3 generated. Since the $NaNO_3$ is the only basifying manure, except lime, it is fully intelligible that its favourable effect should be so manifest on the crops).

3. *Effect of anaërobic micro-organisms on the pH of the soil.* — If badly aërated and water-logged soils are especially rich in strictly anaërobic micro-organisms, this should not be the case with healthy, well aërated soils where the anaërobic flora should property consist mainly of potential anaërobes, and to a secondary extent, of anaërobes in the strict sense. Apart from this hypothesis which is the logical one we should find a difficulty in interpreting the figures obtained which are grouped in the following table.

TABLE V.

Plots	Initial pH	Final pH	Difference	Yield per *are*
Complete manuring	6.55	6.85	0.30	25.833 Kgs
Without nitrogen	6.50	6.70	0.20	30.833 »
Without P_2O_5	6.60	6.95	0.35	24.166 »
Without K_2O	6.70	7.10	0.40	15.833 »
Without manure	6.80	7.05	0.25	23.333 »

While badly aërated soils have a distinctly acid reaction, sound soils the aëration of which has been completely destroyed for 48 hours under a temperature of 23°C. show a perceptible decrease of their acidity or even have become alkaline.

The reaction of the soil is therefore subjected to the action in opposite directions of two forces of micro-organic origin. If one of these two forces happens to be entirely lacking, the action of the other will in the course of time markedly change the reaction of the soil so as to hinder all normal vital development. In sound soils, owing to the antagonistic action of these two forces, the reaction oscillates to left and right like the point of the hand of a self registering barometer.

4. *Relation between the two categories of micro-organisms and the yields.* — Two methods are in use for evaluating a soil from an agricultural point of view :— chemical analysis and physiological analysis.

The former is a rapid method, but by itself only gives very slight indications, while the latter is more efficient, but only gives results after the lapse of much time.

Our investigations enable us to discover a new process which we will call " biological ". The following comparative table brings out our starting point.

TABLE VI.

Plots —	Yields per *are* —	Aërobic bacterial activity (Table II) —	Anaërobic bacterial activity (Table V) —
2. No nitrogen	30.833 Kgs.	0.70	0.20
1. Complete manuring	25.833 »	0.55	0.30
3. No P_2O_5	24.166 »	0.40	0.35
5. No manure	23.333 »	0.35	0.25
4. No K_2O	15.833 »	0.10	0.40

It is seen that in normal conditions the yields are proportional to the richness in the aërobic bacteria of the soil, and inversely proportional to the richness in anaërobic bacteria, and in a more general way :—

The fertility of a soil is directly proportional to its aërobic bacterial activity and inversely proportional to its anaërobic bacterial activity. This is readily admitted if it is realised that a soil must become enriched in anaërobic bacteria according as it loses its physical properties favourable to plants (good aëration due to a lumpy character of soil, for example). The investigation of several categories of soils (clay, sand, sandy-clay, humus, etc.) of different qualities makes it possible to draw up tables which will give directly the degree of fertility of the soil examined.

D. — STAGONOMETRY : — NEW PROCESS FOR DETERMINING PH.

The utility of the extension of hydrionometric research has led us to seek for a less cumbrous method at least as precise as the ordinary colorimetric method which required considerable preparation and apparatus and in which moreover the shades of the scale become paler under the action of light, leading to errors.

When 1 cub. centimetre filtrate is treated with an appropriate indicator, a change in colouring results of which the degree of transformation measures the H ion concentration.

This degree of transformation is rapidly determined by adding drop by drop an " alkaline reagent " to 1 cubic centimetre of type solution of known pH. The number of drops added to get the same coloration as the soil filtrate, to which an equal quantity of the indicator has been added, measures the (H^+) of the soil solution, concentration being read on the curve which corresponds to the indicator used. The " alkaline reagent " and the known pH are prepared commencing with CLARK and LUBS' stock solutions. The indicators are thus the same, but diluted to 0.01 %, which enables 1 drop of the indicator to be added for 5 drops of " alkaline reagent ", 20 drops of the drop measure used equalling 1 cc. of the alkaline reagent.

The "alkaline reagent " is composed of :—

$$50\ c^3 \text{ of } KCl\ \frac{M}{5}$$

$$50\ c^3 \text{ of } H_3BO_3\ \frac{M}{5}$$

$$43.9\ c^3 \text{ of } NaOH\ \frac{M}{5}.$$

The solution of known pH is the CLARK and LUBS' type solution pH 5.8, no soils treated by us having given a stronger acidity than pH 6.2. The vessels in which the colorimetric (or stagonometric) (1) tests are made, consist of at least two small pure white porcelain basins. The covers of small crucibles upside down are very suitable for the purpose.

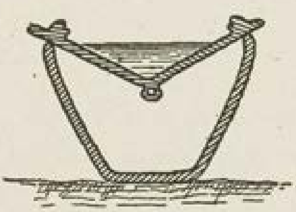

FIG. 9. — Vessel for stagonometric tests.

Into the first is put one cubic centimetre of very clear soil filtrate and 4 drops of the appropriate indicator. Into the second, in its turn, 1 c.c. of the solution of pH 5.8, 4 drops of the same indicator, and drop by drop " alkaline reagent " until perfect identity of coloration is reached.

Note that one additional drop of the same indicator per 5 drops of " alkaline reagent " is required to maintain approximately con-

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(1) From the Greek stagon = drop.

stant the relation between the quantity of indicator added and the volume of the liquid affected.

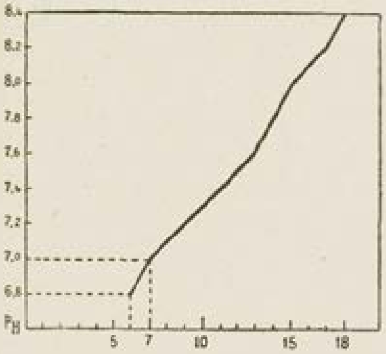

FIG. 10.
Phenol Red (6.8 to 8.6) Curve

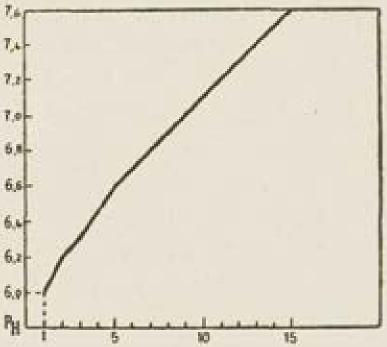

FIG. 11.
Bromothymol Blue (6. to 7.6) Curve

A curve can be drawn for each indicator. The method can be adapted to cover the whole pH scale.

GRAPHIC REPRESENTATION OF THE KOPECKY SOIL CLASSIFICATION SCHEME FOR TECHNICAL PURPOSES.

By Dr. E. G. Doerell,

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Ing. J. Spirhanzl published in the January number, 1925, of this Review a " graphic aid " to the Kopecky soil classification scale. The same reasons which caused Ing. Spirhanzl to reduce the Kopecky scales to a more synoptical form led me to find the following method (exhibited at the Exhibition of the Fourth International Soil Science Congress at Rome).

The form of the circle was chosen partly on account of easier survey, but also in order to be able at the same time to inscribe a " drain distance curve ".

For it is in the first instance the question of the distance between the drains which the agricultural engineer wishes to have answered.

We have not yet any scientifically based law on the interdependence of drain distance and drain depth. We only know that water drains less easily through heavy soil than through more permeable soil, and it follows from this that in the latter case a greater distance apart is permissible than in the former.

As regards the choice of the distance apart of the drains the expert was dependent on his experience.

It is a great service on the part of Kopecky to have brought his " experience " in regard to drain-distance into mathematical correlation with the mechanical composition of the soil. The expert is thus enabled to determine the drain-distance on the available basis of the composition of the soil. Fauser and Gans have calculated the results of Kopecky for the climatic conditions of Würtemberg. But in these data of Fauser there were principles derived from experience. By experiment Krüger gave to these principles a scientific basis, which confirmed the accuracy of Kopecky's observations. (Kruger, Int. Mitt. f. Bodenkunde, Vol. XI, pp. 105-110, Berlin, 1921).

I have now brought the soil classification scheme of Kopecky to a system of sectors of a circle. The circumference of the circle is divided into 80 parts, for the percentage content of fraction I (diameter less than 0.01 mm). On the radius the proportion of fraction II is drawn to contents of 40 %. The sectors so formed represent the types of soil.

Kopecky's, experience for our climate, according to the composition of the soil, with a drain depth of 1.30 m., distances of 8-24 m. have proved correct.

The direct reading, which corresponds to the distance suitable to the mechanical composition of the soil determined by analysis, can be taken from the graph without compasses or any other aid, direct on the inscribed " drain distance curve ".

It is of course natural that the measurement of the distance, based on the mechanical composition of the soil, may undergo certain alterations due to local circumstances (sloping land, lime and iron contents). But the basis of the determination of the drain distance can here be formed in accordance with mathematical view points, and estimation, with its subjective errors, is avoided. This determination is only valid, of course, on the hypothesis, which indeed can seldom occur, that the soil is of uniform quality to a depth of 1.3 m. throughout.

In general we shall have to deal with different layers of soil. Each of these layers would, however, require a different drain distance. Dr. Blauth, Lemberg (comp. Friedrich, Wasserbau, Vol. I, p. 340) gives a graphic method of determining the correct distance with layers of different permeability. The process corresponds approximately to the penetration of a ray through different media, it being sumed that " ideal water " moves in a similar manner in the ground.

The results obtained, in any case, agree pretty well with experience with regard to the correctly measured dike distance, so that this method can be considered as practicable.

With my curves, with only two different layers, the corresponding distance can be read off, without any measuring or drawing (such as Blauth gives).

For instance, the upper layer is sand (50 cm.) ; the corresponding dike distance for sand would be 20 m. ; the lower layer is clay (80 cm.); the corresponding dike distance 8 m.

The determination now takes place in the following manner : we only require to look for the intersecting point of the curve with a connecting ray which indicates the corresponding thickness of a layer : e. g. 50 cm. sand, or 80 cm. of clay. The perpendicular on the abscissa axis gives direct the corresponding drain distance ;

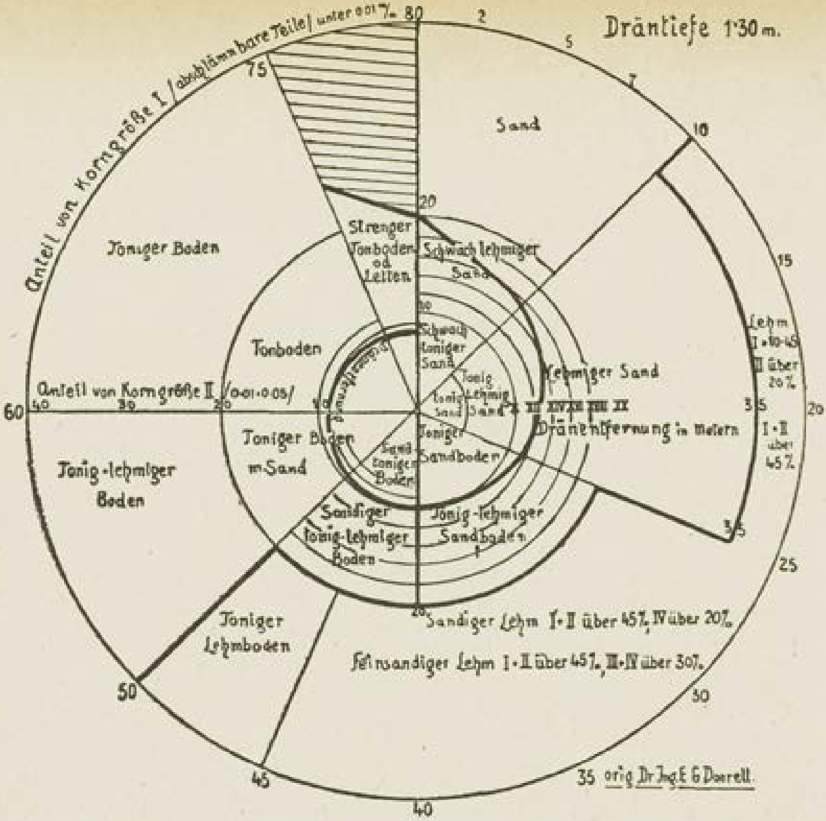

FIG. 12. — Representations of the KOPECKY Soil Classification Scheme, with 'drain distance curve'.

Explanation of the diagram.

Dräntiefe 1,30 m.	Drainage depth 1,30 m.
Anteil von Korngrösse I (Abschlämmbare Teile). unter 0.01 mm.	Proportion of particles of Type I (part capable of decantation) of diameter less than 0.01 mm.
Sand	Sand.
Lehm	Loam.
I = 10 — 45	Type I = 10-45.
II über 20 %	Type II over 20 %.
I + II über 45 %	I + II over 45 %.
Sandiger Lehm I + II über 45 % : IV über 20 %	Sandy loam I + II over 45 % : IV over 20 %
Feinsandiger Lehm I + II über 45 % III + IV über 30 %.	Fine sandy Loam I + II over 45 % : III + IV over 30 %.
Toniger Lehmboden	Clayey Loam soil.
Tonig-lehmiger Boden	Clay loamy soil.
Anteil von Korngrösse II (0.01-0.05 mm.)	Proportion of particles of Type II (diameter of from 0.01-0.05 mm.)
Toniger Boden	Clayey Soil.
Strenger Tonboden od. Letten	Heavy Clay Soil.
Schwachlehmiger Sand	Sand slightly loamy.
Lehmiger Sand	Loamy sand.
Dränenentfernung in Metern	Drain distance in metres.
Tonig lehmiger Sandboden	Clay loamy sandy soil.
Sandiger tonig-lehmiger Boden	Sandy clay loamy soil.
Toniger Boden mit Sand	Clayey soil with sand.
Tonboden	Clay soil.
Schwachtoniger Sand	Slightly clayey sand.
Tonig lehmiger Sand	Clay-loamy sand.
Toniger Sandboden	Clayey sandy soil.
Sandtoniger Boden	Sandy clay soil.
Dränentfernung	Drain distance.
Toniger Sand	Clayey Sand.

in the above example 12.70 m., therefore 13 m. The same applies with other layers combinations.

In case we have to deal with several different layers, we first proceed to determine graphically (after BLAUTH) the drain distance of

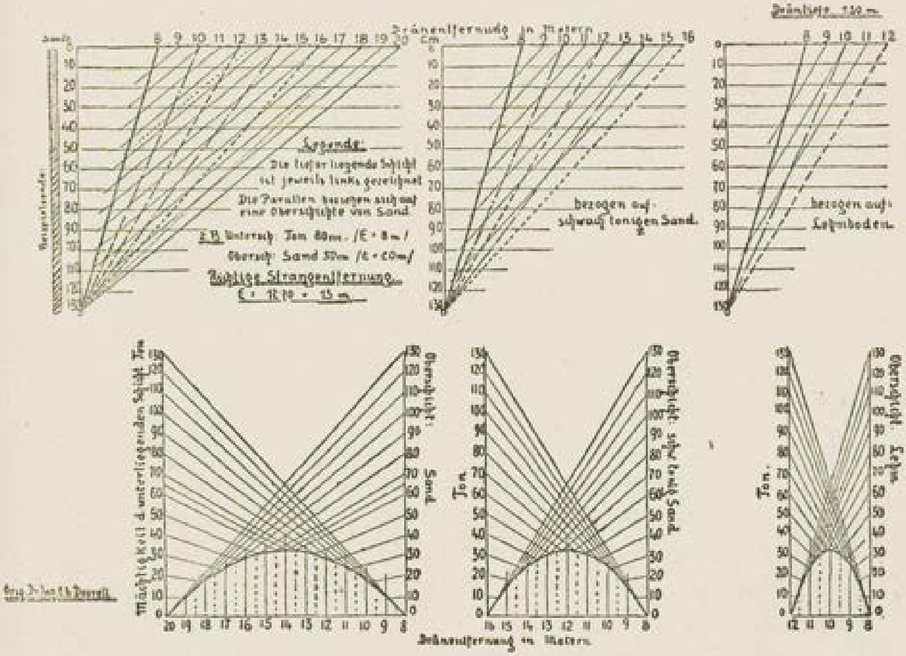

FIG. 13. — Diagram (or graphs) for the determination of the drain distance in layers of soil with varying permeability.

Explanation of the text.

Dräntiefe	Drainage depth.
Dränentfernung	Drain distance.
Sonde	sounding or probing.
Beispielsonde	sample probing.
Die tiefer liegende Schicht ist jeweils links gezeichnet.	the lower layer is always shown on the left.
Die Parallelen beziehen sich auf eine Oberschichte von Sand	The parallels refer to an upper layer of sand.
Z. B. Untersch. Ton 80 cm. (E = 8 m.)	e. g. Lower layer clay 80 cm. drain distance 8 m.
Obersch. Sand 50 cm. (E = 20 m.)	Upper layer sand 50 cm. drain distance 20 m.
Richtige Strangentfernung E = 12.70 — 13 m.	Perpendicular distance E = 12.70 i. e. 13 m.
bezogen auf schwachtonigen Sand	Referring to slightly clayey sand.
bezogen auf Lehmboden	Referring to loamy soil.
Mächtigkeit d. unterliegenden Schicht Ton	Thickness of clay substratum.
Oberschicht Sand Ton	Upper stratum of sand.
Oberschicht schwachtoniger Sand	Upper stratum of slightly clayey sand.
Oberschicht Lehm.	Upper stratum loam.

