Reprinted from:
Soil Science in the Netherlands, Indonesia and Suriname (1950)

EVALUATION OF SOIL TESTING IN THE NETHERLANDS

F. VAN DER PAAUW

In the subsequent paper of DECHERING a survey will be given of the development of soil testing. Before this agronomical testing and its organisation will be discussed.

The reason of the introduction of Soil Testing

The occurrence of serious symptoms of diseases with crops on sandy soils, resulting in a considerable decrease in yields, was the first induction to soil research. It was proved that manganese and magnesium deficiencies were responsible. These deficiencies are closely connected with the reaction of the soil. Even if the typical symptoms were not evident, the large importance of soil reaction of sandy and silt (clay) soils for the attainment of optimum yields was apparent.

The need of investigations on phosphate and potash, the large scale use of which was an early practice in the Netherlands, was less related to the distinction of differences in fertility, inherent to the soil, than to the establishment of rational methods of application of these fertilizers.

Adoption and development of methods

The choice of methods was decided by scientific and practical insight. From a practical point of view methods must conform to the following requirements: 1. the scale of application must be extensive, especially in the sensitive part, 2. the determination must be quickly accomplished, 3. the method must be applicable to as many types of soil as possible under varying circumstances.

It will be clear that what will be determined, must relate to that constituent of the soil, which is decisive to plant growth. The attainment of this objective has been aimed at as much as was possible with the knowledge available at the time. The development has been an empirical one and a feature in the Netherlands has been that the development has always proceeded hand in hand with the development of trial plot experimentation. The main methods applied will be discussed by DECHERING.

Criticism on Soil Testing

When soil testing was adopted as a basis of practical advice much criticism arose. The proviso that under very varying conditions and for very different types of soil a test must give equivalent results, was considered to be contrary to scientific and practical experience. Another objection was expressed in the fear that a pressure on experimentation in a correlative direction might hinder the development of research along causal lines and might result in inflexibility. The opinions in regard to the usefulness of these methods were therefore divided.

The establishment of the Laboratory for Soil Testing

It is due to the vision and pushing power of men like HUDIG and DE VRIES that soil testing was introduced in the Netherlands and a start

was made with intensive research in relation thereto. The establishment of the Laboratory for Soil Testing took over much routine work from the research institute and the possibility of an advisory function based upon results of soil analyses on a large scale was decisive to the further development of research and advisory work on such a scale as could not even be foreseen at that time.

Field experiments

a) *Provisional evaluation of Soil Testing on behalf of practical farming during the first few years*

The establishment of a laboratory charged with soil testing for practical purposes necessarily led to a careful agronomic evaluation of the data recorded. Considering the then ruling conditions in the system of trial plot experimentation it was a heavy task. Results of existing long-term trial plots of the Agricultural Experimental Station and those of a few other institutions had at first to be used for comparison. New plots could be laid out on a moderate scale. The technique to be applied here developed slowly. It proved to be necessary to establish trial plots on several types of soil, showing a large variation in condition, e.g. in regard to lime content from extreme deficiency to a considerable excess. This course led to a new system of experimentation, viz. application of the graphical method of studying data (VISSER, FERRARI, Transactions, I). From these originated later on the larger series of investigations, the variations not being realized on one field only but by a large number of experiments of the same design on small plots under the varying conditions in agricultural practice, performed simultaneously (VISSER, VAN DER PAAUW, Transactions, I).

Preliminary investigations showed that variations in the contents of lime, phosphate and potash, resulting from different manurial treatments during a large number of years and to which crops show a conspicuous reaction are evident from the results of soil analysis. It was possible to arrive at approximate border-line figures for lime and other plant nutrients. If the content of a nutrient in the soil exceeds the relevant border-line figure, no further dressings of that nutrient are called for, if it is lower it shows the probability of deficiency. The experience gradually accumulating from soil testing applied to practice, afforded as expedient to verify these conclusions.

