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Side Grafting of Unproductive Cocoa: Socio-Economic and Ecological Impact

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ABSTRACT

Cocoa is a tree of the humid lowland tropics produced largely by small farmers, therefore in developing countries it can be used to generate farmer's income, provide labor employment and conserve environment. At the last decade, the cocoa productivity, the size and quality of beans in Indonesia significantly tend to decline due to the ageing of the tree, poor farming maintenance practice, planting of low yielding variety and ravages caused by pest and diseases. Such declining affects the price and the farmer's income, and farmers respond by leaving the plantation, replacing with food crops or oil palm, and increasing forest clearing which will threaten the environment. Such problem can be addressed by increasing the long term cocoa productivity of existing farms through side grafting of unproductive cocoa trees with genetically improved varieties. In 2008, it was reported that there are around 235.000 ha of unproductive cocoa that can be improved though side grafting. There was almost 90.000 ha that has been side grafted in 2009 and 2010 by the government support, and in 2011 evaluation through focus group discussion has been carried out. Side grafting with recommended varieties normalizes the cocoa growth, and cures the diseases. With a recommended cultivation technique, the productivity increases twice which followed by improve seed size. These result probably will gives an impact not only on the income but also farmer's future. Several farmers informed that they will not demolish their cocoa farm or even clear new land for crop food. Normal growth of cocoa and stopping opening new land will have a positive effect to the environment especially in mitigating climate change.

Keywords: side grafting, cocoa

INTRODUCTION

Cocoa is one of the important tree crops in the world which grown for the beans used for the manufacture of drinking cocoa and chocolate (Bindu & Malika, 2008). Cocoa is grown in developing countries across tropical Africa, Latin America and Asia. Cocoa plantation is one of the most important forms of land use and of enormous economic importance (de Graaff, 1986). Most of cocoa beans produced globally are originally from cocoa trees which are cultivated by smallholder farmers who manage only a few ha and generally rely on family labor (Neilson, 2010). Cocoa provides a source of income for a lot of farmers due to its capability for generating high economics value of beans and employment.

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Cocoa trees can start bearing pods within two or three years and reach peak production after ten years (Neilson, 2010). In some cases, they can continue bearing pods for decades and the production usually declines rapidly after 25 years old and ageing trees are normally susceptible to various pest and diseases.

Indonesia is currently belong to the largest cocoa producing countries in the world, mainly bulk cocoa based on forester hybrid (Johnson et al., 2004; Meulemans et al., 2002). Cocoa plantation has been developed since 1980s and smallholders cocoa farmers who own plots ranging from 0.5 to 1.5 ha dominate almost 93% of cocoa area (Abbate, 2007). In 2010, the total cocoa area reaches 1.587 million ha. The boom factors include low cost of labor, abundant suitable land, government aid policy for development (Ruf et al., 1995). At the last decade, the cocoa productivity, the size and quality of beans significantly tend to decline due to the ageing of the tree, poor farming maintenance practice, planting of low yielding variety and ravages caused by pest and diseases. Similar condition and causal factors were reported in Cameroon by Bisseluea (2007). Such declining affects the price and the farmer's income, and farmers respond by leaving the plantation, demolishing the cocoa trees and substituting with food crops or oil palm, and increasing forest clearing which will threaten the environment. Such problem by the government will be addressed by Cocoa National Program which focused on replanting of old and heavy damaging trees, rehabilitation means increasing the long term cocoa productivity of existing farms through side grafting of unproductive cocoa trees with genetically improved varieties, and intensification of low productivity of cocoa trees. In 2008, it was reported that there are around 235.000 ha of unproductive cocoa that can be improved through side grafting and there was almost 59.500 ha spread in 6 provinces has been side grafted in 2009 and 28.400 ha in 10 provinces by 2010. In 2011, almost all side grafted trees in 2009 started bearing pod; evaluation through focus group discussion therefore has been able to be carried out.

MATERIAL AND METHODS

In 2009, there was 59.500 ha low cocoa productivity which spreads in 6 provinces have been rehabilited through side grafting by the Indonesia Government. Four provinces are located in Sulawesi Island, 1 in East Nusa Tenggara, and another in Papua (Table 1).

