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FARM PERFORMANCE AND PROBLEM AREA OF COCOA PLANTATION IN LAMPUNG PROVINCE, INDONESIA

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ABSTRACT

In the last ten years, the trend of cocoa field productivity in this province was decreasing. This study aimed to explore farm performance and problems of cocoa plantation in Lampung. Two regencies representing low land and mountainous land of cocoa smallholder plantations were purposively chosen; in which 500 farmers were randomly drawn to be interviewed from two districts of every regency with large cocoa areas. Field survey was conducted at one cocoa village with highest elevation of black pod disease. We found that cocoa farming system in Lampung was mixed cropping 60.6% and monoculture 39.4%. Coconut and banana were the main mixed crops with importance value (IV) 94.3% and 37.4% and yield index 134% and 119% respectively. Meanwhile, *Parkiaspeciosa*, rubber, clove, coffee, durio, nutmeg, and long pepperwere minor mixed crops. A 94% of sample farmers figured the fall of cocoa yield was because of black pod disease. Irregular pruning and less farm sanitation especially on waste of pod husk and disease infected pod mayinduced black pod disease. From 9 national clones we calculated the severity score was 2.79 (0-10 score level) and from 4 local clones the scoreswas 4.46. However, Sul2 as one of national clones indicated as a tolerant clone with the lowest score of 0.91.

Key words: cocoa, clone, disease, mixed crops, severity, tolerant, yield index

INTRODUCTION

Indonesia is the world's third largest producers of cocoa. Its production in 2013/2014 was 375 thousand tonnes, estimated to drop to 300 thousand tonnesin 2015/2016 (ICCO, 2016). The plantation area in 2015 was 1.6 million hectars of small holders and 39 thousand hectares of private plantations (Directorate General of Estated Crops, 2014), including 68 thousand ha in Lampung Province.

In 2002-2014 cocoa plantation area in Lampung increased by 11.1% but production increased slightly by 7.8% per year. Figure 1 shows the gap between cocoa planted area and production becomes wider indicating the decreasing of productivity. Table 1 exhibits that the productivity of total planted land (P/A) decreased from around 0.6 to 0.4 ton/ha of cocoa bean and the productivity of mature cocoa land (P/M)decreased from 1,0 to below 0.9 ton/ha in the last ten years.Index of productive cocoa land (M/T) also reduced.Productivity and production of cocoa in this province tendto decrease. This study aimed to explore farm performance and problems of cocoa plantations in Lampung.

