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ABSTRACTS

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J. S. Brown. *Papua New Guin. agric. J.*, 26(2, 3 & 4) :31-42 (1975)

Examination of coconut leaf spot collections from high and from low rainfall areas in Papua New Guinea showed that *Drechslera incurvata* and *Pestalotiopsis palmarum* were the two species most commonly found sporulating on the leaf spots considered in this study, the former being the most common species on young spots. There were twice as many non-sporulating spots on collections from low rainfall areas as on a collection from a high rainfall area. *P. palmarum* was the species most commonly isolated from surface-sterilized non-sporulating spots from low rainfall collections, being isolated five times more frequently than *D. incurvata.*

Inoculation tests showed that *D. incurvata* was pathogenic to young leaves of coconut seedlings, infecting the host via stomata on the abaxial leaf surface and producing spots comparable with young non-sporulating spots observed on field collections. *P. palmarum* was not able to infect uninjured coconut seedling leaves but was able to colonize *D. incurvata* spots and was responsible, at least in part, for changes in the size and appearance of *D. incurvata* spots.

Fourteen seed sources were tested in the field for their reaction to *Drechslera* leaf spot. Reactions were variable within any one seed source. Rennell, Buka, Karkar and Madang seed sources were scored as the most susceptible and Ralabang (dwarf), New Hebrides and Kieta as the most resistant. Evidence is presented which suggests that the susceptibility of young coconut palms to *Drechslera* leaf spot decreases with age.

LEAF SPOT OF COCONUTS

J. Sumbak. *Papua New Guin. agric. J.*, 26(2, 3 & 4) :43 (1975)

In trial sowings in the Markham Valley, the variety Karkar was found to be much more susceptible, as assessed by amount of leaf affected, to *Drechslera incurvata*, than the Markham and Rennell Island varieties and several dwarf by tall hybrids.

INVESTIGATION OF SOME COCONUT LEAF SPOTS IN PAPUA NEW GUINEA

J. S. BROWN*

ABSTRACT

Examination of coconut leaf spot collections from high and from low rainfall areas in Papua New Guinea showed that Drechslera incurvata *and* Pestalotiopsis palmarum *were the two species most commonly found sporulating on the leaf spots considered in this study, the former being the most common species on young spots. There were twice as many non-sporulating spots on collections from low rainfall areas as on a collection from a high rainfall area.* P. palmarum *was the species most commonly isolated from surface-sterilized non-sporulating spots from low rainfall collections, being isolated five times more frequently than* D. incurvata.

Inoculation tests showed that D. incurvata *was pathogenic to young leaves of coconut seedlings, infecting the host via stomata on the abaxial leaf surface and producing spots comparable with young non-sporulating spots observed on field collections.* P. palmarum *was not able to infect uninjured coconut seedling leaves but was able to colonize* D. incurvata *spots and was responsible, at least in part, for changes in the size and appearance of* D. incurvata *spots.*

Fourteen seed sources were tested in the field for their reaction to Drechslera *leaf spot. Reactions were variable within any one seed source. Rennell, Buka, Karkar and Madang seed sources were scored as the most susceptible and Ralabang (dwarf), New Hebrides and Kieta as the most resistant. Evidence is presented which suggests that the susceptibility of young coconut palms to* Drechslera *leaf spot decreases with age.*

INTRODUCTION

Leaf spots said to be caused by *Pestalotiopsis palmarum* (Cooke) Steyaert have been recorded from all the coconut growing areas of the world. Most authors agree that they are relatively unimportant in plantations, occurring chiefly on older leaves (Martyn 1949; del Rosario 1967) and associated with unsatisfactory cultural conditions (Park 1930) such as when young palms are overgrown with weeds (McPaul 1962) or are growing in humid conditions caused by interplanting with other crops (Zimmer 1918; Martyn 1949). *P. palmarum* leaf spots are also reported to be manifest under poor conditions of fertility (De Mel 1927; Anon. 1958).

There have been reports of *P. palmarum* leaf spots causing considerable damage in isolated instances. Thompson (1924) reported that *P. palmarum* practically wiped out a small plantation of one-year-old dwarf coconuts in Malaya; Van Hall (1924), Hubert (1957), Orion (1959) and Briolle (1968) warned that *P. palmarum* can cause considerable damage in nurseries or to newly transplanted seedlings.

Drechslera incurvata (Ch. Bernard) M. B. Ellis has been recorded on coconut leaf spots from the British Solomon Islands, Fiji, French Polynesia, Malaysia, New Caledonia, New Hebrides, Papua New Guinea, Philippines, Sri Lanka, Vietnam and Thailand, as well as from Jamaica and Seychelles (Ellis and Holliday 1972). It has been reported as being associated with a severe leaf spot of young coconut palms (Wiltshire 1956; Williams 1966; Era and Celino 1972). In Sri Lanka, *D. incurvata* leaf spot was commonly found on palms growing under poor conditions, such as on unmanured and heavily intercropped lands (Kirthisinghe 1961) and in waterlogged conditions (Anon. 1966).

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Copeland (1931) considered *P. palmarum* to be parasitic on the leaves of coconut palms and that *D. incurvata* follows *P. palmarum* and contributes to the injury. Later authors (Briton-Jones 1940; Martyn 1945), however, considered *P. palmarum* to be an early scavenger, attaching only weakened tissue. The latter view is supported by various workers (Bertus 1927; Cortez 1928; Chowdhury 1946; Sivaprakasam *et al.* 1969; Sasikala and Wilson 1971) who reported inoculation studies in which it was shown that *P. palmarum* was able to infect coconut leaves only through wounds. Stevens (1932) reported that *P. palmarum* infection was frequently centered around a wound due to oviposition of the leaf-miner *Promecotheca cumingii* Baly. Era and Celino (1972) reported pathogenicity tests in which it was shown that *D. incurvata* was pathogenic to young coconut leaves.

