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## IMPRESSIONS OF THE PHILIPPINES AND OF THE UNITED STATES[1]

*From the Notebook of a Soil Scientist.*

Illustrated with Photographs by the Author

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Of the Department of Agriculture.

Early in 1939, when I was planning to take long leave in the United States, the Department of Agriculture named me its representative to the 6th Pacific Science Congress, to be held in California during the summer of that same year. Subsequently I was requested by this, the Thailand Research Society, to represent it also at this Congress. Then, only a few weeks before I was to commence this leave, the U. S. Government requested the loan of my services for a couple of months to join the Mindanao Exploration Commission. This Commission was composed of a group of experts in tropical agriculture and related sciences, who were being sent to the Philippines to study the possibilities of establishing in those Islands a colony for political refugees.

Actually the Mindanao Exploration Commission was unable to relieve me until after more than three months had been spent in the Philippines, so that in order to get to the Congress on time I had to travel by Clipper 'plane from Manila to Honolulu, Hawaii. After the Congress, while still in the U. S., I travelled many thousands of miles by train, by automobile and by 'plane to see as many of the different soil and agricultural conditions as possible, and to meet as many soil and other agricultural scientists as possible.

[1] Presented before the Natural History Section of the Thailand Research Society, Bangkok.

When I started on that trip I did not realize what a large country the U. S. really is! Undoubtedly with but three months to spend in the States I tried to visit too many places and to do too much; nevertheless I believe that certain of my observations and impressions are worthy of record.

## Mindanao and the Work of the Exploration Commission.

Mindanao is an island of the Philippines with a great diversity of topography, geological formations, soils, peoples, and natural vegetation; consequently there is a very wide range of possibilities in its agricultural development. The problem of our Commission was to study the possibilities of white settlements in agricultural colonies in Mindanao, which, if possible, would produce products for sale that would not compete with the staple exports of the Islands.

During the ten years I had spent on the faculty of the College of Agriculture, University of the Philippines, I had had but little opportunity to visit Mindanao; hence I particularly appreciated the privilege of being made a member of this Commission for, as a consequence, I was able to learn at first hand much more about this island than I had previously known. The added privilege of renewing contacts with agricultural and other scientists in the Islands was also of value and was a real stimulus to me for further work here in Thailand.

In Mindanao we spent most of our time travelling. For transportation we relied on motor trucks and horses, though to reach certain localities, where there were not good horse trails, we had to travel on foot. As a vantage point for the study of general relationships nothing is equal to the airplane, particularly in a region where the topographic maps are far from being accurate; hence we were very fortunate to have the use of an army 'plane for several long flights. We were able to see from the air much more in a few hours than we had seen from the ground in as many weeks. And though we had to work fast and to be alert, when using the 'plane for observation, working from the 'plane was the easiest and most interesting part of the entire survey. (Figs. 1, 3.).

One of the particularly striking features of the present development of Mindanao is the following fact: while the natives, except the Moros in the Lanao region, had always raised their crops by the caiñgin

(*rai* or shifting cultivation) method, which usually left the land occupied by a vast expanse of cogon grass (cogonal), Filipino immigrants from regions of heavy population pressure brought with them the knowledge of how to use strong iron plows and the skill to use them (Figs. 2, 3, 4, 5). These immigrants are now successfully cropping the cogonals which formerly had been entirely unproductive, save for providing some poor pasture.

When I visited Mindanao six years earlier, Doctor Copeland and I hiked through a dense forest along a muddy trail, with not a single house or bit of cultivated land in sight in many kilometres. But when we passed through the same route this time, in a car over a good highway, we found a practically continuous settlement of small farmers who have built their own houses, cleared the necessary land and are raising their food and cash crops. More than once local officials pointed out that, if only good roads are built, if police protection is adequate to insure law and order, and if some attention is given to public health, farmers of the most hardy and desirable types will effectively settle the land. To prevent politically powerful interests from becoming landlords, it is, of course, very desirable that the individual settlers be assured of their permanent rights to the land. An unfortunate feature of this development is that the Philippine Bureau of Lands is laying out this hilly land on the square, making no adequate provision for branch roads to run on the contour or on easy grades. It is the same mistake which was made in the middle western U. S. some generations ago when the section lines were all run on the square. It is a mistake which can be corrected later only at great expense and only with much difficulty.

Since from time to time during many years the Phillippine Government has subsidized agricultural colonization in one way or another, it was interesting to hear local comments to the effect that there was no need for the Commonwealth government to expend great sums to develop settlements; for as long as the people had roads and law and order they were quite able and willing to do the rest themselves. Therefore, if the government would invest all the available funds it had in further extending the highway system and properly maintaining it, the Island as a whole would be much better developed agriculturally.

In Davao province intensive cultivation of abacá (Manila hemp) is particularly striking (Fig. 8). The plants, which resemble very large

and vigorous banana plants, are grown as a pure stand and usually under clean culture, though there is some use of creeping leguminous vines as a cover crop. But already the abacá in certain localities, after only about fifteen years, is succumbing to disease. It seems that the soil is deteriorating. By contrast, the abacá grown under the half shade of big forest trees in the Bicol provinces of the island of Luzon continues to produce modest quantities of fibre even though the plantations are hundreds of years old, for the tall forest shade trees have maintained the soil fertility in a normal, natural way (Fig. 7). It is indeed a striking contrast to the exploitive agriculture in the Davao region. The clean culture methods used in Davao are closely related to the other temperate zone clean culture methods, which have been introduced into the tropics for the production of tea, coffee, rubber and pineapples, etc.—exploitive agriculture all. Because the normal supplies of ramie from China had been cut off by war, when we were in Davao, ramie was proving a profitable crop to replace the fields of abacá which had died from disease.