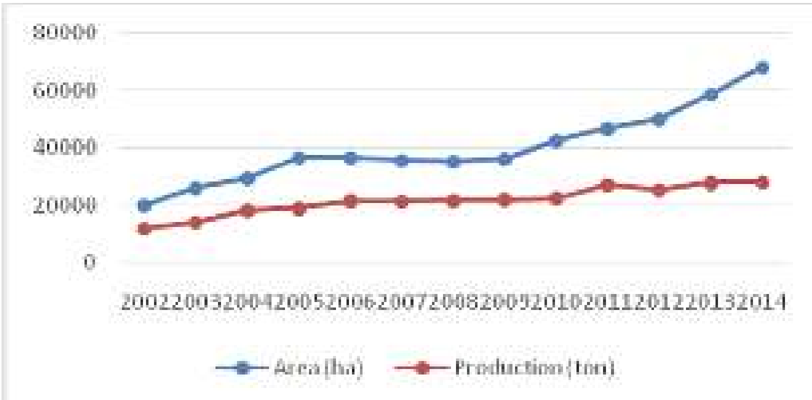


Figure 1. Trend of planted area and production of cocoa bean in Lampung

Table 1. Figures of Lampung cocoa plantation in 2002-2014

Year	Young (Y, ha)	Mature (M, ha)	Old (ha)	Y/M	Total area (T, ha)	M/T	Production (P, ton)	P/T	P/M
2002	7,549	12,005	561	0.63	20,115	0.60	11,579	0.57	0.96
2006	14,263	21,379	966	0.67	36,597	0.58	21,548	0.59	1.00
2008	11,674	22,780	1,003	0.51	35,457	0.64	21,662	0.61	0.95
2010	17,962	27,454	1,042	0.65	46,458	0.59	26,598	0.57	0.97
2011	19,441	29,451	1,051	0.66	49,943	0.56	25,541	0.51	0.87
2012	22,823	29,994	1,015	0.76	53,832	0.56	28,495	0.53	0.95
2013	27,287	33,532	1,436	0.81	62,265	0.54	30,907	0.50	0.92
2014	35,014	32,057	1,081	1.09	68.152	0.47	28,067	0.41	0.87

Note: Young = not yet productive, mature = productive, Old = unproductive

Source: Calculated from Statistics of Lampung Province, 2003-2015

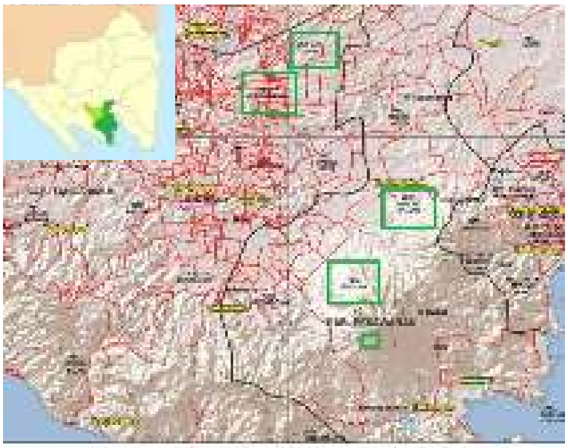
METHODS

Field Study

The site of this survey covered two regencies of Lampung Province which were purposively sampled representing low land (Pringsewu Regency) and mountainous land (Pesawaran Regency) of cocoa smallholder plantations. In each regency we purposively sampled two districts with large area of cocoa, and randomly sampled 500 farmers to be interviewed. The sampled districs were Sukoharjo and Adiluwih of Pringsewu and Gedung Tataan and Way Lima of Pesawaran Regency. We askedabout cocoa land area, cocoa age, cocoa population, cocoa plant management, pests, diseases, yield and revenue from cocoa and mixed crops.

Field survey was conducted in one cocoa village (Harapan Jaya Village, Pesawaran Regency) with the highest elevation to survey problem of black pod disease in the farms where chemical fungicide were not applied.Fields were purposively sampled to observed severity of national and local clones from Phytophthora pod rot or black pod disease. Cocoa trees having pod disease symptoms were randomly sampled.

Pringsewu Regency is located at 104º42’ - 105º08’ E and 05º20’ - 05º57’ S with elevation of 100-200 m above sea level. Pesawaran Regency is located at 104º94’ - 105º20’ E and 05º14’ - 05º77’ S with elevation 100-400 m above sea level. Harapan Jaya village is located at 105º05’ E and 05º33’ S with elevation 400-600 m above sea level. Rainfall is 1500-2300 mm year^{-1} with 2-5 dry months occurring in June – October.



Source: Geospasial PNBP, 2010

Figure 2. Location of study site (in green mark)

Data analysis

We based cocoa trees spacing of 3x3 m with population 1111 trees/ha (Koko et al., 2013) and calculated the effective land for cocoa as percentage of existing population/1111. Analyses of Impotance Value (IV) was modified from Mardi et al. (2014) and Ofori-Bah &Asafu-Adjye (2011) using frequency and revenueshare (mixed crop revenue/cocoa revenue). It was based on consideration that the bigger the frequency and revenue share, the more important the mixed crops are. We calculate IV as sum of Relative frequency and Relative revenue. We expressed Economic Yield Index (EYI) ofmixed cocoa system as EYI = (1 + mixed crop revenue/cocoa revenue) x 100%.

