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Development of Plant Virology in India*

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It is a great honour and unique privilege to speak briefly about Sir Edwin John Butler, who is considered to be the father of Indian Mycology. It was he to whom we shall be grateful for developing mycology and plant pathology with a band of young scientists at the then a remote village Pusa in Bihar.

Sir Edwin was born at Kilkee, Co. Clare in 1874. He came from a Norman-Irish family and his father, Thomas Butler was a resident magistrate. Sri Edwin lived mostly in England and India and was educated at Christian Brothers' School, and later at Queen's College at Cork in Ireland, where he was a medical student. After obtaining his degree of M.B.B.S. and B.A.O. of the Royal University of Ireland, he became an active worker in *Saprolegnia*; which is a water mould, and took interest in mycology. He could have become a medical practitioner, but his liking for mycology took him away from his medical profession. Later, he worked on *Pythium.*

He spent nine months at Jordin des Plantes in Paris for working with Ph. van Tieghem, who was the first to apply cultural methods in lower plants. Butler was associated with many outstanding scientists like Fr. Oltmanns, D. H. Scott, G. Massee, E. S. Salmon, and others.

During the end of 1900, Butler became the Cryptogamic Botanist to the Government of India and came to Calcutta. From there onwords, he started his classical work on fungi and studies on the agents causing diseases of plants. In 1902 he was transferred to Dehara Dun where he worked under the Imperial Agricultural Department.

In 1905, he was appointed the first Imperial Mycologist at the Imperial Agriculture Experiment Station at Pusa, Bengal (now in Bihar). In 1906 he published the monograph on the Indian Wheat Rusts with J. M. Hayman. In the same year, he monographed on Sugarcane Diseases of Bombay. The account on the genus *Pythum* was written by him in 1907 and later he did enormous work with Indian colleagues like, Jehangir Ferdung Dustur

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and due to their herculien efforts, mycology and plant pathology in India became an important focal point. He wrote his classical book, 'Fungi and Diseases of Plants' in 1918, which is considered to be a bible for the students on mycology and plant pathology and which has not yet been replaced by any other book of its kind.

Fungal pathogens infecting plants have been known from recent geological periods. Genera of Sooty Mould, like, *Asterina* and *Meliola* as well as Spheriales and Erysiphales have been known for since ages. Fossilized spores of rust fungi like *Puccinia*, *Uromycis* have been found in Miocene strata (14 million years) in North America and India. Polypores including *Ganoderma* spp. have been recorded in Pleistocene (two million years). This indicates that, historically fungi are very important although they were not studied by modern practices. I need not go into the details due to shortage of time.

Robert Hooke (1633-1703) developed microscope in England and he was one of the first persons to use it. Italian botanist Marcello Malpighi (1628-1694) used microscope for studying and illustrating fungi. If the students would care to read classics, they will get interesting materials for their konwledge.

If you look back to the science of Virology and its development, the initial interest on viruses as such may be ascribed to general feeling for better understanding and control of contagious and epidemic diseases which affect human and animal health as well as agricultural production. Edward Jenner was perhaps the first person to create the feeling if imaginative studies which may be regarded as the begining of experimental virology in 1798. Prevention of smallpox which killed innumerable people all over the world at one time or other was possible by vaccination with cow pox virus. Thus, he gave a strong and scientific foundation which saved many human lives by making them smallpox resistant. He also initiated the basic ideas on immunising agents and immunity. The next remarkable contribution was made by Pasteur in 1882 and 1884 who was very much acquainted with Jenner's work. His classical work on demonstration of rabies virus which was 'ultra-microscopic' and which could be cultivated by implantation in the laboratory and his later discovery that this was due to the 'invisible virus' had indeed been a milestone in discovery of virus as pathogenic agents.

