# Vol. II

Papers: Page

PROCEEDINGS OF THE INTERNATIONAL
SOCIETY OF SOIL SCIENCE

N. S. Vol. II, No. 3 — July-September 1926.

*Papers.*

# THE EFFECT OF LIME AND FERTILISERS ON THE POTASH CONTENT OF SOIL AND CROP.

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During the past 25 or 30 years many thousands of soil and crop samples have been analysed by the various experiment stations in the United States. Many of these analyses have been published in bulletins, books and journals. In some cases authors have compiled analyses from various sources, including work done in foreign countries. Probably in the majority of cases no record has been made of the type of soil, or of the fertiliser treatment that was given to the particular crop from which the sample was taken. It is well known, however, that the composition of the crop may be distinctly influenced by the fertiliser treatment, and since it has become quite customary to calculate the amount of plant food removed by a given crop by reference to such tables of analyses, the importance of having reliable information with regard to the soil type and fertiliser treatment is at once apparent. Otherwise the value of such calculations may well be called in question.

If, for example, the dry stalks of corn (maize) grown under one condition show on analysis 1 per cent of potash and under different conditions 3 per cent of potash, how can one fairly calculate the amount of potash removed by one ton of the stalks grown under average conditions without knowing which sample most nearly represents this average condition? In the one case a ton of the stalks would remove 20 pounds of potash and in the other 60 pounds.

In studying the analyses of crops from the nitrogen availability experiments at the New Jersey Experiment Station, it became evident that in many cases the compositions of the crop had been distinctly influenced by the fertiliser or lime treatment. Since these experiments have established conditions which are especially favourable for such a study, it seems well to record some of the results obtained from field experiments which have been in progress since 1908.

## PLAN OF EXPERIMENT.

In connection with the nitrogen availability work, 40 one-twentieth acre plots have received definite fertiliser treatments annually. Twenty of these have been limed (carbonate) at intervals of five years, and 20 have received no lime treatment during the period. Some of the plots have received no fertiliser, some have received one ingredient only, some two, others two plus farm manure, and still others three of the common fertiliser ingredients both with and without manure.

The soil is a loam of fair quality, which had not been farmed for some years preceding the starting of this work in 1908.

With the completion of 15 years work, which includes the crop of 1922, samples of soil were taken from these plots (1) and their potash content was determined. Potash has also been determined in the corn stalks taken from these plots in 1923, and in samples of some other crops from these plots as indicated in table 2.

## POTASH IN SOILS.

Table 1 shows the fertiliser and lime treatments that these plots have received and also the percentage of potash in the soil and in the corresponding crop. An examination of the figures for the soils shows that in nearly every case the percentage of potash is lower in samples from the limed than from the unlimed series, the average for the limed plots being 1.088 per cent and for the unlimed 1.268 per cent. The differences noted here can hardly be due to accident but must be attributed to the differences in treatment. The lower percentage of potash on the limed series is undoubtedly due, in part at least to the exchange of bases, the lime of the applied limestone taking the place of the potash in the soil. Since the crops on the majority of these limed plots have been only slightly larger than those on the unlimed series, the difference could hardly be attributed to the greater utilization of potash on the limed series.

(1) Samples taken to the depth of about 6 $^2/_3$ inches.

TABLE I. — *Potash ($K_2O$) in soils and in corn stalks from corresponding unlimed and limed plots, with different fertiliser treatments.*

| Plot No. | Fertiliser treatment (per acre) | $K_2O$ in soils-1922 |  | $K_2O$ in corn stalks 1923 |  |  |  |
|---|---|---|---|---|---|---|---|
|  |  | Unlimed (A) per cent | Limed (B) per cent | Unlimed (A) per cent | Unlimed (A) lbs per acre | Limed (B) per cent | Limed (B) lbs per acre |
| 1 | Nothing | 1.364 | 1.038 | 0.779 | 14.49 | 0.604 | 14.13 |
| 2 | 320 lbs muriate of potash | 1.371 | 1.030 | 2.177 | 43.98 | 1.838 | 48.52 |
| 3 | 640 lbs acid phosphate | 1.464 | 0.984 | 1.406 | 28.12 | 0.426 | 10.99 |
| 4 | Minerals *) only | 1.426 | 1.031 | 2.346 | 59.12 | 1.834 | 67.86 |
| 5 | » + 16 tons cow manure | 1.186 | 0.953 | 2.872 | 83.29 | 2.246 | 83.10 |
| 6 | » + 16 tons horse manure | 1.395 | 1.228 | 3.200 | 94.72 | 2.636 | 106.49 |
| 7 | Nothing | 0.742 | 1.085 | 0.593 | 5.04 | 0.618 | 17.92 |
| 8 | Minerals + 160 lbs. $NaNO_3$ | 1.310 | 1.186 | 2.784 | 75.17 | 2.345 | 81.14 |
| 9 | » + 320 » $NaNO_3$ | 1.267 | 1.015 | 3.185 | 87.27 | 2.014 | 66.86 |
| 10 | » + $Ca(NO_3)_2$ **) | 1.353 | 1.046 | 3.181 | 87.16 | 1.832 | 67.05 |
| 11 | » + $(NH_4)_2SO_4$ **) | 1.189 | 1.038 | 2.278 | 19.14 | 1.949 | 61.98 |
| 12 | » + $CaCn_2$ **) | 1.216 | 1.104 | 3.208 | 102.01 | 2.090 | 68.55 |
| 13 | » + Blood **) | 1.453 | 1.036 | 1.960 | 62.72 | 1.968 | 62.98 |
| 14 | » + Ground fish **) | 1.650 | 1.100 | 2.172 | 58.21 | 2.175 | 73.52 |
| 15 | » + Tankage **) | 1.034 | 0.938 | 1.997 | 64.30 | 2.478 | 98.62 |
| 16 | » + 2 tons alfalfa hay | 1.062 | 1.050 | 2.549 | 68.31 | 1.831 | 49.07 |
| 17 | » + 2 tons rye straw | 1.445 | 1.356 | 2.488 | 68.67 | 2.435 | 90.58 |
| 18 | » + Cow manure + 320 lbs. $NaNO_3$ | 1.085 | 1.228 | 2.832 | 104.22 | 2.218 | 85.17 |
| 19 | » Only | 1.135 | 1.093 | 2.674 | 82.89 | 2.794 | 89.97 |
| 20 | » + Rye straw + 320 lbs. $NaNO_3$ | 1.216 | 1.220 | 2.185 | 62.05 | 3.103 | 98.68 |
|  | Average | 1.268 | 1.088 | 2.343 | 63.54 | 1.972 | 67.16 |

*) Minerals = 640 lbs. acid phosphate and 320 lbs. muriate of potash per acre.
**) Equivalent to 320 pounds $NaNO_3$ per acre.

On the other hand there are differences within the series which are probably due to inequalities in the soil or to errors in sampling, or both. That these differences within the series are not due to the potash treatment is shown by comparing the results from plots 2 and 3 unlimed (A's) with 2 and 3 limed (B's). Plots 2 A and 2 B have received annual applications of muriate of potash equivalent to 320 pounds per acre for about 15 years, whereas plots 3 A and 3 B have received no potash fertiliser during this period. It will be noted, however, that in the case of 2 A and 3 A the difference in potash content is easily within the limits of experimental error; the same may be said of 2 B and 3 B. To take another example, plot 4 B receives the annual application of muriate of potash and plot 5 A receives the same plus an annual application of manure, which adds about as much potash as the muriate (160 pounds per acre), but on analysis 5 A shows a lower percentage of potash than 4 A. In this case the difference may be due, in part at least, to the fact that 5 A has always yielded larger crops than 4 A, as shown by the total potash removed.

In case of plot 7 A which receives no fertiliser it would appear that the potash content of this soil has been distinctly depleted during the 15 years, for it now contains only a little over half as much as plots 6 A and 8 A, these being the plots which touch it on either side. There are other differences which should probably be explained on the ground of a difference in location rather than differences in treatment. For example, plot 14 A contains 1.65 per cent potash and 15 A, 1.034 per cent potash, but these plots are separated from one another by two one-twentieth acre plots, and furthermore 14 A occupies a little lower ground than 15 A.

Potash was determined in certain of the subsoils (6-13 in.) with the following results:

| Plot No. | Unlimed (A) per cent | Limed (B) per cent |
|---|---|---|
| 2 | 1.467 | 1.178 |
| 3 | 1.569 | 1.383 |
| 7 | 1.122 | 1.046 |
| 14 | 1.530 | 1.399 |
| 20 | 1.399 | 1.159 |
| Average | 1.417 | 1.233 |

## POTASH CONTENT OF CORN STALKS.

When we study the percentage of potash in the stalks from the different plots, we find a much greater difference than was found in the soil. A comparison of the results for the two sections shows that in the majority of cases the percentage of potash is higher in samples from the unlimed than from the limed section. It will be recalled that this same relation exists between the soils of the section, but it hardly seems possible that this difference in the soils is great enough to influence the potash content of the stalks to the extent that is here noted.

Attention may be called to some of the striking differences. For example, sample 2 A contains approximately one and a half times as much potash as 3 A, and 2 B contains over three times as much as 3 B. Samples 6 A, 10 A and 12 A contain close to eight times as much potash as sample 3 B. Sample 13 A contains the same amount of potash as 13 B, and 14 A the same as 14 B ; on the other hand 15 A and 15 B differ by about .5 per cent ; although they are quite close together and have received the same potash treatment. Samples 7 A and 7 B (no fertiliser) contain about .6 per cent potash while samples 6 A and 6 B, the adjoining plots respectively on the one side, and 8 A and 8B the adjoining plots respectively on the other side, contain about 2.75 per cent potash.

The lowest percentage of potash is .436, representing sample 3 B, which is equivalent to 8 ½ pounds of potash to the ton of stalks ; the highest percentage shown is 3.208 for sample 12 A, which is equivalent to 55.6 pounds of potash to the ton of stalks.

There is a considerable variation even where the potash treatment has been uniform. Samples 9 A, 10 A, and 12 A show over 3 per cent of potash, whereas sample 17 A, which receives the same amount of muriate of potash as the others shows only 2.28 per cent of potash. It is difficult to reconcile some of these differences. That it cannot be due wholly to the natural supply of potash in the soil is indicated by the fact that the soils from 16 A and 16 B contain almost exactly the same amount of potash, whereas the stalks from these two plots differ by almost .75 per cent. Neither can it be attributed to a difference in the amount of available nitrogen, for 18 A receives a large excess of available nitrogen, whereas 19 A receives no nitrogen, but the potash content of the stalks is very nearly the same in each case.

It seems worth while to call attention to the fact that for the unlimed section the samples from the six plots which have received a basic nitrogenous fertiliser ($NaNO_3$, $Ca(NO_3)_2$ or $CaCn_2$) give an average of 2.896 per cent potash, while the samples from the five plots that have received an organic nitrogenous fertiliser give an average of 2.233 per cent potash. For the limed section the corresponding figures are 2.267 and 2.177 per cent potash. In this connection it is interesting to speculate as to whether, through an exchange of bases, soil potash was released and in turn taken up by the plant.

The average percentage of potash for all samples from the unlimed section is 2.343 per cent, and the average for all from the limed section 1.972 per cent. Here we may raise the question as to why stalks from the limed section should contain less potash than those from the unlimed section. It may be that the repeated applications of lime, having helped to reduce the potash content of the soil, particularly the more readily displaceable portion of it, discouraged excess (luxury) consumption of this ingredient. With our present knowledge a positive answer cannot be given. It may also be that on the limed section a part of the plant's basic requirement has been met by the utilization of lime to the exclusion of a part of the potash. Determinations of the lime content of the plant may throw some light on this point. Lime was determined in a limited number of samples from both the limed and unlimed sections, and without exception the percentage of lime (CaO) is higher in samples from the limed than from the unlimed section ; with one exception the reverse is true of the potash. Further work should be done on this point but this gives some ground for believing that in the presence of a liberal supply of lime the plant may take less potash than where the supply of lime is limited. The comparative lime and potash figures are shown in Table 2.

Reference to the columns of Table I showing pounds of potash removed per acre by the corn stalks, makes it clear that there is a wide variation in the amount thus removed, the lowest for the unlimed series being 5.04 pounds and the highest 104.22 pounds per acre ; the lowest for the limed series is 10.99 pounds and the highest 106.49 pounds per acre.

TABLE 2. — *Lime ($CaO$) and Potash ($K_2O$) in Corn Stalks from Limed and Unlimed Plots.*

| Plot No. | $CaO$ in Stalks | | $K_2O$ in Stalks | |
|---|---|---|---|---|
| | Unlimed per cent | Limed per cent | Unlimed per cent | Limed per cent |
| 3 | 0.823 | 0.885 | 1.406 | 0.426 |
| 10 | 0.660 | 0.781 | 3.181 | 1.832 |
| 21 * and 22 | 0.694 | 0.918 | 2.112 | 1.362 |
| 35 * » 38 | 0.751 | 0.800 | 2.897 | 3.210 |
| 42 * » 45 | 0.844 | 1.151 | 1.844 | 0.926 |
| Average | 0.754 | 0.907 | 2.288 | 1.551 |

*The first number in each case represents the unlimed plot.

Plots 8 to 15 inclusive received like treatment with reference to potash, and the average amount removed in the stalks from these plots, on the unlimed section (plot 11 A omitted from average), is 76.7 pounds per acre, the average amount removed in the stalks from plots 8 to 15 of the limed section is 72.6 pounds per acre. The average for all the plots in the unlimed section is 63.54 pounds per acre, and the average for all in the limed section 67.16 pounds per acre.

The stalks from plots 8 to 15 of the limed section yielded, with slight exception, somewat over 50 bushels of corn per acre. Thus it appears that the stalks from a 50 bushel crop of corn will remove about 75 to 100 pounds of potash. To this must be added about 12 pounds for the 50 bushels of grain. This brings the total amount well above the amount usually estimated for a 50 bushel crop of corn. The figures clearly indicate that in the case of some crops, or part of crops, it is useless to undertake to calculate the amount of potash removed by the crop unless the soil conditions and crop treatment are definitely stated.

## POTASH IN OTHER CROPS.

Determinations of potash have been made in other crops or parts of crops, from certain of these plots. The samples on which determinations were made, were wheat straw, oat straw, oat grain, timothy hay and corn grain. The details of these analyses will not be given here. It will suffice to state that the influence of the fertiliser and lime treatment is not as clearly and consistently reflected in the composition of the small grained plants as it is in the composition of the corn stalks. Nevertheless even here applications of potash salts increased, and applications of lime decreased, in most instances, the potash content of the crop.

## SUMMARY.

Potash was determined in soils from a number of plots that had received definite fertiliser and lime treatment for a period of 15 years. It was also determined in several crops, or parts of crops, grown on the plots from which the soil samples were taken.

For the series of plots having parallel fertiliser treatment for the limed and unlimed sections, the percentage of potash in the soil was slightly lower, in nearly all cases, for the limed than for the unlimed section.

The fertiliser treatment does not appear to have had very much influence on the potash content of the soil. Such variations as are noted are to be attributed, in the main, to natural variations in the soil or to limitations in the methods of sampling.

There is a consistent variation in the percentage of potash in the corn stalks grown on the limed and unlimed sections and with the different fertiliser treatments.

The average percentage of potash in the stalks from 20 limed plots is, approximately, 0.4 per cent less than the average for the stalks from 20 limed plots.

The lowest percentage of potash found in the stalks was 0.426 per cent, and the highest 3.208 per cent.

It would appear that a 50 bushel crop of corn (maize), grain and stalks, will remove from the soil about 100 pounds of potash. It has been shown that the potash content of some crop, at least, is greatly influenced by heavy applications of potash salts and this emphazises the importance of carefully stating the conditions under which crops are grown when reporting percentages of plant food constituents in the crops.

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# ON THE PERMEABILITY OF LOAM SOILS.

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## I. — THE FORMULATION OF THE QUESTION AND THE METHODS OF THE INVESTIGATION.

In my earlier investigations 1) I established the fact that the suspensions of the finest particles of soil produced from acid soils are much less sensitive to electrolytes than are the clay suspensions of neutral soils and soils containing $CaCO_3$. There is also the circumstance that the coagulation of the former clay suspensions is hindered much more powerfully by $NaHCO_3$, if this is in the solution together with calcium salts. As the permeability of the soil is connected with its degree of dispersiveness, it is conceivable that the low permeability of podsol soils, as regards water, is connected with the reaction, and consequently also with the formation process of these soils. The numerous data of analyses of podsol soils of various districts show that the development levels of different depths have also different mechanical and chemical composition. In this respect the podsol soils both of the Caucasus, which have developed at a yearly temperature of 12° C., and of the Italian Apennines, form no exception. The upper levels of the soil ($A_1 + A_2$) have not only lost their finest constituent parts, but also considerable quantities of Na and K, and even the coarser grains of the felspar and other minerals. The surface of the felspar of the upper level is always covered with a white or grey weathering skin. The $Na_2O$ — and partly also $K_2O$ — content of the skin is considerably reduced (1). The whole upper level ($A_1 + A_2$) has in some cases lost as much as 0.25 % $K_2O$ and 0.5 % $Na_2O$, which, calculated on 1 hectare, means very large quantities of $NaHCO_3$ and $KHCO_3$. We now also find actually in the underground and surface waters very large $Na_2O$ and $K_2O$ contents, which have a detrimental effect on the physical qualities of the soil, and may reduce its permeability for water. The content of $NaHCO_3$ is especially high in the brown forest water, often exceeding 0.1-0.25 g. per litre, i. e., it reaches a concentration of about 0.0012-0.0030 n, which already has an injurious effect.

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1) The work had to be abbreviated for editorial reasons; the literature cited by the author is appended at the close of the essay.

The object of the investigation was to find out the factors which reduce or increase the permeability of various kinds of podsol soils. The experiments were carried out with different levels of the podsol soil, especially with marl loams. The latter are often found in Latvia, and are to be regarded as sedentary loamy podsol soils. All the experiments were carried out with pulverized air-dried soil, granulated through a 1 mm. sieve. Grains of 1-2 mm. diam. only were used in tests regarding the permanence of the structure of the soils, the finer constituent parts being sieved off in this case.

After numerous preliminary tests, I found the following apparatus the most suitable (Illustration 21). The apparatus consists of a bottle or Erlenmeyer flask, a little tube with perforated end (the perforation is very simple to carry out on a spirit lamp with a blowpipe) and a round flask containing 100-400 ccm. Instead of the latter, a bottle with a perforated stopper can be used. A glass tube 6-8 cm. long by 0.8-1.0 cm. diam. passes through the stopper. I used 10 g. of soil for the tests. The soil was put into the tube, the perforated end of which was covered with a little wadding. It is an advantage also to draw the wadding into the hole with the aid of a small wire. The tubes were 16 cm. long and 1.6 cm. diameter. They are also advantageous because their diameter is $2\ cm^2$, which facilitates the calculation of the filtrate from the depth of the water layer,. 2 ccm. of the filtrate corresponding to 10 mm. change of water level. 10 g. of soil occupy about 4.5-5.5 cm. of the length of the tube, according to the density of the soil. In filling the soil into the tube I mixed it up again by turning the tube round. After filling, the little tubes were furnished with a rubber ring, a piece cut off a rubber pipe, with an edge which was not smooth, so that the air should not be cut off. The rubber ring does not allow the little tube to sink into the bottle or Erlenmeyer flask. Then the tube is filled with water

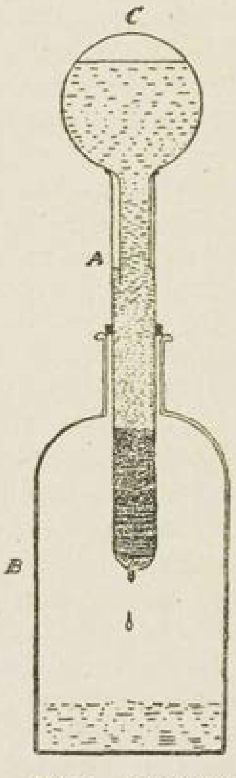

FIG. 21. — Apparatus for investigation of permeability.

over the soil, up to 12 cm. from the lower end of the tube. The third part of the apparatus is a round flask, which holds water to a certain height. The little flask is filled with water or with the salt solution to be examined, and stuck into the tube neck downwards. If the water in the tube sinks so far that air comes between the tube and the neck of the flask, then the air will immediately penetrate into the flask, and a sufficient quantity of water will flow out into the little tube to again shut off the neck of the flask from the air. The principle of the apparatus can also be adapted to sand and other materials easily permeable by water; in this case a larger bottle must be used, into which the little tube goes, and a larger round flask for holding the water or salt. In this case the round flask must be fixed to a support, as the little tube may break in pieces if the flask contains more than 400 ccm. of liquid. In order that the water can easily flow out of the flask into the tube, the neck of the flask must have a diameter of about 0.8-1.0 cm., and be cut off obliquely at the end.

After a few preliminary experiments I have found the best amount to be 10 g. of soil in conjunction with a depth of filtering material of about 5 cm. If the filtering layer is deeper, then relatively small quantities of filtrate are obtained; if the latter is smaller, however, then the finest constituent parts of the soil are many times vigorously washed, and those salt solutions which increase the degree of dispersiveness filter even more quickly than distilled water. This circumstance is of especial significance in the experiments with « Gley » soils: thus, for example, the filtration through a layer of « Gley » soil 5 cm. deep was distinctly retarded by a 0.0001 n $NaHCO_3$ solution, but the filtration through a layer 2 cm. deep of the same soil was furthered because in the first case the pores were stopped up by the finest constituent parts of the soil, whereas in the second case these finest constituent parts were washed out, and filtration consequently increased. The quantities of water filtered through the soil were measured, the measurement being for the most part carried out once a day. In the tests extending over several months, even two years, the measurements were carried out more seldom, every two days, and in some cases every twenty days.

