Distribution and progression of stem bleeding disease of coconut (*Cocos nucifera* L.) in some areas of the Philippines

Nemesia C. San Juan – Bachiller[1] and Reynaldo G. Abad

Abstract

Records of disease occurrence in surveyed provinces show Davao del Sur having the highest disease incidence of stem bleeding caused by *Thielaviopsis paradox*a (de Seynes) von Hohnel. Disease incidence in Malayan Yellow Dwarf x West African Tall (MYD x WAT) hybrid at the PCA's Zamboanga Research Center was relatively lower than the other areas observed. Tall genotypes are less susceptible to the disease as shown in the province of Quezon where the cultivar Laguna Tall is predominantly grown. The incidence of stem bleeding was found to be related with palms age. More incidence of the disease was noted in palms between 11-15 years old.

Study on the spatial distribution of the disease from l991 to l995 show that the disease initially occurred in random foci, and, subsequently infected adjacent palms.

The disease progress curves suggest that stem bleeding follows a sigmoid curve. It follows that the progress of the disease at any given time is a function of the initial inoculums and the number of effective contact points between susceptible host and inoculums per unit time. Analysis of the infection rates using logistic growth model showed that the rate of disease increase ranged from 0.029 to 0.218 per unit per year and 0.227 per unit per year in all the six experimental areas.

Increase in disease incidence is directly related to high amount of rainfall.

Key words: Distribution, progression, stem bleeding and coconut.

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Introduction

Stem bleeding disease has a very wide geographical distribution starting from Sri Lanka where it was first described by Petch in l903 (Child, l974) and India (Menon and Pandalai, l958) to Southeast Asia namely: the Philippines (Lee, l922), Malaysia (Sharples, l923) and Indonesia (Renard *et al.,* l984; Kartika *et al.,* l984) and further to the Carribeans in Jamaica (Martin, l945), Trinidad and Tobago (Goberdhan, l961) including the Dominican Republic and as far as Ghana in Africa (Chona and Adansi, l970). The disease can be found in areas near the sea, inland, at sea level or at the upper limit of the coconut zone (Petch, l903; Goonewardene, l955). There are different reports about the effects of the disease. Brahamana (l986) reported that in Indonesia, the disease had no effects on the number of female flowers and nut harvested during one year of observation. Gapasin (l983) reported that the disease decreased the yield and could kill palms in the Philippines.

In the Philippines, stem bleeding was reported by Lee (1922). Teodoro (l925) considered it to be a disease of sporadic occurrence. Abad and Pacumbaba (l971) reported occasional heavy localized incidence on local dwarfs. The disease is now becoming a serious problem in hybrid replants. For instance, in an experimental area inside the PCA-Davao Research Center planted with Malayan Yellow Dwarf x West African Tall (MAWA) hybrids, the incidence of stem bleeding has been recorded in 90 out of 200 coconut palms (PCA, l989). The objective of the study is to assess the geographical distribution and incidence of the disease at the PCA's Coconut hybrid farms and Research Centers and private coconut plantations.

Materials and methods

Distribution and assessment of stem bleeding

Disease survey and mapping were done in coconut farms in Philippines in the provinces of Albay, Quezon (Luzon), Leyte (Visayas), Camiguin Island, Misamis Oriental, Davao del Norte and Davao del Sur (Mindanao). Data on the incidence of stem bleeding cases were reviewed and consolidated on a yearly basis from l989 to l994.

Data were augmented by monitoring disease incidence in different experimental plots planted with various coconut hybrids / cultivars at the PCA's Davao Research Center (DRC) at Bago-Oshiro, Davao City and the Zamboanga Research Center (ZRC) at San Ramon, Zamboanga City for at least 5 years. The data gathered were: a) cultivars/hybrid, b) palm age, c) total number of palms, d) number of diseased palms, e) percentage of disease incidence, f) disease incidence by cultivars and g) yield of different coconut cultivars planted at DRC and monitored for stem bleeding.

The record of percentage incidence is based on number of infected palms against total number of palms planted in an area.

Mapping of stem bleeding

Actual mapping of disease spread was done in at least ten hectares per area with approximately 1,000 coconut palms. These were established in the Zamboanga Research Center (ZRC) and in two private coconut plantations namely, La Filipina Plantation and Ayala Agricultural Development Corporation (AADC) in Tagum, Davao del Norte and Davao del Sur, respectively. With the use of farm maps indicating the distribution of coconut palms, the exact location and number of diseased palms were recorded.

Data gathering of disease incidence was done every three months. In addition, rainfall data within the period of observation were gathered. Disease proportion expressed as the ratio of the number of infected palms and the total number of palms was computed in each experimental area per year.

Disease progress curve

Disease progress curves of stem bleeding were determined in six selected disease-mapping areas. Data on disease occurrence from l991 to l995 were used. The disease proportion was then expressed as the ratio of the number of infected palms to the total number of palms in each area. The disease progress curves were established by plotting disease proportion with time (year).

Infection rates

Infection rates of stem bleeding in six disease-mapping areas were determined using the data obtained from the study of disease progress curves. Logistic disease growth models described by differential equation dY/dt = rYt (1-Yt) (Van der Plank l963) where the change in proportion of disease Y, with time, t, is equal to the rate of infection, r, multiplied by the proportion of the disease at any given time and then multiplied by a correction factor (1-Y) was used in the estimation of infection rates. Disease proportion was transformed according to the disease growth model and regressed with time. The infection rate that was the slope of the line was determined.

