PHYTOPATHOLOGY IN THE TROPICS

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Tropical life is a luxurious life. Nowhere does plant and animal life show itself in such variety and abundance as on the equator.

As the conditions in those regions are uncommonly favorable to plant growth, it would appear that the plant parasites also have a good chance of living. In several tropical countries plant diseases have been studied in a more or less extensive way, but the general features of plant diseases in the tropics, unlike those of the temperate regions, have hardly been touched. I have been for some time studying plant diseases in our colonies of the East Indies, the so-called Malayan Archipelago, and I wish to give you some general impressions on fungous diseases in those countries. My remarks can be only suggestions, as thorough investigations on these tropical problems have never, so far as I know, been made.

The Malayan Isles have an average temperature of 30°C. in the lower parts, accompanied by a humidity of 80–100 per cent. The climate is a monsoon climate. In the time of the wet season it pours every afternoon, but in the dry time the rains are very scarce in the lowlands but not infrequent in the forest-covered mountains.

One would be inclined to think that this combination of high temperature and moisture would be extremely favorable for fungous growth, and that therefore fungous diseases would play a large part in the culture of economic plants. This, however, is not the case. We find that insect troubles prevail, and that, compared with our temperate regions, few diseases exist. We would not conclude these facts from the literature, as a large number of diseases caused by fungi have been described. But in visiting the countries it struck me that only a few diseases are of real importance; a great

many of those described must have been found occasionally, and have had no serious influence upon the cultivation of plants.

Not only among the cultivated plants do we find little fungous growth, but also in the natural vegetation. In the virgin woods the trees have few enemies among the fungi, and even the flora of mushrooms on the ground, so characteristic of our woods, is absent. Everything seems to point to the conclusion that conditions are unfavorable to fungous growth.

Why is this so? As has already been said, there are two conditions which characterize a tropical climate: (1) a high temperature which is about equal through all seasons, and (2) a high humidity, the latter varying somewhat in the different monsoons, but being altogether much higher than in our climates.

It seems to me that the tropical temperature is too high for many fungi. I cultivate in my laboratory over 600 fungi, and this collection shows clearly that the temperature of optimum growth of the greater part of the fungi lies beneath 30° C., often under 25°C. An exposure to high temperature prevents many parasites from forming their spores or fruiting bodies, whereas others require a change of temperature for normal growth. The *Polyporaceae,* for instance, bear exposure to frost very well, but many of them scarcely develop at 30°C. High temperature very often gives rise to an abnormally abundant mycelial growth, combined with an absence of spores. On the other hand, the high moisture content of the air must be favorable to fungous development.

But every fungous disease of plants involves two organisms, the parasite and the host, and the same conditions may influence these two in a very different way. The heavy rainfalls, combined with the abundant transpiration—owing to the intense heat, must cause a high water-content and a small air-content, of the wood-vessels of the trees, thereby making a substratum poor in air. We know that this is an important factor in fungous growth. This fact, combined with the high temperature, would explain the rare occurrences of *Hymenomycetae* and other wood-destroying fungi in the tropics.

I shall begin the consideration of the different groups of fungi which cause plant diseases in the tropics by mentioning one biological group of hymenomycetous fungi the members of which attack tropical cultivated plants. These are the so-called root fungi. It is certain that the root parasites belong to different species of *Hymenomycetae,* and that one species of host-plant may be attacked by a number of species of these fungi. Several of the latter, if not all, are characterized by the peculiar mycelium characteristic of the *Hymenomycetae;* in many cases, however, fruiting bodies have never been found. Practically all cultural woody plants —tea, coffee, rubber, quinine, cacao, coca—may suffer from the attacks of root-fungi, these attacks occurring mostly on virgin soil. The fungi develop on the decaying stumps of the forests, grow through the soil, and reach the roots and stem bases of the young tea, coffee, or quinine plant. The bark is penetrated and the mycelium destroys both bark and wood (the mycelium strands can be very clearly seen between bark and wood). Whereas young plants up to three or four years old nearly always are killed, older ones may resist; different species of plants, however, behave differently in this respect. In some districts the fruiting bodies of *Fomes semitostus* appear on the dying plant or on the dead roots, but in others fruiting bodies have never been found.

A second biological group of fungi, so common in our latitudes, has only a few representatives in the tropics under discussion. I am speaking of those ascogenous or imperfect fungi which cause the die-back diseases of our orchard, forest, and park trees, e.g., *Valsa, Diplodia,* and others. These fungi kill the branches by penetrating into the bark and sometimes into the wood. They appear on our trees when these are in a dry condition, and in dry climates or in dry years such diseases are of importance. Not so, however, in the tropics. The only die-back disease which is common is caused by *Corticium javanicum,* which, however, belongs to the *Hymenomycetae* and forms red layers on twigs, branches, and even trunks of all cultural woody plants, e. g., rubber, coffee, quinine, tea, cacao, coca, and fruit trees. We find the disease

mostly in very moist valleys, where the wind has no free play. The fruiting bodies of many *Ascomycetae* develop in dry air, and it is not remarkable that that type of disease is found in some parts of the West Indies, which have a drier climate.