Based on growth stage of fruit using BBHC scale (Niemenak *et al*., 2010), the rotten fruits were scored. The healthy cherelles, cherelle wilts, healthy and diseased pods (minimum 0,5 cm^2 of black spot) were counted. The scores were 1 for cherelle wilt (BBHC 70-74), 3 for small pods (BBHC 75-76), 5 for big pods (BBHC 77-80), and 1 for ripe pods (BBHC 81-89). Severity score is total of each fruit stages score.

Severity score = ∑ fruit stages score

Fruit stage score = number of disease fruit x score/number of fruits

RESULTS AND DISCUSSION

Cocoa plantations in Lampung have less ideal of plant age structure (Figure 3)in which young productive trees (age of 5-9 year) are dominant (46%) and trees in highest productive phase (10-14 year) are the second (28%).It is supported by data in the last ten years, that the areas of young cocoa rise consistanly by 28% a year, indeces of expansion area (Y/M) shows a positive trend (Table 1). Cocoa plantations in Lampung are smallholders of ≤2 ha land area; mostly (57%) farmers have less than 1 ha (Figure 4). Lampung was a beginning destination of transmigration from Java Island. Starting in period of 1905 – 1922 inhabitants came to along Gedung Tataan (Pesawaran) to Wonosobo (West Kota Agung, Tanggamus) (Levang and Sevin, 1990) that occupied limited land for agriculture (Kingstone, 1990) including for cultivating rice, other food crops, fruits and cash crops such as cocoa, coffee, coconut, and banana.

