ASEAN PLANT QUARANTINE CENTRE AND TRAINING INSTITUTE

COCOA SWOLLEN SHOOT VIRUS COMPLEX

Fig. 1. **Swollen shoot outbreak area in Ghana: breaking cocoa canopy, developing ground vegetation, dying trees.** Fig. 2. **Cocoa seedling with conspicuous swelling due to swollen shoot.** Fig. 3. **Young leaf showing transient red-vein banding pattern.**

Main virus synonyms

Swollen shoot strain A
Theobroma virus 1A
Marmor theobromae var A
Theobromavirus inflans

Main strains

New Juaben strain
Virulent strain

Principal host

Theobroma cacao. L. and spp.

Alternate hosts

Sterculiaceae eg. *Cola caricaefolia* (G. Don) K. Schun, Bombacaceae eg. *Adansonia digitata* Linn, Tiliaceae *Corchorus stridens* Linn

Host range

Experimental host range is limited to about 30 species in the Bombacaceae, Tiliaceae, sterculiaceae and Malvaceae (20). Besides *Theobroma cacao*, natural host range is restricted to *Cola chlamydantha*, *Ceiba pentadra*, *Cola gigantea* var. *glabrescens* (13) and *Sterculia tragacantha* (7).

Vectors

Mealybugs spp. eg. *Planococcus njalensis* (Laing), *Planococcus citri* (Risso), *Ferrisia virgata* CKLL.

Geographical distribution

Widespread in West Africa (Ghana, Ivory Coast, Nigeria, Togo and Sierra Leone); it also occurs in Sri Lanka, Colombia, Trinidad, Venezuela, Indonesia and possibly in Sabah.

Economic importance

Cocoa swollen shoot virus (CSSV) is considered one of the most important factors limiting the production of cocoa and is one of the most economically important plant diseases in the world (18). Losses due to CSSV have been high; for instance, the Eastern region of Ghana experienced destruction of over 150 million diseased cocoa trees since 1946 (6) with an estimated monetary loss of over L3 million per year.

On a global scale, cocoa crop loss due to swollen shoot has been estimated to be about 10% (10). The seriousness of the economic effects involves not only annual losses of production but those of 'capital depreciation' through destruction of trees.

In Ghana, the virulent New Juaben type of CSSV can kill infected cacao trees within one to three years (9); elsewhere the disease could cause a yield reduction of 5—20%.

Virus strains and isolates

Within the CSSV complex, at least 90 strains and isolates have been recognised. The best known is the severe New Juaben strain (Strain A: *Theobroma* virus 1A) which is widespread in Ghana. Other well known strains, which occur in Ghana (Bisa, Bosumtwe, mild New Juaben and Nkawkaw), Nigeria (Balogun and Ilesha) and Ivory cost (Kongodia), are of less virulent strains (19).

Properties of the virus

The virus particles are bacilliform, about 121-130 X 28nm, with no discernible substructure when mounted in neutral 2% potassium phosphotungstate (3).

Strain B virus (Bisa strain) was not inactivated in budwood immersed in water at 45°C for 30 minutes, or at 50°C for 10 minutes.

Strain A virus was not inactivated in budwood immersed in water at 45°C for 30 minutes, at 50°C for 12 minutes, or at 52°C for 10 minuter (16).

Means of entry

Via pods from infected trees. Pods containing virus may or may not show disease symptom (17) and testa of beans from an infected pod can also have virus. Thus testas of beans should be removed before treatment for export

Since increased tourist movement and trade can help introduce CSSV, it is necessary to impose strict quarantine measures of goods and passengers.

Diagnosis

Early work revealed that virus infection by strain A increased the speed at which woody stem stained in acidified methyl alcohol (12).

Recent physiological studies showed that detection of the virus could be made by a reduction in the number of ovules per ovary (11). Plant quarantine stations should adopt this technique for early disease diagnosis.

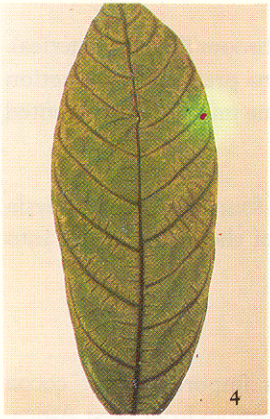
Symptoms — Identification

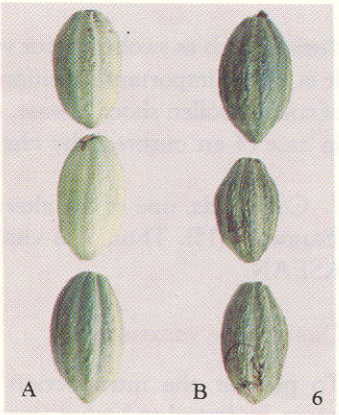
The first recogizable symptoms of virus infection caused by isolate strain A are shoot swellings (Fig. 2) on both the nodes and internodes. This is due to the enlargement of xylem and phloem without necrosis. Swellings occur especially on tap roots and severe virus infection often induces necrosis of fine roots as well. In some infections, symptoms are also induced on leaves together with the swellings (12, 17).