Coconut leaf spots can cause serious damage on young palms in some high rainfall areas of Papua New Guinea (Dr Dorothy E. Shaw, pers. comm.). Sumbak (1971) reported severe *Drechslera* leaf spot damage in coconut seedling establishment trials on the Gazelle Peninsula of New Britain, Papua New Guinea. The present work was carried out in order to determine the organisms causing leaf spots in some areas of Papua New Guinea and to obtain information on the role of some other fungi commonly found associated with the leaf spots. Observations were also carried out on 14 different seed sources to determine their field reaction to *Drechslera* leaf spot. The work was carried out at the Konedobu Plant Pathology Laboratories and at the Laloki Plant Introduction Station, both of which are, unfortunately, in a low rainfall area of Papua.

MATERIALS AND METHODS

Examination of leaf spot collections

The fungi sporulating, and the type of spots on which they occurred, were recorded for nine field collections from two low rainfall areas, Laloki and Kapogere, in Papua and for one field collection from a high rainfall area, Keravat, in the New Guinea Islands. A number of leaflets from each collection were selected at random and each spot on the leaflet examined. Non-sporulating spots, together with about a millimetre border of healthy-looking tissue, from the Papuan collections were surface-sterilized for 30 seconds in mercuric chloride (1:1000 w/v), followed by washing in sterile water, or for three minutes in 0.35 per cent sodium hypochlorite, and cultured on potato dextrose agar (P.D.A.) and the fungi isolated recorded. The collections examined were as follows: PNG 8271, P. Hicks, Keravat, 5.IX.72; PNG 8838 and 8839, D. Shaw and J. Brown, Kapogere, 14.III.74; PNG 9275, 9276, 9277, 9278, 9279, 9280, J. Brown, Laloki, 18.III.74.

Inoculations

Seedlings for inoculations were obtained, as germinated nuts, from various unspecified seed sources growing at the Kapogere Agricultural Station, Papua, and were grown adjacent to the Konedobu Laboratories. They were subject to ambient environmental conditions plus two waterings on the soil per week during the dry season. Inoculations were confined to the four youngest leaves of four to twelve months old seedlings.

The fungi used for inoculations were isolated from coconut leaf spot specimens from localities within Papua New Guinea and were as follows: *Drechslera incurvata* (Ch. Bernard) M. B. Ellis, PNG 7781a; *Pestalotiopsis palmarum* (Cooke) Steyaert, PNG 7672b (IMI 186023); and *Chaetophoma* sp., PNG 7645d (IMI 159357). Inoculum was bulked on P.D.A. for *P. palmarum* and *Chaetophoma* sp. and on autoclaved *Axonopus compressus* (Sw.) Beauv. leaves for *D. incurvata* and was used when about two weeks old. Germination of spores was checked in sterile water and on P.D.A. prior to inoculations and was greater than 85 per cent on all occasions.

Inoculations were effected by spraying spore suspensions in de-ionized water onto both leaf surfaces (unless otherwise indicated) with an "Atomist" or a "National Jet-Pak" atomizer. Leaves were covered with plastic bags for 48 hours following inoculation to maintain a high humidity. De-ionized water and unsprayed controls were included in each inoculation. The number of inoculations for each experiment are given in the tables of results.

In experiments involving inoculation of *P. palmarum* onto *D. incurvata* spots two procedures were followed. The first involved spraying leaves previously inoculated with *D. incurvata* with *P. palmarum* inoculum; separate *D. incurvata* inoculated leaves being sprayed with de-ionized water for controls. The other

procedure involved spraying one longitudinal half of the leaf with de-ionized water and then covering with a folded cardboard sheet before spraying *P. palmarum* inoculum onto the other half of the leaf. The latter procedure was to enable detection, by comparison of both halves of the leaf, of any change in spots following *P. palmarum* inoculation. Preliminary tests involving spraying with dyes showed that with the "National Jet-Pak" one half of the leaf could be sprayed without contaminating the other, but the cardboard was used as an additional precaution. *P. palmarum* was inoculated onto *D. incurvata* spots on five separate occasions, the intervals between inoculation with the two fungi being 26, 31, 32, 42 and 69 days.

Re-isolations

Re-isolations were made from non-sporulating spots, plus about a one millimetre border of healthy-looking tissue, two to three weeks after inoculation. The leaf pieces were surface-sterilized, by either of the two procedures used for spots from field collections, and cultured on P.D.A.

Stomata count

To determine the concentration of stomata on each leaf surface, five leaflets were selected at random from the test seedlings, cut into one centimetre squares and cleared in 95 per cent ethanol and glacial acetic acid (50:50 v/v). One hundred squares were mounted in glycerol, half with the abaxial surface uppermost and half with the adaxial surface uppermost, and the number of stomata in a 0.25 mm^2 area counted. The procedure was repeated on two separate occasions.

Behaviour of germinated D. incurvata *spores on the leaf surface*

The behaviour of germinated *D. incurvata* spores on the leaf surface was determined by removing 10 mm x 5 mm sections of leaf three days after inoculation, clearing by the method used for stomata count and staining by gentle heating in lactophenol cotton blue. The leaf pieces were mounted in clear lactophenol and germinated *D. incurvata* spores on the surface examined.

