*International Journal of Agriculture and Environmental Research*

ISSN: 2455-6939

Volume:04, Issue:01 "January-February 2018"

# THE ROLE OF GENETIC DIVERSITY ON CACAO SUSTAINABILITY IN CENTRAL SULAWESI

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## ABSTRACT

The genetic of cacao clones have many various of diversity in area cacao farm, that are showed on morphology of its fruit. Commonly, development of cacao in Central Sulawesi using national varieties or clones from Coffee and Cacao Research Institute in Jember were RCC 70, RCC 73, ICS 13, ICS 60, TSH 858, Pa 300, UIT 1, GC 7, and Hybrid Cacao. Also, the clones from local farming exploration were sulawesi 1, sulawesi 2, MCC 01, MCC 02, ICCRI, Panther, Irian, and Medan has began to develop in Central Sulawesi. This study was aimed to determine the percentage of resistance to *Cocoa Pod Borer* (CPB), *pytoptora palmivora* disease, and *Vascular Streak Dieback* (VSD) disease on eleven cacao clones which have been developed in Central Sulawesi. That clones were S1, S2, MCC01, MCC02, Irian, ICCRI 1, GC7, RCC 72, RCC 73, SCA 6, TSH 858. The result showed that S1, S2, MCC 01, MCC 02, Irian, and ICCRI 1 were potential clones to developed on the future. MCC02 clone was the best potential genetic compared other clones which observed and it would need studied and developed to be a superior clone that expected have resistance on pest and disease of CPB, *phytoptor*a and VSD with high production.

**Keywords:** cacao, genetic diversity, sustainability

## 1. INTRODUCTION

Cacao is the kind of parennial plant which has important of economic value, that specific grows in tropic area and the main of it product is bean as raw materials for industry which used chocolate food and drink processing. As commodity export in Indonesia, cacao has important of the role national economy for employment provider approximately 1.716.613 to farmers which giving their income source and adding foreign exchange [1,2].

  

ISSN: 2455-6939

Volume:04, Issue:01 "January-February 2018"

Central Sulawesi is the most important cacao-producing country in Indonesia, with the highest export of production in 2008 were 140.000. Since 2009, cacao have exported as much as 120.000 tons, in 2011 were 60.000 tons, and 2012 were 30.000 tons, it was extremely decreased of production [3]. Indonesia as the main cacao producer in worldwide shows that cacao from Indonesia has probably held global market. In terms of quality, cacao beans from Indonesia could compete with cacao in worldwide, it would achieve if beans well-fine fermented and to reach flavour as cacao beans from Ghana and Ivory Coast, also, it have advantage that high of melting point [4,5]. The main challenge in the future is how to increase productivity and quality of cocoa beans in a sustainable.

A total of cacao area in Indonesia are 1.641.817 ha with 811 kg/ha of cacao beans produced [6]. The productivity of Central Sulawesi cacao plant is lower than the productivity in Indonesian that is 0.645 tons / ha per year, but if it compared with the genetic potential, it will increase that can reach 2.5-3.5 tons / ha [7,8]. The decrease in productivity and quality of cacao beans have a negatif impact on farmers, local governments and even the central government. Even further will affect the sustainability of cacao in Central Sulawesi and Indonesia in generally. If this incident continues, it will affect the regional economy in that have contribution to the provision of jobs, sources of income for the region and foreign exchange for the country. The main causes of the decrease in productivity and quality of cacao beans are pests and diseases such as cacao pod borer (*Canopomorpha cramella* Snell), black pod disease (*Phytoptora palmivora*) and vascular streak dieback (VSD). [9] Bowers states that the decrease in production due to pests and diseases can reach 30-40%. Also, [10] Hooen stated that pest and disease of cocoa production has decreased global production in 40% every year. CPB (Cocoa Pod Borer) is losing 184.500 tons/years of yields or equivalent Rp 3.69 trillion [11]. Vascular streak dieback is caused by *Oncobasidium theobromae* bacteria which attack 30-45% in plants and can cause death in seedling [12]. Other diseases that also become one of the factors of decrease productivity in Central Sulawesi is black pod disease caused by *phytoptora* sp. That can reduce 20-30% of yields per years [13]. Furthermore [14] Wahyudi stated that 40% of the cost of cacao plant maintenance is the cost of pest and disease control. During periods these pests and diseases control used chemically excessive by farmers. The method of pest and disease control in cacao plants must be an integrated method, where the first component using varieties or clones which resistant to pests and diseases, and the others are maintain nutrition available in the soil, pruning, and shading management.

