12. A REVIEW OF PLANT VIRUS DISEASE IN PENINSULAR MALAYSIA

Ching Ang ONG* & Wen Poh TING**

Introduction

The importance of virus diseases was only recognized of late. Hitherto no detailed studes of viruses have been carried out. Of the virus diseases reported in Malaysia, penyakit merah virus disease of rice is by far the most important, and has been studied by numerous workers (Ou et al., 1965; Ting and Paramsothy, 1970; Ting, 1971; Lim, 1972; Ting and Ong, 1974).

Most of the insect-borne viruses reported in Malaysia are transmitted by aphids. This is followed by leafhoppers which is responsible for the transmission of 3 diseases of rice. The only white-fly transmitted virus disease is yellow vein-banding on *Ageratum conyzoides*. So far no vrus diseases have been reported to be transmitted by thrips, mealybugs, mites, nematodes or fungi.

The characteristics of the virus diseases studied in Malaysia are discussed in this paper, including a disease reported to be caused by mycoplasma (Singh et al., 1970) viz.: paji jantan.

Cereals

Rice Penyakit merah virus (PMV) disease of rice has been observed in Peninsular Malaysia for a long time (Coleman—Dascas, 1935). However, it was not until 30 years later that the nature of the disease was established (Ou et al., 1965). Earlier workers attributed the disease to nutrient toxicity, nutrient deficiency (Lockard, 1959), nematode and soil acidity. The symptom and host range of the virus are given in Table 1.

Penyakit merah virus is similar to tungro virus in the Philippines. Both viruses are transmitted by *Nephotettix virescens* and *N. apicalis* in a non-persistent manner (Ting and Paramsothy, 1970). However, the host range of PMV and that of tungro virus appear to differ. *Echinochloa crusgalli*, a symptomless carrier of tungro virus, was not infected by PMV; the symptoms of *Eleusine indica* infected with penyakit merah and with tungro were found to be different (Ting, 1971). In addition, *Oryza ridleyi*, a susceptible host of tungro virus was shown to be not susceptible to PMV (Ting and Ong, 1974).

The incidence of PMV varies from locality to locality and appears to be cyclic. Yield losses of 69 to 92% have been recorded (Lim and Goh, 1969). The severity is dependent on the variety and time of infection.

The second virus disease reported on paddy is orange leaf. The disease is of limited economic importance, and is transmitted by the leafhopper, *Recilia dorsalis* (Singh, 1971). The only known host of the virus is *O. sativa*. Symptoms of affected plants are described in Table 1.

Padi jantan has also been observed by farmers for a long time. The disease is of

* Plant Pathologist and ** Assistant Director, Malaysian Agricultural Research and Development Institute, Malaysia

