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SOIL FERTILITY STUDIES IN THE NETHERLANDS INDIES

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Since the beginning of this century agricultural research work has been carried out in the Netherlands Indies on an increasingly large scale, chiefly for the European plantation crops (sugar, rubber, tobacco, tea, coffee, cinchona and so on) but also to a considerable extent for native crops (rice, maize, tapioca, potatoes, etc.). The methods adopted and the results obtained are well worthy of general attention; they are relatively little known, as publications appear in local journals in Dutch and not always with a summary in another language, so that they are not easily accessible to most workers in other countries. The invitation by the Organising Committee of this Congress to read a paper on this subject offers a welcome occasion to make you acquainted with this work, although, of course, time will permit only to touch upon some of the more interesting aspects.

AREA AND STAFF

The area covered is, in round figures, about one million ha. for European crops, and, as far as the principal island Java goes, seven million ha. for native crops; about 1930 as follows :—

TABLE I

Crop	ha.	
European		
sugar	190,000	
rubber	600,000	
tobacco, Sumatra	20,000	
Vorstenlanden	8,000	
Besoeki	20,000	
tea	95,000	
coffee	90,000	
cinchona	15,000	
oil palm, cacao, etc.	70,000	
Total European, about		1,000,000 ha.
Native (Java & Madura only)		
rice, irrigated	3,000,000	
dry	450,000	
maize	1,900,000	
cassava	800,000	
others	700,000	
Total Native in Java and Madura, about		7,000,000 ha.

For this area twelve to fifteen smaller or larger experimental stations were put to work—one central station for native crops in Buitenzorg, and the others, for the European crops, in different places—with a staff which, gradually increasing from a few pioneers, counted at last nearly 150 fully-qualified academic graduates, with a corresponding number of European and native field assistants, analysts and other helpers. The three principal centres—Medan, on Sumatra's East Coast, Batavia-Buitenzorg, and East Java—are 2,000 Km. apart, and distanced about as London, Warsaw and Leningrad, communication between Medan and Java being only by ship (3-4 days) until recent airmail developments. The experimental stations for European crops are financed by separate planters' associations, but despite the large distances and the separate organisations there has always been a strong tendency to co-operation, including also the Government's institutes and ranging from exchange of data, common scientific and popular journals and organisation committees on different subjects, to one association of scientific workers of which most of the staff are personal members.

FIELD EXPERIMENTS

Soil fertility studies, the subject of this paper, have, of course, always taken a large place in the different programmes; in addition, plant breeding, diseases, preparation and quality of product, and other subjects were given due attention. It is the more stimulating to give you a general review of the work, since soil fertility studies, in the last quarter century, have developed for most crops along different lines from those in Europe and America. In the beginning (1890-1910) much was hoped from chemical plant analysis and from soil analysis. The former, however, never acquired practical importance; the latter gave little satisfaction and the methods then in use made it pass, as elsewhere, through a time of depression. Field experiments were then adopted for the principal crops, as the chief means of studying problems of manuring, cultivation and planting; this method took a large flight, and has remained predominant till the time of the world crisis, although soil mapping and soil analysis on a modern basis are more and more being called into aid.

A second feature which may strike you is that these field experiments, for the very large majority, were annual, in contrast to manuring work in several European countries, where static field experiments are more in vogue and are regarded by some, rather one-sidedly, as the only reliable and safe means to solve the problem.

Sugar Experiments

The development along these lines was organised on a scale seldom paralleled, by the Sugar Experiment Station at Pasoeroean (East Java), which, for an area of European plantations of 175,000 to 200,000 ha., ran a yearly number of 3-4,000 field experiments as indicated in Table II.

Table II

Number of field experiments of the Sugar Experiment Station Pasoeroean

Subject	Year 1930	1931	1932
Clones	518	1052	608
Optimum sulphate of ammonia	1403	1125	1370
Phosphatic manures	396	692	412
Potassium manures	132	525	367
Other manures	330	234	200
Planting (time, distance, etc.)	393	307	317
Tillage	40	208	276
Others	18	208	25
	3230	4351	3575