Development of cacao in Central Sulawesi using national varieties or clones from Coffee and Cacao Research Institute in Jember are RCC70, RCC73, ICS 13, ICS 60, TSH858, Pa 300, UIT 1, GC 7, and hybrid cacao. Also, the clones from local farming exploration are Sulawesi 1,

  

ISSN: 2455-6939

Volume:04, Issue:01 "January-February 2018"

Sulawesi 2, MCC 01, MCC 02, ICCRI, Panther, Irian, and Medan have been began to develop in Central Sulawesi [15,16].

Efforts to control pests and diseases are expected by using varieties or clones resistance, high production and adaptation in various environment conditions to improve productivity and quality. Therefore, study of several cacao clones in area of cacao in Central Sulawesi are needed to know potential clones on its production and resistance to *cocoa pod borer* (CPB), *Phytoptora palmivora* disease, and *Vascular streak dieback* disease. Also, this research could be an information for breeding activities of both conventional and biotechnology breeding plants to produce superior cocoa clones in future.

## 2. MATERIAL AND METHODS

### 2.1 Study Area

There were 2 areas used in this research from main area of cacao farm in Central Sulawesi, that explained in the following table 1

**Table 1: The Area of Research**

| No. | Name of Area | Coordinate | Height (m above sea level) |
|---|---|---|---|
| 1. | Parigi | S 00$^o$ 56.919’<br>E 120$^o$ 13.002’ | 182 |
| 2. | Poso | S 01$^o$ 18.943’<br>E 120$^o$ 35.171’ | 82 |

This research was conducted on February 2012 – April 2013 in Nambaru Village, Parigi Moutong Regency and Kilo Village, Poso Regency, Central Sulawesi.

### 2.2 PROCEDURES

Only eleven clones of all clones which developed in Central Sulawesi were used in this study that were S1, S2, MCC01, MCC02, Irian, ICCRI 1, GC7, RCC72, RCC73, SCA6, TSH858. The pattern of the measurement in a randomized block design (RBD) which clones as a treatment.

The percentage of attack by using diagonal lines on the experimental plot, the number of plants that became the object of observation on each plot was 6 x 2 = 12 plants, the total plant was used 396 plants as the sample in Parigi and Poso. Observation of pests and diseases was not separation

  

ISSN: 2455-6939

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between the level of heavy, medium and light attack (only based on the attack on each fruit or plant attacked).

1. The fruit was considered infected CPB if it indicated the presence of yellow spots (in contrast to the color of ripe fruit). While the fruit was considered *Phytoptora* if it indicated the presence of black color on the fruit (different if the fruits have deficiency nutrient) [17]. The determination of percentage damage of Vascular Streak Dieback (VSD) by taking branches that indicated the presence of symptoms include a green-spotted chlorosis and fall of leaves beginning on the second or third flush behind the stem apex, raised lenticels, and darkening of vascular traces at the leaf scars and infected xylem [18,19].
2. The plants that became object of this study was a plant from cacao side grafting since 2008.
3. The sample was collected over the period of harvesting (April and November).

### 2.3 Data Analysis

Average of percentage damages Cacao Pod Borer (CPB) and *Phytoptora* by formula according to Guzman [17

$$\boldsymbol{P = \frac{\sum Br}{\sum Bs}\, x\, 100\%}$$

Where Br is infection fruits and Bs is fruits health. Analysis of variance was used to determine the differences on level of attack among treatments. If treatments showed significantly different, Duncant analysis would be further performed.

## 3. RESULTS AND DISCUSSION

Figure 1 and 2 are the result of percentage of damages CPB, *pytoptora*, and VSD eleven clones in Parigi and Poso. Figure 3 and 4 are the result of wet beans and bean account eleven clones in Parigi and Poso. These percentage were obtained from eleven clones as treatments among intensive and non-intensive cultivation systems.

