Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.3, No.7, 2013
www.iiste.org

The Intensity Distribution of Cacao Pod Rot Disease (*Phytophthora palmivora* Butl.) in Smallholder Plantation in North Maluku Indonesia

Suratman Sudjud[1)], Ika Rochdjatun Sastrahidayat[2)], Gatot Mudjiono[2)], Anton Muhibuddin[2)]

1. Doctoral student of Agriculture Science Program, Major in The Pest and Desease Plant of Agriculture, Brawijaya University, Malang, East Java, Indonesia/Lectur in The Agriculture Fakulty Khairun University, Ternate, North Maluku, Indonesia.
2. Lecturers in The Agriculture Faculty Brawijaya University, Malang, East Java, Indonesia.

* E-mail of the corresponding author: suratmansudjud@ymail.com

Abstract

One of important diseases in cacao is pod rot disease. Production loss caused by the disease in Indonesia and other cacao producer countries is more than 30% every year. The research aims to find out the incidence and intensity of cacao pod rot disease in smallholder plantation areas and their distribution pattern in North Maluku.

The research is conducted in West Halmahera and South Halmahera regencies in four locations with different altitude in three repetitions. Plant sampling is conducted systematically. In every experience unit, five observation sub-plots are determined. The number of plant sample for every observation sub-plot is ten plants; therefore, the number of total plant sample in every smallholder plantation is 600 plants. Observation variables include cacao pod rot disease incidence, intensity and distribution pattern in North Maluku.

Research result shows that the average of pod rot disease incidence based on the altitude is 12.27% (at 8-15m a.s.l), 18.76% (at 18-30m a.s.l) and 20.70% (at 186-210m a.s.l) for infected pod incidence and for infected plant incidence is 64% (at 8-15 m a.s.l), 68,67% (18-30 m a.s.l), 84% (at 55-76 mdpl), and 84,67% (at 186-210 m a.s.l). In average, the intensity of cacao pod rot disease in various altitudes is 27,20% (at 8-15 m a.s.l), 27,87% (at 18-30 m a.s.l), 36,00% (at 55-76 m a.s.l), and 39,87% (at 186-210 m a.s.l). The distribution pattern of disease intensity is distributed evenly in all observation locations in North Maluku with the highest infection intensity is 39.87% (moderate). Result from comparison test (t-test) indicates that there are significant differences on disease incidence and intensity among altitudes except between 8 – 15 m a.s.l and 18 – 30 a.s.l.

Keyword : *Theobroma cacao, pod rot, altitude, desease incidence and intensity*

1. Introduction

Pod rot disease is one of important diseases causing a reduction on cacao production, either in cacao producing countries or in Indonesia, including North Maluku. In general, the loss caused by this disease is estimated at 20 – 30 % of cacao production every year (Djocgoue et al, 2010). The loss can reach 90% if the cultural technique (variety) is used in a long period and with supporting environmental factors (Iwaro et al, 2005).

In Indonesia, the loss is different among plantations and it is varied between 26 – 50% (Semangun, 2000; Sukamto, 1985). The loss in Central Java, East Java and West Java can reach 49.8%, 46,43% and 42,30%, respectively (Pawirosoemardjo and Purwantoro, 1992). In North Maluku, the intensity of damage caused by pest and disease in smallholder cacao plantation is 62% and production loss can reach 47% (Sudjud, 2009).

There are no studies conducted regarding the intensity of pod rot disease attack in smallholder cacao plantation in North Maluku Province. Whereas, cacao plant in this area tends to decrease overtime. According to data from directorate general of plantation (2013) that cacao production in North Maluku for 2008-2012 is fluctuated and it tends to decrease. It can be seen from cacao production for 2008 – 2011. In 2008, the production is 12.534 ton and it increases to 13.228 ton in 2009; however, in 2010 and 2011 the production is decrease to 12.884 ton and 9.846 ton, respectively.

Various factors are assumed as the cause for fluctuation in cacao production. These factors include the condition of cacao planted, disease-causing pathogen and environmental or weather factors supporting the disease development. The incidence of a disease is the result of interaction of various factors that mutually supporting, which are, disease-causing pathogen, host plant, and supporting environmental factors (Van der Plank, 1963).