Results and discussion

Distribution and assessment of stem bleeding incidence

Geographical distribution

Records of stem bleeding occurrence in some coconut growing provinces in the Philippines are presented in Table 1 and Fig. 1.

In Albay and Quezon provinces stem bleeding incidence was 3.7 and 3.2%, respectively. In Leyte, specifically the Visayas State College of Agriculture (VISCA), the average percent incidence was 16.1%.

In the Mindanao provinces, the highest percentage of disease incidence was observed in Davao del Sur (28.5%) where large areas of MAWA hybrids were planted. It was noted that in Camiguin Province the incidence of stem bleeding was relatively high (9.9%) especially in the local Tall genotype. Less incidence of stem bleeding (6.8%) was observed in Davao City particularly in the Davao Research Center (Table 2) where most of the genotypes planted are local cultivars. The high incidence observed in Camiguin Province may be due to high relative humidity in the foot slopes of Mt. Hibok-Hibok, which considerably favors disease development.

Assessment of stem bleeding by age group

Table 2 shows the effect of coconut age on the incidence of stem bleeding. Coconut palms with age ranging from 11-15 years were more susceptible with percent incidence of 15.2%. This was followed by palms ranging from 5-10 and 16-20 years (9.1%). Coconut palms ranging from 30-35 years old had the least occurrence of stem bleeding. This observation may be attributed to the physical properties of coconut wood, which depended largely on its density, moisture content and shrinkage (Palomar, l990). He reported that the basic density of the wood (oven-dry weight divided by green volume) decreases with increasing height of the stem and increases from the core to the cortex at any given height. The amount of moisture in coconut stem increases with increasing stem height and decreases from the core to the cortex. The dimensional stability of the wood is determined by its shrinkage or swelling which accompanies a decrease or

Table 1. Distribution and incidence of stem bleeding

Province	Location	Cultivar/ Hybrid	Age group (Years)	Total no. of palms	No. of infected palms	Percent disease incidence
Albay	PCA-ARC	YMD X WAT	15-20	143	3	2.1
		GDH X WAT	15-20	143	4	2.8
		NRC X WAT	15-20	143	6	4.2
		YMD	15-20	124	7	5.8
		Orange Dwarf	15-20	116	7	6.0
		Catigan	15-20	111	2	1.8
Quezon	Dolores	Laguna Tall	30-35	616	20	.3.2
Leyte	VISCA, Baybay	YMD X WAT	10-15	715	115	18.1
Camiguin Island	Payahan, Mambajao	Laguna	30-35	1884	186	9..9
Misamis Oriental	Medina	YMD X WAT	15-20	556	96	17.3
Davao City	PCA-DRC, Bago-Oshiro	Catigan	15-20	977	75	7.7
		Laguna	15-20	756	16	2.1
	Poblacion, Calinan	YMD X WAT	8-10	1590	145	9.1
	Baguio, Calinan	Laguna	20-25	500	23	4.6
Davao del Sur	AADC, Darong	YMD X WAT	10-15	1126	436	38.7
	PHF Bato, Sta. Cruz	YMD X WAT	15-20	675	102	15.1
	CII, Guihing	YMD X WAT	10-15	5244	300	5.7
Davao del Norte	PHF Mabini	YMD X WAT	15-20	456	64	14.0
	La Filipina	JVA	10-15	1301	436	33.5
Zamboanga City	PCA-ZRC Block 1	Catigan	10-15	1263	427	33.8
	PCA-ZRC Block 2	Baybay, Karkar, Markham Gazelle, Laguna, Tahiti, WAT, Gatusan	10-15	1518	78	5.1
	PCA-ZRC Block 3	MYDXWAT, BAYXWAT, LAGXWAT, BAOXWAT, RITXWAT. SNRXWAT ZAMXWAT, TAGXWAT	10-15	1176	263	22.4
	PCA-ZRC Block 4	MYD	10-15	1090	233	21.4
	PCA-ZRC Block 5	MYDXWAT, TAGXCRD, BAYXCRD, LAGXCRD, BAOXCRD, BAYXGDS, MRDXBAO, MRDXLAG, TACXBAO	10-15	1474	201	13.8
	PCA-ZRC Block 6	MYDXWAT, MYDXTAG, MYDXBAY, MYDXPYT, MYDXLAG, RITXGDS RITXCRD	10-15	1,307	247	18.9

increase in moisture content below fiber saturation point.

Assessment of stem bleeding by cultivars/hybrid

Among the dwarf cultivars, the highest incidence was observed in MYD (24.6%) followed by Catigan (21.4%). Among the tall cultivars, WAT had highest incidence (26.0%) while LAG and BAY showed the lowest disease incidence (4.3 and 3.1%).