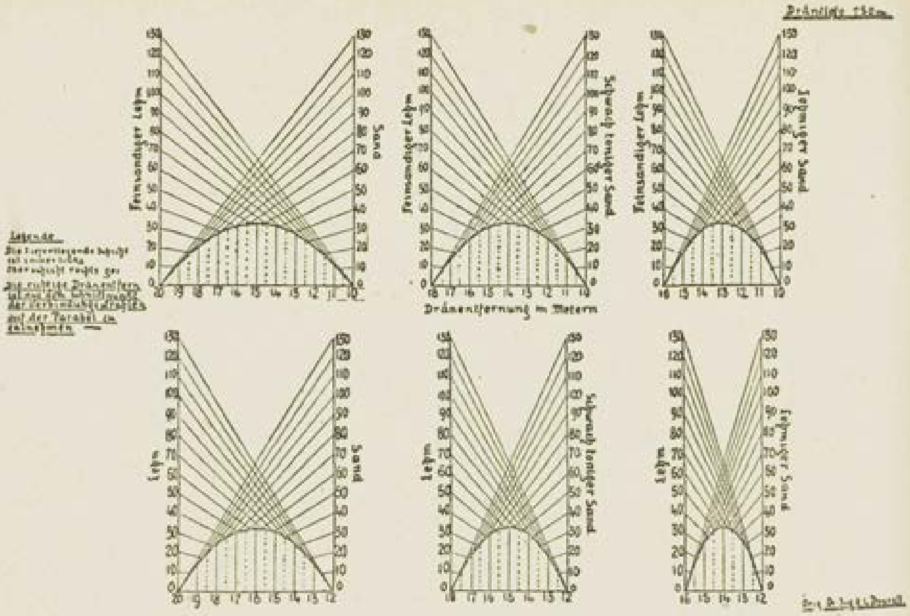

FIG. 14. — Diagrams for the determination of the drain distances in layers of soils of varying permeability.

Explanation.

Feinsandiger Lehm	Fine sandy loam.
Sand	Sand.
Schwachtoniger Sand	Slightly clayey sand.
Lehmiger Sand	Loamy sand.
Lehm	Loam.
Dränentfernung in Metern	Drain distances in metres.
Die tieferliegende Schicht ist immer links, Oberschicht rechts gez.	The deeper layer is always shown on the left, the upper stratum to the right.
Die richtige Dränentfernung ist aus dem Schnittpunkt der Verbindungstrahlen auf der Parabel zu entnehmen.	The right distance between the drains is to be inferred from the point of intersection of the connecting rays on the parabola.

the two lower layers, and then simply apply the ascertained value in the sense of the above explanation, as though we had to deal with a uniformly composed layer.

Of course, there might still be mentioned the very difficult point whether, in such cases where layers occur which are permeable with difficulty, to a small depth e. g. clay or loam, we could maintain a drain depth of 1.30 m. In general, the tendency to-day, in such cases, is to reduce the drain depth.

INVESTIGATIONS INTO THE RESISTANCE OF SANDY SOILS TO WETTING.

By R. ALBERT and M. KÖHN,

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The water conduction of a soil is influenced in a high degree by the ease of wetting of the soil particles. Even though in general no great differences are to be observed in the susceptibility of the soils to moisture, yet it can often be noticed, especially with loosely laid dusty soils, that after long drainage they only absorb water with difficulty. This fact, however, is in no way confined to dusty soils (amongst these, in this sense, must also be counted powdery peat, "dust mould" and road dust) (1). Even on light-mould sandy soils, as RAMANN (2) has already mentioned, collections of water can occasionally be found in small depressions many hours after rain, whilst the sand lying underneath is still powder dry. Recently BUNGERT (3) has thoroughly observed and described this fact.

As to the reasons for this "resistance to wetting" (4) of the soil, various theories have been advanced. Originally it was assumed that the non-susceptibility to moisture of drained peat or mould particles was caused by a coating of resinous or wax-like matter (5), and RAMANN (6) also traces back the high moisture-resistance to the like substances. "Once drained, these impervious substances coat the soil particles, and offer strong resistance to their saturation". This assumption is controverted on other sides, especially by EHRENBERG (7), in conjunction with PUCHNER (8) and FLEISCHER (9).

These authors assign, as a reason for the difficulty of absorbing moisture by dry soil particles, in particular dried humous material, that these have a great capacity for absorbing air, a less capacity for absorbing water or moisture, and are protected from the moisture by this absorbed air covering (10). As a further factor, these investigators adduce the fact that the air in the capillary spaces of the soil prevents the penetration of water. One of the authors has already shown that in addition to all these factors there are still others, for example the condition of the organic matter to be taken into account in judging the ease for absorbing moisture (11). "Soils with preponderance of acid humus become moist even when only air dried, with disproportionately greater difficulty, and slowness than so called sweet humus soils with an equal percentage of organic matter".

On the occasion of other investigations our attention was drawn to a soil with extraordinarily poor moisture-absorbing capacity, and its resistance to wetting could not be explained in any of the above ways. It was a fairly coarse diluvial sand with little humus from the Chorin high forest, on which acacias did not thrive. The sand, under a very thin layer of humus after long rainfall, and the thawing away of a fall of snow about 5 cm. deep, contained only 0.63 % of water. Placed in water, its moisture resistance showed itself in the fact that after 24 hours th ewater could be poured off from the unaltered dry soil. A superficial film of water clinging to the sand broke up on being touched. The difficult absorption of water was still more clearly recognisable by the fact that a considerable part of the sand remained floating on the surface of the water, and could be made to sink neither by shaking nor by stirring. These floating portions, however, were in no way composed of the finest fractions of the soil, nor of organic constituent parts. Observation under the microscope showed that grains of quartz predominated, mixed with small grains of felspar or the like, and very small particles of mould. There were also throughout grains of considerable size. A few samples, which had remained floating for about 250 hours, were measured on an oaken ocular micrometer. Out of about 350 grains:

61 grains, about	17 %, had a diameter of about	0.02	mm.
35	10 %	0.05-0.08	mm.
117	32 %	0.1	mm.
89	25 %	0.2	mm.
37	10 %	0.3	mm.
14	4 %	0.4	mm.
5	2 %	0.5	mm.
2	0.6 %	0.6	mm.

1 large grain, length about 1.6 mm., width about 0.6 mm.

The measurements must in no way be claimed as being of special exactitude as regards the actual sizes of the grains of sand, or as an exact selection of average samples. They show, however, plainly enough that about 55 % of the floating grains have the considerable size of 0.1 to 0.2 mm., that a large proportion are still larger whilst particles below 0.02 mm. diam. are practically absent.

Similar estimates were applied to a whole series of other samples.

It is obvious that the moisture resistance of grains of this size cannot be due to absorbed air coverings, which in the case of the finest dust no doubt play a part (12), nor to the air retained in the capillary spaces, nor to any coating of resinous or wax-like substances (13). Acid humus, difficult to wet, probably does no enter into the question. The humus content of the sands determined as loss on ignition amounted to 1,17 % and the acidity of the soil was in no way high.

There was found :

Exchange-acidity according to DAIKUHARA : 4.8 ccm.n/10 NaOH to 100 gm. soil.

Hydrolytic acidity : 21.2 ccm. n/10 NaOH to 100 gm. soil.

We now tried, by increasing the vapour pressure, to make the soil capable of absorbing moisture. For this purpose a sample of air dried soil was kept for 36 hours over water in a vacuum dessicator. At the same time other samples were allowed to stand over different concentrations of sulphuric acid, so that an idea could be formed of the hygroscopicity of the sand. The determination of the water contents of the samples treated in this way gave the following values (14).

Contents of the dessiccator	H_2O	H_2SO_4 %									
		10	20	30	40	50	60	70	80	90	100
H_2O content of the soil in % ...	0.98	0.62	0.35	0.26	0.10	0.03	0.01	0	0	0	0

None of the samples showed any difference as regards their capacity for wetting.

On the contrary, moistening at once occurred when a few drops of ammoniac were added to the water.

Treatment of dry soil with gaseous ammonia had a similar result. Ammonia gas, obtained by heating a strong solution, was cooled in a spherical cooler directed downwards, the water condensed in a receiver previously dried being collected. The gas was further dried in a large drying tower having layers of carbonate of lime, and then conducted at a measured rate (about 3-4- bubbles per second) over the soil spread out in a wide glass pipe. After being conducted over for half an hour the superfluous ammonia was removed by drawing through air for 20 minutes. After that the soil was at once susceptible to wetting. It did not lose this property after it had been exposed to the air for 24 hours in a thin layer.

The objection might be raised that it was originally the absorbed air films which protected the grains of sand from moisture, and that the action of the ammoniac caused the air films, as a result of a greater absorption power of the grains of sand for ammonia to be driven out and replaced by ammonia. The moistening would then be attributed to the very great solubility of the ammonia gas in water. This objection will, however, fall to the ground, as the soil also, became moistened in water containing a little Na_2CO_3. We tried however whether the moistening of the soil might not be attained by the action of other gases but the gases used by us, carbon dioxide and sulphur dioxide, in no way altered the moisture resistance of the soil, in spite of the great solubility, especially of the sulphur dioxide, in water.

We now followed the moistening process of the soil in water and in dilute ammonia under the microscope. Even though an exact picture could not be obtained, as with the necessarily considerable enlargement only a very small part of the surface of a grain could be closely observed, yet we received an impression as though the grains of sand were covered over by a thin, brownish skin, which quickly dissolve in dilute ammonia, and after that allowed the moistening of the grains concerned. It could consequently be deduced with reason that these skins were formed of humus substances. If this supposition was correct, then it should be possible to make the sand take up moisture by removing the humus coating. It seemed to us that heating (although the sand was thereby made saturable) and similar processes were too drastic, and we chose therefore the method, first proposed by ROBINSON (15) and recently recommended by HISSINK (16) for another purpose, for the destruction of the humus substances by means of hydrogen peroxide. It was shown that the soil became moistened after standing for several hours in 3 % H_2O_2, and in 30% H_2O_2 became moistened almost immediately. When the soil, after treatment with H_2O_2, was filtered, washed with water and dried, or stirred directly with H_2O_2 in the water bath and dried by evaporation it still remained easily saturable, whilst a sample treated with water only in like manner maintained its high resistance to wetting.

Another means of removing the humus coating is an acid solution of oxalate of ammonia, as used by O. Tramm (17) for the removal of inorganic gel coverings of soil grains and also recommended by K. Lundblad (18). As the investigations of Tamm (17) showed that the Tamm solution (31.52 gm. oxalic acid and 62.1 gm. neutral oxalate of ammonia to the litre of water) does not attack the mineral grains of the soil, it appeared to be specially suitable for this purpose. In fact the sand became moistened in a short time in the Tamm solution.

Another proof may be given that the above mentioned operation of the ammonia gas does not depend on the absorption of this gas by the grains of soil. A weighed sample of the sand dried at 105°, treated with ammonia in the manner mentioned and afterwards with air, was boiled with water, and the escaping ammonia was conducted into n/10 sulphuric acid. By titration with n/10, alkali the quantity' of sulphuric acid neutralised by the ammoniac was fixed. It was shown that 100 gm. soil had absorbed 0.0204 gm. NH_3, whilst the soil after the destruction of the humus with peroxide of hydrogen, and after washing with water, only retained 0.004 gm. NH_3 (calculated on 100 gm. soil and determined in like manner). It is shown quite clearly, therefore, that the absorption of ammonia only takes place with the co-operation with the humus substances in notable extent, and that the sand free from humus is not favourable to this adsorption.

The question now remains how the influence of the *humus coating on the moisture capacity* of the soil is to be explained. The interpretation that the humus substance covering the sand grains has become irreversible by great drying, and thereby resists the moistening, appears to us not very probable, because if so, these light humus sands, difficult of saturation, would, in our opinion, be found much more frequently. The occasion for the formation of humus coverings, and the drying of these, must arise very often, whilst the high degree of moisture resistance here described is not so often observed. It is possible that the humus molecules, as (according to Langmuir (19) the large molecules on border surfaces often do) range themselves in regular formation on the surface of the sand grains in such a way that "lyophobe" groups of molecules are directed outwards. The relative infrequency of the difficult saturability might then, therefore, give the impression, either that not all kinds of humus contain lyophobe groups, or that the humification does not always result in the formation of lyophobe groups, or that the relationship of humus molecules only occasionally, or only under still unknown conditions, takes place in such a way that the lyophobe groups are turned outwards. It is up to now equally uncertain why the removal of the moisture-resistance is effected by ammonia. It might be that, as mentioned above as being improbable for sand grains, the ammonia is physically absorbed on the humus covering. These ammonia films would immediately dissolve in water, and cause the wetting of the soil particles. Consequently the humus films could then be detached and dissolved by the resulting local concentrated ammonia solutions. In fact, soil treated with NH_3, when covered with water, after some time acquires a brownish colour. That not physical adsorption alone comes into the question is proved by the fact that on boiling soil treated with NH_3 in water, only about half of the ammonia rendered removable by distillation with oxide of magnesia is recovered. There may therefore occur, at least as regards physical adsorption, a chemical reaction between ammonia and mould. If highly humus soils and pure sphagnum peat, all dried at 105° to a constant weight react with ammonia gas under great heat, as we could establish, then theoretically both processes, chemical reaction and physical adsorption may occur even though in our estimation the chemical reaction is more probable.

Unfortunately we must postpone our experiments with reference to the above matter until summer, on account of other pressing work, and above all, for lack of suitable material. Nevertheless it seems to us that our investigations up to now, which in every respect are only considered as preliminary experiments, show plainly that the vegetable humus coverings of the grains of soil play, at least in many cases, a decisive part in the saturability of the soil concerned. And this result appeared to us sufficiently interesting to warrant a preliminary communication.

The treatment of the soil with ammoniac in the form of gas also appears to us interesting in another direction. In this connection we have investigations in train as to whether the adsorption capacity of a soil for NH_3 can be applied to determine its humus contents, and whether eventually conclusions can be drawn from this on the nature or condition of the humus. We will report in due course on the results of these investigations.

ANNOTATIONS AND BIBLIOGRAPHY.

(1) Compare, as to this, e. g. B. Ehrenberg: Die Bodenkolloide, 2. Ed. 1918, pp. 246, seq.

(2) Ramann, Bodenkunde, 2. Ed. (1911), p. 345.

(3) Diss. Forstl. Hochschule Eberswalde 1925; Z. f. Forst- und Jagdwesen, Fasc. 11, p. 547 seq. (1925).

(4) Ramann, *l. c.*, S. 344.

(5) Literature data Ehrenberg, *l. c.*, p. 248 et seq.

(6) *l. c.*, p. 345.

(7) *l. c.*, p. 259 et seq.

(8) H. Puchner, Forsch. Geb. Agrikulturphysik 19, 11 (1896).

(9) M. Fleischer, in Vogler, Kulturtechnik, 2. Ed. (1898), Vol. 1, p. 119.

(10) Experimental proofs and literature see Ehrenberg, *l. c.*, p. 250 et seq.

(11) Albert, *Journal für Landwirtschaft*, 56, p. 370, 1908.

(12) See the experimental proofs in Ehrenberg, *l. c.*, p. 250 et seq.

(13) To determine whether absorbed air might not be the reason for this appearance, we made the following experiment: A sample of the sand, floating on water in a small dish placed in a desiccator, was exposed for several hours to a vacuum of about 12 mm. No moistening took place after 36 hours.

(14) All the analysis data are average values, each of two denominations.

(15) Jnl. of Agric. Science, XII, p. 287 et seq. (1922).

(16) Mitt. d. Intern. Bodenkundl. Ges., New Series, Vol. I, No. 3, p. 158 (1925).

(17) *Meddelanden fran statens skegsförs öksanstalt*, Fasc. 9, No. 4 (1922). Communications of the Swedish State Experimental Station for Forestry.

(18) *Ibid.*, Fasc. 21, 1924.

(19) Journ. Amer. Chem. Soc. 39, 1894-1906-1907) comp. Zsigmondy, Kolloidchemie, 5. Ed., pp. *109-114*. Leipzig (1925).

ON THE LIMITS OF BIOLOGICAL INQUIRY IN SOIL SCIENCE.

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"*Some unknown cause*" — it would seem — led Georges Ville to the much challenged results of his celebrated experiments establishing the remarkable gain of nitrogen which takes place during the cultivation of leguminous plants.

The ancient world which lived — and unavoidably so — in ignorance of micro-organisms was nevertheless aware by intuition that something must intervene before the indirect elements of nutrition could enter into the structure of the plant organism; and while labouring under the disadvantage of the virtual impossibility, with the means then available, of following the metamorphosis of alimentary materials in agricultural soil, it arrived at the assertion of the existence of transformations such as had effects of manifestly fundamental importance.

The important subject of the fertilisation of the soil was really involved in the question.

This subject deeply engaged the minds of students; all kinds of paradoxical theories were indulged in by scientists; feeling ran high between manufacturers and dealers of manures.

Theories of all kinds found acceptance, deriving life from organic matter, from a vital principle, from humus, from nitrogen, from minerals.

While this *unknown cause* was for the "vitalists" who were the most advanced section of the "humists" a transcendental one, if for them it was not necessary to go much further than the *vital matter* of Treviranus, for the true "humists" everything consisted, at most, in some physical and chemical actions, play of movements and attractions of masses or of elemental affinity.

Even the ideas diffused with great energy by Liebig and defended by him against those who maintained theories on organic substances and nitrogen were not free from errors, some of a serious and fundamental nature. The relinquishment of experimental work in favour of polemics conducted with liveliness, not to say acrimony, led LIEBIG to form that erroneous inference, which consisted in attributing to the organic substance of the soil and manures value only such and so far as mineral bodies resulted as the final product of its destruction. Reasons of space do not allow of the quoting of certain very striking passages in the works of LIEBIG.