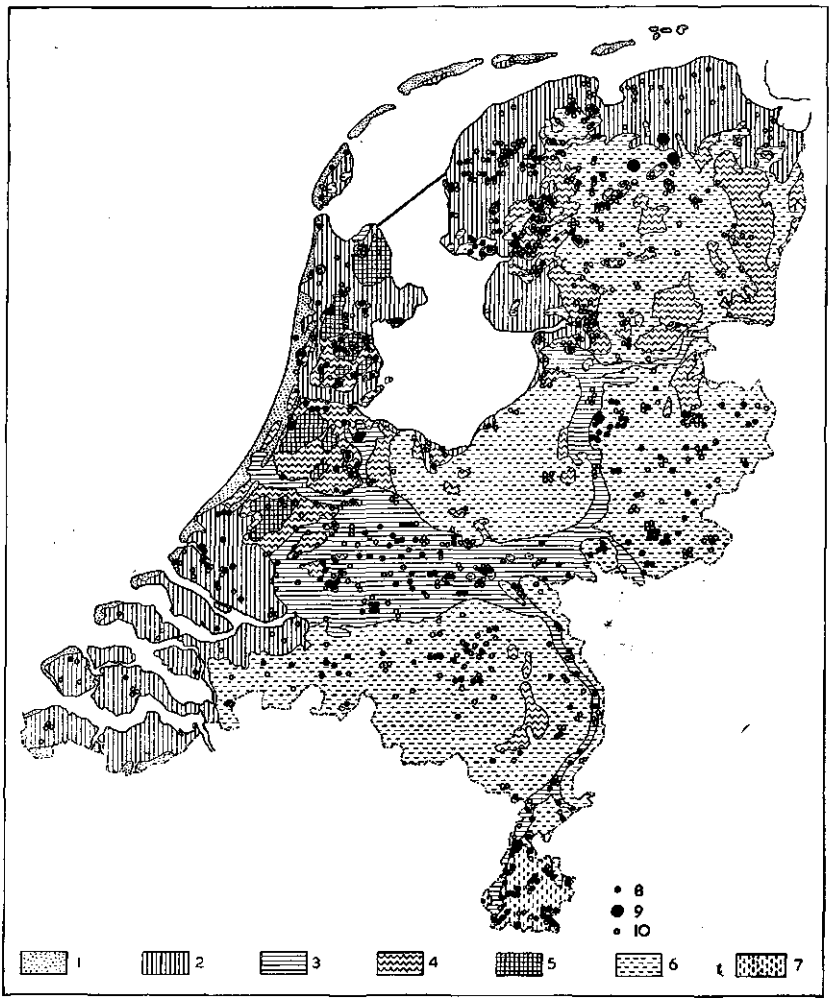
The most thorough test was obtained of the pH determination. The results of a rather large number of lime experimental plots in different parts of the country became available. It was possible to determine the relation of pH and yields of different crops. The optimum value of pH varied rather much, on sandy soils nearly always between 5 and 6. It was also clear, however, that the degree of fertility of the soil affects the optimum value of pH, very fertile soils tolerating a lower pH than less fertile ones.

b) *Soil Testing as a basis of research*

Except plot experiments to evaluate soil testing other experiments were devised simultaneously. In the first place investigations on the method of drawing soil samples and on sampling errors should be referred to. These also offered an opportunity to get an idea of the unifor-

mity of the soil. Chemical experiments with solvents of various concentration, varying extraction ratios, repeated extraction of the same quantity of soil, resulted in a deeper insight in the nature of the constituents of the soil and created a clearer conception of the soil analysis method itself.

A great drawback of soil testing became apparent after it had been repeatedly applied to the same field. Some values showed te be susceptible to considerable variations endangering its practical applicability. Some of the causes were found on further investigation. Later on it became clear that next to variations due to seasonal influences also annual fluctuations exist showing a remarkable periodicity (VAN DER PAAUW,



Phosphate experiments on grassland for soil testing in the Netherlands. 1. marine sand, coastal dunes; 2. younger sea clay; 3. fluviatile clay; 4. peat; 5. older sea clays; 6. preglacial, glacial and postglacial sand; 7. loess; 8. experimental fields in 1947 or 1948; 9. series of 20—21 exp. fields on clay, peat and sand in 1939, 1940 and 1941 respectively; 10. "experimental spots" in 1943.

Transactions, II). However, attention is still being paid to the use of methods, less susceptible to these influences.

The extensive application of soil testing to experimental plots supplied well defined knowledge concerning the assimilation of nutrients by crops, losses caused by washing out and fixation. Soil testing afforded the possibility of comparing the results of existing trial plots, formerly only of local importance.

The ever expanding investigations in behalf of practical farming procured data for the mapping out of the fertility conditions obtaining in practice (DECHERING). The intention is to arrange all results attained in a punch-card system. An extremely valuable record will then be available as a basis for studying chemical soil-fertility all over the country.

It should be stated that also various methods applied abroad have been compared with those applied here. The most elaborate work in this respect has been done by studying the results of a large number of experimental fields. The results did not justify the substitution of any method for another one. Obviously alternative methods will only be adopted by an already operating organisation if they are evidently better than those being applied.

c) *Organized check on the results of Soil Testing on a larger scale.*

The continuous development of soil testing for practical purposes brought about the realization that the preliminary and rather incidental check on the merits of soil testing was absolutely unwarranted. Systematical and detailed evaluation had to take its place. In course of time the opinion arose that this was only practicable by collecting results of numerous observations accomplished under comparable conditions.

