

Pineapple and Cacao Mealy-bugs of Economic Importance in Ceylon

H. E. FERNANDO, Entomologist, Department of Agriculture, Ceylon

Received 20.6.56

Introduction

Mealy-bugs are a group of insects responsible for considerable damage to agricultural crops. This damage is always associated with the feeding of the insect and may be caused by (a) the depletion of plant nutrients by the sucking up of the plant sap and thereby causing a loss of vigour, stunting and even death of plants, or (b) the injection into the plants of toxins which form part of the salivary secretions of the insect and cause pathological reactions in the plant strongly reminiscent of a plant disease, or (c) the transmission of plant diseases from diseased to healthy plants. The economic importance of mealy-bugs to agriculture in Ceylon at present centers chiefly around the toxic effects one species of mealy-bug induces in the pineapple plant and the transmission of a virus disease by other species in the cacao crop. While some work had been done by both the Division of Plant Pathology and the Division of Entomology on these two important aspects of mealy-bug damage in Ceylon until 1953, the work of Dr. Walter Carter, conducted during an F.A.O. assignment in Ceylon in that year served to clarify some features of these problems and also as a basis for intensified studies in this field of work. Dr. Carter's observations during his stay in Ceylon have recently

appeared in the F. A. O. Bulletin (1956). The purpose of this article is to describe the nature of the problems involved and to review some of the results of studies on pineapple and cacao mealy-bugs.

Mealy-Bugs and Pineapple Wilt

Etiology of Pineapple Wilt. The relationship of the mealy-bug, *Pseudococcus brevipes* (Ckl.), to wilting in pineapple plants was first suggested by Illingworth (1931) working in Hawaii and the nature of this relationship was conclusively elucidated by Carter (1933). This mealy-bug was first recorded in Ceylon in 1926 but the affliction of pineapple plants by wilt was first diagnosed as mealy-bug induced pineapple wilt by Pieris (1950) on the basis of the symptoms exhibited by affected plants and confirmed by Carter (1953) by artificial infestation experiments. Pineapple wilt is found today wherever pineapples are grown in Ceylon.

Carter (1945) classified the sequence of symptom development of pineapple wilt into four stages with a fifth indicating a recovery stage. Stage 1 involves the preliminary reddening of the leaves. In stage 2 a definite colour change from red to pink occurs accompanied by a reflexing of the leaf margins (Plate 1). In stage 3 the affected leaves loose their



Plate 1—Series of wilting plants in foreground. Note the reflexed edges and loss of turgor of the leaves

