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Results of a survey of biological control agents of the coconut mite, Eriophyes guerreronis

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In recent years, the eriophyid mite, Eriophyes guerreronis, has become a serious pest in coconuts in the Caribbean, West Africa and South America. In contrast, in the Pacific and Indian Ocean areas, damage similar to that induced by E. guerreronis occurs only sporadically and is of no economic importance.

E. guerreronis feeds on the epidermis beneath floral bracts of the coconut and can cause severe distortion of the husk (Fig. 1) with consequent serious reduction in copra yields in some areas. Beneath the shelter of the bract, E. guerreronis is well protected from pesticide application so that biological agents well adapted to spread are favoured for control. Predators of E. guerreronis are known, but, being considerably larger, they are unlikely to penetrate beneath the tightly adpressed bracts (Mariau, 1977). Until now, no pathogens of coconut mites have been isolated. Indeed, only one microorganism, the fungus Hirsutella thompsonii, is definitely known to be pathogenic to the Eriophyidae. This fungus is, at present, under extensive trial in Florida to control the citrus rust mite, Phyllocoptruta oleivora (McCoy et al., 1975; McCoy and Selhime, 1974).

In this paper, the results of a preliminary survey to find biological control agents of E. guerreronis are presented. The survey focussed mainly on the Pacific and Indian Ocean areas in the hope of finding natural mortality factors of E. guerreronis, which were not prevalent in the badly affected regions elsewhere. Also, the results of pathogenicity tests with fungi discovered during the survey are given.

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Materials and Methods

Collection of Material

In response to a postal circular, coconuts bearing symptoms of mite damage were despatched from various localities to England by air.

Pathogenicity experiments

Fungi were isolated from mites on Sabouraud dextrose agar (Oxoid Ltd.) containing 100 µg/ml of streptomycin sulphate (Sigma Ltd). For pathogenicity experiments, H. thompsonii strains were cultured in flasks containing 100 ml of Sabouraud liquid media, agitated on a reciprocal shaker for 6 days at 20° ± 1°C. The resulting mycelial growth was blended for 1 minute immediately prior to spraying on to mites. For the other fungal species which, in contrast to H. thompsonii, sporulated well in agar culture, conidia were harvested and standardised using the methods of Hall (1976). For spraying, the bracts of infested coconuts were gently removed revealing the mite colonies beneath. Spores or mycelial fragments were sprayed briefly on to the colonies whereupon bracts were replaced and secured with rubber bands. Control mites were sprayed only with distilled water. Four to five nuts were used for each treatment. The nuts were held at 20° ± 1°C in perspex cages at high RH. Mite colonies were periodically examined for mortality and infection.

Results

As a result of the postal circular sent to localities in the Pacific and Indian Oceans, replies pertaining to the prevalence of mite-type damage were received from 18 localities:- Mauritius, Seychelles, Sri Lanka*, India, Thailand*, Indonesia*, Sarawak, Brunei, Sabah, Philippines*, New Britain (Papua New Guinea)*, Tonga, Gilbert & Ellice Islands. Solomon Islands*, New Hebrides*, New Caledonia*, Cook Islands*, and Tahiti*. Place names marked with an asterisk* indicate positive replies concerning the existence of nuts bearing symptoms of mite damage. All other replies were negative. However, since damage can be subtle and even pass unnoticed, it is felt that the negative replies should not be regarded as definitive.

Coconuts bearing symptoms of mite damage were received in good condition in England from the following localities in the Pacific and Indian Oceans:- Philippines, New Hebrides, New Guinea and Sri Lanka. Nuts were dispatched also from badly affected zones (Jamaica) and the Ivory Coast) for comparison and experimental purposes. The damaging mite, E. guerreronis was found only on nuts from Jamaica and the Ivory Coast. Nuts from the Pacific localities bore only mild symptoms, the causal agent being another eriophyid species, Colomerus novahebridensis which occupied the same feeding niche as E. guerreronis. The nuts from Sri Lanka were damaged more extensively though this was regarded as exceptional (Mahindapala, pers. comm.) and was apparently caused by an as yet underscribed species of Dolichotetranychus (Tenuipalpidae).