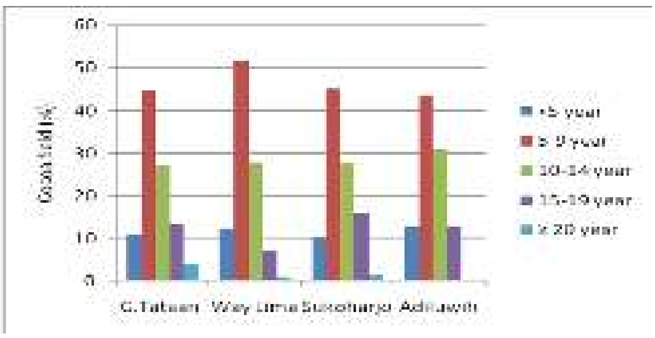


Figure 3. Structure of plant age

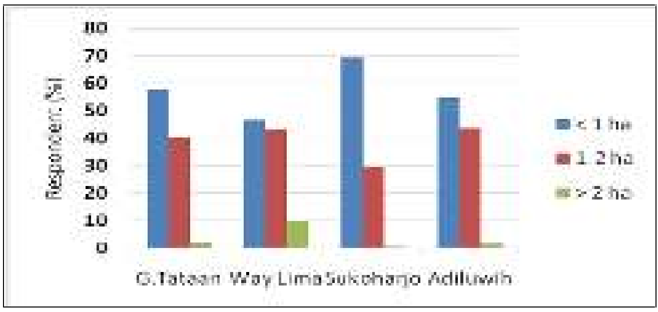


Figure 4. Farmers' cocoa land area

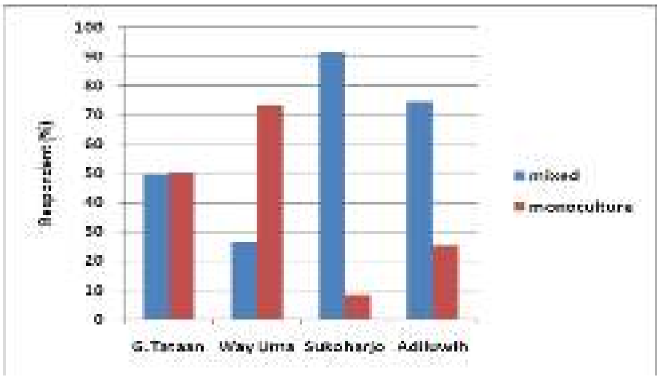


Figure 5. Cocoa fields of mixed culture and monoculture

Most cocoa plantation in Lampung is mixed culture (61%) particularly in ex-transmigration Regencies (Gedung Tataan, Sukaharjo, and Adiluwih) and the rest (39%) is monoculture (Figure 5). Cocoa farmers owning small land tend to cultivate mix crops in the same land to increase land equivalent ratio (LER) and income. Tree diversity within the cocoaproduction systems is variable, depending on management, cultural differences, locationand farm history (Schroth and Harvey, 2007). We found at least 17 tree cropspecies mixed with cocoa including food crops, fruits, spices, timber, and other cash crops that generate family income. The mixed crops were more diverse in Pesawaran District than those in Pringsewu District. Coconut is most common crop found as mixed crop in cocoa field (f=152) especially in Pringsewu District as a lowland, followed by banana (f=69). Based on importance value (IV), the important mixed crops found in cocoa field were coconut, banana, Parkiaspeciosa, and rubber with the value 94.3%, 37.4%, 17.38, and 17.33% respectively (Table 2). Intercropping cocoa-coconut is commonly recommended due to high yield of cocoa bean about 600-2300 kg ha^{-1} (Osei-Bonsu et al., 2002). Cocoa-banana is commonly usedsince banana gives shade for cocoa trees (Schroth and Harvey, 2007). Parkia speciosa is a legume tree that is commonly found in smallholder plantations in Lampung as its fruit has high economic value and provide shading for cocoa and coffee. Rubber intercropped with cocoa is also recommended as it provides shade, revenue and ecological service (Langenberger *et al*., 2016).

Effective land for cocoa trees (or its population) mixed with coconut, banana, or coffee tend to lower than those with Parkiaspeciosa, durio, rubber tree, or cloves. Mixed cropping with coconut, banana, and coffee reduced population of cocoa trees. Coconut and banana was the most popular mixed crops for cocoa. Coffee is a traditional crop in medium and high altitude land while rubber tree is common in low altitude land. Dupraz and Morisson (2015) stated that cocoa trees could gradually replacing and mixed cropping with traditional crops including coconut, coffee, rubber, and banana that developed various types of diversification.

Table 2. Importance value index of cocoa mixed crops

Mixed crop	Pesawaran District				Pringsewu District				IV aver
	Gedung Tataan		Way Lima		Sukoharjo		Adi Luwih		
	% Rev (F)	IV	%Rev (F)	IV	%Rev (F)	IV	%Rev (F)	IV	
1. Coconut	8.07(8)	11.52	14.23(3)	23.86	33.99(105)	162.77	36.34(36)	179.07	94.30
2. Banana	18.28(35)	68.98	7.80(7)	42.69	18.65(24)	28.26	11.42(3)	9.71	37.41
3. Parkia speciosa	34.07(9)	25.12	36.27(3)	42.95	0(2)	1.45	0(0)	0	17.38
4. Rubber	14.07(18)	31.53	10.18(5)	33.92	0(2)	1.45	0(1)	2.44	17.33
5. Clove	26.82(3)	7.24	29.52(2)	24.73	0				7.99
6. Coffee	55.61(4)	15.64	24.19(1)	10.83	0				6.62
7. Durio	11.68(8)	13.02	2.06(3)	13.32	0		0	0	6.58
8. Nutmug	19.57(8)	16.30	0	0	0				4.07
9. Long pepper					98.18(1)	3.11	90.94(1)	8.78	2.97
10.Kayu Jabon			0(2)	7.69	0				1.92
11.Candle nut	22.96(2)	4.43	0(0)	0	0				1.11
12. Kapuk	30.30(1)	2.59		0	0				0.65
13. Avocado	17.54(1)	1.93		0	0				0.48
14.Salak	12.50(1)	1.67	0		0				0.42
15.Waru					0(2)	1.45			0.36
16. Pinang					2.29(1)	0.78			0.19
17. Acasia sp.					0(1)	0.72			0.18
Sum	(n=98)	200	(n=26)	200	(n=138)	200	(n=41)	200	