With good mixing of the soil, and good filling, the parallel measurements give mostly correspondingly good results, especially good with marl loams and neutral soils. With very acid soils, the deviations fo the parallel determinations are greater, especially with the examination of such solutions as increase the degree of dispersiveness of the finest constituent parts of the soil. The differences in the quantities of filtrate are in this case particularly great for a single day, whereas the total quantity of filtrate for a longer period shows small differences in the parallel determinations. The alterations in permeability apparently are here very erratic, being suddenly reduced or increased. That is quite comprehensible; if the finest particles are taken out of the soil with the filtrate, then stopping up or freeing of the pores occurs, which requires no special explanation. The methods described for investigating permeability cannot give results which are equal in accuracy to those obtained by the methods of analytical chemistry. Still, even with these methods, very many complicated questions can be answered. This method withal is very simple, requires no expensive apparatus, no great space, and is suitable for carrying out very numerous parallel examinations of long duration. In the simply equipped laboratory I have carried out up to now about 300 such examinations, lasting at least a month each, which have already led to many important conclusions, and these I will consider briefly in the present work.

With such an apparatus, the influence of the water pressure on filtration can be demonstrated in lectures by the use of quartz sand (grains about 0.15 mm.) as a filtering layer, and by the use of diluted clay suspensions for filtration the stopping up of the pores can be shown. To obtain greater water pressure, instead of the little tube a longer piece of corresponding glass tube can be used.

## II. — EXPERIMENTS WITH MARL LOAMS.

Three different kinds of marl loam have been examined. I. Band clay of about 3 m. deep, with a $CaCO_3$ content of 28.37 %. The sample of soil originates in the district of Tuckum, in the neighbourhood of Renge. II. Band clay from the neighbourhood of Kauzmünde, of a depth of 50-60 cm., $CaCO_3$ content 4.02 %. On the band clay was a little changed neutral soil similar toRendzine soil. The $CaCO_3$ content of the deeper layers of band clay rises to 20 % ; therefore the upper layers of the band clay must be considered as pretty strongly washed out, having lost up to 16 % of their original $CaCO_3$ contents. III. Unstratified marl loam of a depth of 60-70 cm., from the neighbourhood of Kursichi, district of Goldingen. Typical podsol soils have already formed on the marl loam.

All three marl loams mentioned are very rich in the finest constituent parts of soil, clay particles which do not deposit in the course of 24 hours from a suspension 10 cm. deep; this is particularly so with the last two samples of soil. This is seen from the following data:

TABLE I. — *Mechanical composition of the marl loam.*

| Size of grain *) in mm. | Time of deposit | I | II | III |
|---|---|---|---|---|
| | | % | % | % |
| 1 — 0.05 mm. | 1 minute | 6.47 | 7.24 | 48.57 |
| 0.05 — 0.01 mm. | 10 » | 16.48 | 19.0 | 14.03 |
| 0.01 — 0.005 mm. | 6 hours | 41.91 | — | 17.11 |
| 0.005 — 0.001 mm. | 24 » | 11.70 | 73.76 | 5.76 |
| under — 0.001 mm. | — | 23.44 | — | 14.63 |

* The size of grain is designated after Prof. W. R. WILLIAMS, *Nachrichten der Akademie Petroffskaja* 1889. The microscopic check has shewn that the size of grain is somewhat different, thus for example, particles whose diameter is rather smaller, about 0.003 mm, are deposited in 6 hours. The samples of soil were in this case prepared for mechanical analysis by heating slowly with a few drops of $NH_3$. The $CaCO_3$ was not separated. All further mechanical analyses carried out in this treatise are obtained without heating with ammonia. The samples of soil were however prepared by treatment with NaCl normal solution after Prof. K. GEDROIZ.

The two first marl loams contained no constituent parts which were larger than 1 mm., the last sample contained 17.2 % of such; these particles were, however, granulated, and for the tests only soil was used which had been put through a 1 mm. sieve.

Although the loams contain fairly large quantities of constituent parts which were not deposited in the course of 24 hours, yet the ultra-mechanical constituent which is not deposited within three weeks could not be obtained by treating the soil several times with normal NaCl solution in accordance with the methods of GEDROIZ (2). After the washing out of the NaCl, fairly large quantities of Ca ions passed over into the solution, by which the finest constituent parts were pretty quickly coagulated. The explanation of this fact must indeed be sought in the influence of the NaCl on the $CaCO_3$; this raises the hydrolytic decomposition of the $CaCO_3$. My last investigations show that with $NaHCO_3$ and $NH_3$ better results can be obtained, because the $NaHCO_3$ and $NH_3$ reduce the hydrolysis of $CaCO_3$.

(a) *Experiments with band clay of the deeper layers of soil from Renge.* — The results are to be seen from the curve of Illustration 22, in which the quantities of filtrate which passed through the soil in the first 21 days are set out graphically. The quantities of filtrate are shewn on the ordinate axis, the days on the abscissa axis. The experiments were carried out with : I. distilled water, II. saturated Ca $(HCO_3)_2$ solution of about 0.02 normality ; the solution also contained free $CO_2$, III. $CaSO4$ solution of 0.012 normality ,IV. with water saturated with $CO_2$ (about 1 g. $CO_2$ to the litre).

The permeability was lowest for distilled water, but also very constant at about 3 ccm. per day ; only in the last weeks of the experiment did the permeability rise to 4 ccm. per day.

The permeability for $Ca(HCO_3)_2$ solution was also low; it was only at the end of the experiment that a quick rise of permeability was noticeable.

FIG. 22. — Experiments with band clay from Renge.

I. .................. Distilled water.
II. ———————— 0.02 n Ca $(HCO_3)_2$ solution.
III. -------------- 0.012 n $CaSO_4$ solution.
IV. ++++++ $CO_2$ = solution about 0.5 = 1 g. $CO_2$ per litre.
Left = Total quantity of filtrate in 21 days.

The greatest quantities of filtrate were obtained with $CaSO_4$ solution ; in this case also a quick rise in the permeability is observable at the end of the experiment.

With water saturated with $CO_2$ a quick increase in permeability was produced in the first nine days of the experiment ; afterwards the permeability became gradually lower.

(b) *Experiments with band clay from Kauzmünde.* ($CaCO3$ = 4.02 %. — The results of the experiments are graphically represented in Illustration 23. These come very near to those of the first band clay, especially with distilled water. The influence of the electrolytes $CaSO_4$ and $Ca(HCO_3)_2$ was in this case greater from the very be-

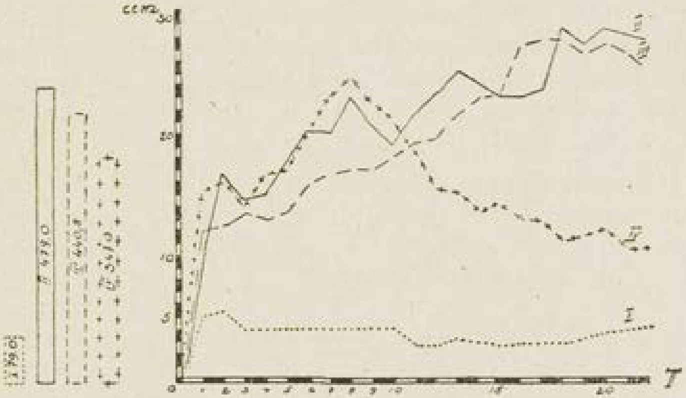

FIG. 23. — Experiments with marl loam from Kauzmünde.

I. .................. Distilled water.
II. ———— 0.02 n $Ca(HCO_3)_2$ solution.
III. --------------- 0.012 n $CaSO_4$ solution.
IV. +++++ $CO_2$ solution about 0.5 = 1 g. per litre.
Left = Total quantity of filtrate in 22 days.

ginning. With water saturated with $CO_2$ a strong rise in permeability was here produced at the beginning followed by a correspondingly rapid fall from the 8th day.

(c) *Experiments with rubble marl loam, on which podsol soil is formed.* — The results are graphically represented in Illustration 24. The permeability of the rubble loam was on the whole higher than that of the first two band clays. There was a particularly steep rise of permeability at the beginning, under the influence of gypsum, and on the 5th day it reached the extent of 75 cm. per day. It is characteristic that in this experiment the permeability was not increased at all under the influence of the $Ca(HCO_3)_2$ solution. The experiment with $Ca(HCO_3)_2$ solution lasted 30 days, the others several months (The curve only shows the data for the first 60 days). After 36 days the soil in the little tube was stirred by a wire, which however had no special influence on the permeability, in fact pronounced reduction of permeability took place in the experiment with distilled water. From the 40th day onwards the $CaSO_4$ solution and distilled water still remaining in the little tube was replaced by a 0.01 n solution of

$Ca(OH)_2$. The permeability for $Ca(OH)_2$ solution after gypsum mounted very steeply and afterwards for four months, to the end of the experiment, kept constant at 55-50 cm. per day.

No influence of the $Ca(OH)_2$ solution, after distilled water, was observable in the course of 8 months. Not until then did the permeability rise somewhat, up to 6 ccm. per day, and not until after 16 months did it reach the height of 7 ccm. per day. At first the $Ca(OH)_2$ was greatly absorbed by the marl loam, and the filtrate was not coloured with phenolphtalein until after 1 ½ months, when more than 200 ccm. $Ca(OH)_2$ solution had already passed through the layer of soil. Even after the $Ca(OH)_2$ had appeared in the filtrate, no alterations in permeability were observable, with the exception of the increase of the quantity of filtrate by 0.2 ccm. per day. Several special investigations were carried out regarding the influence of $Ca(HCO_3)_2$ on the rubble loam, from which it can be established that the permeability for these electrolytes is very small. Closer examination of the filtrates showed that they contain $NaHCO_3$, and in pretty high concentrations, at the beginning as much as 0.0035 n, after a month about 0.0015 n, and even 8 months still 0.0004 n. Experiments with other levels of the podsol soils gave much lower $NaHCO_3$ content in the filtrate. It may be assumed that the $NaHCO_3$ content also has an effect on the alterations of the $Ca(HCO_3)_2$ concentrations: in the filtrate through marl loam the latter, after 8 months, was only of 0.0018 normality, whereas the filtrates through other levels of Podsol soils showed concentrations of $Ca(HCO_3)_2$ of 0.0028-

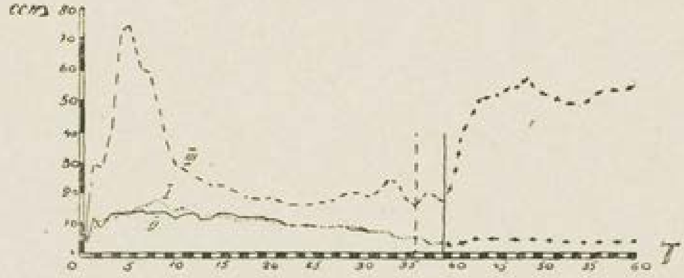

FIG. 24. — Experiments with rubble marl loam from Kursischi.

I. ·················· Distilled water.
II. ———————— 0.01 n $Ca(HCO_3)_2$ solution, interrupted after 31 days
III. - - - - - - - - - 0.012 n $CaSO_4$ solution.
+++++ Continuation of the experiment with 0.01 n $Ca(OH)_2$ solution. The soil was stirred after 36 days.

0.0040 normality. As $NaHCO_3$ has the same anion as $Ca(HCO_3)_2$, it favoured the separation of $CaCO_3$. In the filtrates through the upper levels of the podsol soils the $NaHCO_3$ content was at the beginning only of 0.001 normality; after 8 months, however, in the filtrate through level A = 0.0003 N., through level B = 0.00004 N.

The filtration of 1 litre of $Ca(HCO_3)_2$ solution through a layer of marl loam 1 cm. deep produced the following quantities of $K_2O$ and $Na_2O$ per 100 g. soil:

| | $K_2O$ | $Na_2O$ |
|---|---|---|
| | g. | g. |
| Band Clay from Renge . . . . . . . . . . . . . . | 0.0096 | 0.0057 |
| Stony marl loam from Kursischi . . . . . . . . . | 0.0038 | 0.0085 |

These data show that the rubble marl loam really contains greater quantities of $Na_2O$ than the band clay from Renge, which, in the experiment conducted, may have had an effect on the permeability for the $Ca(HCO_3)_2$ solution. The influence of the gypsum solution on permeability must have been more favourable, because in this case no $NaHCO_3$ can have arisen as a product of chemical change, only $Na_2SO_4$.

Illustration 25 gives a graphic representation of the effect of the 0.01 n $Ca(OH)_2$ solution on the permeability of the rubble loam (Line C); although the experiment was continued for longer than 6 months, the permeability never rose particularly steep and high, and the greatest quantity of filtrate was only 15 ccm. per day. In the course of the experiment reduction and increase of permeability was observable several times. It is characteristic that the permeability was smallest at the beginning of the experiment, between the second and sixth days. The data obtained shows *that the permeability of the marl loams for distilled water, and also for the electrolytes examined, even in experiments of very long duration, does not increase, although great fluctuations are observable in the permeability. In all cases the permeability was raised by gypsum solutions, also the permeability for* $Ca(OH_2)$ *solution was much greater* (10 *times*) *after gypsum than after distilled water.* It must be pointed out that in all the experiments with marl loam the filtrates were perfectly clear, without any cloudiness. I tried to filter clay suspensions of the finest constituent parts of soil of acid podsol soils through marl loam, but in these cases also the suspensions were already coagulated on the surface of the filtering bed, and did not even penetrate into the loam if the depth of the filtering bed was reduced to 2 cm.; the suspensions filter almost as quickly as distilled water. As permeability was favourably influenced by gypsum solution, I made thorough investigations with gypsum and band clay from Renge. The following concentrations of gypsum were

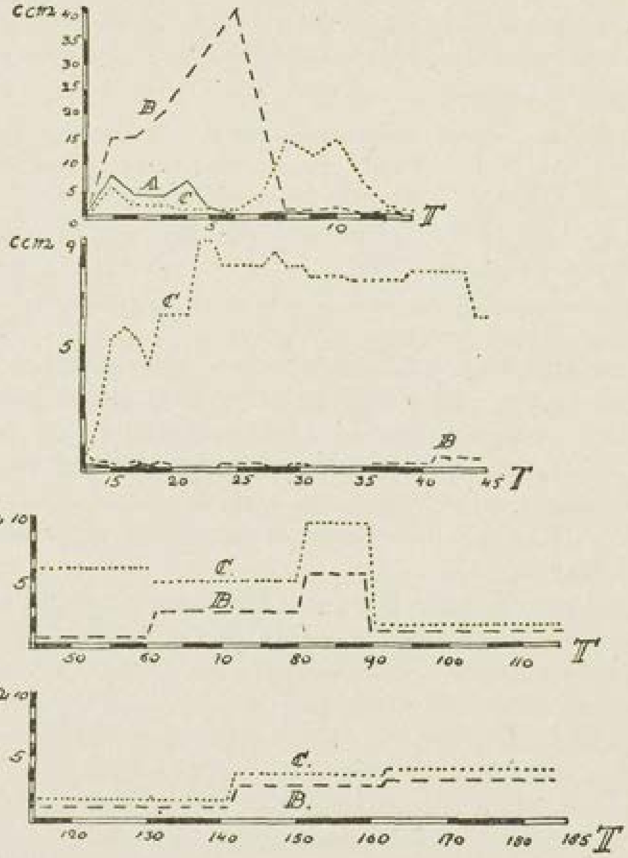

FIG. 25. — Permeability of the 3 levels of Podsol soil for 0.01 n $Ca(OH)_2$ solution in 185 days.

———— Level A: After 6 days the permeability is already almost completely interrupted, after 30 days completely interrupted, and does not rise again.

-------- Level B: The permeability is interrupted after 31 days, but afterwards rises again.

........ Level C: The permeability is not interrupted.

examined : 0.012 n, 0.006 n, 0.003 n, 0.0015 n, 0.0007 n, and distilled water was used as control. At the beginning the permeability was much increased by the first four concentrations of gypsum, by the highest concentration up to as much as 30 cm. per day, but afterwards the permeability fell gradually and the differences were equalized. The permeability for distilled water after 40 days was 3 ccm. per day, for gypsum solutions, even the weakest, 6-10 cm. per day. After 40 days the gypsum solutions were replaced by 0.01 n, solutions of $Ca(OH)_2$ and the experiments continued for another 3 months. The permeability for $Ca (OH)_2$ was considerably increased in those samples through which Gypsum solutions of 0.0015-0.012n were previously filtered. The quantity of filtrate with $Ca(OH)_2$ in the sample after the weakest concentration of gypsum, 0.0007 n, was even smaller, although in the filtrate from this sample also traces of $Ca(OH)_2$ were noticeable after a month. Before the appearance of $Ca (OH)_2$ in the filtrate, great fluctuations of permeability were observed, from 1-6 ccm., per day and on 3 days the permeability was even completely interrupted, which points to the stopping up of the pores of the soil, and afterwards unstopping. At the close of the experiment the permeability for $Ca(OH)_2$, after the four stronger concentrations of gypsum, reached 14-27 cm. per day, after the lowest concentration 5 ccm., after distilled water 7 ccm. per day.

With band clays I and II (from Renge and Kauzmünde) I made tests, after the gypsum and $(Ca(HCO_3)_2$ solutions, with distilled water. The tests lasted only 10 days, the permeability was considerably reduced.

Finally, tests were again made with the rubble loam with different concentrations of $NaHCO_3$.The results of these tests are not graphically represented, but they speak for themselves.

$NaHCO_3$ in the concentration of 0.005 n greatly reduced the permeability. The experiments with 0.001 n $NaHCO_3$ solution and distilled water were carried out twice with good corresponding results. All other concentrations of $NaHCO_3$ which were examined reduced the permeability, with the exception of the concentration of 0.00003 n, with which the permeability was almost equal to that for distilled water. It is hardly probable that such weak $NaHCO_3$ solutions as 0.0000001 n could so strongly influence the permeability; it may be that in this case other factors, remaining unknown, were decisive. The filtrates in all these experiments were also perfectly clear, with the exception of the concentrations of $NaHCO_3$ of 0.001 normality ;

TABLE II. *Experiments with rubble loam with different concentrations of* $NaHCO_3$.

| | Concentrations of $NaHCO_3$ in terms of N/1 | Quantities of the filtrate in 20 days in ccm. |
|---|---|---|
| 1 | 0.05 | 26 |
| 2 | 0.001 | 178 |
| 3 | 0.001 | 163 |
| 4 | 0.0003 | 171 |
| 5 | 0.0001 | 187 |
| 6 | 0.00003 | 246 |
| 7 | 0.00001 | 188 |
| 8 | 0.000003 | 160 |
| 9 | 0.000001 | 142 |
| 10 | 0.0000003 | 143 |
| 11 | 0.0000001 | 175 |
| 12 | Distilled water | 262 |
| 13 | » » | 280 |

in this experiment a very weak opalescence, and in time a very slight deposit were noticeable. This was the only case in the experiments with marl loams.

In my earlier treatise on the coagulation of clay suspensions I have already given expression to the assumption that marl loam, under the influence of $Ca(HCO_3)_2$ solutions, develops $NaHCO_3$. In the investigation submitted I have not indeed been able to establish the pronounced retarding influence on coagulation of the marl loam, still it may be assumed that in the filtration experiments the $NaHCO_3$ raises the degree of dispersiveness and hinders filtration. This may be concluded also from the high $NaHCO_3$ contents of the filtrates on filtration of the $Ca(HCO_3)$ solution.

I have already established that the permeability of marl loams is raised more strongly by gypsum solutions than by $Ca(HCO_3)_2$ solutions, especially those marl loams on which Podsol soil has already developed, and consequently larger amounts of $Na^\cdot$ and $K^\cdot$ ions from the transformed upper level have trickled through the soil. With the absorbed $Na^\cdot$ and $K^\cdot$ ions gypsum gives no carbonic acid but sulphates, whose influence is different. In time, however, the permeability of the gypsum solutions is also reduced; it is conceivable that in this case those $Na^\cdot$ and $K^\cdot$ ions operate which arise on the hydrolysis of the silicate. That this hydrolysis takes place in experiments extending over several weeks can be seen from the fact that hydrocarbonates can be found in this case in the gypsum solution which filters off, even if the filtering soils contain no $CaCO_3$.

### *Experiments with loams free from $CaCO_3$.*

For the experiment level B of the podsol soil was used, the same from which the clay suspensions were obtained with which the experiments regarding coagulation were carried out. The sample of soil was taken from the same place in the neighbourhood of Kursischi, from which also the rubble loam was taken, and was found directly over the latter. The content of CaO soluble in hot hydrochloric acid is pretty high, namely, 0.93 %, though this loam after a few hours shows acid reaction on litmus paper. The explanation is to be sought in the very fine grained mechanical composition. The mechanical analysis was carried out by the method of Prof. GEDROIZ, in pursuance of which the the loam was first treated 15 times with normal NaCl solution. The mechanical composition was as follows :

TABLE III. — *Mechanical composition of the sample of soil.*

| Size of grain in mm. | Time of depositing from water 10 cm. deep. | Contents of fractions in % |
|---|---|---|
| 1 — 0.05 | 1 minute | 35.64 |
| 0.05 — 0.01 | 10 minutes | 7.50 |
| 0.01 — 0.005 | 6 hours | 12.12 |
| 0.005 — 0.001 | 24 » | 6.05 |
| 0.001 — 0.00022 | 3 weeks | 11.78 |
| below — 0.00022 | — | 23.63 |

In this case the sample of soil was not heated. In the analyses with which samples of soil of the same loam were previously prepared by heating with $NH_3$, I only obtained 24.36 % of grains which were not deposited in 24 hours ; with the kind of preparation now used this amount is raised to 35.41 %.

It must be mentioned as a characteristic of the loam that it is fairly rich in $K_2O$ and $Na_2O$, as is shown by the following data :

| | $K_2O$ | $Na_2O$ |
|---|---|---|
| I Dissolves in hot 10 % HCl . . . . . . . . . . | 0 555 % | 0.05 % |
| II » in cold 0.015 n. HCl . . . . . . . . . | 0.015 % | 0.019 % |
| III » out of 100 g. soil in 1 litre 0.02 n Ca $(HCO_3)_2$ . . . . . . . . . . . . . . | 0.0042 g. | 0.0043 g. |

This loam proved particularly sensitive in the experiments for permeability. The results of the examinations are shown graphically in Illustration 26.