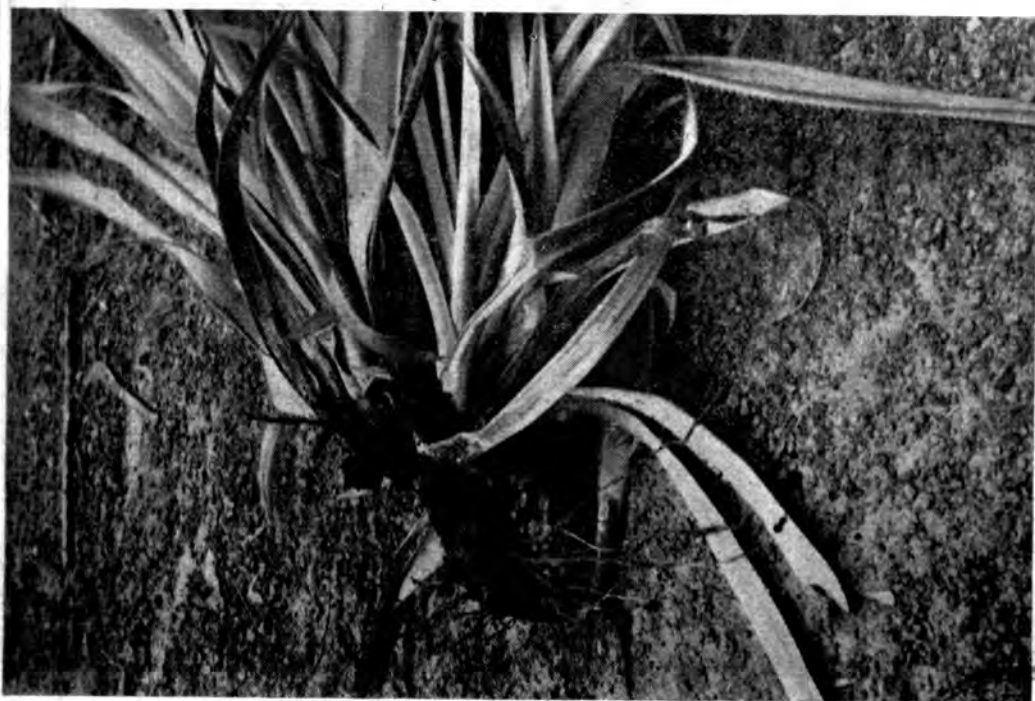


Plate 2—Wilted plants showing almost complete disintegration of root system

1976-3

turgor and droop and in stage 4 the affected leaves have dried up for the greater part of their length. The death of the root system accompanies the other symptoms (Plate 2). According to Carter (1945) a relatively small proportion of plants develop to stage 4, stage 3 usually being followed by recovery. In Ceylon the reverse appears to hold true as once wilt appears in a plant it proceeds through all its phases until the plant ultimately dies and recovery of plants from wilt is relatively rare. This may be due to the absence of effort to control the damage at this stage.

A common observation on pineapple wilt, when it first appears in a new planting, is that it commences from the edge of the planting and spreads inwards. This led to its being referred to as "edge wilt" in Hawaii. This phenomenon of "edge wilt" is the result of invasion of the new planting by mealy-bugs carried by ants from wild alternate host plants at the boundaries of the plantation. Wherever suckers used for planting are infested with mealy-bugs and no effort had been made to disinsect these suckers prior to planting, however, wilt develops at random within the plantation. Both conditions have been recognized in local pineapple plantations.

In Hawaii several alternate host plants of *Pseudococcus brevipes* have been identified (Carter 1951) but in Ceylon to date the only alternate host identified has been the thorny leaved *Bromelia pinguin*. This plant is commonly grown on boundaries of pineapple and other plantations particularly in the Western Province.

All the symptoms of pineapple wilt are strongly suggestive of a virus

disease, but Carter (1953) has produced conclusive evidence that a toxin secreted by the insect and not a virus is responsible for wilt of pineapple. Some of the strongest points in favour of the toxin idea are (a) that complete recovery of plants from wilt is possible if the mealy bugs are controlled, (b) that the symptoms of wilt cannot be induced in any other plant, (c) that the capacity to produce wilt is inherent in the insect, and (d) that vegetative propagations from wilted plants are wilt-free.

Pineapple wilt does not develop in plants immediately feeding by mealy-bugs takes place and furthermore not all plants infested by mealy-bugs will eventually develop wilt. While occasional plants may develop symptoms of wilt after being fed upon by even a single mealy-bug, most plants require larger numbers of bugs feeding for a length of time before wilt symptoms will appear. Carter (1937) has established that the percentage of plants developing wilt as a result of infestation by mealy-bug colonies of varying size varied with the number of mealy-bugs involved. Furthermore there is considerable variation in the susceptibility of individual plants to wilt. On younger plants, ranging around 5 months old, Carter (1945) has found that the period between mealy-bug feeding and the appearance of symptoms of wilt is between 58 and 77 days with a mode at 70 days whereas for older plants about 9 months old when first feeding by mealy-bugs took place, the period required for appearance of symptoms was between 82 and 181 days with a considerable number of cases requiring much longer periods. From limited experiments done in Ceylon it has been observed that a period of about 65 days

was required for the appearance of wilt symptoms after feeding by mealy-bugs on 6-month old plants.

The influence of fertilizers on the susceptibility of pineapple plants to wilt has been studied by Carter (1945 a and b). He found that plants grown at various levels of nitrogen, phosphorus, potassium, calcium and iron showed no variation in susceptibility to wilt. He also found that recovery of plants from wilt was influenced by nitrogen fertilization but the age of the plant at the time of infestation with mealy-bugs was a factor in this respect.

Biology of the Pineapple Mealy-bug.