Table 2 Age-wise distribution of stem bleeding

Age group	Average incidence (%)
5 - 10	9.1
11 - 15	15.2
16 - 20	9.1
21 - 25	8.2
30 - 35	4.6

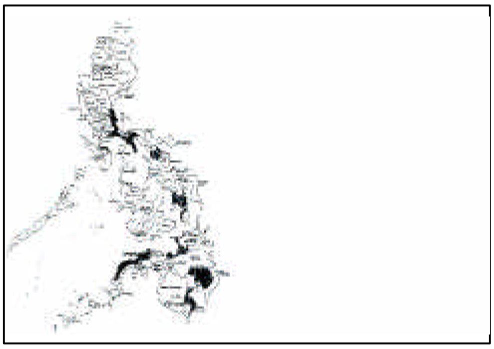

Fig. 1. Map of the Philippines showing stem-bleeding areas infected

Among the hybrids planted in different places in the country, disease incidence was relatively high (53.1%) in MAWA plantings compared with the local cultivars (Table 3). This can be attributed to MAWA as a susceptible hybrid since the parent materials, MYD x WAT, also had the highest disease incidence. Higher incidence of stem bleeding (33.5%) was also observed in the JVA-1 hybrid where MYD is one of the parent materials. Less incidence of the disease was observed in LAG x WAT hybrids (6.3%) as compared to MAWA. This may be attributed to the tall cultivars (such as LAG) as less susceptible to the disease.

Table 3. Disease distribution of stem bleeding in different cultivars/hybrids

Genotype	Average incidence (%)
Dwarf	
Catigan (CAT)	21.4
Equatorial Green Dwarf (EGD)	13.3
Malayan Yellow Dwarf (MYD)	24.8
Orange Dwarf (OD)	6.0
Tall	
Baybay (BAY	3.1
Gazalle	7.4
Laguna (LAG)	4.3
West African Tall (WAT)	26.0
Hybrid	
BAO x WAT	26.0
BAY x WAT	18.8
LAG x WAT	6.3
MYD x Hijo Tall (JVA-1)	33.5
MYD x WAT (MAWA)	53.1
TAG x WAT	17.8
SNR x WAT	25.9
ZAM x WAT	13.2

In six-year observation period (1989 to 1994) disease incidence was closely monitored at the Davao Research Center (Fig. 2).

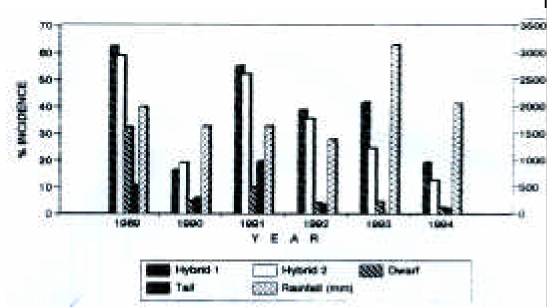

Fig 2. Year wise incidence of stem bleeding

The 1989 survey showed that NRM x WAT had the highest incidence rate of 83.0% while NRC x WAT, GDH x WAT and YMD x

WAT had 76.7, 53.9 and 36.9% incidence, respectively. Among the local dwarfs, Tacunan had the highest incidence (56.7%) compared to Catigan (7.7%) and Laguna (2.4%).

In the 1990 survey, a decreasing trend of disease incidence among the entries was observed except for MAWA, which had the highest (42.9%). Local hybrids (CAT x BAO and TAC x BAO) had disease incidence of 26.4% and 16.1 % respectively. This incidence in the local hybrids was less compared to the 1989 survey. This observation may be related to rainfall, which favors disease development. The total number of rainy days in 1990 was 136 with total amount of rainfall 1,626.6 mm whereas the total rainfall in 1989 was only 1,250.5 mm.

An apparent increase in disease incidence during the 1991 survey was noted in all cultivars with MAWA consistently the highest with 73.0% incidence. The disease incidence in the year was similar to the 1989 survey. Again this observation may be attributed to higher amount of rainfall (1,985.2 mm) with 144 total numbers of rainy days. Salgado (1942) reported that "Bleeding disease" might primarily be due to physiological causes such as bleeding due to heavy rains following a period of drought.

The occurrence of stem bleeding in 1992 showed that MAWA consistently had the highest disease incidence rate of 94.0%. Among the local hybrids, CAT x BAO had the highest (11.3 %) disease incidence. On the other hand, BAO Tall had zero incidences.

In the 1993 survey, the total incidence among hybrids showed that NRC X WAT had the highest incidence 68.5%. This was followed by MAWA and NRM x WAT with incidences of 41.7 and 32.1%, respectively. Among the local dwarfs, Tacunan and Catigan showed incidences of 5.6 & 3.4% respectively, while local genotype such as TAC x BAO, CAT x BAO, LAG and BAO Tall did not show presence of the disease.

In the 1994 survey, a decreasing trend of disease among the cultivars/hybrids was observed especially in local hybrids (such as TAC x BAO) and BAO with zero incidences.

Records of disease incidence on MAWA plantings in the Pilot Hybrid Farms (PHF's) of Bato Sta Cruz, Davao del Sur and Mabini, Davao del Norte from 1990 to 1994 showed that incidence of stem bleeding fluctuated yearly (Fig. 3).

Figure 4 showed less nut production at DRC in infected palms compared to healthy palms. Regardless of cultivars there was a decreasing trend in nuts harvested from 1990 to 1994.

Mapping of stem bleeding

Data on actual yearly observations on disease incidence in six experimental areas in AA DC, La Filipina and ZRC are presented in Table 4.