The normal red colour of young leaf persists in an infected leaf to give a characteristic **red-vein banding** pattern (Fig. 3). **Chlorotic areas** subsequently develop in a mature infected leaf (Figs. 4 & 5). These transient symptoms of pigmentation followed by clearing and chlorosis vary according to the type of virus strains and are variously named according to the pattern of symptom.

Permanent vein banding restricted to the veinlets may be described as **speckling** or that extends along larger veins **angular flecks. Mosaic** pattern is one showing general chlorosis of young leaves with small irregular chlorotic spots and flecks. Chlorotic bands extended irregularly along the main veins may give a **fern leaf pattern.** The leaf laminae may also be **distorted** and **crinkled** when chlorosis is restricted to part of the laminae.

Pods that are affected become abnormally small, smooth and rounded (Fig. 6). The degree of leaf and pod pigmentation varies according to varietal characteristics. Some isolates may also cause mottling and pigmentation on pods.





Figs. 4 & 5. **Mature leaves showing two types of chlorotic symptoms.** Fig. 6. **Immature pods from a healthy tree (A) and those from a tree infected by virulent strain of virus (B). (Note the effect of virulent strain on pod size and the green rugosity of the pod surface.)**

Transmission by vector

At least 14 mealybug species (Hemiptera: Coccidae) are capable of transmitting the disease (3) from tree to tree. *Planococcoides njalensis*, *Planococcus kenyae* and *Planococcus citri* are generally most abundant with *P. njalensis* often the most important. *P. njalensis* has a life cycle of six weeks with three nymphal instar stages. The mobile immature mealybugs and third instar nymphs being the most active feeders are mainly responsible for transmitting the disease (2). The disease is transmitted by grafting but not through pollen or seed.

Spread

Two methods of rapid spread are possible. Firstly, the 'continuous' or 'radial' spread, which is achieved by mealbugs walking from infected to healthy trees, is the commonest at the beginning and end of the wet season. The second method is the dispersal of mealybugs by wind in 'discontinuous' or 'jump' spread, which is responsible for long distance spread (2). In addition, spread can be achieved when mealybugs are carried by their attendant ants (*Crematogeoustea striatula*) which also serve to protect mealybugs from parasites, predators and fungi.

Potential within Asean

CSSV disease can spread unquestionably if measures are not taken to prevent introduction of inoculum source via cocoa germplasm materials. Suspected virus diseases had been detected on cocoa in Java and Sabah (1, 14), though transmission of the virus had not been proven.

CSSV is a major threat to the cocoa industry in ASEAN where cocoa is one of the main agricultural earners, particularly in Malaysia. Occurrence of CSSV can mean severe economic losses to Malaysia and can create further havoc to the cocoa and chocolate industry of the world. Cocoa importers have considered Malaysia an important cocoa supplier since other cocoa producing countries had been seriously affected by cocoa

diseases such as swollen shoot virus (West Africa) and witches' broom (South America). It is, then, important to enforce strict quarantine measures to prevent introduction of cocoa swollen shoot disease. An emergency action programme must be implemented in case of an outbreak by chance introduction.

Cola nitida, one of the alternate hosts for the virus, is also found in East Malaysia (Sarawak) (15). Thus, it is vital to prevent the transmission of the virus disease into ASEAN.

Quarantine measures

To prevent the introduction of CSSV, ASEAN prohibits importation of cocoa beans, budwood and other cacao materials such as seedlings or cuttings from West Africa, known to be a host of swollen shoot or other viruses. Cacao materials to be imported for propagation purpose are usually sent first to the intermediate plant quarantine Kew (5). On arrival at the country of import, cocoa seeds and budwood packets are fumigated to kill all pests. Post entry quarantine of plants are carried out by raising germplasm (plant) material in an insect-proof house to determine whether it is disease or pest-free before releasing it for field planting.

For budwood material, carry out disease indexing by extracting and patch-budding buds of introduced budwood on to vigorous healthy root stocks. Use single or double patch-budding technique (17). When the young buds sprout, remove top of the root stock, about 5cm above the point of bud union. Top-bud young budling (1cm in diameter) with a bud from a cacao clone, highly susceptible to CSSV such as Amelonado.

Raise cutting from the top of each of the newly-introduced budling materials simultaneously in another compartment of the quarantine house.

Control

Cutting out diseased trees and replanting with resistant varieties appear to be the measure to slow down the infection in Ghana (8).

If after three successive flushes, the indexing budling exhibits no CSSV symptom, certify release the successfully-rooted cutting as virus-free and release them for field planting.

There is no completely effective treatment for controlling CSSV. **Cordon sanitaire** where infected trees are cut to keep the disease under control is practised in Western Nigeria. Depending on the severity of outbreaks, recommendations have been made to cut out accordingly a zone of trees surrounding the infected trees to eradicate chances of 'jump' spread. The problem in control is accentuated by the lack of characteristic symptom on virus-infected trees and the passive air dispersal of mealybug vectors which cause latent infection (6). The presence of wild plants (like *Cola chlamydantha*) as alter-

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