One of factors causing decrease in cacao production in Norh Maluku is pod rot disease. The disease can occur in young pod (*cherelle wilt*) to the ripe one. The symptom on infected pod is discoloration of pod with clear boundary between the healthy part and the infected one. The infected part of the pod quickly spreads to the whole pod surface and turns the pod color into blackish brown. The infected pod will undergo dry weight decrease if the pod is big or ripe; however, it cannot be harvested if the infected pod is still young. According to Semangun (2000) and Umayah (2004), the general symptom of pod rot disease infection on cacao is pod discoloration started from the tip of the pod or near the stem and quickly spread to the whole pod. The research

aims to find out pod rot disease incidence and intensity in smallholder plantation and the distribution pattern of the disease in North Maluku.

2. Research Method

Survey on the intensity of cacao pod rot disease was conducted in four locations. Two separated locations were Akediri Village with altitude of 18-30 m a.s.l and Hoku-Hoku Kie Village with altitude of 55-67 m a.s.l in Jailolo Sub-district, West Halmahera Regency and in Hidayat and Kampung Makian Village in Bacan Sub-district South Halmahera Regency with altitude of 8-15 m a.s.l and 186-210 m a.s.l, respectively. Distance between West Halmahera and South Halmahera Regencies is ± 188 km. Survey was conducted on Pebruari to Juni 2012. Research locations have flat to slope topography and are applying intercropping and mixcropping. Plant spacing was varied between 3 x 3 m, 4 x 2 m and 3 x 2,5 m. Research location is displayed in Figure 1.

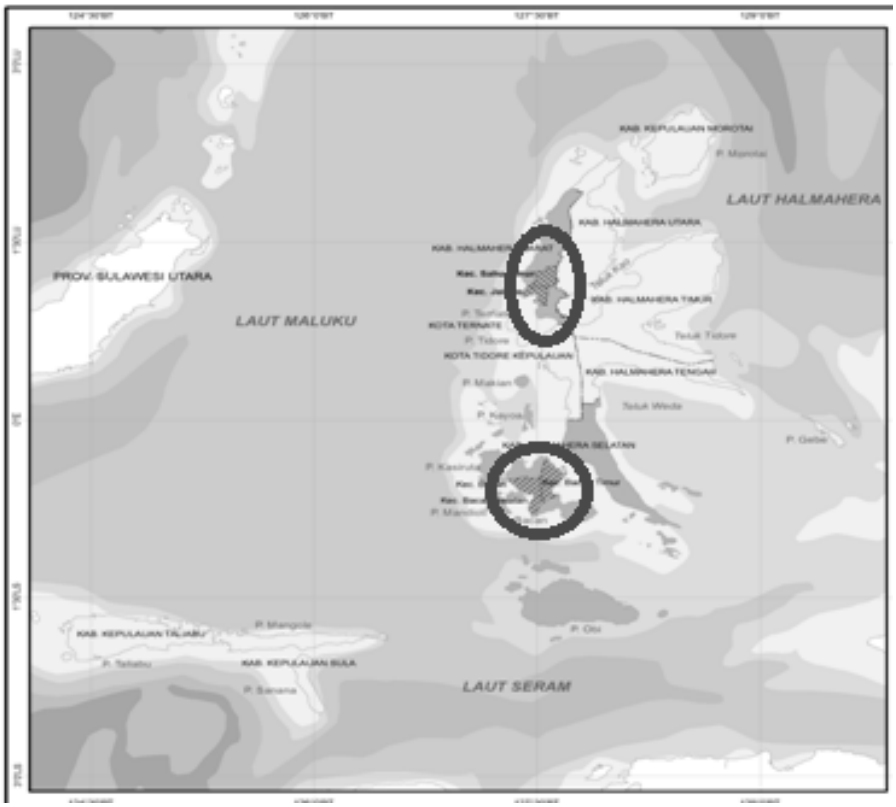

Figure 1. Map of Pod Rot Disease Research Location

Determination of sample size can be done with purposive sampling method with certain consideration based on Sugiyono (2010) or using formula from Parel et al (1973) as follow:

$$n = \frac{N.Z^2.s^2}{N.d^2 + Z^2.s^2}$$

Where: N : unit number of total sample in a population, d : maximum accepted error, Z : normal variable, which is distribution with normal pattern, S^2: variance, n : sample size

In each altitude of observation location, the experiment was repeated three times, thus resulted in total 12 units of experiments at smallholder cacao plantation area.