The life history of the pineapple mealy-bug is of special interest on account of the presence of several strains of this insect (Carter 1933 a ; Ito 1938). In Hawaii a pink strain and gray strain of this mealy-bug have been recognized. The pink strain reproduces parthenogenetically with no males present and its members are not responsible for the production of green spots surrounding the point of feeding on the leaves. The gray strain reproduces sexually and causes green spotting on leaves. Both strains are viviparous and capable of causing wilt. While a colour distinction has not been observed between the strains of this mealy-bug in Ceylon, a distinction of strains into parthenogenetic and sexual forms has been found to exist here. To date only the sexual green-spotting strain has been observed in the western province while the parthenogenetic form has been recognized in the Bibile area. The detailed biology of this insect in Ceylon will be reported elsewhere.

Mealy-bugs are found on pineapple plants especially located under the

basal portions of the leaves. As the colonies of these bugs increase in size they may be found on the exposed parts of leaves (Plate 3), on fruits when present and on the subterranean parts of plants such as the butt and roots. Mealy-bug populations have been found to be particularly heavy in the basal regions of the plants in the plantations where coconut fibre dust has been used as a mulch for weed control. The conditions of moisture content and of general protection afforded by the mulch surrounding the base of the plants are very favourable for the build-up of the mealy-bugs. This mulch, unless removed, renders insecticidal control of the mealy-bugs extremely difficult.

Pineapple mealy-bugs are always found associated with various species of ants. In Ceylon the ants *Solenopsis* sp. *Paratrechina longicornis* Latr. and *Bothriomymex wroughtoni* Forel have been found in association with the pineapple mealy-bug. *Bothriomyrmex wroughtoni* has to date been found only in the western province and is of special interest because it constructs extensive earthen galleries, very similar to those constructed by termites, as a protective roofing over the mealy-bug colonies thus making the latter insect less accessible in the normally exposed parts of the plant to insecticidal treatment. The function of the ant associates of mealy-bugs is two-fold, viz., the consumption and therefore the disposal of honeydew excreted by the mealy-bugs and the dissemination of the mealy-bugs from plant to plant. With the progressive development of symptoms of wilt in pineapple plants, ants invariably remove the mealy-bugs from such plants to wilt-free healthy plants.

