7. VIRUS PROBLEMS OF CROP PLANTS IN BRAZIL: PAST AND PRESENT

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With an area equal to practically half of South America, extending from the torrid to temperate zones, Brazil has a great diversity of soil and climatic conditions that allow the cultivation of almost any crop plant in its territory. In the more advanced agricultural areas, many are grown simultaneously as summer or winter annual crops, whereas perennials such as coffee, citrus, grapes, pineapples, and others are planted all over the country.

Conditions that favor Brazil's diversity of crops also lead to the existence of a wide range of plant species of the natural vegetation that act as virus reservoirs and host of insects and other virus vectors, thus resulting in the presence of virus diseases the year around. All these factors together explain the relatively large number of plant viruses and mycoplasma-like organisms so far identified in the country.

The importance of some of the plant virus or mycoplasma diseases for the agricultural economy of Brazil can better be grasped through a few examples: Brazil is now one of the major citrus growing and exporting countries in the world. About 150,000 tons of citrus juice, at the value of US$ 80 million, will be exported this year. However, during the '40, a severe outbreak of the tristeza virus on orange orchards, budded almost exclusively on sour orange rootstock, destroyed over 10 million trees. The problem was first solved through the use of tristeza-tolerant rootstocks and later by the use of premunized budwood as described later, permitting a quick comeback of Brazil's citrus industry.

Vegetable crops, especially tomatoes and peppers, suffered consistent losses induced by infection with several viruses. Breeding programs introduced resistance and even immunity against some of these viruses, contributing to the improvement in the yield and quality of these crops. The sugar industry had problems with the sugarcane mosaic virus in the past, but introduction of resistant varieties and further breeding programs solved this problem. Strawberry used to be a minor crop because of the degenerescence diseases induced by a complex of viruses. The correct diagnosis of the situation, and the application of an indexing program to produce virus-free basic stocks resulted in a 3 to 4-fold increase in the production within few years, now placing Brazil among strawberry exporters.

In the following lines, some of the virus problems present in our main crops will be described, as well as some of the applied or proposed control measures.

At the moment, one of the most serious virus problem is probably the bean golden mosaic (BGMV) transmitted by the whitefly *Bemisia tabaci*. The same disease is causing also serious concern to bean growers in Central America. Brazil is presently the largest world bean producer, although this leguminous crop is seldom cultivated at the main crop.

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Bean also represents one of the most important protein sources for the less privileged part of the population, therefore bean yield reduction has not only economical but also sociological implications. BGMV was identified about 10 years ago as a minor problem to the bean crop. But in the last 4–5 years BGMV became the limiting factor for the bean production in most of the traditional bean growing areas such as the northern Paraná, most of the São Paulo State, eastern Minas Gerais and southern Goiás. This epiphyty of BGMV is explained on the basis of the rapid expansion of the areas cultivated to soybean, an excellent host for the whitefly vector. The dense population of whiteflies bred on soybean then spread the BGMV from the reservoir plants (bean and some native leguminous plants) to the bean crop. Early infection of the bean plant by BGMV might result in a complete loss of the yield. Screening of the existing bean cultivars (up to 10,000) gave only indicatons for tolerance in some of them. For the moment, the only viable solution seems to be growing beans in areas where soybean is not cultivated.

Citrus tristeza is omnipresent in Brazil, but has been practically under control through the use of suitable scion/rootsock combinations. Some years ago, however, a very severe strain, the so-called Capão Bonito, was found in southern São Paulo, where it was causing damage to sweet orange plants tolerant to the ordinary strains. Considering that this severe strain could eventually reach the main citrus growing area (northern S. Paulo State) because of the efficient aphid vector (*Toxoptera citricidus*) and also due to the indiscriminate movement of citrus plants throughout the state, a scheme was organized to prevent such a problem. This was based on premunization, and it was started at the Instituto Agronômico several years ago. Essentially the idea is to infect the citrus plants with a very mild strain of the tristeza virus, which through interference would protect the plant against a further infection by a severe strain. Some suitable mild strains were obtained, and they proved to have good protection qualities in challenge tests either under experimental or natural conditions. Budwood from premunized plants was distributed to several citrus growers, and an estimate of 2–3 millions of orange trees in the São Paulo State are probably premunized, therefore giving reasonable perspectives of control in case of an outbreak of the severe strain.

