Bunchy and malformed top of papaya cv. Eksotika caused by *Thrips parvispinus* and *Cladosporium oxysporum*  
(Penyakit berumpun dan berkerekot atas pada betik cv. Eksotika yang disebabkan oleh *Thrips parvispinus* dan *Cladosporium oxysporum*)

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Key words: bunchy and malformed top, papaya cv. Eksotika, *Thrips parvispinus*, *Cladosporium oxysporum*

Abstract

The cause of bunchy and malformed top of papaya cv. Eksotika, was investigated. Inoculation studies showed that *Thrips parvispinus* through their feeding (scraping and sucking) on young developing leaves provided the infection site (the damaged tissues) for invasion by the normally saprophytic fungus, *Cladosporium oxysporum*. The damaged leaf, on expansion, exhibited the typical malformed symptoms, characterized by shattered and distorted leaf spots/streaks and shot-holes on the lamina. Thrips, in the absence of *C. oxysporum* only caused slight mottling or streaking of the leaf without malformation, while *C. oxysporum* without thrips could not cause infection.

A field trial on chemical control showed that weekly fungicidal sprays of benomyl (0.05% a.i.) alternated with mancozeb (0.1% a.i.) provided very...
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good control of bunchy/malformed top while only limited control was obtained with insecticidal sprays (decamethrin 0.003% a.i. and methamidophos 0.1% a.i.).

Introduction
A previously unrecognized disease of papaya (cv. Eksotika) was first observed on nursery plants in MARDI, Serdang in late 1985. The disease was also observed in the field where more than 50% incidence was recorded. Plants showing the symptoms, viz. bunchy and malformed tops, were slow to recover, and had almost no yield if infection occurred before fruiting.

At a cursory glance, the symptom appeared similar to papaya mosaic virus disease which has not been reported in Malaysia thus far. Closer examination, however, revealed that the leaves did not exhibit the marked chlorosis and vein clearing of the crown leaves which are characteristic of papaya mosaic disease (Hine et al. 1965). Preliminary investigations to determine the possible cause of the bunchy and malformed top disease had implicated thrips (*Thrips parvispinus* Carney) as introduction of the thrips onto healthy plants reproduced the symptoms (Vijaysegaran, S., MARDI, Serdang, pers. comm. 1986) and insecticidal sprays on affected plants resulted in recovery (Vijaysegaran 1986).

Examination of diseased leaves consistently revealed the presence of a grey coloured mould associated with diseased lesions on the leaf. Attempts were made to identify the fungus and to investigate its role, if any, in the bunchy/malformed top syndrome. The research findings are reported in this paper.

Materials and methods

Isolation
Diseased plants in the field were examined and observed regularly for symptom development. Diseased leaves were taken to the laboratory and examined under the binocular microscope for fungal growth and sporulation. Infected leaf pieces were cut and surface sterilized in 10% Chlorox for 2 min and placed on sterile potato dextrose agar (PDA) plates. The colonies obtained after 1 week's incubation at 28 ± 2 °C were transferred to PDA test-tube slants and incubated for a week. The cultures were examined under the microscope to determine their identity and to ascertain their purity. Selected isolates were sent to the C.A.B. International Mycological Institute (CMI), Kew, England for identification.

Cultural and morphological characteristic
Colonies obtained from hyphal tips were used to study the cultural and morphological characteristics. The isolates were grown on PDA plates and incubated at 28 ± 2 °C for 10 days.

Pathogenicity
Isolate PY5 was selected for pathogenicity studies on 6-month-old papaya (cv. Eksotika) plants, planted in polybags. The treatments were as follows:

- T1: Thrips only
- T2: Thrips, followed 2 days later by *C. oxysporium* spray (PY5)
- T3: *C. oxysporum* (PY5) spray only
- T4: Control 1, sprayed weekly with decamethrin (0.003% a.i.)
- T5: Control 2, no insecticide spray

Each treatment had eight plants. After treatment the plants were kept in the nursery for observation. Thrips were collected from the field together with freshly opened flowers in which they were found. Only flowers with more than four thrips each were collected. Each flower was then tied to the leaf axil, adjacent to the apex of the plant (for treatments T1 and T2). When the apex was examined 2 days later, thrips were seen on the young leaves.
The C. ovspsorun spore suspension was prepared from 10-day-old cultures grown on PDA plates by brushing off spores from the surface with distilled water. Spore concentration was determined using a haemacytometer and diluted to ca. 10^7 spores/mL. A Desaga spray gun was used to spray-inoculate the leaves.