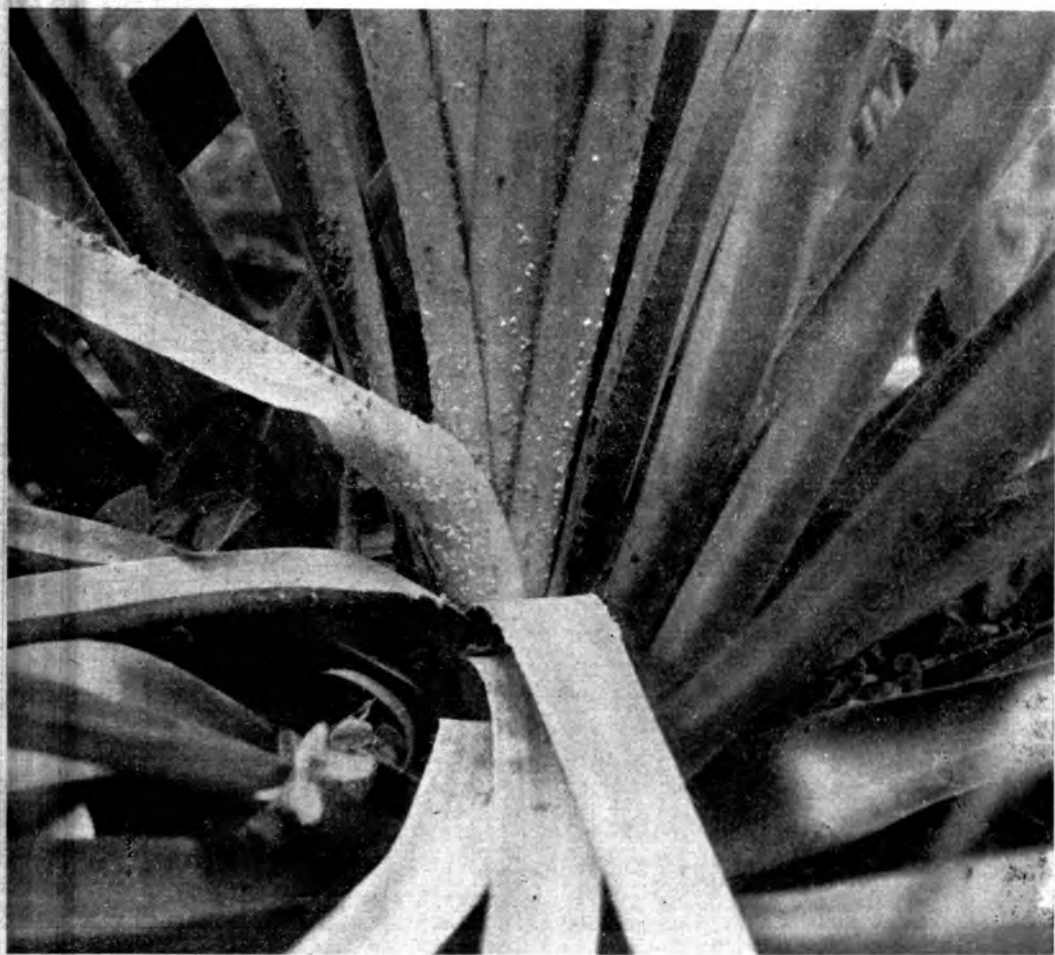


Plate 3—Pineapple plant infested by mealy bugs on under-surface of basal parts of the leaves. The remnants of the earthen galleries formed by the ant *Bothriomyrmex wroughtoni* can be seen on some leaves

Control of Mealy-bugs and Wilt of Pineapple. The control of this pest and therefore the wilting of pineapple plants can broadly be divided into three phases, viz., (a) the production of mealy-bug-free planting material, (b) the control of ants and thereby the prevention of the dissemination of the mealy-bugs in the field, and (c) the control of mealy-bugs occurring on plants in the field by insecticidal methods. In Hawaii it was found that the spread of wilt into a plantation from its boundaries was slower across rows than along rows (Carter 1932). Several rows of plants were therefore planted parallel to the boundary of the plantation as barrier rows to retard the spread of mealy-bugs into the plantation. Insecticidal treatments were concentrated on the barrier rows. While the planting of barrier rows of pineapple plants is to be recommended for implementation in Ceylon it is more important that the practice of the improper use of coconut fibre dust as a mulch on pineapple plantings should be avoided if mealy-bug populations are to be minimized. The quantity of this mulch around each plant should not exceed one inch in depth otherwise it provides ideal moisture conditions and protection for the heavy build-up of mealy-bug colonies at the base of the plant and renders such colonies of bugs inaccessible to insecticidal control measures.

The earliest insecticidal treatments for the control of pineapple mealy-bugs were oil emulsions and with the advent of DDT a measure of control was achieved by using high concentrate emulsions of this insecticide. It was however not until the organophosphorus insecticides became available that effective control of mealy-bugs became

practicable. Published data on insecticidal control of this pest are scarce. However Carter (1952) has reported the results of the comparative tests with a series of organophosphorus insecticides (parathion, malathion and systox) in the control of this insect.

Insecticidal Trials for the Control of Pineapple Mealy-bugs and Wilt. We have conducted a series of experiments towards (a) development of simple chemical techniques for obtaining mealy-bug free planting material, (b) the control of ants within a plantation, and (c) the control of infestations of mealy-bugs existing on plants in the field.

Detailed descriptions of these experiments and the data obtained will be published elsewhere. However a summary of some of the results achieved is given below.

(a) *The Control of Mealy-bugs on Suckers intended for Planting.* If the spread of mealy-bugs and wilt is to be prevented and if new plantings are to be maintained free of mealy-bugs it is of prime importance that the suckers used in the new planting are free of mealy-bugs before they are planted. In the earliest tests conducted with this end in view fumigation of the infested suckers with hydrocyanic acid gas and methylbromide gas was carried out. While both these fumigants proved effective in disinsecting the suckers it was felt that fumigation as such could not be practised by the average grower in Ceylon. A simpler method of disinsection of suckers was therefore devised. This consisted of rapid dipping of the suckers, butt first, into a diluted emulsion (in a 4-gallon bucket) of any of the organophosphorus chemicals, malathion, diazinon or parathion, and then stacking the suckers in an erect