PATHOGENS

With the exception of the mites from Sri Lanka, which were all dead on arrival, both live and dead colonies of eriophyid mites were found beneath virtually all coconut bracts examined. The dead colonies fell into two categories: firstly, many dead colonies, like healthy specimens, were white in colour and bore no internal or external symptoms of fungal or bacterial disease. Preliminary examination of such mites under the electron microscope revealed no trace of virus-like particles. The cause of the death of such colonies remains unknown. Secondly, some dead colonies were in the mass, coloured brown and often, but not always, associated with fungi. These fungi were predominantly yeasts, actinomycetes and three Deuteromycetes, Acremonium curvulum, Fusarium moniliforme, var. Subglutinans and Hirsutella thompsonii, all of which are evidently ubiquitous (Table 1). H. thompsonii was also observed on Dolichotetranychus sp. from Sri Lanka. These fungi except the latter strain were isolated in pure culture on Sabouraud dextrose agar. All the H. thompsonii strains except the New Hebrides isolate, produced synnemata readily after 2-4 weeks incubation at 20°C on SDA (Table 2). Recently, Samson et al. (1979) have proposed a new variety of H. thompsonii (var. synnematosa), to accomodate synnematous strains.

The natural incidence of H. thompsonii was low (Table 3), but when present on a nut, the fungus had assumed epizootic proportions beneath the bracts of coconuts, except in the sample from the New Hebrides, where the disease was incipient.

Predators

Few predators were discovered on the samples. Many other non-eriophyid mites were present in the micro-environment of the bract and were thought to be mainly detritus feeders. However, on nuts from both the Ivory Coast and New Guinea, tarsonemids (Lupotarsonemus spp.) were observed feeding on the eggs and occasionally the adults of E. guerreronis and C. novahebridensis. The importance of these slow-moving predators, perhaps only twice as large as their prey, as natural control agencies is probably limited because thy exist in at least one area (Ivory Coast) where the eriophyid mite problem is serious and since they were only found on a small percentage of nuts, are not naturally widespread.

Fungal Pathogenicity Tests

One strain of F. moniliforme and one of A. curvulum, together with all the strains of H. thompsonii, were tested for pathogenicity to E. guerreronis on nuts imported from Jamaica. Also tested against E. guerreronis was a strain of Verticillium lecanii isolated from another eriophyid mite, Cecidophyopsis ribis on blackcurrants (Kanagaratnam et al., unpublished).

The method of testing pathogenicity was not totally satisfactory since nuts deteriorated rapidly after removal and replacement of bracts so that experiments could not be continued beyond 6 days at 20°C, because control mortality increased, usually by drowning in the exudate from the nut. Injection of fungal suspensions underneath the intact bract killed mites extremely rapidly. Artificial rearing of the mite in the laboratory would permit the development of a more sensitive mode of pathogenicity testing but this has not so far been accomplished.

All strains of H. thompsonii were pathogenic to E. guerreronis, killing mites after only two days (Table 4). Invading hyphae could be seen inside live mites mounted and cleared in Hoyer's fluid. The Ivory Coast strain killed mites most rapidly and sporulated most profusely both from particles of sprayed mycelium and on mite bodies. The strain of V. lecanii grew and sporulated profusely on mites in 3-4 days apparently killing them but, despite exhaustive searching, no live mite bearing internal fungal growth was discovered. In contrast dead mites, bore extensive internal hyphal growth of V. lecanii. F. moniliforme and A. curvulum grew and sporulated only on the nut surface and did not kill any mites (Table 4) and were

presumed to be saprophytic. Control mites remained generally healthy for up to 6 days and dead specimens were never associated with the fungi.

Discussion

Naturally occurring control agents of E. guerreronis found in this survey were restricted to the fungus, H. thompsonii and the predacious mites, Lupotarsonemus spp. In the samples of nuts received, the incidence of these agents was low, indicating that their spread is inefficient in nature. Furthermore, Lupotarsonemus spp. when present seemed to be having little impact on mite populations. However, H. thompsonii, once beneath the bract, where the relative humidity of the microclimate is high and thus favourable for fungal development, spread effectively within mite populations. It is possible that field applications of H. thompsonii may increase the incidence of disease amongst mites by establishing reservoirs of sporulating mycelium on the foliage and nuts from which spores may be carried, perhaps by itinerant mites and other insects to the bracts where the presence of the fungus would hopefully render nuts immune from damage. Spores of H. thompsonii cannot easily be mass-produced but mycelial fragments in a nutrient formulation can be sprayed instead which, under favourable conditions will grow and sporulate (McCoy et al 1975). Thus, active growth and sporulation of H. thompsonii in the field is a prerequisite to mite infection and a virulent strain which, like the Ivory Coast isolate, sporulates well on coconuts after application should be selected for field trials. It is possible that the strain of H. thompsonii currently under consideration for commercial production by Abbot Laboratories Inc. (McCoy, in press) may fulfil these requirements. Verticillium lecanii has only once been implicated as a pathogen of eriophyid mites by Massee (in Taylor, 1909). The strain of V. lecanii isolated from C. ribis is possibly pathogenic but further tests are required to confirm this.