Reaction of different seed sources to Drechslera *leaf spot*

One hundred and thirty-one young palms, from 14 different seed sources, growing at the Laloki Plant Introduction Station, Papua, were included in this trial. Seed nuts for the trial came from palms growing in an agronomy seed source trial at Kapogere and were planted at Laloki, by the Chief Agronomist, as a germination trial in June 1972. The original seed sources came from outside and from within Papua New Guinea and were as follows:

New Hebrides—a sample representative of commercial plantations in the New Hebrides, collected from the I.R.H.O. Station at Santo;

Solomon Islands—Local—a sample from the local variety grown by Levers Pacific Plantations Pty Ltd in the Russell Islands, British Solomon Islands Protectorate;

Solomon Islands—F.M.S.—descended from seed introduced to the Russell Islands from the Federated Malay States; as it is two generations removed from the original introduction some interbreeding with local palms may have occurred;

Rennell—a representative sample from Rennell Island, British Solomon Islands Protectorate;

Singapore—a random sample of nuts from village groves in Singapore;

Markham—a random sample from a Markham Valley, Papua New Guinea, plantation;

Kieta—a random sample from village groves near Kieta, Bougainville, Papua New Guinea;

Buka—a random sample from Buka Island, north of Bougainville;

Karkar—a random sample from a block on Karkar Island, near Madang, Papua New Guinea;

Madang—a random sample from a plantation near Madang;

Luburua—a random sample from Luburua Plantation, New Ireland, Papua New Guinea;

Ulaveo—a random sample from Ulaveo Plantation, Gazelle Peninsula, New Britain, Papua New Guinea;

Natava—a random sample from Natava Plantation, Gazelle Peninsula;

Ralabang—dwarf nuts from Ralabang Plantation, New Britain, grown from Malay Dwarf seed introduced from Fiji.

The seed nuts for this trial were designated by the female parent. As coconuts are usually out-pollinated, except for dwarfs which are largely self-pollinated (Menon and Pandalai 1958), the male parent was unknown, except for the dwarf variety Ralabang, but as parents were in 12-palm plots (4 x 3) there was a probability that male parentage would, in some cases, have come from another palm of the same seed source in the same plot. Thus seed nuts for this trial had 50 per cent of their genotype contributed by the female parent and the male contribution could have been 0 or 50 per cent from the same seed source and 50 or 0 per cent from other seed sources.

To provide a source of inoculum, 12 young palms infected with *D. incurvata* were interplanted with the test palms on May 30, 1973, 11 months after the seed nuts were planted at Laloki. The first spots were noted on the test seedlings one month later.

A measure of the susceptibility of the test palms to *Drechslera* leaf spot was obtained by counting the number of spots under a 5 cm x 20 cm piece of clear plastic placed about the centre of the leaf and parallel to the midrib. One count was made on each side of the midrib and the two counts averaged to give a final count of spots per 100 cm^2 for each seedling. This measure is hereafter referred to as the 'spot count'. Spot counts were made on the second fully unfurled leaf, counting from the youngest, 13 (July 23, 1973), 17 (November 15, 1973) and 21 (March 11, 1974) months after the seed nuts were planted at Laloki.

Rainfall at Laloki during the period of the trial averaged 39.8 mm per month between June 1 and October 31, 1973, and 227.0 mm per month between November 1, 1973, and March 31, 1974. During the dry period (June to November) sprinkler irrigation was applied to the trial area for up to four hours on two to five afternoons per week. Wind directions recorded at Jackson's Airport, Port Moresby, 12 km from Laloki, by the National Meteorological Service, were as follows: June to October 1973, south-east; November 1973, variable; December 1973 to March 1974, north-west to south-west.

RESULTS AND DISCUSSION

Examination of leaf spot collections

A comparison of the fungi sporulating and the number of spots on which they occurred on coconut leaf spot collections from low and from high rainfall areas is given in *Table* 1. On the low rainfall collections the majority (85.7 per cent) of the spots were uniform brown and less than 6.0 mm long by 5.0 mm wide, while a further 5.3 per cent of the spots were slightly larger and had a pale brown centre. The remaining 9.0 per cent were grey necrotic spots with or without a brown border. This contrasted with spots on the collection from the high rainfall area where there were fewer spots (only 32.5 per cent) in the first category and many more in the second and third categories (33.8 and 33.7 per cent, respectively). There were twice as many non-sporulating spots on the low rainfall collections as on the high rainfall collection (84.7 and 48.1 per cent, respectively). Thus it would appear that development of leaf spotting is favoured by high rainfall as there were many more sporulating spots and a greater proportion of the spots in the larger size categories on a collection from a high rainfall area than on collections from low rainfall areas.

Pestalotiopsis spp. (mainly *P. palmarum*) and *D. incurvata* were the fungi most commonly found sporulating on the spots (*Table* 1). The former was sporulating on 36.3 per cent and the latter on 30.0 per cent of the spots on the high rainfall collection, and on the low rainfall collection the two species were sporulating on 9.84 and 8.04 per cent of the spots, respectively. It can be seen from *Table* 1 that in both rainfall regimes *D. incurvata* was encountered more frequently than *Pestalotiopsis* spp. on young spots but on older spots *Pestalotiopsis* spp. were the more common. When *D. incurvata* and *Pestalotiopsis* spp. were found together on the same spots, *D. incurvata* conidiophores had commonly finished shedding spores before *Pestalotiopsis* spp. acervuli had ruptured the epidermis. Young spots on which *D. incurvata* and *Pestalotiopsis* spp. sporulated were commonly larger on the high rainfall collection than on the low rainfall collections.