In northern Mindanao is a plantation of many thousands of acres of pineapples. The soil is carefully managed according to scientific principles to prevent deterioration and erosion. Down on the coast is a large modern cannery where the fruit is preserved for the export market. This pineapple cannery replaces a modern fish cannery, which failed with the loss of much more than half million Baht because of the lack of an adequate supply of fish ;—tropical waters, while extremely rich in different varieties of fish, seem generally to be lacking in sufficient quantities of sorts suitable for canning to make such an industry worth while.

On the other hand the extensive development of fish ponds in the Philippines leads one to believe that there may be greater possibilities in Thailand for the pond culture of fish.

### By Seaplane across the Pacific.

From Manila to Honolulu, four one-day hops were made by clipper 'plane. Scientifically this trip was interesting for the following reasons: (1) meteorologically, since it is necessary for the 'plane to launch out each day on the flight with the meagrest of meteorological data and a very sketchy forecast. This is because there are no sources of information anywhere between the point of departure and the destination of each day's flight, a distance of

between 1,000 and 1,800 miles. For example, when we left Manila we knew that there was a typhoon somewhere between there and Guam, our destination for the night. To avoid this typhoon, we went more than a hundred miles south, only to find about noon that we were in the center of a new one! From our unexcelled vantage point we could see many thin wisps of cloud in a pattern which indicated clearly the cyclonic nature and direction of the winds in a typhoon. (2) At Wake Island we saw the equipment used for growing vegetables in water cultures, the so-called hydroponic method. The practical results and advantages of this particular project seem to have been much overrated by the popular press. (3) The halt at Honolulu gave me a much better than average opportunity to meet leaders of scientific research and to learn of the facilities for graduate study in various branches of agricultural science; and also to see research being applied to the solution of problems in subtropical agriculture, particularly with reference to those of sugar cane, pineapples, tree fruits and livestock. A notable feature of the elaborate and thorough agricultural research in sugar cane and pineapples in the Hawaiian Islands is that it is supported entirely by private funds. Enormous sums of money are annually invested in research by the cane planters and manufacturers of sugar, associated in the Hawaiian Sugar Planters' Association; and by the pineapple growers and canners in the Cooperative Pineapple Association. These organizations maintain experiment stations and pay good salaries for they hire the best agricultural scientists they can obtain in any country, and give them a free hand in carrying on of their research. Entomologists are sent for years to far away cane regions to hunt for parasites on cane pests, that the parasites may be taken back to Hawaii and used to control the pests there. And plant collectors have been sent for months to South America to get pineapple breeding material.

## SIXTH PACIFIC SCIENCE CONGRESS.

Reading a paper in a scientific congress is often thought by the folks back home to be a great accomplishment, but unless the author is adept at gaining and holding the attention of his listeners, the presentation of scientific papers containing even epochal discoveries may be most dull and uninteresting for the listeners. To make such programs more worth while and interesting, as well as to permit the substance of a larger number of papers being presented before the meetings, there is an increasing tendency to group papers and to present them as symposia. This gives an opportunity for the leader of the symposium to present various sides of the topic, as contributed

by the various authors. Interesting questions often arise, and the resulting discussions are most helpful, the new ideas or angles of approach to the subject being often of more value than the papers themselves. The papers in full as well as the gist of the discussions are made record of in the Proceedings.

The opportunity of meeting scientists, working in many different parts of the world, and interested in the same or related problems is, by far, the most important feature of all such scientific meetings or congresses. The personal contacts made and the friendships, which commence in such meetings, often last a lifetime and enable scientific workers by correspondence and exchange of publications to accomplish very much more than otherwise is possible. To make as many of these personal contacts as possible and to maintain them later by correspondence and exchange of publications is most important. In normal times there is much to be gained from correspondence for the exchange of information and of ideas. For us here, since we are so widely separated from others specialists in the same fields of research, the personal contacts are particulary prized. At the Berkeley meetings a large international group, of which I was a member, had the added advantage of living together in a beautiful and commodious dormitory, and many and valuable were the off-the-record conferences regarding equatorial soils and other pedological problems.

The Science Congress was organized into different sections ,with many of the sessions being held and discussions proceeding simultaneously. Because I had the responsibility of leading the discussions on tropical soils and laterites, it was impossible for me to do more than attend the meetings of the soil section which dealt with soil resources and the methods of classifying and mapping soils in use in the countries represented. However, at the general or plenary sessions of the Congress, public lectures, social affairs and excursions there were opportunities to get acquainted with the specialists in other branches of science.

The really great pity, as far as Thailand is concerned, was that I was the only representative from this country. None of my coworkers were able to be present—no Thai was there to get the inspiration and to establish the contacts which would mean much in the years to come.

## SOIL RESOURCES SECTION.

This Section was composed of representives from Australia, China, Hawaii, Mexico, Canada, Thailand and the Philippines, as well as the heads of a number of the state soil surveys and higher members of the U. S. Soil Survey staff. From time to time there were numerous visitors who were interested in the geography, geology, agriculture, and forestry of the regions being discussed. The average attendance of the Section was between 20 and 30.

In this Section the reading of formal papers was firmly discouraged, the preference being given to informal presentation, with abundant time for discussion and consideration of the maps, illustrations, and samples brought to illustrate and support the statements made.