Cumulative disease incidence of stem bleeding in 6 disease mapping areas showed that in La Filipina plantation where MY D X HJT hybrids are planted, the disease incidence was 9.0%, 16.0%, 26.2%, 31.1 % and 36.9% in 1991, 1992, 1993, 1994 and 1995, respectively. The rate of disease increase in this area was 7.0% at the end of 5th year. In AADC plantation, the percentage disease incidence was 7.9% during the first year. A year later the percent incidence increased to 11.7%. In 1993, 1994 and 1995, disease incidence of 19.6%, 28.1% and 31.4% respectively were recorded in the observation palms infected by the disease. The rate of disease increase in this area for five years was 5.9%.

In the Zamboanga Research Center (ZRC) where different cultivars/hybrids were planted 4 experimental areas gave different rates of disease increase. Initial data showed that Catigan dwarf gave the highest disease incidence (16.2%) of stem bleeding while in MYD, hybrids and Tall genotypes gave 7.7%, 3.8% and 2.4% disease incidence respectively.

Incidence of stem bleeding in the different hybrids in ZRC with WAT percentage showed that less incidence was noted as compared with Catigan Dwarf. This may be due to heterogeneity of the genotype in the experimental plots that limit continuous spread of the disease.

The rate of disease increase in ZRC experimental plots differs in each cultivar. The disease appeared more in dwarf cultivars Catigan and MYD with (32.8% and 21.4%)

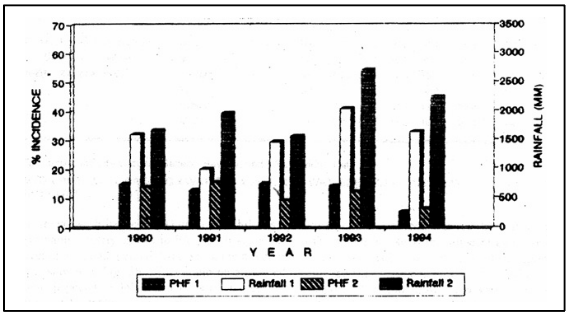

Fig. 3. Incidence of stem bleeding in MAWA hybrid in pilot hybrid farm (1990-1994)

while the Tall cultivars gave the lowest (9.0%) disease increase at the end of the 5th year. In La Filipina plantations, where hybrid of MYD x HJT are planted rate of disease increase was higher (7.0%) as compared with 5.9% rate of disease increase in MYD x WAT in AADC plantations. In Tall genotype rate of disease increase was 1.7% (Table 4). The temporal and spatial increase of stem bleeding in AADC, La Filipina and ZRC were shown in Fig. 5a-5e. The distribution pattern of the disease spread across the row or within the row progressed at moderate rate in the succeeding year. The pattern of spread was regular with in the row especially on hybrids as shown in ZRC experimental plot and highest disease spread in MYD x WAT. Disease spread in Tall genotype was less as compared to Dwarf genotype. In ZRC where different germplasm collections were planted, sporadic spread was found in tall cultivars however at the end of the 5th year disease spread was with in the row (Fig. 5d). While in Catigan dwarf cultivars spread was regular with in the adjacent palms as clearly shown in Fig. 5c. It appeared that the pathogen infects the adjacent palms from the infection foci and gradual dispersal of infection propagule usually occurred within the row of susceptible palms as shown in Fig. 5b. This could be attributed to rain splashes that somehow contributed to the pathogen dispersal. Goberdhan (1986) repotted that the spores of *Thielaviopsis paradoxa* can be disseminated by water or rain splashes. *Diocalandra rastigmaticollis* Gyll. A small brownish black weevil was found in very large numbers of coconut palms in India associated with the stem bleeding. The study gave some information on the behavior of the disease in terms of the spread in time and space thus improving chances to develop a management system. The disease maps (Fig. 5a to 5f) from 1991 to 1995 show the nature of spread of the disease in different coconut genotypes.

Table 4. Cumulative disease proportion of stem bleeding in disease mapping areas (1991-1995)

Province	Genotype	Total no. of palms	Disease proportion (%)					Average disease incidence
			1991	1992	1993	1994	1995	
La Pilifina, Tagum, Dvo, del Norte AADC, Darong, Dvo, del Sur PCA-ZRC, Zamboanga city	MYD x Hijo Tall	969	9.0	16.0	26.2	31.1	36.9	7.0
	MYD x WAT	1151	7.9	11.7	19.6	28.1	31.4	5.9
	Catingan	1263	16.2	24.2	27.6	30.7	32.8	4.2
	Tall*	1505	2.4	4.5	5.2	7.8	9.0	1.7
	Hybrid**	1176	3.6	9.8	12.4	19.8	22.4	4.7
	MYD	1090	7.7	13.3	15.5	18.3	21.4	3.4