Between the premise that a successive series of crops impoverishes the soil and the conclusion that for a return *to the fixed point* nothing is necessary but the restitution to the soil of the elements of the plant ashes previously removed, we shall find that LIEBIG interposes this scientific contribution :– Ammonia and the combustible substances of manures have a stimulating effect ; fallowing and tillage are of value for cleaning the soil of weeds or for mechanical modifications of the soil ; organic substances have no power of producing abundant crops; the action of stable manure depends solely on the mineral elements contained in it. For that reason it must be useless, or even harmful, for fodder to pass through the digestive system of animals ; stable manure was not indispensable to plant production ; and, in short, everything would be reducible for plants to the preparation and administration of tabloids, just as has been prophesied for the nutrition of Man, who is to be, in the future, a non-material being. To form an idea of the phenomena of capital importance which develop in the soil and which these theories completely ignore, it suffices to go back to that biochemical cycle of phosphoric anhydride which is made evident by our researches and in which is involved the active power of almost all mineral salts useful to the plant (Fig. 15).

The action of phosphorus in the soil is accomplished in two opposite senses, namely it passes from monometallic phosphate, through bimetallic, trimetallic phosphate and viceversa. In the first case the action is physical and chemical, in the second case biochemical, both, one and the other, in a fixed correlation.

Along with the interplay of the acids and acid salts of phosphorus with the various bases of the soil, the micro-organisms cause an evolution in the organic substance of the soil, from which originate more or less complex *phosphorganic substances*, acid or containing acid radicals which easily become free, and they too contribute largely to the mobility of the potash, lime, magnesia, iron, etc.

Hence there are two cycles of the phosphorus in the soil :— the *mineral* and the *organic*. The extreme limits of the first are basic phosphate and acid phosphate. This once formed, and a certain proportion of bases attacked, unless some factor maintain-ing the biochemical conditions of its existence intervenes with the occurrence of chemical and physical actions, it returns to the insoluble state.

In the organic cycle, on the other hand, this *retro-gradation* does not take place ; and the phosphorated substance, more or less salified, soluble or easily soluble by saponification of the large nuclei from which it results, is to a great extent employed directly in the metabolism of new forms of life which succeed one another unceasingly in the soil.

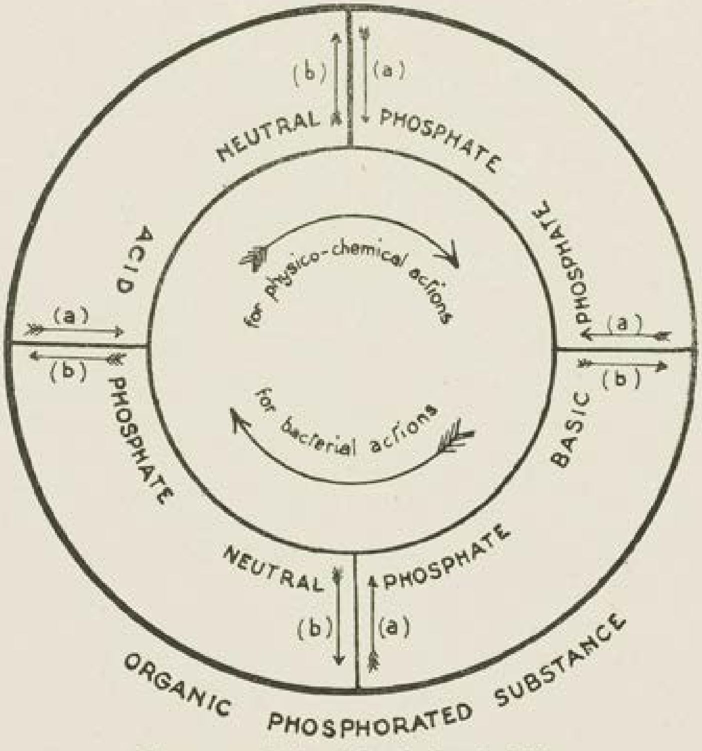

FIG. 15. — Cycle of phosphoric anhydride in the soil.

Moreover, continuous relations of transformations exist both in one sense and the other between the two cycles by which one form of phosphorus can pass more or less indirectly into the other. And, on the one hand, forms of autotrophic life, and on the other those of heterotrophic life intervene. By the one, mineral phosphorus may at any moment pass from its circle into the organic; by the other, on the contrary, it may return to the mineral state. But since the organic combinations of phosphorus constitute a material productive of energy, they tend to effect biochemical transformations in the way of mineralisation which is agriculturally disadvantageous; however the opportune provision of dynamogenetic materials interferes with the play of bio-reactions and leads to useful results.

We are inclined to dispute the right of anyone to suppress, with or without LIEBIG, in the name of science and of the so-called results of practice, the fundamental function of organic matter in the economy of the medium in which plants live. Nor can we admit that any one should endeavour to specify the contribution of science to agriculture by a simple mathematical relation such as:

$$\begin{array}{ccccc} P & = & A & - & O \\ \text{production} & = & \text{available food} & - & \text{opposing factors} \end{array}$$

A biological phenomenon, one may say a complex series of biological phenomena relating to production, is not represented by any mathematical formula, either simple or complex. Besides it presupposes that *the environment in which plants live is something fixed, unchanging and that the vegetable kingdom is directly dependent on the mineral kingdom.*

The real truth is that agricultural soil is not an unchanging entity and that between minerals and cultivated plants there is interposed such a complex series of phenomena and factors dependent on the new realm of micro-organisms as to make Liebig's equation appear an irony.

Organic matter, considered as the stimulating force of the life which teems in vegetable soil and of its perpetual mutability, is evidently not the matter of TREVIRANUS and of other "humists" and still less is it that accessory or superfluous element which LIEBIG conceived it to be.

To organic matter we attribute in agricultural economy a preponderant and absorbing function in the unfolding of that micro-organic activity which cannot be wholly suppressed and in the well ordered and useful action of the material substratum, where these exchanges of matter and energy take place whence the higher plant draws the very possibility of its existence — namely the soil.

Our conclusion then is that the manifold forms of life may be united under a single general conception of correlativity which corresponds to the real *functional correlation* (*symbiosis*), as it exists and, is every day more fully proved to exist, in Nature.

* * *

The tendency for two or more elementary organisms to unite to form higher grades of individuality is clearly manifest in ontogenesis as in phylogenesis : between these organisms there exist relations of descendance. But where such relations are non-existent, there arises this new fact which originally formed the subject of morphological investigation by De Bary and which is called *symbiosis*.

A new chapter of the biological sciences was thus begun, to which as time went on a development brilliant beyond expectation was assured by the progress of research : that, in general, of the relation between organisms which, governed by the need of food, lead to reciprocal exchanges of substance and therefore to more or less intimate relations, pacific or hostile.

The type of nutrition known as *saprophytic* will be dealt with here under *symbiotic nutrition*, which is interesting in itself apart from its characteristics, as it is a phenomenon of extraordinary importance in natural economy and, particularly, in the investigation of the soil.

A primary distinction which has been made as regards life in common is that of *mutualistic* life and *antagonistic* life, according as the exchange of matter takes place with reciprocal advantage, with one-sided advantage (commensalism), or with injury of one of the organisms.

Antagonistic symbiosis, which is *parasitism*, is here considered as throwing light upon the other form of symbiosis which is the true form and constitutes in nature the evolutionary fact while in soil science and agriculture it is a subject of study and a means of technical improvement.

Between antagonism and mutualism there is no precise boundary, and through all the transition states from the facultative to the obligatory, from variability to fixity, from one-sidedness that is of no consequence to that which is injurious, absolute reciprocity is ultimately attained, without excluding the phenomenon, perhaps more astonishing, of alternation between one and the other kinds of life.

It used to be thought that pathogenic power, within quantitative limits — varying between virulence on the one hand, and receptivity on the other — was a characteristic property of certain species, but this theory is not now generally held, while the view is gaining ground that certain species, essentially saprophytic, are forms capable of developing a pathogenic power.

Indeed, the power of adaptation among microbes is very great and if this is easily established in the case of the antiseptics, it is presumed that it can be verified also against the antibacterial actions of the humours and cells of the host organism. With the alternation of the conditions of occurrence of activity of one or other organism may come alternation of the two regimes of life with opposite characters ; and hence the mechanism of nutrition becomes extraordinarily instructive.

The contrasting play of actions and reactions between the two organisms only begins when the saprophyte becomes an *epiphyte*.

The phenomenon is also more interesting when the number of the individual epiphytes increases and they become *endophytes*.

Thus one passes to still more advanced stages of infection and to still closer relations of commensalistic and mutualistic symbiosis.

It is a very instructive fact that the attack of *Rhizoctonia* is essential for the germination of the greater number of the orchids, the influence even persisting on the later development causing more or less profound manifestations and morphological changes ; but the examples of relations between vegetable organisms of different nature, phanerogams and cryptogams, especially fungi, are varied and numerous, a striking example being that of the *mycorhizae*. The phenomenon of the mycorhizae constitutes in fact one of the many cases of struggle between a given organism and a parasite which invades its tissues. Phagocytes on the one hand and anti-bodies o the other, it may be supposed that they would enter into play in the mechanism of nutrition of a large number of plants which, whiln they hold the invader in check, avail themselves either of the materiae constituting its body or of its functional character. And this underl conditions of an unstable equilibrium, which, while normal and indefectible, is still the resultant of many conflicting forces, such as may on the one hand work for improvement but on the other have the power to bring about vital destruction.

* * *

But the physiological research on entomophytic fungi, begun about 1900, would lead, as regards the association of bacteria with the higher plants, to an order of ideas diametrically opposite to that held in relation to the micro-organisms when they invade the organs of a plant.

The notion of *pathogenic agent* has been contrasted with the clear demonstration of the distinct tendency which organisms have to utilise the useful physiological work of symbiotic micro-organisms. This fact is demonstrated by the forms of *Isaria* and *Botrytis* in the larvae of wood-eating insects (PORTIER), by bacteria localised in the blind diverticoli of the middle intestine of the larva of the olive fly (PETRI), by the photogenic bacteria contained in special organs of many luminous deep-sea fish or other forms of life. (PIERANTONI), etc.

The conception of *physiological micro-organism* is thus formed and enters also into the study of symbiosis in plants, marking the beginning of a series of very interesting enquiries.

The bond between bacteria and leguminous plants was carefully studied, but outside this case which was considered rather unique than rare, any schizomycete which might attack a higher plant was judged to be some kind of infective micro-organism or other. The researches of VON FABER on *Mycobacterium rubiacearum* in the genus *Pavetta*, of MIEHE on the bacteria *foliicola* and *repens* in *Ardisia crispa*, of GEORGEWITSCH on the leaf nodes of *Kraussia floribunda*, of CAUDA on *Bac. cruciferae* and finally the author's own researches on the root bacteria of *Diplotaxis erucoides* and of *Calendula officinalis*, all mark a highly important change in the direction of the enquiry into bacterial symbiosis in plants.

Investigators of the biological significance of the union of a bacterium with a plant limited themselves to determining if such union constituted, or not, the medium for the utilisation of the elemental atmospheric nitrogen. Does the bacterium fix the nitrogen or not ?; and the discussion ended there. This question is not, however, a main consideration, as we have maintained and now maintain that, in symbiosis, not merely a single function, such as that of assimilating nitrogen, but many functions may be performed by one of the partners. In the cases investigated it was possible to prove that there was secretion by the bacterium of proteolytic and amylolytic diastases, by which the circulation of nitrogenous substances and carbo-hydrates in the body of the plant may be greatly influenced.

It is, accordingly, undoubtedly desirable to take wider views in regard to bacterial symbiosis in the higher plants and this conviction has been confirmed by further researches, whereby it was possible to ascertain the presence of bacteria in the roots of a great number of phanerogams.

Bacteria have been found in Caryophyllaceae, Chenopodiaceae, Compositae, Cruciferae, Euphorbiaceae, Gramineae, Labiatae, Malvaceae, Papaveraceae, Poligonaceae and Solanaceae ; diffused in the thickness of the cortex, in some cases in the outermost zone of the bast, in the intercellular spaces and even in the interior of the cells ; this occurring in 75 % of the species examined and in such numbers as to exclude all possibility of accidental presence.

The presence of these bacteria may have been non-essential but in view of the physiological conditions of the subjects examined it was doubtless advantageous ; and in this sense we have described the fact as *normal.*

To this form of union between green plants and bacteria, newly discovered, we have given the name " *batterioriza* " (" bacteriorhiza ").

The infection — if it is permissible to call it so — is limited to a well defined zone of the root, namely the cortex and the outermost part of the bast, indicated as the *symbiotic region* or the zone of occurrence of these inter-relations of the common life of the different organisms : beyond that zone no more bacteria are traceable, and in the so-called *metasymbiotic* region is begun the biophysical and biochemical evolution of the useful and useless products of their cumulative metabolism.

That the forms giving rise to this " bacteriorhiza " should constitute a single fixed species, whether for a given family or a given group of plants, is inadmissible. It is probably a question of *physiological types.*

Some stocks, behaving functionally in a similar if not identical, way, differ by the intensity of the attack : it is a case, so to speak, of micro-organisms of the same functional type ; though it is not very easy to say whether the similarity is an original or an acquired characteristic.

In the case of other stocks which show more marked differences of functional activity it is doubtful whether they should be attributed to different species, which, happening to find themselves in identical conditions of life, have come to show the same activity in a greater or less degree.

In the first case we have phenomena of adaptation *in divergence,* in the other *in convergence* and, this, with varying degrees of divergence from a common stock of origin or of approach in similarity made by a number of originally differing types: in either case that equilibrium which is the condition of bacteriorhiza results from it.

The accompanying diagram will make this clear (Fig. 16).

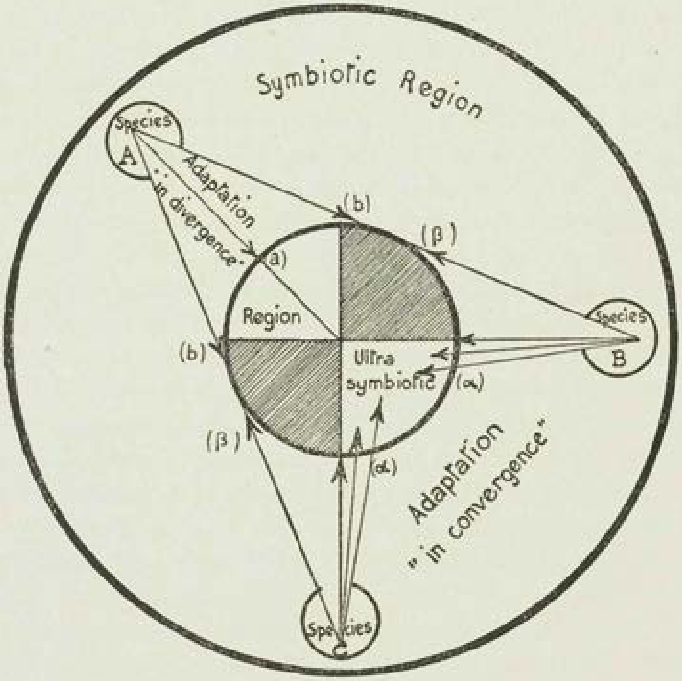

FIG. 16. — Diagram of the adaptation of forms in "bacteriorhiza".

The individuals of species *A*, in unfavourable struggle with the physiological activities of the plant, adapt themselves to a limited extent and in small numbers to the conditions of life of the symbiotic region into which they have penetrated; and while one part, indicated by the arrow *a*, enters into symbiosis, the greater part avoids adaptation exhibiting abnormal characters, as indicated by the arrows *b* forming tangents to the ultra-symbiotic region.

The individuals of the different species *B* and *C*, undergo this adaptation more easily, and even if to a certain extent they follow the part marked by the tangential arrow *B*, for the most part they come out victorious in the struggle with the plant which is their host, as indicated by the numerous arrows, drawn into the orbit of its functional activity, assuming morphological and physiological characters to a great extent similar and determining the bacteriorhizical equilibrium.

The sectors cross-hatched indicate the reunion and superposition of influences of the symbiotic individuals of all the species *A*, *B*, *C*... which re-inforce each other's value.

* * *

In typical mutualistic symbiosis alimentary exchanges take place directly between the organisms thus united ; but very similar relations may exist without any morphological bond, so that a greater or less reciprocal dependence may arise between two or more separate organisms. Hence the distinction between *conjunctive* and *disjunctive* symbiosis.

Disjunctive symbiosis has not yet been duly considered, except from a general and speculative stand point for some limited cases. It deserves, however, a much fuller investigation, since it does not fall within the scope of this article to consider the cultivated plant in itself, as did the " humists " and the " mineralists ", but in intimate connection with all the biological environmental factors influencing its growth, and in particular micro-organisms. Disjunctive symbiosis conduces to the formation of food material ; it induces changes in nutritive soil and in the surrounding medium ; it determines specific actions of certain products and of certain secretions. Thus unassimilable substances become assimilable ; and while toxic secretions or elaborations of certain substances determine the occupation of the soil as between competing forms, other products render possible catalytic or chemiotactic influences or exercise a stimulating effect on exchanges of matter in very many lower and higher forms of plants. Numerous observations have abundantly shown that in the environment surrounding the root are evident, more or less intensively, attractive and selective influences of micro-organisms, the micro-flora thus appearing more numerous and more active. This peculiar environment we indicate as " *rhizosphere* " On the other hand it is evident that throughout the whole depth of cultivable soil, not directly in contact with the root, in relation to the proportion and composition of humic matter certain remarkable and continuous relations of functional correlations are established in the micro-flora, such relations contributing more or less remotely to the metabolism of the higher plant.

There arise in such a way, between micro-organisms *combined effects* of great importance; effects simultaneous or successive, distinct or combined; with final results depending more often on multiple and variable conditions, always self-regulated. And, as in any specified organism, functioning occurs as the result of interaction of elements differing in form and function, so in the *great polymorph colony*, as which it is desirable to consider "*edaphon*", the great organic laws of the division of physiological labour and of correlativity are undoubtedly at work. The conception of agricultural soil, as a *living unity* which has been ours for a long time, has found confirmation in successive researches and still appears fully justified.