Every area of smallholder cacao plantation divided into five sub-plots, each 30 m^2 of area. Plant samples were selected systematically in sub-plots (Silk, 1979; Rivai, 2006; Yunus, 2010; Morissan, 2012). According to Silk (1979), systematic sampling method in spatial distribution of a planting or heterogenic soil will give smaller sampling error compare to simple random sampling method. Ten plant samples were taken from every sub-plot that made total 50 plant samples for experiment area of 1 ha, so total plant samples observed was 600 plants.

Observation variables of pod rot disease were based on disease incidence, intensity and distribution pattern. The percentage of disease incidence usually states with following formula:

$$\boldsymbol{KP = \frac{n}{N}\, x\, 100\%}$$

Where: KP : disease incidence , n : number of infected plant individual or organ, and N: number of plant

observed
Disease intensity was calculated using Townsend and Heuberger formula (1943) in Unterstenhofer (1976):

$$IP = \frac{\Sigma(ni \; x \; vi)}{Z \; x \; N} \; x \; 100 \; \%$$

Where: IP : disease severity , ni : number of tree with attack category, vi : numeric number of every attack category, Z : numeric number of the highest attack category, and N : number of observed tree
Description of symptoms on every plant samples is displayed in Table 1.
Tabel 1. Category for Disease Intensity Assessment

	Symptoms Description
0	X = 0 %
1	0 < X 10 %
2	10 < X < 25 %
3	25 < X < 50 %
4	50 < X < 75 %
5	X > 75 %

Note X : The Percentage of Infected Pod from All Pods on Plant Sample

3. Result and Discussion

3.1. The Condition of Cacao Smallholder Plantation in North Maluku

North Maluku is one of islands province in the East Indonesian Area (Kawasan Timur Indonesia/KTI) and it is located between 3^0 of north latitude – 3^0 of south latitude and 124^0 – 129^0 of east longitude. Province boundary areas of North Maluku are Pacific Ocean in the north, Halmahera Sea in the east, Maluku Sea in the west and Seram Sea in the south. As an islands area, North Maluku province has 397 big and small islands with various natural resources potential. One of the potential is plantation sector.
Plantation sector is the main sector in North Maluku with such commodities as coconut, *Theobroma cacao*, *Eugenia aromatica*, and *Myristica fragrans*. *Theobroma cacao*, as one of the main commodities of the community, is mostly planted in all islands areas in North Maluku. According to BPS (2012), until 2011, cacao is the main commodity of North Maluku after coconut (*Cocos nucifera*); whereas, *Eugenia aromatica* and *Myristica fragrans* are following in the third and fourth rank.
Cacao cultivation in North Maluku has been in this area since 1829 (van Hall, 1949). The area of cacao plantation in 2007 is 33.972 ha, and it increases in 2008 to 34.841 ha and 34.947 ha in 2011 (BPS, 2012). All of this data are the area of cacao plantation managed by the community or smallholder plantation. Based on the data, the area of cacao plantation is increasing; however, the production fluctuates and tends to decrease. Data from directorate general of plantation (2013) states that cacao production in Indonesia especially in North Maluku has fluctuated since 2008-2012 and tended to decrease (Figure 2).

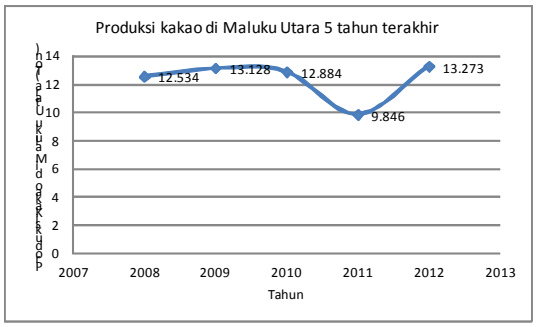

Figure 2. Cacao production in North Maluku for 2008-2012

Fluctuation and decrease on cacao production in North Maluku based on survey result is caused by three main problems. First, conventional management consists of the seed used, planting, cultivation, and post-harvest activities. The seed used came from the existed seed or from mather plant in the planting area of cacao farmer. Even seedlings that have been growth in the area around the plantation often being used in cacao cultivation, they were removed and planted in cacao plantation area. Second, unproductive plant (age above 30 years) and third, plant pests (OPT).

3.2. Cacao pod rot disease on smallholder plantation in North Maluku

Survey results on cacao pod rot disease in smallholder plantation area in West Halmahera and South Halmahera Regencies, North Maluku Province show that cacao pod rot disease is found in all observation locations with different attack level among the locations.