Two sets of control treatments were compared. In control 1, the plants were sprayed weekly for 2 months with decamethrin to control contaminant thrips while Control 2 was unsprayed.

The plants were observed daily for symptom development and recorded for:
- thrip damage on maturing leaves
- Cladosporium leaf spot on maturing leaves (the number of spots/leaf was counted)
- leaf blight (severe necrosis) on very young leaves (before expansion) and
- bunchy and malformed top

Diseased leaves were removed and reisolated for the pathogen, as described above. The young leaves at different stages of development were marked (with paint) on the petiole and its disease development was followed. The experiment was terminated after 2 months.

The experiment was repeated 3 months later using 3-month-old papaya plants. Some minor changes were made, viz. the plants were kept in 1.2 m x 0.6 m x 0.9 m plastic cages (one treatment of 10 plants/cage) and only Control 2 was used.

Chemical control
A 10-month-old papaya plot about 0.1 ha in MARDI Jalan Kebun was showing early signs of bunchy malformed top symptom. Because of the urgency of the problem, it was decided to use it as an observation plot (non-replicated) for chemical control of the disease: a proper replicated trial will be conducted later.

The treatments were:
S1 : Benomyl (0.05% a.i.) alternated weekly with mancozeb (0.1% a.i.)
S2 : Decamethrin (0.005% a.i.) alternated with methamidophos (0.1% a.i.)
S3 : Decamethrin (0.005% a.i.) alternated weekly with benomyl (0.05% a.i.)
S4 : Control

An 18-L knapsack sprayer was used. The plants were sprayed until run-off and extra effort was made to ensure that the developing leaves were thoroughly sprayed. Each treatment consisted of 30–50 plants. The treatment was continued for 2 months and the plants were observed weekly for bunchy and malformed top symptoms. Only plants showing severe bunchy and malformed top (Plate 1) were considered in the disease count.

Results and discussion
Isolation and identification
Examination of infected tissues revealed the presence of grey velvety mould on the lesions. Microscope examination of the grey mould showed a proliferation of spores belonging to the genus Cladosporium. Isolation from diseased leaf tissues consistently yielded the same fungus which sporulated readily in culture. Isolates sent to the C.A.B. International Mycological Institute (CMI), Kew, England, were identified by Dr D. W. Minter as Cladosporium ovspsorun Berk. & M. A. Curtis.

Cultural characteristics
Cladosporium ovspsorun is a slow growing fungus, attaining a diameter of 11 mm after 6 days growth on PDA medium at 28 ± 2 °C. The colony is effuse, dark grey, densely floccose and velvety, with smooth white margin. The reverse is dark grey with white margin. Conidiophores are straight or slightly flexuous, nodose, pale brown and smooth, up to 250 μ long. Conidia arise from terminal swellings, in
symptoms Bunchy and malformed top symptoms are found on both nursery plants (5–6 weeks old) as well as on mature plants in the field. A plant may be producing healthy leaves, and 'almost suddenly' the new flushes appear malformed with leaf spots and shot-holes (1–3 mm wide) in them (Plate 1). In severe cases, the leaf appears distorted and shattered, with some segments of the lamina missing (Plate 2). Frequently, the undeveloped young and tender leaf is completely blighted, leaving a stub of petiole behind (Plate 2). When the lamina is intact, the mature leaf becomes distorted with a number of necrotic spots, ranging from 1 mm to 3 mm in diameter. The spots later develop into shot-holes with necrotic yellow border. Short light yellow streaks (especially clear when seen against the light) are sometimes interspersed among the spots.
Table 1. Effects of thrips and/or *C. oxysporum* on 6-month-old papaya plants cv. Eksotika (Expt. 1)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plants with thrip damage (streaking/mottling) (%)</th>
<th>Cladosporium leaf spot severity (mean no. spot/leaf)</th>
<th>Plants with bunchy/malformed top (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrips only</td>
<td>100</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>Thrips and <em>C. oxysporum</em></td>
<td>100</td>
<td>62.0</td>
<td>100</td>
</tr>
<tr>
<td><em>C. oxysporum</em> only</td>
<td>0</td>
<td>4.3</td>
<td>0</td>
</tr>
<tr>
<td>Control 1 (Decis)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Control 2</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
</tr>
</tbody>
</table>