Table 1.—Summary of the fungi sporulating and the number of leaf spots on which they occurred on nine field collections from two low rainfall areas and on one collection from a high rainfall area

Fungi* sporulating	Rainfall	Spots dark brown, uniform or with concentric bands, up to 6 x 5 mm		Spots pale brown centre, wide dark brown margin up to 10 x 8 mm		Spots grey centre, dark brown margin, up to 12 x 10 mm		Spots uniform grey, up to 15 x 12 mm		Total No. of spots with each combination	Total % of spots		
		No. of spots	% of total	No. of spots	% of total	No. of spots	% of total	No. of spots	% of total		With each combination	With D	With P
Nil	low	1882	82.8	44	1.9					1926	84.7		
	high	51	31.9	26	16.3					77	48.1		
D alone	low	18	0.8	21	0.9	28	1.2	9	0.4	76	3.4		
	high	1	0.6	13	8.1	9	5.5	1	0.6	24	15.0		
D + P	low			8	0.4	66	2.9	24	1.1	98	4.3		
	high			8	5.0	3	1.9	6	3.8	17	10.6		
D + P + C	low							1	0.04	1	0.04	8.04	
	high							1	0.6	1	0.6	30.0	
D + P + Ph	low												
	high							6	3.8	6	3.8		
D + P + S	low							7	0.3	7	0.3		9.84
	high												36.3
P alone	low	9	0.4	42	1.8	30	1.3	24	1.1	105	4.6		
	high			6	3.8	15	9.4	7	4.3	28	17.5		
P + C	low							3	0.1	3	0.1		
	high												
P + Ph	low							12	0.5	12	0.5		
	high					3	1.9	3	1.9	6	3.8		
C alone	low	40	1.8	6	0.3					46	2.0		
	high			1	0.6					1	0.6		
	low	1949	85.7	121	5.3	124	5.5	80	3.5	2274	100.0		
	high	52	32.5	54	33.8	30	18.7	24	15.0	160	100.0		

*D = *Drechslera incurvata*
P = *Pestalotiopsis* spp., mainly *P. palmarum*
C = *Chaetophoma* sp.
Ph = *Phyllosticta* sp.
S = *Sporidesmium sp.*

The other species sporulating on young spots, *Chaetophoma* sp., was recorded alone on 2.0 per cent of the spots, all of which were young, and together with other fungi on 0.14 per cent of the spots, all of which were old, on the collections from the low rainfall areas. Comparable figures for the high rainfall collection were 0.6 and 0.6 per cent, respectively (*Table* 1). *Chaetophoma* sp., however, was recorded on only one of the nine collections from the low rainfall areas, but was noted on 30 per cent of all coconut leaf spot collections examined by the author over a three-year period.

The other fungi recorded on the collections considered here were *Phyllosticta* sp. and *Sporidesmium* sp. and occurred in association with *Pestalotiopsis* spp. or *D. incurvata* on 1.2 per cent of all spots examined, all of which were old. *Phyllosticta* sp. occurred on 7.6 per cent of spots on the high rainfall collection and on 0.5 per cent of spots on the low rainfall collections. *Sporidesmium* sp. was found on only 0.3 per cent of spots on the low rainfall collections and not on the high rainfall collection. These findings suggest that *Sporidesmium* sp. and *Phyllosticta* sp. are secondary invaders growing saprophytically on the dead tissue and that high rainfall allows growth of these fungi on the leaf spots.

The fungi isolated from surface-sterilized non-sporulating spots from the nine collections from low rainfall areas are listed in *Table* 2. *P. palmarum* and *D. incurvata* were the species most commonly isolated, being 43.0 and 8.0 per cent, respectively, of the colonies isolated, while *Chaetophoma* sp. was only 1.2 per cent of the colonies isolated. Examination of the fungi sporulating on field collections suggested that *D. incurvata* was the primary pathogen and that *P. palmarum* was an early secondary invader, although the results of these isolations suggested that *P. palmarum* was possibly a primary pathogen. The occurrence of *Chaetophoma* sp. on twice as many young spots as *D. incurvata* and four times as many young spots as *P. palmarum* on the low rainfall collections suggested that this species may also be a primary pathogen in some localities.

Inoculation and associated studies

Of the three fungi tested *D. incurvata* was the only one able to infect young leaves of coconut seedlings (*Table* 3). Four days after inoculation a chlorotic spot 2.0 mm in diameter with a 0.5 mm light brown centre appeared. This enlarged to a spot 1.0-2.5 mm in diameter with a yellow area 1.0-2.0 mm wide external to the spot. The spot was composed of concentric rings, i.e., a light brown centre surrounded by alternating dark and light brown rings and with an orange-brown margin. Further development of the spots involved an increase in size to 4.0-8.0 mm long by 2.0-5.0 mm wide, with most spots being at the lower end of the range. The concentric rings persisted for up to six weeks, after which they became indistinct, the pale centre merging into a darker outer area. The yellow area external to the spots persisted. *D. incurvata* was re-isolated from the spots (*Table* 3).

