PESTS AND DISEASES OF SHADE TREES AND THEIR RELATION TO COCOA IN PAPUA NEW GUINEA

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ABSTRACT

In the 1950s, most of Papua New Guinea's cocoa was grown either under coconuts or a leguminous shade, Leucaena leucocephala *(Lam.). During the 1960s, increasing problems with pests of* Leuceana *transferring to the cocoa resulted in a gradual replacement of this shade with an alternative legume;* Gliricidia sepium *(Jacq.). Currently,* Gliricidia *is the preferred permanent shade for establishing cocoa where coconuts are not grown. Pests and other problems with* Gliricidia *are discussed and the recent problems with establishing high yielding hybrid coconuts as permanent shade are highlighted.*

***Key words**: Pod rot, vascular dieback, longicorns, mirids, pantorhytes, scolylids, shade management.*

INTRODUCTION

Cocoa (*Theobroma cacao* L.) is native to South America where it is found as an under-storey tree of dense tropical rain-forest (Wood 1985). It is therefore adapted to grow under heavy shade, but like any other plant, still requires adequate light for photosynthesis. German settlers in 1905, introduced cocoa into Papua New Guinea (PNG) all of which were the Trinitario type (Green 1938, Moxon 1983).

Interplanting of cocoa with coconut was established in the 1920s (Green 1938, Gorringe 1966). Shade trials in the early 1950s looked at the major potential shade types, of which *Leucaena leucocephala* (Lam.) de Wit, and *Cocos nucifera* (L.) were selected as agronomically the most satisfactory for local conditions (Byrne 1971).

Various problems relating to shade type, shade density, incidence of pests and diseases resulted in alternative shades such as *Gliricidia sepium* (Jacq.) to be considered, and these have been recently reviewed (Smith 1985).

Recommendations on shade requirements for cocoa were formulated, following Smith's 1985 review (Smith 1985, Moxon 1992 a). Coconut shade, particularly the high yielding hybrid variety was recommended as permanent shade for cocoa with *Gliricidia* as the temporary shade.

This review concentrates on the history of changes in shade species and touches on particular pests and diseases presently categorised to be of major economic importance in the cocoa industry within Papua New Guinea (Anon. 1992, Moxon 1992 a). Points are also raised on the present problems of shade density requirements and types of positive or negative associations within the shade, pest and disease complex. Reference is made to present pest and disease control recommendations which are diametrically opposed to each other (Bailey 1979, Smith 1981 a, Smith 1981 b, Moxon 1983).

HISTORY OF SHADE REPLACEMENT

The initial recommendation for a cocoa shade tree in the 1950s was *L. leucocephala* based on Green's work (1938). Problems of insect pests and to a lesser extent proliferating seed production (Urquhart 1961), which were difficult to eradicate, resulted in preference for the agronomically more suitable *G. sepium* in the Oro Province during the early 1970s (Baker 1972).

L. leucocephala has now been further reduced in priority as a shade for cocoa with the arrival in

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1986 of a South American Psyllid pest of *Leucaena*, *Heteropsylla cubana* Crawford (Hem: Psyllidae) (Moxon 1986, Arura 1989). Feeding of the psyllid on *Leucaena* can cause complete defoliation leading to death of the tree and has been observed to devastate shade in cocoa plantations. A predatory ladybird *Curinus coeruleus* (Muls.) (Col: Coccinellidae) was introduced and tested in quarantine for control of the Psyllid but not released due to its wide host preference (Moxon 1986).

A number of leguminous shade species were studied during the 1930s, particularly as temporary shade species (Green 1938, Byrne 1971). These include *Crotalaria anagyroides* Kunth; *Tephrosia candida* (Roxb.), *Tephrosia vogelii* Hook. and *Flemingia congesta* (Roxb.).