position, for at least 24 hours so that accumulation of the insecticidal emulsion would be retained at the leaf bases for some time to percolate into the spaces between the leaf bases and affect the mealy-bugs present. By this method complete control of the mealy-bugs present in suckers has been achieved when approximately 0.05 per cent. malathion, .025 per cent. diazinon or .01 per cent. parathion emulsions were used for the dip treatment. The chlorinated hydrocarbon insecticides such as DDT, BHC, etc., even as high concentrate emulsions, gave poor control of the insects by this method.

(c) *The Control of Mealy-bugs on Plantation.* Formicides such as aldrin, dieldrin and chlordane sprayed around the bases of the plants have been found effective in controlling ant populations associated with mealy-bugs but no formicidal treatments have been tested so far with a view to eliminating entirely all ants from pineapple plantations. However the spray treatments found satisfactory in the control of field infestation of mealy-bugs on pineapple plants have also proved very effective in the control of the ant associates.

(c) *The Control of Mealy-bugs on Growing Pineapple Plants in the Field.* Mealy-bugs are located chiefly under and between the leaf bases of pineapple plants, extending from growing point to the butt. When colonies of bugs increase in numbers to a point where this region of the plant becomes overcrowded the bugs spread out to the roots, exposed parts of the leaves and various parts of the fruits, when present. Exposed colonies of bugs present on the plants are relatively easily controlled by direct contact sprays of organophosphorus insecticides. Colonies existing between the

leaf bases present some problems for their control, while those found in the roots and the sub-surface parts of the butts of the plants are most difficult to control. Tests have been carried out both in the laboratory and in the field where insecticides have been employed either as contact or as systemic sprays for the control of field infestations of this bug. Nearly complete control of the butt and leaf base colonies of the pest has been achieved by spraying the plants and especially the basal regions of the leaves with a 0.05 per cent. malathion, 0.025 per cent. diazinon or a .01 per cent. parathion spray in the emulsion form. The best results were achieved where the leaf bases were cleared of all debris and as much as possible of the butt region of the plant exposed after removal of the older dead leaves before spraying. Spraying was of the high volume type using a knapsack sprayer and spraying at the rate of at least 250 gallons of prepared spray per acre. Special care had to be taken to ensure that the spray liquid accumulated in small quantities at the leaf bases if complete control of the bug was to be achieved. Laboratory studies using the organophosphate insecticides malathion, diazinon, parathion, chlorothion, dipterex, ekatin and metasystox against leaf colonies of pineapple mealy-bugs have confirmed the efficacy of these insecticides as contact sprays against this pest. The two systemic insecticides ekatin and metasystox which show distinct systematic activity against plant sucking bugs on other crops had no activity whatsoever against the mealy-bugs on pineapple when tested for systemic action. Carter (1952) reported similar results with another systemic insecticide, systox.

Present Position relating to Pineapple Wilt Control in Ceylon. Although relatively effective measures are now available for the control of pineapple wilt, the average grower has not yet fully understood some of the most salient features of the causal basis of wilt and has therefore not implemented as he should a proper wilt control programme on his plantation. The prime concern of the grower should be the planting of mealy-bug-free suckers in all new plantings. It is much simpler to control mealy-bugs on suckers than to control them on growing plants in the field for the reason that in the latter condition mealy-bugs are frequently present in the lower regions of the butt of the plants or even the roots both of which are not easily accessible to attack by insecticidal sprays. When completely disinfested suckers have been planted in a new planting the grower should concentrate his attention to maintaining his new planting mealy-bug-free. This can only be achieved by routine observation of the planting for the presence of mealy-bugs, and the prompt spraying of every infested plant and also the neighbouring plants. More often than not however the grower considers spraying his crop only after wilt has developed in his plantation. Spraying at this stage generally gives poor results in wilt control as toxic levels of mealy-bug feeding have already occurred in many of the symptomless plants and in time wilt symptoms appear (as would theoretically be expected) in spite of the spraying. The grower is then disappointed with the results of the spraying. What the grower should concentrate on therefore is not the spraying of the crop when wilt appears but the control of mealy-bugs on his

crop as soon as they appear and thereby reduce the chances of feeding by these insects to toxic levels which would inevitably result in wilt. If timely spraying is carried out and even if early symptoms of wilt develop, the plants, particularly if young, should not be abandoned as lost because the complete control of the bugs coupled with heavy nitrogen fertilizer treatment will help greatly in the recovery of the plants.