During the congress there were 2 two-day trips into different sections of California some hundreds of miles apart, to study various types of soils and their relation to agriculture and other human activities (Figs. 9, 10). We travelled in the passenger cars belonging to and driven by soil survey and soil conservation service officials in the State. A special effort was made to vary the seating of the delegates from time to time, shifting them about from car to car, so that each could get acquainted with as many others as possible.

Subjects discussed in the meetings: Much time was devoted to the most recent methods of soil survey technic and mapping. It was evident that soil survey technic is still more an art than a science—it is still necessary for the student to learn soil surveying by doing actual mapping in the field under the guidance of an experienced surveyor, and to learn to identify soils by seeing them at home, in their natural setting. No correspondence courses or text books or manuals in soil surveying are of any use in themselves. In fact, they don't exist! Much time was spent considering methods and systems of land classification—its relative value for agricultural and other particular uses. Soil erosion, land classification, and related requirements continue to introduce additional complications into soil mapping.

The almost universal use in the U. S. of aerial photographs as base maps for soil mapping in the field, and the use of the negatives of those same photographs for the preparation of contour and other base maps was very impressive. Greatly increased accuracy and speed in getting the maps out are notable.

The Soils Section spent considerable time in discussing the nature of tropical soils and the methods of agriculture in the tropics, particularly of caiñgin (*rai*) cultivation (Figs. 2, 5). It fell to me to lead this discussion as well as that on laterites.

Tropical soils are still far from being well understood by scientists in temperate regions, so that there is more than ever a demand from us for information concerning the nature of the soils of this country. To inform them is of course less important than to get the data about Thailand soils to help us solve our agricultural problems, but the fact that there is also an interest overseas in our soils does stimulate us in our work here.

Laterite was a subject which aroused considerable interest particularly because I had numerous samples of laterite from this country to show the audience. And what keen interest there was in getting specimens when I came to divide the samples for the different institutions! There was not nearly enough laterite to go around. In temperate regions there is too much speculation and too little data for a proper understanding of the real nature of tropical soils and particularly of laterite. Laterite is an iron-cemented hardpan which has developed in certain soils. In some localities laterite has from ancient times been quarried and used structurally.[1] (Figs. 15, 16).

One resolution passed by the Soil Resources Section was a happy surprise to me in that it gave strong support to the publication of my English translation from the Dutch of Professor Mohr's book on tropical soils. One result is that the project is now recognised as official and material help has been given toward transcription and editing so that the book should be out this year. Another resolution, less welcome to me, made me the leader of the permanent committee for Soil Classification and Mapping, and hence responsible for the sectional program at the 7th Pacific Science Congress, to be held in Manila in 1943.

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[1] A subsequent illustrated lecture before The Thailand Research Society dealt with the nature and uses of laterite. The material presented in that lecture has now been published under the title:

*Laterite and its structural uses in Thailand and Cambodia.* The Geographical Review **31**, 177–202. Figs. 63. April 1941.

A large amount of analytical data dealing with the laterites of Thailand will be published elsewhere.

TRAVELS IN CALIFORNIA AND OTHER PARTS OF THE UNITED STATES.

While international congresses of soil science have helped greatly to widen the knowledge of soil scientists in soils of the world as a whole, a comprehensive world-wide classification and understanding of soils is greatly handicapped by the great distances and heavy expenditure of time and money needed to see in their natural position and surroundings the soils of the main regions of the world. Since in most cases it is impossible for practical purposes to collect profile or monolithic samples of soils and assemble them at some central points for study and comparison, for a true understanding of the interrelationships of the soils of the world, it is imperative for the soils expert to personally visit the different regions and make observations[1]. As a consequence of the above-mentioned handicaps international classification of the soils on a thoroughly comprehensive basis has not yet been achieved, for the various groups of workers as a whole still seem unable to break away from the conceptions developed in their respective home regions.

In order to enlarge my field knowledge of soils as much as possible, while on leave, and so to better comprehend the nature of the soils the American soil scientists are working with, I visited many agricultural experiment stations and soil erosion experiment stations under the State Experiment Stations, the Forest Service, the Soil Conservation Service, etc. (Figs. 11, 12). In ten states in widely separated parts of the U. S. I spent many days in the field with the chief of the State soil survey or other experienced soil scientists (Fig. 13). Because of the importance of making comparisons with tropical soilt particular attention was paid to soils in the southeast, the moss nearly tropical portion of the States.

Much interest was manifested in my lantern slides of the soil and other agricultural conditions in Thailand, so that many of the slides were shown and discussed in a number of universities as well as in the U. S. Department of Agriculture in Washington, D. C.

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[1] Striking evidence of the peculiar importance for soil science of travels by a competent observer is a report, received after the above was written, by G. Milne, soil chemist of the East African Agricultural Research Station, Amani, Tanganyika Territory, entitled: "A report on a journey to parts of the West Indies and the United States for the study of soils. February to August 1938."

## The Triumph of Research in Agriculture.

In spite of certain rather odd local explanations of the meaning of the word, research is of basic importance, and I am glad that it has been incorporated into the new name of this Society. During my visits to scientific institutions in the States I did not often hear the word itself, though a very large proportion of scientists with whom I came in contact were seriously engaged on some research problem or other. Research may be defined as the search for the fundamental truths of nature, that the natural laws may be employed in more effective ways to enable man to accomplish his purposes—in agriculture, to produce bigger crops of better quality products at a less cost per unit of product. The employment of research in the agricultural sciences means a more efficient agriculture.

Now that the natural sciences have progressed so far and there is such an enormous mass of data available to be drawn upon, it is not at all economical to attempt research without a comprehensive and properly catalogued reference library, that the most may be made of the discoveries already known and that the mistakes of others may be avoided. Library facilities are excellently developed at the important research centres.