C. anagroides and the two *Tephrosia* species were susceptible to pink disease (Smith 1981 a). *F. congesta* was not recommended because it was found to be an alternative host of the mirid *Helpeltis clavifer* (Walker) (Hem: Miridae). It was also hard to remove after permanent shade was established. Other shades which were considered for permanent shade include species of *Albizia*, *Casuarina* and *Erythrina* (Henderson 1954, Smith 1985).

Gliricidia shade has been the recommended shade since 1980 in areas known to have outbreaks of pests feeding on *Leucaena* (Moxon 1983). However increasing high management costs in regulating such a vigorous growing species, resulted in *Gliricidia* being recommended only as a temporary shade for cocoa establishment, with coconut, as the permanent shade (Sitapai 1983).

In recommending coconuts, preference was given to high yielding hybrid varieties. The cross between the Malaysian Red Dwarf (MRD) and Rennel Island Tall (RIT) from the Solomon Islands was evaluated (Brook 1985).

A greater economic return per unit area could be obtained from this intercrop establishment (Sitapai 1983, Brook 1985). Catastrophic pest damage on the hybrid coconut particularly in the Islands Region by the indigenous Rhinoceros beetles, *Scapanes australis* (Boisd.) (Col: Dynastidae) and the Black Palm Weevils, *Rhynchophorus bilineatus* (Montrouzier) (Col: Curculionidae) has halted the distribution of this hybrid throughout Papua New Guinea and led to the closing of both government and commercial hybrid coconut production centres (Woruba 1987, Ovasuru 1990).The Black Palm Weevil usually enters the coconut via damage caused by rhinoceros beetles, either *S. australis* or *Oryctes rhinoceros*. *R. bilineatus* lays its eggs in the damaged tissue and its larvae destroy the apical region resulting in the death of the coconut. The initial approach to controlling the rhinoceros beetle pests involved routine checks and treatment with lindane (gamma BHC) granules to frond axils of young palms up to five years old (Smith 1981 a, Morin 1992).

A recent and more promising approach is the use of a pheromone identified for the black palm weevil.The compound is a 4-methyl-5 - hydroxynonane (Oehlschlager *et al.* 1992). After identification of the specific isomers involved in the compound, it may be possible to use it as a control measure as well as for monitoring the populations of *R. bilineatus*.

Due to the continuing pest problems on *Leucaena* and coconut the high management *Gliricidia* shade is now being used both as a temporary and permanent shade.

GENERAL SHADE REQUIREMENTS OF COCOA

Shade trees are required to act as a buffer against change in the cocoa canopy. This would act as a lateral protection, as a windbreak, and overhead shading to control the amount of solar radiation and humidity. Shade requirement usually diminishes as the cocoa tree grows older and forms an interlocking canopy. Both the shade trees and cover crop can be used to reduce competitive weeds and the latter, to reduce soil erosion (Wessel 1985). Shade trees also affect temperature and relative humidity around the plant which in turn affects transpiration (Wessel 1985).

Generally cocoa requires shade throughout its life but shade is more important in the first three to five years than when the trees are mature and achieve a closed canopy. Yield has been stated, to some extent, to be inversely proportional to shade density (Smith 1985). Charles (1961)

also showed that there was a clear negative correlation between yield and shade density.

Height of the shade tree and the distance between cocoa canopy with shade canopy has a strong influence on the type and severity of insect pests and incidence of diseases in a cocoa block in PNG (Smith 1985). Pest problems on cocoa are far fewer when cocoa is grown under the tall coconut shade than the relatively low *Leucaena* and *Gliricidia* shade trees, though the precise reasons for this are unknown. Urquhart (1961) also stated that there is no evidence of competition between cocoa and coconut when intercropped at optimum spacing.

PESTS AND DISEASES OF IMPORTANCE TO PNG COCOA

Over 300 insects species (Szent-Ivany 1961, 1963) and over 47 diseases (Shaw 1965) have been recorded on cocoa in Papua New Guinea. However, only about 10 pests (Moxon 1992 a) and 4 diseases (Anon.1992) can be categorised as important economically. Important pests include defoliating caterpillars (Table 1), Mirids, Trunk Longicorns, the cocoa web worm *Pansepta* and *Pantorhytes* (Table 3).The diseases include, Vascular Streak Dieback (VSD), *Phytopthora palmivora* (Pod rot, stem canker and seedling blight), Pink diseases (Table 3) and root diseases (Table 3).