The spots that developed following inoculation with *D. incurvata* resemble young leaf

Table 2.—Fungi isolated from surface-sterilized non-sporulating spots from nine field collections from two low rainfall areas

Species isolated	No. of colonies arising from 100 spots	Isolation frequency
Pestalotiopsis palmarum (Cooke) Steyaert	37	43.0
Drechslera incurvata (Ch. Bernard) M. B. Ellis	7	8.0
Botryodiplodia theobromae Pat.	5	5.8
Pestalotiopsis theae (Saw.) Steyaert	4	4.7
Colletotrichum sp.	2	2.3
Chaetophoma sp.	1	1.2
Curvularia sp.	1	1.2
Rhizoctonia solani type mycelium	1	1.2
Unidentified species (at least 7 different types)	28	32.6

Table 3.—Results of inoculating *D. incurvata*, *P. palmarum* and *Chaetophoma* sp. individually and together in pairs

Inoculant	No. of inoculations	No. of leaves		Re-isolation from spots		
		Inoculated	Developing spots	No. of spots planted into P.D.A.	No. of colonies of inoculated species	Identity
D. incurvata	7	106	100	86	32	*D. incurvata*
P. palmarum	3	30	0			
Chaetophoma sp.	3	27	0			
D. incurvata plus	2	14	12	25	11	*D. incurvata*
P. palmarum					2	*P. palmarum*
D. incurvata plus	2	14	13	25	10	*D. incurvata*
Chaetophoma sp.						
P. palmarum plus	3	30	0			
Chaetophoma sp.						
De-ionized water control	20	60	0			
Unsprayed control	20	60	0			

spots from field collections and were comparable with the first two spot categories of *Table* 1, but are smaller than those noted by Era and Celino (1972) who reported spots 8-20 mm long by 4-13 mm wide. However, the zonation of spots reported herein was also noted by Era and Celino (1972).

No sporulation occurred on spots arising from *D. incurvata* inoculations at Konedobu. This was similar to the situation revealed by the examination of leaf spot collections from Kapogere and Laloki, where 93 per cent of comparable spots were non-sporulating. It would seem from examination of field collections that environmental conditions, particularly low rainfall, were responsible for the high proportion of non-sporulating spots recorded in this study as on one of the collections from Laloki (PNG 8684), collected towards the end of the wet season, and on the collection from the high rainfall area, 54.5 and 72.6 per cent of comparable spots, respectively, were non-sporulating. In one attempt to induce sporulation on the spots resulting from *D. incurvata* inoculation, water was sprayed onto the leaves for three hours each afternoon, five afternoons per week, for two months. No sporulation occurred during that time and there was no change in the appearance of the spots.

When *D. incurvata* was inoculated onto either the adaxial or the abaxial leaf surface it was found that spots developed only on leaves inoculated on the abaxial surface (*Table* 4), indicating that infection only occurred on that surface. Examination of both leaf surfaces revealed that stomata were confined to the abaxial surface (*Table* 4). Study of the behaviour of germinated *D. incurvata* spores on both leaf surfaces showed that appressoria-like structures were produced only on the

Table 4.—The behaviour of *D. incurvata* on the leaf surfaces in relation to the stomata

	Leaf surface	
	Abaxial	Adaxial
No. of leaves— Inoculated	12	12
Developing spots	12	0
No. of stomata per mm² of leaf surface	118	0
No. of germinated spores examined	102	177
No. of germinated spores		
Forming appressoria-like structures		
Over a guard cell	87	0
Not over a guard cell	4	0
Not forming appresoria-like structures	11	177

abaxial surface and almost always over a guard cell (*Table* 4). Although no infection hyphae were observed it was concluded that penetration is probably via the stomata on the abaxial surface of the leaf.

P. palmarum alone was not able to infect young, uninjured leaves of coconut seedlings (*Table* 3). However, *P. palmarum* was isolated from spots that developed following simultaneous inoculation of *D. incurvata* and *P. palmarum* (*Table* 3). The results of inoculating *P. palmarum* onto *D. incurvata* spots are set out in *Table* 5. *P. palmarum* was isolated from 1.5 per cent of spots following *D. incurvata* inoculation. When *P. palmarum* was inoculated onto *D. incurvata* spots the former species was isolated from 60.0 per cent of inoculated spots compared with 17.0 per cent of control spots, thus showing that *P. palmarum* was able to colonize *D. incurvata* spots. As it was considered unlikely that there was any contamination of controls, the increase in recovery of *P. palmarum* in control spots was probably a result of the colonization of spots with *P. palmarum* spores from the atmosphere.

D. incurvata was recovered from 20.5 per cent of spots two weeks after inoculation with that species, but five to six weeks later, *D. incurvata* was isolated from only 3.0 per cent of control spots and 4.1 per cent of *P. palmarum* inoculated spots (*Table* 5). This decline, over a period of time, in the recovery of this species, together with the twofold increase in recovery of other fungi, indicated that *D. incurvata* was not a vigorous pathogen in the dry environment at Konedobu. *P. palmarum* was readily able to colonize *D. incurvata* spots and the threefold decrease in recovery of other fungi in *P. palmarum* inoculated spots, compared with control spots, indicated that this was a more vigorous species than *D. incurvata* once it had gained entry into the leaf. This view is supported by the results of isolations from field collections (*Table* 2) where it was found that *P. palmarum* was isolated five times more frequently than *D. incurvata.*

There was no change in the appearance of the majority of *D. incurvata* spots inoculated with *P. palmarum.* However, ten spots on three leaves in three separate inoculations underwent change. Spot size doubled and spots changed from uniform brown to straw coloured with a broad dark brown margin. *P. palmarum* sporulated on two of these spots, both of which were on the same leaf. Sporulation was not detected on any other spot in this study.