  

ISSN: 2455-6939

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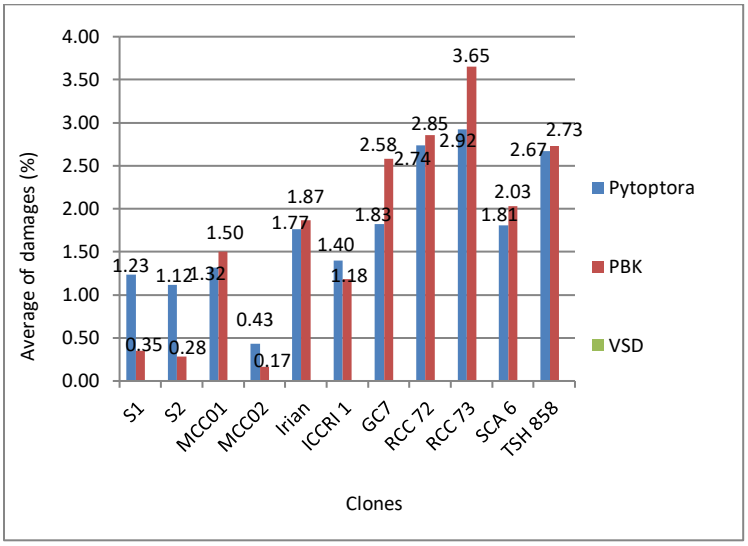


**Fig 1: Percentage of damages CPB, Pytoptora, and VSD in Parigi**

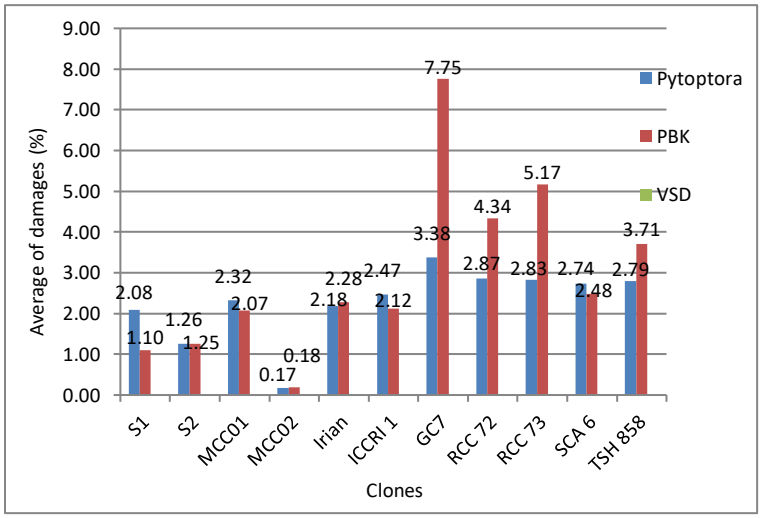


**Fig 2: Percentage of damages CPB, Pytoptora, and VSD in Poso**

The results showed that the rate of pytoptora, PBK, and VSD attack on cacao clones in two study areas had various and intensity of attacks. The analysis results in Parigi and Poso areas (Figure 1 and 2) showed that S1, S2, MCC01, MCC02, Irian, and ICCRI 1 had the lowest percentage compared GC7, RCC72, RCC73, SCA6, and TSH858. The eleven clones observed showed that the RCC73 clone was the highest-frequency attack in Parigi, while the GC7 clone showed the highest frequency of attacks in Poso. The VSD attacks in all locations showed that all clones

  

ISSN: 2455-6939

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absence of attack at the time of observation. This can be seen in the figure showing 0% of attacks in all clones in Parigi and Poso areas.

a. Percentage of Cocoa Pod Borer (CPB)