Cassava is mainly used to produce starch, and also is part of the basic diet of a large part of the Brazilian population. Fortunately this crop has only a few virus diseases of minor importance, besides an occasional witches' broom associated with a mycoplasmalike organism. The main menace is represented by the African cassava mosaic, a whitefly transmitted virus disease, which affects 100% of the cassava crop in Africa. Presently a severe quarantine procedure is being recommended to avoid the introduction of this disease.

Ratoon stunting disease of the sugarcane, induced by a rickettsialike bacteria and disseminated either by infected propagative parts or by cutting instruments, is prevalent in this industrial crop in Brazil. Conservative estimates indicate that this disease must cause yield losses of about 30%. The usual control measure is to treat the cane by hot water before planting, but it has been demonstrated to be ineffective. There has been little progress toward the control of the disease, and one of the basic factors responsible for this failure is the lack of a suitable indicator plant for indexing programs. Elephant grass appeared promising, but the symptoms, discoloration of the nodes, revealed to be nonspecific in later experiments.

The soybean crop has been expanding quickly, and it already represents Brazil's first export plant product, being cultivated from the southern states up to central Brazil. Bud blight (Brazilian tobacco streak virus) and soybean mosaic viruses are commonly found in this crop, although not causing serious concern. Soybean varieties resistant to soybean mosaic are available and being a seed borne disease, clean seed production also helps to reduce the infection by this virus. A potential virus menace to the soybean

crop is that a strain of BGMV might become eventually adapted to soybean.

Black pepper is an important crop in the Amazon Basin. An outbreak of a virus disease occurred in this crop, and was identified as being caused by the cucumber mosaic virus. Propagation of virus-free plants, control of the aphid vector and the erradication of affected plants apparently controlled the disease.

Cotton has minor, but consistent virus problems, such as a whitefly-transmitted mosaic, aphid-borne vein mosaic and anthocyanosis, and late mosaic caused by Brazilian tobacco streak virus. Anthocyanosis causes a reddening of the leaves of infected plants, usually identified as magnesium deficiency. It was also found that infection of cotton plants by the tobacco streak virus that causes late mosaic, requires the preconditioning of the plant by infection with the anthocyanosis virus.

Corn, rice and wheat are the most important cereal crops in Brazil. There has been no report of outbreaks of virus diseases of rice in the country. Hoja-blanca has been recorded in a few cases as a minor disease. Several virus diseases were identified infecting corn, but none is of importance. Corn stunt, caused by a leafhopper-borne spiroplasma, might cause yield losses on off-season corn planted in between two successive annual crops. On wheat, barley yellow dwarf is an important factor in reducing yields and soil-borne wheat mosaic is becoming widespread and assuming greater importance.

Oil plants such as peanut, sunflower, and castor bean usually have no important virus problems. The same is true for some tropical major crops as rubbertree, cocoa and coffee.

Vegetable crops are often intensively cultivated in the green belts surrounding most of the large cities, and they are commonly affected by several viruses. None probably is as devastating as the tomato spotted wilt virus in summer plantations of tomato, associated with a high population of the vector (thrips). The use of systemic insecticides prior to and after transplanting reduces infection to a tolerable level. For some of the aphid-borne viruses such as potato virus Y and watermelon mosaic virus, the use of a repellent background as rice husks reduced the early infection rate up to 90%, by preventing the landing of the aphid vector on the nursery seedlings.

Under experimental conditions Pangola stunt virus induced a considerable yield reduction and led to premature death of plants. It is leafhopper-borne, and apparently is not widespread in Brazil yet, but potentially seems to be the most important virus problem for the pasture grasses.

Discussion

H. Kitajima, Japan: Do you think that mild strain of CTV for one variety, always act as mild strain to the other varieties of citrus?

Answer: As a general tendency yes, but not necessarily so. Moller and Costa worked out these details, which I cannot remember completely. Usually, a mild strain was selected for each citrus species, and care has taken so that this particular strain would not be harmful for other species, which normally are grown nearby, otherwise this "vaccination" program would fail.

W. P. Ting, Malaysia: 1. Can you please elaborate on the use of repellent background as rice husks in the control of PVY and watermelon mosaic?