*Plants not enclosed in cage, eight plants/treatment*

Table 2. Effects of thrips and/or *C. oxysporum* on 3-month-old papaya plants cv. Eksotika (Expt. 2)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plants with thrip damage (streaking/mottling) (%)</th>
<th>Cladosporium leaf spot severity (mean no. spot/leaf)</th>
<th>Plants with bunchy/malformed top (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrips only</td>
<td>100</td>
<td>3.7</td>
<td>20</td>
</tr>
<tr>
<td>Thrips and <em>C. oxysporum</em></td>
<td>100</td>
<td>38.5</td>
<td>100</td>
</tr>
<tr>
<td><em>C. oxysporum</em> only</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Control 2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Plants enclosed in separate plastic cages, 10 plants/treatment.*

Translucent spots or streaks first appear on young leaves, during early development. Thrips have been observed on the undeveloped leaf and apex of the plant. As the leaf enlarges, the spots and malformation appear more evident and shot-holes later develop from the spots. The initial damage, therefore, first occurs on very young developing leaves although damage becomes apparent only after the leaf has enlarged. Once a leaf has matured, new infection does not occur. A grey mould is usually found growing on the affected tissue, especially on severely blighted young leaves.

**Pathogenicity**

The results from Experiment 1 and Experiment 2 showed conclusively that the bunchy and malformed top syndrome was due to the attack of thrips followed by infection of *C. oxysporum* on the young leaves (*Table 1* and *Table 2*). Examination of the affected leaves showed that two distinct types of primary symptoms could be distinguished:

- light mottling and streaking due to direct thrip damage (*Plate 3*)
- leaf-spotting and leaf-blight due to infection by *C. oxysporum* (*Plate 4*)

Plants inoculated with thrips alone only developed typical thrip damage symptom, viz. light mottling and streaking, without any severe malformation (*Table 1* and *Plate 3*). The thrips, while feeding on the young leaves, rasp and lacerate the leaf tissues (superficially) with their mouth-cone, and suck up the resulting chlorophyll and juices. Symptoms of mottling and streaking were evident as the young leaves enlarged, appearing about 4–5 days after the introduction of the thrips. The control plants and plants sprayed with *C. oxysporum* spores alone did not exhibit thrip damage symptom or leaf spot symptom; they remained normal and healthy. However, plants inoculated with both thrips and *C. oxysporum* spores (2 days later), showed both thrip damage...
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Plate 3. Typical light mottling and streaking caused by feeding by thrips (from plant inoculated with thrips only)

Plate 4. Cladosporium leaf spot symptoms on plant inoculated with both thrips and C. oxysporum spores (Note also the leaf malformation and shot-holes)

Plate 5. Very young leaf showing severe blight symptoms after inoculation with thrips and C. oxysporum

and severe leaf spot symptom on the developing leaves (Table 1 and Table 2). Chlorotic spots were evident on the young leaves 2–3 days after spore inoculation. These plants subsequently developed the typical bunchy and malformed top symptom 10 days later (Plate 4). Some young leaves, about 5 mm wide, were so severely blighted that only a short petiole eventually remained (Plate 5). Bunchy and malformed top, therefore, is a consequence of an initial attack of the young leaves by thrips, followed by infection by C. oxysporum resulting in distorted and stunted development of the expanding leaves.

Only the treatment with combined thrips and C. oxysporum resulted in bunchy and malformed top, while the control and either thrips or C. oxysporum alone were free from the symptom. However, the treatment with C. oxysporum only and Control 2 had very low levels of Cladosporium leaf spot symptoms, presumably due to the presence of contaminant thrips. This is confirmed in the repeat experiment (Experiment 2) done under enclosed conditions when the same two treatments were free from the disease (Table 2).