* - Tall cultivars include Laguna, Gazelle, Baybay, and West African Tall

**- MYD x WAT, BAY x WAT, LAG x WAT, BAO x WAT, RIT x WAT, SNR x WAT, ZAM x WAT, TAG x WAT

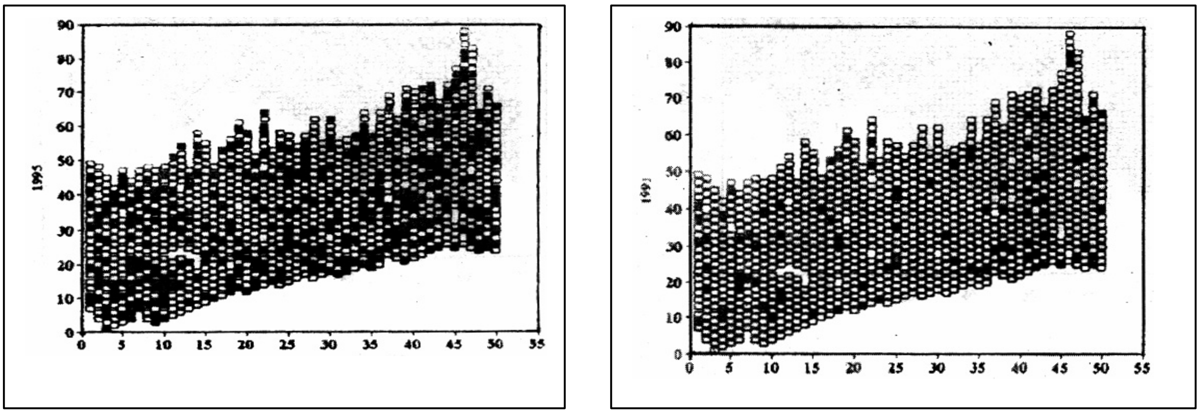

Fig. 5a. Spatial distribution of stem bleeding in MYD x WAT at the AADC coconut plantation during 1991 and 1995

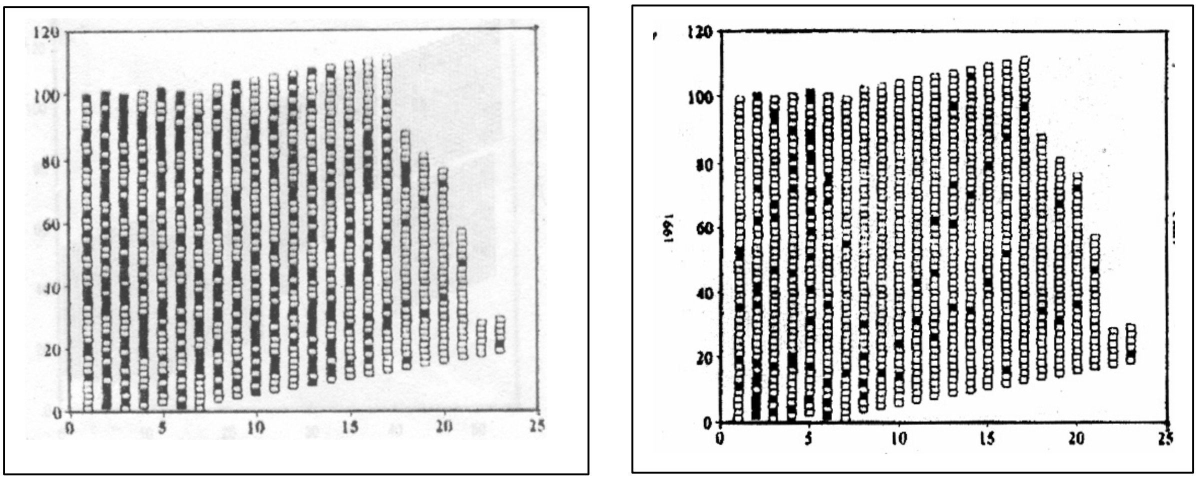

Fig. 5b. Spatial distribution of stem bleeding in MYD x Hijo Tall at La Filipina coconut plantation during 1991 and 1995

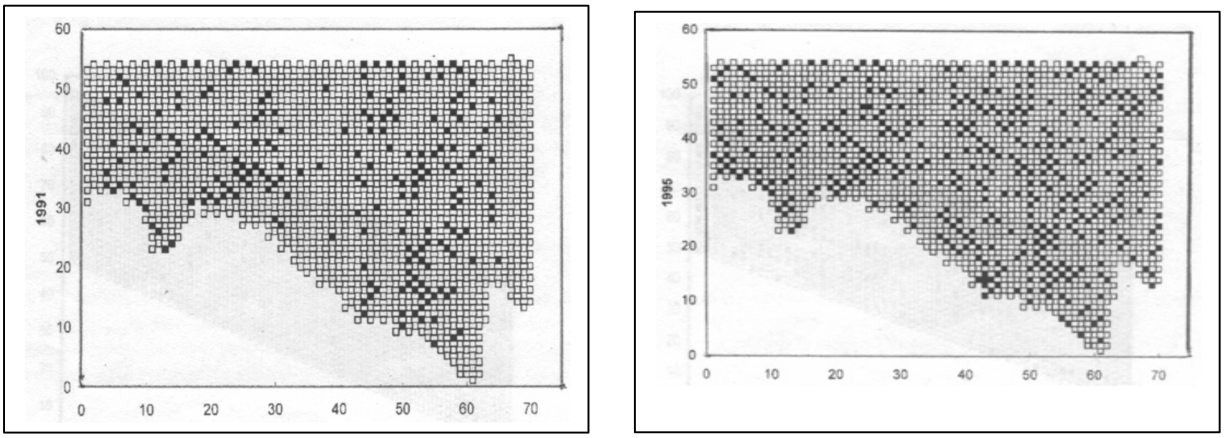

Fig. 5c. Spatial distribution of stem bleeding in Catigan Dwarf at PCA-ZRC area during 1991 and 1995