Therefore there was roughly one field experiment on every 50 ha. yearly. The number of treatments per experiment ran from 2 to 6 or more; after a serious study of the size of the experimental error, a number of 12 replications has been prescribed for the last 15 years, and 10 replications was the strict requisite; experiments with less replications being rejected in the centralised compilation of results. At first (about 1912) the number of field experiments was in the neighbourhood of two hundred per year; as practical results became evident this increased to one thousand, and by better organisation, training of staff, etc., to 3-4,000 per year, so that in a period of 20 years roughly 40,000 field experiments of this elaborate type were undertaken. To illustrate the practical scope we may mention that the new clone 2878 POJ was compared with older clones by means of the number of field experiments indicated in Table III; on the base of these results it was found justified to increase its part in the planted area from practically nil in 1924 to 93% in 1928, so that in four years the risk could be taken of planting the whole area by this clone, excepting some special types of soil where other clones did better. As soon as it became evident that clone 2878 was outstanding, the optimum amount of nitrogenous manure (sulphate of ammonia) was studied in the number of experiments mentioned in column 5 of Table III, so that in 1932 managers had at their disposal one experiment for every 30 ha., an ample material of well-established results to base their manuring plans on.

TABLE III

Introduction of clone 2878 P.O.J.

Year of planting	area ha.	% of total area	Experiments for comparison with other clones	Optimum sulphate of ammonia experiments
1924	43		38	
1925	1190	4	164	
1926	21700	12	851	209
1927	121000	66	724	763
1928	172000	93	350	1038
1929				1397
1930				1075
1931				1288
1932				578
			2127	6348

One other example. Potassium as a manure was not found necessary on these rich volcanic soils, fertilised by irrigation; the number of field experiments remained small, about 320 in the years 1908-1929. The potassium question then came into an acute stage, because certain disease phenomena were supposed by some to point to potassium deficiency. Within three years 1,024 field experiments were undertaken (compare Table II), with 3 to 12 treatments (different potassium salts, increasing quantities) and 10 to 12 replications, so that the types of soil where manuring with potassium deserved attention were quickly detected. The majority of Java sugar soils was found not to respond to potassium manures, and potassium work could further be concentrated in special regions.

Experiments of this extensive type require a large amount of calculation and computation work, with which a staff of native helpers is engaged. Blank experiments and experiments on methodical points were, of course, taken in ample number; the results of all experiments were compiled statistically and summarised in regularly appearing publications (see Review of Literature below), so that full use could be made of the wealth of data collected. To control such a mass of facts, special methods had, of course, to be developed, of which we only mention that increase or decrease in yield is, for comparisons, always expressed in terms of the standard error of the difference between the two treatments in question, as illustrated in Table IV.

TABLE IV

312 Phosphate experiments on soils with 0·009% P_2O_5 or less (in 2% citric acid)

	The advantage is						
	for no phosphate				for phosphate		
	3 m	2 m	2/3 m	0	2/3 m	2 m	3 m
Number	2	1	23	106	78	33	69
Percentage	1	0	7	34	25	11	22

From these figures it will be seen that phosphatic manure is more often advantageous than not on soils with 0·009% P_2O_5 or less (in 2% citric acid), but that the limit of 0·009% P_2O_5, which was adopted in the first period of soil analysis, is no satisfactory criterion and gives only 33% practical certainty and 58% good chances that phosphatic manure is indeed advantageous.

It is not possible to go into details here, and to give you a review of the subjects that have been investigated in this way. Amount of manure, type of manure, influence of the different principal plant nutrients on the amount necessary of each; local manures, new types of commercial manures were all given their share, and in addition other questions such as tillage and cultivation, water supply, time and distance of planting, and many more, as you will be able to imagine.

For all these questions the field experiment was used, and in such numbers that planters got a reliable basis for their planting programmes. Every plantation had one or more European field assistants, with special training for this work, and this assistantship was one of the regular stages a man had to pass in his career on a sugar plantation. Once this organisation developed, its handling and extension were comparatively so easy that it grew to a size that may prompt one to ask whether such large numbers of elaborate field experiments were indeed necessary, and paying.

It is not contended here that the way followed in the Netherlands Indies, and in which the Sugar Experiment Station has taken the undisputed lead, is the only one or the best one; things developed, for various reasons, the other way round than in Europe, and it is not denied that the extensive use of field experiments has its drawbacks—just as the extensive use of chemical or physiological soil analysis has its limitations, often giving a semblance of certainty and leading to conclusions which differ considerably from actual results in practice. As always in agriculture with its difficult problems, a combination of the two methods—field experiment, and analysis—gives better chances; we will see later what steps in that direction have been taken in the Netherlands Indies.