* * *

But the combined influences do not and could not stop at the dividing limit between the external medium and the internal medium of the plant, *i. e.* at the cell wall of the root hairs. They find their complement in the diosmotic exchanges which take place through the cell wall; so that with the continuity of the anatomical elements of the root and of the rhizosphere, corresponds a functional continuity which starting *from the disjunctive microbe, may be considered as developing up to the elementary green organ.*

We have been able to show how the green plant modifies variously and considerably the environment of the micro-organisms in humus, bringing about in them a selection, which is reflected directly in the principal microbic functions of the soil and, consequently, in the functioning power of the plant itself.

Plant and micro-organisms therefore tend alike towards that functional equilibrium which, while subordinate to necessary and sufficient condition of the nutritive phenomena, even *without conjunction*, seems characteristically a form of symbiosis — the first step, that is, of specific relations between superior and inferior organisms in the soil.

Such relations may exist for each group of allied plants, in a defined area of soil which we have called the "edaphosphere".

* * *

As the final, elementary limit of phenomena of correlativity and therefore of the scale of all the symbiotic relations is to be considered the *chloroplast* and it is with its functioning, directly bound up with the *edaphosphere*, that the circle of the general evolution of matter in Nature is closed.

If we indicate by the term " histophere ", the internal environment of the plant where conjunctive symbiosis can take place, we obtain the accompanying diagram (Fig. 17).

The " edaphosphere ", that is to say the nutritive sphere of the soil, which teems with micro-organic life at the expense of the humic and mineral substances contained in it, — the seat for that reason of incessant biochemical changes, by which matter is made soluble and *induced* —, is tributary to the " rhizosphere " that is to say to the sphere of soil adjacent to the roots of a plant with chlorophyll, where the micro-organic development, influenced by the osmotic exchanges depending on root absorption, is increased and made *selective*.

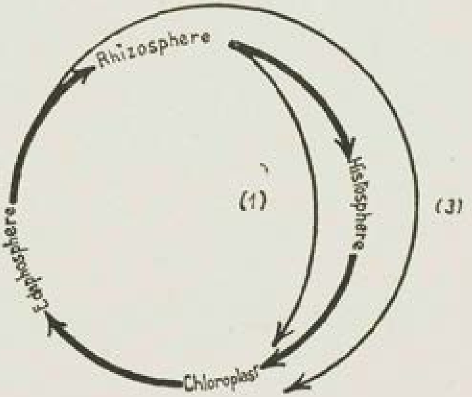

FIG. 17. — Simplified diagram of the relations between the micro-organisms and the given plant.

The " rhizosphere " in its turn is tributary to the " histosphere " that is to say to that area of the root tissues in which bacterial forms and fungoid forms assume close and direct relations of morphological and functional correlativity, so that such forms may be considered as having come to be part, in a special state of *equilibrium*, of one single organic entity, individualised in the harmonic complex of the absorbent, conducting, assimilating, and reserve systems of the plant.

Direct relations of the edaphosphere and of the rhizosphere with the chloroplast itself are not however to be excluded (indicated in the diagram by tracings 1 and 3), since they depend on two facts of capital importance :— *that the edaphosphere and the rhizosphere constitute the source, perhaps the most important source, of carbon dioxide for the plant and the histosphere is part of the organs of synthesis of the complex substances.*

There are *terrestrial plants* and *aërial plants* — aërial, in the sense that they have a crown of foliage and spread their branches on high, utilising the smallest quantities of carbon dioxide ; while the others, accustomed to higher tensions of this gas, remain low, creeping and with thick leaves and utilise directly the carbonic dioxide which is formed in the soil. The gas in fact circulates from the atmosphere to the soil and from the soil to the atmosphere, meeting, in both passages, defined organs of synthesis and of transformation which are in the histosphere.

It follows that it is indispensable to consider the necessity of encouraging such gaseous exchange which, in conjunction with the complex of the very important phenomena above described, neither humists nor mineralists took into consideration ; sometimes they had no suspicion of it, and at other times denied it in more or less good faith !

* * *

We may summarise, thus, in the accompanying diagram (Fig. 18).

The diagram shows primarily the edaphosphere, the general sphere of elaboration of the foods for the plant.

It includes immediately the rhizosphere, the particular sphere of elaboration of the actual foods, in which the processes become more active and selective.

We pass next into the internal environment of the plant distinguished in the histosphere and in the ultra-symbiotic region. The attack of the symbiotic bacterium is limited to the histosphere where it succeeds in finding its conditions of *equilibrium*. In it are realised three different degrees of conjunctive symbiosis :—

(1) *bacteriorhiza* (PEROTTI) ;
(2) *mycorrhiza* (TRANK) ;
(3) *Organorhiza* (tubercles, mycodomazi, bacteriodomazi).

In the meta-symbiotic zone the tissues of the plant are immune from the attack of any micro-organic form whatever and in them are elaborated the products of the separate activities, as conjunctive activities of the symbiotic organisms with the centre of gravity of the phenomena: the assimulating organ — the chloroplast.

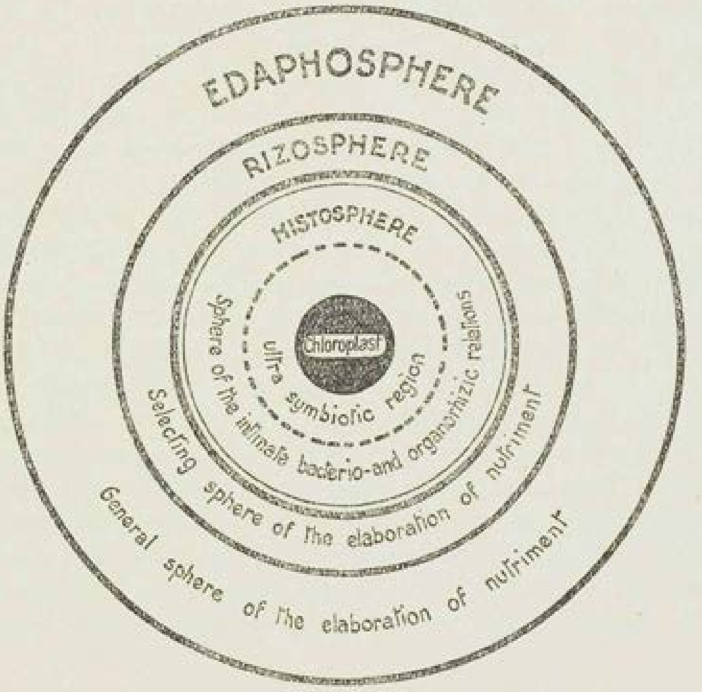

FIG. 18. — General diagram of the symbiotic relations in Nature with reference to the nutrition of plants.

Taking all these facts into consideration, the limits of the biological enquiry in soil science are easily perceived.

The organic world cannot be conceived as resulting from distinct, and perhaps not even from fixed units. Every phenomenon is the consequence of another vital phenomenon which has preceded it: thus a *form* finds its reason for existence in another form — apart from the question of *origins* which does not concern us here. The cultivable soil is thus considered as a living unity, with its skeleton, more or less broken down, and its morphological elements, more or less differentiated — the whole in the most harmonic complex that can be imagined.

No absolute and crude separation should be made, as is done in the technical operations depending on our theoretical speculations, between one element and another which in Nature exist in a fruitful correlation, nor is such separation intended here.

Therefore the biological study of the soil should pass on beyond the limits of the edaphosphere to the more intimate limits of the histosphere ; from the microbe scarcely influenced by the surplus products of the life of a determined species, to the microbe which has found its way into the convolutions of the structural joints of the green plant until that condition of equilibrium is reached which binds them more or less indissolubly together.

And thus the chloroplast is reached, the ultimate expression of the activities of synthesis which in conjunction with the opposing activities of analysis constitute the tangible aspect of that eternal interplay which is life, the succession of all lives. It was thus justly resolved to include in the general theory of *soil science*, the section of plant physiology. Human thought moves by induction and by deduction ; science progresses with analysis and with synthesis. Every time that in the history of physiology, as of science, one or the other of the methods is observed to prevail, the results prove fallacious. Progress is only there, where deduction is blended with induction and analysis harmonises with synthesis. Let us conform our enquiry to this criterium at the same time rendering homage to the supreme law of the indestructible harmony of Cosmos.

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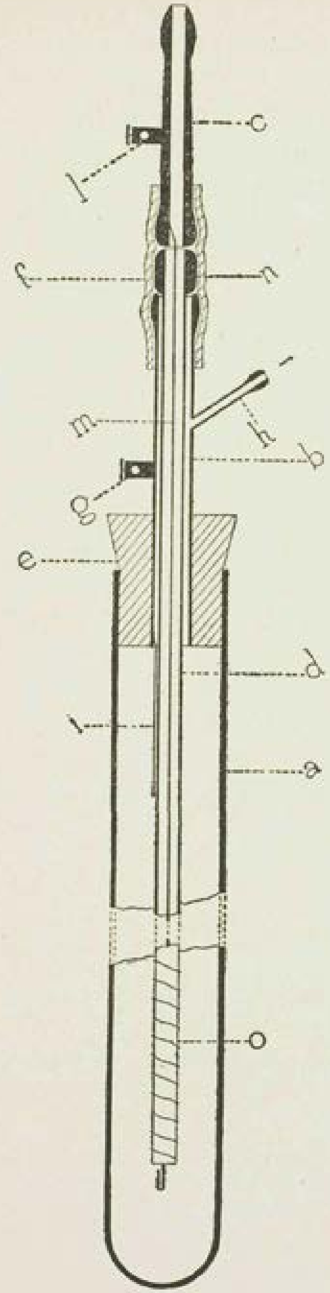

FIG. 19. — The CARRASCO-PLANCHER Apparatus for the elementary analysis of organic substances in the soil.

THE CARRASCO-PLANCHER APPARATUS IN SOIL ANALYSIS.

By PERICLE PARISI,

of the Laboratory of Agricultural Chemistry of the « Regio Istituto superiore agrario » of Milan, January 1926.

The CARRASCO-PLANCHER (1) apparatus for the elementary analysis of organic substances has proved of great service in this Laboratory of Agricultural Chemistry, where for some years it has been used for rapid determination of organic matter in the soil.

It would therefore seem not out of place to direct attention to its utility for chemico-pedological purposes and to give an account of certain modifications made in the apparatus, to render its construction and use easier and more certain.

The apparatus (Fig. 19) consists of a tube *a* of transparent quartz closed at one end, of an inside diameter of 25 mm. and a length of 240 mm. The tube is closed by a rubber stopper *e*, which is perforated by a metallic tube *b* of nickel, bearing on the one side a rheophore *g* and on the other a pipette *h* which conducts the combustion gases to the absorbing apparatus. Through this tubing passes a small quartz tube *d*, of an external diameter of 5 mm. and a length of 280 mm. The upper end of the quartz tube terminates in a bulb *n*, which isolates this metallic part from a second tubing *c*, also of nickel, furnished laterally with a rheophore *l* and internally soldered to a silver wire *m* of a diameter of 1.5 mm., which runs through the whole length of the lower metallic tubing and the small quartz tube. The two sets of tubing and the upper end of the small quartz tube are held together by a rubber tube *f*.

To the lower end of the silver wire is attached, by means of a platinum joint, a resistance coil *o* of platinum of a diameter of 0.35 mm., which is wound in a spiral on the outside of the small quartz tube until it reaches a second platinum wire *i*, soldered internally to the lower metallic tubing (2).

The analytical process for the determination of the organic matter in the soil is as follows :— Gm 0.5-5 of soil (to set free about gm. 0.2 of CO_2) are mixed in a mortar with gm. 1.5-15 of oxide of copper and with a little chromate of lead placed in the quartz tube.

If the soil contains carbonates it should be subjected to a preliminary treatment with warm dilute phosphoric acid, so as to drive off the carbon dioxide of the carbonates.

The stopper is fastened and the spiral is heated red-hot, then the CARRASCO-PLANCHER apparatus is connected with the absorbing apparatus; the current of oxygen is passed, heating at the same time the lower end of the quartz tube with a MECKER lamp.

Combustion is completed in about half an hour. A carbon content of 58 % is attributed to the organic matter in the soil (humus); multiplying the weight of the carbon anhydride by 0.273 we therefore get the organic carbon, and by 0.471 the organic matter in the soil.

NOTES.

(1) O. CARRASCO and G. PLANCHER. — On the new CARRASCO-PLANCHER method for determining the carbon and hydrogen in organic matter by means of electric incandescence. — *Gazzetta Chimica Italiana*, XXXVI, 1906, pp. 492-504.

(2) The apparatus is made by the firm ANGELO LIVRAGHI. Milan (28), Corso Como, 9.

Abstracts and Literature.

General.

Moor Science.

BÜLOW, K, v. *Moorkunde.* 142 pages. 20 illustrations. Sammlung Göschen, Vol· 916. Published by Walter de Gruyter and Co., Berlin and Leipzig, 1925.

The object of this manual is to state within definite limits and with reference to practical requirements the main principles of moor science so far as they can be said to be established. This is achieved in a commendable way, all purely theoretical or debateable subjects being omitted.

SCH.

Exact Soil Cultivation.

BURMESTER H. Die exakte Bodenwirtschaft.. A text-book for students and practical farmers. Published by Wilh. Gottl. Korn, Breslau.

The author has made soil cultivation the basis of a system of farming and explains in this book, basing his statements on his scientific experience of twenty years, the co-ordination of all the principles of " his exact soil cultivation ", and the interaction necessary to bring about those high crop yields required by the needs of the present day from the farmer and from the farmland. The marked successes achieved by the author in the capacity of agricultural consultant, together with the practical advice he gives for securing large crops with comparatively little application of labour or fertilisers and a minimum of seed, give this book great value as indicating new departures in agricultural science.

SCH.

The Methods of Geology as a Historical and Biological Science.

WALTHER, JOHANNES. Fasc. 185 of the " *Handbuch der biologischen Arbeitsmethoden* (E. ABDERHALDEN) " Part X, 5. 45 illustrations. 1 Table. Published by Urban and Schwarzemberg. Berlin-Vienna, 1928.

This well-known writer gives in this work a comprehensive review of the process of formation of the earth's crust, as revealed by the rocks and the fossils found in them, as well as by the earth forms, both tectonic and superficial.

SCH.

Problems of the Earth and their Solution by the Law of Transformation of Energy.

ZUNKER F. Published by the Journal " *Der Kulturtechniker* " 9 illustrations. 1925.

It is impossible to review, or to discuss critically in the short space available, this book, dealing as it does with the important problems of the origin of the earth, but very careful study may be recommended of a work which goes so deeply into these scientific questions. SCH.

Soil Physics.

Alkali Soil Investigations. Origin of Alkali Soils ; Physical Behaviour under Treatment.

JOFFE J. S. and MCLEAN H. C. *Soil Science*, vol. XVIII, no. 1, pp. 13-30, Baltimore, 1924.

With due regard to the views of other workers the authors discuss the problems and the treatment of alkaline soils. The effects of the treatment of alkaline soils with alum and with peat, and the results of the oxidising action of sulphur, are discussed, particularly with regard to the rise of capillary water in the soil. L. G.

Contribution to the Knowledge of the Physical Properties of Soils.

SOKOLOWSKI H. N. and LUKASCHEWITSCH E. S. (Communication from the Laboratory for Soil Science of the Moscow Agricultural Academy).

Uspechi Agronomii. — Progress of Agricultural Science (formerly *Izwestija Selsko-chosjaistwennoj Akademii* — Yearbook of the Moscow Agricultural Academy), Vol. I, pp. 47-58 ; 1925).

The purpose of the investigation was to find the influence of salts on certain properties of soils. The experiments of K. K. GEDROIZ (1) and A. N. SOKOLOWSKY (2) have clearly proved that in this case the effect is not due to the salts themselves, as was formerly supposed, but to the cations absorbed by the soils. Thus the phenomena which we are investigating are closely bound up with the absorbent powers of soils.

In our experiments, 50 gms. of tschernosem (from the Kharkov Experiment Station, upper layer, 0.20 cm.) was placed on a funnel and washed with one per cent. normal solutions of NaCl, $MgCl_2$, $FeCl_3$ and with 0.05 % normal solution of HCl (after GEDROIZ). This washing was continued until the filtrate no longer gave the Ca reaction, and in this way the soil samples were saturated with different cations. During the filtration of the $FeCl_3$ solution a change of colour from yellow to red-brown was noticeable.

The soil has thus a considerable (catalytic) accelerating effect on the reaction $FeCl_3 + 3\,H_2O \rightleftarrows Fe\,(OH_3) + 3HCl$, The excess of reagents was removed from the sample by washing, but in the case of samples treated with NaCl and NH_4Cl, as it was not thought possible to use dialysis, the excess of reagents was removed by washing on a parchment-paper filter under diminished pressure. But it proved impossible to remove the

(1) *Russian Journal of Experimental Agricultural Science* 1908-1923

(2) *Moscow Agricultural Accademy* 1919; *Intern. Mitt. f. Bod.* 1923; *Journal of Experimental Agricultural Science* 1921-1923.

last traces of NaCl as the filtration through the parchment-paper soon stopped. All samples were then dried (at 11° R).

The soil samples had the following appearance: those saturated with Na and NH_4 were hard, compact lumps, and the samples saturated with $CaCl_2$ and $MgCl_2$ solutions and particularly those samples treated with $FeCl_3$ and 0.5 normal HCl were loose and crumbled easily. At the same time and for comparative purposes a sample was prepared which had been washed with distilled water only and dried.

In the pressure-resistance experiments it was found very difficult to prepare test samples (test-cylinders) which would give, on crumbling, comparable numbers. At last, to ensure a uniformity of the test samples we used the following method: 10 gm. of soil, rubbed into a fine powder, were poured through a wide funnel into a glass-tube (6 cm. long and 2 cm. wide), particular care being taken that the upper surface should always be horizontal and the tube had been tapped with the finger. The soil samples thus prepared, were then saturated with water through capillary action and pushed out of the tube by means of a wooden piston. The soil cylinder was cut to about 3 cm. length, dried at 100° and crushed on Prof. Williams' apparatus. The following results were obtained:

Complete crushing of normal soil samples:

7,95 ; 8.85 ; 8.40 ; 8.85 kg. Mean 8.54 kg. Amplitude 15 %.