And since the publication of the results of research is very important, it is cause for commendation that this Society continues to support the publication of scientific papers so generously.

And while scientists are apt to be individualists, and to resent discussion of their plans and results with others, experience has abundantly proved that cooperative research and frequent discussion of the progress of the work are extremely productive of new points of view and ideas which a solitary researcher is not nearly so likely to hit upon.

In occasional instances I came upon some rather amusing examples of spending more upon equipment than upon trained and experienced scientists. Elaborate and expensive equipment does make a show, and is at times essential for obtaining results, but there is much more chance of worth while results in agricultural research with capable and experienced men and modest equipment than with expensive equipment combined with less than the best brains.

While it is true that the U. S. has ten times as many inhabitants as has this country, and that the average standard of living there is very much higher, it does make one pause to see the new *annex* to the headquarters of the U. S. Department of Agriculture in Washington. Covering two large city blocks, it is a six storey building in which more than 6,000 agricultural scientists and their assistants work daily. After trying to locate different offices in that enormous building, I can easily believe the boast that there are eighteen kilometres of hallways in that one building—*one hundred and fifty times as much space as we have in our new central building for scientific agricultural research at Bang Khen* ! In addition to the four large regional research laboratories for the study of special agricultural products now being established by the U. S. Government, there are about fifty state agricultural experiment stations supported in part by the Federal Government. Then there are the extensive, elaborate and very expensive soil erosion research stations, most of which are under the Soil Conservation Service.

Fortunately for Thailand, we have many friends abroad who are glad to help us in any way they can with data and the products of their agricultural research. However, there is a very great deal we must do ourselves if we are to solve the agricultural problems which are facing us, and so to help our farmers. Much of our land is not at all suited to farming and should be left in forest, so that our chief problem is to help the farmers to produce more certainly a larger amount of rice of higher value for home consumption and of better quality for the export market, at a less cost per cartload, as well as to help them to produce a larger variety of vegetables and other crops for themselves and for their livestock, and to produce more livestock for sale.

Referring to the importance of basic research steadily employing capable scientists who work under good conditions, I am reminded of what I saw in Java, when there as a delegate to a previous Science Congress. In contrast to the art of sugar cane agronomy in the Philippines, where the average yield of sugar is still not much above 5 tons of sugar per hectare per year, during the last forty years the average annual sugar yield in Java has been raised to about 15 tons per hectare through basic research, sugar cane breeding

and selection, study of diseases and pests, survey and mapping of the soils, and testing the fertilizer requirements of sugar cane lands on a fantastically extensive scale. And all this has been privately paid for by subscription on an area basis of all cane grown, the research and extension organization being entirely private, so that scientific merit and not political affiliation determines the selection of staff and experimental policy.

### Changing Standards of Soil Managemnt.

Conventional methods of doing things are *not* always the best. As a boy on the prune ranch, where I grew up, a single mustard plant in the orchard was a disgrace. As soon as one was detected, I was sent to pull it up. Contrast this with what I saw last summer: Orchardists in the fall are seeding their orchards to mustard and other "weeds" and in the spring breaking the plants down and only half plowing them in, for under certain conditions the trash cover is a very beneficial mulch on the soil (Fig. 10). Fortunately for tropical soils it was more than a decade ago that rubber and tea plantation managers discovered that the clean soil cultivation copied from temperate zone orchard practice was ruinous for their tropical soils. Verily throughout the world there is taking place, as a British agriculturist said, "a degree of return from the highly artificial system of crop production," so that there is more hope of generally "preserving the biological fertility of the soil, upon the maintenance of which not only the yield but also the wealth of our crops must ultimately depend." Here in Thailand, in growing our cotton and other upland crops, should we insist upon plowing the soil, and other clean cultivation methods? or a modified caiñgin (*rai*) method? As yet we do not have experimental evidence to help us answer. There is indeed much to be said in favour of caiñgin cultivation.

At long last, through the pioneering work of H. H. Bennett, the United States has been aroused to the seriousness of soil erosion. Annually the U. S. Government is spending tens of millions of dollars in research upon the best means of conserving the soil, and of remedying the damage already done, and in demonstrating to the farmers how they can more effectively care for their soils. Replanning the farmstead for strip or contour cultivation, planting steeper slopes to trees,

improving pastures, protecting highways against erosion—, a few years ago the Soil Conservation Service placed much emphasis upon dams, fills, ditch protection by the use of concrete or timber structures, etc. But these are expensive and since deterioration is rapid such structures require constant vigilance for maintenance in the proper condition. Only lately has it been realized that the use of vegetation is more effective, is cheaper, and will in the long run better take care of itself in protecting the land. Explorers for hardier and more effective plants, sent out from Washington are searching throughout the world for new kinds of plants for this purpose. Moreover, plant relationships under the conditions of use are being studied intensively. For example: While Bermuda grass has been proved most suitable for preventing the erosion of waste-ways from terraces, when used for this purpose, it is almost certain to spread into the adjacent cultivated fields. Buffalo grass, however, though not protecting the soil so well against erosion, if planted in a strip above the Bermuda grass, keeps the latter from spreading into the cultivated fields, and sufficiently protects the sides of the drainage way. Therefore drainage ways are protected with the two sorts of grass.