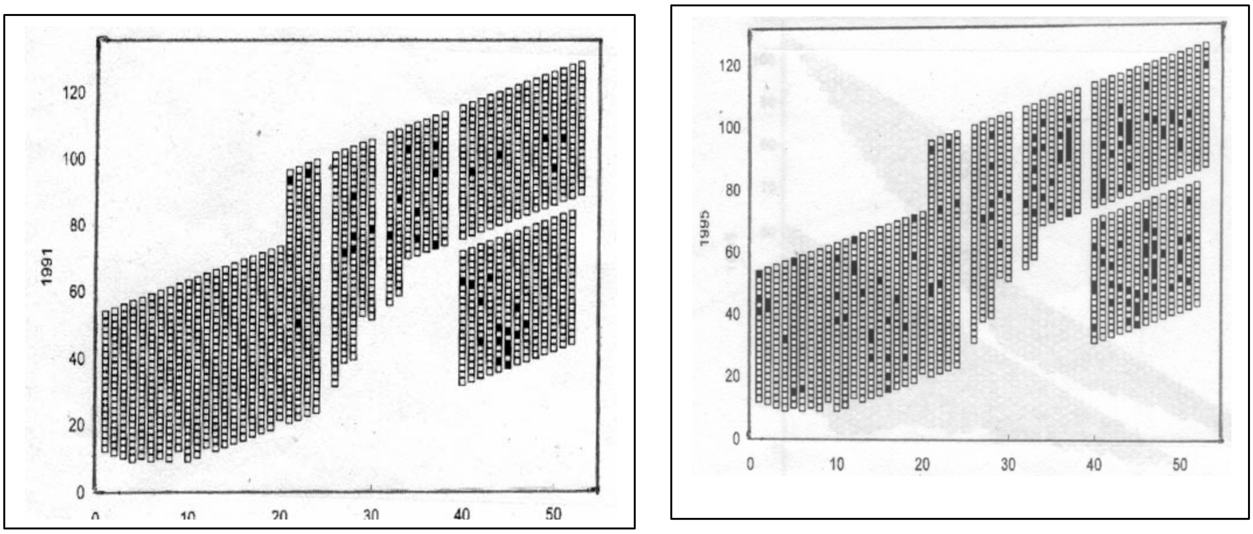

Fig. 5d. Spatial distribution of stem bleeding in different tall genotype at PCA-ZRC area during 1991 and 1995

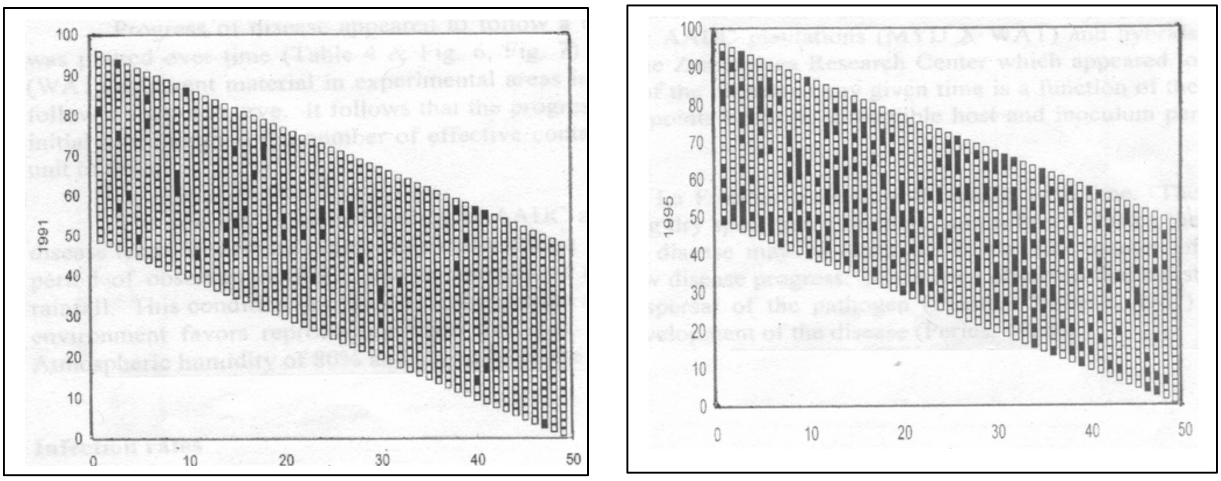

Fig. 5e. Spatial distribution of stem bleeding in different hybrids at PCA-ZRC area during 1991 and 1995