A group which has no representative in the tropics is that of the powdery mildews (*Erysiphaceae*). These fungi occur only in colder climates. The so-called false mildews or *Peronosporaceae,* on the other hand, are of considerable importance, these fungi seeming to thrive well under the moist and hot weather conditions. We find the canker of rubber and cacao (caused by *Phytophthora Faberi*) of far-reaching importance. In both the rubber and the cacao the disease attacks the bark and, in the case of the cacao, also the fruit. The growth of this fungus depends upon a very moist air. This is proved by the fact that when the trees are cut back severely so that the trunk is exposed to sun and wind, the wounds often heal and the disease is stopped. A plantation in which the trees are planted far apart also suffers less.

Another fungus—*Phytophthora Nicotianae*—belonging to the *Peronosporaceae* is the cause of a dangerous tobacco disease. The parasite kills the seedlings in the beds, the plants "melt," and even the mature tobacco plants are attacked. The fungus penetrates into the pith of the lower part of the stem and the "tobacco-tree" falls. A third member of this family destroys a large part of the Indian corn, so widely grown by the natives. It is *Peronospora Mayidis,* unknown, so far as I am aware, in the large corn areas of the United States. The exceedingly moist climate, combined with the excessive heat, evidently favors the attack by the fungus. In the potato fields of the mountain districts of Java we find a friend of our countries, *Phytophthora infestans.* Potatoes are grown in the tropics between 1500 and 6000 feet altitude. In the lower areas we find phytophthora-infected regions only rarely, but the higher we ascend, the lower the temperature (frosts may even occur in the nights) and the more destructive the phytophthora becomes. The spores of the fungus (it has been proved) cannot germinate at a high temperature, which explains the occurrence of the disease only in the higher

altitudes. It is very remarkable that in the tropics tubers are never, so far as I observed, affected. This fact might help us to discover the cause of the difference in susceptibility of the tubers of different potato varieties in our climate.

Speaking of potatoes, I wish to point out another disease of our regions which I found in the tropics and which has the greatest influence upon tropical potato culture. I am speaking of the internal brown spot, the nature of which has not been recognized. Nearly every potato tuber shows this disease and in a much more striking way than in the temperate regions. The brown spot is accompanied by a soft consistency of the tuber and a small amount of solid substance. As far as we know to-day, this trouble is a physiological one, caused by particular conditions of "climate and soil," the nature of which is unknown to us. The cause of the disease may be different in the tropics and in our regions, but a careful study of it in warm climates might give us an indication as to what conditions favor it.

Among the large group of rust-fungi, there is only one representative which is of importance to tropical agriculture. This is the coffee-leaf disease, due to *Hemileia vastatrix,* a rust which to a considerable degree ruined a large part of the coffee culture of Eastern Asia, and obliged the growers to introduce other species, which, unhappily, are of poorer quality. On other cultural plants, however, no rust of any importance occurs. The important cereal crop of the tropics, the rice, has no rust enemy. The rust of the sugar-cane is of no consequence in cane growing. The same is true of the smut diseases. Rice smut is found exceptionally, and smut of sugar-cane is a rarity; smut of corn is even rarer than in our regions.

Leaf spot diseases, belonging to ascogenous or imperfect fungi, are much less frequent than in Europe or the United States. The leaf spots of sugar-cane (*Leptosphaeria Sacchari, Cercospora Sacchari,* and *Cercospora Kophei*) are widely spread but have little influence on cane production. They are of more importance in the moist western part of Java than in the drier east. The tea blights (*Pestalozzia palmarum* and

Laestadia Theae) cause but small losses of tea leaves in our colonies.

The sugar-cane evidently is the crop which is most subject to the attack of fungi. This becomes clear when we look upon the method of propagating the saccharum. Small pieces of the cane stem are used as cuttings, which are put into the soil. The soft pith, rich in sugar, is an ideal substratum for fungous growth, and we must not be astonished that even saprophytes enter it. *Thielaviopsis ethaceticus* and *Colletotrichum falcatum* are two typical destroyers of sugar-cane cuttings.

Bacterial diseases are scarcely to be found. I will admit that more bacterial diseases may be discovered, but up to the present time the only bacterial disease of importance is the tobacco wilt due to *Bacillus Solanacearum,* the same trouble which occurs in the United States. The same bacillus also causes a disease of peanuts. Probably the gum-disease of sugar-cane is also caused by bacteria. It is curious that algae in some cases (*Cephaleuros virescens*) cause diseases of tea and coffee plants, as they kill not only leaves but, as is true in the case of tea, also the twigs.

Here I have come to the end of the list of fungous troubles. Compared to the fungous diseases of the United States and even to those of Europe, those of the tropics are smaller in number. Tropical agriculture might be compared to the agriculture of the United States more than to that of the Old World. Vast areas are covered with one crop and often with one variety of a crop, so far as we know anything definite about varieties and races of tropical plants. In the subtropical regions of the United States, where at certain times the temperature equals that of the tropics, the air is much drier and there is a certain change of temperature, even in the region of eternal spring in California, which is foreign to the tropical climate. In the tropics of Asia and the subtropics of the United States insect troubles have assumed immense proportions, but as to fungous diseases, these are of more importance in the subtropics of the New World.

Different groups of fungi are much less restricted in their geographical distributions than are phanerogams. Up to the present time, no special tropical families among the fungi are known, and, as far as I know, the only fungus group that has no representatives in the tropics is that of the *Erysiphaceae*. The secondary part which fungi play in the plant diseases of the tropics is not caused by the absence of fungi, but by the particular conditions which influence both the host and the parasite, and their relations to each other. To establish the exact nature of these influences is a problem for the future.