Experiments on Rice

On the same main lines, but of a different scope, has been the work for native crops by the staff of the Department of Agriculture at Buitenzorg. Economic conditions for the Javanese who work on the hand-to-mouth system, practically without capital, are in many respects diametrically opposed to those for the European plantations; the significance of the results of field experiments is smaller because often, when it pays and pays well to use artificial manure, the layout of money is an insurmountable difficulty for the native farmer.

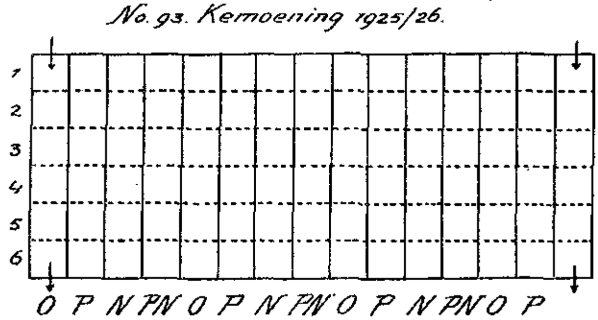
We can here only mention cursorily the work for one of the principal crops, rice on irrigated fields, of which Java and Madura count more than 3 million ha. Experimental work began in 1911, and now totals more than 1,000 field experiments, with 5 to 8 treatments (for instance O, N, P, NP, NPK, or in addition also K, NK and PK) and mostly 10 replications, therefore 50 to 80 plots per experiment. The yearly number of experiments was 1 on 30,000 ha. or thereabout. The results were often striking; the rice crop was frequently increased by 100% and more by the application of phosphatic and nitrogenous manures.

To multiply the usefulness of these large, 50 to 80 plot experiments, an ingenious method, well adapted to the mentality of the small farmer, was followed by reproducing the principal results, on fields of the same type of soil in the neighbourhood, in a large number of simple experiments in which only the manurial combinations which gave good results were taken, in a smaller number of replications. The big model experiment so formed the nucleus for a series of simple tests on an area with comparable soil conditions, whereby its results were broadcasted and at the same time a valuable check under varied practical conditions was obtained.

It may be of interest to point out that experiments on irrigated fields present special difficulties, not only because each plot requires a separate inlet and outlet of water, but also because the irrigation water, loaded with fertile silt, has its maximum manuring value where it enters and is of considerably less influence as soon as its rate of flow has decreased and the silt has been deposited. This gives considerable irregularities when the plots of one treatment are scattered over the experimental field at random or even after some regular arrangement, because the " fall " in fertility of the water is so large. This could be overcome by plotting in parallel strips (say, four treatments in five replications all alongside, as in *Fig.* 1) and harvesting each strip in, say, 6 parts, of which the upper ones were equally favoured by first-hand water, while the second ones also formed a comparable set amongst each other, and so on.

Field experiment with irrigated rice.

No. 93. Kemoening 1925/26.



direction of irrigation water.

Fig. 1.

Other Crops

Work for tobacco was started along similar lines, but had to be developed in the direction of quality testing. Yield is not the only aim, and for wrapper tobacco not even the principal one : size, colour, thinness of leaf, type of burn and colour of ash form a complex of properties determining quality and price, and the experimenter has to copy the sorting done by the estate, and the grading as used by the market, on the lots of bottom and middle leaf which are harvested 5-8 times, as they ripen. Determination of quality in such a product cannot be done by analysis, but is expert work; to express quality in figures suitable for the interpretation of the results of field experiments required the building up of adequate methods and organisation, the special training of women sorters, and so on. One field experiment with such a crop gives considerably more work than a number of them with cereals or potatoes.

Other crops such as tea, with its leaf harvest all the year round and its special quality requirements *re* colour and flavour of extracts; or rubber, with its regular tapping, year after year, and its many problems of plasticity and vulcanisation quality, gave rise to a number of special problems. Field experiments, in these cases, are difficult and tedious; for tea, endeavours to reach the goal along other ways, principally soil analysis, were more to the fore, but in later years special methods for field experiments were developed. These took a place, although not on so large a scale as for sugar, numbering only one or more hundreds against the several tens of thousands of sugar experiments (compare Table V).