Disease Incidence pod rot cacao

The incidence of cacao pod rot disease is based on disease's symptoms found on plant samples. The level of disease incidence can be known by comparing the number of cacao infected or attacked by pod rot disease in every plant sample with the number of pod observed.

Survey found that in various altitudes in South Halmahera and West Halmahera Regencies, the level of disease incidence, either on attacked pod or attacked plant, in each location is different as displayed on Figure 3.

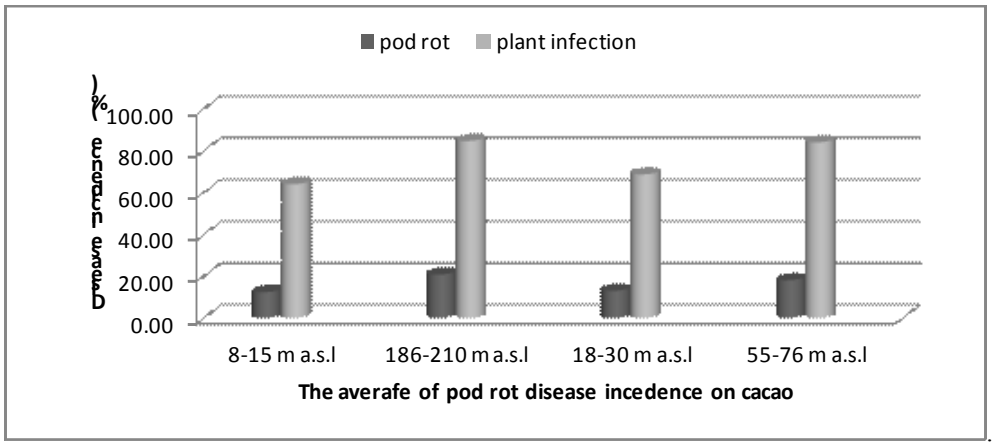

Figure 3. The average of pod rot disease incidence on cacao

Figure 3 shows level of disease incidence of cacao pod rot. It indicates that the average of disease incidence level of cacao pod rot in various altitudes (Figure 3) is 12,27% (at 8-15 m a.s.l), 13,00% (at 18-30 m a.s.l), 18,76% (at 55-76 m a.s.l), and 20,70% (at 186-210 m a.s.l) for incidence of pod attacked. Whereas for plant attacked the average is 64% (8-15 m a.s.l), 68,67% (at 18-30 m a.s.l), 84% (55-76 m a.s.l), and 84,67% (at 186-210 m a.s.l). It means that in every altitudes 54 (at 8-15 m a.s.l), 47 (at 18-30 m a.s.l), 24 (at 55-76 m a.sl), dan 23 sample plants were obtained that did not attack by pod rot disease from 150 sample plants in every altitudes or 600 sample plants as a whole.

Based on data of disease incidence, it can be seen that the incidence is relatively higher for attacked plant compare to attacked pod. It is because the assessment was based on the existence of pod determined to be having symptoms of pod rot disease. Whereas, assessment on attacked pod was based on the comparison between the number of pod showing pod rot disease symptoms and the number of pod observed in every sample plant. Data on disease incidence, either on attacked plant or on pod, indicates that disease incidence increases with the increase of location's altitude.

Result from normality test analysis (kolmogorov-smirnov), based on disease incidence of cacao pod rot in each observation location in West Halmahera and South Halmahera, shows that the number of disease incidence for infected pod is 0.663 and 1.129 for infected plant. While, the number of disease incidence among observation locations is 0.754. This number shows that data is normally distributed because it is less than 1.97 (standard of kolmogorov-smirnov normality). Data of comparison analysis between t-test and observation variable of disease incidence (%) both on infected pod or on infected plant for each locations is presented in Table 2.

Table 2. Data of comparison analysis of disease incidence

Comparison Analysis			Disease Incidence (%)	
			Pod	Plant
			t-test Value (95%)	
8-15 m a.s.l	-	186-210 m a.s.l	0.000*	0.000*
8-15 m a.s.l	-	18-30 m a.s.l	0.711^{tn}	0.504 ^{tn}
8-15 m a.s.l	-	55-76 m a.s.l	0.002*	0.000*
186-210 m a.s.l	-	18-30 m a.s.l	0.003*	0.030*
186-210 m a.s.l	-	55-76 m a.s.l	0.058*	0.667 ^{tn}
18-30 m a.s.l	-	55-76 m a.s.l	0.021*	0.037*

Note : * significant; ^{tn} insignificant

Based on result from t-test analysis in Table 2, it is shows that there was significant difference between disease incidence on infected pod and infected plant in each observation location in West Halmahera and South Halmahera Regencies at confidence level of 95%. The insignificant difference was found in disease incidence (%) at 8-15 m a.s.l and 18-30 m a.s.l and at 186-210 m a.s.l and 55-76 m a.s.l for attacked plant; however, significant difference was found in attacked pod.