MAJOR PESTS AND DISEASES OF SHADE TREES

The major pests of *Leucaena* are the *Leucaena* Psyllid, *H. cubana* (Moxon 1986, Arura 1989) (Table 2) and the defoliating caterpillar, *Tiracola plagiata* Walker (Lep. Noctuidae) (Catley 1962, Moxon 1992 a). Major pests of *Gliricidia* are the grey weevils of which only the biology, ecology and control of *Hypotactus ruralis* (Col: Curulionidae) is clearly understood (Moxon 1983, 1992 b). Major pests of coconuts are the Rhinoceros beetles and the Black Palm Weevils and on restricted localities *Sexava* and *Promocotheca* (Bedford 1976, Ismay & Dori 1985, Ovasuru 1990, Morin 1991 and Woruba 1987) (Table 2). Major disease outbreaks are not common on any of the shade species in Papua New Guinea (Table 1 & 2) though root rots such as *Phellinus noxius* can be an occasional local problem.

ASSOCIATIONS WITHIN THE INSECT, PATHOGEN AND SHADE COMPLEX

The fluctuation in the pest status of a number of the insects recorded and often not categorised as important, seems to have been partly influenced by the species of shade tree and the shade densities involved.

Mirids such as *H. clavifer* and *Pseudodoniella* spp. (Hem: Miridae) become a problem when there is inadequate shade (Smith 1981 a) (Table 3). Too much shade removal promotes water shoot production which increases mirid feeding.

H. clavifer and *Pantorhytes* are positively associated with cocoa grown under *Leucaena* or without shade but negatively associated with cocoa grown under coconut shade (Room & Smith 1975). It has been observed (Baker 1972, Moxon 1983) that the crazy ant *Anoplolepis longipes* (Jerdon) (Hym: Formicidae) and the arboreal kurakum ant *Oecophylla smaragdina* (F) (Hym: Formicidae) elimates *Pantorhytes* from the cocoa under coconut shade. Smith (1985) also refers to negative associations between ants and *H. clavifer*. Pantorhytes and mirids have remained the most important pest of cocoa since the 1950s (Szent-Ivany 1961, Moxon 1992 a).

Populations of crazy ants, *A. longipes*, are known to be unstable (Room & Smith 1975) but may persist longer arboreally due to the presence of honey producing homopterans such as mealybugs and scab insects often abundant on *Gliricidia* shade tree. Sometimes efficient tending of *Coccids* results in unusually high populations of mealybugs such as *Planococcus pacificus* (Hem: Pseudococcidae) which sometimes may be directly injurious to the cocoa tree and reduce photosynthesis from sooty mould (Lewis *et al.* 1976). The crazy ants then harass *Pantorhytes* and mirids on the cocoa tree. In some areas this beneficial association has been disturbed by improper use of insecticides. The Kurakum ant, *O. smaragdina* is negatively associated with the coconut *Amblypelta cocophaga*

Table 1. **A Lists of pests and diseases of major shade trees and of which cocoa is also a host.**