TABLE V

Yearly frequency of field experiments

Netherlands Indies	roughly
Sugar	1 on 50 hectare
Tobacco, Vorstenlanden	1 on 1000 hectare
Rubber, West-Java	1 on 2000 hectare
Rice (native)	1 on 30000 hectare
Netherlands	
experiments on arable land	1 on 2000 ha.
,, ,, grassland	1 on 4000 ha.

Moreover, for most other crops it was found neither necessary nor advisable to increase the number of replications to 10 or 12, as did the Sugar Proefstation : 6 replications or thereabout were mostly found sufficient. The general idea was adhered to: to attack the problem by well-planned field experiments, so that a sound basis of practical results in the field is gained, and to see afterwards how far soil analysis and soil type mapping can be called in to aid in predicting results in other places. In recent years, now that soil analysis is undergoing a metamorphosis and is regaining new and promising growth, investigations have again been started to see what may be achieved by these methods under tropical conditions.

IRRIGATED FIELDS

As we already remarked, methods of tillage and other measures which may do much to promote soil fertility receive due regard in the planning of field experiments; a special feature for the lowland crops is, of course, the important influence of irrigation, with its marked fertilising effect. This presents many interesting aspects, from the deposition of silt and the supply of soluble nutrients, to the swelling effect on soil colloids and the dissolving of mineral plant nutrients, promoted by a temperature of 40° C. to which the sun-baked standing water on the rice-fields may rise. Another extreme of soil conditions is presented by the complete drying of the soil during the dry monsoon, which takes, as it were, in the Tropics, the place of freezing in the temperate zones and which has a similar intense, beneficial influence on soil structure, particularly of heavy soils.

We can here only mention in passing the studies on the effects of irrigation, on the content of silt and soluble substance in the irrigation water of different rivers and on related subjects, which form an important part of soil fertility studies.

Annual v. Perennial Experiments

As already pointed out, one of the most striking features of this well-organised, large-scale work is, for one accustomed to European views and methods, that all experiments for sugar and tobacco, and many for rice and the perennial crops, are annual. For sugar and part of the tobacco this finds its principal explanation in the fact that these crops are planted in rotation with irrigated native rice; another part of the tobacco (Sumatra wrapper) is planted in rotation with 6-9 years light jungle or afforestation. In both cases the artificial manure is only applied to the crop for the foreign market; soil conditions are completely altered during the intervals. Perennial or static experiments lose much of their importance under such conditions and are only undertaken for special problems, for instance for comparing different systems of tillage, where the breaking up of deeper layers may have a distinct after-effect. Although the effect of a first-year application of manure, in European conditions, should, of course, always be supplemented by a study of its after-effect and of the cumulative effect of continued yearly application, the tendency, in Europe, to investigate manuring problems only on the basis of static experiments, is subject to criticism; one often sees unwarranted or unallowable conclusions drawn from them. The system built up by the Sugar Experiment Station is exemplary of how annual field experiments should be undertaken; in large numbers, so that all casual factors (weather conditions of the year, local climate, local soil conditions, etc.) are eliminated, and well-founded general results are obtained, which can then, by systematic calculations and study, be brought into relation with different factors (chemical composition of soil, lime or base status, phosphoric acid or potassium status and so on).

For tea, rubber and other perennial crops the manuring experiments often ran several years, although the special type of static experiment that suits European conditions so well, to study the nutrition balance reached by a certain manurial treatment, and to investigate the after-effects of accumulated by-products, was not in the foreground under tropical conditions where rainfall is so much higher, humus turnover and other factors so different. There is, as far as I know, only one experiment which resembles somewhat the well-known and much venerated experiments at Rothamsted, Halle, Sappemeer, Göttingen, etc., namely a nitrogen experiment on a special type of light grey (" white ") clay on the East Coast of Sumatra, started in 1918, where rubber responded very markedly to nitrogenous manures, and yields decreased to a disastrously low level without manuring.

Pot Cultures

Pot cultures take a much smaller place than in Europe, chiefly because most tropical crop plants are so large. Rice and some of the smaller crops are suitable; the former has even been tried for physiological soil testing of the Neubauer type. Tobacco and sugar have been used in pot cultures, but the size of the plants (2-3 and 4-5 metres respectively) puts a limit to the number of pots that can be taken. Shrubs, such as tea and coffee, or trees, such as rubber and oil palm, are not suitable for pot cultures, and, if desired, are treated and studied individually in the field.