### LAG BETWEEN PROGRESS OF KNOWLEDGE AND ACADEMIC INSTRUCTION.

In the course of my travels, during a discussion regarding tropical soils and laterites in one of the leading agricultural Colleges, one member of the faculty speaking to the author of a leading text on soil science said "B. . . the new edition of your book is already out of date regarding laterites." Suggestive of the progress of soil science, B. replied to the effect that if it had not been out of date regarding laterite, it would have been out of date in some other respect anyway. Thus it always is with subjects like soil science which are developing rapidly—it is quite impossible for an author to keep a text book up to date; there is an inevitable lag. A much worse state of affairs results when an author attempts to describe and explain the soils of the world, and must deal with regions of which he has no first hand information, such as the soils of the tropics. Inadequate observations and opinions of others are used with no chance to critically judge the value of the material. And the

saddest situation of all is when teaching soils in the tropics we use such texts. Text books are teaching tools, and without good tools the results cannot be expected to be of the best. Dean Baker, referring to the very tardy appearance of suitable text books in the Philippines for the students of agriculture wrote "If an adequate corps of the best obtainable specialists had been put on from the beginning, such basic work could have been accomplished far earlier, to the great advantage of a large number of students in the intervening years, and to the vast acceleration of investigation and actual progress" (in agricultural science). "The Philippines has sufferep great loss by failure to (adequately staff, develop, and support agricultural experiment stations). Colleges of Agriculture in new and virgin regions should not be built by "house-that-jack-built" methods. Human life is too short, and the pressing living interests of too many human beings are at stake!"

### Excessive Quantities of Certain Substances in Soils.

Though in the popular press there has been a good deal about selenium, this element occurs in quantity only in certain soils, from which it is at times taken up by plants in considerable quantities. This makes the plants and their products poisonous to animals and to man. Much more important are the more common "alkali" salts, which occur in soils in excessive quantities in some arid regions and near certain sea coasts, as along the Thai gulf. Just inside the sea dike at Bangpu are great expanses of saline soils at present just too high to be irrigated without pumping.

In southern California I renewed my acquaintance with researches bearing upon the reclamation of alkali soils, and had the privilege of visiting the new salinity laboratory at Riverside; there appallingly elaborate facilities are used for growing various sorts of indicator plants, including citrus trees, to maturity in big tanks of sand and/or soil with all the ecological factors under control. Dozens of large cement tanks with individual pipes and pumps are used to periodically deliver the desired nutrient solution to each tank or set of tanks. At that station, too, are air conditioned greenhouses. Glass roofs are necessary to help in controlling some of the growth factors, but in a bright sunshine such roofs entrap a dangerously large amount of the

sun's heat. We need greenhouses here at our experiment station; but we cannot afford air conditioning for them, and it is indeed a problem how we shall be able to keep the temperature within bounds.

### MINOR OR TRACE ELEMENTS.

The mention of such elaborate facilities for growing plants under controlled conditions in an attempt to solve soil fertility problems recalls another group of important problems for us here connected with the *minor* or *trace* elements.

In Florida the startling discoveries were made that in order to keep pecan and tung trees healthy it was necessary to fertilize the soils annually with zinc sulfate (Fig. 14), and that to successfully grow vegetable crops on other important soils in that State manganese must be applied. Across the continent, in Oregon, there was discovered the great benefit of the extensive application to alfalfa and other crops of boron and sulfur. These discoveries lead us to believe that in our poorer sandy soils in Thailand there may not be enough of these or other elements as well as nitrogen, phosphorus and potassium to produce really good crops of rice or other plants. Too long the trace elements have been entirely overlooked in the conventional methods of soil analysis; a spectrograph is almost imperative.[1]

Not only are the minor elements of importance in the nutrition of plants but they are also of great importance for the animals or people who eat the plants. In California at one of the large salt works I saw 50 lb. blocks of salt prepared for stock use; special formulae were followed in preparing these blocks for stock in countries where the animals were known to be suffering from certain deficiency diseases. For sale in New Zealand the salt blocks had a cobalt compound added, since livestock there suffer from cobalt deficiency. Other types of blocks were destined for the Australian ranges where phosphorus is deficient.—While our livestock are extraordinarily well adapted to thriving on the poor pasture available here, it is likely that the discovery and replacement of the particular deficien-

[1] Fortunately the Department of Science of the Thai Government has an excellent spectrograph of modern type. It is hoped that soon it may be kept busy making the very much needed spectrographic analyses of the soils.

cies in the nutrition will make a startling difference in the health and vigor of the livestock of this Kingdom.

### Value of Chemical Analysis of Soils.

Repeated reference has been made to the chemical analysis of soils, for it is important. If upon careful and accurate analysis there is shown to be a complete absence of essential elements, or there is a marked excess of certain elements, there is sufficient reason to believe that the low or high quantities of those elements are of importance. But the very large majority of soils have at least modest supplies of all the essential elements, as well as other elements which are of value, though probably not essential. Chemical analysis, however, is often unable to distinguish between important differences in the solubility or availability of the compounds in which the elements exist in the soil. An enormous amount of effort has been devoted to development of methods in the attempt to measure the availability of the different elements, but the results thus far are disappointing, for there is no known way of imitating in the laboratory the action of the plant roots in taking the necessary elements from the soil. So it is that while chemical analyses are made, and are helpful [1], on the average about 9/10ths of the useful information about soils and the amounts of nutrient elements available, or the fertilizer needs is obtained by studying field conditions and by "asking the plant the question."—:In other words, growing the plant one is interested in raising, on the soil that it is intended to use, and then by varying the conditions, i. e. adding different amounts and kinds of fertilizers, irrigating with differing amounts of water, etc. then watching to see what happens. Even tests made in this way are not as simple as they previously were thought to be, for soils are variable, plants are variable, and there are so many unexpected and unevaluable factors coming in that it is imperative to replicate the various treatments enough times to reduce to within narrow limits the chances of an erroneous result. Thus there has grown up the biometrical analysis of experimental data; in fact, there are indications that the use of statistics has been