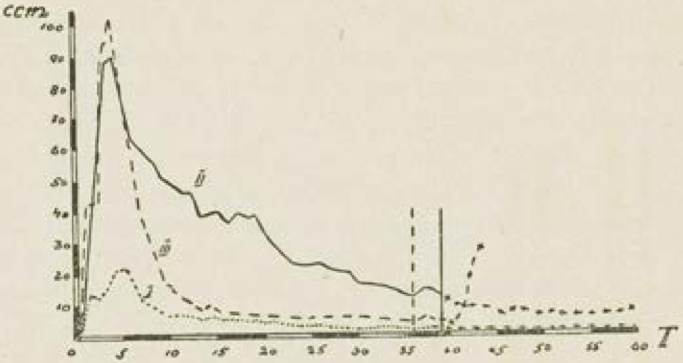

FIG. 26. — Experiments with level B of the Podsol soil from Kursischi.

I. .................. Distilled water.
II. ——┬—— 0.01 n $Ca(HCO_3)_2$ solution.
III. --------------- 0.012 n $CaSO_4$ solution.
+++++ Continuation of the experiment with 0.01 n $Ca(OH)_2$ solution. Stirring up of the sample of soil on the 36tht day.

*Distilled water* filters pretty well at first, but the quantity of filtrate already reaches its maximum (22 cm. per day) on the 5th day, and afterwards falls fairly fast after 30 days almost reaching zero. The breaking up of the sample of soil, which was done between the 36th and 39th days, also had no effect. After 40 days the experiment was interrupted, and instead of distilled water 0.01 n $Ca(OH)_2$ solution was used. This solution also had no influence, the permeability was not raised. This loam proved much more sensitive to $Ca(HCO_3)_2$ and $CaSO_4$ solutions. The permeability was greatest for gypsum solutions and on the 4th day reached the quantity of 102 ccm. per day, which must be described as a very great amount. The permeabilbility fell very fast in the following days, however, and the breaking up of the soil then carried out had no effect. After replacing the Gypsum solution with $Ca(OH)_2$ the permeability again rose rapidly. The permeability of the loam was also much increased by $Ca(HCO_3)_2$ solution, and with this did not become less so quickly as in the experiments with gypsum solution.

The influence of various stronger concentrations of $Ca(HCO_3)_2$ solution on the permeability of the loam were also investigated. Illustration 27 shows the total quantity of filtrate in 21 days. Each concentration was examined in two parallel tests, and results were obtained which corresponded pretty well with each other. After 21 days, instead of $Ca(HCO_3)_2$ solution, a 0.01 n solution of $Ca(OH)_2$ was used. With this the permeability in all samples was very much reduced, and only after several months did it rise again in the first four tubes to 10-20 ccm. per day. The experiments were continued for 15 months. The general impression at the conclusion of the experiment was as follows: The permeability of the samples of soil, after previous filtration of $Ca(HCO_3)_2$ solutions of 0.02 n, 0.01 n and 0.0025 n, amounted to 7 - 15 ccm. per day, with which similar variations were also observable in parallel examinations. The permeability for $Ca(OH)_2$ of the remaining samples of soil, after previous filtration of the remaining $Ca(HCO_3)_2$ solutions of 0.003, 0.0012 and 0.0006 normal and also of the distilled water, was almost completely eliminated becoming not greater than 0.5 ccm. per day.

FIG. 27. — Level B of the Podsol soil. Quantities of filtrate in 21 days with distilled water and different concentrations of the $Ca(HCO_3)_2$ solution.

No. 1 = 0.02 n, No. 2 = 0.01 n, No. 3 = 0.005 n No. 4 = 0.0025 n, No. 5 = 0.0012 n, No. 6 = 0.0006 n, No. 7 = distilled water.

Direct examination of the 0.01 n $Ca(OH)_2$ solution (illustration 25) showed that the permeability rose pretty quickly, on the 4th day attained 41 ccm. per day, but already on the 8th. day stopped almost completely, not to rise again until after 40 days. At the conclusion of the experiment the quantity of filtrate amounted to 3 ccm.per day.

A 0.05 n and 0.001 n solution of $NaHCO_3$ were also examined. In 20 days the total quantity of filtrate amounted to:

| | |
|---|---|
| 0.05 n $NaHCO_3$ . . . . . . . . . . | 42 ccm. |
| 0.001 n » . . . . . . . . . | 123 ccm. |
| Distilled water . . . . . . . . . . . . | 117 ccm. |

The filtrates after distilled water and 0.001 n $NaHCO_3$ were not quite clear, but opalescent, but with the 0.05 n $NaHCO_3$ solution no solid constituent parts were washed out of the soil. It is interesting to note that the weaker concentrations of $NaHCO_3$ exerted no retarding effect on the filtration.

The qualities of the loam examined are very bad in nature, it is therefore described as "sticky" and "builder's" loam. Through the level of the loam mentioned, on the development of podsol soil, the washed out levels ($A_1 + A_2$) of the rubble loam are eliminated. The permeability of this loam is very greatly influenced by drying, as also by deeply penetrating freezing of the damp soil; if, however, the soil has been very damp for a long time, the permeability will be greatly reduced. The experiment carried out, which shows the increase of permeability with the $Ca(OH)_2$ solution after gypsum, leads to the assumption that the qualities of the loam mentioned can be improved by gypsum solutions. It is possible that the contents of absorbed $K^{\cdot}$ and $Na^{\cdot}$ ions in the loam are reduced by gypsum solutions.

### *Experiments with humus levels.*

In these experiments great variety could always be observed associated with the reaction of the humus levels. The permeability of neutral samples of soil differs greatly from that of acid samples.

For the first experiment a neutral soil from the neighbourhood of Sigulda was used. This soil contained 12.2 % of particles finer than 0.01 mm., 3.2 % humus, and 0.86 % $CaCO_3$. The results of the experiments are represented in Illustration 28. On the first day of the experiment the permeability for distilled water reached 91 ccm. per day, but then became fairly quickly and considerably reduced, and amounted to only 9 ccm. per day on the 18th day. From the 18th to the 25th day 0.12 n gypsum solution was used instead of distilled water, but this did not exert any special influence; later, however, a 0.01 n $Ca(OH)_2$ solution was used, by which the permeability was increased in the next 7 days to 80 ccm. per day. From the 32nd. day onwards distilled water was again used, and consequently the permeability was again quickly reduced.

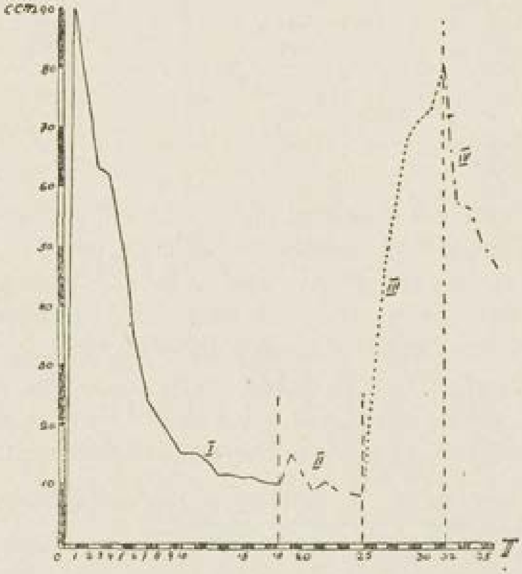

FIG. 28. — Permeability of level A of the neutral arable soil from Sigulda.

I. ———— Distilled water.
II. ------------ Continuation of the experiment with 0.012 n $CaSO_4$ solution.
III. .................. Continuation of the experiment with 0.01 n $Ca(OH)_2$ solution.
IV. —.—.—.—. Continuation of the experiment with distilled water.

More thorough investigations were made with two other samples of soil; the 1st similar to the Rendzine soil is neutral, from the neighbourhood of Kauzmünde, containing 4.34 % humus and 0.43 % $CaCO_3$; the 2nd soil is typical Podsol soil, of a similar kind to that whose clay suspensions were investigated in an earlier work. It contains 2.52 % of organic matter, which, however, is but slightly decomposed and cannot really be designated as humus. Lime-marl, reckoned as $CaCO_3$, amounts to 0.25 %. The soil of course contains no $CaCO_3$. The quantity of CaO soluble in hot HCl amounts to 0.089 %. The mechanical composition of the soil can be seen from the following data (see Table IV page 226.

In comparison with the above mentioned marl loam, both the soils mentioned have much coarser composition. Both soils were prepared for the mechanical analysis by treating the sample of soil 15 times with NaCl n solution. This treatment was quite sufficient for the acid soil, but in the neutral soil the constituent parts which

TABLE IV. — *Mechanical composition of both samples of soil.*

| Size of grain in mm. | Time of depositing | Contents in % | |
|---|---|---|---|
| | | Neutral soil | Acid soil |
| 1 — 0.05 | 1 minute | 36.8 | 41.38 |
| 0.05 — 0.01 | 10 minutes | 33.30 | 18.18 |
| 0.01 — 0.005 | 6 hours | 18.88 | 23.76 |
| 0.005 — 0.001 | 24 » | 3.38 | 6.26 |
| 0.001 — 0.00022 | 3 weeks | 2.54 | 6.35 |
| below 0.00022 | — | 2.31 | 3.30 |

were not deposited in 6 hours still contained fairly large quantities of coagulated particles and organic matter; the mechanical composition of this soil must therefore be fine grained. It is also characteristic that on washing out with salt solution, great quantities of organic matter from the neutral soil went into solution, but very little from the acid soil. The colour of the soils was also dissimilar: that of the neutral soil almost black, of the acid bright grey. Also the contents of $Na_2O$ and $K_2O$ in the podsol soil were fixed:

| | $K_2O$ | $Na_2O$ |
|---|---|---|
| Dissolves in hot HCl . . . . . . . . . . . . . . | 0.165 % | 0.021 % |
| » in cold 0.05 n HCl . . . . . . . . . . | 0.010 % | 0.013 % |
| » out of 100 g soil per litre $Ca(HCO_3)_2$. . . | 0.0026 g. | 0.0042 g. |

The results of the examination of the neutral soil with distilled water are represented in Illustration 29.

The permeability at the beginning increased quickly, on the 4th day it already reached almost 200 ccm. per day, which can be described as the maximum permeability for water in my experiments with loamy soil. Afterwards the permeability fell quickly and by great bounds, and after 183 days it amounted to only about 0.2 ccm. per day; after another month no more filtration took place; after 3 months however, therefore 10 months from the commencement of the experiment, the lower part of the soil in the test tube began to dry up, although water was present for the whole time in the tube and also in the round flask.

The results of the examination of the neutral soil with 0.01 n $Ca(OH)_2$ solution are represented in Illustration 30. The permeability for this solution was at the beginning even greater than 200 ccm. per day; afterwards it was indeed reduced, but never fell below 15 ccm. per day. After 6 months, at the conclusion of the experiment, it amounted to almost 40 ccm. per day.

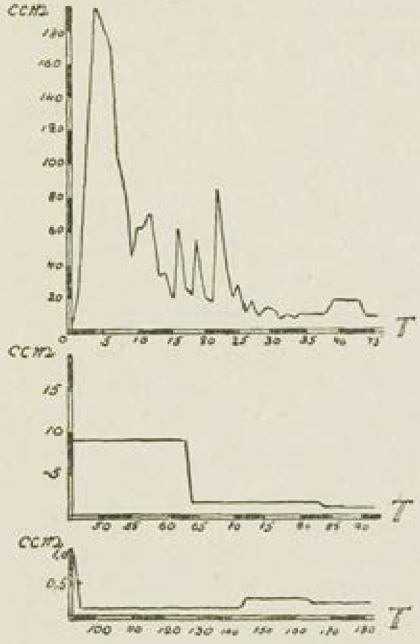

FIG. 29. — Permeability of the upper level of neutral arable soil from Kauzmünde in 183 days. On the continuation of the experiment the permeability was completely interrupted.

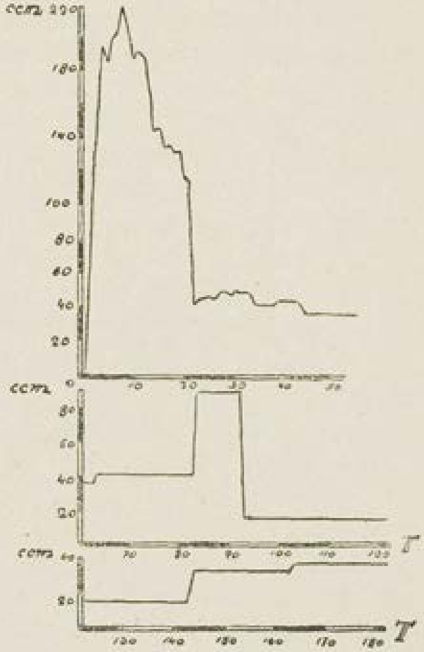

FIG. 30. — Permeability of the upper level of the neutral arable soil from Kauzmünde for $Ca(OH)_2$ solution.

We see quite another picture on the examination of the acid Podsol soil. The results of these examinations are represented in Illustration 31.

Although the soil has no great quantities of the finest constituent parts, the permeability for distilled water is very low. The permeability was raised by $Ca(HCO_3)_2$ and $CaSO_4$ solutions, although relatively little, the effect of the $Ca(HCO_3)_2$ solution being the greater. Here also the breaking up of the soil did not help. From the 39th day onwards 0.01 n $Ca(OH)_2$ solution was filtered through all the test tubes. The permeability for this salt also was very slight. The filtration of the $Ca(OH)_2$ solution was still continued for 4 months, with which at the close of the experiment the permeability in all the tubes was almost alike, about 1 ccm. per day. During the whole period of the experiment the filtrate gave no colouring with phenolphtalein, the $Ca(OH)_2$ was therefore absorbed the whole time from the soil through which the solution trickled. The absorption must probably in this case also be considered as the main reason why the permeability for $Ca(OH)_2$ was not greater under the conditions of the test.

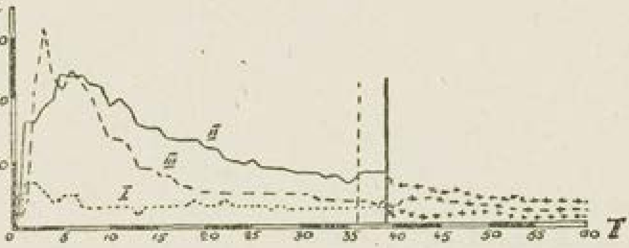

FIG. 31. — Experiments with level A of the podsol soil.

I. .................. Distilled water.
II. ———— 0.02 n $Ca(HCO_3)_2$ solution.
III. - - - - - - - - 0.01 n $CaSO_4$ solution.
+++++ Continuation of the experiment with 0.01 n $Ca(OH)_2$ solution.

Illustration 25 shows us the results of the comparison when from the beginning onwards $Ca(OH)_2$ solution is filtered through acid soil. The permeability indeed is increased at the beginning, but does not exceed 7 ccm. per day; after 6 days, however, scarcely any filtration takes place.

Only 2 concentrations of $NaHCO_3$ — 0.05 n and 0.001 n — were examined. The permeability for these solutions, in comparison with distilled water, showed no great difference; in 20 days the following quantities of the solution passed through:

0.05 n $NaHCO_3$ . . . . . . = 81 ccm.
0.001 n $NaHCO_3$ . . . . . . = 76 ccm.
distilled water . . . . . . . = 95 ccm.

In all experiments with distilled water, $NaHCO_3$, Ca $(OH)_2$ (the latter was completely absorbed by the soil) considerable washing out of the finest constituent parts of the soil was observable. The filtrate was cloudy, and a portion of the cloudiness deposited itself in the flask as fine sand. With this a characteristic layer developed in the test tube which was very easily seen. Such layers occur also in the loam (level B) in the experiments with distilled water, and in the clay soil, but never in the marl loams. Regarding the dried experimental soil which exhibited layers, I was not successful in dividing this into individual layers, as I had been with the band clays. Such stratification can also be observed in the upper levels of the Podsol soils, which are much washed. The formation of the layer is regarded by Prof. K. GLINKA (3) as the result of a high degree of dispersiveness of the soil. The commencement of the formation of the layers can already be seen after a few days in the experiments with distilled water, after a few weeks, however, the layers are already very well formed, the layers at the lower end of the tube being formed the best, but in the experiments with $NaHCO_3$ also in the upper part. In all experiments with acid soils, especially with levels $A_1$ and $A_2$ of the podsol and clay soils, strong washing out of the $Fe(OH)_3$ could be observed, whereas in the experiments with neutral soils and soils containing $CaCO_3$ no notable washing out of $Fe(OH)_3$ could be observed.

### *Experiments with gley loams.*

" Gley " loams are described as the upper levels of such more or less loamy soils as are greatly transformed under the influence of excessive moisture and organic matter. The loam acquires a blue grey colour, is very sticky when in a damp condition, and very hard in a dry condition. Pits dug in gley loam, and open ditches, soon fill up, because the sides soon fall in. The content of clay particles in the gley loam is very varied, from 10-70 % and more. The permeability for water is very small; drains often act badly in gley loam, for the water forces its way to them with difficulty. The upper levels of the gley loam contain no $CaCO_3$, they have even a strongly acid reaction; at a relatively small depth, however, we find marl loam but it has very bad physical qualities. The gley loams contain small quantities of organic matters, the upper level, however, contains large quantities of the same, which are acid.

We find typically formed gley loam on making a vertical cutting of the earth where the subsoil is loamy; the width of the gley loam seldom exceeds 20-50 cm.

The experiments were carried out with 2 gley loams, the first from the neighbourhood of Kasdanga, the second from Sigulda. The mechanical composition of these gley loams is as follows:

TABLE V. — *Mechanical composition of the two samples of gley loam.*

| Size of grain in mm. | Time of depositing | Contents in % | |
|---|---|---|---|
| | | I. Kasdanga | II. Sigulda |
| 1 — 0,05 | 1 minute | 4.14 | 24.70 |
| 0.05 — 0,01 | 10 minutes | 14.34 | 30.60 |
| 0.01 — 0.005 | 6 hours | 28.60 | 22.50 |
| 0,005 — 0.001 | 24 » | 8.53 | 3.67 |
| 0.001 — 0.00022 | 3 weeks | 17.82 | 6.54 |
| below 0.00022 | — | 26.07 | 6.78 |

We see, therefore, that the first gley loam is especially rich in the finest constituent parts, even richer than the above mentioned level B of the podsol soil. The content of finest constituent parts of the second loam is lower, but greater than that of the level of the podsol soil. Both loams react on litmus paper in a pronouncedly acid manner. In my earlier experiments on the influence of electrolytes on the clay suspensions of these soils it was established that these clay suspensions are not very sensitive to electrolytes: In order to produce coagulation, very strong concentrations of electrolytes are necessary. By the presence of very small quantities of $NaHCO_3$ the influence of the electrolytes is further reduced. The contents of $K_2O$ and $Na_2O$ soluble in hot 10 % HCl were fairly high:

| | $K_2O$ | $Na_2O$ |
|---|---|---|
| | % | % |
| I. Clay soil (Kasdanga) . . . . . . . . . . . . . | 0.505 | 0.105 |
| II. » » (Sigulda) . . . . . . . . . . . . . . | 0.240 | 0.065 |

Also in cold 0.05 n HCl fairly large quantities of the oxide mentioned were dissolved:

| | $K_2O$ | $Na_2O$ |
|---|---|---|
| | % | % |
| I. Clay soil (Kasdanga) . . . . . . . . . . . . . | 0.019 | 0.032 |
| II. » » (Sigulda) . . . . . . . . . . . . . . | 0.012 | 0.012 |

By the filtration of 1 litre 0.02 n $Ca(HCO_3)_2$ through 100 g. soil were dissolved :

| | $K_2O$ | $Na_2O$ |
|---|---|---|
| | g. | g. |
| II. Clay soil (Kasdanga) . . . . . . . . . . . . . . | 0.0108 | 0.0175 |
| II. » » (Sigulda) . . . . . . . . . . . . . . . | 0.0020 | 0.0016 |

From the data quoted it is to be concluded that the first gley soil, with filtration of $Ca(HCO_3)_2$, will give much greater quantities of $NaHCO_3$ in the filtrate than will the second, and at the same time filtration through the first soil will also proceed more slowly ; the experiment has confirmed this.

In Illustration 32 the results of a few experiments with the second (II) gley soil during the first 23 days are graphically represented.

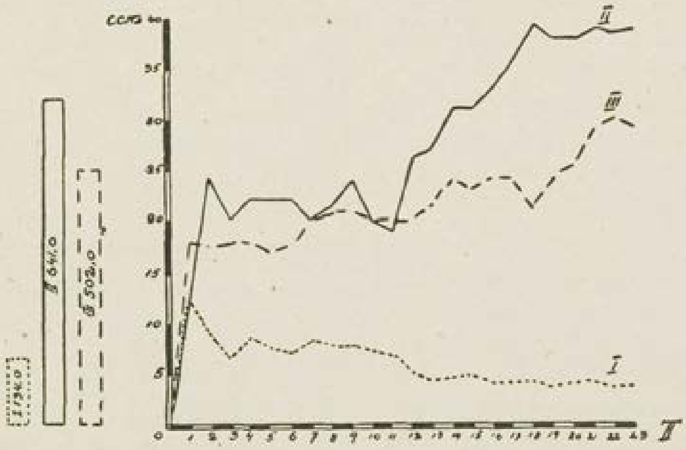

FIG. 32. — Experiments with gley loam (II) from Sigulda.

I. .................. Distilled water.
II. ———————— 0.02 n $Ca(HCO_3)_2$ solution.
III. --------------- 0.012 n $CaSO_4$ solution.
Left = Total quantity of the filtrate.

The permeability for distilled water was at the beginning pretty good, but after 23 days it fell to 4 ccm. per day. In the further course of the experiment this quantity became smaller, and after 6 months it amounted to only about, 0.3 ccm. per day.