Soil Mapping

The soil analysis work of the first decades, as well as field experiments in later years, led to endeavours to draw up soil maps, in which soil types visible to the eye were distinguished and classes or groups were formed within which the results could be generalised. In several cases this at first took the form of estate maps, in which the experience for each field in subsequent years was recorded so as to give guidance to successive assistants and managers. Only in later years, when the limitations of field experiments as a basis for planting programmes became more evident and soil type mapping gave some striking results, did this means of classification come more into the foreground.

Several more or less different systems have been adopted dependent upon the aims of the mapping work; the principles of the Russian or climatogenetical, the German or petrogenetical, and the American or agrological systems, have been used as seemed desirable, so that the systems adopted in the Netherlands Indies are combinations of these different types of classification, built up so as to give a maximum useful effect. The different systems of soil mapping are fully dealt with in Section V of this Congress, and I will here only give some examples of the practical results obtained in two cases, one for Sumatra wrapper tobacco and one for sugar.

In the former case, agrogeological mapping made it possible to distinguish between different types of soils, of which the colour after weathering had become the same, so that the planter saw no difference and brought them all into one class of red soils, or black soils, etc. Striking differences, for instance in the liability to certain diseases such as bacterial wilt disease (*Bacillus solanacearum*), were found to coincide with differences in agrogeological soil type, not visible to the eye. One of the plates shows figures for an attack by this disease, and the soil types distinguished by agrogeological mapping; the accordance is conspicuous. In a similar way, the average market prices over a large number of years—so divergent, and so important in a quality crop like wrapper tobacco—show a close agreement with the modern soil map, and many discrepancies could be explained when a more adequate system of soil classification had been developed.

Based on a general agrogeological mapping, the detailed mapping for the sugar plantations has been done according to heaviness and to colour; these two maps, combined, gave a soil type map. The results of field experiments were then, of course, plotted in these soil type maps, and one of the slides to be shown illustrates how these results, for phosphatic manures, agree with the soil types. At the same time the soil map shows in which places further field experiments should be undertaken.

SOIL ANALYSIS

I have already pointed out that a large amount of work on soil analysis was done. Chemical analysis always took a considerable place, and in earlier years it was hoped to develop suitable relations or limits. But this hope did not materialise, at least not with the older methods of soil analysis. As an example I mention the case of the relation between effect of phosphates and the phosphate content in sugar soils (from 1,072 experiments of 1930-1932) depicted in *Fig.* 2, which shows a considerably higher response for soils with less than 0·005% P_2O_5, so that a distinct limit presented itself. The provisional limit, chosen at 0·009% P_2O_5 on the basis of older analyses, had to be corrected on this basis. However, when investigating separate cases, this new limit was found not to hold, and divergences were so wide that it did not provide a general basis for determining the need for phosphatic manure. The same was the case with other soil analysis figures.

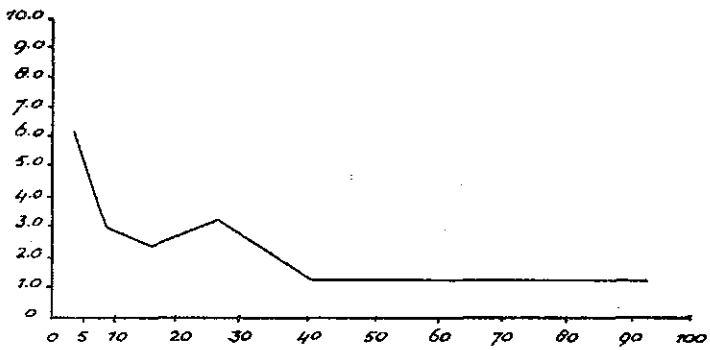


FIG. 2.—Increase in yield, q/ha. sugar, by phosphatic manures, on soils of different phosphate content (abscissæ, P_2O_5 in thousandths of 1%, soluble in 2% citric acid).

The result of all the work of this first period was that in a series of motions adopted by the Soil Congress held in Djocjakarta (Mid-Java) in 1916, soil analysis was rejected as a basis for advice in manurial problems, being only deemed useful when limited to soils of one type and on the basis of the results of field experiments and practical yield figures. It may be asked, by the way, what the result would be when the analysis figures, which at present take a prominent place in some European countries, were put to the test by such a large number of elaborate field experiments. It would not be astonishing if the confidence now put in the analytical data by many workers was found as unwarranted as in Java.