Table 1. Characteristics of virus diseases in Malaysia

Natural host	Virus	Symptoms	Host range	Transmission	Virus-vector relationships	Morphology and physical properties
Padi	Penyakit Merah (Tungro)	Yellow to orange discoloration of leaf; mottling of young leaves, stunting; reduction in tillering.	*Oryza sativa*, *O. fatua*, *Echinochloa colonum*, *Eleusine indica*	Graft : — Sap : — *Nephotettix virescens* *N. nigropictus*	Min.Acq.: 10m. Inb.: 3hrs. Ret.: 5d. Min.Inoc.: 30m. Type: NP	
Padi	Padi Jantan (Yellow dwarf) (Mycoplasma)	General yellowing, severe stunting; excessive tillering.	*Oryza sativa*	Graft : — Sap : — *N. virescens*	Min.Acq.: 10m. Inb.: 20–40d. Ret.: 27d. Min.Inoc.: 10m. Type: P	
Padi	Orange leaf	Leaves orange coloured; rolled; slight stunting; death of plant.	*Oryza sativa*	Graft : — Sap : — *Recilia (Inazuma) dorsalis*	Min.Acq.: 3hrs. Inb.: 1–14d. Ret.: — Min.Inoc.: 3hrs. Type: P	
Citrus sp.	Tristeza	General decline; die-back of twigs and branches; vein clearing; corky veins; stem pitting; yellowing of foliage.	*Citrus reticulata* (Mandarin orange, Limau Chembol, Limau Kupas, Limau Kopek), *C. sinensis* (Limau Potong), *C. aurantifolia* (Limau Nipis), *C. grandis* (Limau Basar), *C. microcarpa* (Limau Katsuri), *C. histrix* (Limau Purut, Limau Kedangsa), *C. limon* (Limau Susu, Limau Kapas), *C. swinglei* (Kumquat), *C. aurantium* (Standard sour)	Graft : + Sap : — *Toxoptera citricidus*		
Passion fruit	Passion fruit mosaic	Chlorotic spots; mottling; curling; puckering; distortion; stunting; sorter internodes; ring-spotting.	*Passiflora edulis*, *P. foetida*, *P. laurifolia*, *P. ligularis*, *P. quadrangularis*, *P. platyloba*, *P. maliformis*, *P. macrocarpa*, *P. vitifolia*, *P. mollisima*, *Cassia occidentalis*, *Gomphrena globosa*, *Chenopodium amaranticolor*	Graft : + Sap : + *Myzus persicae*, *Aphis gossypii*, *A. caccivora*	Type: NP	Shape: sphere TIP: 69–70°C DEP: 10^{-2}–10^{-3} LIV: 5–6d.

Table 1. (Continued)

Natural host	Virus	Symptoms	Host range	Transmission	Virus-vector relationships	Morphology and physical properties
Chilli	Chilli venial mottle	Mottling, veinclearing, veinbanding, stunting, distortion.	*Capsicum annuum*, *C. chinensis*, *C. frutescens*, *Hyosyamus niger*, *Nicandra physaloides*, *Nicotiana tabacum* 'Dutch A' 'White Burley', *Physalis floridana*, *P. minima*	Graft : + Sap : + *Aphis gossypii*, *A. craccivora*, *Myzus persicae*, *R. maidis*, *I. citricidus*, *A. spiraecola*, *H. setariae*	Min.Acq.: 5s. Inb.: — Ret.: 3hrs. Min.Inoc.: 5s. Type: NP	Shape: flexuous rod TIP: 55–60°C DEP: 10^{-3}–10^{-4} LIV: 7–8d.
Tomato		Necrotic streak, bunchy top, stunting	*Lycopersicum esculaentum*	Graft : + Sap : +		
Cucumber, Periwinkle, Banana	Cucumber mosaic	Severe mottling; dark-green blister; distortion; stunting.	*Cucumis sativus* (Cucumber), *Cucurbita pepo* (Pumpkin), *C. maxima* (Squash), *Momordica charantia* (Bitter cucumber), *Trichosanthes anquina* (Snake gourd), *Benincasa cerifera* (Tong Qua, Mau Qua), *Crotalaria usaramoensis*, *Calopogonium mucunoides*, *Chenopodium amaranticolor*, *Gomphrena globosa*, *Vinca sinensis* (Periwinkle), *Amaryllis* sp., *Musa sapientum* (Banana), *Passiflora edulis*, *Amaranthus viridis*, *Citrullus vulgaris*, *Commelina nudiflora*	Graft : + Sap : + *Myzus persicae*, *Aphis gossypii*, *A. craccivora*, *Rhopalosiphum maidis*	Min.Acq.: 30s. Inb.: — Ret.: 40m. Min.Inoc.: — Type: NP	TIP: 60–62°C DEP: 10^{-4}–10^{-5} LIV: 4–5d.
Lettuce	Lettuce mosaic	Veinclearing, veinbanding, mottling.	*Chenopodium amaranticolor*, *Gomphrena globosa*, *Lactuca sativa*, *Lathyrus odoratus*	Sap : + *Myzus persicae*		

Table 1. (Continued)

