Hundred years of Koch's Postulates and the history of etiology in plant virus research

L. BOS

Research Institute for Plant Protection, Wageningen, the Netherlands

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Abstract

The centenary of Koch's Postulates in plant pathology is a moment to look back at the history of etiology in the study of plant virus diseases and at the development of our knowledge of plant viruses.

Koch's Postulates were long considered inapplicable to viruses. These very postulates, however, together with the application of Chamberland filters allowed the discovery of viruses and their distinction from micro-organisms. But for some time, the true nature of these 'new' pathogens remained obscure and their identification was hard, of not impossible, since Koch's Postulates in their literal sense did not apply to viruses.

After 1935, techniques of virus isolation were elaborated, at first very gradually but with the advent of molecular biology since World War II booming. They made viruses accessible to experimental manipulation and research, and permitted the study of causal relationships between virus and disease by application of Koch's Postulates, though adapted and now redefined.

Such etiological studies and the gradual introduction of methods and philosophies, implicitly derived from Koch's Postulates, have allowed the description and classification of a rapidly increasing number of true viruses as disease incitants. They have also allowed the detection of a continuously increasing number of other pathogens previously mistaken for viruses, but differing in essence. This is helping us to purify the virus concept and to define it better.

Introduction

Plant virology originated as an agricultural discipline towards the end of the last century. Plant viruses were first detected because of their harmful effects on crops. Most plant virus research is still in agricultural research institutions. Such institutions first came into being around the middle of last century in Germany as a consequence of von Liebig's theory on the role of mineral elements in plant nutrition first published in 1840 (Von Liebig, 1840). Von Liebig continuously stressed the importance of experimentation. Adolf Mayer (Fig. 1), who later became known for his pioneering work on tobacco mosaic, had a thorough background in agricultural research in Germany and had even published a German textbook on agricultural chemistry a few years before coming to the Netherlands in 1876 (Mayer, 1870).

1 Elaboration of an opening address at the virus session of an FBPP/SGM conference on 'Plant disease etiology, 100 years of Koch's Postulates' held in London, 17-19 December 1980.
Since the dawn of history, all sorts of ailments, often developing into disastrous epidemics, had already attracted attention and appealed to superstition. In the nineteenth century, micro-organisms increasingly found in or on diseased plant tissues were considered a consequence rather than a cause of disease. But about the middle of the century, awareness of their involvement as disease incitants was gradually increasing. Such ‘venomous’ or ‘slimy’ causative agents were often called ‘viruses’, but this name is as vague as the term ‘bug’ for any insect or other creeping or crawling invertebrate or even for a disease-producing germ or other micro-organism. Study of their role in disease etiology was one of the early tasks of expanding agricultural research.

That was the scene when Koch and his ‘Postulates’ entered. Up to now, very little attention has been paid to them in plant virology. Hardly any textbook on plant viruses has ever referred to them. Are they really inapplicable to true plant viruses? Why have they been neglected, and to what effect? To answer these questions better, we must look to the philosophy behind the Postulates and we will have to do so in historical perspective.

Koch and the origin of microbiology

Research on fermentation by Pasteur (1860) had shown that under present conditions life never originates spontaneously, that it needs germs, however small, to develop from. But what about infectious diseases? Where do they come from and how do they get about? These were questions increasingly haunting the young country doctor Robert Koch in the small Prussian town of Wollstein during the early 1870s.

It is tempting to narrate Koch’s life history as interestingly recorded by Paul de Kruif in ‘Microbe hunters’ (1926). Infectious diseases were haphazardly levying their toll without Koch being able to control them. Anthrax was such a strange disease, worrying farmers all over Europe. ‘Here and there, it ruined the prosperous owner of a thousand sheep or killed the only cow of a widow and unpredictably spread to further victims including farmer, shepherd or a hide dealer’.

During snatched moments between calls to sick people, Koch studied with the microscope blood samples from animals that had died of anthrax and found peculiar threads and rods. They were always absent from blood from healthy animals. White mice inoculated with carefully cleaned and oven-heated slivers of wood were then found to serve as inexpensive means for growing the microbes. For one month, the mice were serially inoculated from one to another. Under the microscope the microbes could afterwards be directly observed multiplying in the watery liquid from the eye of an ox in Koch’s ingeniously developed hanging-drop preparations. After propagating microbes under such conditions for eight generations pure from any other microbe and away from the animal, he back-inoculated to white mice. So he finally succeeded in artificially reproducing the disease in these animals with characteristic symptoms and swarms of the same microbe. In 1876, Koch had been able without modern aids such as syringes, test tubes and Petri dishes to prove that one kind of microbe caused one definite kind of disease.

However, this epoch-making achievement did not yet revolutionize scientific thinking until Koch’s appointment at the Imperial Health Office in Berlin in 1880.