The earliest record of a plant virus disease was 'breaking' or mosaic in tulips which was described by Carolus Clusius in 1756 and since then numerous papers on such meladies of plants were recorded. However, the first authentic work in plant viruses was done by Adolf Mayer in 1886 when he published his monumental work on tobacco mosaic disease. Indeed, in Netherland this disease caused severe damage to tobacco plants and Mayer designated it as 'Mosaik-krankheit'. Mayer also successfully established for the first time that tobacco mosaic could be transmitted mechanically and by budding but not by soil or seeds.

In late 19th century great advancement was made by wide application of vaccination tests in virus research. Further, definite proof of contagious nature of viruses infecting tobacco plants was established beyond doubt by the Russian Botanist Dimitrii, J.V.V.Iwanowsky who established the etiology of plant and animal virus diseases. He also denonstrated that tobacco mosaic particles could pass through a porcelain filter that would remove bacteria. At almost the same time in 1898 Marimus Willen Beijerinck, the famous Dutch Bacteriologist, gave us the current concept of plant virus etiology. He propounded the

'Contagium vivum fluideum' theory and was the first to use the term 'virus' as causal agent for tobacco virus disease. He believed that the virus must be present in the living protoplasm of the cell for its multiplication and also felt that many such plant diseases could be caused by viruses.

F. W. Twort was the first scientist who reported that viruses could attack bacteria and this was confirmed two years later by F. d'Herrele who designated these as 'Bacteriophages'. The potentiality of these viruses forming a model for studying nature of viruses was realised in the 1930's and most of our current knowledge on viruses is based on such studies. About a decade after discovery of 'Bacteriophages', T. C. Venterpool reported the winter blight of tomato in Quebec. Although several reports appeared on plant virus diseases in the first half of 20th century which were demonstrated in 90 families including 500 genera and more than 1000 plant species, appearance of strains of viruses became apparent in 1925 when like variations in animal viruses, plant virus variants were also observed. Also attenuated viruses were observed and, thus, varieties of symptoms observed in infected plants could be recognised. This was followed by studies on mixed infections and Venterpool was the first to report that (streak or winter blight of tomato) was due to combined infection of Tobacco Mosaic Virus and Potato Mosaic Virus.

Francis C. Holmes in 1929 with whom I had worked at the Rockefeller Institute (now Rockefeller University) did his classical work on local lesions produced by tobacco mosaic virus which became the main criterion for measuring virus infectivity and even now this technique is followed by many students and teachers in several laboratories. In fact, universally *Nicotiana glutinosa* is used as a test plant. In 1930 Max Theiler with whom I was very close at the Rockefeller Institure made significant progress by his research on animal viruses, specially yellow fever in mice. He successfully developed a yellow fever vaccine. In fact developments of milder strains of viruses which could protect infection of man and animals with severe or fatal strains have been monumental work for saving human and animal lives.

In Asia, the first classical work on a plant virus which is transovarially transmitted was clearly demonstrated by Teikichi Fukushi in Japan.

He published his first paper in 1931 concerning dwarf disease of rice and its insect vector *Nephotettix apicalis* Motsch var. *Cincliceps* Ubl confirming earlier findings of Hatsugo Hashimoto in 1883. Two years later in a single experiment carried out during the period of more than one year in a very methodical but laborious way has proved beyond doubt that rice stunt virus is transmitted through the eggs of leafhoppers to the progenies upto six generations. Similarly, I. M. Black in the U.S.A. following the same procedure could successfully transmit clover club leaf for 21 generations. These are findings of great importance in the science of Plant Virology. Now, I pass on to the modern concept of plant viruses.

Wendell M. Stanley formerly of the Rockefeller Institure for the first time isolated and crystallised tobacco mosaic virus in 1935. He demonstrated that at higher dilutions crystals of tobacco mosaic virus could produce tobacco mosaic disease. In fact, this was the begining of modern era of plant virology. The findings of his colleagues paved the way for intensification of biochemical and biophysical studies as well as to chemical and standardised analysis of plant viruses. Since then several well known scientists all over the

world contributed much to classification of viruses which was termed by Stanley in the U.S.A. as macromolecules. At about the same time independently F. C. Bawden and N. W. Pirie in U.K. purified and crystallised tomato barley stunt and proved that it was nucleoprotein in nature. After these investigations quite a few viruses have been purified and studied by various scientists.