Shade Species	Pest / Disease spp.	Order: Family	Author
Leucaena sp.	**Pests**		
	Ectropis sabulosa Warrengren	Lep: Geometridae	Smee 1963
	Hyposidra talaca Walker	Lep: Geometridae	Smee 1963
	Tiracola plagiata Walker	Lep: Noctuidae	Catley 1962
	Ferrisia virgata (Cockerell)	Hem: Pseudococcidae	Szent-Ivany & Catley 1960
	Planococcus citri (Risso)	Hem: Pseudococcidae	Szent-Ivany 1956
	Neotermes papuana Desuus	Isop: Kalotermitidae	Moxon 1992 a
	Diseases		
	Phytophthora palmivora (Butler) Butler		Newhook & Jackson 1977
	Corticium salmonicolour Berkley & Broom		Shaw 1963
	Phellinus (*Formes*) *noxious* (Corner)		Thrower 1965
Gliricidia sp.	**Pests**		
	Ceroplastes chiton Green	Hem: Pseudococcidae	Shah 1976
	Neotermes sp.	Isop: Kalotermitidae	Smee 1963
	Hypotactus ruralis	Col: Curculionidae	Moxon 1992 a
	Paractus sp.	Col: Curculionidae	Moxon 1992 a
	Cyphopus sp.	Col: Curculionidae	Moxon 1992 a
	Oribius sp.	Col: Curculionidae	Moxon 1992 a
Cocos nucifera			
	Diseases		
	Phytopthora palmivora (Butler) Butler		Muthappa 1987
	Rigidoporus (Formes) lignosus		Shaw 1965

Table 2. **Major pests of recommended shade trees.**

Shade Species	Pest Species	Order: Family/Subfamily	Author
Leucaena leucocephala	*Heteropsylla cubana* (Crawford)	Hem: Psyllidae	Arura 1989
	Tiracola plagiata Walker	Lep: Noctuidae	Catley 1962
Gliricidia sepium	*Hypotactus ruralis (Fst.)*	Col: Curculionidae	Moxon 1992 a
Cocos nucifera	*Scapanes australis* (Boisduval)	Col: Dynastidae	Bedford 1976
	Oryctes rhinoceros Linnaeus	Col: Dynastidae	Bedford 1976
	Rynchophorus bilineatus (Montrouzier)	Col: Curculionidae	Morin 1991
	Sexava Wilemse	Orth: Tettigoniidae	Morin 1991
	Promecotheca papuana Csiki	Col: Hispinae	Ismay & Dori 1985

China which causes some degree of premature nutfall (Stapley 1971).

The establishment of cover crops such as *Pueraria* has been observed to improve the foraging of *Oceophylla* on coconut shade (Stapley 1971).

Outbreaks of the defoliating caterpillar *Tiracola plagiata* Walker (Lep: Noctuidae) (Catley 1962, Dun 1967) on cocoa in the Oro Province in blocks under *Leucaena* shade resulted in a shift to rubber, coconut, *Erythrina* and thin forest as shade. Consequently *T. plagiata* damage to cocoa decreased due to the reduced use of *Leucaena* as shade. *Achaea janata* (Lep: Noctuidae) (Room & Smith 1975) on the other hand increased as a result of *Leucaena* shade removal.

Cocoa planted under coconut, rubber and bush remain free from serious infestations of both *T. plagiata* and *A. janata* (Anon. 1968).

Glenea sp. (Col: Cerambycidae) becomes a problem when there is too much shade (Smith 1981 a) (Table 3). Heavy shade also results in growth of high jorquette on the seedling (Dennis & Keane 1992).

Grey weevil such as *Hypotactus ruralis* (Fst.) (Col: Curculionidae) retard growth and deform the growing point of young cocoa seedlings, and sometimes devastate young *Gliricidia* shade (Moxon 1992 b). Grey weevil pests are problems on cocoa throughout the country (Moxon 1983).

Pansepta teleturga Meyrick (Lep: Xylorictidae) is a problem when there is inadequate shading and becomes severe in areas of complete shade removal (Byrne 1971).

The giant termites *Neoterme* sp. (Isop: Kalotermitidae) build nests in stumps of cocoa and *Leucaena* shade trees from where a New Ireland species invades adjacent cocoa trees through the root system (Anon. 1965). The species *N. papuana* Desnus commonly invades through dead wood of cocoa tree where they tunnel into the green timber (Smith 1981, Moxon 1992 a).