This study has shown that *D. incurvata* is a pathogen of young leaves of young coconut palms, a finding which is in agreement with that of Era and Celino (1972). Infection by this species provides an injury through which *P. palmarum* can colonize the leaves and the latter species is responsible, at least in part, for changes in the size and appearance of *D. incurvata* spots. This finding supports those of Bertus (1927) and others, who reported that *P. palmarum* was able to infect coconut leaves only through wounds. The high (43 per cent) isolation frequency of *P. palmarum* from surface-sterilized non-sporulating spots from field collections is probably a reflection of the ease with which *P. palmarum* can colonize *D. incurvata* spots.

Chaetophoma sp. was not able to infect

Table 5.—The results of inoculating *P. palmarum* onto *D. incurvata* spots

No. of leaves		No. of D. incurvata spots		Re-isolation from spots			
					% of spots yielding each species		
				Fungi isolated	After D. incurvata inoculation (132 spots)	After P. palmarum inoculation	
Inoculated	Control	Inoculated	Control			Inoculated (145 spots)	Control (100 spots)
36	33	4498	4358	*D. incurvata*	20.5	4.1	3.0
				P. palmarum	1.5	60.0	17.0
				P. theae	2.3	0.0	0.0
				Other*	47.7	29.0	84.0

*Other fungi isolated were *Nigrospora* sp., *Colletotrichum* sp., *Curvularia* sp. and *Phoma* sp.

young leaves of coconut seedlings, nor was it isolated from spots that developed following simultaneous inoculation of *D. incurvata* and *Chaetophoma* sp. (*Table* 3), thus showing that this species is not a primary pathogen as was suggested by its occurrence on young spots on collections from low rainfall areas. The occurrence of this species on 30 per cent of leaf spot collections examined by the author, together with its low (1.2 per cent) isolation frequency from surface-sterilized non-sporulating spots from field collections and the results of these inoculations indicate that *Chaetophoma* sp. is a secondary invader of coconut leaf spots, in areas where the fungus is located, but its role in the development of the spot symptoms was not determined.

The reaction of different seed sources to Drechslera *leaf spot*

The spot count range and the mean spot counts for each seed source studied are given in *Table* 6. In general, the spot counts recorded in the seed source study were low and there was probably no appreciable retardation of growth of the worst affected seedlings. Within any one seed source a wide range of spot counts was recorded. It can be seen from *Table* 6 that there were seedlings in each seed source with spot counts as low as zero or one. However, the maximum spot count recorded in each seed source varied from 175 for Rennell to 55 for Ralabang, with the other 12 seed sources exhibiting a range of maximum spot counts between these two values.

The seed nuts used in this study, except for the dwarf variety Ralabang, were probably cross-pollinated. However, if it can be assumed that for each seed source there was an equal probability of crossing with other seed sources the results of this study should be indicative of the damage that could be expected if seed nuts from these seed sources are planted in areas where *Drechslera* leaf spot is known to occur. The results obtained in this study suggest, then, that if the seed sources Rennell, Buka, Karkar and Madang are planted in high

Table 6.—Spot count ranges and mean spot counts for each seed source

Seed source	No. of palms	Spot count range over 3 readings	Mean spot count for each reading*			Mean spot count over 3 readings
			1	2	3	
Rennell	8	0-175	59	54	4	39
Buka	21	0-140	48	26	11	28
Karkar	9	0-136	41	28	31	33
Madang	12	0-127	42	33	9	29
Solomon Islands-Local	15	0-98	31	31	6	23
Markham	9	0-94	15	23	22	20
Solomon Islands-F.M.S.	6	0-87	43	32	1	25
Natava	9	1-87	27	30	5	21
Singapore	11	0-83	23	31	4	20
Luburua	4	1-79	39	36	22	32
Ulaveo	9	0-63	48	26	11	28
New Hebrides	6	0-63	33	14	4	17
Kieta	6	0-58	26	22	9	19
Ralabang	6	0-55	31	25	1	19
All palms	131	0-175	36	29	9	25

*Reading 1 was taken 13 months after seed nuts were planted
Reading 2 was taken 17 months after seed nuts were planted
Reading 3 was taken 21 months after seed nuts were planted

rainfall areas, where *Drechslera* leaf spot is likely to be severe, there is a higher risk of seedling failure as a result of *Drechslera* leaf spot damage than if the seed sources Ralabang, Kieta and New Hebrides are planted.

Spot counts were recorded 13 (first reading), 17 (second reading) and 21 (third reading) months after the seed nuts were planted at Laloki. Environmental conditions were the same between the first and the second readings (low rainfall plus frequent supplementary sprinkler irrigation—the greatest interval between applications being eight days, but was usually one to four days—and winds from the south-east). Between the second and the third readings there was a much higher rainfall, no supplementary irrigation, and winds were variable for the first month of the period and from the north-west to south-west for the remainder of the time. Only on four occasions was the interval between falls of rain greater than five days, the longest interval being nine days. As palms with high and low spot counts were randomly distributed throughout the trial at all three readings, the incidence of *Drechslera* leaf spot was considered to be unaffected by wind direction. It could, therefore, have been expected that if there were no decrease in susceptibility the incidence of *Drechslera* leaf spot would have at least been maintained between the first and the second readings. As the intervals between falls of rain during the period between the second and third readings were slightly greater than the intervals between sprinkler irrigation applications during the period between the first and second readings, conditions may have been slightly less favourable for the fungus during the former period and a slight fall in the incidence of *Drechslera* leaf spot would be expected.