Cocoa Pod Borer (CPB) caused by *Canopomorpha cramella* Snellen is a harmful indigenous pest in cacao farms in Southeast Asian and Pacific countries, including Indonesia. The current pest attack of CPB has spread to all cacao farms areas in Indonesia, including Central Sulawesi. Based on the graph showed that the percentage of CPB in clones S1, S2, MCC01, MCC02, Irian and ICCRI 1 were low both on Parigi and Poso which the highest attack rate was only below 8% compared with report by Juneanto and Sulistyowati [20] about 39-79% and Muslimin research results, 2017 (unpublished) in two locations namely Lindu and Palolo respectively 33% and 25% of the attack rate. It indicated that the intensification of fertilizer with organic fertilizer, regular pruning, shade management and the use of very low chemicals has caused the environment of cacao growth in two experiment sites to be good and plant health support so that the plant had high of resistance on CPB attacks. That was according with the principle of integrated pest management that an environment health will affect the health of plants and will further increase the resistance of pest and disease against. In the Parigi area, the MCC02 clone was the clone with the lowest level of attack then followed by S2, S1, ICCRI 1, MCC01, Irian, Sca6, GC7, TSH858, RCC72, and RCC73. In the Poso region, MCC02 clones also became the lowest level of attack followed by S1, S2, MCC01, Iccri 1, Irian, Sca12, TSH858, RCC72, RCC73, and GC7. It refers to Wahyudi et al. (2008) statement that the intensity and frequency of pest attacks is a component of cocoa borer pest control in long-term. Therefore, the diseases in cacao plants affected by climate and varieties or clones.

MCC 02 clone was the lowest level of damages in two locations. Apparently that was potential clone to develop in the future because its character was tolerance to CPB and well bean account (63 and 67) (result from laboratory of Comextra Palu branch, 2013 and Sucofindo Laboratory Jakarta, 2016). This was appropriate with Hui et al, [21] that cacao clones recommended for commercial planting must have the following characteristics sustainable high yield with more than 2.5 t/ha/year, acceptable and uniform beans (>1.0 g and <12% bean uniformity), high in fat content (>50%), tolerant to main past and diseases (e.g. *cocoa pod borer* (CPB), VSD, and *phytoptora*), preferably adaptable to a wide range of agro-climatic conditions.

The results indicated that two location were given different percentage of CPB attacks, where the rate of CPB were lower in Parigi (1.75%) than in Poso (2.95%). The difference in the percentage of attacks were caused by environment conditions. The area in Parigi has been applied intensive cacao maintenance (organic fertilizer, pruning, shade tree management, pesticides, herbicides

  

ISSN: 2455-6939

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and insecticides controller (since October 2010) compared in Poso (April 2011). Also, that indicated the difference by soil pH where the average soil pH in Parigi was 5.8-6.2 and the average soil pH in Poso was 5.4-5.7. It refers to Susilo [22] statement that if the selection of planting material is not superior even on applied intensively cultivation treatment, the result would not increase significant of yield.

b. Percentage of *Phytoptora palmivora*

The cacao black pod disease is caused by *phytoptora palmivora* Bult. That is the most important cacao pathogens because it can damage young fruit to mature fruit and death to seedling and young plant. Based on the graph was showed that the frequency of *phytoptora palmivora* disease in S1, S2, MCC 01, MCC 02, Irian and ICCRI 1 clones was low attack 3% only both in Parigi and Poso that lower compared the data obtained by McMahon and Purwantara [23] was 30%. The low level of *phytoptora* in two locations were indicated that it had good environment which no provided disease development. This was related with the statement of Aini et al [24] that the disease can appear due to interrelated factors. That interactions occur between pathogens and susceptible hosts, then supported by the existence of environment factors which support the development of pathogens were the cause of diseases in plants.

The result showed that MCC 02 clone was the lowest frequency clone in both Parigi and Poso followed by S2, S1, MCC 01, ICCRI 1, Irian, Sca 6, GC 7, TSH 858, RCC 72, RCC 73. This consist with the result of Suhendi research, that among of the various species of cacao can be found a species that have resistance to *phytoptora* disease as shown in the experiment result where the cacao clones were ICCRI 03 and ICCRI 04 performances the production, quality and resistance to *phytoptora palmivora*. The percentage of attacks on the Parigi was lower (1.75%) than in Poso (2.28%). This was also suspected because the environment conditions of study area in Parigi was better than in Poso.

c. Percentage of *Vascular Streak Dieback* (VSD)

Vascular Streak dieback disease (VSD) is one of the factors causing the decrease of cacao production in Indonesia. That is caused by the fungus *oncobasidium theobromae* Talbot and Keane. It can cause death in plants both young plants and old plants. Plant damage is estimated to achieve 100% in susceptible clones and 15% in resistant clones with the average 25% to 50% [12]. Based on the observation of the eleven clones in Parigi and Poso did not show the attack disease of Vascular Streak Dieback (VSD). The results of VSD disease did not indicate the presence of attacks, that was suspected that the disease has not spread in these locations. It was proven that all clones in this reseach did not show any symptoms of attack.