Mechanical soil analysis on the basis of ten fractions gave more useful results and in later decades took a prominent place in soil classification.

Meanwhile, newer methods of chemical analysis have been worked out and are being compared with the results of field experiments. For the phosphate problem especially there is some hope that a combination of figures for the water soluble content, the gradual supply and the phosphate fixation may furnish data on which a prognosis of phosphate needs can be based.

Attempts have also been made to carry the usefulness of chemical analysis a step further by analysing the separate fractions obtained in mechanical analysis, which seems a reasonable proposition for obtaining an insight into phosphate nutrition possibilities, differentiating between phosphate from mineral and that from other sources. In the example (Table VI, very heavy, old marl soil) the coarser fractions are found to contain a larger percentage of phosphate, but this is less easily available to the plants in the Neubauer test; the reverse is the case for the five silt and colloidal fractions.

TABLE VI

Fraction	Size mm	% of Soil	mg P_2O_5 in 10 g 25 % HCl	mg P_2O_5 in 10 g 2 % Citr.	Neubauer mg P_2O_5 in 10 g	HCl / plant	Citr. / plant
I-V	2 – 0·05	6·0	11·0	6·5	2·0	5·5	3·3
VI	0·05 – 0·02	9·2	9·6	4·8	1·6	6·0	3·0
VII	0·02 – 0·005	14·2	6·4	3·4	2·4	2·7	1·4
VIII	0·005 – 0·002	18·5	4·7	2·4	1·6	2·9	1·5
IX	0·002 – 0·0005	25·8	3·5	1·5	3·3	1·1	0·4
X	<0·005	26·3	2·5	1·0	3·5	0·7	0·3

The ratio of acid soluble to root soluble phosphate is, in the coarse fractions, about ten times as high as in the fine fractions. From the finest fraction (X) the roots, in the Neubauer test, take up more phosphate than is dissolved in one extraction by citric or even by cold 25% hydrochloric acid. Studies in similar directions may undoubtedly explain some of the discordances between soil analysis and field results.

Taken as a whole, soil analysis in the Netherlands Indies has not yet gained great importance in soil fertility problems. We see several reasons for this state of affairs. In the first place, nitrogen, for which soil analysis gives no indications, is by far the most important manure; phosphate and potassium are of little importance on the rich volcanic soils which form the majority. Further, for the lowland cultures (sugar and tobacco), irrigation in the rotation with rice has, as already pointed out, such a predominant influence, and brings such large changes in the amount of available plant food, that the manurial status is vagrant and much more difficult to characterise than on a regularly manured European farm; the rather simple picture furnished by soil analysis is not enough to give an insight into the complicated changes that are taking place. As for the hill crops, these are grown on such a variety of soils that only analysis on a very broad basis can give a sufficient foundation for predicting manurial needs, and even then it is a difficult task to interpret the many figures in their mutual interdependence and their united effect on nutrition supply and fertility.

CODIFICATION OF METHODS OF TESTING

To those who regard it as one of the aims of the International Society of Soil Science to promote uniformity in methods of testing and analysis, it may be of some interest to hear that methods of soil testing were standardised in the Netherlands Indies more than twenty years ago. I made a plea for unification at the yearly meeting of the scientific staffs of all Experimental Stations in 1912; it was known that the Second Soil Conference at Stockholm, held in 1910, had appointed three committees for international agreements on methods of testing and nomenclature, but as this might be expected to take considerable time, a small working committee was appointed to draw up proposals for a Codex for soil testing, which was adopted in 1913. These codified methods, at present, are still in use, but are in want of modernisation and extension to bring them up to the standard of our present state of knowledge. Proposals have been under study for some time. Besides the standardised methods, new methods are being used on a considerable scale as occasion requires.

Of course, standardising a certain method should never mean that new methods are excluded or given the cold shoulder. It seems, however, of little importance in an absolute sense what the strength is of acids or other chemicals used for extraction or the temperature and time for certain operations; once a choice on these details is made and adhered to, things become much easier and results are better comparable. International standardisation, as desired by the Stockholm Conference, was found difficult to establish; perhaps the knowledge that standardisation of a fairly complete set of methods has existed for nearly a quarter of a century in a country much smaller, no doubt, than Europe, but still large enough to give rise to local chauvinism and to differences of opinion, may afford some confidence and inspiration to those members, who see a task in promoting standardisation on the international scale of this Society.