The permeability for $CaSO_4$ and particularly for $Ca(HCO_3)_2$ was much greater, but if, after these salt solutions, the experiment was continued with distilled water, then the permeability was reduced very gradually, especially after $Ca(HCO_3)_2$, so, for example, for the next 11 days the quantity of filtrate after $Ca(HCO_3)_2$ amounted to 259 ccm., and after $CaSO_4$ to 90 ccm. The permeability of the clay soil was considerably increased by $Ca(HCO_3)_2$. It is to be assumed that in this case the $Ca^{\cdot\cdot}$ ion had operated which was absorbed by the soil and had thereby altered the qualities of the soil. This conclusion is confirmed by the further series of experiments, the results of which are represented in Illustration 33. In this series of experiments the gley soil from Sigulda (II) was used, from which the lime-marl was removed (Line 1). The gley loam was several times throughly mixed with $Ca(HCO_3)_2$ solution, the solution poured off every time, and the gley loam afterwards dried and pulverized anew. By this treatment the quantity of absorbed K and Na was reduced, which in this loam generally is not very great. The original, unchanged gley loam from Sigulda (line 2) serves for comparison. For the first 3 days distilled water was filtered. In the sample in which the lime-marl was removed (L 1) this filtration proceeded better. After 3 days, instead of distilled water, gypsum solution was used. The filtration of this solution also proceeded better through the first loam, although the difference was not great. From the 16th day onwards, instead of gypsum solution, 0.02 n $Ca(HCO_3)_2$ solution was used. With this solution the difference was very great: the permeability of the first gley soil increased very quickly, the permeability of the second soil acid decreased strongly at first, then increased again, and not until about two months after starting the experiment did the differences equalize. Three months

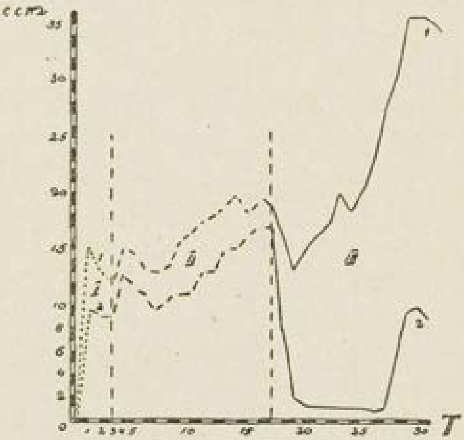

FIG. 33. — Experiments with gley loam from Sigulda. No. 1 = lime-marl removed, No. 2 = natural clay loam.

I. .................. Distilled water.
II. --------------- Continuation of the experiment with $CaSO_4$ solution.
III. ———————— Continuation of the experiment with $Ca(HCO_3)_2$ solution.

after starting the experiment a 0.01 n $Ca(OH)_2$ solution was used instead of $Ca(HCO_3)_2$. With this solution the quantities of filtrate fluctuated very little during the whole course of the experiment, the permeability for the first gley soil amounted to 15-20 ccm. per day, for the second (natural) 8-12 ccm., with which the greatest quantities were obtained at the end of the experiment, after 7 months.

In Illustration 34 the results of the experiment with both natural

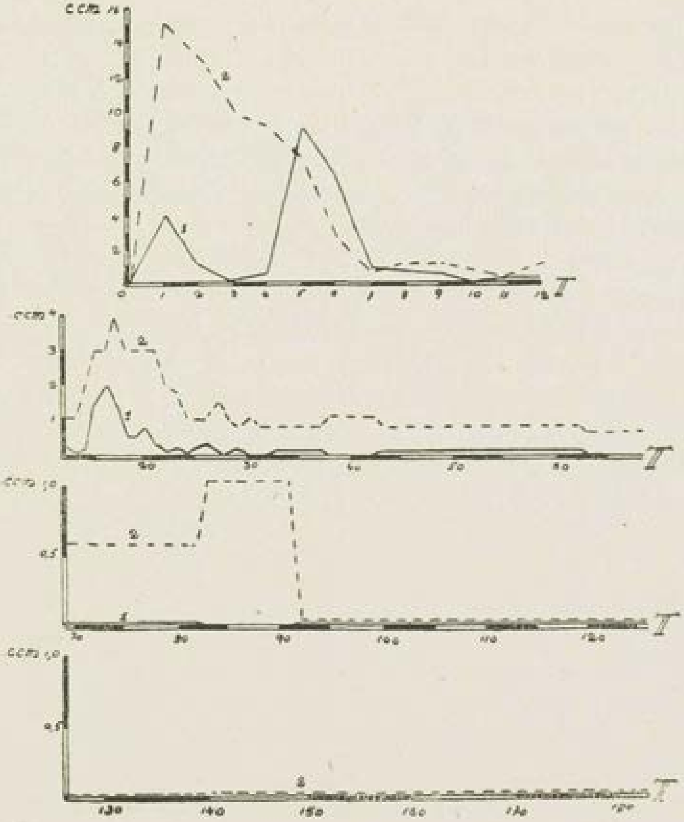

FIG. 34. — Permeability of the Gley soils for $Ca(OH)_2$ solution.

I. ———— Gley loam from Kasdanga; the permeability stops completely after 36 days.

II. -------- Gley loam from Sigulda; after 91 days the permeability is very small.

clay soils are put together, with which from the beginning ($Ca(OH)_2$ solution was used. The permeability did not increase greatly in either of the soils examined, not even at the beginning: the highest quantity of filtrate in the clay from Kasdanga amounted to 9 ccm. (5th day), in the clay from Sigulda 15 ccm. (1st day). Afterwards the permeability decreased, and in the sample from Kasdanga filtration ceased altogether after 60 days; in the sample from Sigulda the permeability after 90 days amounted to about 0.2 ccm. per day. There was no $Ca(OH)_2$ present in the filtrate, it being completely absorbed by the soil.

With the II. Gley soil from Sigulda thorough examinations were carried out with various concentrations of $NaHCO_3$. The gley soil showed itself very sensitive to even very weak concentrations of $NaHCO_3$: the permeability sank greatly, especially at the beginning, and the finest constituent parts of the soil showed in the filtrate. In a few cases the permeability afterwards increased again, which can be seen from the following data:

TABLE VI. — *Gley loam from Sigulda, quantities of filtrate in ccm.*

| | The first 20 days | The next 6 days |
|---|---|---|
| 1. Distilled water | 131 | 0.8 |
| 2. $NaHCO_3$ 0.001 n | 55 | 8.5 |
| 3. » 0.003 n | 59 | 10.0 |
| 4. » 0.0001 n | 79 | 29.0 |
| 5. » 0.00003 n | 26 | 0.4 |
| 6. » 0.00001 n | 50 | 12.5 |

Experiments were also carried out with higher concentrations of $NaHCO_3$. With these it was established that by 0.1 n $NaHCO_3$ solutions very great quantities of organic matter and $Fe(OH)_3$ were washed out; the filtrate was dark brown. With lower concentrations of 0.01 n much less organic matter is present in the filtrate. With these, however, mineral matters are strongly washed out, not only amorphous and colloidal, but also finely crystallized. The quantities of filtrate are very small. With the gley soil II from Sigulda experiments were carried out regarding the influence of the structure of the soil on permeability, for which particles of soil from 1-2 mm. diameter were taken from the pulverized soil, but the finer constituent parts were granulated. With this the permeability increased very strongly, but the parallel determinations gave very varying results; the variations were much greater than in the corresponding experiments with gley loam pulverized and granulated through a 1 mm. sieve. The particles dissolved very soon, especially under the influence of the distilled water and the $NaHCO_3$ solution. In 15 days the following quantities of filtrate were obtained :

TABLE VII. — *Gley loam from Sigulda. Soil particles 1-2 mm. diameter.*

| | I. | II. |
|---|---|---|
| | ccm. | ccm. |
| 1. Distilled wafer | 343 | 515 |
| 2. 0.01 n $Ca(OH)_2$ | 1220 | 1990 |
| 3. 0.01 n $CaSO_4$ | 719 | 1410 |
| 4. 0.00003 n $NaHCO_3$ | 118 | 57 |

The greatest quantity of filtrate per day, amounting to 192 ccm. was obtained with $Ca(OH)_2$ solution. It is of interest that in this experiment also the permeability was greatly reduced by the very weak concentration of $NaHCO_3$ of 0.00003 n. In proceeding further, the filtration ceased completely. Experiments were also carried out with low concentrations of $NaHCO_3$, with which a distinctly retarding influence was exerted by a 0.00001 n $NaHCO_3$ solution ; the influence of still smaller concentrations, however, was no clearer.

The results of the experiment with the clay loam from Kasdanga are represented in Illustration 35. The permeability of this loam was greatly reduced by $Ca(HCO_3)_3$ solutions. The filtration of the same proceeded even more slowly than that of the distilled water. In

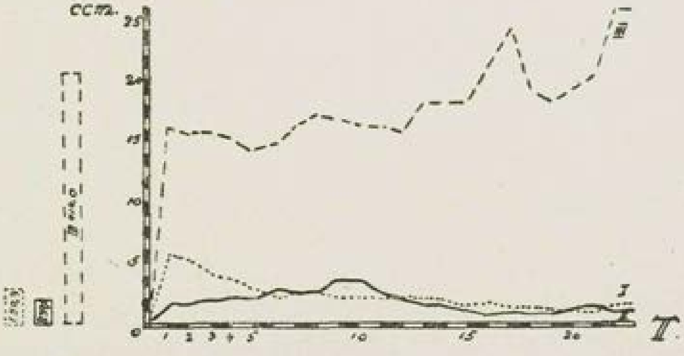

FIG. 35. — Experiments with Gley loam from Kasdanga.

I. .................. Distilled water.
II. ———— 0.02 n $Ca(HCO_3)_2$ solution.
III. -------------- 0.12 n $CaSO_4$ solution.
Left = Total quantities of filtrate.

the filtrate of these solutions direct $NaHCO_3$ and even $Na_2CO_3$ could be determined, which can also be assumed as the main reason of the slow filtration. The permeability for gypsum solution was pretty good, but after a longer time — several months — this fell also here to 4-6 ccm. per day. With distilled water on the first day of the experiment there was only obtained 5.5 ccm. of filtrate; the permeability was afterwards lower, after about a month it amounted to only 1 ccm. per day, and after 2 months the filtration ceased completely.

On account of these qualities of the gley loam from Kasdanga, and also on account of its high content of the finest soil particles, and its great quantities of absorbed $Na^{\cdot}$ ions, I have again examined the permeability of the loams mentioned for solutions which at the same time contain $CaSO_4$ and $Ca(HCO_3)_2$ in varying proportions to each other. As basic solutions 0.012 n $CaSO_4$ and 0.02 n $Ca(HCO_3)_2$ were used. After 40 days the following quantities of filtrate were obtained:

TABLE VIII. — *Permeability of the gley loam from Kasdanga.*

| Used for filtration | Quantity of filtrate in 40 days in ccm. |
|---|---|
| 1. 0.024 n $CaSO_4$ | 299 |
| 2. 0.012 n » | 316 |
| 3. 90 % 0.012 n $CaSO_4$ + 10 % 0.02 n Ca $(HCO_3)_2$ | 500.4 |
| 4. 70 % » » + 30 % » » | 298 |
| 5. 50 % » » + 50 % » » | 839.5 |
| 6. 30 % » » + 70 % » » | 528 |
| 7. 10 % » » + 90 % » » | 234 |
| 8. 0.02 n Ca $(HCO_3)_2$ | 219.7 |
| 9. 0.01 n » | 47 |
| 10. 0.005 n » | 74.9 |

The permeability was much increased if the gypsum solution at the same time contained $Ca(HCO_3)_2$, although the permeability for 0.01 n $Ca(HCO_3)_2$ solution was very small. After 40 days all solutions were replaced by 0.01 n Ca $(OH)_2$ solutions, and the experiments continued. On the next day $Ca(OH)_2$ could only be indicated in the filtrate in tube No. 3, through which previously 90 % gypsum and 10 % $Ca(HCO_3)_2$ were filtered; the quantity of filtrate here rose quickly to 40 ccm. per day and kept at this height for about 5 months running. After 5 months distilled water was used instead of lime water, and with this the permeability was again reduced. I still continued this experiment for another year, but even at the end of the experiment the permeability was fairly strong, the quantity of filtrate fluctuating between 8-9 ccm. per day.

The experiments with all the other test tubes of the same series were also continued for 18 months, but $Ca(OH)_2$ appeared in the filtrate only in 2 other tubes: in tube No. 2 after 45 days from the beginning of the $Ca(OH)_2$ filtration, and in tube No. 5 after 3 months, but the permeability was here only slightly increased. The permeability of the last 3 tubes was very low, and in tube No. 9, through which 0.01 n $Ca(HCO_3)_2$ solution was previously filtered, the filtration very quickly ceased completely.

The last series of experiments show that the permeability of a few gley loams can be strongly raised by solutions which contain at the same time $CaSO_4$ and $Ca(HCO_3)_2$. The influence of the gypsum in hindering the formation of $NaHCO_3$ and in helping the washing ont of the absorbed $Na^\bullet$ ions was here very obvious, whereas by the $Ca(HCO_3)_2$ the content of $H^\bullet$ ions in the soil that is, the acidity of the soil is reduced.

In the district of Hasenpoth, whence the last sample of gley loam (Kasdanga) comes, the liming of the soil with meadow or orginal lime has already been known for a long time, and has given good results pretty quickly. The results have only been rather indefinite with gley soils, which here showed an acid reaction to litmus paper. In these cases the application of gypsum is necessary for the improvement of the qualities of the soil, as is shown by the experiments carried out.

### *Experiments with n* (5.85 %) *NaCl solution.*

The results of these experiments differ very much from the others, it is therefore fitting to consider them separately. The experiments were carried out with the six most important samples of soil which were also used in the earlier experiments. The concentration of NaCl used was strong, 1.0 normality, which in all the soils examined produced coagulation of the finest constituent parts of the soil. The earlier experiments showed that by 0.2 n salt solution the clay suspensions of the acid soils were coagulated, whereas coagulation of the clay suspensions of the marl loam was already brought about by 0.04 n solution.

Illustration 36 shows the results of the experiments with the three main levels of the Podsol soil. The permeability for NaCl in solution was smallest in the marl loam, followed by level A ; level B has the greatest permeability, however, although even here in the first few days 15-19 cm. per day was not exceeded, which amounts are much smaller than those of the experiments with $Ca(HCO_3)_2$ and $CaSO_4$ solutions. From the 8th day onwards we see strong and steep reduction of the permeability ; the line resembles that obtained by D. J. HISSINK 4.) in his experiments with distilled water after previous filtration of the common salt. After 8 days, in my experiments, I loosened the soil in the test tubes with copper wire about 1 mm. thick, but continued the filtration of the normal NaCl solution. Such loosening of the soil had no injurious effect on the filtration of the $Ca(HCO_3)_2$, $CaSO_4$ solutions and the distilled water in the above experiments, but with NaCl the influence was very great. From this it is to be seen that common salt solutions, even in strong concentrations, cause alterations in the qualities of the soil. It is characteristic that after the loosening of the soil the permeability of level A was the greatest, then followed that of level B, and it fell greatly in the marl loam of level C, which here also was not helped by the high contents of $CaCO_3$. Here the filtrate through the marl loam was very alkaline.

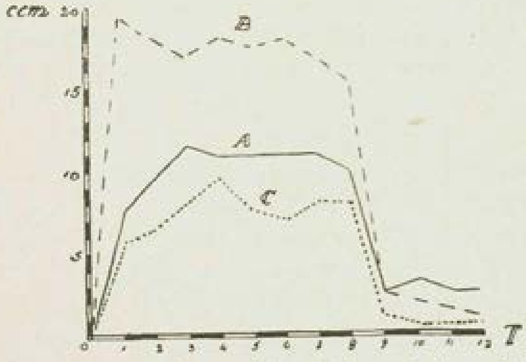

FIG. 36. — Experiments with n NaCl = solution with levels A, B and C of the Podsol soil (C = rubble loam).

It may be taken that in this experiment the circumstance of the absorbed soil cations towards Na and hydrolytic decomposition is of the greatest importance. It must be taken into consideration that the reaction of the first two levels is acid, and here, under the influence of NaCl, small quantities of HCl appear. If other salts are also present in the solution, the HCl, even in very small concentrations, assists coagulation. According to GEDROIZ (5) $H_2SO_4$ has a coagulating effect even in concentrations of 0.000075 normality. The action of common salt on marl loams might be quite otherwise. As an electrolyte with different anion and cation, NaCl has here increased the dissociation of the $CaCO_3$. In the solution might form certain quantities of $OH^{\bullet}$ ions, perhaps even NaOH, whose influence on the increase of dispersiveness is particularly great. The quantity of filtrate through marl loam only amounted to 60 ccm. in the first 8 days; it is difficult to suppose that NaCl could exchange even greater quantities of $Ca^{\bullet\bullet}$ for $Na^{\bullet}$.

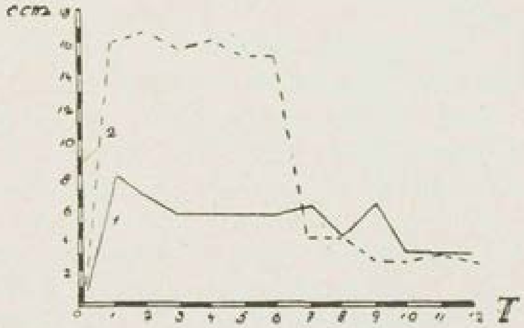

FIG. 37. — Experiments with n NaCl solution in Gley loams.

1. ———————— Gley loam from Kasdanga.
2. ---------------- Gley loam from Sigulda.

The results of simultaneous experiments with gley loams are represented in Illustration 37. It must be pointed out here that the permeability of the very acid I. gley loam from Kasdanga, which is rich in the finest constituent parts, altered very little after 8 days from the loosening of the soil; on the other hand the permeability of the II. gley loam from Sigulda was already reduced a day before the loosening, to fall still more strongly after the loosening. The permeability of the neutral, upper level from Kauzmünde was already reduced after 7 days. The reduction was especially great, however, after the loosening of the soil (8th day). The experiments carried out show that in comparison with very weak $CaSO_4$ and Ca $(HCO_3)_2$ concentrations, the common salt as such greatly reduced the permeability, the reduction being much greater, and proceeding more quickly in soils carrying $CaCO_3$ than in acid soils. As under the influence of the NaCl the content of absorbed $Na^{\cdot}$ ion is greater, it is obvious that in the further course of the experiment, and particularly on filtration of $Ca(HCO_3)_2$ the results can only be relative. We have already seen that in the experiment with gley loam from Kasdanga, which, with the filtration of $Ca(HCO_3)_2$, from 100 g. soil gave to the filtrate 0.0108 g. $Na_2O$. In the filtration experiments this gley loam with $Ca(HCO_3)_2$ gave smaller quantities of filtrate than with distilled water.

## VII. — GENERAL CONCLUSIONS.

The results obtained can be summarized briefly as follows:

1. Great fluctuations of permeability (quantities of filtrate per day) could be observed. In sandy soils the permeability may fall, in the conditions of the experiment, to 0.1 ccm. per day from 2 litres, in loam and gley soils it fluctuates from 0-200 ccm. per day. *The mechanical composition of the soil* offers only a small clue to its permeability

2. The fluctuations of permeability are greater in the loam soils the more these contain finest particles of such a size of grain as are not deposited in 3 weeks after raising the degree of dispersiveness. The fluctuations of permeability of those soils, which contain few grains of this arrangement of size, as for example level A of the Podsol soils, are relatively small, but the permeability is also small even under the action of electrolytes.

3. The permeability is in time considerably reduced by distilled water, in acid soils filtration ceases completely after a few months, as also in the neutral humus level ; in marl loam, however, it is only reduced, and still goes on after 1 to 1 ½ years from the beginning of the experiment. The explanation is to be sought in the combinations which are released from the soil by water : in acid soils the $Na''$ ion has the first place, but in the marl loam the $Ca^{\cdot\cdot}$ ion. If before the experiment the acid soil is neutralized, and $Ca(OH)_2$ filtered through it, then the filtration of the distilled water proceeds much better, and does not cease even after a few months.

4. The filtration of water containing greater quantities of $CO_2$ proceeds much better than that of distilled water. With that the permeability of marl loam with high $CaCO_3$ contents is particularly increased ; in acid soils the difference is smaller, but is very noticeable if the $CO_2$ content reaches 0.5 g. to the litre.

5. The permeability for 0.02 n $Ca(HCO_3)_2$ solution is very different, and is very greatly influenced by the absorbed $Na^{\cdot}$ ion content of the soil. The permeability of the marl loam is very good for this solution, if there is still no podsol soil developed on it, or if it is taken from deeper levels. The permeability for this solution is

also good in level B of the podsol soil, whilst the permeability of the upper level of the acid soil is pretty small, which may well be explained by the strong absorption of the $Ca^{\cdot\cdot}$ ions. Very great differences of permeability for this solution are also observed in the gley loams. The permeability of the gley loam from Kasdanga, which contains considerably more absorbed $Na^{\cdot}$ ion, is very small, even smaller than for distilled water. If before the experiment the lime-marl is removed and at the same time the absorbed $Na^{\cdot}$ ion partially removed, then the permeability is distinctly greater.

It must also be noted that the $Ca(HCO_3)_2$ solution also contained free $CO_2$, with which the content of $CO_2$ showed great fluctuations, which might also influence the permeability.

6. The permeability for gypsum was fairly similar to that for $Ca(HCO_3)_2$, except for the marl loam on which podsol soil had developed, and the gley loam from Kasdanga; these are soils which contain great quantities of absorbed $Na^{\cdot}$ ion. The permeability was also good for gypsum in these soils, because in the exchange reaction not much $NaHCO_3$ could arise.