Many growers have had the experience of finding pineapple plants heavily infested with mealy-bugs but not developing wilt. They have therefore hurriedly concluded that this observation invalidates the view that mealy-bugs are responsible for pineapple wilt. This may however be accounted for by the fact that (a) the plants are of low susceptibility to the mealy-bug toxin causing wilt, (b) the strain of the bugs involved may be of low toxic value so that a toxic dose of salivary secretion for the development of wilt does not build up in the plants, (c) the time required for the development of wilt symptoms after the first feeding by mealy-bugs may not have yet been passed.

The use of coconut fibre dust, available in large quantities particularly in the western province, as a heavy surface mulch on pineapple plantations has its advantages in that good weed control is achieved and ideal moisture levels are maintained at the base of the plants. This practice has however encouraged the heavy build-up of mealy-bug populations at the base of the plants protected by the mulch. This mulch also renders the basal infestations of mealy-bugs inaccessible to insecticidal sprays. If both the advantages of the mulch and wilt control are to be obtained the base of the plants should be kept clean

and the mulch should be reduced to a maximum of one-inch depth around the plants.

Mealy-bugs and Cacao Virus

Field Observations on Cacao Mealy-bugs. Three species of mealy-bugs are commonly found on cacao plants in Ceylon. These are *Pseudococcus lilacinus* (Cockerell), *Pseudococcus citri* (Risso) and *Ferrisia virgata* (Cockerell). While *P. lilacinus* is the dominant species of mealy-bug on cacao *P. citri* and *F. virgata* are to be found in much smaller numbers on this crop. *Pseudococcus lilacinus* and *P. citri* are to be found in particularly large infestations on pods when these are present and in smaller colonies or as individuals on leaves, stems, flower cushions and trunks of the plants. *Ferrisia virgata* is to be found chiefly on flower cushions and on stems.

All three species of mealy-bugs have powerful ant associations. *Pseudococcus lilacinus* and *P. citri* are most frequently associated with the large red ant, *Oecophylla smaragdina*. Other ants found in association with *P. lilacinus* are *Solenopsis nitens* Bingham, *Technomyrmex detroquens* Walker and *Odontomachus haematoda* L. These ants are responsible, to varying degrees, for the protection of the mealy-bugs against parasites and predators, the consumption of honeydew excreted by the bugs and the dissemination of mealy-bugs. Among the several species of ant associates of the mealy-bugs on cacao only *O. smaragdina* is entirely tree-nesting.

Of the various natural controlling factors of mealy-bugs of cacao in Ceylon, predatism by larvae of the Lycaenid

butterfly *Spalgis epius* and the Cocci-nellid beetle *Exochomus nigromaculatus* may be mentioned. Furthermore the abundance of mealy-bug populations on cacao has been observed to be seasonal. High populations of these insects are observed during prolonged spells of dry weather, with such populations dwindling with the rains.

Transmission of Cacao Virus by Mealy-bugs. The virus disease of cacao was first indentified by Pieris (1953). Carter (1956) in 1953 conducted studies on the insect transmission of the cacao virus in Ceylon. This worker obtained positive transmission of the disease with *P. lilacinus* and *P. citri* but was not able to obtain transmission of the disease by *F. virgata*. In view of the fact the *F. virgata* is known to transmit the cacao virus in the Gold Coast (Posnette 1947) intensive transmission experiments were pursued with this mealy-bug but no positive transmission was achieved although over 200 seedlings were used in the tests.