We also prepared test cylinders of soils, which had been saturated with different solutions by means of the above method, and also determined their resistance to pressure.

The capillary rise of water up to a height of 3 cm. took place in the different cylinders with different speeds.

	The Normal experiment with 0,99 % of displaceable $Ca^{\cdot\cdot}$	The absorption capacity is saturated with the following cations					
		$H^{\cdot}$	$Fe^{\cdot\cdot\cdot}$	$Ca^{\cdot\cdot}$ (1.1 repl.)	$Mg^{\cdot\cdot\cdot}$	$NH_4^{\cdot}$	$Na^{\cdot}$
Rate of rise of water	3.5 mins.	2 mins.	2 mins.	3.5 mins.	5.5 mins.	10 hrs.	After 2 days 1.2 cm.; After 1 month 3 cm.
Water-capacity (in weight per cent.).	44 %	43 %	41 %	43 %	42 %	43 %	—

As the soil samples saturated with $Na^{\cdot}$ behaved very peculiarly while saturating with water, the water becoming strongly coloured by dissolved humus, a different method had to be to devised for their preparation. A glass-tube was therefore filled with soil saturated partly with $Na^{\cdot}$ and partly also with tschernosem which had been kneaded with water (after ATTERBERG).

The soil cylinders prepared in this way were dried at the ordinary temperature in a vacuum desiccator over concentrated sulphuric acid, all changes which high temperatures produce in soil colloids being thus excluded. (The resistance to pressure of normal soil samples dried at 100°, was nearly half that of samples dried at ordinary temperature).

With the apparatus of Prof. WILLIAMS we obtained the following results as to the resistance under pressure of our different soil samples:

	Sample cylinders prepared by our method						Samples according to ATTERBERG	
	Unchanged samples	Samples saturated with cations of					Unchanged	Saturated with Na
		Ca	Mg	H	Fe	NH_4		
Appearance of cracks	8.85 kg	6.0	16.5	2.3	0.75	—		
	9.3 »	7.5	—	2.1	0.75	—		
Complete crushing . .	15.0 »	10.2	29.3	4.5	3.75	—	36	Not crushed even by a weight of 156 kg.
	16.5 »	11.7	30.5	4.8	3.3	70.5		

Taking the resistance to pressure of a normal sample of blackearth (*tschernosem*) as 100, we get for the soils saturated with different cations the following numbers:

Saturated with.	$Fe^{\cdots}$	$H^{\cdot}$	$Ca^{\cdot\cdot}$	$Mg^{\cdot}$	$NH_4^{\cdot}$	$Na^{\cdot}$
Resistance to pressure .	22	30	70	180	440	> 440

In the action of 0.05 n. HCl we are undoubtedly dealing with the influence of the $H^{\cdot}$ on the soil colloids as well as with the influence of the $Fe^{\cdots}$ extracted from the soil.

Only in this way can we explain the remarkable similarity of the results obtained in the case of soil samples treated with either 0.05 n. HCl or 1.0 n. $FeCl_3$ solutions. In both cases not only the $Fe^{\cdots}$ ion but also the iron oxide soil is active, and the coagulating action of the latter is not removed even on washing with soda.

We have also determined the plasticity and the capacity of our soil to be rolled out. The samples saturated with $Na^{\cdot}$ gave on rolling a thin, elastic ribbon which could be bent very easily, while the soils saturated with $Fe^{\cdots}$ gave, on the contrary, very fragile thick cylinders. The normal sample and those formed with soils saturated with $Ca^{\cdot\cdot}$, $Mg^{\cdot\cdot}$ and $NH_4^{\cdot}$ were average in this respect and no noticeable differences were remarked among them.

Similar results were obtained in the water-content determinations when the limit of rolling has been reached.

Soil sample saturated with	$Na^{\cdot}$	Normal sample	$NH_4^{\cdot}$	$Ca^{\cdot\cdot}$	$Mg^{\cdot\cdot}$	$Fe^{\cdot\cdot\cdot}$
Water content (Limit of rolling) .	21.9	25.1	27.1	27.8	28.3	28.8

Summary: —

(1) The absorbed cations have a different effect on the physical properties of the soils which absorb them.

(2) The resistance and plasticity of a soil are increased by replacing the absorbed $Ca^{\cdot\cdot}$ by $Na^{\cdot}$ somewhat less so, if replaced by $NH_4^{\cdot}$ But if the $Ca^{\cdot\cdot}$ ion is replaced by $Fe^{\cdot\cdot\cdot}$ these properties are not very strongly marked.

(3) The capillary properties of and the rise of capillary water in a soil are inversely proportional to its resistance to crushing.

AUTHORS.

The Mechanics of Earth Structure from a Soil-physical Basis.

TERZAGHI K. 399 pages, 65 illustrations. Published by Franz Deuticke, Leipzig and Vienna, 1925.

This work is of greater value to the soil scientist than the title would seem to indicate. It is based on A. ATTERBERG's researches into the physics of the soil, but it also contains the results of the author's own researches in the same subject, which undoubtedly constitute a contribution to science.

This applies particularly to the following chapters: Structure and pore volumes of soils; thermal properties of soils; consistency and coherence of soils; the frictional forces in the soil; the caking tendency in binding soils; the water content of air free clayey soils, as a function of the loading of the soil surface; the relation between loading and the pore index of sands when there is no possibility of lateral expansion; the adhesion of binding soils; the relations between the tenacity indices, the internal pressure and internal frictional resistance; the permeability of soils; the statical effects of running ground-water; the capillary rise of soil-waters; the evaporation of the soil-waters from the surfaces of clay layers; the thermodynamical equation to express the time course of hydrodynamic tension phenomena; approximations for the numerical treatment of tension balance in binding soils.

The last two chapters on "soil statics" and on "the soil as building land" are of special interest to engineers.

A brief mention only can be made here of this important work, which contains the tabulated results of numerous experiments. It should be in the hands of all soil scientists.

I. STINY.

Chemistry and Agricultural Chemistry of the Soil.

The Estimation of Nitrate Nitrogen in Rain-water, Drain-water and in the Soil.

HANSEN F. Om Bestemmelse af Nitratvälstof i Regnvand, Dränvand og Jord. (*Tidskrift for Planteavl*, Vol. 32, p. 69-119, 1926).

The author has investigated the different methods of nitrate nitrogen estimations and recommends the "Devarda" method, in the modified form, as devised by the chemical laboratory of the Rothamsted station. The Phenol-sulphonic method gave too uncertain results. No doubt, for rapid estimations, the phenol method is the best, but to get accurate results not more than 0.1 gm. of nitrate should be used, and the results obtained should be corrected by the formula

$$N = 1.06 \text{ N (found)} + 0.33.$$

The investigations show that the nitrate concentration of drain-water is largely influenced by the precipitations. The nitrate concentration falls very considerably after a heavy rain and rises to its normal value in dry weather, until fresh precipitation again disturbs the equilibrium.

This article is a communication from the Askov Experiment Station, where the laboratory analyses of soil samples prove that nitrification is more intensive on plots treated with stable manure than on those treated with artificial fertilisers. K. A. BONDORFF.

Comparative Experiments on Different Methods of Estimation of Phosphoric Acid in Soils.

HISSINK D. J. with collaboration of DEKKER M. (Vergelijkend onderzoek van eenige methoden ter bepaling van het gehalte aan phosphorzuur in de grond. Published by the *Landbouwkundige Onderzoekingen der Rijkslandbouwproefstations*, No. XXX, pp. 142-161, 1925.

Three typical soils were chosen (clay soils with different contents of humus) and their phosphoric acid content was determined by a large number of the usual methods. The following are the conclusions drawn from the results obtained.

(1) The separation of silicic acid has no influence on the results.

(2) In the case of not heating to a red heat, the fact of destruction or not of the dissolved organic matter present in the soil is of great importance in the determination.

(3) Heating of the soil to red heat gives in all cases and with all methods higher figures.

(4) In the case of soils not heated to a red heat where the organic matter has been destroyed, the nature and strength of the acid, the quantity of soil used and the length of boiling are of the greater importance the more humus the soil contains. The importance of these factors is slight in the case of soils heated to redness where the boiling has been continued for some time.

After a critical review of the data obtained the following two methods A and B were adopted.

A. *Determination of the phosphoric acid soluble in acid.*

12.5 gm. of air-dried soil were rubbed to a fine powder and heated to redness in a platinum dish over a small flame for 5 hours, stirring it from time to time. The soil was then transferred into a 250 cc. flask and shaken up with 150 cc. of HNO_3 (12.5 %) and then heated in a glycerine bath for 75 minutes to a temperature of 105° C, the flask being shaken from time to time. When shaking the flask the glycerine in the bath was diluted with a little water. After the heating is completed the flask was cooled and the 5 cc. of conc. H_2SO_4 were added and the flask rapidly cooled. The flask is filled with water up to the mark, stirred and filtered. 50 cc. of filtrate are next taken and the phosphoric acid is determined by LORENZ's method by adding 50 cc. of molybdenum-sulphate reagent, and, after allowing to stand over-night, filtered through a NEUHABER funnel. The residue is washed on the funnel with NH_4NO_3 and acetone and dried for half-an-hour in vacuo. The volume of the soil is taken into account.

B. *Determination of the phosphoric acid soluble in citric acid.*

55 gm. of soil, air-dried, finely powdered, but not heated to redness, are digested at room temperature in the course of 48 hours, with repeated shaking, with 500 cc. of a 2 % citric acid solution. In the case of soils containing $CaCO_3$ 500 cc. of a stronger citric acid solution were used. 200 cc. (in the case of soils with more than 5 % $CaCO_3$ only 100 cc. of soil were used) were then evaporated in a porcelain evaporating dish on a water-bath and to oxidise the citric acid 5 × 10 cc. of NHO_3 (sp. gr. 1.4) were added. To prevent splashing the water-bath should not boil too vigorously. The residue is dissolved in 10 ccs of 10 % HNO_3 and in some hot water and filtered while still warm into a beaker, and evaporated to about 15 cc. on a water-bath. 35 cc. of a H_2SO_4-HNO_3 mixture are added (LORENZ) and while the solution is boiling the P_2O_5 in it is precipitated by the addition of the molybdenum-sulphate reagent (LORENZ).

The relative solubility of the P_2O_5 is equal to B : A.

v. d. S.

Investigations on the Influence of Calcium Carbonate on the Reaction of a Soil.

JENSEN TOVBORG S. (Undersgelse over Kalciumkarbonats Reaktionsändrende Virkning i Jordbunden. *Tidskrift for Planteavls.* Vol. 31, No. 7, pp. 744-777, 1925).

The author set himself the problem to find whether it is possible to determine from the titration curve of a soil the quantity of lime to be added so as to bring its hydrogen ion concentration up to pH = 7.0. In this enquiry he relied to a great extent on his field experiments with graduated applications of lime which he had carried out over a number of years. The result of his laboratory experiments is briefly, that, to ascertain the quantities of lime required in actual field practice, the quantities calculated from the titration curve (titration with $CaCO_3$) must be multiplied by the factor 3. He also finds that sandy soils require larger quantities of lime than loamy soils, to obtain the same rise in pH, and that there is a rough relationship between the pH existing at the moment and the amount of lime required for reaching $pH = 7.0$. He emphasises also very strongly that it often happens that very different quantities of lime may be needed on soils with the same pH to bring about the same reaction change. Thus two sandy soils, both of $pH = 5.8$-6.0, required, one 3000 kg. of $CaCO_3$ per hectare, the other as much as 32,500 kg. per hectare to bring the pH up to 7.0. Details cannot be given here, but the attention of soil scientists generally is drawn to this memorandum and it may be confidently asserted that with this work of the State Plant Cultivation Laboratory a new epoch begins in the study of the liming question. K. A. BONDORFF.

Alkali Soil Investigations: Chemical Effects.

JOFFE, I. S. and McLEANS H. C. *Soil Science*, Vol. XVIII, No. 2, pp. 133-149. Baltimore, 1924.

The question is discussed how much sulphur has to be used to change the character of the alkaline soils, or to neutralise the soda which is either present or is being formed. The authors discuss also the question of the treatment of those soils with either alum alone or combined alum and sulphur. L. G.

On the Decomposing Action of Peat on Phosphorite.

PRIANISCHNIKOW D. (Moscow). *Fortschritte der Landwirtschaft*, I, No. 1, p. 1. Vienna 1926.

The author first draws attention to the researches of FLEISCHER, KISSLING, KNIERIEM and others which proved that high-moor peat possesses the property of decomposing phosphorites, and that the quantity of phosphoric acids dissolved is increased by an admixture of the neutral salts of strong acids. Ca salts however in comparison with the K, Na and NH_4 salts tend rather to reduce such quantity, although in the opinion of the author this is only the case when the non-saturation of the peat, expressed in Ca, has passed a certain limit. With these conclusions in view the author carried out a number of experiments, which proved, that the acidification produced by the addition of $CaSO_4$ is larger than on the addition of KCl, and that the highest acidification i. e. the largest increase in the water soluble P_2O_5 occurred in the mixtures peat + phosphorite + $CaSO_4$ ($pH = 4.0$ against peat $pH = 6.1$). If 100 gm. of peat contained 0.01 gm. of water-soluble P_2O_5, then in the mixture it rose to 0.326 gm. This was the maximum figure for all experiments. On being allowed to stand the phosphorite solubility sunk from 46.17 % at the beginning to 29.17 % after four months. In the meantime about 63 % of the P_2O_5 in the phosphorite have been decomposed, because the $CaHPO_4$ formed has no effect either on the acidification or the solubility of the P_2O_5. If the ratio of phosphorite to peat is very large, e. g. 1:100, the solubilities are even more favourable. Hence the question arises: could we not obtain the effects of superphosphate fertilisation if in its stead we supplied to the soil a mixture of 12 parts of 25 % ground phosphorite together with six parts of gypsum and 600 parts of ground peat? And in fact sand cultures of oats (according to HELLRIEGER) showed an exceptional utilisation of the phosphoric acid in the peat-phosphorite mixture. In the crops were found the following percentages of P_2O_5: without phosphorus: *0.10 %*; phosphorite alone: 0.14 %; peat alone: 0.21 %; peat and phosphorite: 1.21 %; complete nutritive solution of HELLRIEGEL, 0.51 %. H. FISCHER.

Some Properties of Soil Colloids.

SOKOLOVSKI A. N. *Izvestia Petroskoj Selskochosjajstv. Akademii* 1919, *I-IV*, 85-275. *Moscow.* (Annals of the Agricultural Acadèmy 1919 I-IV. Moscow).

The colloid part of the soil is its active fraction which determines the composition, physical and chemical properties and morphological character of the soil, that is, the nature of its profile.

Also the absorptive power is a function of the quantity of colloid clay and humus.

In connection with the conditions of soil formation the profiles of different soil types show quite characteristic curves of distribution of absorptive power, from top to bottom. The maximum of absorption in relation to ammonia is shown by black soil (tschernosem), with great decrease to N. and S. from the black soil belt.

The acidity of soils depends mostly upon a low degree of saturation of soil colloids with lime.

The amount of clay and of humus and also the structure of the soil, are in close connection with absorbed lime.

The possibility of the formation of black soils depends generally upon the content of lime in soil-forming deposits. In this relation an exceptional role belongs only to absorbed lime. The soil represents a system of unstable equilibrium between its colloids and absorbed lime. After removal of lime and washing with water striking changes take place: destruction of the crumb structure, swelling, reduction of its filtration-capacity, of consistence of the soil, and finally dissolution of soil colloids (black solutions from tschernosem).

These phenomena play a great part in nature to the North of the tschernosem belt, under the action of water, in combination with CO_2 and some other acids, as also in Southern (SE) countries, in the soils of which the losses of lime are due to replacement by soda.

Also, the content of absorbed lime is a regulating factor as regards the chemical as well as the physical properties of the soil.

The colloidal part of the soil is divided into two fractions: one, which is in continuous unstable equilibrium with absorbed lime and the other which is not connected in its properties with lime, but represents an insoluble combination of clay and humus; separation of that fraction from soil is possible only by boiling with water (very incomplete) or, better by oxidation by means of H_2O_2. Those fractions are termed : active and passive slime (clay + humus). The former, containing absorbed lime, is a factor in good structure. This active slime is relatively great in black soil and very small in podsol, in close relation with lime content and physical properties of those soils. It is an analogue of " matière noire " when in a more natural state without the changes necessarily effected by the action of strong chemical reagents. Its importance for soil fertility depends in the first instance upon its influence on the physical properties of soil.

These phenomena form a basis for elaboration of a method of mechanical analysis of soil for the determination of conditions of good structure in our soils. The enormous importance of absorbed lime compels us to study not only its proportion in different soil types but even more the degree of relative saturation of soil in regard to lime. The top layers of black soil are most saturated by lime ; lime is partially replaced by magnesium ; sodium and potassium are not present in the absorbed state. In soils of semi-desert regions and especially in alkali soils, the degree of saturation by lime is very small because lime is replaced to great extent by sodium and magnesium.

The coefficient by expression of degree of saturation is calculated in this manner : coefficient $= \frac{am}{ka}$ (*am* and *ka* are proportions in which NH_4 and Ca are absorbed by soil from equivalent solutions of their chloride expressed in m-mol. for 100 gm. of soil). Different soil types have their own individual curves of changes of this coefficient in their profiles. This fact is a useful indicator of origin of soils or geological deposits.

The strikingly low degree of saturation of South-Russian loess (in spite of high $CaCO_3$ content) and enormous absorptive capacity in relation to lime is of great importance when attempting to form hypotheses of the origin of those deposits.