A first attempt in this direction was the check on the P and K status of Northern sea silt soils by the results of 170 trial plots laid out in 1937 and 1938 according to the same simple design. The result of this investigation opened quite new views on the value of the figures for this type of soil. It became apparent that in interpreting the data it is necessary to take also other soil factors into consideration. To give an example, the value of the potash content is also affected by the $CaCO_3$ content of the soil whilst also the suspensible fraction must be taken into account.

This circumstantial investigation showed how this problem should be tackled and how the recorded data should be interpreted diagrammatically. Encouraged by the success, an extensive P and K investigation on grassland on some types of soil was carried out in the neighbourhood of Groningen in the years 1939—1941.

The investigations, however, still bore too much a local character and it was thought necessary to include the whole country in further investigations. In 1941 this resulted in the design of a national plan for experimental field-work, comprising in the first place the evaluation of soil testing for the principal types of soil in the Netherlands. Except large series of a simultaneously run small size experimental plots of one year's duration, long term experimental plots have been devised in order to study the development of soil conditions with different manurial treatments. These investigations were started in 1943 during the German occupation. Nevertheless the laying out of some 50 long-term phosphate experimental fields, distributed all over the country, was accomplished.

As it seemed probable that the serial experiments necessary to checking could not be performed during the next few years, attempts were made to satisfy the needs by some simple means. The most successful attempt

was the correlating of the results of soil testing with the P and K contents of the young crop instead of correlating with differences in yields from experimental plots. Usually the latter are supposed te be decisive in checking. But differences in yields are often affected by secondary factors. From a physiological point of view it is not very likely that the reaction to a soil factor is best shown by differences in yields (VAN DER PAAUW, Transactions, I). In this case the design of experimental plots becomes redundant and therefore recourse has been taken to so called "spot investigations". Samples were drawn simultaneously from the growing crops of very small areas of ¼ m² and from the soil of these spots in many places in the country. The investigations were performed on grassland and on arable land under rye. In both cases approx. 520 samples were collected (fig. 6).

After the war national planning has been taken up again. A number of about 60 long-term lime-potash experimental plots were added to the phosphate plots.

Series investigation could be started in 1947. In that year 200 P trial plots were laid out on grassland in various parts of the country and in 1948 another 130 trial plots (fig. 6). In the same year 75 K experimental plots were started on grassland.

All these experiments showed in general the high practical utility of soil testing. If we now look back to the criticism aroused when soil testing was in its infancy and make a comparison based upon experience, then it can be stated that the effect of soil factors is indeed not the same under all circumstances, but that it is influenced by other factors. These influences, however, have proved to be regular in many cases. Therefore, their identification enables us to take them into account. It is even safe to say that the results of soil testing, in eliminating secondary factors, are generally applicable to quite different soils. The variation of properties of the soil, decisive in evaluation, are apparently of less significance than was presumed.

Owing to this state of affairs soil testing becomes an indispensible attribute te recognise the numerous factors affecting fertility, decisive to the producibility of the soil. Investigations to disentangle the effect of all factors effecting the yield are at present performed in the Netherlands (VISSER, FERRARI, Transactions, I). The importance of these investigations cannot be easily overstated as they may supply a basis to radical land improvement schemes for large areas. That such schemes should be put into operation without soil testing is impossible.

d) *Determination of and check on other factors.*

Though determination of lime, phosphate and potash has always been most prominent, endeavours to determine other factors have not been wanting. An improved microbiological Aspergillus method is applied to determine the copper content. The suitability of this method has been confirmed by field experiments. Also other elements are determined by this method.

It can further be stated that the adoption of a chemical method for the determination of magnesium has recently been introduced. Physiological investigations have clearly shown that application of this method for practical purposes will be difficult as the influence of other factors (N, K, Ca), are to a large extent decisive to the effect of Mg and therefore its determination will be mainly of scientific interest. The same applies

even more to trace elements. Their determination according to colorimetric and spectographic methods is under investigation.

e) *Organization and technical aspects of investigation.*

It goes without saying that the development of the investigations described above had to go hand in hand with the development of organisation and technique. In the beginning the possibilities were very few and pot experiments anda few field experiments, mainly on experimental farms, had to suffice. Help offered by practical farmers was gratefully accepted. Gradually the service could be extended and the necessary technical experience in the management of experimental plots was attained. They were usually laid out on land of farmers. Also the insertion of experimental plots designed by Agricultural Advisers where soil testing could be applied, proved to be very useful. In this way data could be collected in other parts of the country as well. This co-operation was established on a voluntary basis, but from some parts of the country no data were available, simply because manurial experiments were not considered as being urgent there.