2. Black pepper infected with CMV—is it readily a transmissible?

3. What bean do you refer to which is infected with BGMV?

Answer: 1. Credit of these work has to be given to our colleague Claudio L. Costa, who carried out the experiments. Materials such aluminium foil were known to provide repellent surface, but they are expensive and usually difficult for the farmers to get. Thus a material which would be easily obtained was searched, and rice husk came as an answer. As mentioned landing of the aphid on soil covered with the rice

husk could be prevented up to 90%, and this is believed to be related to the wave length of the light reflected on this light-yellow surface. Estimates were obtained using water-traps. Parallel to the reduction of the landing of winged aphids, there was a reduction of the incidence of the transmitted virus diseases. This system is particularly useful in annual crops, such as tomato, pepper, cucurbitaceae, etc., on which certain virus diseases, if attacking young plants might cause severe losses, but not in grown plants. Thus covering soil of the site of nursery seedlings is highly recommended. More detailed information can be obtained from Dr. C. L. Costa, who works with me, presently, at Brazilia.

2. The cucumber mosaic virus affecting black pepper, as far as I remember—the work was done by Dr. A. S. Costa—was mechanically recovered from this plant, and also would be mechanically inoculated in it, either using other CMV—infected plants or black pepper as inoculum.

3. Common bean—*Phaseolus vulgaris*.

D. A. Benigno, Philippines: 1. What is the best section—stock combination against citrus tristeza virus?

2. What symptom pattern would you consider a severe strain and mild strain of tristeza?

3. How do you premunized citrus for citrus tristeza?

Answer: 1. In Brazil mandarins and sweet oranges are commonly used as root-stocks, since the 40's when all the orange trees grafted on sour orange were wiped out by tristeza. In Argentina and Uruguai, *Poncirus trifoliata* is widely used, because it withstand better lower temperatures.

2. I am not an authority to answer that, but I would say that mild strain practically do not produce symptoms (vein—clearing, stem pitting, etc.), nor significant yield or plant size reduction. Indeed infected plant cannot be distinguished from healthy, control. Severe strains, on the other hand, usually cause visible symptoms, in susceptible hosts, the degree of which may vary.

3. By budding, using budwood of the plant invaded by mild strain. Again, I am not aware of the details, but I suppose this is done simultaneously to the budding the root-stock with the scion.

P. Shivanathan, Sri Lanka: 1. Has the whitefly borne virus of bean located in the whitefly?

2. What is the relationship of this virus to the vector whitefly?

Answer: 1. Not yet. Indeed it (bean golden mosaic virus) was not yet clearly identified even in the plant tissues. I have found occasionally virus-like particles clustered in the phloem vessels of affected plant leaves, but it is not yet convincing to me that they do represent BGMV in situ. Furthermore, whiteflies are awful to deal with, in terms of electron microscopy. So far I have found large difficulties in getting decene fixation.

2. I cannot answer as an authority, but the fragmentary knowledge I have, is that, it might be semi-persistent, but I think that there are not yet clear cut evidences showing that BGMV is either circulative or propagative, in the whitefly body.

T. Soelaeman, Indonesia: Some people are rather sceptical on the so called premunization, owing to the fact that not all cells could be protected from the severe strain. This in turn is caused by the not completely systemic spread of the protecting virus. What do you think of this?

Answer: Well, this objection exists. Another objection is that a mild strain might reverse to a severe form. Muller and Costa had these possibilities in mind, but considering that tristeza virus is omnipresent, even that some few escapes (infection of premunized plants or some mutation of mild to severe which would occur in a very

low %) could occur. This would not affect the program at all. Furthermore since the program was started, about 15 years ago, not a single case of mutation was observed, and the few selected mild strains (from some few hundreds tested), have demonstrated a complete protection, when challenged with severe strains, either in experimental or natural conditions, even when heavily inoculated (by aphid or tissue union). Implying that the protective strain has a good systemic distribution. These were the reasons, why presently the distribution of mild strains was approved to the citrus growers.

N. Yamada, Japan: You have shown a slide on African cassava mosaic. I wonder whether your country is completely free from the disease at present, or you have the disease at some places to some extent?

Answer: We believe that African cassava mosaic (whitefly transmitted) virus is not established in Brazil yet. Not a single outbreak of this virus has so far been reported. On the other hand, we constantly warn cassave breeders to avoid any introduction of living parts of cassava from Africa, which in a way does not make sense, since cassava is native in South America.

R. Kishimoto, Japan: You mentioned on the Pangola stunt virus. What is the vector species?

Answer: I know it is a leafhopper, but I can't remember the species. We can send you the correct information when back home. It might belong to the genus *Sogata* or *Sogatella*.