The absorbed lime influences to a great extent the absorption of P_2O_5. The process of displacement of absorbed bases and that of passing into solution are in the opinion of the author which differs from that of M. PARVER, qualitatively quite different ; (by the action even of weak HCl solutions, Fe_2O_3 and P_2O_5 pass into solution). This may occur as a secondary phenomenon in the case of unsaturated soils. AUTHOR.

The Calcium Content of a Soil in Relation to its absolute Reaction.

SWANSON C. O., GRAINEY, P. L. and LATSHAW, W. L. *Soil Science*, Vol. XVII, no. 3, pp. 181-191. Baltimore, 1924.

The contribution deals firstly with the investigation of 293 soils of very different geological origins. The acidification of soils is primarily due to the removal of bases by washing-out in the process of weathering, the weathering process being hastened largely by the presence of organic substances in the soil. The soils were investigated in the following way : 25 gm. of soil were agitated in a shaking-machine, for several hours with

250 cc. of HCl in a 500 ccs. flask. The soil was then allowed to settle and, in three samples respectively: (1) the time was quantitatively determined, (2) the Hydrogen-ion concentration was measured, and (3) a nitrogen bacteria test was taken. The results show that there exists a relation between the calcium content and the pH index of soils of approximately the same physical character and of similar climate, and also, that in many cases the nitrogen-bacteria test reacts similarly. But the authors are of opinion, that in the case of unknown soils conclusions should not be drawn from results obtained from a single one of the three tests, and advise the carrying out of all three tests in all cases.

L. G.

Ground-water Movements and Stagnation Processes explained by Oxygen Analyses of the Ground-waters of North Swedish Moraines.

TAMM O. (Swedish, with a full German review) *Meddelanden fran Statens Skogsförsksöanstalt, 22,* p. 1. Stockholm, 1925.

The North Swedish soils are covered in their greater part by peat. As already shown by HESSELMAN, water which has trickled through a layer of peat is free from oxygen. On the other hand, the water of normal moraine soils is rich in oxygen. By means of a mercury pump and of a specially constructed boring apparatus, the author was able to obtain water samples from different depths of moraine soils. In the process of pumping these water samples lose only very small quantities of the dissolved gases and the oxygen present was determined by WINKLER's method. It has been found, that while there are peat soils with moraine ground-waters free from oxygen beneath the peat, on the other hand there are peat-soils with ground-waters rich in oxygen. It was found that the moraine ground-waters under the peat of the fringes of peaty soils were always rich in oxygen, while on the same spot the waters of the lower peat layers were completely free from oxygen. By means of a large number of oxygen determinations in water samples taken from the fringes of peaty soils and from different depths and soil profiles, it has been afterwards possible to tell more or less exactly whether the given sample of ground-water came from a spot covered by, or free from, peat. Thus the determination of the oxygen content of samples of ground-water furnishes a means of determining the movements of the ground-water and consequently the process of stagnation. The analyses carried out gave data as regards these phenomena.

O. TAMM.

Experimental Studies on Chemical Processes on the Formation of Glacial Clay.

TAMM O. *Experimental Studies on Chemical Processes in the Formation of Glacial Clay.* (English). *Sveriges geologiska Undersökning.* Arsbok, 18 (1924), No. 5, Stockholm, 1925.

The glacial clays have been formed through the grinding of rocks (in Sweden very often granites and gneisses) by the melting of interstitial ice, i. e. through wet grinding. The water formed by the melting ice must also contain dissolved carbon dioxide. The process is from a physico-chemical point of view very similar to the well known Daubrée experiment. Daubrée ground felspar in water, the liberated silicate being chemically decomposed to a large extent. The author carried out a number of experiments by rotating quartz flasks in a thermostat, the flasks containing a number of very small pieces of granite, pea-nut size or smaller, and also water, either free from or containing carbon dioxide. The granite was analysed very carefully. The rotation caused the pieces to rub against each other resulting in formation of clay. After 12 hours rotation the liquid was titrated and the dissolved bases estimated.

First were studied the general conditions of granite decomposition. As expected, the rate of decomposition was very nearly independent of the temperature, but depended to a large extent on the intensity of grinding and on the quantities of carbon dioxide ($= H^{\cdot}$ ion concentration present).

In two parallel experiments carried out on a larger scale, with and without carbon dioxide, the products, which were in one case clay and silt, and in the other dissolved salts, were investigated very carefully. The clays thus prepared are very similar to the natural glacial clays even as regards their chemical composition. The dissolved bases ($MgO + CaO + K_2O + Na_2O$) represented, in water containing carbon dioxide, 3.24 %, and, in water free from carbon dioxide, 1.17 % of the clay formed at the same time (<0.002 mm.).

The author was then able to calculate the content of the two clays in chemically dissociated minerals. He found: for the experiment with carbon dioxide 15,6 %, for the other 6,0 %. The analyses indicate a higher content in biotite in the clays artificially formed.

Some experiments with potassium felspar also indicated a large decomposition. This mineral must therefore also play an important part in the chemical processes taking place in the change of granite into glacial clay.

These experiments throw light, in some respects, on the chemical processes, taking place in the formation of glacial clay, and furnish a method which may enable us to clear up the processes of hydrolysis and decomposition of the silicate minerals. O. Tamm.

Biology of the Soil.

The Bacteriological Sulphur Oxidation in Pond Soils and its Practical Importance.

Fischer H. *Zentralblatt für Bakteriologie*, II, p. 35, 1925.

The formation of SO_4'' ions in pond waters and in pond soils appears to be of the greatest practical importance, as by their means we may be able to recover from the soils the insoluble phosphates lying there inactive. It has been found necessary in all pond manuring experiments to introduce PO_4 ions into the water and in most cases, this has been done by using either different sulphates or fertilisers physiologically acidified by means of SO_4, but it can be brought about just as well by natural bacterial sulphur oxidation. This sulphur oxidation is chiefly caused by autotrophic micro-organisms. Their action is facilitated by alkalinity of the soil and of the water, and inhibited by acidity of these media. The experiments were made with pure sulphur, sulphides, thiosulphates, sulphites and sulphuretted hydrogen. From all these sulphur compounds considerable amounts of sulphates were obtained by means of bacteria. But under certain circumstances, e. g. in sewage sludge, there takes place a reduction of sulphites and thiosulphates to sulphides. In the case of weighing experiments by passing through a current of air and sulphuretted hydrogen, with the calcareous soils only energetic oxidation took place and retention of sulphur as newly-formed sulphates. In the event of weak oxidation the sulphuretted hydrogen passed through the vessel with the soil and soil suspension and then passed through attached flasks containing a caustic soda solution. In all experiments, about 10 % of the sulphuretted hydrogen could not be recovered. This percentage must have been retained in the soil either biologically or by purely chemical action.

AUTHOR.

The Influence of Hydrogen-ion Concentration on Bacteriological Processes.

GERRETSEN F. C. Over den invloed van de waterstofionen concentratie op bacteriologische processen. Verslagen van *Landbouwkundige Onderzoekningen der Rijkslandbouwproefstations*. No. XXX, pp. 1-44, 1925.

In the determinations of the hydrogen-ion concentration in biological solutions one is restricted almost solely to the use of the colorimetric method.

The author describes an arrangement called by him a bicolorimeter by which the pH may be exactly determined without the use of a "buffer" solution even in small quantities (0.25 cc.) of solution whether coloured or turbid.

For less exact determinations an ordinary colorimeter was devised using a small basin, which contains the different indicators in the yellow (acid) form and in sufficient quantities.

The pH values obtained by this colorimetric method in the case of centrifuged aqueous soil suspensions were sufficiently in agreement with the values obtained by the electrometric method with the same suspensions to justify its use in practice for pH determinations. The pH values of soil extracts obtained by PARKER's method of filtration or percolation are unreliable. With regard to the influence of the hydrogen-ion concentration on the nitrite and nitrate bacteria, the author's experiments prove. that in culture solution the nitrite formation lies between pH 5.6 and 9.7 with an optimum between 7.8 and 8.2; the limits of nitration lie between pH 5.2 and 10.0 with an optimum between pH 8.3 and 9.2. However, the limits of nitration appear to be conditioned by the character and place of origin of the bacteria. It has been found in addition that the influence of the hydrogen-ion concentration on bacteriological processes depends to a large extent on the mode of preparation of the culture medium.

Experiments with soil suspensions and soils proved that in those media nitrification may bring about much lower pH values (as low as 3.5) than in pure cultures, and moreover that nitrification depends not so much on the number of bacteria, as on the original pH value and the extent of the buffer action of the soil.

In the author's opinion it is possible by means of nitrification experiments to conclude up to what point $(NH_4)_2SO_4$ may be added to a soil before it becomes acid.

In alkaline soils there may occur an accumulation of nitrite because of the slowness of nitrification. This accumulation of nitrite as well as the process of formation of the nitrite itself are influenced to a large extent by the water content of the soil.

In conclusion the author proves by means of experiments that in the process of nitrification both in the soil and in culture solutions an acid is formed which is capable of dissolving insoluble phosphate. Whether this dissolving does take place depends on the amount of acid, on the original pH value and the extent of buffer action of the soil. v. d. S.

Alkali Soil Investigations: Chemical and Biological Effects of Treatments.

JOFFE I. S. and MCLEAN, H. C. *Soil Science,* vol. XVIII, no. 3, pp. 237-251. Baltimore, 1924.

The authors describe, in respect of the soil solutions of variously treated alkali soils, the reaction, the content in plant nutritive material, and the bacterial numbers. The influence of each soil on plant growth is also indicated. L. G.

A Contribution to the Biology of the Thiosulphate Bacteria.

KLEIN G. and LIMBERGER, A. *Biochemische Zeitschrift,* Vol. 143, p. 473, 1923.

Bacteria can live aerobically on inorganic as well as organic nutrients. They are capable of oxidising all forms of sulphur, and potassium nitrate is reduced by their action to nitrite and ammonia. Ammonium chloride also yields nitrite. Sulphur was deposited as rhombic crystals.

H. FISCHER.

Investigations into the Importance of Tree Mycorrhizae.

MELIN E. An ecological-physiological Study. With 48 illustrations in the text. Published by G. Fischer. Jena, 1925.

Contents : The state of our knowledge about the root fungi of trees ; the root fungi in pure culture ; tree seedlings in pure culture ; tree seedlings and fungi in pure culture; conclusions as to the mycorrhizae of the conifers in nature; tables; literature. SCH.

The Relation between the Nitrogen-bacteria Test of a Soil and its Reaction Character.

PETERSEN ERIK, I. Undersgelse over Forholdet mellem Azotobacterproven og Jordens Reaktionstilstand. *Tidsskrift for Plantaeavl*, Vol. 31, pp. 246-336, 1925.

The nitrogen-bacteria test discovered by H. R. CHRISTENSEN was, as is well-known, of great importance in the investigation of Danish soils, the non-appearance of nitrogen bacteria indicating a lime shortage. The author has made a very thorough and exhaustive study of all the different factors conditioning the results of the test. He concludes that such results are influenced not only by the buffer action of a soil, but also by the nitrate content, the general microbiological structure and the quality of the inoculation material. The author lays special stress on the fact that it is impossible with ordinary inoculation to equalise the differences in the microbiological character of different soil samples, and he therefore suggests omitting the nitrogen bacteria test in future experiments and instead taking a titration curve of the soil and thence determining the lime requirements. The article is contributed from the State Plant Cultivation Laboratory. K. A. BONDORFF.

A Contribution to the Knowledge of Edaphic Mucorini in Jugo-Slavia.

PISPEK, A. (Prinos peznavanju edafskih mukorineja Jugoslavije). (Croatian with a review in French *Acta Botanica Instituti Botanici R. Universitatis Zagrebensis*. Vol. I. Zagreb, 1925.

Taking as basis HAGEM's and LENDNER's researches on mucorini the author investigated 270 soil samples from 200 different localities. He was enabled to isolate 40-50 different varieties. The soil samples were taken from the following different districts of Jugo-Slavia: Croatia, Slavonia, the Croatian Coast-land, Dalmatia, Herzegovina, Vojedovina Slovenia and Serbia. The soil mucorini varieties recognised by him with certainty were: *Mucor Mucedo, M. Ramannianus, M. flavus, M. racemosus, M. hiemalis, M. griseo-cyanus, M. sylvaticus, M. sphaerosporus, M. spinosus, M. circinelloides, M. Praini, M. stolonifer, M. Cambodja, M. arrhizus, Absidia cylindrospora, Ab. glauca, Ab. orchidis, Ab. Lichtheimi, Zygorhinchus Mölleri, Cunninghamella elegans.*

The author recognised many varieties of mucorini and considers that the occurrence of such a large number of varieties may be ascribed to the great heterogeneity of soil and climate in Jugo-Slavia. In the alpine districts, varieties are found which were isolated by LENDNER in Switzerland and particularly by HAGEM in Norway, e. g. *M. flavus, M. hiemalis, M. griseo-cyanus, M. stolonifer, Ab. cylindrospora, Ab. glauca* and *Ab. orchidis.* The other regions e. g. Karst, Pontic and Mediterranean regions are also distinguished by special varieties. In all these regions there are often found representatives of the species *Cunninghamella* (2-3 varieties), more seldom of the species *Ab. Lichtheimi*. However, these three regions not only differ in their varieties from the Alpine districts, but they even differ among themselves. Thus, e. g. *M. Mucedo, M. Ramannianus* and *M. arrhizus* have been found only in the Karst region, *M. Praini, M. Cambodja*, and several not yet recognised varieties of the species *Absidia, Cunninghamella* and *Zygorhinchus* in the Pontic region only, and two varieties of the species *Cunninghamella* only in the Mediterranean region. In addition, these three regions are each characterised by the occurrence in them of preponderating numbers of one or the other common variety, thus the Mediterranean region is characterised by *M. stolonifer*, the Pontic region by *M. circinelloides* and the Karst region by *Ab. cylindrospora.*

In general, the most widely distributed variety on Jugo-Slavian soil is *M. stolonifer* (about one-quarter of all samples) and the least frequent are *M. Mucedo, M. spinosus* and *M. arrhizus*. After *M. stolonifer* these follow in the order of the frequency of their occurrence: *Ab. cylindrospora*, then *M. circinelloides*, then *Cunninghamella elegans, M. glauca, M. hiemalis* and finally *Ab. orchidis* and *Zygorhinchus Mölleri*. The other varieties are very rare.

In a future scheme of further investigations Bosnia and Macedonia will be included.

A. SEIWERTH.

Regional Soil Science.

Precipitation, Drainage and Evaporation in the Region of the Sources of the Weser.

FISCHER K. *Jahrbuch für die Gewässerkunde Norddeutschlands.* Vol. V, No. 3. 4 illustrations, 5 tables. Published by E. S. Mittler and Son. Berlin 1925.

In this work the whole region of the sources of the Weser is dealt with in relation to rainfall, drainage and evaporation, excellent diagrams and maps being appended. Detailed studies of this kind are of the utmost value in connection with special work in geology or soil science.

SCH.

A Contribution to the Knowledge of the Properties and Degeneration of the Soils of the Brown-earth Type in Southern Sweden.

LUNDBLAD K. (Swedish, with a resumé in German). *Meddelanden fran Statens Skogsförsökanstalt.* 21, p. 1, 1924.

The brown earth type (following the nomenclature of RAMANN) is characteristic of the beech forest soils of Southern Sweden. Where conifer woods are grown on beech forest soils, podsolation or degeneration of the brown earth occurs, and at the same time productivity diminishes. The author carried out a series of comparative chemical analyses on normal brown earth profiles and on brown earth profiles somewhat degenerated by growth of conifer woods, and compared the results obtained with those of the same tests on true podsol profiles. In some cases mass analyses were made, in others the gel complexes of the soil were analysed by the TAMM method : extraction of the soil sample with a previously determined solution of a slightly acid mixture (pH = 3.25) of neutral and acid ammonium oxalate. By this method the gel complexes in sandy soils can be dissolved out and the solutions analysed for SiO_2, Al_2O_3 and Fe_2O_3.

While the podsol profiles indicate a quite definite maximum of gel complexes in the mother rock, the brown earth profiles usually show a uniform distribution of these in the upper soil layers down to a depth of 40 to 50 cm., when the content in gels begins to decrease. As soon as a slight degeneration could be detected, the analysis showed a gel complex distribution very nearly similar to that in genuine podsol profiles.

A live rock profile was also investigated for the gel complexes. It was proved that though the cementing was fairly hard there was no large content of gels. A number of other facts of interest, relating to the chemistry of soil formation in Sweden, are established by the author.

O. TAMM.

Certain Directions for the Drainage of North Swedish Peat Soils.

MALMSTRÖM C. *Skogliga rön.* No. 4, Stockholm, 1925.

From a peat sample newly taken from a moor there is very little, and in some cases no flow of water. The large quantities of water present in peat samples are thus present as hygroscopic moisture, and may so exist under three forms viz. either as capillary moisture or in a colloid-chemical form, or in a purely chemical form. Capillary water is only found in considerable quantities in the slightly humified peat varieties. The hygroscopic water of the strongly humified peat varieties is present in a chemical or colloid-chemical form, as can be readily shown.

The permeability of the different peat varieties to flowing water is very different. The author has carried out experiments to determine the relative permeabilities of the different peat varieties. It appears that the strongly humified peat varieties are absolutely impermeable, in their deeper layers, to flowing water, while the deeper layers of the weakly humified varieties are permeable to considerable quantities of water.

In view of these properties of the different peat varieties it may be *predicted on theoretical grounds* that, where strongly humified peat varieties exist, two ground water levels (groundwater free water) will be formed. One exists in the upper, loose, layers of the peat and very often evaporates in summer, the second layers exist in the sandy subsoil (e. g. moraines) layers of the peat. On account of the loss of water by evaporation during the dry season this ground-water level can be found somewhat below the peat. In the case of the weakly humified peat varieties however only one ground-water level is formed, but it will be in constant communication, through the whole peat mass, with the ground-water of the sub-soil.