The first elaborate investigation referred to above was devised in 1937, when the Agricultural Experimental Station an organization of Groningen farmers joined to conduct soil-fertility investigations. In close cooperation with younger farmers but under the management of the Agricultural Experimental Station, which held a considerable share in the technical work incurred, the investigations were successfully performed. As the technical service of the Agricultural Experimental Station succeeded in managing these 170 experimental plots in addition to all the other work, it is evident that this section had developed considerably.

At the same time a few Advisers decided to devise a large number of experimental plots in order to get a better idea of the value of soil testing for the types of soil in their advisory region.

This feature, however, was incidental. A great change took place during the war, when a strong co-ordination of the Advisory Service was planned. One of the consequences was the design of a national plan for manurial experimental plots. Investigations were co-ordinated and the experimental plots, thought to be of importance to the various types of soil, were projected centrally.

The experiments are conducted under the direction of the advisers, applying the results to their advisory work. The management and central interpretation of the results is in the hands of the Agricultural Experimental Station. Also this arrangement would not have been possible without a considerable extension of the technical staff of these advisers.

Investigations from other centres

So far reference has only been made to the work conducted by the Agricultural Experimental Station at Groningen in collaboration with other institutions. The soil research work of the Zuyder Zee Works is carried out quite independently. This experimental work is exclusively intended for advisory purposes in the newly reclaimed areas. Effects of cropping, which resulted in a great variety of soil conditions on the old land, were absent in the new polders, and therefore quite a different problem had to be solved.

Horticulture has problems of its own. In the research centre of Naald-

wijk in the Westland with its glasshouse culture, numerous experiments have been performed to study the mutual effects of manurial factors and to interpret the data of soil testing. As horticultural crops require large amounts of nutrients special attention has been paid to the constituents soluble in water. The concentration of plant nutrients in horticulture is usually considerably higher than in agriculture and problems of interactions and the effect of trace elements are of particular interest. For this reason there is a need of simple methods of investigation (MORGAN, modified by VENEMA) which allow for the determination of many factors simultaneously. The content of muriates and the conductivity of the soil suspension are important indications of injurious salt concentrations originating from heavy dressings of fertilizers and frequent irrigation with water containing small amounts of salt.

As to orchards, next to soil testing much attention is paid to tissue tests (Zeeland Experimental Garden at Goes).

Finally I must not omit to mention the important share the fertilizer manufacturing industry has had in the development of research and advisory work.

Fundamental research to assist correlative soil testing

The risk of inflexibility, when purely correlative soil testing was introduced, has already been referred to. Those engaged in the investigations as well as those rendering advice are apt to consider correlative factors as causal ones. Though undoubtedly this research has resulted to a certain degree in actual understanding, for example of the mutual influence of factors, it seldom leads to fundamental knowledge of causal relations. Therefore it is of importance to continue these investigations in this direction in concurrence with and as a support to conventional research. In this respect the experiments on assimilation of ions coupled with plant analysis performed at the Wageningen Agricultural University and the Agricultural Experiment Station should be mentioned here. By this investigation also the position of plant analysis was ascertained. Though of less avail to practical advice in agriculture (not in horticulture, see p. 45) it renders another aspect next to soil testing, i.e. the nutritive conditions obtaining in the crop, which are of great importance to the scientific study of plant nutrition and manurial problems.

More particularly the prospects of investigations on the essence of soil testing, being conducted at the Agricultural University should be referred to here. Instead of determining the concentrations of nutrients in the soil solution the determination of the physiological activity of the ions is attempted. What will be the prospects for science and practice, resulting from these investigations is an open question.

Prospects of Soil Testing

It has been stated that soil testing has become an indispensable expedient in agricultural research and that it renders its ever extending services in various directions. The question may be asked: What is the position in regard to its development into a basis for agricultural advisory work? Higher technical perfection will be necessary, in addition to the checking of effective methods not very sensitive to unreal variations in the field. The check on soil testing can certainly be still more extended and more up to date soil scientific views on the nature of different types of soil must be taken into account.

Yet, it is evident that a practical limit must be put to the value of such a check. The adviser will not be able to consider the subtle effects of many factors of minor importance. Simple methods are wanted which can be used by assistants with secondary agricultural school certificates. The best must be attained by the simplest means. This affords to the research workers a permanent stimulus to self criticism. It is their task to disseminate amongst practical farmers all their findings as far as they are scientifically justified through the offices of advisory institutions and agricultural schools.