Disease intensity pod rot caco (%)

Result from survey in various altitudes in South Halmahera and West Halmahera Regencies indicates variation on disease intensity in each altitude for both West Halmahera and South Halmahera Regencies. Result for intensity of pod rot disease is presented in Figure 4.

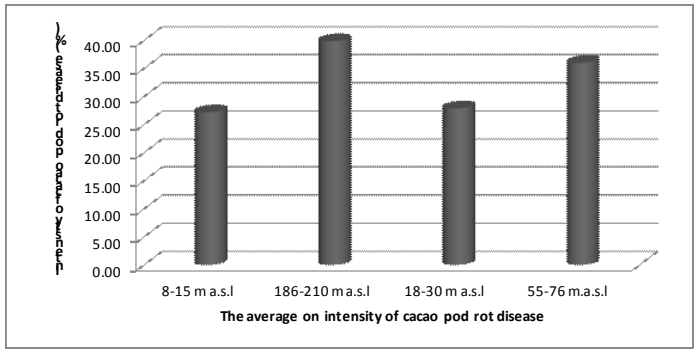

Figure 4. The Average of Intensity of Cacao Pod Rot Disease

Figure 4 shows that the average of intensity of cacao pod rot disease in various altitude is 27,20% at 8-15 m a.s.l, 27,87% at 18-30 m a.s.l, 36,00% at 55-76 m a.s.l, and 39,87% at 186-210 m a.s.l. The amount of disease intensity determines by the number of pod having pod rot disease symptoms or being infected by the disease-causing pathogen. The more the number of infected pod in every sample plants, the more the intensity of the disease, and vice versa.

Based on data on disease intensity, it can be seen that disease intensity is increasing with the increasing of altitude. It is also shown in the assessment of disease incidence. Therefore, it can be assumed that altitude can have influence on the intensity of cacao pod rot disease. According to Miller (1976), tropical area is generally characterized by similar climate; however, with geographical differences, such as altitude above sea level (a.s.l), weather and climate will be completely different in the area, especially temperature, humidity, and rainfall. In addition, the rate of temperature decrease varies for every place. These differences are assumed to influence differences in the intensity of cacao pod rot disease in every observation location.

The amount of disease intensity in every observation location is used as a base to make a distribution map for cacao pod rot disease in North Maluku. Determination on categories of mild, moderate, severe and very severe is based on disease intensity scoring resulting from disease intensity assessment obtained from cacao plantation in every observation location with different altitude.

Normality test analysis (kolmogorov-smirnov) based on data on disease intensity of cacao pod rot in every observation location in West Halmahera and South Halmahera Regencies resulted in figures of disease intensity of 0.759 and between observation locations is 0.754. These figures indicate that data is distributed normally

because it is less than 1.97 (standard of kolmogorov-smirnov normality). Data of comparison analysis between t-test and observation variable of disease intensity (%) among observation locations is presented in Table 3.

Table 3 Data of comparison analysis of disease intensity (%)

Comparison Analysis			Disease Intensity (%)
			t-Test (95%)
8-15 m a.s.l	-	186-210 m a.s.l	0.000*
8-15 m a.s.l	-	18-30 m a.s.l	0.850^{tn}
8-15 m a.s.l	-	55-76 m a.s.l	0.003*
186-210 m a.s.l	-	18-30 m a.s.l	0.006*
186-210 m a.s.l	-	55-76 m a.s.l	0.050*
18-30 m a.s.l	-	55-76 m a.s.l	0.033*

Note: * significant; ^{tn} insignificant

Table 3 indicates that there are significant differences on disease intensity (%) in every observation locations in West Halmahera and South Halmahera Regencies at confidence level of 95%. Significant differences can be found in the comparison of disease intensity between 8-11m a.s.l and 186-210 m a.s.l, 8-11m a.s.l and 55-76 m a.s.l, 186-210 m a.s.l and 18-30 m a.s.l, 186-210 m a.s.l and 55-76 m a.s.l and 18-30 m a.s.l and 55-76 m a.s.l. Whereas, no significant difference is found between 8-11m a.s.l and 18-30 m a.s.l with 0.850.