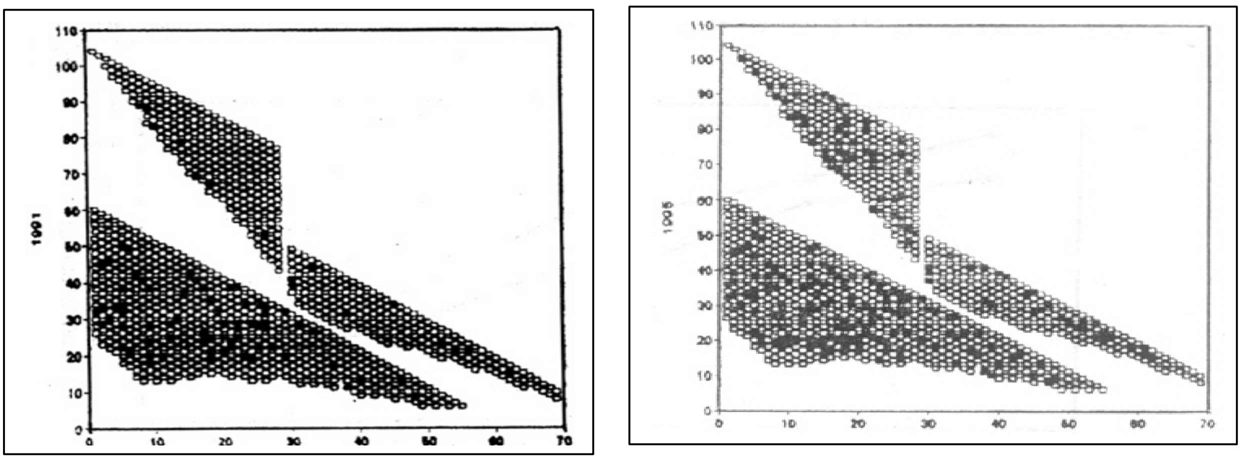

Fig. 5f. Spatial distribution of stem bleeding in MYD at PCA-ZRC area during 1991 and 1995

Disease progress curves

Progress of disease appeared to follow a normal curve when the calculated disease proportion was plotted over time (Table 4, Fig. 6, Fig. 7) for AADC plantations (MYD x WAT) and hybrids (WAT) as parent material in experimental areas in the Zamboanga Research Center, which appeared to follow a sigmoid curve. It follows that the progress of the disease at any given time is a function of the initial inoculums and the number of effective contact points between susceptible host and inoculum per unit of time.

The severity of stem bleeding at AADC and La Filipina plantations increased with time. The disease tends to increase rapidly especially after a long dry spell then immediate rain follows. During the period of observation (1992) less occurrence of the disease may be attributed to the low amount of rainfall. This condition appeared to influence the slow disease progress. It has been observed that moist environment favors reproduction and eventual dispersal of the pathogen (Planters Bulletin, 1967). Atmospheric humidity of 80% and above favors the development of the disease (Peries, 1968).

The infection rates in the 6 affected experimental areas according to logistic growth model range from 0.029 to 0.218 per unit per year (Table 5). Different hybrids of coconut where WAT was a parent material, planted at Zamboanga Research Center (ZRC) gave the highest rates of infection while in MAWA hybrids the infection rate was 0.11 per unit per year. Catigan dwarf gave the lowest rate (0.029) per unit per year. Regardless of genotype, the rate of infection of the disease was 0.227 per unit per year (Fig. 8). In Comparison with other coconut diseases in the Philippines, apparent infection rate of stem bleeding is much slower compared to "Soccoro Wilt" which ranged from 0.156 to 0.389 per unit per year (San Juan, 1984). Apparent infection rate of cadang-cadang disease was 0.312 per unit per year (McCoy, 1980).

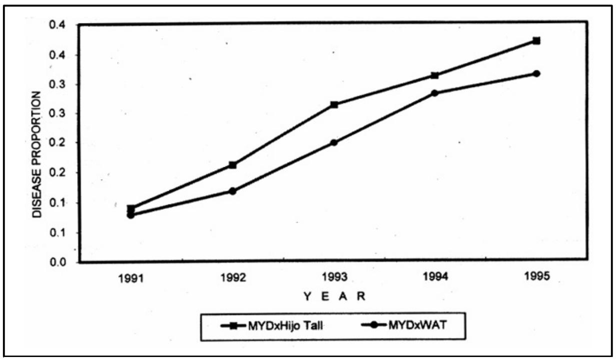

Fig. 6. Disease progress curve of stem bleeding of coconut in La Filipina and AADC plantation in Davao del Norte and Sur

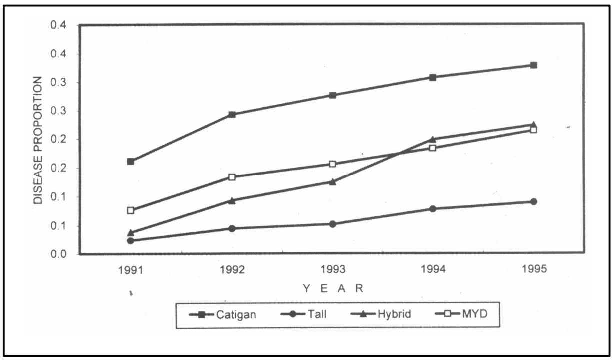

Fig. 7. Disease progress curve of stem bleeding of coconut in Zamboanga Research Center

Table 5. Simple linear regression of disease progress in six affected areas of stem bleeding using logistic model