Mixed cropping cocoa with other trees generated more revenues. Economic yield index of mixed cocoa system was about 110-135%, but it tend to be higher in cocoa-coconut, cocoa – P. speciosa, and cocoa-coffee (134-135%) than othercropping systems. Bean yield of cocoa mixed with various cash treeswas about 790-860 kg/ha/year. Itsvariabilitywas high with standard deviation about 150-520 kg.Compared to other reports, this yield was considerably low. Mixed cropping cocoa-orange or cocoa-avocado resulted about 1.3 ton ha^{-1} $year^{-1}$ cocoa bean (Koko *et al*., 2013). Associating timber trees with cocoa did not negatively affect cocoa yield (Somarriba and Beer, 2011). Diversified (or mixed) cocoa farms are more efficient than single crop (or mono-crop)cocoa farms, indicating possibilities for cost complementarities between production of cocoa and mixed crops (Ofori-Bah and Asafu-Adjye, 2011).

Productivity of cocoa field on average in 2011-2013 is presented in Figure 6. In 2011-2012 productivity ranged from 1300 to 1500 kg ha^{-1}. In 2013 productivity dropped to about 800 kg ha^{-1}. During the focus group discussions it revealed that in 2014 the productivity drops by nearly 50% so that some farmers converted cocoa plants to rubber or nutmeg plants. The decline in productivity occured due to pests (particularly *Conopomorpha cramerella*) and diseases (particularly black pod) as well as low rainfall followed by high rainfall. According to Wood and Lass (2001), annual rainfall in excess of 2500 mm may lead to a higher incidence of fungus diseases, particularly *Phytophthora* pod rot (black pod disease). Moreover, Adjaloo et al. (2012) reported that rainfall positively affected flowering and phonological cycle.In addition, Sabatier et al. (2013) concluded that the behavior of cocoa agroecosystems (pests, diseases and yields) depends on its management.

Table 3. Effective land for cocoa, economic yield index, and cocoa bean yield

Mixed crops in cocoa field	Effective land for cocoa[1] (%)	Cocoa bean yield (kg/ha)	Economic yield index (%)
Coconut	73.51± 24	792.16 ± 519	134.10 ± 21
Banana	73.71± 16	863.51 ± 469	118.93 ± 22
Parkia speciosa	81.13± 19	801.42 ± 381	134.61 ± 29
Durio	97.61± 38	816.60 ± 361	110.15 ± 12
Rubber	80.26± 28	845.10 ± 455	116.18 ± 21
Clove	80.41± 12	855.74 ± 149	120.96 ± 20
Coffee	72.13± 15	854.19 ± 300	135.51 ± 13

Note: 1. based on spacing 3x3 m, population 1111

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Since 2011-2013 productivity declined. In 2013, in Gedung Tataan and Way Lima, productivity was dominated (82%) by low (<500 kg/ha) and middle levels (500-1000 kg/ha). In Sukoharja the productivity are quite similar among the levels. In Adi Luwih, productivity was dominated by middle and high levels (>1000 kg/ha) (Figure6). Farmers in Adi Luwih showed an intensive maintenance of cocoa farming in terms of pruning, fertilizing, manuring and applying pesticide.In small land tenure of cocoa farming, it is important to achieve high production.