The above theoretical conclusions were confirmed by field experiments, in the case of the different peat varieties. On the basis of many exhaustive researches into peat soils, which to a large extent have already been published (1), and taking into account previous experiments in the drainage of peat-soils, the author was able to give a number of theoretically and empirically established directions for the drainage of such soils. Many failures in the drainage of peat soils will it is hoped be prevented if when planning, care is taken to determine the structure and the permeability of the peat varieties, which can be easily effected by means of a quite simple field examination.

O. TAMM.

Researches on Soil Reaction and the Cartography of the Degree of Acidity, in the Fields of the Experimental Farm of the College of Agriculture and Sylviculture of Prague at Netluky Uhrineves.

NÈMEC A. and GRACANIN M. Studie o povaze a vȳznam reakce pūd a mapováui pozemkū dvora Netluky školniho závodu vysoké zemēdělsa kého a lesniho inzěnýrstir v Uhřiněvsi. Sborník Výzkumnyek ústavû zemždělských, Vol. VII. Edition. Ministry of Agriculture of the Czecho-Slovayekian Republic at Prague, 1925. (With a review in French and one map).

In the present paper, the writers have studied the nature of the soil reaction on the Netluky experimental farm near Uhřiněves in Bohemia, attached to the College of Agriculture and Sylviculture at Prague. The results of these researches have been expressed on a chart of the reaction of the soils investigated. The reaction, varies from pH=5.8-7.5 in soils under cultivation, specially adapted for the growth of the sugar beet and wheat, and between pH = 6.1-7.5 in the grasslands. On the farm investigated no soils were found of extreme acidity. From the results of chemical analyses it appears that there is no precise relation between the total lime content and the soil reaction; however, the most acid soils contain the lowest amount of lime. It is possible to observe the influence of the manures applied during recent years on the reaction of the soil: — lands manured by means of physiologically alkaline manures (carbonate of lime, nitrate of soda, basic slag and farmyard manure) show a tendency towards a more basic reaction than those on which physiologically acid manures (sulphate of ammonia, kainit) have been applied in a preponderant measure. It should be remarked that superphosphate adjusts itself in the soil like a physiologically neutral manure.

By comparing the yields of different crops with the reaction of the soil some interesting relations can be established.

The yields of sugar beet on acid soil are found to be very inferior. With decreasing acidity of the soil, the yields of beet increase; on the more alkaline soils, however, they again decrease. Yields of wheat vary inversely with the acidity of the soil. Barley generally obeys the same law.

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(1) C. MALMSTRÖM: Degere Stormyr. A botanical, hydrological developmental investigation into a North Swedish moor complex. Swedish and German. *Medd. fr. Statens Skogsförsöksanstalt*, XX, 1923, pp. 1-205. Stockholm, 1923.

Variation in the hydrogen ion concentration of the soil	Yield in quintals per *hectare*		
	Sugar beet	Wheat	Barley
6.0 — 6.90	234	16	—
6.55 — 6.80	280	19	23
6.65 — 6.70	310	—	26
6.35 — 7.20	340	—	21
5.90 — 7.30	280	21	26
6.75 — 6.90	300	24	22
6.40 — 7.30	315	21	21
6.90 — 7.30	280	—	23
7.15 — 7.30	300	22	26
7.10 — 7.40	245	25	—

Entirely different relations have been found for potatoes : the yields increase as the acidity of the soil increases : —

Variations in the hydrogen ion concentration of the soil	Yield in quintals per *hectare*		
	Potatoes	Oats	Rye
6.0 — 6.9	—	25	20
6.25 — 6.55	95	23	20
6.75 — 6.80	—	24	—
6.75 — 6.90	—	—	22
6.70 — 7.30	50	21	—
6.80 — 7.25	50	—	22
7.10 — 7.40	40	22	21
7.10 — 7.50	36	—	—

On strongly alkaline soils (pH 7.5) the yield of potato tubers was particularly small.

As regards oats, the highest yields were found on the most acid soils. Rye showed its capacity for giving good yields over the whole range of the soil reactions examined, the optimum yield however corresponds with the highest hydrogen ion concentration of the soil.

Investigation of the physical properties of the soils examined brought into prominence the relation of the degree of acidity or alkalinity of the soil with the absolute capacity for air, determined by Prof. KOPECKY'S method. The most acid soils showed the lowest value of absolute capacity for air, whilst the optimum corresponds with very slight acidity of the soil (pH = 6.8.)

Thence, the increasing alkalinity of the arable soil is in inverse function to the absolute capacity. for air : —

Reaction of the soil in pH	Absolute capacity for		Remarks
	moisture	air	
6.35	36.36	3.80	—
6.36	29.68	3.36	—
6.35	50.06	9.38	Grass land
6.40	49.34	10.41	Grass land
6.59	33.13	14.07	—
6.60	30.51	11.80	—
6.73	26.91	10.84	—
6.75	26.52	14.70	—
6.81	36.03	18.36	—
6.84	29.65	17.68	—
6.97	40.01	15.02	—
7.25	39.29	12.57	—
7.25	48.57	10.22	—
7.31	28.25	8.89	—

As regards porosity, the existence of similar, though less precise, relations between it and the hydrogen ion concentration of the soil can also be remarked.

The changes of physical properties and especially of the absolute capacity for air and porosity have a notable influence on the yields of agricultural crops.

The investigation of the relations of the soil reaction to the presence of weeds has shown interesting results. Weeds such as *Sonchus laevis, Veronica serpyllifolia, Sinapis arvensis* and *Raphanus Raphanistrum* are found on soils of acidity varying between pH 5.8-7.5. The presence of *Centaurea Cyanus, Dianthus Armeria* and *Achillea Millefolium* has been noted only on slightly acid soils (pH = 6.3).

On the other hand, weeds such as *Galium Aparine, Taraxacum officinale* and *Tussilago Farfara* have been met with only on neutral or alkaline soils.

The writers consider that the last two plants are indicators of neutral or alkaline reaction of the soil.

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General Notices.

E. Ramann †. On 19 January 1926 there died at Munich at the age of 75 the Nestor of Soil Science, E. RAMANN, a life of great usefulness being brought to an end by a sudden heart failure.

EMIL RAMANN was born on 30 April 1851 in Dorotheenthal near Erfurt, being the seventh child of his parents. His father was greatly interested in natural sciences and until the boy went to the Higher School his instruction was carried on by the parents, the mother being a Hamburg lady of great cultivation of mind. After the father's death, his unfinished work on butterflies was prepared for publication by the young RAMANN. He himself took up pharmacy and devoted himself to chemical studies in the Hamburg State Laboratory. Subsequently he studied chemistry and science at the University of Berlin; in 1881 he graduated at the University of Rostock, his dissertation being entitled: "Untersuchungen über die Passivität des Eisens", while in the previous year he had received his first appointment as assistant at the Eberswalde School of Forestry.

In 1880 he was given charge of the chemico-physical practical course. In 1885 he took rank as a lecturer, while in 1886 he became director of a

PLATE II.

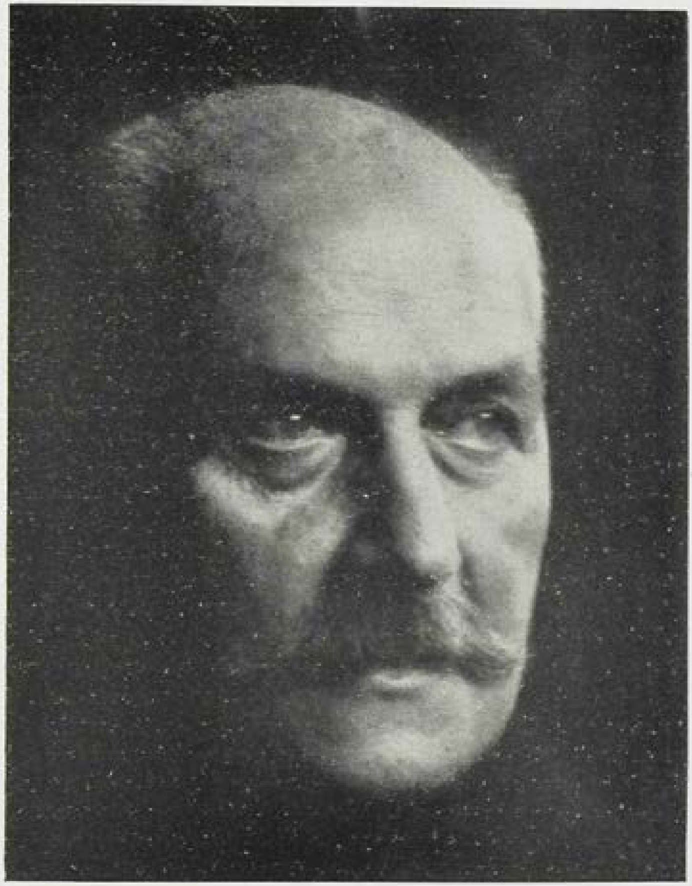

FIG. 20. — RAMANN †. Born 30 April 1851 at Dorotheental near Erfurt, died at Munich 19 January 1926.

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department of the Prussian Forestry Experiment Station and in 1890 professor.

In the year 1900 he was appointed at the University of Munich as the successor ot EBERMAYER in the chair of Soil Science and Agricultural Chemistry, which he filled up to 1 December 1925. He was at the same time Director of the Soil Science Institute of the Bavarian Forestry Experiment Station and was also honorary president of the Soil Science Research Institute which he had organised with funds raised in Germany and from other countries.

On the occasion of RAMANN's seventieth birthday a communication by E. A. MITSCHERLICH relating to his life and work appeared in this Review,.

A vivid recollection of RAMANN's impressive figure will be retained by many of those present at the last Soil Science Congresses. Widely known and honoured as pioneer in the domain of Soil Science, RAMANN took a keen interest in those institutes which came into being after the war, and their unqualified success afforded him special satisfaction in the last years of his life. He was fully convinced that in soil science the advance of scientific knowledge is only possible if there is close collaboration between all countries of the most various climatic and soil zones. It was partly due to RAMANN that after the war scientific intercourse was so speedily and generally renewed, both in correspondence and personally. This was especially noticeable in his championship of his Russian fellow congressionists.

The writer, who was one of RAMANN's students and an assistant of many years standing, feels that in responding to the invitation to contribute this account of him he should begin with RAMANN's life work for the development of general soil science, known as it was to all his fellow workers in the subject. The stages through which the science has passed and its present situation are fully expounded in the three editions of his basic work on soil science. Not so well known may be his essays which deal with his more restricted sphere of work as Professor of Forest Soil Science.

Mention should also be made ot the experimental work planned on far-sighted lines which RAMANN during the last years of his life was able to undertake at the Soil Science Research Station with a view to the elucidation of certain fundamental problems. He accomplished this work up to a certain point but was not able to see the publication of the results.

RAMANN's world wide reputation was made by his book on Soil Science, which first appeared in 1893 under the title of " Forstliche Bodenkunde und Standortslehre ". With the second edition in 1905 his interest had been transferred rather to the general sphere of Soil Science and he set before himself the aim of bringing together all that was previously known of the soil, and grouping the material along well defined lines.

Where he observed gaps, he made his own investigations and imparted a stimulus to others. Dr. J. HISSINK says of him : " RAMANN saw problems and knew how to attack them successfully ".

When to his sure scientific sense it was clear that gaps could not be filled from existing knowledge, he used to bridge the subject in a provisional way, thanks to remarkable synthetic powers. For this he could rely upon his experience of many years, work on the soil in its pristine condition and upon the lively intuition which he had acquired through his keen observation and acutely critical intelligence in the course of yearly journeys taken to all parts of the continent of Europe.

In this way from a number of single observations, even though gaps occurred, causal connections of the processes of soil-formation and transformation could be worked out, and by taking into account the results gained by other research workers it became possible to develop a consistent conception of natural processes in the soil and to state fundamental principles.

Hence a beginning was made of a systematic construction of the whole subject, and the recently developed branch, soil science, now became a science in itself, independent of geology and agricultural chemistry (E. A. Mitscherlich).

During the twenty years at the Academy of Forestry, Ramann made the study of the soil in its pristine condition the main point of his experimental work. As is well known, in civilised countries such soil is practically only to be found in forests.

At the University of Munich he devoted himself, so far as opportunity allowed, to the work of applying the advances in general scientific knowledge, especially in physical and colloid chemistry, to the problems of soil science. This new direction of his studies is very clearly reflected in the third edition of his Soil Science, published in 1911, though much that appears there had to remain in the form of provisional statements, and soon became out of date owing to the rapid progress made by science in general.

Although for a long time this third edition was out of print, and after the war was reprinted only in unrevised form, Ramann could not decide to bring out the new work, which was generally looked for, without first making a comprehensive study of the present situation of the general theory of soil science. Unfortunately, fate did not allow him the opportunity of carrying out this project. In the first place, the isolation of the scientist, during and after the war, had prevented all study of foreign scientific works, and when the literature of the subject was again available as a whole, Ramann's interest and energy were fully occupied by the Soil Science Research Station which he had founded in 1919.

He was very anxious to be relieved of his work of teaching, but this could only be arranged on condition that he relinquished all part in the direction of the Institute. His sudden death, a few months after his resignation of his professorship, is the more regrettable on account of the non-completion of his book, Ramann having been a master of the general theory of Soil Science with all its border territories, whereas his younger colleagues are more or less compelled to specialise.

The articles contributed by Ramann on the various branches of soil science, and forest chemistry are about one hundred in number, published in various reviews. The following is an account of some of the most important of these.

He began with researches on the circulation of mineral substances of the forest trees indigenous to Germany. By means of numerous ash-analyses further light was gained as to the extent of the utilisation, by the different types of timber, of the nutritive material in the soil, and at the same time important knowledge was acquired as to the withdrawal of these substances from the forest, as the result of timber and firewood requirements and removal of litter. These studies are to be found throughout the *Zeitschrift für Forst- und Jagdwesen*. In the *Jahrbücher der Preussischen geolog. Landesanstalt* for 1884 and 1885 there are inserted articles on weathering of diluvial sands and on the formation of mother rock.

Next follow investigations of soil in the pristine state, as for example, into the circulation of water in different forest soils.

In 1887 RAMANN wrote the section 'Forstliche Standortslehre' in LOREY's handbook on the science of forestry.

He then made a detailed study of the cover or litter transformation and humus formation in the forest, in particular the question of raw humus; the work of RAMANN, taken in conjunction with that of others, P. E. MÜLLER, etc., effecting a radical change in the views originally prevailing in Germany on these subjects. RAMANN also gave attention in this connection to the subject of moor formation.

RAMANN was among the first to examine thoroughly the reciprocal action between the soil and the natural plant cover.

In 1901 he brought out a treatise on European soil zones. Then followed proposals for classification and nomenclature of the humus materials and further essays on moors and slime deposits.

In 1910 his first essay on colloid chemistry was published, and in 1911 an investigation of the life history of the small animals in the German forest soils.

Some years before a new cycle of work was instituted by RAMANN and his school relating to the absorption of the mineral substances from the soil by forest plants, special attention being paid to the annual intake of nutritive material and to the consequent "body building" as well as to the restoration of this nutritive material to the soil by the autumnal fall of leaves. This was followed by chemical investigations for the study of soil solution.

In 1918 a small volume appeared: "Bodenbildung und Bodeneinteilung" (soil classification), a short treatise on climatic types of soils from the standpoint of economic geography and the history of civilisation.

During his last years of life, articles appeared on the importance of carbon dioxide and hydrolysis in weathering, on the buffer action of bicarbonates in the soil, and a longer discussion on "Umsetzungen in heterogenen Systemen" (Influencie of Solubility) as well as essays on the importance of lime in the soil and several articles on questions of acidity.

In the article on the buffer action of the bicarbonates RAMANN emphasises very strongly, on the basis of some unpublished results of experimental work and their physico-chemical value, the conception of the harmful weathering or disaggregation' (*die schädliche Verwitterung*) which is caused by *pure* solutions of carbon dioxide. This *schädliche Verwitterung* is counteracted by the bi-carbonates. The recognition of this fact throws light on the important part played by calcium carbonate in the soil.

Among the work published in part only are RAMANN's articles representing several years' work on permutite, an artificial water-containing clay silicate, which, as a 'model' substance to some extent chemically defined, was used, instead of natural clays, by various investigators for quantitative examinations into soil chemical transformations. In close connection with some published work on exchange of bases, there are in existence some still unpublished experimental researches into permutite debasification (removal of the bases in permutite) as the result of the action of carbon dioxide, and on the relation of this process to the various forms of acidity. (E. RAMANN and H. JUNG).

A comprehensive work on the dispersoid physical and chemical conditions of the exchange of bases in permutite (E. RAMANN and J. DANZL) is also unpublished.

Collected articles by RAMANN on quartz suspensions will appear in the *Kolloidchemische Beihefte* for 1926. They cover more than ten years of separate research on chemically cleaned quartz powders of known granular composition and surface development. These cleaned and sedimented quartz particles have proved an experiment medium, sufficiently indifferent chemically and physically as a dispersoid, valuable both for the study of electric charge and discharge phenomena (by electrolysis, in particular below the threshold value of flocculation) as well as for adsorption investigations. By the introduction of these quartz powders, RAMANN made possible exact colloidal chemical researches into natural soil processes, reduced to the most simple case, and under forms admitting of calculation and of microscopic observation.

RAMANN laid great store by these studies on quartz suspensions and it was a very real satisfaction to him that he was able in the last few months of his life, thanks to the devoted work of his colleague, H. SALLINGER, to see the experiments completed and the work at least to some extent collated.

Although the non-completion of the fourth edition of the Bodenkunde is greatly to be regretted, full concurrence may be expressed with what was said of RAMANN by the representative of the University of Munich at the cremation:

" He attained all the objects which he placed before himself in his profession ".

As marks of professional recognition may be mentioned his appointment as member of the

Russian Academy of Sciences,
L'Académie d'Agriculture de Suède,
Scientific Forestry Societies of Finland,
Hungarian Academy of Sciences

and as

Honorary President of the International Soil Science Congress 1922 and 1924.