Scolytid beetles have been associated with bark canker on cocoa in Papua New Guinea (Prior & Smith 1981). Thirteen species have been recorded in Papua New Guinea (Anon. 1983, Ismay & Dori 1985) of which the genera *Xyleborus* and *Xylosandrus* are most common. The presence of weeds or heavy shade may also increase the attack of the Scolytid beetles (Entwistle 1972). Weeds and cover crops however may sometimes act as a barrier to the flightless insects such as *Pantorhytes* and grey weevils.

Vascular Streak Dieback, Phytopthora Pod Rot (Ppr), Pink (bark) and root diseases (Table 1 & 2) are most damaging in overshaded conditions (Keane & Turner 1972, Thorold 1975, Dennis & Keane 1992).

General recommendations on the management of cocoa diseases include the use of light to moderate shade levels (Anon. 1992).

Light shade creates drier conditions which reduce the number of pods lost to Ppr and increases flowering. It also creates low humidity, increases aeration which simultaneously reduces sporulation of Ppr. The same light shade condition slows down and delays the onset of VSD disease epidemic and reduces spread and incidence of Pink disease (Anon. 1992, Dennis & Keane 1992) (Table 3). More light penetration into the canopy encourages vegetative growth which improves tolerance to VSD (Anon. 1992).

Pink disease can use both *Leucaena* and *Gliricidia* as alternative hosts (Anon. 1992).

Root diseases (Shaw 1965, Anon. 1992) invade dead shade stumps and most commonly provide the source of inoculum to adjacent cocoa trees via the root systems though aerial infection on stumps is also possible.

Generally, good management of shade in a cocoa block will reduce conditions suitable for disease spread and establishment (Anon .1992).

Shade types and density affect cocoa pollinators. Planted shade seems to be less favourable to pollinating midges than thin jungle. Bees are more frequently associated with cocoa flowers in the sun on the edge of blocks and midges prefer heavy shade (Young 1982).

COMPLETE SHADE REMOVAL AND SPACING

Complete shade removal may increase the cocoa yield (Charles 1961, Wessel 1985) and reduce some of the pests and diseases. However *Helopeltis*, *Pantorhytes* and *Pansepta* become serious problems (Entwistle 1972). In Malaysia, Lim (1978) reported that complete shade removal excepting around the block boundaries increases mirids, thrips and defoliators.

The yield increase is difficult to maintain over a long period because of the imbalance between available nutrients in the soil and the rate of photosynthesis (Charles 1961). Fertilizer input to maintain health and yield of the tree will be laborious and costly. Complete shade removal therefore shortens the economic life of the tree, creating a condition which causes premature decline in yield (Wessel 1985).

In Papua New Guinea yield differences between 17 and 30% were in favour of the unshaded plots, in October and September 1992 (Anon., in press). It is suggested that the difference may have been due to less Ppr in unshaded plots and competition for nutrient and light between the cocoa and shade trees in the shaded plots.

Spacing of cocoa and shade trees has also considerable influence on the effect of certain pests and diseases (Byrne 1971). The light environment of cocoa can be modified by the standard planting of shade trees especially coconuts in rows along an East-West direction for the maximum use of sunlight in the shaded condition (Jayasuriya 1987).

In the Papua New Guinea situation, it is essential that some shade should be used. Without shade weeds become a problem particularly if the canopy is not closed. Competition for nutrients with the weeds occurs and the grey weevil population will increase if grasses are established. More regrowth of water shoots attracts mirids and enables their number to increase rapidly.

Complete shade removal will result in a greater input into the management and control of pests and diseases, and shorten the economic life of a cocoa tree.