Relationship of Cacao Virus to Vein-flecking on Dadap. Pieris (1953) has described the virus-like symptoms observed on the leaves of dadap trees, *Erythrina lithosperma*, commonly grown for shade on cacao plantations and has suggested that this plant might be an alternate host of the local cacao virus. Insect transmission studies were therefore conducted with a view to investigating a possible relationship between the cacao virus and the vein-flecking symptoms on dadap leaves. Gravid females of *P. lilacinus*, *P. citri* and *F. virgata* were caged on cacao leaves showing virus symptoms and on dadap leaves showing vein flecking symptoms. After five days the crawlers which were obviously feeding upon the

leaves were carefully removed and used for infection feeding. Crawlers from the dadap leaves were introduced on to germinating cacao seeds as described by Posnette (1947) while the crawlers from the cacao leaves were introduced between the cotyledons of germinating dadap seeds where they settled down to feed around the plumule. Close observation of the plants grown from these seeds showed no development of any abnormal appearance in the leaves. It would appear therefore from these experiments that the cacao virus is not transmissible to dadap by the species of mealy-bugs known to transmit the disease among cacao plants and that the vein flecking symptoms observed on dadap leaves are not likely to be related to the cacao virus.

The Control of the Cacao Virus. Unlike the cacao virus of the Gold Coast no spectacular damage has been done to the cacao crop in Ceylon by the existing cacao virus disease. While the disease is noted to be spreading, this virus, as a single factor, cannot definitely be said to be either reducing the vigour of the plants or the yield of the crop. No serious effort has therefore been made to control the mealy-bug vectors of this virus disease. Attempts to control the spread of this disease by the insecticidal control of mealy-bugs in the Gold Coast, where some of the most potent modern systemic insecticides have been used have not yet proved successful. The control of mealy-bugs on cacao by controlling ant associations through simple barrier treatment on trunks of the infested trees will meet with little success in Ceylon on account of the tree-nesting habit of the predominant ant species, *Oecophylla smaragdina*. It is therefore fortunate that the strain of

cacao virus found in Ceylon at present is not a virulent one.

BIBLIOGRAPHY

- CARTER, WALTER, 1932. Border plantings as guard rows in pineapple mealy-bug control. *Jour. Econ. Ent.*, 25 (5) : 1027-1030.
- CARTER, WALTER, 1933. The pineapple mealy-bug, *Pseudococcus brevipes*, and wilt of pineapples. *Phytopath.*, 23 (3) : 207-242.
- CARTER, WALTER, 1933. The spotting of pineapple leaves caused *Pseudococcus brevipes*, the pineapple mealy-bug. *Phytopath.* 23 (3) : 243-259.
- CARTER, WALTER, 1937. The toxic dose of mealy-bug wilt of pineapple. *Phytopath.*, 27 (10) : 971-981.
- CARTER, WALTER, 1945a. Some etiological aspects of mealy-bug wilt. *Phytopath.*, 35 (5) : 305-315.
- CARTER, WALTER, 1945b. The influence of plant nutrition on susceptibility of pineapple plants to mealy-bugs wilt. *Phytopath.*, 35 (5) : 316-323.
- CARTER, WALTER, 1951. The feeding sequence of *Pseudococcus brevipes* (Ck.) in relation to mealy-bug wilt of pineapples in Hawaii. *Phytopath.*, 41 (9) 769-780.
- CARTER, WALTER, 1952. Organic phosphates and systemic insecticides on pineapple plants. *Jour Econ. Ent.*, 45 (6) : 981-984.
- CARTER, WALTER, 1956. Notes on some mealy-bugs (Coccidae) of economic importance in Ceylon. *Plant Protection Bull. F. A. O.* 4 (4) : 49-52.
- ILLINGWORTH, J. F., 1931. Preliminary report on evidence that mealy-bugs are an important factor in pineapple wilt. *Jour. Econ. Ent.*, 24 : 877-889.
- ITO, K., 1938. Studies on the life history of the pineapple mealy-bug, *Pseudococcus brevipes* (Ck.) *Jour. Econ. Ent.*, 31 (2) : 291-298.
- PIERIS, J. W. L., 1949. Cacao virus in Ceylon. *Ceylon Administration Reports of Department of Agriculture*, 1949, p. 44.
- PIERIS, J. W. L., 1953. A virus disease of cacao in Ceylon. *Tropical Agriculturist* (Ceylon), CIX (2) : 136-138.
- POSNETTE, A. F., 1947. The use of seeds in the insect transmission of some plant viruses. *Nature* 159 : 500-501.