[1] Since the Dept. of Agriculture does not have adequate chemical laboratory facilities, the Dept. of Science makes large numbers of chemical and physical analyses for us. We are grateful for this vast amount of work.

somewhat overdone, for in some quarters mathematics has become a fetish.[1]

Reverting to the question of chemical analysis, at the present time in certain of the Agricultural Experiment Stations in the United States the use of "QUICK TESTS" has become almost a fad. Other experiment stations, on the contrary, take but little stock in these methods. These quick tests have been devised in an attempt to obtain rapidly a rough measure of the quantity of available plant nutrients in the soil, that is, whether or not fertilizers and soil amendments should be added. Some well-buffered extracting solution is shaken up with a little soil, the extract poured off, and by means of turbidity or colour reactions a rough measure of the quantity of the element dissolved is obtained. The Hawaiian Sugar Planters' Experiment Station has undoubtedly worked out the most elaborate series of methods for the tests, control of reagents, conditions, and equipment, etc. Though fertilizer salesmen are said to be using the tests in an endeavour to sell more fertilizers in the United States; soil scientists realize that these methods can give results of value only when norms have been established for the particular types of soils tested. And practical knowledge of field conditions by the tester is essential if the interpretation of the test is to be realiable.— Again we come back to the fact that chemical analysis is often valueless or even misleading without a sound and broad basis of field experience and knowledge of the soils.

## SOIL-LESS CULTURE.

As mentioned above, I had an opportunity at Wake Island during my flight across the Pacific, to see the widely written up system of *hydroponics* or the growing of plants without soil. In California I was to learn much more. In fact, it was in the University of California, more than twenty-five years ago, that with my instructor in soil chemistry, Mr. Gericke, we grew many sorts of plants in water cultures. It was almost impossible for us to raise any of the plants to maturity, for we had not discovered all of the secrets of the process. Nevertheless Gericke always insisted that it should be possible to get plants to set fruit or grain in such cultures. He kept on try-

[1] It was in Honolulu that I heard the following definition of statistical analysis: "Statistical analysis is like a lamp post to a drunken man: it helps him to stand when he could not do so by himself; it sheds some light, but not where it will do him any good."

ing, and finally succeeded making much of the process commercially. Be that as it may, while it is now possible to grow excellent vegetables to maturity in water cultures, and by modifying the composition of the culture solution to get special effects in the fruit, yet to use a slang expression, "it does take some doing." The solutions must be carefully prepared, and they must be continuously aerated by some sort of pump to force air through the solution in which the roots are. Through their life processes the roots growing in the solution quickly throw the solution out of balance, because of excretion of carbonic acid and other effects; therefore it is imperative to have very large quantities of the solution, flowing more or less continuously through the vessel in which the roots are growing. Last summer the University of California was making a very careful comparison of the maximum ability of soil and water cultures to produce good plants. The comparison plants showed very clearly that those grown in the water cultures and in the best soil obtainable, well fertilized, were equally good and bore equally heavy crops of high quality. For greenhouse and for use here in the tropics, where the soil is apt to be contaminated with pathogenic microorganisms, there should be real advantages in water cultures. But it takes a capable chemist or a plant physiologist to do the work right and get satisfactory results —the pipe dreams of a window box garden, supplying an entire family, will not soon be realized, particularly not by the average amateur gardener.

## Summary & Conclusions.

1. In 1939 your representative at the Sixth Pacific Science Congress had unusual opportunities to study agricultural problems, methods of research, and some of the results of agricultural research in the Philippines and in Hawaii, as well as in the United States. Clearer than ever is the conviction that personal consultation with specialists in one's field is of the utmost importance, especially for scientists working far from scientific centres.

2. During extensive travels to see the soils, more especially in the humid and subtropical portions of the United States, it became more and more evident that, if correct ideas are to be gotten as to the nature and relationships of different kinds and groups of soils,

they must be studied undisturbed in the field, in their natural state, first; then suitable laboratory methods employed to interpret the field observations. It follows that an adequate and comprehensive world classification of soils must await more extensive field studies by experienced soil scientists in all the continents.

3. Particularly since it has been generally appreciated in recent years that conservation of the soil and the maintenance of its fertility is more important than intensive methods of cultivation, which may destroy the soil in a few years, in temperate zones as well as in the tropics, in the last decade, there have been very marked changes in the conception of the "best" methods of soil management. This adds to the conviction that for many tropical soils caiñgin (*rai*) agriculture suitably modified may, after all, be the ideal method.

4. Great interest was noted among soil scientists concerning the nature of "laterite" and other tropical soils, for there is an appalling lag before the results of field studies find their way into and modify out-moded text book statements. There is more reason than ever to believe that Mohr's theory of laterite formation and his definition of laterite are the correct ones.

5. Quick test methods for estimating the probably available quantities of many of the plant nutrient elements in soils are being more and more widely used. Fortunately it is now generally realized that these chemical methods are subject to the same drawbacks and limitations which apply to all chemical methods that attempt to assess the plant nutrient supplying power of soils.

6. As so clearly demonstrated on the poor sandy soils of Florida, it not only pays to grow good green manure crops and heavily fertilize tung and other tree plantations with the "usual" fertilizers, but also with small amounts of others substances, such as zinc and manganese, not usually thought of as essential for plant growth. Great is the importance of spectrographic analysis in estimating the quantities of such elements in soils.