Between the first and the second readings, the spot count decreased on 51.8 per cent of the palms and between the second and the third readings it decreased on 86.4 per cent of the palms. Over the whole period there were six different trends shown in the spot counts. These are shown in *Table* 7. Three of these, which included 91.5 per cent of the palms, were indicative of an overall decrease in spot count between 13 and 21 months and were as follows: initial increase followed by a larger decrease in spot count; continual decrease in spot count; and initial decrease followed by a smaller increase in spot count. The remaining three categories, which included 8.5 per cent of the palms, were indicative of an overall increase in spot count between 13 and 21 months and were as follows: continual increase in spot count; initial decrease followed by a larger increase in spot count; and initial increase followed by a smaller decrease in spot count.

Table 7.—The proportion of palms showing different trends in spot counts over three readings

Patterns of spot counts over 3 readings	No. of palms	% of palms	
Initial increase followed by a larger decrease in spot count	56	42.7	
Continual decrease in spot count	55	42.0	
Initial decrease followed by a smaller increase in spot count	9	6.8	
∴ Overall decrease in spot count			91.5
Continual increase in spot count	5	3.8	
Initial decrease followed by a larger increase in spot count	4	3.0	
Initial increase followed by a smaller decrease in spot count	2	1.7	
∴ Overall increase in spot count			8.5
	131	100.0	100.0

With four exceptions, the mean spot count for each seed source continually declined over the period 13 to 21 months after planting the seed nuts, but at varying rates (*Table* 6): for example, Solomon Island-Local recorded no decrease between 13 and 17 months, but recorded a large decrease (25) between 17 and 21 months; Buka recorded a large decrease between 13 and 17 months and between 17 and 21 months (22 and 15, respectively); Kieta recorded an overall decrease of 17; and Rennell recorded an overall decrease of 55. Of the four exceptions, Karkar recorded a large decrease (13) between 13 and 17 months but recorded a small increase (3) between 17 and 21 months; Markham recorded a moderate

increase (8) between 13 and 17 months but recorded a small decrease (1) between 17 and 21 months; and Natava and Singapore recorded a slight increase (3 and 8, respectively) between 13 and 17 months and a large decrease (25 and 27, respectively) between 17 and 21 months. When all the palms were considered, the mean spot count decreased from 36 at 13 months to 29 at 17 months to 9 at 21 months (*Table* 6).

The results of this study, therefore, suggest that, in general, for palms between 13 and 21 months after planting as seed nuts, the susceptibility to *Drechslera* leaf spot decreases with age. The interpretation was complicated by the fact that conditions were probably slightly less favourable to the fungus between 17 and 21 months than between 13 and 17 months. However, as the decrease in spot count between 17 and 21 months was three times greater than the decrease between 13 and 17 months, it can probably be concluded that there was a decrease in susceptibility between 13 and 21 months after planting. Amongst the seed sources susceptibility to *Drechslera* leaf spot decreased with age at different rates: for example, Rennell exhibited a large decrease, Karkar exhibited a small decrease and Markham showed an overall increase in susceptibility.

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LEAF SPOT OF COCONUTS

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ABSTRACT

In trial sowings in the Markham Valley, the variety Karkar was found to be much more susceptible, as assessed by amount of leaf affected, to Drechslera incurvata, *than the Markham and Rennell Island varieties and several dwarf by tall hybrids.*

During recordings on a coconut variety trial at the Agricultural Research Centre, Bubia, damage due to *Drechslera incurvata* was noted and damage was assessed on the various varieties.

The four youngest fully emerged fronds were rated as below and their individual ratings totalled to constitute the reading for each seedling. The ratings in *Tables* 1 and 2 are the means of the individual seedling ratings.

0 = no obvious infection
1 = less than 20% leaf area affected
2 = 20-40% leaf area affected
3 = 40-60% "
4 = 60-80% "
5 = 80-100% "

Additional recordings were carried out on blocks of Karkar and Markham coconuts established at Bubia as potential pollen sources. Twenty seedlings at random were selected for each sample (type x planting time) and the results are given in *Table* 2.

It can be seen from *Tables* 1 and 2 that the Karkar variety proved more susceptible than the other varieties under observation. Therefore, plantings of Karkar seedlings can be expected to show more disease than many other varieties, particularly in areas of higher rainfall, which favours the development of this disease.

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Table 1.—*Drechslera incurvata* ratings recorded 5th and 6th August, 1975

Variety	Approximate age of transplanting	Date transplanted	Rating* Rep. 1	Rep. 2
Karkar†	6 months	Feb., 1975	12.42	9.72
Markham	7 "	"	4.25	1.75
Dwarf x Gazelle Tall	12 "	"	3.08	2.25
Rennell Island	14 "	"	3.00	1.75
Dwarf x Solomons Tall	14 "	"	2.67(6)*	1.43(7)*
Dwarf x Fed. Malayan Tall	14 "	"	2.00(5)*	1.00(3)*
Dwarf x Rennell Island	14 "	"	1.08	0.92

* There were 12 seedlings in each plot except where figures in brackets represent the number recorded.

† In the Karkar variety, three seedlings in Rep. 1 and one in Rep. 2 had been killed by the disease, and some others in Rep. 2 were in poor condition.