7. Especially great influence on the raising of the permeability in very acid gley loam (from Kasdanga) was exerted by such solution as contained $CaSO_4$ and $Ca(HCO_3)_2$ together, and therefore considerably more gypsum than hydro-carbonate of calcium. *The permeability of the very bad gley loam was in this case very greatly increased.*

8. The permeability of the neutral soils is very greatly raised by $Ca(OH)_2$ and remains very great for some months. The permeability of the very acid soils, on the contrary, is quickly reduced, and relatively quickly the filtration ceases completely. Where the permeability of the soil in the foregoing experiments has been found very low, it is not always possible to raise it to an appreciable extent by the application of $Ca(OH)_2$ solutions.

9. The permeability is considerably reduced by $NaHCO_3$ solution of even very weak concentration. If the soils contain no $CaCO_3$, then the finest constituent parts are much washed out; in such cases the permeability is sometimes even increased, but after a few days is again reduced and filtration ceases completely. Level A of the podsol soil, which contains very small quantities of the finest constituent parts, is not very sensitive to $NaHCO_3$. The negative influence of $NaHCO_3$ is greatest in gley soils with which the structure suffers most, if the gley soil contained any before the experiment.

An injurious influence is exerted even by concentrations of 0.00003 n $NaHCO_3$, i. e., less than 0.003 g. to the litre.

It is to be expected that even very diluted solutions of ammonia may have a retarding action on the permeability, especially those of the marl loams and clay soils. The degree of dispersiveness of the marl loams is already notably increased by very diluted ammonia solutions such as 0.0003 n, and the decomposition of the carbonate of calcium is even reduced by 0.0001 n ammonia solution.

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# A CONTRIBUTION TO THE KNOWLEDGE OF THE DETERMINATION OF SOIL FERTILITY.

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The life of micro-organisms in the soil is the result of the phenomenon of assimilation in its entirety. The vital processes are characterized by the rearrangement of the chemical molecules in the living being and by a constant exchange between latent and kinetic energy. The carbo-hydrates contained in the soil, as also the nitrogenous organic substances, are assimilated, and exchange takes place in the cells of the carbo-hydrate and albumen. A part of the carbon and nitrogen is used to build up new living molecules, but the greater part of the carbon, in the form of carbohydrates and albumen, gradually disappears in the process of oxidation.

The decomposition products, being poisonous, are rejected by the cells, or deposited in a harmless form. The quantity of carbon-dioxide exhaled by the soil when there is free admission of air, shows us the living energy of the bacteria, as does also the easy decomposition of the organic substances in the soil. The heterotrophes find in the organic substances not only a source of energy for their breathing process, but also carbon and nitrogen food sources for building up new living material.

In the bio-chemical analysis of the soil, the concentration of hydrogen ions in the soil must always be kept in view. The absorbent, unsaturated soils of humid districts, which are rich in humus and colloidal clay, usually show an acid character. The following data plainly prove how both the number of the vegetative spores, of the bacteria in the soil, and also the quantity of carbon-dioxide exhaled by the soil, are influenced by the active acidity of the soil. The experiments were carried out for 24 days in soil with 20 % water at 20° C.

From these data it can be seen how important it is to observe the concentration of the hydrogen ions of the soil when making the experiment. Soils, the acidity of which rises to $pH = 4.7 - 4$, are very rich in easily decomposed organic substances, but the acidity is so great that the bacteria cannot develop sufficiently.

TABLE I. — *Influence of the acidity of the soil on the number of bacteria and on the quantity of carbonic acid in the soil.*

| pH | Carbon contents of the soil in dry substance | Average quantity of carbon-dioxide exaled by 1 kg. of soil in 24 hours | Number of vegetative spores of the bacteria in 1 g. of soil |
|---|---|---|---|
|  | % | mg. | Millions |
| 7.2 | 2.58 | 85 | 78 |
| 6.9 | 2.17 | 90 | 76 |
| 6.6 | 1.93 | 66 | 52 |
| 5.8 | 2.64 | 48 | 20 |
| 5.3 | 1.87 | 22 | 16 |
| 4.7 | 2.88 | 9 | 8 |
| 4.0 | 3.16 | 5 | 6 |

With a concentration of hydrogen ions pH = 4, the number of bacterial vegetative spores varies, between 4 - 6 millions per 1 g. soil.

By the addition of calcium carbonate, namely, from 25-50 g. per 1 kg. soil, the acidity is neutralised, and the bacteria then find in the organic substances a good source of energy. The organic acids then no longer hinder bacterial assimilation. I append an example of this:

The peat soil of Sadskâ, which is not rich in ferro- and ferri-sulphates, has an acidity of pH = 4.2. This soil, with 20 % water, exhaled 8 mg. carbon-dioxide per 1 kg. in 24 hours at 20° C. Following the addition of calcium carbonate, namely, 50 g. per 1 kg. of soil, the quantity of carbon-dioxide exhaled under the above conditions rose after 30 days to 21.4 - 27 mg.

All organisms in the soil, require, for the construction of new living substances all the other biogenous elements in addition to carbon, which is always contained in the organisms up to 42-48 %. The form in which the biogenous elements, particularly nitrogen, are offered to the soil is not unimportant. In arable, meadow, wood and garden soils, types of bacteria predominate which either assimilate nitrogen from easily soluble substances containing nitrogen, or such as give the preference to ammonia salts, or bacteria which prefer nitrates. The rise in the intensity of breathing of the bacteria in various kinds of soil following the addition of organic or inorganic combinations containing nitrogen, depends on the character of the bacteria which predominate in the soil concerned. We have undertaken experiments in our experimental fields, also in the various arable and wood soils of Czecho-Slovakia, on the effect of mineral, nitrogenous manures on the breathing intensity of the soils. I give here only a few examples, in order to show the different effects produced by manuring with sulphate of ammonia and Chili saltpetre on loamy, sandy soils, loamy lime soils, clay soils and humus soils.

The fact certainly remains that the application of mineral, nitrogenous manures increases the breathing intensity of the microorganisms of the soil, particularly in such soils as contain easily decomposed organic substances in sufficient quantity.

TABLE II. — *The quantity of carbon-dioxide produced in 24 hours from 1 kg. soil with 20 % water, at 20° C., and with 20 l. of air being passed through. In mg.*

| Kind of soil | Unmanured soil | Soil manured with 80 kg. nitrogen per hectare in the form of ***sulphate of ammonia*** | Soil manured with 80 kg. nitrogen per hectare in the form of Chili saltpetre |
|---|---|---|---|
| | mg. | mg. | mg. |
| Loamy sandy soil . . . . . . . | 15.5 | 30.6 | 35.9 |
| Loamy lime soil. . . . . . . . | 38.3 | 49.6 | 58.3 |
| Clay soil . . . . . . . . . . . | 27.5 | 32.4 | 35.8 |
| Humus soil . . . . . . . . . . | 32.6 | 36.6 | 44.2 |

From these data it can be plainly recognized what a great increase of breathing capacity the soil, especially the loamy lime soil, has acquired from the addition of sulphate of ammonia and sulphate of sodium. The breathing intensity was also raised with loamy sand soil and clay soil. The least effect was shown in humus soil.

The contents of carbon in the dry substance amounted to:

| | |
|---|---|
| in loamy sandy soil. . . . . . . . . . | 1.04 % |
| » loamy lime soil . . . . . . . . . . . | 1.16 % |
| » clay soil. . . . . . . . . . . . . . | 1.53 % |
| » humus soil . . . . . . . . . . . . | 3.28 % |

By the constant use of mineral, nitrogenous manure, the humus substance in the soil is broken up to carbon-dioxide, and so the soil always suffers a shortage of carbon. The same appearance was shown on the application of superphosphates. The experiments were carried out in the same manner, and with the same soils as in the experiments with nitrogen, except that 60 kg. of phosphoric acid in the form of superphosphate were used per hectare. In the following table the breathing intensity of the manured and unmanured plots of the various soils is quoted:

TABLE III. — *The quantity of carbon-dioxide, in mg., produced on an average in 24 hours from 1 kg. soil with 20 % water, at 20° C., and with 20 l. of air being passed through.*

| Kind of soil | Unmanured soil | Soil manured with 60 kg. phosphoric acid in the form of superphosphate |
|---|---|---|
| Loamy sandy soil | 15.8 | 19.4 |
| Loamy lime soil | 39.6 | 43.7 |
| Clay soil | 27.5 | 30.8 |
| Humus soil | 32.6 | 45.6 |

These data show that even with the addition of phosphoric acid soluble in water, an increase in the breathing capacity of the soil is effected, and this increase is greatest in the humus soils. Then follow loamy lime soil and sandy soil.

We have found in our laboratory experiments, and those on the experimental fields, that the increase in the production of carbon-dioxide with the use of stable manure is effected on one side by the native active bacteria of the stable dung, and on the other by the supply of its organic easily decomposed substances. This raising of the breathing intensity depends not only on the number of bacteria, but also on the degree of capacity for decomposition of the organic substances contained in the stable dung. In order to produce an increase of activity in the bacterial world in the soil the food molecules must split up into easily oxidizable decomposition products.

The stable manure must be so treated that it brings about a certain fermentation in the sense of oxide reduction. The decomposing processes of the organic substances are occasioned by the intermolecular respiration. *The action of the stable manure depends not only on the quantity used, but on the quality of the decomposable organic substances and on the activity of the bacteria.*

Even small quantities of stable manure can effect a notable increase of the respiration processes of the microorganisms. On our experimental fields we have carried out experiments regarding the increase of carbon-dioxide production of the soil by stable manure. The soil of the experimental fields was a good loamy soil, which, calculated on the dry weight, showed a carbon content of 1.8 % and a calcium carbonate content of 0.3, and in 1 g. contained 46 million bacterial vegetative spores. The unmanured soil exhaled on an average 4.02 g. of carbon-dioxide per square metre in 24 hours. On the application of 200 quintals to the hectare of well treated stable manure containing 40 kg. nitrogen, an average of 5.03 g. carbon-dioxide per square metre in 24 hours was exhaled from the soil by diffusion. The experiment lasted 15 days. Air was conducted through the bell 6-8 hours daily.

On the application of 400 q. stable manure per hectare containing 80 kg. of nitrogen, 6.59 g. carbon-dioxide per square metre were exhaled in 24 hours by the same methods of experiment.

In order to prove that stable manure, in its action of increasing the production of carbon-dioxide, cannot be replaced by nitrogenous fertilizers, we have at the same time carried out manuring experiments with Chili saltpetre. We again used, as in the experiments with stable manure, 80 kg. nitrogen per hectare. After 15 days observation 5.58 g. carbon-dioxide per square metre was produced in 24 hours.

With the control plots, where no stable manure and no nitrogenous fertilizer was used, the production of carbon-dioxide amounted to 4.02 - 4.01 g. per square metre in 24 hours.

The experiments were proceeded with steadily for 30 days after the manuring with stable manure, urea or Chili saltpetre commenced, and were carried out in the month of September.

By the experiments made, our opinion which we had already expressed in the year 1906 was confirmed, namely, that stable manure is to be regarded as the best producer of carbonic acid. It was certainly of great interest to learn how green manuring affects the carbon-dioxide production of the soil. In these experiments we again used the same soil as in the experiments with stable manure, and made use of so much organic substance of *Lupinus luteus*, that there was again added the soil 80 kg. nitrogen per 1 ha. in the form of green plant manure. The green plant substance of *Lupinus luteus* was superficially ploughed into the loamy soil, and after 30 days the carbon-dioxide production of the soil was ascertained. By a 10 days' analysis it was determined that *on* *an average* 5.03 *g. carbon-dioxide per square metre of soil was produced in 24 hours.*

In the experiments with stable manure we ascertained that, after the addition of 80 kg. nitrogen per hectare, in the form of stable manure, there was, after 15 days' observation, an average production of carbon-dioxide by the soil of 6.59 g. per square metre in 24 hours. By manuring with stable manure, therefore, the respiration intensity obtained is much greater than by green manuring, namely, by 1.56 g.

According to our investigations, every cultural plant possesses its own specific characteristics in the processes of photosynthesis and assimilation. This is to be traced to the dissimilar working efficiency of the cells containing chlorophyll and the cells without chlorophyll of the various plant organisms. Only now can we form a conception of the enormous quantities of carbon-dioxide assimilated out of the air under the influence of the sun. If during the development of the cultural plants the climatic vegetation factors are at a minimum, then of course the photo-synthesis sinks, and nitrogen, phosphorus, chlorine, sulphur, potassium, magnesia, aluminium, iron, etc. cannot be used so largely for the synthesis of cell building as they can when the vegetation factors are at their highest. On the climatic vegetation factors, therefore, depends the whole assimilation of the carbon-dioxide from the air, as also the resorption of the mineral foodstuffs out of the soil, and therefore the total working efficiency of the plant. In our case 96.8 q. carbon, 1.68 q. nitrogen, 2.20 q. oxide of potassium and 0.6 q. phosphoric anhydride were resorbed and used for the synthesis of cell building. For every 100 kg. of the assimilated carbon there escaped barely 1.74 kg. nitrogen, 2.27 kg. oxide of potassium and 0.62 kg. phosphoric anhydride. If the assimilation of carbon falls, then naturally the nitrogen, phosphorus, potassium etc. will not be sufficiently utilized, and will remain for the greater part in the soil for future vegetation. The resorption of the mineral food material from the soil is connected therefore in a certain way with the building and reconstruction of the cell contents.

It is a fundamental fact that under the natural conditions of growth, with the present state of the cultivation of the soil and the culture of plants, the carbo-hydrate factor is generally at a minimum. It has already been plainly proved by the investigations of FODOR, WOLLINY, STOKLASA, BORNEMANN, FISCHER, REINAU and LUNDEGARDH that by the respiration of the soil an enrichment of carbonic acid is effected in the ground layer of the atmosphere. The carbon-dioxide, which escapes from the soil by diffusion, owes its origin to the respiration of the *Auto-* and *Heterotrophes* in the soil. The results of our experiments, obtained 30 years ago, plainly show that a great deal depends, on whether the soil is well cultivated mechanically, manured and tilled, or not. Further, it is not a matter of indifference with what genus of cultivated plants the soil is planted. We were able to observe greater respiration energy of the micro-organisms in soil planted with beetroot and potatoes, than with soils set with cereals. The ascertained degree of air capacity, with all the soils investigated by us, stands intimately related to the quantity of carbon-dioxide exhaled. The greater the air capacity of the soil, the greater the respiration intensity of the micro-organisms in the soil. The determination made by us 30 years ago of the life activity of the *Auto-* and *Heterotrophes* in the soil, by measuring the quantity of carbon-dioxide exhaled, is a reliable method for ascertaining the intensity of the process of exchange of matter of the *Auto-* and *Heterotrophes* in a given quantity of soil. The quantity of carbon-dioxide produced in a given time, at a given degree of humidity, and at a fixed temperature, gives us an exact picture of the size and the mechanics of the physiological combustion. The respiration intensity shows that there is present in the soil not only a considerable quantity of active bacteria, but also decomposable organic substances. By taking into consideration all the factors just mentioned, the quantity of carbon-dioxide produced on an average in 24 hours from the micro-organisms of various kinds of soil gives us a means of comparison for the output of the micro-organisms in the soil. We find that the respiration intensity of the various micro-organisms varies extraordinarily, and is dependent on different vegetation factors. The quantity of exhaled carbon-dioxide is an indicator of the fertility of the soil. On the basis of our observations, we can maintain that with soils of a different degree of fertility, the quantity of carbon-dioxide exhaled per 1 kg. soil in 24 hours, with 20 % water contents, and at 20° C., varies tremendously. The results obtained from observations and analyses, extending over many years, on arable soils of Bohemia and Moravia, are put together in the following table :

TABLE IV. — *Quantity of carbon-dioxide exhaled from the soil, as a measure of fruitfulness.*

| Nature of soil | Quantity of carbon-dioxide per 1 kg. soil in 24 hours | Quantity of carbon-dioxide per hectare in 200 days from a layer 30 cm. deep | Carbonic acid, reckoned on the lower limit of $CO_2$ production at the time |
|---|---|---|---|
| | mg. | q. | q. |
| Fruitful soils which bear, per hectare 25-30 q. corn, 350-400 q. beet . . . . . . . . . . . . . | 60 – 120 | 480 | 131.08 |
| Less fruitful soils . . . . . . . | 30 – 60 | 240 | 65.54 |
| Unfruitful soils . . . . . . . . . | 15 – 20 | 120 | 32.77 |

The carbon-dioxide is in part exhaled from the ground by diffusion, partly absorbed by the water and the carbon is redeposited in the soil in the form of bicarbonates.

In any case the quantities of carbon-dioxide produced from various kinds of soil, which escape from the soil by diffusion, are of interest. According to our investigations, when the temperature of the soil planted with various cultures is 13 - 17° C., this amounts to:

TABLE V. — *Carbon-dioxide production of various kinds of soil.*

| Kind of soil | Carbon-dioxide per 100 kg. in 24 hours | Carbon-dioxide per ha. in 200 days | Carbonic acid production in |
|---|---|---|---|
| | g. | q. | q. |
| Fruitful soils. . . . . . . . . . | 6 – 8 | 120 – 160 | 32.73 – 43.63 |
| Not very fruitful soils. . . . . . | 4 – 5 | 80 – 100 | 21.82 – 27,27 |
| Unfruitful soils. . . . . . . . . | 2 – 3 | 40 – 60 | 10.91 – 16.36 |

We see what extraordinary quantities of carbon-dioxide are produced from the soil in 200 days, and what fundamental importance the respiration of the soil must have for the nourishment of the cultural plants. The plants are not exclusively dependent on the carbon-dioxide contents of the free atmosphere, but the leaves also assimilate the carbon-dioxide escaping from the soil, and so a great addition of carbon is made possible for the plant organisms.

Of course, an increased respiration of the soil means also an increased demand for a store of humus in the soil, for which the organic residue of the individual kinds of our cultural plants does not suffice. The total quantity of stubble and root remains which are left in the fields after the harvest, although considerable, are not sufficient.

TABLE VI. — *Stubble and root residue left per hectare.*

| Kind of plant | Dry weight of the plant substance | Carbon content | Carbon |
|---|---|---|---|
| | kg. | % | kg. |
| Rye | 4328 | 44.8 | 1938.94 |
| Wheat | 4316 | 49.7 | 2145.05 |
| Oats | 4285 | 49.1 | 2103.93 |
| Barley | 4894 | 50.6 | 2449.93 |
| Red Clover | 9163 | 46.9 | 4297.44 |
| Lucerne. | 11432 | 45.2 | 5167.26 |

These figures show plainly the quantities of carbon which remain in the stubble and root residues of the individual cultivated plants, and how important it is to put clover and lucerne in the crop rotation. In all countries in which clover and lucerne are little cultivated, as for example in some districts of Czechoslovakia, Poland, Jugoslavia, etc., the carbon content sinks, and even manuring with phosphoric acid and potash cannot be utilized with full effect. By the influence of the organisms in the soil the withered root system is gradually decomposed, the celluloses, pentosanes, etc. hydrolysed and further decomposed (1).

It must in any case be taken into consideration that by the bio-dynamic processes of the micro-organisms in the soil, a certain quantity of carbon is collected in the vital layer of the soil, though here it is only a question of a few hundredweights per year. It has so far been impossible to determine the exact quantities satisfactorily.

The deeper we penetrate into the knowledge of the processes taking part in the bio-dynamics of the micro-organisms of the soi the more we get the impression that the micro-organisms in the soil in a certain sense co-operate. This applies particularly to the autochthonal flora according to WINOGRADSKI, and the microbes occurring in the soil in the form of spores, and which only have the opportunity of vegetative growth by alterations in the soil, or under the influence of added inorganic manure, such as nitrate of ammonia, nitrate of potassium, nitrate of soda, calcium-nitrate, sulphate of ammonia, and of organic substances such as urea, organic plant material and stable manure, also phosphates, as we have already mentioned. The activity of the bacteria, fungi, actinomycetes and protozoa depends mainly on the decomposition of cellulose which is easily decomposed and of lignin which is very resistant to decomposition, because the cellulose represents a very important carbonaceous material for the provision of energy and the exchange of matter of the micro-organisms of the soil. If besides cellulose there are merely small quantities of nitrogenous organic substances in the soil, then the process of decomposition is quite different to that shewn in the presence of large quantities of nitrogenous organic and inorganic substances and easily soluble phosphoric acid. In this case the cellulose is much more energetically decomposed, and the intermediary products formed by the decomposition of the cellulose and the nitrogenous organic substances will serve as valuable material for building up new living molecules of the micro-organisms. SELMAN A. WAKSMAN (2), in his classic work "The soil population", has described these living processes of the bacteria in an excellent manner. When all vegetation factors are present, the vitality of the bacteria rises energetically, and the organic substances are quickly decomposed.

*Assuming that the soil contains even* 2 % *carbon, then* 1 *ha. of soil, to a layer of* 30 *cm., contains* 80 000 *kg. carbon. If the fertile soil exhales* 40 *q. of carbon in* 200 *days, then, if no replacement of the carbon takes place, the store of carbon in the soil would be exhausted in* 20 *years. The carbon content of the stubble and root residues of our cereals is not sufficient to cover the deficit. The farmer sees here how extraordinarily important it is to keep the carbon ratio constantly in view.*

We are compelled always to introduce organic substances along with mineral manures, because the organic substances in the soil are much more energetically decomposed in the presence of nitrogen, phosphorus, potassium, calcium and iron. By the conveyance of easily decomposable organic substances, and a great number of active, rhizo-spherical bacteria in the form of bacterial manures, the production of carbonic acid is uncommonly increased, the formation of bicarbonates in the soil proceeds very energetically, and the fertility of the soil is raised.

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## NOTES AND LITERATURE.

(1) A striking difference is seen in the development of the garden flora on the coasts of Istria and Dalmatia as compared with the French and Italian Riviera. On the French and Italian Riviera a great quantity of stable manure, especially horse dung, is used; in Istria and Dalmatia, on the contrary, relatively very small quantities. On the French and Italian Riviera the soil contains 1.3-2.4 % of carbon and, calculated in dry weight, 40-110 million active bacteria per 1 g. The soil in Istria and Dalmatia contains 0.5-0.6 % carbon, and, calculated on the dry weight, 10-20 million bacteria per 1 g. of soil. The poor results in the cultivation of garden plants on the coasts of Istria and Dalmatia can be explained by the bad heating of the soil in the night. The samples of soil from the French and Italian Riviera, which were taken from a depth of 30 cm., exhaled on an average 70-120 mg. carbon-dioxide per 1 kg. in 24 hours, with 20 % water-content, at 20°C. The soil in Istria and Dalmatia, on the other hand, under the same conditions, exhaled on an average scarcely 30 mg. carbon-dioxide.