Table 3. **Shade density recommendations for the control of pests and diseases.**

Pest Species	Over-shade	Light-shade	No-shade	Author
TRUNK LONGICORNS				
Glenea aluensis Gahan	-	+	++	Smith 1983, 1981 a
Glenea elegans Oliver	-	+	++	Smith 1983, 1981 a
MIRIDS				
Helopeltis clavifer (Walker)	++	-	--	Smith 1981 a
Pseudodoniella laensis Miller	+	+	-	Smith 1981 a
Pseudodoniella pacifica China and Carvalho	+	+	-	Smith 1981 a
PANTORHYTES				
Pantorhytes sp.	++	--	-	Smith 1981 a
PANSEPTA				
Pansepta teleturga Meyrick	++	--	-	Byrne 1971
SCOLYTIDS				
Xyleborus sp.	-	+	++	Entwistle 1972
Xylosandrus sp.	-	++	+	Entwistle 1972
Diseases				
POD ROT				
Phtophora palmivora (Butler) Butler	--	++	+	Anon. 1992
VSD				
Oncobasidium theobromae Talbot & Keane	-	-+	+	Dennis & Keane 1992
PINK DISEASE				
Corticium salmonicolour Berkley & Broome	-	+	+	Anon. 1992

- Not recommended - problems will arise
-- Worse problems will arise
+ Recommended
++ Better than ideal

Present control measures of pests and diseases are conflicting. Recommendations for control of the mirid, *Pansepta*, *Pantorhytes* and sometimes Scolytid beetle borers are diametrically opposed to control of Longicorns, Ppr, Pink disease and VSD.

VSD is a problem when the shade is heavy and or nil shade which however will increase weed problem but on the other hand accelerates flowering. Pollinators prefer heavy shade as opposed to thin shade.

CONCLUSIONS

Establishment of light shade will simultaneously reduce incidence of Ppr, Pink disease and reduce and delay the onset of VSD disease epidemics. It will also reduce Longicorn and scolytid beetle populations. Light shade however will simultaneously encourage the build up of populations of *H. clavifer*, *A. janata*, *Pantorhytes* and *Pansepta*.

Leucaena shade is a host for *Pantorhytes*, three species of defoliating caterpillars, and is an alternate host of Pink disease, root rots and termites. *Leucaena* produces many seeds which readily germinate and are difficult to eradicate. The recent arrival of the *Leucaena* psyllid which severely damages and can kill the trees, further reduces its value as a shade.

Gliricidia is a vigorous growing plant that requires regular pruning with high management costs. In the young, i.e, establishment phase *Gliricidia* is attractive to adult grey weevil, termites and is an alternative host of Pink disease. However it harbours homopterans that provide a food source for the Crazy ant which has been beneficial against important cocoa pests such as mirids and *Pantorhytes*.

Coconut shade, particularly the hybrid variety gives more return per unit area when intercropped with cocoa and as a tall shade produces conditions unsuitable for a number of cocoa pests and diseases.

Complete shade removal, although causing a temporary increase in yield, is not an ideal long term economic practice. A greater input is also required in managing and controlling disease and pest problems.

The predatory ant, *Oecophylla* favours coconuts for establishing its leaf nests and affects beneficially both cocoa and coconut pests. Severe damage by rhinoceros beetles and Black Palm Weevils on coconut shade has halted continued planting and distribution of hybrid coconut seedlings to farmers. A coconut breeding programme is currently engaged in producing and evaluating superior coconut hybrids from local materials. These materials may have some degree of resistance or tolerance to the indigenous *Scapanes* and *Rhynchophorus* beetles. Some farmers are therefore using *Gliricidia* as temporary and permanent shade while some are using existing local tall coconuts as permanent shade.

To simultaneously control major pests and diseases, critical shade levels will have to be established, with a consideration of agronomic factors as well as other aspects of the cocoa ecosystem, and farming practices.

In Papua New Guinea, this has led to conflicting recommendations which are further complicated by the range of environments under which cocoa is grown with local fauna of pests and diseases. However coconut would appear to be the most acceptable permanent shade with *Gliricidia* as a temporary shade. Loss and damage to coconuts, both hybrid and local talls by debilitating rhinoceros beetles and Black Palm Weevils remains a serious constraints in areas where beetle damage is high. Until effective control measure for the beetles are developed, coconuts, particularly the high yielding variety, cannot be recommended as a permanent shade for many areas of Papua New Guinea.

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