  

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The VSD has not yet spread on these areas indicated that the environment conditions of areas did not provide pathogen development, because the areas had good environment management of cacao growth. That was related with the statement by Aini et al [24] that environment conditions can support the development or absence of pathogens that can affect to plant growth, so that the interaction between pathogens, plant genetic, and environment will affect the attack rate of diseases.

Also, the results were to give evidence that the environment of this study had a good condition that were to decreased spread of diseases. It showed that the results had absence of VSD attacks at all study area which difference compared to report by Anita Sari and Susilo [12] that VSD can reduce production in 30%.

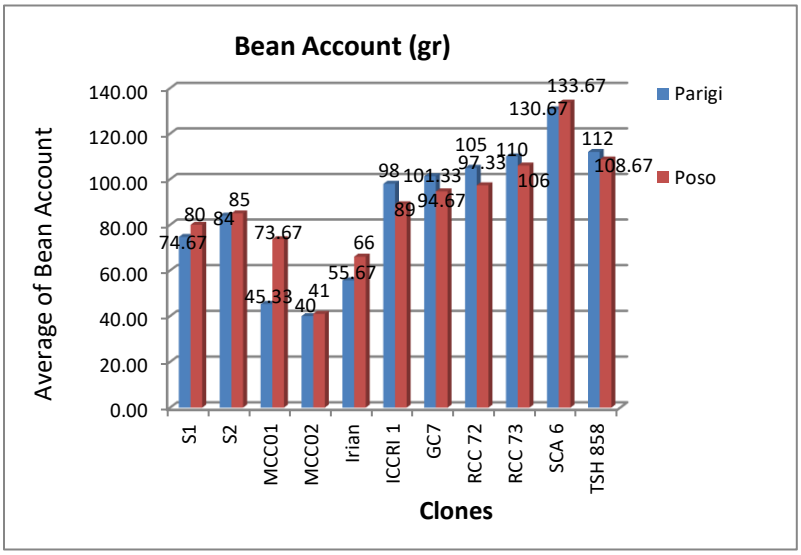


**Fig 3: Average of bean account eleven clones in Parigi and Poso**

Based on the average of bean account showed that MCC02 clone was the best potential genetic compared other clones which observed. MCC02 was the best of bean account then followed by MCC01, Irian, S1, S2, ICRRI 1, GC7, RCC72, RCC73, TSH858, Sca 6.

Beans account and fat content are included as the parameters for quality and quantity of the beans. Those parameter in addition determined by genetic factors as well as by environmental factors. The Figure 3 and 4 indicated that clones MCC02, MCC01, S1, S2, Irian and ICCRI 1 genetically have production potential if compared with clones Sca 6, GC 7, TSH 858, RCC 72, and RCC 73. These figure also shows that clone with good genetic if developed in good environment conditions will produce good results. The result of study were in line with Winarno

  

[25] and Syukur [26] that the growth and productivity of cacao determined by genetic of planting material and interaction with environment of planting area.

## 4. CONCLUSION

1. MCC02 clone was the best potential genetic compared other clones which observed and it would need studied and developed to be a superior clone that expected have resistance pest and disease of *CPB*, *phytoptor*a, and *VSD* with the high production.
2. The eleven clones which has observed its damages on *CPB* and *pythoptora* were low only 7% and 3% respectively. The VSD disease in this study was absence of attack which compared a prior research that showed a percentage of 35-40% attack for *CPB*, *Phytoptora* palmivora, and *VSD*.
3. S1, S2, MCC01, MCC01, Irian, and ICCRI 1 were good genetic and potential clones to be developed in the future.
4. The interaction between a good environment and plant genetic can reduce the attack rate of both pests and diseases, hence the decrease of cocoa production can be reduce.

## ACKNOWLEDGMENTS

We would like to thank the cacao farmers in Parigi and Poso. The authors are grateful to DGHE (Directorate General Higher Education) from the Ministry of Research, Technology and Higher Education of the Republic of Indonesia was supported this research.

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