Table 2.—*D. incurvata* ratings recorded 3rd September, 1975

Variety	Approximate age at transplanting	Date transplanted	Rating
Karkar	7 months	June, 1974	5.10
"	6 "	March, 1975	4.35
"	10 "	July, 1975	3.95
Markham	6 "	June, 1974	1.75
"	9 "	July, 1975	1.67*

* Only 15 seedlings used in assessment.

BOOK REVIEW

MILK AND BEEF PRODUCTION IN THE TROPICS

M. A. BARRETT and P. J. LARKIN

Oxford University Press (1974) 240 p. Paperback (£2.75)

This book is written by two men who have been involved in cattle production in East Africa (Kenya and Uganda) at Universities, in extension work and as a private veterinarian, for more than 20 years. The book is directed towards degree and diploma students and also farmers.

There are thirteen chapters. 1. Climate and the Animal. 2. Plant ecology and animal enterprises. 3. Pasture. 4. Water and bulk feeds. 5. Concentrate feeds. 6. The principles of rationing. 7. Minerals and vitamins. 8. Breeding for production. 9. Calf rearing. 10. Milk production. 11. Beef production. 12. Structural aids to stock production. 13. Livestock records.

In general the book successfully achieves its objectives. They are not up to date on some recent research findings (e.g. they state "Selenium may be essential", while most nutritionists have been convinced that it is, for the last 10 years). However such omissions are not of primary importance in a book written for this level of reader.

Readers in P.N.G. must bear in mind that this book is written about Eastern Africa, and cattle husbandry there has a number of important differences. Some of these are as follow: The people of Africa have a tradition of cattle husbandry over many centuries. This is not an unmixed blessing; traditional views are very hard to change. Africa seems to be the home of most of the worst cattle diseases. The constant reference to these in the text should be taken by P.N.G. readers as a warning to maintain vigilance in excluding these diseases. Eastern Africa is not nearly as wet as P.N.G. The plant ecology maps show very considered as a possible component of cattle little rainforest in Eastern Africa, while P.N.G. is marked as more than half rainforest. Rainfall in rainforest in Africa is 1800 mm to "over 3000 mm". In P.N.G. there are large areas with rainfall from 4-5000 mm. Some of the climate areas he describes (desert, thorn scrub) do not occur in P.N.G. while dry savannah, as they describe it, is rare in P.N.G.

There are many other areas of the tropics where cattle are raised, South and Central America, India, South-east Asia, which may have as much or more relevance to P.N.G. For example, there is no reference to the use of cattle for draft. The successful use of cattle for draft in India and South-east Asia must be production in P.N.G.

The chapter on Climate and the Animal (Ch. 1) is perhaps a little brief. Its position in the book attests its importance. The authors rightly criticize the importation of European livestock to "upgrade" the local stock before determining whether the local low performance is a characteristic of genotype or environment.

Chapter 2 describes the range of environments, which, as mentioned, include some not found in P.N.G. The descriptions adequately cover the characteristics and limitations of each environment.

Chapter 3, Pasture, is all too short, but this possibly reflects the shortage of accurate information on grasses under tropical conditions. The authors are in favour of purposeful burning, not indiscriminate fire lighting. On the management of pastures, they refer immediately to the use of mowing, which is not practicable in much of P.N.G. Their advocacy of rotational grazing has not been borne out by research in tropical Australia. The use of hay and silage is made to sound easy. Most experience in the tropics seems to be that good hay-making weather is rare where the pasture is at a stage to make good hay, and the low sugar content of tropical grasses makes the production of silage difficult. This chapter, with its mechanical emphasis, is not appropriate to the likely development of cattle production here.

Chapter 4 includes a section on tropical legumes, and describes a number of beans grown as crops then fed off to cattle, a development which may occur in P.N.G. *Leucaena glauca* and *Leucaena leucacephala* are described as 2 species, not one (*L. leucacephala*). No details are given of its management, which proves difficult in practice. The discussion of

pasture grasses and legumes is very brief, to the point of inadequacy.

The chapters on concentrate feeds and rationing (Ch. 5 and 6) collect together information on tropical feedstuffs and pastures which is not often found in conventional nutrition texts and this section could prove very useful. Chapter 7 on Minerals and Vitamins contains the expected information, with little that is specific to the tropics. In the wetter tropics, such as P.N.G., it is unlikely that Vitamin A deficiencies will occur.

The chapter on breeding is practical, emphasizing selection for characters of economic value and is well worth reading. Calf rearing for dairying is dealt with (Ch. 9). Milk production (Ch. 10) is the longest chapter and covers the material well. As in the section on pasture management, a high degree of management, mechanization and fodder conservation is described, but in the case of dairying this may be justified.

Chapter 11, Beef Production, describes several systems of cattle and grazing management, discussing the use of indigenous breeds, the assessment of breeder efficiency, and feedlotting using agricultural wastes such as molasses. The use of hormone implants is discussed.

Chapter 12 has some useful points on the construction of yards, fences, etc. A notable omission is the need for a kunai roof over the crush, to keep man and cattle cool. The section on fencing, watering and buildings has a lot of useful points, especially in dimensions of structures.

The final chapter stresses the importance of record keeping and describes some systems. These appear too complex for smallholders' use.

In general the book is informative and can be recommended for diploma and degree students. As is to be expected in a book by an animal husbandry man and a veterinarian, the weakness is on the pasture side, and an alternative source of information should be sought for this aspect of animal production.

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