7. While under special conditions, the growth of plants without soil (hydroponics) is practicable, under most conditions growing plants in chemical solutions has no advantage over the use of good, fertile, garden soil. Moreover there are very great difficulties in maintaining healthy plant growth in the absence of soil.

8. Thorough-going scientific research in all branches of agricultural science is fundamental and is the only foundation on which can be carried out within any reasonable time effective and significant improvements in agriculture. And agricultural research is normally quite properly a governmental function, and as such is magnificently supported by the United States Government. Nevertheless, privately supported agricultural research institutes and experiment stations for sugar cane, pineapples, rubber, coconuts, cotton and many other crops in many tropical countries continue to prove conclusively that agricultural research is financially profitable directly to the agriculturists.

Fig. 1. Such a caiñgin (clearing) as this in the dense tropical forest was made at the expense of much valuable timber, which was burned. Usually these clearings are planted but once, and, even before the one crop is harvested, invasion by the forest commences. Observation from a airplane is the only effective way to detect such damage in time. Northern Davao province, Mindanao, Philippines, June 1939.

Fig. 2. The tropical rain forest, which originally occupied these mountain slopes and plains in Bukidnon, were destroyed as a result of caiñgining by the natives in the production of food crops. Annual burning and pasturing by large herds of cattle prevent the forest returning. Elevation 400-500 meters. Nellore Ranch, Lurugan, Mindanao, Philippines, June 1939.

Fig. 3. The native Bukidnons on this mountain in Bukidnon produce their food by forest clearing (caiñgin) methods, annually clearing new forest higher up the slopes and leaving cogonals in their wake, for their primitive methods and tools cannot cope with the cogon grass. These dark plowed fields in the tall grass, planted to maize and upland rice, are the work of more progressive and energetic immigrant Filipinos, who brought iron plows and trained draft cattle with them. Mt. Katanglad, Mindanao island, Philippines, June 1939.

Fig. 4. Plowing with an iron plow a cogonal (grass land) on the slopes of Mt. Katanglad, above Malaybalay, Mindanao. Before planting upland rice and maize, this land should be plowed 3 times, then harrowed three times with a bamboo harrow. These energetic immigrants into Bukidnon are able, thru thus preparing the land, to keep down the cogon (*yaka*) and raise crops for 4 years on land, which the native Bukidnons are unable to cultivate by caiñgin methods. Bukidnon

Fig. 5. Rather than try to plant crops in cogon infested pasture land on the flat uplands, the natives of Bukidnon clear the forest and plant upland rice and maize on such very steep fields as that on the extreme right. Km. 17 on the Cagayan—Malaybalay road. Misamis province, Mindanao, Philippines, June 1939.

Fig. 6. Cinchona Nursery of the Philippine Bureau of Forestry, at about 1,200 meters elevation on Mt. Katanglad, Bukidnon, Mindanao. The clay soil under this tropical rain forest is so friable that logs must be used to retain the soil in the nursery beds. May 1939.

Fig. 7. A cross section of an abacá (Manila hemp) plantation was left when a landslide in Sorsogon province, Philippines, carried away enormous quantities of soil and the loose volcanic ash underlying it. The tall forest partially shades the dense stand of banana-like abacá 3-4 m. high, and is most important in maintaining soil fertility, insuring permanency for the plantings. Patag, Irosin, Luzon island, May 1934.

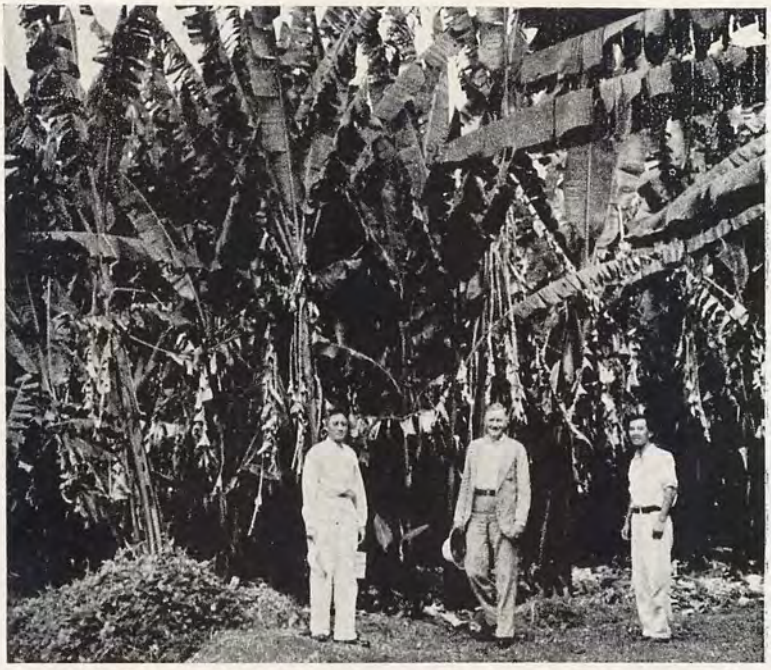

Fig. 8. Manila rope is made from the fibers in the leafsheaths of abacá (*Musa textilis*). Here shown is the Tangongon variety, as intensively cultivated on the Ohta Plantation, Talomo, Davao, Philippines. To the reader's left, below is visible some of the *Centrosema*, used as a permanent cover crop in this intensive culture. May 1939.

Fig. 9. From many different countries came these members of the Soils Section of the Sixth Pacific Science congress. As a group they travelled hundreds of miles to see important types of soils. During a halt the late Prof.-Charles F. Shaw, on the extreme left, explains the relationship between this and other soil profiles and land utilization in this locality. July 1939.