Natural host	Virus	Symptoms	Host range	Transmission	Virus-vector relationships	Morphology and physical properties
Brassica rapa, Radish		Mottling, distortion, stunting.	*Chenopodium amaranticolor*, *C. quinoa*, *Brassica shinensis*, *B. rapa*, *B. oleracea perviridis*, *B. albo-glabra*, *B. napus*, *B. oleracea*, *Gomphrena globosa*	Sap : + *Aphis gossypii*, *Myzus persicae*, *L. erysimi*	Type: NP	TIP: 55–60°C DEP: 10^{-3}–10^{-4} LIV: 6–8d.
Groundnut	Groundnut mosaic	Mottling with patches of dark-green; chlorotic spots and ring spotting; stunting.	*Arachis hypogaea*, *Cassia occidentalis*, *Glycine max*, *Calopogonium mucunoides* *Crotalaria anagyroides*, *Stylosanthes gracilis*, *Phaselous vulgaris*, *Chenopodium amaranticolor*	Graft : + Sap : + *Aphis gossypii*, *A. craccivora*, *Myzus persicae*, *Rhopalosiphum maidis* *Tosoptera citricidus*	Min.Acq.: 5s. Inb.: — Ret.: 40–45m. Min.Inoc.: — Type: NP	Shape: flexuous rod TIP: 62–65°C DEP: 10^{-3}–10^{-4} LIV: 40–48hrs.
Long bean		Mottling, distortion, stunting.	*Vigna sesquipedalis*, *V. sinensis*, *Chenopodium amaranticolor*, *C. quinoa*, *C. muconoides*, *Glycine soja*, *Pisum sativum*, *Phaseolus vulgaris*	Graft : + Sap : + Seed : + *Aphis gossypii*, *A. craccivora*, *Myzus persicae*, *L. erysimi*	Type: NP	TIP: 70–75°C DEP: 10^{-3}–10^{-4} LIV: 1–2d.
Orchids	Cymbidium mosaic	Sunken black necrosic spots on under surface of leaves on *Vanda* & *Dendrobium* spp. Diamond spotting and chlorotic spots on *Spathoglottis* sp. clourbreaks.	*Spatoglottis* sp., *Vanda* sp., *Dendrobium* sp., *Phlaenopsis* sp., *Cattleya enidson*, *Cattleya* sp. (True Depth), *Cassia occidentalis*, *Chenopodium amaranticolor*, *C. quinoa*, *Datura stramonium*, *Gomphrena globosa*	Graft : — Sap : + Vector : —		
Hydrangea spp.		Mottling, distortion	*Chenopodium amaranticolor*, *Cassia occidentalis*, *Gomphrena globosa*, *Nicotiana glutinosa*, *N. tabacum*, *N. xanthi*	Sap : +		

Table 1. (Continued)

Natural host	Virus	Symptoms	Host range	Transmission	Virus-vector relationships	Morphology and physical properties
Amaryllis		Dark green mottles	*Chenopodium amaranticolor*, *C. quinoa*, *Gomphrena globosa*, *Nicotiana rustica*, *N. glutinosa*, *N. tabacum* 'White Burley'	Sap : +		
Tobacco, Tomato, Chilli	Tobacco mosaic	Severe mottling with dark-green islands; distortion and stunting	*Nicotiana tabacum*, *N. xanthi*, *N. glutinosa*, *N. rustica*, *Capsicum annuum*, *Lycopersicon esculentum*, *Chenopodium amaranticolor*, *C. quinoa*, *Gomphrena globosa*, *Phaseolus vulgaris*, *Vinga sinensis*, *Cucumis sativus*, *Datura stramonium*, *Physalis floridana*, *P. minima*	Graft : + Sap : + Vector : —		Shape: rod
Sugarcane	Sugarcane mosaic	Scattered elongated whitish strips.	*Saccharum officinarum*, *Zea mays* 'Golden Hammer' 'Cinta', *Sorghum bicolor* 'Rio' 'Atas'	Graft : — Sap : +		
Ageratum conyzoides	Yellow veinbanding	Veins appeared as yellow bands with normal green interveinal areas; thickering of veins and curling	*Ageratum conyzoides*	Graft : + Sap : — *Bemisia tabaci*	Type: P	
Jussiaea linifolia		Systemic yellowing	*Jussiaea linifolia*	Graft : + Sap : — *Bemisia tabaci*		