Retrospect

Soil fertility problems are complicated; our means and methods, each of them separately, are inadequate. The problem has to be conquered by attacking it from several sides.

Each of the crops in the Netherlands Indies had, more or less, its own history of research according to its special needs and the special difficulties it presented; the over-estimation of one method always led to a deadlock and, in the advanced stage, the general tendency in all cases is very clearly in the direction of combining all methods. For cinchona, not dealt with above, the scientific investigation of soil fertility problems is most recently begun, and, being from the first put distinctly on the basis of combined methods, it gave relatively quick and good results.

Of the four chief expedients discussed above, plant analysis, for various reasons, played only a minor role in the Netherlands Indies. Soil analysis, favourite at first, lost importance and was replaced by large-scale field experiment work, which has done its part and for some crops is more or less exhausting its possibilities. Modern soil type mapping, combined with soil analysis on modern lines, is providing a better base for the laying out of field experiments and the interpretation of their results.

Time did not permit me to give you more than a sketchy review of some of the outstanding features of soil fertility work in the Netherlands Indies. In my paper I have mentioned no names of investigators, as these, in their Dutch pronunciation, would probably not be familiar to you; a review of some of the principal investigations is added in the printed volume. I would, however, not let this occasion pass without paying due and sincerely meant homage to my colleagues, those of past decades and those still actively at work in the Tropics, who did so much under often trying conditions to develop the work of which I could only give you a passing glimpse. A study of methods and results, differing in several respects from those in Europe, and partly built out to such a considerable size, might well be worth your while, and it will be a great satisfaction indeed if I have succeeded in arousing your interest in the remarkable work that has been done in this field.

REVIEW OF LITERATURE

Of the voluminous literature only a short summary of authors' names can be given here. A review of Scientific Institutions, Experiment Stations, etc., with their staff, organisation and publications is published (in English) in the book "Science in the Netherlands East Indies," issued by the Royal Academy of Science at Amsterdam in 1929. A list of older publications on Soil and Soil Analysis has been given in the yearly Report of the Sugar Experiment Station for 1911; only some of the most characteristic papers from that period are mentioned below.

All articles are in Dutch. Only some (in the Arch. Rubb.) appeared with a full English translation; many others, but not all, have a Summary in a foreign language, mostly English.

The following abbreviations have been used for the principal journals, mostly Communications issued by the different experimental stations.

Arch. Rubb.: Archief voor de Rubbercultuur in Nederl. Indië (Archives for the Rubber Plantation Industry in the Netherlands Indies).
Arch. Koff.: Archief voor de Koffiecultuur in Nederl. Indië (same for coffee).
Arch. Suik.: Archief voor de Suikerindustrie in Nederl. Indië (same for sugar).
Arch. Thee: Archief voor de Theecultuur in Nederl. Indië (same for tea).
Bergc.: De Bergcultures (journal for hill crops).
Bull. Deli: Bulletin van het Deli Proefstation (Bulletin of the Deli Proefstation).
Cinch.: Journal Cinchona.
Dept.: Departement van Economische Zaken (Department of Economic affairs), Batavia; (formerly: Departement van Landbouw, Nijverheid en Handel te Buitenzorg).
Diss.: Dissertation for the degree of doctor.
Ind. Merc.: De Indische Mercuur (journal issued at Amsterdam).
Landb.: Landbouw (agricultural journal issued at Buitenzorg).
Med. Avros: Mededeelingen van het Algemeen Proefstation der AVROS (Communications of the General Experiment Station of the AVROS at Medan, Sumatra).
Med. Bes.: Mededeelingen van het Besoekisch Proefstation (Communications of the Besoeki Experiment Station at Djember, Java).
Med. Deli: Mededeelingen van het Deli Proefstation (Communications of the Deli Proefstation at Medan, Sumatra).
Med. Dept.: Communications issued by the Department of Agriculture (different series, called Mededeelingen uit s' Lands Plantentuin, and Mededeelingen van het Departement van Landbouw, successively).
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