Fig. 10. In the foothills of the Sierra Nevada Mountains, California, the U. S. Soils Conservation Service representative is explaining to the Soils Section of the Pacific Science Congress how it is that this seemingly very badly cared for fruit orchard embodies the best possible practices for soil erosion control and fertility conservation. July 1939.

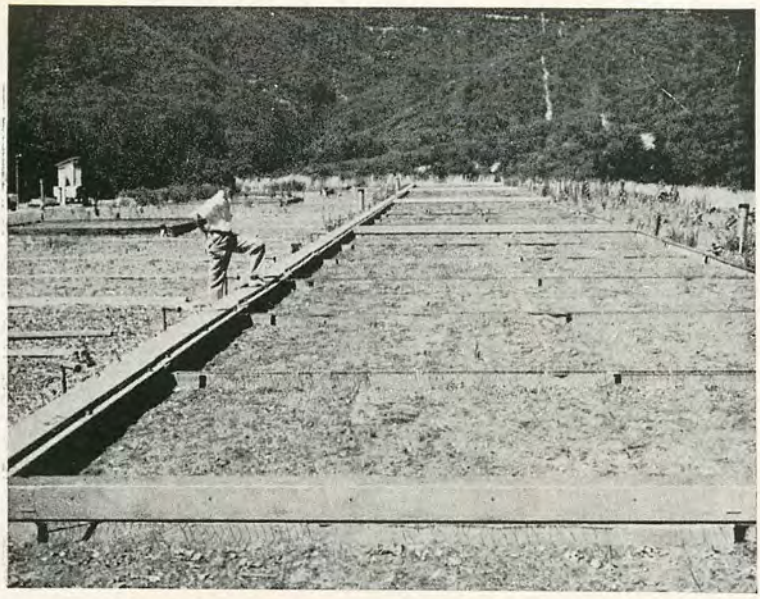

Fig. 11. In this region of scant rainfall the amounts of water which can be held by the soil and *supplied* to forest vegetation is most important. To study these water relationships of Southern California forest soils, this unusually large lysimeter installation has been set up. Each of these 26 "plots" about 10 × 21 ft. is really a cement tank about 6 feet deep filled with local forest soil. On different plots different combinations of local forest trees, shrubs and grasses will be planted to learn more about their soil moisture needs. San Dimas Experimental Forest, California, August 1939.

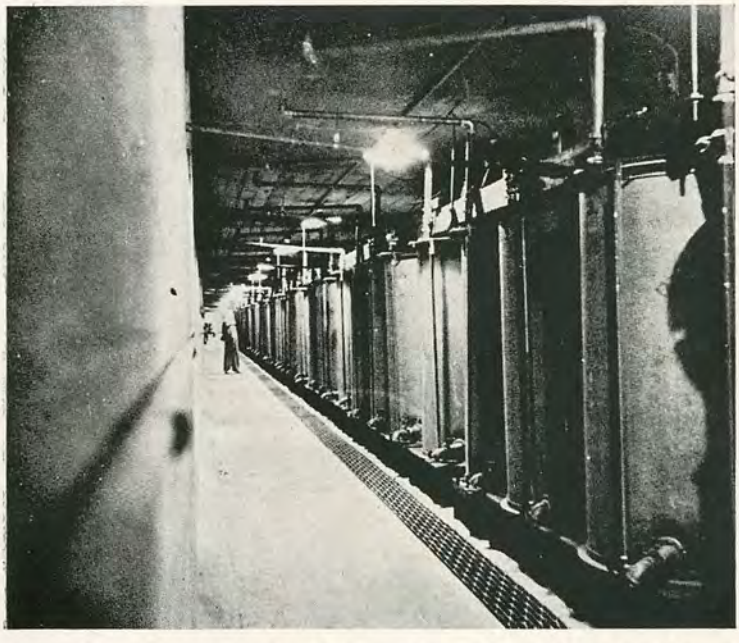

Fig. 12. Here in a concrete tunnel beneath the lysimeters shown in Fig. 11 are 78 large metal tanks, 3 for each plot, one to catch and measure the rainfall about the plot, a second for the water which runs off the surface of the plot, and a third for the water which percolates down thru the 2 meters of soil. The quantities of water in each tank are recorded continuously by electricity on charts in the central control room. San Dimas Experimental

Fig. 13. Having brought the writer hundreds of miles to reach this Cleremont soils profile, Professor Guy W. Conrey, chief of the Ohio State Soil Survey, explains its principal features. South-western Ohio, U.S.A., August 1939.

Fig. 14. This tung (*Aleurites fordii*) plantation near La Crosse, Forida, is representative of thousands of acres of carefully cared for tung trees which are fertilized, green manured, and cultivated that they may produce large quantities of nuts for tung oil. Zinc being deficient in this soil, zinc sulfate is added annually to maintain the trees in a healthy condition. October 1939.

Fig. 15. A recently abandoned *laterite quarry*, with some of the blocks of laterite. Only a little soil overlies the firm laterite. Gaw Kwang, a few kilometers south of Chantaburi, southeastern Thailand.

Fig. 16. A detail of the wall of *laterite blocks* surrounding the Ta Prohm ruins, in the Angkor region. Note the pen at left edge for scale. This clearly shows the vescicular character of much laterite, and why it is popularly, tho eroneously, believed to be of volcanic origin. Cambodia, French-Indochina.

While searching for the cause of failure of a cover crop, Mom Chao Chakrabhandhu and Robert L. Pendleton, of the Soils Section, Department of Agriculture, were surprised by a candid camera shot. Pepper experiment station, Tamai township, Chantaburi province, south-eastern Thailand. April 1936.