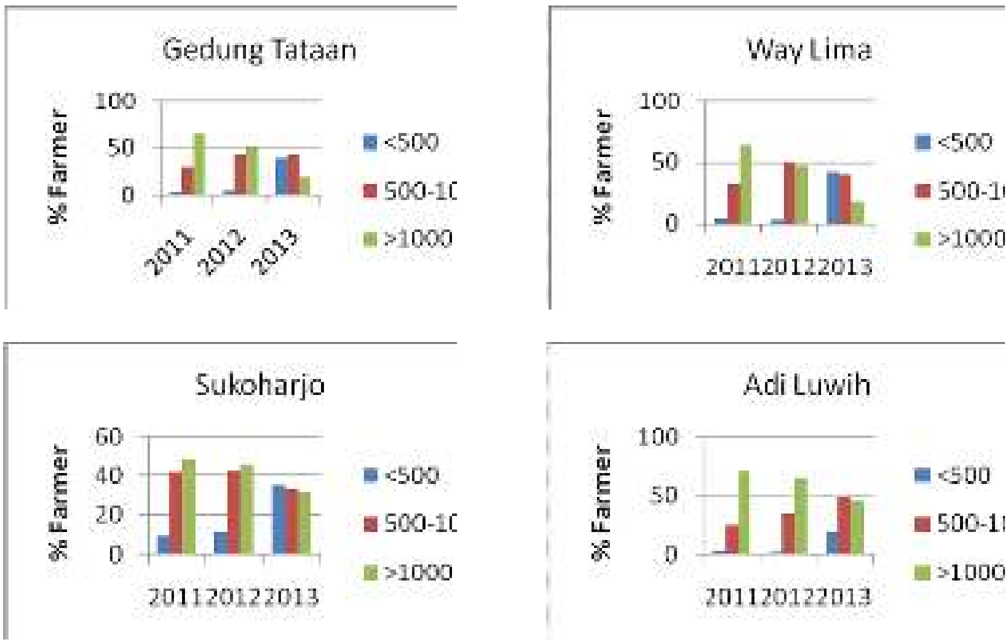

Figure 6. Dynamic of cocoa productivity by district

To achieve high production, farmer in Sukoharjo and Adi Luwih were more eager to expand cocoa plantation. Farmers were optimistic that cocoa farming remains profitable despite some obstacles such as the incidence of pests and diseases and climate change that cause decreased production of cocoa. For example, black pod disease can be overcome by pruning, sanitation, and planting disease-resistant cocoa clones. Related to climate change, Schroth *et al.* (2016) concluded that adaptation measures are needed such as by selecting cocoa varieties and companion trees and crops that are tolerant to high temperatures, drought and diseases, increasing shade to protect cocoa trees and diversifying farmers' income as a buffer against market and environmental risks.

Table 4 showed the important cocoa diseases in Lampung. The most important disease is black pod disease by *Phytophthora palmivora* causing significant lost of cocoa yield in the last 3 years in Lampung. Another important disease is trunk cancer also caused by *Phytophthora palmivora*. Climate change, applying too much fungicide, improper pruning, and bad sanitation may induce the fungi to spread. Another disease called vascular steak dieback (VSD) caused by *Oncobasidium theobromae* is not much important in Lampung.Controlingcocoa plant disease (including black pod) could be achieved if an integrated management strategy is established, with the combination methods such as phytosanitaryand other cultural measures, and selection for resistant clones (Acebo-Guerrero et al., 2012) including local clones from open-pollinated progenies (Thevenin et al., 2012).

Table 4. Types of diseases that attack cocoatrees in Lampung

Diseases	Pesawaran (of 100% respondent)		Pringsewu (of 100% respondent)	
	Gedung Tataan	Way Lima	Sukoharjo	Adi Luwih
Black pod	90.2	90.0	97.4	98.2
VSD	4.9	6.7	91.4	92.7
Trunk cancer	45.1	44.4	64.9	76.4

In average, 66% of respondents did branch pruning irregularly, so that the cocoa trees were 3-4 high, much branching, dense canopy, low light interception, and high air humidity. It makes cocoa trees susceptible to black pod disease. Black pods were remaining hang on the tree that becomes the source of infection. Moreover, farmers harvest ripe pods and commonly peel it at the field (70% respondent) and left it on the ground without any treatment (72% respondent). Only 10% of farmers used cocoa peel as fodder, commonly for goat (Table 5).