Interestingly, in this survey, E. guerreronis was not found in samples received from the Pacific and Indian Ocean areas where mite-damage is almost non-existent. Instead, C. novahebridensis, which occupies the same feeding niche, seems to be widespread in the Pacific regions but causes little damage, which may be due to less toxic salival secretions. The spread of E. guerreronis-damage in the badly affected zone - South America, The Caribbean, West Africa - has been

extremely rapid (Mariau, 1977; Ortega et al 1965) and may yet spread to these unaffected areas in the Pacific. On the other hand, C. novahebridensis may effectively compete with E. guerreronis and would thus constitute a means of control. However, even if this were true, it is possible that the introduction of C. novahebridensis into a new (badly affected) locality may have unforeseen undesirable consequences and so cannot yet be seriously contemplated. Therefore, the most promising candidate for the biological control of E. guerreronis is H. thompsonii. Plans for field trials in Grenada and the Ivory Coast are under consideration.

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TABLE 1

Fungi associated with dead mites on coconuts
Champignons associés aux acariens morts sur noix de cocotier

Origin of nuts Origine des noix	Mite species Espèces d'acariens	Fungi found Champignons trouvés
Ivory Coast	E. guerreronis	Fusarium moniliforme, Acremoni curvulum, Hirsutella thompsoni Yeasts, Actinomycetes
Jamaica	E. guerreronis	F. moniliforme, A. curvulum, H. thompsonii, Yeasts, Actinomycetes
Philippines	C. novahebridensis	Yeasts, Actinomycetes
New Guinea	C. novahebridensis	H. thompsonii, Yeasts, Actinomycetes
New Hebrides	C. novahebridensis	H. thompsonii, A. curvulum, F. moniliforme, Yeasts, Actinomycetes
Sri Lanka	Dolichotetranychus sp.	H. thompsonii

Table 2

Synnemata production of *Hirsutella thompsonii* strains on Sabouraud dextrose agar

Production de Synnemata des souches de *Hirsutella thompsonii* sur le milieu de Sabouraud

Origin of strains Origine des souches	Quality of synnemata production Importance de la production de synnemata
Ivory Coast	sparse, thin, up to 15 cm long éparse, mince, supérieur à 15 cm de long
Jamaica	luxuriant, thin, up to 15 cm long Abondant, mince, supérieur à 15 cm de long
New Guinea	luxuriant, thick, up to 5 cm long Abondant, épais, supérieur à 5 cm de long
New Hebrides	none aucun
Sri Lanka	not isolated in culture non isolé en culture

Table 3

Natural incidence of *H. thompsonii* infection among mite-infested nuts

Incidence naturelle de l'infection de *H. thompsonii* sur les noix contaminées par des acariens.

Origin of nuts Origine des noix	Number of nuts received Nombre de noix reçues	% infested with *H. thompsonii* % contaminées par *H. thompsonii*
Ivory Coast	79	5
Jamaica	72	2
New Hebrides	30	3.3
New Guinea	7	14
Sri Lanka	3	30

Table 4

Pathogenicity* of fungi to E. guerreronis

Pathogénécité des champignons à l'égard de E. guerreronis

Experiment 1 1ª expérience

Species & origin / Espèces et origine	H. thompsonii (Ivory Coast)	H. thompsonii (Jamaica)	Control
Day after treatment. Nb de jours après traitement			
2	++	+	-
3	+++	++	(+)
4	++++	+++	+

Experiment 2 2ª expérience

Species & origin / Espèces et origine	H. thompsonii (Ivory Coast)	H. thompsonii (Jamaica)	H. thompsonii (New Hebrides)	H. thompsonii (New Guinea)	V. lecanii (England) 5.4×10^7 spores/ml	Control
Day after treatment. Nb de jours après traitement						
4	+++(+)	+++	++	++	+++	(+)
6	++++	++++	+++(+)	+++	++++	++

Experiment 3 3ª expérience

Species & origin / Espèces et origine	Fusarium moniliforme (Ivory Coast) 4.5×10^7 spores/ml	Acremonium curvulum (Ivory Coast) 9.8×10^7 spores/ml	Control
Day after treatment. Nb de jours après traitement			
5	-	-	-

* +, ++, +++, ++++: approximately 25, 50, 75 and 100% respectively of mite population killed

approximativement 25, 50, 75 et 100% de mortalité des populations d'acariens.

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