3.3Observation on symptoms of cacao pod rot disease

Observation on symptoms of cacao pod rot disease aims to proof that the amount of disease incidence and intensity as mentioned on previous description is truly cacao pod rot disease. Result from the observation of attack symptoms on infected cacao pod in various altitude shows that pod rot disease could happen in various age, from young pod (*cherelle wilt*) to ripe pod. Harvested cacao also can be infected by pod rot disease if it is pile in one place altogether for a long period before cacao seed is removed from the pod.

Symptom of infected pod is discoloration on pod with clear boundary between healthy part and infected part. This discoloration generally started from pod stem or pod tip (Figure 5). The infected part of a pod will spread quickly to all pod surfaces that turn the color of pod to blackish brown. On spotted part (infected part), white, flour-like layer is emerge that constitute of secondary fungus forming spore. If the infected pod is not removed immediately, this fungus will develop and become inoculums source infected other pods.

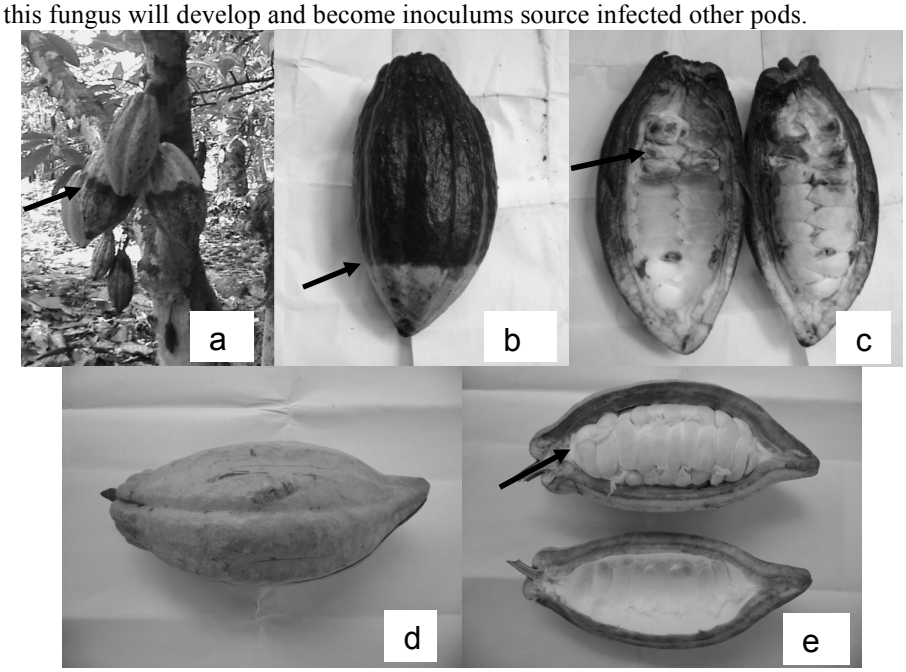

Figure 5. Symptoms of pod rot disease on pod tip (a), infected pod, (b) infected seed in pod (c), healthy mature pod (d), healthy pod seed (e)

Cacao pod with age of ± 60 – 70 days (two months) after flowering (pod size of ± 10 cm), if it is infected, the

pod cannot be harvested. However, if the infection happens on ripe pod, it can be harvested but the infected seed will have blackish brown color and it will reduce the quality and quantity of seed yield. The infected pod will rot in 8 – 15 days depending on the pod size.

Result from other researches state that rotten pod could happen in every age, since it is young to ripe. Generally, the pod color will change from the tip or near the stem and spread quickly to the whole pod (Semangun, 2000; Umayah, 2004; Guest, 2007). Pod will rot in 14-22 days (Purwantara, 1992). Jackson and Wright (2001) in Ramlan (2010) states that infected pod will rot totally in 2 weeks.

According to Guerrero et al (2012), the easiest recognized symptoms from *Phytophthora* infection on cacao is the appearance of black spot on infected pod in any cacao location, the most frequent infection is on the tip of pod near the soil. The infected pod soon turns to black and mummificated, which is the source of secondary inoculum and causing the main economic loss.