(2) SELMAN A. WAKSMAN: The soil population. *Proc. of the Nat. Acad. of Sciences* (U.S.A.), Vol. 11, No. 8, p. 47.

# ON THE DEGREE OF HUMIFICATION OF THE DEAD COVERING OF FOREST SOILS.

by ANTONIN NEMEC, *Prague*.

The nutrition of trees in the forest depends, to a great extent, on the quantity and the composition of the nutritive matter contained in the superficial layers of the dead matter covering the ground and of forest humus. The organic matter which covers forest soils, contains an abundant reserve of nutritive elements; this absolute wealth, however, has only a very relative importance for them. To get a more precise idea of the quantity of organic matter which the trees can profit by, it would be necessary to determine the proportion of organic matter utilizable by plants. The appearance of the different forms of forest humus originating under different kinds of forest trees demonstrates to us considerable differences in the chemical composition of the organic matter and in its aptitude for being subjected more or less readily to the processes of natural decomposition. To make clear the different degrees of decomposition of the dead covering and humus which is formed under the different species of forest trees, I have tried, in the present paper, to apply a new laboratory method enabling the degree of humification of organic matter to be determined.

By causing a 6 per cent. solution of peroxide of hydrogen to act on forest humus and by boiling the liquid at a moderate temperature, it is possible to render the humified organic matter soluble in water, while fibrous organic substances, such as cellulose and lignin remain intact. According to ROBINSON (1) by the action of oxygenated water the humified matter undergoes oxidation and is brought to a condition of soluble compounds, while the attack on fibrous substances remains negligible.

In the following table the results of my experiments on the humification of the superficial layers of humus and vegetable mould rich in organic matter from the forests of spruce, Scots pine and pedunculate oak in the forest of Jirny near Prague, is summed up. These results are compared with the intensity of nitrification, ex-

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(1) ROBINSON, G. W. and JONES, J. O. *Journ. of Agric. Science*, 15, p. 26, 1925.

pressed as difference between the initial content in nitric nitrogen and that after the sample examined had remained for 30 days in a conical phial under laboratory conditions.

TABLE I. — *Forests of spruce, Scots pine and pedunculate oak. Forest of Jirny.*

| Species of forest | Percentage of organic matter in the dry substance | Percentage of humified matter | | Active acidity pH | Nitrogen of nitrates mg. per 1 kg. of dry substance. Difference after nitrification |
|---|---|---|---|---|---|
| | | in dry substance | in organic matter | | |
| Spruce, 100 years, soil covered with moss. | 54.16 | 12.83 | 23.69 | 3.8 | — 10.25 |
| Spruce, 90 years, soil covered with moss . | 51.20 | 30.69 | 59.94 | 4.8 | — 4.37 |
| Spruce, 100 years, open, soil covered with moss. . . . . . . . . . . . . . . . | 31.21 | 20.62 | 66.07 | 5.0 | — 0.80 |
| Spruce, 70 years, close, soil without vegetation . . . . . . . . . . . . . . . | 30.64 | 21.16 | 69.04 | 5.6 | + 4.71 |
| Scots pine, 60 years, veget. moss . . . | 22.59 | 4.16 | 20.66 | 3.2 | — 6.00 |
| Scots pine, 120 years, veget. moss, grass . | 18.39 | 6.42 | 34.90 | 4.2 | — 0.50 |
| Scots pine, 100 years, veget. moss, grass underwood of oak 10 years . . . . . . | 48.37 | 30.02 | 62.06 | 5.4 | + 3.20 |
| Scotspine, 30 years, veget. grass underwood of oak 20 years . . . . . . . | 21.01 | 12.72 | 60.57 | 6.2 | + 9.77 |
| Ped. oak, 100 years, veget. moss, grass. . | 23.19 | 11.33 | 48.86 | 5.0 | — 13.26 |
| Ped. oak, 80 years, open, underwood oak 10 years, veget. grass . . . . . . . . | 34.33 | 18.49 | 53.86 | 5.2 | + 1.96 |
| Ped. oak, 80 years, open, veget. grass . . | 52.56 | 33.00 | 62.78 | 5.7 | + 3.75 |

It is seen from the data in Table I that the proportion of humified matter contained in its entirety in organic matter increases in the cases examined of the humus of spruce, Scots pine and pedunculate oak, with the decreasing acidity of the vegetable mould.

The strongly acid layers of the dead covering under close growing conifers and pedunculate oak hardly produce any nitric nitrogen, with the exception of the more open forests with sweeter humus richer in humified matter, although the intensity of nitrification always remains very low.

Tables II and III include the results of experiments in the forest region of St. Margueritte near *Jindřichiw Hradec* and in the region of *Třemošnice* near Čáslav in Bohemia.

TABLE II. — *Forests of St. Marguerrite near Jindřichiw Hradec, Bohemia.*

| Species of forest | Percentage of organic matter in the dry substance | Percentage of humified matter | | Active acidity $p^{H}$ | Nitrogen of nitrates mg. per 1 kg. of dry matter. Difference after nitrification |
|---|---|---|---|---|---|
| | | in dry substance | in organic matter | | |
| Ped. oak, 80 years with underwood of beech. Soil without vegetation . . . | 38.78 | 32.04 | 82.62 | 5.9 | 43.85 |
| Spruce, 80 years, close. Soil without vegetation . . . . . . . . . . . . . | 42.49 | 17.32 | 40.76 | 4.1 | 2.66 |
| Oak, beech, silver fir, spruce. Hartig's felling area, 70 years. Soil without veget. | 45.07 | 24.86 | 55.16 | 4.9 | 14.15 |
| Scots pine, 70 years, without underwood . | 81.34 | 31.39 | 38.59 | 4.2 | 14.03 |
| Scots pine, 60 years, with underwood of beech, 20 years . . . . . . . . . . | 64.00 | 35.37 | 55.27 | 5.4 | 21.72 |

TABLE III. — *Forests of Třemošnice near Časlav in Bohemia.*

| Species of forest | Percentage of organic matter in the dry substance | Percentage of humified matter | | Active acidity $p^{H}$ | Nitrogen of nitrates mg. per 1 kg. of dry matter. Difference after nitrification |
|---|---|---|---|---|---|
| | | in dry substance | in organic matter | | |
| Spruce, 90 years, soil without vegetation. | 52.38 | 16.28 | 31.08 | 4.0 | — 9.00 |
| Spruce, 70 years, soil without vegetation. | 69.29 | 29.39 | 33.88 | 4.8 | 12.63 |
| Clearing of spruce forest 2 years after deforestation. Vegetation: — *Epilobium angustifolium*, *Rubus idaeus*, *Deschampsia flexuosa* etc.. . . . . . | 34.21 | 28.13 | 82.23 | 5.4 | 108.03 |
| Beech, 70 years, soil without vegetation . | 43.47 | 22.14 | 50.93 | 5.2 | 0.17 |
| Beech, spruce, Scots pine, 70 years soil without vegetation . . . . . . . . . | 36.85 | 18.34 | 49.77 | 5.1 | 33.40 |
| Hornbeam, young coppice of 20 years. | 25.25 | 17.52 | 69.27 | 5.6 | 99.06 |
| Beech, hornbeam, maple, ash, young coppice of 20 years . . . . . . . . | 18.17 | 13.25 | 79.92 | 6.0 | 49.87 |
| Beech, maple, hornbeam, ash, high forest of 70 years. *Anemone nemorosa*. . . | 28.72 | 21.94 | 76.39 | 6.5 | 193.98 |

It appears from the above mentioned experiments (Tables II and III), that the layers of humus in broad-leaved forests generally show a very considerable degree of humification and at the same time a lively intensity of nitrification.

The acid humus of conifers, exposed to the action of sunlight is more easily rendered soluble than that found under the dense shade of the crowns of the standing trees.

In high forests of Scots pine, the favourable influence of the beech underwood is shown by the greater degree of humification of the superficial layer of humus. The same observation appears from the comparison of close grown forests of conifers with mixed stands composed of broad-leaved species and species with persistent leaves.

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## *Abstracts and Literature.*

### General.

#### A New Soil Core Sampler.

POWELL, E. B. (Missouri Agr. Exp. Sta.), *Soil Science*, Vol. XXI, pp. 53-57. Baltimore, Md., 1926.

The author describes a sampler that would take an undisturbed core of soil with the desired dimensions. The sampler consists essentially of two cylinders, one within the other, the outer one being furnished with cutting knives. A diagram of the sampler with a detailed description of its construction and two photographs are given in the article. Anyone especially interested can make arrangements with the Agricultural Experiment Station Columbia, Mo., U. S. A. to secure blue prints and specifications of this sampler. J. S. JOFFE.

#### Tschermak's Mineralogical and Petrographic Review.

New Series ; Vol. 38 ; 623 pages ; 93 illustrations ; 11 tables ; Published by Hölder-Pichler-Tempski A. G. Vienna 1925.

The 38th volume of this review appears as a special number in honour of the 70th birthday of FRIEDRICH BECK and as such is particularly well got up. Contributions have been sent by a large number of his former pupils, and of them this number contains thirty-five. Most of the contributions deal with mineralogical and petrographic problems, but to a soil-scientist the following will be of particular interest : (1) On the formation of the phosphates of lime in the gault of the Vorarlberg (p. 206-209) ; (2) On the weathering processes in the augite-porphyrites (melaphyres) of the Waldenburg highlands (p. 309-352) ; (3) Structure-statistics (p. 392-423) ; (4) On the numerical treatment of the structural properties of rocks

(p. 479-493) and (5) On the Cenomanian phosphate deposits in the Dnjester districts of Polish Podol (p. 599-609). In article (1) Schadler describes the diverse forms of occurrence of the phosphates of lime (phosphorites) in the glauconite sandstones and limestones. In article (5) Tokierski deals also with the phosphates. He describes the geological and petrographic relationships of the Podolian phosphates, and deals also with their chemical composition and their economic importance for Poland. Article (2) of Milch and Alaschewski forms a very valuable contribution to the knowledge of the relation between the habit, chemical processes and the changes in mineral composition of weathering rocks. Unfortunately lack of space prevents us from dealing with this most interesting paper in greater detail, but the reading of it can be recommended to every soil-scientist. The same applies to articles (3) and (4) on the structure of rocks which give very valuable suggestions when applied to soils. Hellmers.

## Soil Physics.

### On the Mechanical Analysis of Soils containing Heavy Minerals.

Marchand B. de C., *South African Journal of Science*, Vol. XVIII, pp. 223-226. Johannesburg, 1922.

In the Transvaal many red loams are derived from basic igneous rocks like norite and diabase, which in some places contain bands of magnetite. Such soils consequently also contain a relatively high percentage of heavy minerals, principally magnetite. The author has examined the fine gravel and sand fractions — where a separation of heavy minerals by Thoulet's solution is possible — and has found in the sand as much as 39 per cent. heavy minerals (30 per cent. magnetite).

It is clear that sedimentation and elutriation methods of mechanical analysis would not give a correct idea of the smaller sized fractions of such soils, such fractions no doubt containing also a high percentage of heavy minerals. The author sought after a method for reducing these soils to a common basis, but without success, it being impossible to separate the soil as a whole into heavy and normal particles. Malherbe.

### The Contribution to the Discolloidity of the Soil.

Smolík L. Přispěvek k diskolloidním proměnám v půdách, *Věstník Ceskoslovenscké Akademie Zemědělské*, p. 221. Prague, 1926.

The colloidal state of the soil is not constant. It depends on the action of temperature (freezing) on the different electrolytes (fertilisers) and on ploughing. These factors may modify the total surface and consequently the hygroscopicity which is proportional to it. The variability of the total surface of the soil has been studied in connection with the disthermical influences. The hygroscopicity has been determined as well as the absolute dessication of the soil after Rodewald-Mitscherlich, and the activity of catalase with the apparatus of Koenig. The author gives a few results:

1) The total surface of the soil particles is a function of the temper-

ature at which the soil was dried. The hygroscopicity of the soil decreases with increase of temperature. Air dried soils shrink about 11-15 % of their surface. This decrease of the active surface is, from a practical standpoint very important, for the production of nutritive substances in the soil after a hot summer. The total surface of soils dried at 50° and 100° is reduced only by about 0.7-5.6 %. With absolute dessication the surface is decreased by about one-fifth for mineral soils, and two-fifths for peat. It seems that the temperature has greater effect on the pectisation of humus than on that of other organic matter.

2) The activity of catalase of the dried soil decreases with hygroscopicity (except at a temperature of 50°).

3) Intermittent frost has little action on the shrinkage of the surface of air dried soils. On the other hand the surface of the moist soil is increased about 4 %. In the case of air dried soils the activity of catalase is decreased by about 3.5 $cm^3$ oxygen, in the case of moist soils by about 4 $cm^3$.

4) The leaching of electrolytes, if continued sufficiently (20-27 litres of water for about 150 gms. of soil) causes the peptisation of hydrogels, and the hygroscopicity increases about 10 %. The activity of catalase is also increased. When on the contrary the electrolyte content of the soil is increased, the total surface of the soil is decreased.

5) The variations in the colloidal state, which have begun under the influence of temperature, are only partly reversible, over a short period. AUTHOR.

### On the Chemical Changes in Granites under Moors.

BLANCK, E. and RIESER. A. *Chemie der Erde*, Vol. II, part 1, pages 15-48. Jena 1925.

This piece of work is a contribution to the elucidation of the question of kaolin formation. Before dealing with their practical work, the authors review critically all the different views propounded on the formation of kaolin. As the object for their investigation the authors chose "brocken" granite, and their investigations and analyses were not concerned only with the granite, but also with the overlying peat and moor-waters. They investigated also atmospherically weathering granite particles. The results of these investigations are given in numerous analytical tables. The authors conclude that the weathering of the "brocken" granite does not tend in the direction of kaolin, and also that the bleaching of the rock is caused by the sulphuric acid formed. HELLMERS.

### Effect of Various Methods of Applying Fertilisers on Crops and on Certain Soil Conditions.

COE DANA G. (Iowa State College), *Soil Science*, Vol. XXI, pp. 7-21. Baltimore, Md., 1926,

Fertiliser applications in direct contact on the ridge or in direct contact in the drill-row with seed are likely to be injurious to the best germination of the seed. Planters designed with fertiliser attachment for direct contact are not advised for use. In place of direct contact it is recommended to use the methods of " above the ridge or drill row " the " below the ridge or drill row " and the " sides of ridge or drill row " method. J. S. Joffe.

### The Effects of Various Methods of Applying Fertilisers on Crop Yields.

Coe Dana G. (Iowa State College). *Soil Science*, Vol. XXI, pp. 127-141. Baltimore, Md., 1926.

This is the second part of a study (see above first part) on the effect of various fertilisers, applied in different ways, on some important farm crops. The results do not warrant definite conclusions, neither do they allow the recommendation of a satisfactory fertiliser practice. The experiments indicate, according to the author, some very sound suggestions. Moderate applications of non caustic fertilisers gave the best returns by the direct contact in the seed rows method. Drilling of fertilisers as a separate operation to the seeding was not equal to the direct contact method. A second set of delivery tubes distributing the fertiliser above the seed served to safeguard germination, but failed to give the benefits desired. When broadcasting discing is important. J. S. Joffe.

### The Solid Acidity of the Soil.

De Dominicis, A. and Dojmi, S. (R. Istituto Superiore agrario di Portici). *Annali di Chimica applicata*, v. 15, No. 5, p. 183-206. Rome, 1925.

In the soil, bases may be found in a free or fixed state. The latter enter, in definite and constant proportions, into the composition of the molecule, forming part of the constitution of the crystalline and colloidal elements and cannot be separated without considerable chemical and structural alterations. The free bases, on the other hand, come at any rate for the most part, from the colloidal elements which cause them to be condensed by the action of a bond which differs from common chemical affinity ; from such compounds all characters of saline combinations are excluded.

Loss and impoverishment of bases in these compounds do not give them either the composition or function of acids or of acid salts. The peculiarity of abstracting the cation from electrolytes leaving the solution acid, is due in these conditions, to power of absorption. The energy of the absorbing power decreases in consequence of increase of the proportion of the fixed bases, which at a certain moment acquire the capacity of repassing into solution with very great ease. At this point, powers of absorption are still possible, inasmuch as the cations of the electrolytes go and take the place of the bases repassed into solution. The process, however, does not correspond to chemical reactions by double exchange.

Dissociation of the fixed bases cannot take place if the combinations from which they are derived, have not abandoned their coagulated condition. The increased degree of disjunction which results is the cause of such an intensification of absorbing power on the part of the soil that the condition arises of the soluble nutritives elements remaining too actively abstracted from the action of the roots. In protecting the free bases from being washed away, carbonate of lime acts precisely through its nature of coagulant electrolyte. The conditions which calcium compounds are required to correct in soils already impoverished in free bases, are not therefore caused by the properties of non-existent or inactive compounds of acid function. In these cases, the calcium compounds do not act as neutralizers, but, on the contrary, by the known mechanism of coagulation of the electrolytes, that is by bringing back the colloidal elements from the dispensed condition to the condition of coagulated "absorbed elements" and fixing them in that condition. A. F.

### Potassium Ferrocyanide and Ferric Ferrocyanide as Sources of Iron for Plants.

DEUBER C. G. (University of Missouri), *Soil Science*, Vol. XXI, pp. 23-26. Baltimore, Md., 1926.

The use of the compounds mentioned in the title as a source of Fe for *Spirodela polyrhiza* and soybeans in solution cultures with buffer mixtures gave the following results: with 0.033 and 0.056 parts per million in the form of potassium ferrocyanide the soybeans and *Spirodela* made fair growth. Higher concentrations of iron in this salt produced a slight stoppage of growth. MERCK's ferric ferrocyanide was a satisfactory source of iron for soybeans plants when the solution had a reaction of pH 5.0 but at less acid reactions growth of the plants and chlorophyll development was restricted. J. S. JOFFE.

### The Dynamics of Potash Assimilation by Potash containing Silicate minerals.

DOBRESCU-CLUV, J. M. *Chemie der Erde*. Vol. 2, Part 1. pages 83-102. Jena, 1925.

The absorption of food by a plant depends on the solubility of the given compounds in the available solvents. Purely chemical means cannot entirely solve the question of food absorption by plants, since in each case we are only able to determine the salts dissolved in a certain given solvent. The author investigated the question of food absorption using varying quantities of different potash minerals, and also different solvents. The results are summarised in tables and represented graphically. He points out that in the study of solubility the logarithmic function $\log (S - y) = K - C$ can be applied, which gives the velocity of monomolecular functions. For the determination of the velocity of solution the factor C serves, and not the factor S introduced by MITSCHERLICH. From the experiments of MITSCHERLICH it follows that the determination of $P_2O_5$ absorption is best carried out in water saturated with $CO_2$, whereas for the determination of potash assimilation hydrochloric acid is the best solvent. Mica supplies the soil with potash in a much more easily assimilable form than do potash-soda-felspars. HELLMERS.

### On the Erratic Weathering Solvents in New Red Sandstone in their Dependence upon External Influences.

Klander, E. *Chemie der Erde.* Vol. 2, Part 1, pages 49-82. Jena, 1925.

The author has been investigating the new red sandstone region of Reinhausen near Göttingen in which weathering causes the appearance of formations similar to those found in the new red sandstone of the Pfalz and in the freestone of the Saxon " Switzerland ". He has investigated very carefully the weathering solutions and has found in them mainly sulphate together with a small amount of chlorides. Usually the concentration of these solutions depended on the thickness of the percolated rock layer, their sulphuric acid percentage depending on the layers of humus overlying these rocks. This explanation is made the more probable by the presence of ammonium. Hellmers.

### Agricultural Chemical Exercises. Part I. Methods of Analysis.

Maiwald, K. and Ungerer, E. Published by Theodor Steinkopff. Dresden and Leipzig.

As an introduction the scope of the book is clearly set out and defined and the most necessary apparatus and the rules to be observed in quantitative analyses are described. In the next part are described the fundamental methods of analysis and their application to fertiliser investigations (potash and phosphoric acid determination, methods of titration, determinations of nitrogen and lime). Two further chapters are devoted to the analysis of fodders. The last three chapters deal exhaustively with the different methods of soil analysis: physical methods, physico-chemical and chemical and biological methods. In the case of the more important methods e. g. waterholding capacity, Atterberg's slime analysis, Comber's Hasenbaeumer's and Daikuhara's methods of acidity determination and foodstuff analysis the authors give a full description of the correct method of carrying out an experiment together with order of analysis; whereas other methods *e. g.* electrometric determination of the pH factor, determination of fertiliser requirements by the method of Mitscherlich, Schone and Kopecky's slime processes and the seedling methods of Neubauer and Schneider are just mentioned and the theory of them explained.

It is primarily intended to be a book of practical exercises for the use of students and college trained farmers. L. G.

### Laboratory Book for Agricultural Chemists.

Metge, Gustav. Laboratory books for the chemical and related industries. Vol. 18; 232 pages. Published by Wilhelm Knapp. Halle, 1926.

The author divides his book into three main parts: natural soil elements, agricultural products, requirements of agricultural lands. In the first part he deals with the properties and with the methods of investigation of water and of soil. In the second he distinguishes between the methods of investigation of plant products and those of animal products, while the last part deals with fertilisers and commercial foodstuffs both with regard to their investigation and the judging of them. Of particular interest from the standpoint of this journal is the second section of the first part: the soil. He deals with the physical, chemical and mechanical investigation of a soil, with the biological seedling experiments, with the investigation of moor-soils and also with the determination of substances detrimental to plant life. Even the most recent methods are described. The section closes with a chapter on the essential points to be observed in judging a soil.