Two provinces i.e. South Sulawesi and Central Sulawesi were randomly chosen as sample. From the two provinces, some districts were further randomly selected to collect the socio-economic impact of side grafting. Information from South Sulawesi was collected from North Luwu, Sidrap and Soppeng district; whereas Parigi Mutong and Banggai districts were chosen from Central Sulawesi. Information was collected through survey both by field visit and focus group discussion using questionnaire as manual.

Field visit is used to see the field condition and tree performance included pest attack, pods number and size, and even seed size. In the focus group discussion, the types and cost of input, beans price and the socio impact of rehabilitation will be questioned. To estimate the ability of side grafting cocoa trees in sequestrating carbon,carbon in the leaves form measured by Moesser et al., (2010) will be exploited. Information will be analyzed descriptively to come with comprehensive conclusion.

Table 1. Side grafting area realization in 2009

Province	District number	Area (ha)
West Sulawesi	5	22.000
South Sulawesi	10	20.900
Central Sulawesi	8	3.500
South East Sulawesi	5	11.500
East Nusa Tenggara	2	800
Papua	4	800
Total	34	59.500

RESULT AND DISCUSSION

Bertin (2000) mentioned that the low cocoa productivity is generally caused by the ageing of the tree, poor maintenance practice, planting of low yielding variety and ravages due to pest and diseases attack. Nielson (2010) stated that cocoa production usually decreased rapidly after 25 years old. Cocoa boom happened in Indonesia in 1980s and due to the cultivation of low yielding variety, the national productivity only reaches 1.100 kg dry beans/year/ha. Since 2003, the productivity tends to decrease. Indonesian cocoa is affected by three main diseases and pest problems such as pod borer caused by *Conopomorpha cranuella*, vascular streak disease (VSD) by *Oncobasidium theobromae* and fungal disease by *Phytophtora palmifora* (McMohan et al., 2004). VSD fungal disease has been attacking across the Sulawesi Island which account for three quarter on cocoa nationwide output. The attack of VSD tends to be very severe even cocoa trees come to die. A successful method to combat VSD is the side grafting technique using improved genetic materials which are resistant to it and high productivity. There are almost 984.475 ha productive age of cocoa trees around the country with the age is less than 15 years and several of them have been side grafted either by Government or other agencies. With side grafting, the productivity of existing cocoa tress can be extended and restoring the abandoned lands (Rice and Greenberg, 2000). Study will focus only the areas which are side grafted with improved genetic material by the Government in 2009.

To do side grafting, rootstock must be in the active growth phase, which is characterized by flushing. Land tillage, fertilizer application, pruning and sometime irrigation may stimulate the plant growth. The best time of side grafting should be done on dry season, at 40 – 60 cm height of the rootstock. Shoot-stock (scion) must be protected using transparent plastic and tightly bound so that rain water has not damaged the grafting. After 3-4 weeks, the plastic cover was removed and tree must be pruned to provide enough sunshine to the shoot. The main stem must be cut out when the shoot reaches 6 months old. Later on, fertilizer must be applied in the dosage of 200 g NPK per plant a year to support the trees growth.

Evaluation ofthe impact of side grafting on cocoa growth and productivity

Based on survey, the original tree means rootstock was 13 years old. Some of them showed VSD symptom and the productivity was reported only 519 kg dry beans/ha/year (Table 2). The condition of original tree in Central Sulawesi seems better than South Sulawesi shown by the still better productivity in the Central. Side grafting in Sulawesi Island can be executed in July. In January in the coming year, the plastic cover could be opened. The cocoa side grafting grew normally. Two-three months after main stem cutting, the new shoot showed vigorous growth (Figure 1.) and after 14 months some trees started bearing pods (Figure 2). Side grafted cocoa is characterized by free from VSD disease, shorter trunk with pods coming from the new shoot and sometime also from the main stem (Figure 3). Shorter cocoa trees are preferred due to easily pod harvesting and pruning.