In 1950 Kenneth M. Smith of U.K. and Ralph W. G. Wyckoff of U.S.A. studied the insect vectors. They observed that larvae of two tiger moths were infected with a polyhedral disease of cytoplasmic type wherein the virus was spherical while rod-shaped forms were noticed in nuclear infections. The spherical viruses contained RNA while the rod-shaped ones contained DNA.

L. C. Kunkel's classical work on yellows diseases mostly transmitted by leaf hoppers, many of which have now been recognised to be associated with mycoplasma/spiroplasma/ rickettsia paved the way for better understanding of chemotherapy and heat treatment for controlling such diseases. Karl Maramorosch, besides his pioneering work on virus-vector relationship recently with his group could isolate spiroplasma from plants infected with aster yellows agents. He also proved that aster yellows could multiply in insect vector. Rober E. Davis developed techniques for culturing spiroplasma.

As regards techniques for viral studies the work of Russel L. Steere by use of electron microscope is well known. His freeze-etching technique has been widely recognised. T. O. Diener did excellent work on viroids which are naked nucleic acids which has opened up an entirely new field of plant pathology while F. Nienhaus in Bonn (Germany) successfully cultivated rickettsia like organisms in 1978 from infected grapevines earlier suspected to be due to virus infection. A. C. Calavan and his group in California, U.S.A. as well as Saglio and his co-workers in France succeeded in isolating the characterising *Spiroplasma citri* from stubborn-affected citrus plants.

In India the first authentic proof of tobacco leaf curl and its transmission by *Bemisia tabaci* was established by B. P. Pal and R. K. Tandon and H. S. Pruthi and C. K. Samuel in Pusa, Bihar, during 1937-1941. Researches on Plant Virus investigations was initiated in a methodical way by B. N. Uppal in 1939-1940 in Poona.

During the last five decades many plant viruses and their insect vectors have been described in India and beginning was made on MLO's associated with diseased plants like Sandal spike, rice yellow dwarf, little leaf of brinjal etc. Work has also been done on tissue culture in relation to plant viruses, heat and chemotherapy as well as cross protection studies for control of plant viruses and some ideas have been given regarding classification of plant viruses. As regards plant quarantine, it is most essential to control viruses which are transmitted through bulbs, tubers, rhizomes etc of ornamental plants besides those which are transmitted through seeds like the viruses infect in leguminous plants. We have also no properly organised seed certification organisation besides potatoes. Creation of a sera-bank will be most useful. In India, practically, no work has been done on nematode and fungal transmission of plant viruses, spiroplasma, Rickettsia as well as viroid diseases of plants and also the effect of pollution and toxicology vis-a-vis virus affected plant cells and insect vectors.

In this short account I attempted very briefly to bring out some salient points which paved

the way to proper understanding of viruses and mollicutes. It is indeed a very interesting field of research which by basic studies some day may bridge the gap between human, animal and plant diseases which may have the same pathogenes involved in such maladies. Currently in India we are mostly working on Plant Virology in a descriptive manner. I am sure in the near future our various centres of excellence for viral studies will prove many yet unsolved facts for which the band of excellent workers of Plant Virology are devoting their time. Fortunately, our authorities are also encouraging such attempts on fundamental studies which are directly concerned with the applied side and not before long we hope to solve many problems in the field of Plant Virology.

At the end, while paying my homage to the great mycologist and plant pathologist, Sir Edwin, I may be permitted to state that, one discipline of plant pathology which he would have liked to develop in India during his presence here is the science of plant virology. With all humility and humble submission, I request this august body to think of this science, i.e. Plant Virology and give its proper place of importance. It may be mentioned that in many leading Universities, plant virology is not properly organised including of course, this University where I am delivering the second Sir Edwin John Butler Memorial lecture.

Nothing will give me more pleasure than to see that this specialised subject is developed in this University which is my *alma mata.*