Keyes: Min.Acq. =Minimum acquisition period
Inb. =Incubation period in insect vector
Ret. =Retention period
Min.Inoc. =Minimum inoculation or test feeding period
NP =Non-persistent
P =Persistent
TIP =Thermal inactivation point
DEP =Dilution end point
LIV =Longevity *in vitro*

minor importance. The disease was found to be transmitted by *N. virescens* (Lim and Goh, 1968; Lim, 1970). Recently mycoplasma like structure was observed in the phloem cells of padi jantan—infected plants (Singh et al., 1970). Similar structures have also been shown to be associated with yellow dwarf disease of rice in Japan and the Philippines.

Fruits

Citrus Tristeza is widespread in all the citrus growing districts and all citrus varieties, with the possible exception of kumquat (*Citrus swinglei*), are affected by the virus (Ting and Arasu, 1970). The disease is one of the main limiting factors in the production of citrus. The widespread distribution of the virus has been mainly attributed to the vegetative propagation of virus-infected planting materials. The aphid vector, *Toxoptera citricidus* is commonly found on citrus. Several major citrus growing areas in Peninsular Malaysia have been abandoned as a result of the disease.

Passion fruit Indigenous species of *Passiflora* e.g. *P. foetida* have been frequently observed to be affected by mosaic. Similar symptoms have also been found on passionfruit vines (*P. edulis, f. flavicarpa*, introduced from Hawaii). Comparative studies of two isolates of the mosaic disease showed that while sharing many common characteristics and properties (Table 1), they can be readily differentiated using indicator plants and aphid vectors. *Cassia occidentalis* is highly susceptible to the isolate which cannot be transmitted by *Aphis craccivora* and *A. gossypii* (Ong and Ting, 1973). Results of studies indicated that it is likely that the two viruses are related. Field spread of the viruses is mainly affected through prunning operation as well as by aphids which transmit them in the non-persistent manner.

Vegetables

Most of the vegetables commonly grown in the country belong to the family Cruciferae, Solanaceae, Cucurbitaceae, and Leguminosae. Vegetables grown have been frequently observed to be affected by viruses.

Chilli Field grown chilli plants have been found to be infected by a number of viruses. The most prevalent one is chilli veinal mottle virus, a member of the potyvirus or potato virus Y group. The host range, symptomatology and physical properties of the virus are presented in Table 1. All the chilli varieties tested so far have been found to be highly susceptible. The virus is transmitted in the non-persistent manner by all the aphid species tested. Chilli plants infected a month after sowing can result in yield reduction as high as 58%. Polyethylene sheet coated with aluminum paint has been found to be effective in reducing disease incidence by repelling the aphid vectors (Ong, 1975).

Tobacco mosaic virus (TMV) has also been found to infect chilli. The same virus was also found on tomato and brinjal. Comparative studies on some of the TMV isolates have shown the possible presence of strains or variants in Peninsular Malaysia.

Tomato In addition to TMV, tomato plants have recently been reported to be infected by a virus which causes systemic necrotic streak on the leaves and stems of infected plants (Ong, unpublished). The virus has been found to be readily graft and sap transmissible from diseased to healthy tomato plants. The following plant species have been found not to be susceptible to the virus:–

Chenopodium amaranticolor; C. guinoa, Capsicum annuum; Datura stramonium; Gomphrena globosa; Hibiscus esculentus; Nicotiana rustica; N. tabacum; N. xanthi; Phaseolus vulgaris; Physalis floridana; Solanum melongena; Vigna sinensis; and *V. sesquipedalis.*

Detailed characterization of the virus is currently being carried out. Another virus reported on tomato, cucumber mosaic virus (CMV) will be discussed in the following section.