Location	Genotype	Intercept	Slope (apparent infection rate)	R-Squared
La Filipina,Davao del Norte	MYD x Hijo Tall	0.312	0.098	0.172
AADC, Davao del Sur	MYD x WAT	0.214	0.006	0.978
PCA-ZRC, Zamoanga City	Catigan	0.237	0.007	0.944
PCA-ZRC, Zamoanga City	Tall	0.003	0.001	0.992
PCA-ZRC, Zamoanga City	MYD	0.014	0.004	0.981
PCA-ZRC, Zamoanga City	Hybrid	0.011	0.003	0.977
	Average	**0.182**	**0.023**	**0.047**

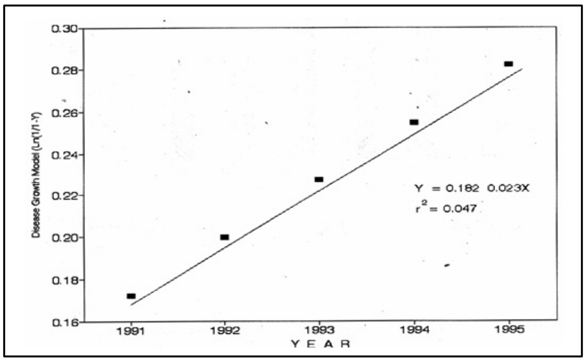

Fig. 8. Regression line showing the relationship of transformed disease proportion to the time in six disease mapping areas

Effect of rainfall on stem bleeding incidence

The incidence of stem bleeding in the AADC and La Filipina plantation increased with higher amount of rainfall received (Fig. 9).

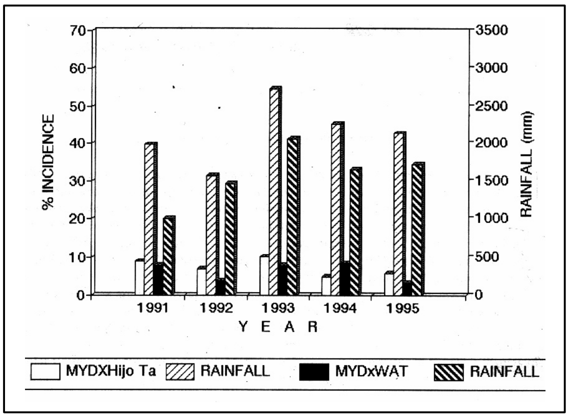

Fig. 9. Effect of rainfall on stem bleeding incidence in the La Filipina and AADC Plantation

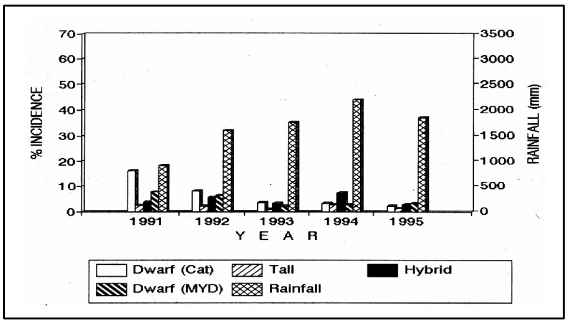

Fig. 10. Effect of rainfall on stem bleeding incidence in the Zamboanga Research Center (ZCR)

Likewise, in the Zamboanga Research Center the percent incidence of stem bleeding was higher in 1994 after a heavy rainfall (Fig. 10). This suggests that stem bleeding was intense during the wet period. According to Ohler (1984), growth cracks in the stem may develop after sudden rains following a prolonged dry period. This growth cracks are the likely entry points of the pathogen. Climatic factors such as rainfall and humidity affect disease development by *T. paradoxa*. High rainfall intensity in certain areas causes low solar radiation and high air humidity. The optimum annual rainfall for coconut is 1,200 - 2,500 mm (Abeywardene (1985), Thampan (1960), Child (1964) and Darwis (1985). Coconut is sun-loving crop, it requires high solar radiation and high humidity but these conditions promote the development of fungal diseases.

Conclusion

Records of disease occurrence in different provinces show that Davao del Sur had the highest disease incidence. This observation may be attributed to large areas of MAWA hybrids that are planted in this province. Incidence of stem bleeding in MAWA at the Zamboanga Research Center was relatively less probably due to the heterogeneity of the genotypes planted in the experimental plots that limits continuous spread of the disease. Tall genotypes are less susceptible to the disease as shown in the province of Quezon where the cultivar Laguna Tall is predominantly grown. The incidence of stem bleeding was found to be affected by age of the palms. More incidence of the disease was noted in palms between 11-15 years old. This can probably be attributed to the physical properties of the coconut wood which at this age develops fibro-vascular tissues that are still soft with higher moisture content present in the stem than as the palms become older.

The spatial distribution of the disease was mapped in the series of disease maps from 1991 to 1995. The disease initially occurred in random foci. From a focus, the disease infected adjacent palms. This indicates that the rapid spread of the disease within the field could be attributed to rain splashes that somehow contributed to pathogen dispersal. The disease progress curves suggest that stem bleeding follows a sigmoid curve. It follows that progress of the disease at any given time is a function of the initial inoculums and the number of effective contact points between susceptible host and inoculums per unit of time. Analysis of the infection rates using logistic growth model showed that the rate of disease increase ranged from 0.029 to 0.218 per unit per year and 0.237 per unit per year.

Increase in disease incidence is directly related with the occurrence of a high amount of rainfall.

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