Research result shows that different morphological characters of cacao pod will bring differences on attack intensity. These differences can be seen from variation of disease incident on infected pod or plant either at locations with the same altitude or different altitude. Based on field observation, cacao pod with surface character of relatively rough till rough and with plot that relatively deep till deep is very susceptible to pod rot disease compare to pod with smooth surface and invisible plot. These differences on morphological character on cacao pod show different genotype characters. This will bring different character or accession on cacao pod as a remark for sustainability level to pod rot disease in area of smallholder cacao plantation.

3.4Observation on pathogen causing cacao pod rot disease

Cacao pod showing symptoms of pod rot disease in various observation locations was further observed for disease-causing pathogen at the laboratory. Observation result at the laboratory of disease-causing fungus is presented in Figure 6.

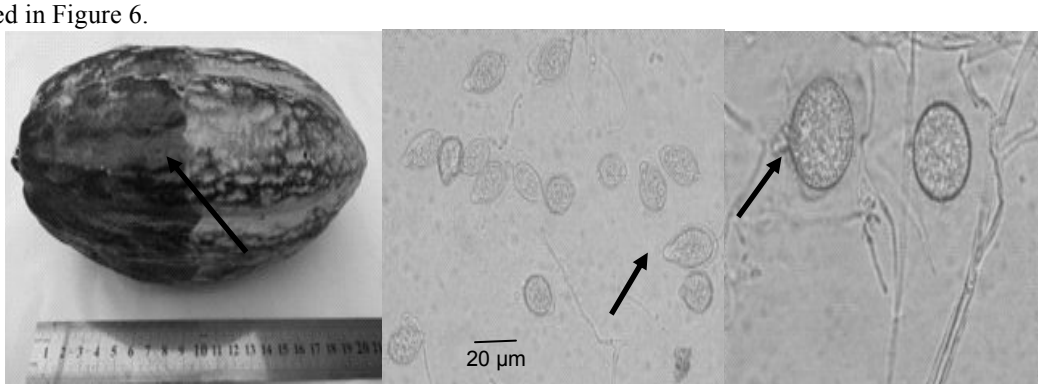

Figure 6. Cacao pod infected by *P. palmivora* (a), variation on sporangium size
(b) 25,4 - 39,8 µm x 19,3 - 24,7, chlamydospore (c)

Research at the laboratory on observation of fungus causing cacao pod rot disease using inoculums and skin of infected pods in area of smallholder plantation resulted in sporangium and chlamydospore that causing cacao pod rot disease.

The sporangium has special form, which is ovoid or similar to pear fruit with bigger part near sporangium stem, and the shape is varies from oval to round. The size of sporangium is varies between 25,4 - 39,8 µm x 19,3 - 24,7 µm. The mycelium is aseptate and ramified. It has round chlamydosphore in the middle part or in the tip of mycelium. Based on the shape, size and mycelium characteristic, fungus causing pod rot disease in the area of smallholder plantation is *Phytophthora palmivora*. Sporangium and clamydospore of fungus causing pod rot disease gained in the research is similar to the shape and chlamydospore stated by Holiday (1980), Sukamto (1985), Semangun (2000), Umayah dan Purwantara (2006).

According to Holliday (1980), sporangium shape is varies depend on the isolate, but generally the shape is oval to round. Twenty sporangia can be obtained in one sporangium stem. Sporangium has caducity characteristic or it is easy to be detached from the stem. It has length around 40-60 µm and width of 25-40 µm. Chlamydospore has shape of globose to sub-globose, intercalary located at mycelium with diameter of 32 – 42 µm. Chlamydospore mostly found in the tip or middle part of mycelium. According to Sukamto (1985), sporangium has special shape, which is elipsodial or ovoid with wider part at the bottom, it has papilla and stem (*pedicel*). Semangun (2000) states that *P. palmivora* sporangium causing cacao pod rot disease has shape like pear fruit with size of 30-60 x 20-53 µm. The sporangiophore is growth sympodially with ovoid and ellipsoid sporangia. It has papilla with l/b ratio of 1,6 – 2,0 and the size of sporangia is 35-60 x 20-40 µm. This variation on shape is caused by different condition of medium, host, the age of breeding, humidity and light, among others.

Result from Umayah and Purwantara (2006) research states that from twenty isolates of *Phytophthora* sp isolated from various parts of cacao plant and collected from six provinces in Indonesia, North Sumatera, Lampung, West Java, East Java, South Sulawesi and Southeast Sulawesi, it can be concluded that all isolates are *P.*

palmivora based on their morphological characteristics. In general, the sporangia has pear-like shape (ovoid), with clear papilla, caducous character (easy to detached from sporangiophore) and short stem. All isolates also produce chlamydospore with round shape, terminal and some are intercalary, with sporangiophore branch is simple sympodial, caduceus and the size of pedicel is 4-6 µm.