Cucumber A number of the vegetables cultivated in the country belong to the family Cucurbitaceae. The major virus disease of cucurbits is CMV. The virus has also been found to infect banana (*Musa spientum*) and periwinkle (Ong, 1971). The properties of the virus are listed in Table 1.

Lettuce The occurrence of lettuce mosaic virus on lettuce was first reported in 1973 (Ong). The virus is of minor importance and was probably introduced into the country through infected seeds.

Turnip and Radish *Brassica rapa* and *Raphanus sativus* have been found to be naturally infected by a virus disease which causes mosaic symptoms on both hosts. The virus is readily transmitted by sap inoculation and aphids to other Brassicas, including Chinese cabbage and kai-lan (*B. albo-glabra*). The host range, symptomatology, physical properties and virus-vector relationship of the virus appear to be similar to those turnip mosaic virus (Ong, unpublished).

Legumes

Groundnut One of the most important leguminous crops grown in Peninsular Malaysia is groundnuts. Field grown groundnuts are commonly observed to exhibit systemic mottling. Ting and co-workers (1972) showed that the disease is caused by a virus, groundnut mosaic virus (GMV). The virus is considered to be one of the most widespread diseases of groundnut. The characteristics of the virus are listed in Table 1. It is evident that except for *C. amaranticolor*, the host range of GMV is mainly confined to the family Leguminosae. It is transmitted in a non-persistent manner by all the aphid species tested so far. The main vector being *Aphis craccivora*.

Longbean (*Vigna sesguipedalis*) Surveys carried out in some of the long bean farms have shown that most of the plants are infected with a mosaic disease caused by a virus (Ong, unpublished). The virus is readily graft and sap transmissible and has been found to be transmitted by all aphid species tested. Recently, the virus was found to be seed-borne, studies have shown that the percentage of seed transmission can vary from 2–50% depending on time of infection.

Ornamentals

Orchid Orchids are one of the most important group of ornamentals grown in the country. The various genera of orchids like *Spathoglottis* sp., *Vanda* sp., *Dendrobium* sp., *Phalaenopsis* sp., and *Cattleya* sp. are often found to be infected with cymbidium mosaic virus (Ting and Ho, 1971). In a recent survey of virus diseases of orchids it was shown that *Arachnis Maggie Oei* cv. Red Ribbon; *Aranthera James Storei; Aranda Wendy Scott* cv. Greenfield, and *Oncidium Golden Shower* cv. Caldwell are frequently infected with cymbidium mosaic virus and/or tobacco mosaic virus—orchid strain. Presently, much effort has been made to produce virus-free planting materials using tissue culture techniques.

***Hydrangea* sp.** Virus infected plants showed mottling and distortion of the leaf (Ting, unpublished). The virus is sap transmissible and the host range of the virus is listed in Table 1. The virus is of limited importance.

Others Amaryllis and periwinkle have been found to be infected with virus diseases. The virus on Amaryllis may have been introduced into the country through infected bulbs. Periwinkle are often infected with CMV, and may play an important role in the epidemiology of CMV.

Miscellaneous

Tobacco Tobacco mosaic virus which has been discussed in the previous section, is the most prevalent virus disease of tobacco. This disease is very widespread throughout

the country. The main properties of the virus are presented in Table 1.

Sugarcane Planting materials from overseas were found to be infected with a virus. Leaves of infected cane show elongated systemic mottling. The virus is sap transmissible to monocotyledons like maize and sorghum. Attempts to transmit the virus using *Rhopalosiphum maidis* and *Hysteroneura setariae,* known aphid vectors of sugarcane mosaic virus, have so far been unsuccessful.