The whole work reviews clearly with a guide to the literature on the subject the most important and most generally used methods of investigation and can be most strongly recommended as a concise handbook of research in scientific agricultural chemistry especially soil research.

L. G.

### Soil Investigation by means of the Seedling Method.

NEUBAUER, H., *Illustrierte Landwirtschaftliche Zeitung*, Vol. 46, page 77, 1926.

The author, deals with and rejects various criticisms of the seedling method as worked out by him. He insists that his method should only be carried out by properly trained and scientifically educated workers. After pointing out the advantages of his method of determining plant-absorbable foods he remarks on the great sources of error inherent in pot and field experiments and claims that the lack of agreement of results between these and his seedling method does not in itself mean the rejection of the latter method. K. SCHARRER.

### The Availability of Nitrogen in Garbage Tankage and in Urea in Comparison with Standard Materials.

PRINCE A. L. and WINDSOR H. W. (New Jersey Agr. Exp. Sta.), *Soil Science*, Vol. XXI, pp. 59-69. Baltimore, Md., 1926.

The object of the paper has been to study the relative availability of garbage tankage and urea in comparison with other organic and inorganic nitrogenous fertilisers and to study the rate of decomposition of urea under various conditions. Vegetation experiments were carried on in pots with sand cultures. Three crops were grown: barley, rape and sorghum It was found that the fertilising value of garbage tankage is very low. Most of the nitrogen which it contains is very slowly available and its total percentage of nitrogen is low in comparison with other forms of organic nitrogen. As a fertilising material its chief value will probably be in its use as a filler. Urea was found to be a very desirable source of nitrogen and was very nearly equal to $NaNO_3$ in availability. In some cases the crop was even better than with $NaNO_3$. In all cases it was better than $(NH_4)_2SO_4$. On the basis of 100 for $NaNO_3$, urea rates 98 % available; $(NH_4)_2 SO_4$, 88.2 %; standard tankage, 53.4 %; fish 49.2 % and garbage tankage, 14.2 %. Chemical availability tests were made by three methods: 1. neutral permanganate, 2. alkaline permanganate and 3. oxalic acid method of KELLOG (*J. Ind. Eng. Chem.* U. S. A., Vol. 16, pp. 371-372, 1924) and compared with the vegetation tests. Not much dependence can be placed on the present chemical tests for the determination of available organic nitrogen. The rate of decomposition of urea was studied in cultures of sand, of a mixture of half sand and half soil, and soil alone. The index for determining the decomposition was the amount of ammonia found over various time periods. After 5 days only 3 % urea was converted into ammonia in sand culture, 67 % in the half sand and 90 % in the soil alone. In the soil alone 50 % was converted in 3 days. On an acid soil the rate of decomposition was retarded: after 11 days only 50 % of urea was converted to ammonia.

J. S. JOFFE.

### Numerous Reactions of Moravian Soils.

SMOLIK, J. Reakeni cisla moravskych pud. *Vestnik Ceskoslovenske Akademie Zemedelske*, p. 219. Prague. 1926.

The reaction of the soil depends on climate, on the parent rock, on the vegetation and on the way it is cultivated. The writer has analysed a great number of Moravian soils and he has published some results of the analyses in *Zorávy výzkumných ústavu zemedelskych c. s.* To make his results more general, he has continued this investigation on soils belonging to various types such as degraded tschernosioms, Central-European brown soils, grey forest soils, podsolized and podsol soils. He has also taken under consideration the endodynamorphian soils (in GLINKA's sense) such as redzinas, recent deposits, etc., and has examined the reaction of all characteristic strata in the soil sections.

To determine the actual reaction (in water and in the normal KCl solution) the process with the hydrogen electrode, an electrode of gold covered with palladium is used. The titrimetric acidity is expressed in milligrammes of H. ions per 100 grammes of dry soil.

It appears from his statement that:—

1) The pH concentration of Moravian soils varies from 4.90 to 8.57 pH. The arable soils always have a higher active pH concentration in water (6.40-8.57 pH), than forest and meadows soils (4.90-7.10) of the same climatic zone and derived from the same parent rock.

2) The exchanged reaction (in the KCl N solution) oscillates between the limits; 4.40-7.30 pH in arable soils; 3.70-6.30 pH in meadow and forest soils.

3) The titrimetric acidity in water reached 0.451, and in the KCl N solution 11.456 milligrammes H.

4) The highest active pH concentration was found in the redzina (8.57 pH) and then follow in order degraded tschernosioms, Central-European brown soils, grey forest soils and podsol soils. The illuvial strata of the last three types have a greater pH concentration than elluvial strata.

5) Neutral or alkaline Moravian soils — especially the redzinas — always show lower pH concentration determined by means of colorimetric

methods than by the electrometric method (with the hydrogen electrode).

6) The pH concentration determined colorimetrically in centrifugal apparatuses approximates to the pH concentration determined in suspension by the method with the hydrogen electrode.

7) The method with the quinhydrone electrode according to E. BILLMANN gives in Moravian soils (slightly) lower results than the method with the hydrogen electrode. Since that decrease is constant and operation is very simple to carry out, BILLMANN'S; method for the practice of pedology may be recommended. AUTHOR.

### Some Residual Effects of Neutral Salt Treatments on the Soil Reaction.

SPURWAY, C. H. and AUSTIN, R. H. (Michigan Agr. Exp. Sta.), *Soil Science*, Vol. XXI, pp. 71-74. Baltimore, Md., 1926.

This article deals with the effects, on the soil reaction of the various horizons of four soil types, profiles, of some different cations fixed by these soils from neutral salts (chlorides), after the soluble products of the soil neutral salt reaction have been practically completely washed from the soils. $CaCL_2$, $MgCl_2$, KCl and NaCl solutions were used in this investigation. The $CaCl_2$ caused only slight changes in the soil reaction whereas the $MgCl_2$, KCl and NaCl treatments increased the values of the soil. The effective order of the several cations is : Ca, Mg, K, Na. Increased solubility and hydrolysis of the soil material containing the fixed cations are believed to be the cause of the increased pH value where increases are noted.

J. S. JOFFE.

### On the Influence of Soil Reaction in Practice.

TRÉNEL, M. Has the soil reaction in practical agriculture really the influence attributed to it as a result of scientific experiments? *Zeitschrift für Pflanzenernährung und Düngung*, Vol. 4, No. 8, 1925.

A contrast is made between the conditions of growth in practical agriculture, where optimum growth can be influenced by many different factors, and those obtaining in scientific investigations where all the disturbbing factors are eliminated. It was shewn in previous experiments that throughout the year the reaction remains fairly constant particularly in the case of soils rich in colloids, but is less constant in the case of sandy soils poor in colloids. The influence of fertilisers and of soil cultivation was also investigated.

The answer to the question put by the author was based on the results of the numerous acidity determinations carried out by means of the " acidometer " on soil samples from 23 large estates. The results and computations were collected and tabulated very clearly.

These results agree to a certain extent with those gained from scientific experiments and it seems that we shall be justified in concluding that the yield can be be increased by adjusting the reaction of the soil to the kind of plant which it is intended to cultivate. Most of our cultivated plants seem to show an optimum growth at a slightly acid to neutral

TABLE I. — *Optimum soil reaction for the development of different cultivated plants.*

| Cultivated plant | After O. ARRHENIUS | After TRÉNEL | |
|---|---|---|---|
| | Optimum at a pH of | Observed range of pH for growth. | probable optimum at pH of |
| Potatoes | 5.2 – 6.3 | 4–8 | 5–6 |
| Oats | 5.6 – 8.9 | 4–8 | 5–6 |
| Rye | 4.5 – 7.8 | 4–7 | — |
| Wheat | 5 – 7 | 4–8 | 6–7 |
| Barley | 7.2 – 7.4 | 5–8 | 7–8 |
| Sugar beet | 7.5 | 6–8 | 6–7 |
| Lupins | 4 – 6 | 4–6 | 4–5 |
| Peas | 6.7 – 8.8 | 5–8 | 6–7 |
| Red clover | 6.0 – 8.4 | 5–8 | 6–7 |

reaction. As an alkali reaction is just as detrimental to the growth of cultivated plants as a strongly acid reaction, the problem of the dependence of plant cultivation upon soil reaction, seems to be not merely a question of "soil acidity" but a question of soil reaction in general.
G. L.

### Dost know thy Soil, Farmer, its Ills and Maladies ?

TRÉNEL, M. *Illustrierte Landwirtschafts-Zeitung*, Vol. 45, page 623, 1925.

Dealing with the problem of soil acidity, the author points out with great emphasis that it is wrong to speak exclusively of "soil acidity diseases", since soil alkalinity is no less injurious to plant cultivation than a strongly acid soil.
K. SCHARRER.

### The Utilization of Water by Plants Under Field and Greenhouse Conditions.

TULAIKOV, N. M. (Agr. Exp. Sta., Saratov, Russia), *Soil Science*, Vol. XXI pp. 71-91. Baltimore, Md., 1926.

The author studied the utilization of water by plants under field and greenhouse conditions. Under conditions of the investigation larger amounts of water are utilized during the first part of the vegetation period in the field than in the greenhouse. The loss of moisture must be ascribed to the indirect evaporation of water by the soil under the plants, something that does not take place in the greenhouse. For this reason the transpiration coefficients of all the plants in the field are higher than in the greenhouse during the first part of the vegetation period. For the majority of the early spring crops the utilization of water is not regular; there are specific periods when the plants require more moisture from the soil. With grain crops this period coincides with the period of heading out and blooming. Plants with a long vegetation period — roots and tubers — are utilizing the soil moisture with great regularity during the whole period of their growth. Early maturing grain crops have to depend on the soil water resources, the late maturing plants may utilize the rainfall during the whole vegetation period and thus not be dependant so much on the soil moisture stored from the spring. In the field the following plants were used : winter rye and wheat, soft and hard spring wheat, oats and barley ; lentil peas and noot ; sorghum, Sudan grass and alfalfa ; buckwheat, corn, sunflower, potatoes, carrots, pumpkins and flax. In the greenhouse the following crops were used : soft and hard spring wheat, oats, buckwheat, peas, clover, flax and sunflower. J. S. Joffe.

### Proceedings of the 2nd Commission of the International Society of Soil Science.

Groningen, February 1926 ; Part A.

This is only intended as a short notice of the proceedings of the 2nd Commission which were made available to all the members of the International Society of Soil Science.

It contains 23 short papers by research workers of different countries dealing with the questions of chemical soil analysis, which were discussed at the Groningen session of the 2nd Commission on chemical soil investigation. The separate papers are reviewed in detail in the literature review of this journal. L. G.

## Soil Biology.

### The Viability of the Nodule Bacteria of Legumes Outside of the Plant I. II.

Alicante Marcos, M. (Univ. of Illinois), *Soil Science*, Vol. XXI, pp. 27-52. Baltimore, Md., 1926.

This paper covers a series of investigations on the problem of viability of nodule bacteria of legumes outside the plant. A series of experimental data is furnished on nodule production as influenced by time of storage, temperature during storage, kind of container, maintenance of organisms in pure and mixed culture in association with other nitrogen-fixing bacteria, with yeasts, moulds, and with non-nitrogen fixing bacteria on and in different media ; the effect of different treatments, such as the reinforcing of the inoculation with sugar, glue, and soil in various combinations and in different concentrations ; the effect of $CaCO_3$, $Ca_3(PO_2)_2$, sunlight, dessication and aeration was investigated. Extensive studies were conducted on the effect of time and dilution upon the number of the legume organisms surviving when grown in liquid media ; the effect of limited and ample quantities of oxygen upon the life of the organisms grown both in liquid and in solid media ; and the comparative effect of cane sugar and mannite upon the life of the legume organisms. The effect of soil acidity on the infective power of nodule bacteria was studied. It was found that when inoculated seeds were variously treated with soil, glue and sugar, alone or in combination, some organisms remained viable and nodule production occurred after 60 days storage. In treatments with sugar, either alone or with glue or soil, the nodules developed were uniformly large and evenly distributed over the root system. Soil and glue showed no particular advantage over the untreated infusions. No significant difference in nodule production was noticed between sugar, $Ca_3(PO_4)_2$ and $CaCO_3$ in different amounts with infected soil when used for inoculation. Soils with 10 % sugar developed acidity unfavorable for *B. radicicola*. Cloth seed bags were superior for storage purposes to glass containers, *B. radicicola* and *Azot. chroococcum* showed no harmful effects upon the life and infecting power of the nodule bacteria. Soybean, sweet clover, cowpea, and garden pea bacteria, when grown together, showed no harmful effect upon each other. The activity of pea bacteria when grown on milk was not impaired by the presence of *B. prodigiosus*, *B. capsulatus*, *B. mesentericus*, pink yeast and moulds. J. S. JOFFE.

### The Viability of the Nodule Bacteria of Legumes Outside of the Plant III, IV, V.

ALICANTE MARCOS, MONDEJAR (Univ. of Illinois), *Soil Science*, Vol. XXI, pp. 93-114. Baltimore, Md., 1926.

This paper is a continuation of I and II already reported and it deals with the effects of certain factors upon the life and growth of the nodule bacteria. The following factors were studied : dilution and storage, cane and mannite liquid media, oxygen supply in solid and liquid media for *B. radicicola*, shaking. The author also studied the thermal death point of nodule bacteria, *B. radicicola* and *Azotobacter chroococcum*, the effect of different kinds of soil, of $CaCO_3$ upon the thermal death point of legume organisms, the effect of soil acidity upon the infecting power of *B. radicicola* of garden pea ; studies were also made on the life cycle of various nodule bacteria as influenced by $CaCO_3$, $Ca_3(PO_4)_2$, acid phosphate, $AlCl_3$, HCl, $CH_3$ COOH, $HNO_3$ and $H_2SO_4$. It was found that the rate of multiplication was greater in high dilution. *B. radicicola* lived 142 days in solution. $CaCO_3$ stimulated the growth of *B. radicicola* better than $Ca_3(PO_4)_2$. The heat resistance of *B. radicicola* of garden pea and sweet clover and *B. radicicola* of cowpea and soybean was lower than the heat resistance of *B. radicicola* and *Azobacter chroococcum*. The legume organisms were killed at 50°C for 10 minutes exposure, whereas *B. radicicola* and *Az. chroococcum* were alive at 50°C for 10 minutes. Peat maintained the life of nodule bacteria at a much higher temperature than brown silt loam. Acid soils decreased the thermal death point of legume organisms. $CaCO_3$ increased the thermal death point and the keeping qualities of legume organisms. Absence of phosphate or carbonate in media resulted in the formation of bacteroids. Acetic, nitric and sulphuric acids changed the legume bacteria into bacteroids and each of these acids affected the form of the organisms specifically. J. S. JOFFE.

### Some Protozoa found in Certain South African Soils.

I. FANTHAM H. B. and TAYLOR E. *South African Journal of Science*, Vol. XVIII, pp. 375-393. Johannesburg, 1921.

II. The same: *Ibidem*, Vol. XIX, pp. 340-371, 1922.

III. FANTHAM H. B. and PETERSON N. *Ibidem*, Vol. XX, pp. 438-49 1923.

IV. The same: *Ibidem*, Vol. XXI, pp. 445-479. 1924.

V. The same: *Ibidem*, Vol. XXII, pp. 355-399. 1925.

The above articles embody the first published data on the protozoan fauna of South African soils. Some hundreds of soil samples from the various regions in South Africa (humid, semi-arid, arid, temperate, subtropical) were investigated as to the number and species of protozoa occurring in them. Environmental factors, such as depth of soil sample, humidity, seasons of the year, soil reaction, frost, application of fertilisers, veldt burning, etc., were studied to some extent, but more from the zoological point of view. Practically nothing has been done to study the influence of protozoa on the fertility of the soil.

Over seventy different species of protozoa have thus far been recorded. In ordinary non waterlogged soils protozoa have normally not been met with in the trophic state. MALHERBE.

### A Comparative Study of the Bacterial Flora of Windblown Soil: I. Arryo Bank Soil, Tucson, Arizona.

SNOW LAETITIA, M. (Wellesley College), *Soil Science*, Vol. XXI, pp. 143-165. Baltimore, Md., 1926.

Only those bacteria which grow aërobically were considered in this study. The soil under consideration was collected at depths of 6, 12 and 24 inches. The region may be called a " true arid " one. The number of bacteria per gram of fresh soil for the depths were as follows: 6 inches, 401 000; 12 inches 1 898 000; 24 inches, 916 000. Of the total number of colonies for all depths 52.4 % were actinomycetes, 0.77 % filamentous fungi, and 46.81 % yeasts and bacteria. The actinomycetes were actually and proportionally more numerous at 24 inches than at 6 or 12 inches. Pure cultures were isolated from the plates and studied morphologically and culturally. Morphologically, 24.1 % were cocci, 20.4 % were short non-spore bearings rods, 13.0 % were long non-spore bearing rods, 42.6 % were long spore-bearing rods and 64.8 % were Gram negative. Culturally 35.3 % fermented glucose; 28.3 % fermented sucrose; and only one form fermented lactose; 70.4 % digested gelatin and 56.5 % digested casein; 32.6 % reduced nitrates to nitrites. J. S. JOFFE.

## Soil and vegetation.

### The Salt Requirement of *Lupinus albus*.

ARNDT, C. H. (Univ. of Pennsylvania), *Soil Science*, Vol. XXI, No. 1, pp. 1-6. Baltimore. Md., 1926.

This is a report of a study on the composition of a solution best adapted for the study of the physiology of *Lupinus albus*. Solution and sand cultures were used and results are summed up as follows : a very favourable total salt concentration for the growth of *Lupinus albus* is 0.0084 N when calculated in respect of the cations. The salt ratio should be 5 : 3 :4 for K, Ca and $Mg^{\cdot\cdot}$; or 5 : 9 : 4 for the nitrate, phosphate and sulphate ions, respectively. A solution composed of 0.0035 N $KNO_3$, 0.0021 N $CaH_3(PO_4)_2$, and 0.0028 N $MgSO_4$ will produce a favourable growth when the H ion concentration is less than pH 3.6 High concentrations of phosphate tend to produce chlorosis. J. S. JOFFE.

### The Lime question, Soil Reaction and Plant Growth.

ARRHENIUS, O. With 40 illustrations and 1 table, 158 pages. Published by Akademisches Verlagsanstalt m. b. H. Leipzig, 1926.

In this book, which the reviewer can heartily recommend, the author gives an exhaustive account of the views held as to soil reaction, its origin and its influence on plant growth and on the micro-flora of the soil, and also of the methods of its determination. In addition there is a chapter on the practical application of the experimental results. The very comprehensive collection of papers on the subject which is appended will be most welcome to all workers in this field.

It would require too much space to go in detail into the different views propounded, and the many suggestions thrown out, by the author. A study of the book itself is recommended and it should prove of the greatest interest to theorist and practical man alike.

R. H. GANSSEN.

### Magnesia Impregnated Soils.

BLACKSHAW, G. N. *South African Journal of Science*, Vol. XVII, pp. 171-178. Johannesburg, 1921.

The so-called Great Dyke in Southern Rhodesia is about four miles wide and extends over a distance of approximately three hundred (English) miles. It is composed of basic igneous rocks, the principal varieties so far determined being serpentine, enstatite and norite. The soils derived from these rocks are red, chocolate-coloured, and black loams, the latter type occuring on the low lying ground, whereas the two former are found on the slopes. Without knowing their geological origin one would expect that they are fairly fertile, but the experience is that they are often most infertile and do not respond to fertilisers. Chemical examination revealed the fact that the infertile type contains a great excess of magnesia over lime when treated with hydrochloric acid as also with one per cent citric acid solution. With the fertile type the lime is in excess of magnesia in both solvents. The infertile type was no doubt formed from either serpentine or enstatite and the fertile one from norite. With the limited data at his disposal the author is of opinion that when the ratio of magnesia to lime, soluble in one per cent. citric acid, exceeds 3 : 1 (lime as 1) the tendency is to experience very poor yields of most of the common crops. The Rhodesian experience is that Kaffir Corn (*Sorghum vulgare*), velvet beans (*Stizolobium* spp.), pearl millet (*Pennisetum spicatum*) and groundnuts (*Arachis hypogaea*) are fairly resistant to an excess of magnesia, whereas maize, wheat, lucerne, clover and mangolds do not tolerate an excess of magnesia. The native grasses (" sweet " grass) also thrive excellently on the magnesia impregnated soils. Liming these soils being locally impracticable, the most effective treatment thus far has been a liberal dressing of farm manure. MALHERBE.

### Soil Reaction and the Growth of our most Important Cultivated Plants.

TRÉNEL, M. *Illustrierte Landwirtschaftliche Zeitung*, Vol. 45, page 558, 1925

The author describes the " acidometer " made by him and details the experiments he has made with it on the correlation of soil reaction and plant growth. K. SCHARRER.

## Regional Soil Science.

### The Distribution of the Main Agricultural Soil Types in Finland.

KRISCHE, P. *Die Ernährung der Pflanze*, 22nd Year, No. 5. Berlin.

In connection with the publication by the author in 1922 dealing with the main soil types in Czecho-Slovakia and in the same periodical review the author has brought out in collaboration with Prof. RINDELL of the university of Abo an exhaustive soil map showing the distribution of the main agricultural soil types in Finland. The map was based on the excellent map " Suomen Suot Finnlands Forfmaker " showing the distribution of moors in the middle and eastern parts of Finland, and published in 1909 by the Finnish Moor Union at Helsingfors, and also on the map sketches by BENJ. FROSTERUS " Finnlands Jordarter och Jordmaner *Geotekniska Meddelanden*, No. 34, Helsingfors, 1922. Supplements dealing with the heavy loamy and clay soils found in the southern parts of Finland were supplied by Prof. RINDELL. The map prepared from these sources shows that the Finnish soils consist mainly of moor soils with forest soils intervening, and that only the southern and western coastal regions contain some heavy soils while the districts round Jammerfors contain in addition some middle soils. Predominantly sandy soils are found in the districts north of Leningrad and south-east of Wiborg. In addition to the main map which proves the great importance of moor culture to Finnish agriculture, there is a map of the Finnish moors by Prof. RINDELL showing that the greatest part of the moor soils are in Central Finland. L. G.