Table 5. Branch pruning, pod peeling, pod waste management

Activities	Treatment	Pesawaran		Pringsewu		Average
		Gedung Tataan	Way Lima	Suko-harjo	Adi Luwih	
Pruning	1 x / year	4.4	5.6	17.9	10.9	9.7
	2 x / year	19.6	10.0	43.7	43.6	29.2
	3 x / year	1.5	0.0	4.0	5.5	2.7
	Irregular	74.5	84.4	34.4	40.0	66.3
Place to peel pod	Field	93.1	97.8	21.2	18.2	69.7
	Home	6.4	2.2	78.1	78.2	28.9
	Field and home	0.5	0	0.7	3.6	1.4
Pod waste management	No treatment	76.0	94.4	57.6	58.2	71.5
	Burning	0	0	3.9	1.8	1.4
	Composting	8.8	2.2	17.2	7.3	8.9
	Buried	0	0	12.6	20	8.1
	Animal fodder	15.2	3.3	8.6	12.7	9.9

This cocoa tree management practices resulted in high incident of black pod especially when season of rainy and foggydays, and the cocoa bean yield has falled below 500 kg/ha/year since year 2013.Moreover, most farmers (77%) cultivated local cocoa cultivars which are susceptable to black pod disease. Farmers made seedlings by themselve using local seed resource. So far, neither local clones nor national clones were really resistant to black pod disease. We observed 4 selected local cloneswhere50% of trees had incidence of the disiease with severity scores 4.46. From 9 national clones we calculated the severity score was 2.79. However, Sul2 of national clone was indicated as a tolerant clone with the lowest score of 0.91 followed by RCC 70 and TSH 858 with scores of 1.49 and 1.83 respectivel (Table 6). Theseclones had low severity score because incidents of black pod were found at cherelle, small, or ripe pods, while their big pods were free from black pods (Figure 7). MCC1 (well known as M 01 clone) selected for high yielding clone was a moderat-tolerant to black pod disease (McMahon et al., 2015).Gradient resistance of black pod disease may occure in testing of genotypes of cocoa (dos Santos *et al.,* 2011).

Table 6. Severity score of black pod disease of national and local clones

	Clone	Diseased Tree (%)	Severity Score
National	RCC 70	36.15	1.49
	RCC 71	21.05	5.83
	MCC1	34.62	2.39
	Sul 3	26.09	2.55
	ICCRI 7	23.08	2.57
	Sul2	21.42	0.91
	ICCRI 3	18.18	2.77
	TSH 858	23.81	1.83
	Sul 1	34.61	4.77
	Average	**27.67**	**2.79**
Local	LT1	57.14	4.28
	LT7	46.15	5.17
	LP1	54.54	4.98
	LP6	42.86	3.43
	Average	50.17	4.46

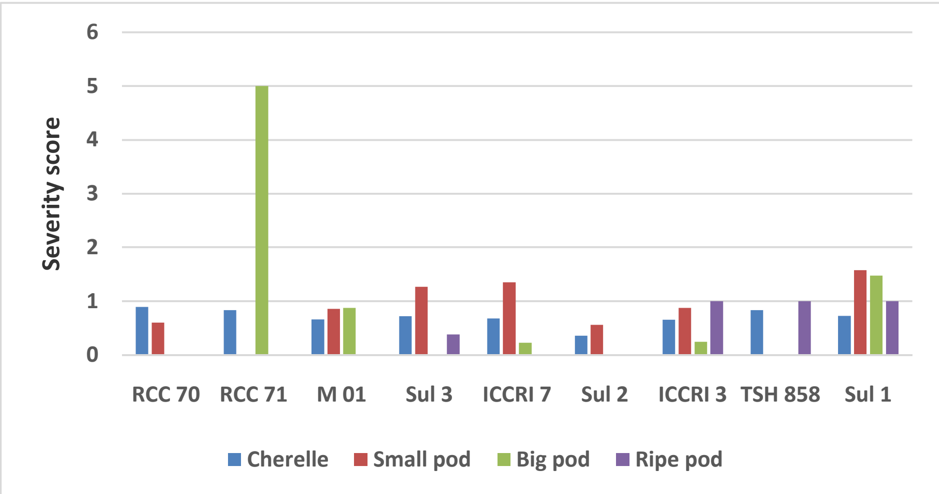

Figure 7. severity score breakdown in fruit development

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