Ageratum conyzoides *Ageratum conyzoides* is a common weed found throughout the lowlands in the country. The infected plants normally show yellow veinbanding symptom. Studies have shown that the virus Ageratum yellow veinbanding virus, can readily be transmitted through grafting but it is not sap transmissible. It is the first whitefly —transmitted plant virus recorded in the country. The host range of the virus is limited to *A. conyzoides.* Brinjal, chilli, cucumber, okra, tobacco and tomato are not susceptible to the virus. (Ong, et al., 1976).

Jussiaea linifolia *Jussiaea linifolia* is a common weed generally found in paddy areas. Symptoms somewhat resembling that of Ageratum yellow veinbanding virus have been observed on *J. linifolia.* The virus has been found to be transmissible through grafting. Attempts to transmit the virus by sap inoculation and insects have been unsuccessful.

Conclusion

Studies on plant viruses carried out so far have shown that aphids are the most important arthropod vectors and are usually associated with mosaic type diseases. All the aphid-borne viruses reported are of the non-persistent type. Most of the important virus diseases of rice on the other hand are transmitted by leafhoppers.

In spite of the relatively high temperature and humidity there is no evidence of masking of symptoms caused by viruses. Observations have indicated that virus diseases are equally important in the tropics as compared to temperate areas. The high temperatures also does not appear to affect the physical properties of the virus e.g. thermal inactivation point, dilution end point, etc.

Further studies need to be carried out in order to establish the true identity of some of the viruses. Frequently minor differences have been encountered while comparing virus diseases present in Malaysia with those reported in other countries. As a result this has caused some problems in establishing the relatedness of viruses occurring in Malaysia and those elsewhere. The problem is accentuated for viruses where antisera are not available. Comparative studies of viruses which appear to be closely related using standard techniques would be extremely useful.

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Discussion

T. Soelaeman, Indonesia: (1) Yellow vein banding of *Ageratum* is found everywhere Indonesia, but studies on this disease is just in the initial stage at Bandung or Bogor. Do you know other hosts than *Ageratum*?

(2) How about Stachytarpheta yellows in Malaysia? Is this disease also present in Malaysia?

Answer: (1) So far as our tests were concerned, the virus appears to infect *Ageratum conyzoides* only, however in our further studies, it is possible that other host may be found.

(2) We are not familiar with this virus in Malaysia.

E. W. Kitajima, Brazil: Do you plant corn in Malaysia? If so, are there any virus diseases on this crop?

Answer: Corn is planted in Malaysia mainly for human consumption. Attempts to grow corn have not developed to the scale where virus diseases are observed. I would not be surprised if viruses occur on maize should large areas be planted to the crop.

M. D. Mishra, India: (1) It seems that you do not have tobacco leafcurl virus in your country. How about any other hosts which may be harbouring tobacco leafcurl virus as in the case of my country?

(2) You have mentioned about the use of tissue culture technique in orchid cultivation, especially for freeing your orchid cultivars from virus infestation. How far it is being used and what is the progress in its use?

Answer: (1) Tobacco leafcurl has been observed on tobacco in Malaysia. We do not have any information on the host range or other host plants which may harbour the virus.

(2) We have only recently started work on the use of tissue culture in combina-

tion with heat therapy to produce virus free planting material. Bioassay will be carried out with the material propagated by means of tissue culture technique.

D. A. Benigno, Philippines: (1) Do you have any studies on the strain of sugarcane mosaic virus?

(2) Your slide of groundnut mosaic virus seems to be similar to the peanut mottle virus reported in other countries. Why don't you call it peanut mottle virus other than groundnut mosaic virus?

Answer: (1) No strain study is carried out at the moment on sugarcane mosaic virus.

(2) Groundnut mosaic virus in Malaysia is very similar to peanut mottle reported by Kuhn, except for minor differences in reaction on indicator plants. Since there is no complete agreement with viruses reported on peanut so far, we have decided to name it as groundnut mosaic virus.