### The Origin of the Black Turf Soils of the Transvaal.

MARCHAND B. de C. *South African Journal of Science*, Vol. XXI, pp. 162-181. Johannesburg, 1924.

The black turf soils of the Transvaal and the adjoining provinces constitute a very interesting soil type about whose mode of formation much has been speculated in the past. The term " turf " is a specific South African designation and does by no means mean a peaty soil. Farmers of the above provinces apply this term to heavy loams or clay soils and thus they also speak of *red* turf soils, meaning a heavy red loam or clay.

Some geologists were of opinion that the black turf soils contain a large percentage of humus and that they occur in low-lying or level localities with deficient drainage. Others however, observed that such soils may occur on hilly or sloping ground and that they are underlain by basic igneous rocks. From the study of South African soil literature and from observations made and from a few soil samples taken during a cursory visit through Africa by his colleague SHANTZ, MARBUT (1) (America) expressed the definite opinion that the above black turf soils constitute a climatic soil type belonging to the tschernozem group and as such may be found on various rock formations. This stands in direct contradiction to the opinion of the Transvaal soil scientists who hold that the black turf soil is formed in situ from the weathering of certain basic igneous rocks only, under varying climatic and topographical conditions. In the above article the author defends this latter view and gives a very full description of the occurrence and characteristics of these black turfs.

Physically these soils are characterised by the very high amount of clay (particles below 0.002 mm.), the percentage ranging between 40 and 50. They are sticky and waxy when wet, and they crack and show a well marked crumbly structure when dry. Although black, the humus content of these soils is by no means high and the nitrogen is normally below 0.10 per cent. The loss on ignition varies from 5-10 per cent, but this includes some carbon dioxide and the water of hydration.

The soils are about 3-4 feet (90-120 cm.) deep, the black colour and the loss on ignition *remaining the same* thruoghout the whole soil profile. The black soil rests on yellow decomposing rock. Typical is the presence of (secondary) calcium carbonate. The first foot of soil usually contains a little and in the deeper soil it is visible as white concretions. At the transition level between the black soil and the decomposing rock there is present frequently, but not always, a real calcareous layer which in some cases, has been consolidated into hard massive limestone.

The black turf occurs in four big areas in Transvaal, of greatly divergent vertical distribution and with an annual precipitation ranging from about 20-30 inches (500-750 mm.). It is usually found on level or low-lying stretches of land but occasionally also on hilly situations. It always occurs as a sedentary soil on certain basic igneous rocks of similar chemical make-up in all the four regions. These rocks are norite, basalt and karroo dolerites. Plagioclase is the principal mineral and from this are formed by weathering kaolin, silicic acid and the carbonates of calcium and sodium. From the ferro-magnesium silicates, hydrated ferric oxide, silicic acid and magnesium carbonate result. All these weathered constituents are typical of the black soils, and from the above it is clear that the " clay " percentage would be high. This clay was analysed and it showed a very high silica-alumina ratio (about 60 % silica, 20 %

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(1) SCHANTZ and MARBUT : *The Vegetation and Soils of Africa.* 263 pp., New York, 1923.

alumina and 15 % iron oxide). To this composition of the clay is ascribed the stickiness and impermeability of the wet soil, the result being that under the prevailing rainfall the carbonate of lime is not leached out. This explanation is the more probable, because *adjoining* the black turf soils there often occurs another very interesting soil type of the Transvaal, namely a chocolate-coloured or red heavy loam. This reddish loam is formed wherever the basic igneous rock is more ferruginous, such as the Pretoria diabase, the amygdaloidal basalt or other basic igneous rocks with bands of magnetite. The mechanical make-up of the black and the red types is practically identical, the red loams also containing from 40-50 per cent. " clay ". The chemical composition of this clay is, however, quite different to the first, the silica-alumina ratio being much smaller (about 42 % silica, 35 % alumina and 2 % iron oxide). The result is that the red loam is a well-flocculated soil and retains the crumbly structure also when wet. The soil thus remains porous and drains well, so that although it occurs under the same rainfall as the black turf and is also formed from minerals containing much " lime ", it seldom contains any calcium carbonate. This is the case throughout its whole profile which is some 15 feet (4 ½ meters) and more.

Why the colour of the relatively small amount of humus in the black turf soils should be so intensely dark, cannot yet be explained. Soil literature, however, mentions many cases where a black colour of the soil and a relatively high percentage of calcium carbonate go hand in hand.

All the above evidence goes to show that the black turf soils of the Transvaal are the normal decomposition product formed in situ from certain basic igneous rocks; in other words, that the mother-rock and not so much the climate is responsible for this type of soil. MALHERBE.

### Sol Formation and Classification.

MARCHAND, B. de C. *South African Journal of Science*, Vol. XXII, pp. 42-48. Johannesburg, 1925.

The author gives a brief general outline of soil formation and its characterisation according to the Russian school. He then discusses very briefly a few climatic soil types of the Transvaal and is of opinion that, owing to the comparatively low rainfall, the Transvaal soils are on the whole immature, *i. e.* consist only of the " C" horizon. There is, however, a strong tendency towards lateritisation especially in soils derived from basic igneous rocks. MALHERBE.

### On the Formation of Soil from Diabase in Central Transvaal.

MERWE C. R. van der. *South African Journal of Science*, Vol. XXI, pp. 235-242. Johannesburg, 1924.

The soil resulting from the weathering of the (Pretoria) diabase in Central Transvaal is a deep reddish ferruginous soil. The author gives ultimate analyses of the fresh and the partly decomposed diabase rock as well as of the residual and subsoil formed from this rock. In addition the results of three soil samples (done by the HCl extraction) from three different districts are given. The average annual rainfall (mostly during summer) of the above localities varies from 23 to 28 inches (584-711 mm.). The altitude varies from about 4,000 to 6,000 feet (1220-1830 metres) and the maximum temperatures also show great variation. The resulting soils from the diabase are, however, very similar in all respect. The author states that the " weathering is mainly due to chemical decomposition accompanied by solution and leaching of the more soluble ingredients ", such as carbonate of lime. MALHERBE.

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Stiny, J. Standortliches aus den österreichischen Uralpen und Schieferbergen. *Zentralblatt für das gesamte Forstwesen*. 61st. year, Parts 11-12. Vienna-Leipzig, 1925.

Terlikowski, F. Szkic profilu glebowego Lachowicze-Lachwa Prypec. (Examination of soil profile of Lacowicze-Lachwa-Prypeé). p. 25. *Roczniki Nauk Rolniczych i Lesnych* 1923. Vol. IX. (Laboratorium für Bodenkunde der Universität Posen).

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# *General Notices.*

## Report on the Meeting of the Second International Committee.

(Committee for Chemical Soil Analysis), Groningen, Holland. 2-6 1926.

The order of the day was as follows :—

Friday 2 April : The meeting was opened by the Chairman Prof. Dr. A. A. J. VON 'SIGMOND. Short explanations by the authors concerning the papers sent in. — Report of Messrs. Dr. H. R. CHRISTENSEN and Dr. D. J. HISSINK.

Discussion.

Saturday 3 April : Continuation of the Discussion.

Monday 5 April : Excursion under the direction of Egr. J. HEIDEMA of Groningen. Study of the 1) high moor culture and 2) visit to the Polder and Kwelder regions.

Tuesday 6 April : Recapitulation of the conclusions and preparation for publication of the proposals for the I Congress of Soil Science (Washington, June 1927). — Official closing session in the University Building. — Visit to the University Building and reception by the Senate. — Dinner to the delegates.

All meetings, except the closing meeting, were held in the " Harmonie " building. The meeting was attended by 43 persons of 12 different nationalities. The following proposal was accepted :

### DETERMINATION AND REVIEW OF SOIL ACIDITY.

### I. *Preparation of the test.*

It is recommended that the soil should be examined in air dried state as soon as possible after taking the sample.

This point must be particularly observed when the buffer action is examined.

It is much to be desired that further examinations on the influence of drying and the fineness of the soil should be made.

### II. *Methods of determination.*

A) *Determination of the state of reaction of mineral soils.* — In examining mineral soils it is proposed always as far as is possible to make the following determinations :

1) Determination of the pH index (firstly in water suspension and if possible also in KCl suspension) ;

2) Determination of the hydrolitic acidity ;

3) Determination of exchange acidity ;

4) Determination of buffer capacity ;

5) Determination of exchangeable lime (in soils with a higher humus content).

B) *Determination of the lime requirement of the soil.* — It is recommended while employing the DAIKUHARA process to take chiefly into consideration the buffer effect of the soil towards bases and acids for the determination of the lime requirement.

### III. *Practice of the methods of determination.*

*a*) In scientific investigations the execution of the electrometrical determination of the pH index (if possible by means of the Quinhydrone electrode) is always recommended. The determination must be done in a suspension (not in a filtrate) of the soil with $H_2O$ or in a n-KCl solution.

Proportion of the soil to the liquid at the start 1 : 2.5.

The distilled $H_2O$ used must have the carbonic acid tension of the outer air.

*b*) The hydrolitic and the exchange acidity must be made in the filtrate from the shaking of the soil with n-KCl or Na acetate and if possible, also with Ca acetate.

Indicator : Phenolphtalein.

Proportion of the soil to the liquid : 100 : 250.

Duration of shaking 1 hour. The number of c. cms. N/10 NaOH used in titrating 125 c.cms. of the filtrate must be indicated.

*Note* : Indication of the particular method of determination is recommended in all publications on soil acidity. If nothing else is said, the index pH stands for the water decantation.

### IV. *Examination of the different methods for the determination of the state of soil saturation.*

For these determinations the following methods are recommended :—

*A*) For the determination of the exchangeable bases " S ":

1) The method of Hissink.
2) The simplified methods of Gedroiz, and more especially that with n $NH_4Cl$ and that with 0.05 n HCl.
3) The method of Kelley.

*B*) For the determination of the degree of saturation " V ":

1) The method of Hissink ;
2) Direct conductometrical titration ;
3) The method of Bobko-Askenasy with $BaCl_2$ ;
4) The method of Gehring-Peggau-Wehrmann.

### V. *Examination of the laboratory methods for the determination of the lime requirement of mineral soils in comparison with field experiments extending over several years.*

It is recommended that in the different countries as many field experiments as possible should be made according to the following plan :

*a*) without lime
*b*) quantity of lime 1/3
*c*) » » » 2/3
*d*) » » » 3/3
*e*) » » » 4/3

of the quantity of lime necessary for bringing the reaction index of the soil in question up to pH 7.0.

As a basis for the calculation of this quantity of lime by means of laboratory experiments the direct determination of the buffer capacity according to the JENSEN-CHRISTENSEN method is to be employed. (Proc. Int. Soc. Soil Sci. XIV p. 112, 1924). It is desirable to use the other methods as well for the determination of the lime condition.

For the technical carrying out of the field experiments attention is called to the paper of CHRISTENSEN-JENSEN: "On the quantitative determination of the lime requirement of the Soil" (*Report on the Proceedings of the II Committee of the International Soil Science Association at Groningen*, pp. 113-114).

As ground-manure there ought to be employed:

N in the form of $(NH_4)_2SO_4$,

$P_2O_5$ in the form of superphosphate,

$K_2O$ in the form of 40 % potassic salt in doses appropriate for the field but not too great

It is intended to publish in a part *B* the proceedings of the meeting at Groningen with the resolutions and an exact description of the methods proposed.

**Appointment on the Committee of the II Commission.** — Following on the proceedings of the II Commission at Groningen Prof. Dr. O. LEMMERMANN was appointed Vice-President in accordance with par. 10 of the Statutes, thus completing the Committee.

Prof. Dr. A. A. J. v. 'SIGMOND.
*President of the Committee.*

### *Communications.*

**Prof. Dr. Lemmermann** was elected President of the German Soil Science Society (A section of the International Society of Soil Science).

**Director Dr. D. J. Hissink** Groningen, formerly Departmental Director of the State Experiment Station has been appointed Director of an independent Soil Science Institute.

### Supplement to the list of Members.

*Germany.*

139. Bibliothek der Landwirtschaftlichen Hochschule. Bonn-Poppelsdorf. Meckenheimer Allee 102, Bonn a. Rhein.
726. Forstliche Hochschule. Eberswalde.
715. Dr. Georg DEINES. Kirchweg, 15. Kassel.
735. M. DUTTENHOFER. Hindersinstrasse 8, Berlin, (NW. 40).
684. Prof. Dr. H. KAPPEN. Institut für Chemie der Landwirtschaftlichen Hochschule Bonn-Poppelsdorf. Meckenheimer Allee, 106. Bonn a/Rhein.
681. Dr. Paul KOETTGEN, Dozent für Bodenkunde am Forstinstitut der Universität. Phil. Gailstrasse, 8. Giessen.
737. Prof. Dr. F. LOEHNIS, Direktor des Instituts für Bodekunde der Universität. Johannisallee 21. Leipzig.

724\. Prof. Dr. Emil WIMMER, Prof. der Forstwissenschaft. Sternwaldstrasse 31. Freiburg i. Bad.

*Austria.*

686\. Landwirtschaftliche chemische Versuchs- und Untersuchungsstelle. Leiter: Ing. R. SCHRAFFL. Imst (Tirol).

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687\. The General Library. The University of Chicago. Chicago, Illinois.
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721\. John S. BURD. Division of Plant Nutrition. University of California. Berkeley, California.
719\. STANLEY W. COSBY. University of California. 320 Hilgard Hall, Berkeley, California.
710\. A. B. CUMMINS. The Celite Company. Lompoc, California.
710\. P. L. GAINEY. Agricultural College. Manhattan, Kansas.
716\. H. V. HALVERSEN. Department of Bacteriology, Oregon Agricultural College. Corvallis, Oregon.
711\. ELMER H. JOHNSON. School of Agriculture. College Station. Texas.
718\. Don W. PITTMAN. Agricultural College. Logan, Utah.
727\. Prof. M. C. SEWELL. Kansas Agricultural College. Manhattan, Kansas.
722\. Alfred SMITH. University Farm. Davis, California.
725\. GORDON SURR. 321 Eight Street. San Bernardino, California.
729\. M. D. THOMAS. Agricultural Experiment Station. Logan, Utah.

*Finland.*

680\. Nordiska Jordbruksforskare föreningens subsektion för Kulturteknik (Prof. HALLAKORPI). Ahlqvistgatan, 5. Helsingfors.
678\. Suomen Salaojitusyhdistys (Finlands Dräneringsförening). Hallituskatu 1. Helsinki.
679\. Tekniska Högskolans lantmäteriavdeling. Boulevardsgatan, 27. Helsingfors.

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732\. Prof. V. AGASONOFF. 4, rue due Chemin de fer. Bourg-la-Reine, Seine.
683\. Georges TRUFFAUT. Etablissements et laboratoires. 90 bis, Avenue de Paris. Versailles.

*England.*

708\. D. V. BAL. Rothamsted Experimental Station. Harpenden, Herts.
689\. H. CLAYE. 9. Cavendish Avenue. Cambridge.

675. J. H. HUMPHREYS. Lecturer in Agricultural Science at the Llysfasi Farm Institute. Putkin (North Wales).
690. Dr. E. McKENZIE TAYLOR. 157. Hills Road. Cambridge.
704. Alex M. SMITH. 13, Viewforth Gardens. Edinburgh.

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392. Dr. A. N. PURI. Punjab Irrigation Resarch Laboratory. Lahore.

### *Canada.*

674. Prof. D. G. LAIRD. University of British Columbia. Vancouver.

### *South Africa.*

755. Dr. M. J. VAN DER SPUY "Ons Rust". Mostert's Drift. Stellenbosch.

### *Hungary.*

742. Zentralbibliothek der königl. ung. Hochschule für Berg- und Forstingenieure in Sopron.
682. Ing. Dr. ZOLTAN VON KUNREY. Gutsbesitzer. Ference József rakpart, 16, Budapest IV.

### *Italy.*

359. Ing. Francesco BILBAO Y SEVILLA. Délégué de l'Espagne dans l'Institut Intern. d'Agriculture. Villa Umberto I. Roma (10).

### *Japan.*

705. Prof. Dr. H. ASÓ. Agricultural Chemical Laboratory. Komaba, (Tokyo).
676. Yutaka KAMOSHITA. The Imperial Agricultural Experiment Station. Nishigahara (near Tokyo).
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736. SHIGERU OSUGI, Prof. of Soil-Department of Agriculture. Kyoto Imperial University. Kyoto.
675. Gentaro YAMANAKA. The Imperial Agricultural Experiment Station. Nishingahara (near Tokyo).

### *Latvia.*

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734. Direktor W. DUGMAN. Kulturtechnische Schule. Jacobsstrasse, 10-12. Riga.

739. Ing. Techn. Karl KRUMIN. Assistent an dem Laboratorium für Bodenkunde und Agrikulturchemie der landwirtschaftlichen Fakultät der lettländischen Universität Kronvalda bulv. n. 1. Riga.

738. Ing. Techn. Peter KULITAN. Dozent für Bodenkunde und Agrikulturchemie der landwirtschaftlichen Fakultat der lettländischen Universität Kronvalda bulv. n. 1. Riga.

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697. H. ROSENDAHL. Konservator. Universitetets mineralogisk-geologiske museum. Tøien. Oslo.

698. Prof. Dr. W. WERENSKIOLD. Universitetets geografiske institutt. Oslo.

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713. Prof. J. H. ABERSON. Wageningen.

712. Dr. C. W. G. HETTERSCHIJ. Scheikundige aan de tweede afdeeling van het Rijkslandbouwproefstation. Prof. H. C. van Hallstraat. Groningen.

### *Dutch Indies.*

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### *Roumania.*

731. L'Académie d'Agriculture. Cluj.

730. Prof. Dr. M. CHIRITESCU-ARVA. Professeur d'Agrologie et Directeur de l'Académie d'Agriculture. Cluj.

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696. Prof. E. BOBKO. Landwirtschaftliches Institut. Omsk.

693. Prof. F. I. LEWTSCHENKO. Politechnisches Institut. Kieff.

695. Prof. G. MACHOW. Lermon owsky str. 26. Wg. 5. Charkoff.

692. M. G. PERESKOPOW. Akkawaksche Versuchstation. Postkiste, 101. Tashkent.

694. Prof. Dr. WILENSKY. Tschaikowskystrasse. 14. Wg. 8. Charkoff.

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728. Dr. Paul TUORILA. Landwirtschaftliches Institut der Eidgenössischen Technischen Hochschule. Universitätssträsse, 2. Zürich.

*Czechoslovakia.*

688. L' Académie Tschécoslovaque d' Agriculture. Jungmannova tr. 18. Praha II.
677. Ståtni vyzkumna stanice zemědělska (Staatliche Landw. Versuchsstation) Opavé.

**Correction in list of Members.**

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Landwirtschaftliche Hochschule. Bonn-Poppelsdorf, *omit, see* Bibliothek
Stickstoffsyndikat G. m. b. H. Neustädtische Kirstrasse, 9. Berlin, M. W. 7.
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### *Cuba.*

P. L. ANDERSON, Cuban Sugar Club, Apartado, 1973. Habana.

J. R. ZELL. Finca "El Conde", The Hershey Corporation. St. Antonio de Rio Blanco. Prov. Habana.

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Siro HUDISE. The Kagoshima Imperial College of agriculture and Forestry. Kagoshima.

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*Latvia.*

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*Lithuania.*

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*Norway.*

Bibliothek der Landwirtschaftlichen Hochschule, sl. pr. Oslo Ås, *omit.*
Det Kongelige Fredriks Universitet Museum. Adresse: Universitetets Kasserer, Oslo, *omit.*
Dr. **Torbjern Gaarder**. Laboratorium Vorsteher, Biokemisk Laboratorium. Bergens Museum. Bergen.
Prof. Dr. **Olaf Holtendahl**. Universitetets geologiske-paleontologiske institut. Tøien. Oslo.
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*Palestine.*

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*Dutch Indies.*

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Proefstation voor de Javasuikerindustrie. Pasoeroean, Java.
Redactie van de Indische Culturen. Soerabaja, Java.
Rubberproefstation West-Java. Directeur Dr. O. **De Vries**. Buitenzorg, Java.
Mevr. N. **Beumée**. Nieuwland. Buitenzorg, Java.
P. W. **Houtman**. Chef proeftuinen der Handelsvereeniging Amsterdam Paree (Karang Dinojo), Paree, Java.
Dr. M. G. J. M. **Kerbosch**. Gouv. Kinaproefstation Tjinjiroean. Pengalengan bij Bandoeng, Java.
Dr. V. J. **Koningsberger**. Cheribon, Java.

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Landwirtschaftliche Versuchsanstalt Post Lomza skr. 32. Kisielnica.
Dr. Benjamin **Cybulski**, Directeur du Foyer de la Culture Agricole et du Champ d'expériences. Kielce. Poste Skalbmierz. Sielec.

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Prof. Dr. Jan ZOLZINSKI. Institut der Agrikulturchemie und Bodenkunde. Dublany bei Lwow.

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Dr. Stefan KEREKES, Chemiker in der Zuckerfabrik, Romania Mare, Fabrica de Zahar, Marosvasarheli, 2. Targu-Mures.
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Prof. A. F. TUELIN. Staatsuniversität, Agrofakultät. Perm.
P. D. WARLIGIN. Grosser Tolmatschewsky pereulok, 18, w. 9. Moskau.
M. A. WINOKUROFF. Sibirien-Landwirtschaftliche Akademie. Omsk.
N. M. ZAITZEFF. Moskau. *omit; read:* M. N. SAYTZEFF.

*Sweden.*

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Lic. fil. GUNNAR EKSTROEM. Sveriges geologiska undersökning. Stockholm. 50.
GUNNAR GIOEBEL, c-o Dr. C. BARTHEL. Experimentalfältet.
Prof. Dr. fil. Henrik HESSELMAN. Djursholm.
Prof. SVEN ODÉN. Experimentalfältet.
Dr. fil. Hugo OSVALD. Docent. Svenska Mosskulturföreningen. Jönköping
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