BUD-ROT OF COCONUT AND OTHER PALMS.

The following papers on "Bud-rot of Coconut and Other Palms" are taken from the Report of Proceedings of the Imperial Botanical Conference held in London in July, 1924.

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A disease of palms, which was stated to have many points of similarity to that known as bud-rot in the West Indies, was described by the writer in 1906 and attributed by him to a species of *Pythium*, which was subsequently, in February, 1907, named *P. Palmivorum* n.sp. This was the first *named* cause of bud-rot which subsequent work has substantiated. The species is one of those forming a connecting link between the genera *Pythium* and *Phytophthora*, and in 1919, when knowledge of the latter genus had considerably advanced, the palm fungus was renamed by the writer *Phytophthora palmivora*.

In the West Indies the bud-rot of coconut palms seems to have been known for about a century, and was ascribed to various causes such as insects, bacteria, soil, and climate. Davalos believed that *Bacillus amylobacter*, which he isolated from the rotted tissues in 1886, was the cause in Cuba. Fawcett attributed it to "an organised ferment" in Jamaica in 1894. Earle also, in 1902, believed it to be a bacterial disease. In 1904 Dr. E. F. Smith definitely stated, as a result of his investigations on the spot, that the

disease in Cuba was a bacterial soft-rot of the terminal bud and its wrappings, the causal organism probably entering through wounds, though no experimental evidence of these statements was given. Petch stated, in 1906, that bud-rot in Ceylon was due to bacteria. Smith induced his assistant, J. R. Johnston, to undertake the detailed study of the disease, and the results of four years' work in Cuba and elsewhere were published by Johnston in 1912. Succesful inoculations were claimed with several varieties of bacteria. Only a few of these inoculations were done on the spot, the rest being on seedling coconuts under glass in Washington. The greater number of the inoculations were made with *Bacillus coli* or an organism indistinguishable from it, while *B. coli* from animals was found capable of setting up a soft-rot similar to that caused by the strains from coconut, when inoculated on green-house seedlings. A preliminary account of these inoculations was published in *Phytopathology* in 1911. It may be mentioned, in passing, that the isolations were made by the poured plate method, which would be unlikely to reveal the presence of such a fungus as *Phytophthora*, and that the bulk of the inoculations were made with a gouge or some such instrument penetrating at least 30 cm. into the bud. But in 1911 Rorer agreed with Johnston's findings and stated that pure cultures of a bacillus (which he isolated but did not identify) could cause bud-rot if poured into the crown without wounding.

In 1914 Shaw and Sundararaman published certain criticisms of Johnston's work and produced detailed evidence, founded on inoculations from pure cultures, that *Pythium palmivorum* (*Phytophthora palmivora*) caused coconut bud-rot in India. Further inoculation experiments, to meet objections raised by Sharples and Lambourne in Malaya, have been carried out by McRae and by Sundararaman in India, with the result that the earlier work was again confirmed. There is now not the slightest doubt that the epidemic outbreak of bud-rot in palms on the east coast of India was due to this fungus and only to this fungus, which is a true parasite capable of penetrating the uninjured tissues almost as readily as *P. infestans* does those of the potato.

In 1918 Ashby stated that there were two forms of bud-rot in Jamaica, one of which was due to the same *Phytophthora* as he had earlier found causing a leaf disease of coconuts. In 1920 this was identified as *Phytophthora palmivora*, the cause of the disease in India, and proof of its ability to penetrate the unwounded tissues was given. In the second type of bud-rot only bacteria were found, but some doubt is expressed as to their causal connection with the disease. In 1923, however, Nowell was still of opinion that after excluding the forms of bud-rot due to fungi there may still remain a large residue of bud-rot of bacterial origin in the West Indies.

In the Philippine Islands the study of coconut bud-rot was taken up by Reinking, who, in 1918, believed it to be a bacterial disease. This view he soon abandoned and, in 1919, he stated that a *Phytophthora*, which he identified as *P. Faberi*, was the cause, the bacteria which are always present in severe cases being secondary agents. In 1923 further studies were published by Reinking which seem to leave no room for doubt that this fungus is a true parasite and is capable of infecting uninjured coconut palms, whether the organism is isolated from coconut or from cacao (the original host of *P. Faberi*).

This at once raises the question whether *P. Faberi* is distinct from the earlier described *P. palmivora*. Reinking answers in the affirmative, but his argument is based on a misconception. No oospores were found in the Philippine fungus, whereas he states they occur in that in India. It is true that in my 1907 paper I stated that oospores were formed, but these were subsequently found to be chlamydospores or resting conidia, of a type previously unknown in *Phytophthora* but subsequently found to be not uncommon. From a careful study of Reinking's figures and description I am of opinion that his fungus is morphologically identical with my *P. palmivora*. Thus both in the west and in the east it has been established that this fungus is at least a chief cause of bud-rot.

As to Reinking's identification of this species with *P. Faberi*, widely known as a parasite of cacao and rubber, a few words more are required. Ashby admits that *P. palmivora* and *P. Faberi* are morphologically indistinguishable but, unlike Reinking, he finds biological differences. In his last paper on the subject, in 1922, he reports the discovery of oospores in mixed cultures of the cacao fungus with other morphologically similar strains from coconut and cotton and also with the distinct species *P. parasitica*. In view of the biological differences and the absence of oospores from all but the cacao strain he maintains *P. Faberi* and *P. palmivora* as distinct species. But it is clear from Reinking's work that the biological differences are not preserved in the Philippines and it is equally clear that oospore-formation is rare and difficult to induce in the cacao fungus, so that I prefer to regard the two as at most strains of the one species, less highly differentiated indeed than many of the strains of the rusts and Erysiphaceae.

Whether there is any such thing as a primary bacterial bud-rot of palms seems to me to be doubtful. Most of the successful inoculations have been carried out through wounds in the tender tissues of the interior of the bud, and with such methods not one but several distinct bacteria have been found capable of setting up a soft rot. Sharples and Lambourne have indeed shown that various common moulds, such as *Mucor*, can cause such a rot in wound inoculation. The same is well known to be the case with ripe fruit and young seeds, always only after injury. I do not regard the fungus as a primary parasite in such cases, and it is at least in a very different category from the parasitism of such organisms as *Phytophthora infestans* or *P. palmivora*. *P. palmivora* remains the only vegetable parasite that has been proved to cause a destructive bud-rot of palms, capable of attacking perfectly healthy trees and inducing severe epidemics of disease.

(A short account of the campaign against bud-rot of palms on the east cost of India was then given.)