The Higher School of Forestry where he passed the first part of his scientific career appointed him in 1923 to a honorary doctorate in Forestry —

" as founder and first teacher of modern soil science and establisher of the scientific regional study of forestry " (*Standortslehre*).

G. KRAUSS,
Tharandt—Dresden.

The International Society of Soil Science. — *Session of the General Committee of the International Society of Soil Science.* Groningen, 10 a. m. 7 April 1926. Commissiezaal, Harmonie.

Present :

Prof. Dr. K. GLINKA, Honorary member.
Dr. Jacob LIPMAN, President.
Dr. D. J. HISSINK, Acting President and General Secretary.
Prof. Dr. F. SCHUCHT, Editor of the Review.
Dr. NOVÁK, Chairman of the First Commission.
Prof. Dr. Alexius A. J. VON' SIGMOND, Chairman of the Second Commission.
Prof. Dr. Eilh. Alfr. MITSCHERLICH, Chairman of the Fourth Commission.
Dr. H. R. CHRISTENSEN, Representative of Denmark.
Dr. Sl. MIKLASZEWSKI, Representative of Poland.
H. J. PAGE, Representative of England.
Prof. J. HENDRICK, Representative of Scotland.
Dr. B. A. KEEN, Representative of the British Colonies.
Dr. K. ZYLSTRA, Auditor

and as guest : Prof. Dr. N. M. COMBER from Leeds.

Prof. Dr. O. LEMMERMANN (Germany) and J. J. GIRSBERGER (Switzerland) were unable to attend. Dr. BORGHESANI, librarian, arrived the following day.

ORGANISATION OF THE SOCIETY.

Statement of Accounts.

		Fl.
Received up till 1 January 1926 :		
363 Foundation members (1924)		1897.77
283 entrance fees 1925	fl. 714.33	
589 members subscriptions' 1925	» 3825.04	
		4539.37
Contribution of the Czechoslovakian Government		72.75
Received for the Reports of the Fourth Conference (Rome 1924)		209.20
		6719.09
Outstanding for 1925 :		
24 entrance fees at fl. 2.50 =	fl. 60.00	
77 yearly subscriptions (part payments)	» 477.53	
		537.53
		7256.62

Expenses up to 1 January 1926:

Expenses of the International Committee of Soil Science from April 1922-May 1924 (Prague, Zurich, Rome)	325.00	
Commission Frosterus-Wiegner-Gessner	25.49	
		350.49

Expenses Groningen 1924:

Printing	fl. 53.50		
Correspondence	» 66.65		
Secretarial expenses	» 120.00		
Cost of translations	» 80.00		
		fl. 320.25	
International Reports on Pedology		» 713.18	
			1033.43

Expenses Groningen 1925:

Printing, paper, etc	fl. 128.74	
Archives etc	» 215.00	
Correspondence	» 205.35	
Secretarial expenses	» 384.50	
Cost of translations	» 138.00	
Contribution journey Berlin	» 42.50	
		1114.09
Editorial Office Berlin		474.26
Commission Wolff, Mitscherlich, Novak, von 'Sigmond		244.41
Contributions sent to Rome for the reports of the Fourth Conference (Rome 1924)		222.61
International Institute of Agriculture 691 Members' subscriptions fl. 2.00	fl. 1382.00	
Reprints, Statutes, Circulars, etc.	» 116.00	
		1498.00
		4937.29
Due Commission Stoklasa and Girsberger		100.00
		5037.29

Balance to 1 January 1926	fl. 6719.09
	» 5037.29
	» 1681.80
Outstanding Debts 1925	» 537.63
	» 2219.33

The auditor, Dr. Zylstra, passed the accounts as in good order with full discharge of the General Secretary.

The General Secretary made the following statement of the expenses per member:

1. Charges for collection of subscriptions		0.50
2. Review expenses		
(*a*) Institute Rome	fl. 2.00	
(*b*) Editorial Office Berlin	» 1.00	3.00
3. Expenses in connection with secretaryship, Groningen .		2.00
4. Expenses in connection with Commissions		0.50
5. Not recoverable etc		0.50
yearly contribution per member		6.50

The General Secretary stated that collection of subscriptions, registration of new members and changes of addresses entailed too much work. It was decided decided to form in the separate countries national sections, which will be responsible for this part of the work. For the following countries the following addresses can be given:

Germany: Prof. Dr. SCHUCHT. Güntzelstrasse 59. *Berlin-Wilmersdof.*
Denmark: Dr. H. R. CRISTENSEN. Planteavls-Laboratorium. *Lyngby.*
Spain: Sr. D. Emilio H. DEL VILLAR, Lista 62, 3º der. *Madrid.*
United States of America: Prof. Dr. Jacob LIPMAN, Experiment Station. *New-Brunswick,* New-Jersey.
England and Dominions: Dr. B. A. KEEN, Rothamsted Experimental Station. *Harpenden,* Herts.
Hungary: Prof. Dr. A. von 'SIGMOND, Technische Hochschule. *Budapest I,* Szent-Gellerter 4.
Italy: Dr. G. A. R. BORGHESANI, International Institute of Agriculture. Villa Umberto I. *Rome* (10).
Norway: Doc. Johs. LINDEMAN. Landwirtschaftliche Hochschule. *As.*
Dutch-Indies: Dr. BERNARD. Algemeen Proefstation voor Thee. *Buitenzorg.* Java.
Poland: Dr. Slaw. MIKLASZEWSKI. Rue Szopena 6. *Warsaw.*
Russia: Prof. A. A. JARILOFF, Wosdwyenka, 5 Gosplan. *Moscow.*
Czechoslovakia: Dr. V. NOVÁK, Chef de l'Institut Pédologique, Kvetna 19. *Brno.*

Letters received:	1924 — 233
	1925 — 1006
Letters sent:	1924 — 258
	1925 — 533

The General Secretary proposes that the costs of sending out Part A of the Proceedings of the Second Commission (amounting to fl. 258.88) shall be paid by the International Society of Soil Science. Approved.

A telegram from the International Institute of Agriculture in Rome was received, requesting that a representative be appointed to attend the General Assembly of the Institute, to be held from 19-26 April in Rome. Dr. LIPMAN was chosen.

Review. The editor, Prof. Dr. F. Schucht, stated that up to the present he had not been able to give collective reviews of the soil science publications in the separate countries. The reviews have, for the time being, been grouped under the headings of physics, chemistry, etc. The editor added that the numbers have been late in appearance while comments have been made as to the technical and linguistic mistakes occurring in the translations. After a long discussion, the President of the Society is commissioned to talk over the matter with the President of the International Institute of Agriculture in Rome. The following resolutions as regarding the Review are passed :

1. To express our thanks to the President of the International Institute of Agriculture in Rome for having the Review printed and published on such advantageous terms for the Society.

2. To ask that the revision and translations of the Review be executed with the utmost care.

The technical revision of the translations of the original texts can only be satisfactorily undertaken by soil scientists of the country, where the language of the translation is spoken.

It is advisable that the first proof in each language be sent to a soil scientist, who would act as sub-editor. This latter should be chosen in consultation with Prof. Schucht, for France, England and Spain. For the Italian and German texts Dr. Borghesani and Prof. Schucht will take the responsibility.

3. The Committee learns with pleasure that the Review will appear more regularly in the future.

At the end of the discussions a vote of thanks was tendered to the editor of the Review.

The First Congress of Soil Science, U. S. A. 1927.

The President, Dr. Lipman, made the following statement :

(1) Several societies in America have offered their moral support to the Congress.

(2) The President of the United States, Calvin Coolidge, will send a message to Congress giving his consent to the invitation of the delegates of the different countries.

(3) Accordingly, the American Organising Committee will recommend to the Governments to appoint as delegates certain soil scientists, and to nominate the members of the Executive Committee and of the General Committee, as well as the members of the Committees of the different international Commissions.

(4) An endeavour is being made to collect 60.000 dollars, to be employed as follows :

(*a*) $5000 for the Secretariat ;

(*b*) $5000 for the Congress proceedings ;

(*c*) $5000 for the Exhibition ;

(*d*) $45.000 for the expenses of 150 official members taking part in the excursions to be arranged after the Congress ($300 per person).

(5) An endeavour is being made to obtain hotel accommodation in Washington at reduced tariffs.

(6) Committees have been formed in the various States to collect funds for the Congress.

The President, Dr. Lipman, gave the following outline of the prolonged excursion to be arranged after the Congress:

It is intended to make an excursion from Washington to California, which will last about 4 weeks and which will be cost free for those members who are not resident in the United States of America.

The minimum cost of the Congress will be about :

Europe-NewYork and back	$250.00
New York-Washington and back	$ 20.00
Hotel expenses Washington	$ 40.00
Extra expenses	$ 90.00
	$400.00

It seems advisable to publish this estimate of the cost as soon as possible and to mention it in the letters of invitation.

It should be noted that the excursion is only gratis for those members who are soil scientists, and not for ordinary members of the Congress. The American Organising Committee will discuss this point with the General-Secretary.

Members of the International Society of Soil Science will not pay any extra contribution to the Congress.

Date of the Congress. The A. O. C. (American Organising Committee) intends to hold the Congress in Washington in June 1927. Some countries proposed September, others June. Dr. Lipman will inform the A. O. C.

Programme of the Congress.

It was decided to recommend to the A. O. C. the following arrangements :

(*a*) Three days for the meetings of the Commissions ;
(*b*) Two days for the Plenary meetings ;
(*c*) One day for the final session (passing of the resolutions) ;
(*d*) One day of rest.
(*e*) One day for short excursions.
(*f*) One day for the Exhibition ;
(*g*) If possible one day for the discussion of the Russian reports.

Programme of the Commissions.

First Commission. The Novák Commission proposes to meet in 1926 in order to draw up the programme.

Second Commission. (von 'Sigmond Commission). The programme of this Commission will appear in part B of the Groningen Proceedings.

Third Commission. The Stoklasa Commission intends to meet in Berlin in June 1926.

Dr. Waksman has drawn up a provisional programme of the questions to be discussed by this Commission : 1. Direct methods of microbiological examination of the soil. 2. Cultural methods of the microbiological examination of the soil. 3. Soil population. 4. Fixation of nitrogen in the soil. 5. Transformation of nitrogen in the soil. 6. Transformation of the organic substance in the soil. 7. Transformation of the mineral elements in the soil. 8. Soil Biology, seen from an agronomic standpoint.

Fourth Commission. The President of the Fourth Commission, Prof. MITSCHERLICH, and the Vice-President, Dr. ZYLSTRA suggest the following programme:

1. Determination of the materials of plant nutrition in the soil.(physiological methods).
2. Influence of the reaction of the soil on plant yields.
3. Plant stimulants and plant poisons in the soil.

Fifth Commission. The provisional programme of subjects for discussion is given in an appendix (see below).

Sixth Commission. No announcement is yet made as regards the Girsberger Commission.

Finally, the programme of the Bureau of the delegates of the Russian soil scientists was announced by Prof. GLINKA, who asked that one day of the Congress might be devoted to the discussion of the following programme:

1. Historical summary of the development of soil science in Russia; 2. Soil morphology; 3. Classification and scientific grouping of the soils; 4. Physical and chemical properties of soils; 5. Humus of the soils; 6. Soil Mapping; 7. The dynamics of soils; 8. The genesis of soils; 9. The post-tertiary deposits and soils; 10. Application of soil science to agronomy, to land surveys, to division into soil regions, to land settlement and improvement.

Further, that an exhibition should be organised as follows to show the soil types of the U. S. S. R.

1. Monolytes of the principal types and varieties of the U.S.S.R. in several zones; 2. Collected samples of the soil profiles; 3. Collection of the morphological characteristics of the soils; 4. Soil maps and plans of different regions in Russia; 5. Literature; 6. Drawings and sketches of apparatus invented by Russian soil scientists.

Finally it was unanimously decided to propose to the Congress in Washington that the second Congress should be held in Russia. If it proves impossible for the Congress to be held in the latter country, the votes of the General Committee will decide between Germany and Poland.

Dr. D. J. HISSINK,
General Secretary.

Appendix. Provisional programme of the Fifth Commission for classification, nomenclature and mapping of soils, by Prof. MARBUT, Washington.

I. *Classification of soils.*

1. The extent to which the geology of the archaic rocks is to be used as a basis for the division of the soils into units or groups of units. 2. The extent to

which the climate of a region and its natural vegetation can be used as a basis for the division of soils into units or groups of units. 3. The extent to which the situation or other geographical circumstances form a basis for the division of the soils into units or groups of units. 4. What significance should be attached respectively to field observations and laboratory characteristics of soils in the statement and definition of the different categories in a comprehensive scheme of soil classification. 5. The extent to which the quantity and nature of the organic soil substance can be used as a basis for the division of soils into units or groups of units. 6. Should the different categories in a scheme of soil classification be founded on soil characteristics or on the forces and conditions under which the soils are formed? 7. General review of the soil in the narrower sense (*solum*) and its profile forming parts. Discussion of the term "soil", changes in its appearance, according to the development of the profiles. Description of different profiles in the soils of the world, relative importance of the appearance, conclusions from the various descriptions of sections and maps exhibited. 8. Submission of proposed schemes of soil classification on the basis of the appearance of soil profiles. 9. Conclusions and Recommendations.

II. *Soil Nomenclature.*

1. Soil nomenclature in the United States of America. 2. Soil nomenclature in Canada. 3. Soil nomenclature in Mexico. 4. Soil nomenclature in the South American countries. 5. The extent to which the present soil nomenclature can be used in designating the different categories in a comprehensive scheme of soil nomenclature. 6. The extent to which a uniform international soil nomenclature is possible. 7. Statement and discussion of proposed systems of soil nomenclature by members of the Commissions. 8. Soil colours and their nomenclature.

III. *Soil Mapping.*

1. Proposal of a uniform colour scheme for the soil survey maps of all countries. 2. Discussion and final establishment of those geographical and general soil conditions, which are to be marked, besides the soils, on the special and the survey maps. 3. The degree of specification to be attempted for the soil survey maps.

Meeting of the First International Commission at Rothamsted. — To the Members of the International Society of Soil Science. With reference to the circular, we have the honour to inform you that the meeting of the First International Commission will be held at Rothamsted in the month of October.

The very important question of International Methodology will be discussed and the resolutions to be submitted to the First International Congress at Washington will be prepared.

Members intending to take part in the Rothamsted meeting are requested to communicate with the Chairman of the Commission Dr. V. NOVÁK (Brno, Kvetna 19, Czechoslovakia) up to the end of June.

The definitive programme of the Rothamsted meeting will be sent later on to those members only who have signified their intention of being present.

Yours faithfully.

Brno, May 4th 1926.

Dr. Ladislav SMOLÍK,
Secretary of the
First International Commission.

Dr. Václav NOVÁK,
Chairman of the
First International Commission.

International Society of Soil Science (Pedology). Subscriptions. — The annual subscription for 1926 has been fixed at *f* 6.50 (Dutch guilders) New members pay an entrance fee of *f* 2.50, i. e., a total of *f* 9.— (Dutch guilders).

Members are requested to forward to me before 1 May, 1926, the sum of *f* 6.50 — or *f* 9.00 for new members — being the subscription for 1926.

There are still a great many members who have not yet paid the annual subscription for 1925 (f 6.60 or f 9.00 guilders, as the case may be), although three separate circulars have been sent to them, calling attention to this point. These members are urgently requested to forward the money for 1925 by return.

In countries where National Sections have been formed, it will be best for the annual subscription and entrance fee to be collected by these Sections.

Members receive the Proceedings and other publications of the Society gratis.

New members who desire to receive Volume I (1925) of the Proceedings, should apply to Dr. G. A. R. BORGHESANI, International Institute of Agriculture, Villa Umberto I, Rome (10).

New members are requested to send me their exact address, typewritten, and to inform me at the same time in what language (French, English German, Italian or Spanish) they desire to receive the Proceedings.

Finally I should be glad if members would work for the formation of National Sections and report to me on the composition of the executive committees.

Groningen, February 1926.

Dr. D. J. HISSINK,
Acting Chairman and General Secretary,
Groningen (Holland), Herman Colleniusstraat, N° 25.

Requests to members.

(1) to form National Sections;

(2) to pay their subscriptions through these Sections or, where such Sections do not exist, to me;

(3) to pay their subscriptions for 1926 by 1 August at the very latest;

(4) with regard to joining the various Commissions, to communicate with the respective Presidents;

(5) to communicate with Dr. BORGHESANI in the event of having any complaints to make as regards the forwarding of the Proceedings.

Groningen, February 1926.

Dr. D. J. HISSINK,
Acting Chairman and General-Secretary,
Groningen (Holland), Herman Colleniusstraat Nr. 25.

Archives of the Society. — With the object of finally arranging the Archives of the Society under the following Sections :—

1. Publications ;
2. Documents ;
3. Maps ;
4. Photographs, drawings, and similar material ;
5. Schedules, forms, etc.,

the Members of the International Society of Soil Science are asked to send direct to the undersigned, all material already available, lately published or still unpublished, relating to Soil Science, whether their own personal work, or otherwise.

The Service of the Archives of the Society will then prepare the slips relating to such material for the card index.

This Service can also supply all bibliographical information, copies of documents and printed matter at cost price.

Dr. G. A. R. Borghesani,
Librarian of the Soil Society,
Scientific Service of the International
Institute of Agriculture.
Villa Umberto I., Rome.

Reconstruction of the Library of the " Laboratoire d'Agronomie Coloniale " (Paris).

Professor Auguste Chevalier, Director of the " Laboratoire d'Agronomie Coloniale " makes an urgent appeal to the Members of the International Society of Soil Science to help him to reconstruct the library of the laboratory which was destroyed by a fire last June. The library consisted of more than 20.000 treatises and manuscripts collected during a period of 30 years.