4. Conclusion

1. There are differences on the level of disease attack of cacao pod rot in various altitudes.
2. The intensity of disease tends to increase with the increase of place from above sea level.
3. The distribution pattern of attack intensity of pod rot disease exists in all observation locations in Norh Maluku.

References

BPS. 2012. North Maluku in Numbers. Bureau of Statistic (BPS). Ternate

Directorate General of Plantation (Direktorat Jenderal Perkebunan). 2013. Cacao Production in Indonesia Based on Province. www.deptan.go.id/...asem2012/Produksi-Kakao. Access on May 13, 2013

Djocgoue, P.F., C. Simo., H.D. Mbouobda., T. Boudjeko., D.J. Nankeu and N.D. Omokolo. 2010. Assessment and Heritability of Productivity and Tolerance Level to *Phytophthoora megakarya* in Ttwo Hybrid of *Theobroma cacao* L. Journal of Plant Pathology. 92 (3): 607-617

Duniway, J.M. 1983. Role of physical factors in the development of Phytophthora Diseases. In Phytophthora its Biology, Taxonomy, Ecology, Phathology. The American Phytopathological Society St. Paul, Minnesota. P 175-187.

Guererro, Y. A., Annia, H.R., Mayra, H. P., Mondher El Jaziri., and Hernandez. L. 2012. Management of Black Pod Rot in Cacao (*Theobroma cacao* L.). Fruit Journal. 67 (1) : 41-48. http://www. Fruits-Journal.org

Holliday, P (1980). Fungus Desease of Tropical Crops. London, Cambridge Univ. Press.

Iwaro, A.D.,J.M. Thevenin., D.R. Butler., and A.B. Eskes. 2005. Usefulness of The Detached Pod Test for Assessment of Cacao Resistence to Phytophthora Pod Rot. European Journal of Plant Pathology. 113; 173-178.

Morissan. 2012. Survey Research Methods. Kencana. Jakarta. pp. 426

Parawirosoemardjo, S. dan Purwantara. (1992). The Infection Rate and Attack Intensity of Phytophthora palmivora on Cacao Fruit and Stem in Several Cacao Varieties. Menara Perkebunan, 60 (2), 67 – 72.

Parel, C. P., G.C. Cardito., Ferrer, P.L., De Guzman, G.G., Sinsioco, C.S., and Tan, R.H. 1973. Social survey research design. Trial Edition, PSSC Social Survey Serial 1. Quezion City. Philippine

Rivai, F. 2006. Yield Loss Caused by Plant Disease.. Andalas University Press. pp.292

Semangun, H. 2000. Plant Diseases in Indonesian Plantation. Gadjah Mada University Press. Yogyakarta. pp. 835

Silk, J. 1979. Statistical concept in geography. George Allen and Unwin Ltd., London. 253p.

Sudjud, S, 2009. The Influence of Cropping System on Yield and Intensity of Damage from Pests and Diseases on Cacao Plant. J. Sains dan Teknologi 9 (1): 18-35

Sugiyono, 2010. Statistic for Research. Alfabeta Bandung. Pp 389

Sukamto, S. 1985. Phytophthora palmivora Butler, One of Causes for Disease on Cacao Plant. J. Menara Perkebunan 53 (1) : 7 -11

Umayah, A. 2004. Analysis of Genetical Diversit of *Phytophthora palmivora* causing cacao pod rot disease in Indonesia. Post graduate school IPB. Dissertation. Unpublished.

Umayah, A dan Purwantara, A. 2006. Identificaton of Pyhtophthora Isolate from Cacao. Menara Perkebunan. 74 (2), 75 – 85. Jakarta

Unterstenhofer, G. 1976. The Basic Principles of Crop Protection Field Trial. Pfazenschutz Nachricten Bayer 29(2):161-168

Van der Palnk, J.L. 1963. Plant Disease; Epidemic and Control. Academic Press. New York and London. pp. 349 .

Van Hall, C.J.J. 1949. Cacao. (Terjemahan. Semangun, H. dan Lahiya A. A. 1986) LPP Yogyakarta. pp.137

Yunus, H.S. 2010. Methodology of Contemporary Area Research. Pustaka pelajar. Yogjakarta. pp450.