However, unlike Experiment 1, when all the plants inoculated with thrips only, remained healthy, 20% of the plants treated similarly in Experiment 2 developed bunchy/malformed top symptom. This was attributed to contaminant C. oxysporum spores.
originating from the detached female flowers used to provide the thrip population for the study. Close examination of the shrivelled convoluted stigma located at the tip of the ovary revealed the presence of sporulating grey mould confirmed to be *C. oxysporum* when examined under the microscope. Decaying petals also harboured the fungus. The humid condition in the enclosed space was especially favourable to the rapid colonization by the fungus.

**Chemical control**

The results of the observation made to evaluate fungicides and insecticides in the control of bunchy and malformed top are presented in Table 3.

Plants sprayed with benomyl/mancozeb gave the best control at 1 month after the start of the experiment, as all the new flushes that appeared were healthy, compared with the unsprayed control which showed 100% disease incidence (*Plate 6*). The insecticide

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*Plate 6. Complete recovery of papaya plants after spraying with benomyl alternated weekly with mancozeb (row on left). The row on the right is unsprayed control; note the severe bunchy malformed top symptom*

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plants with bunchy/malformed top (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benomyl (0.05% a.i.) alternated weekly with mancozeb (0.1% a.i)</td>
<td>0</td>
</tr>
<tr>
<td>Decamethrin (0.003% a.i.) alternated weekly with methamidophos (0.1% a.i.)</td>
<td>40</td>
</tr>
<tr>
<td>Decamethrin (0.03% a.i.) alternated weekly with benomyl (0.05% a.i.)</td>
<td>20</td>
</tr>
<tr>
<td>Control</td>
<td>100</td>
</tr>
</tbody>
</table>

*Based on 30–50 plants/treatment*
sprayed plants had 40% incidence while the insecticide-fungicide combination had 20% incidence. As it is merely an observation, it would be premature to draw definite conclusions from the results. It, however, indicates the importance of *C. oxysporum* in the disease complex, as fungicide alone was able to provide complete disease control; although the new flushes developed normally, signs of thrip damage were apparent on some leaves, indicated by light scattered streaking or motting on some parts of the leaf.

**Conclusion**
The foregoing study has shown that Bunchy and malformed top syndrome on papaya cv. Eksotika is a pest/disease complex, caused by feeding (scraping and sucking) of the young developing leaves by *Thrips parvispinus* followed immediately by infection of the damaged portions by *Cladosporium oxysporum*. Unequal infection and necrosis of the young leaf resulted in unequal expansion of the leaf, leading to malformation on the fully expanded leaf. Thrips by themselves are not serious pests, as their superficial feeding only caused light motting and streaking on the mature leaves, without marked leaf distortion. This was demonstrated in the inoculation experiments with thrips, and in the field experiment, where regular fungicidal sprays alone could completely control the bunchy malformed top disease. The use of insecticides alone was less effective in controlling the disease. Its use in controlling thrips, especially during flowering, is not encouraged as the thrips are believed to be pollinating agents as well; inadequate pollination in papaya may lead to premature fruit drop and reduced fruit size.

*Cladosporium oxysporum* is a common saprophytic fungus in the tropics, found usually on dead parts of leaves and stems of herbaceous and woody plants (Ellis 1971). In Malaysia, it has been associated with pod rot of soybean, leaf mould of rubber, flower mould of rose and branch die-back of cacao (Williams and Liu 1976). On papaya, a *Cladosporium* sp. has been associated with mould on leaves and petal decay (Johnston 1960), and leaf spot and fruit rot (Turner 1971), while *C. oxysporum* was associated with fruit anthracnose (Kueh 1974). Bunchy and malformed top of papaya cv. Eksotika, and the involvement of *C. oxysporum* as described here, has not been reported previously. Observations have indicated that the cultivar Eksotika was highly susceptible while the cultivars Subang and Sitiawan appeared to be tolerant. Further investigations should be done to evaluate cultivar susceptibility to this potentially serious disease.

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**References**

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