Figure 1. Three-months after main stem cutting of side grafted cocoa, 2011

Figure 2. Bearing pods of side grafted cocoa,2011

Figure 3. Mature side grafted cocoa,2011

Almost100 % farmersbelievedthatside grafting can increased cocoa beans productivity crop. According to farmers when the side grafted tree entered thethird year, the productivitywouldreach1.574kgdrybeans/ha/year, an increase of 1.089kgdrybeans/ha/yearor203% (Table 2). In 1995, higher result was achieved till 2000 kg dry beans/year/ha in similar island (Ruf et al., 1995). The production sustainability has been questioned however by a lot of researcher. Since 2003, the national cocoa productivity then has been dropped and the condition in Sulawesi was even worst. In 2008, it was reported that the cocoa productivity in Sulawesi was only 500 kg dry beans/year/ha (Manggabarani, 2008).

As a result of such productivity improvement, farmersinsomedistrictsof SulawesiIsland are moreconfident to rehabilitate their own farms. The productivity will be sustained, especiallyif theplantwas managed with a recommended cultivation technique such asfertilizer application, weeding, pruning, and sanitation through close composting of organic matter such as leaves, pods husk and twig. Direct close composting in the field will improve soil fertility and avoid pest sources.

Table 2. The impact of side grafting on cocoa productivity in 2011

No.	Districts	Realization Area (ha)	Productivity (kg dry beans / ha/year)			Impact (%)
			Before	After	Differences	
1.	Sidrap	1.500	375	1.600	1.225	327
2.	Soppeng	1.500	250	1.200	950	380
3.	Luwu Utara	6.900	600	1.600	1.000	167
4.	Banggai	500	600	2.000	1.400	233
5.	Parimo	300	600	2.000	1.400	233
	Minimum		250	1.200		
	Maximum		600	2.000		
	Average		519	1.574	1.054	203

Comparedwiththe previous cocoa crop, side grafted cocoa using recommended varieties producedgreater number of pods, largerpodsize, more seed number/pod, and largerseedsize. They believed that theproductivity of side grafted cocoa in very suitable agro-ecological areacanreached 3.000 kgdrybeans/ha/year. The yield of cocoa in Sulawesi Island was expected to reach 2500 kg dry beans/ha/year and this yield is being sustained for 20 years (Hartemik, 2005). Farmers excited with side-grafted cocoa especially because some clones are capable of bearing pods throughoutthe year.

Higher productivity has been existed in Malaysia and the Philippines (Hartemik, 2005). To reach very high productivity, cocoa tress were planting in the densities ranging from 2000 plant/ha using grafted varieties intercropped with food crops. They introduced very intensive cultivating

system, non shaded strategies with more chemicals. Unfortunately such high productivity could sustain for longer times, they only produced for 6 – 8 years.

Evaluation ofthe impact of side grafting on farmer's income

When the productivity increases, theoretically the farmer's income will improve. However the farmer's income depends upon the beans price and input cost. Based on focus group discussion, the price of unfermented dried cocoa beans at the survey area is a quite similar between 19.000 – 21.000 IDR (2 – 2.5 USD).

Input cost consists of labor cost, cost of materials such as fertilizer, pesticide, and herbicide, cost of equipment such as chopping knife, sickle, hoe, hand-sprayer, plant-scissor and basket, and also some taxes (Table 3). The most expensive input cost is fertilizer. If an-organic fertilizer is used, each tree needs 400 g/year. The introducing of organic fertilizer especially bio-fertilizer may reduce the cost.

Table 3. Estimated input cost of cocoa field of Banggai district

No.	Expenditure cost	Input Cost (IDR/year/ha)	
		Before rehabilitation (2009)	After rehabilitation (2011)
1	**Labor**		
	Weeding	180.000	450.000
	Pruning	600.000	1.000.000
	Fertilizer	240.000	400.000
	Sanitation	120.000	300.000
	Pest control	180.000	300.000
	Harvesting	720.000	1.500.000
2.	**Materials**		
	Fertilizer	4.000.000	4.000.000
	Pesticide	70.000	70.000
	Fungicide	50.000	50.000
	Herbicide	165.000	165.000
3.	**Equipment**		
	Chopping knife	50.000	80.000
	Sickle	50.000	80.000
	Hand-sprayer	250.000	0
	Plant-Scissor	50.000	160.000
	Basket	75.000	40.000
4.	**Tax**	15.000	15.000

In some districts of South Sulawesi Province, fertilizer was not applied before rehabilitation; therefore the total input cost was much lower than in Central Sulawesi (Table 4). Parigi Motong district showed lower total input cost than Banggai because farmers apply only half dosage of fertilizer.

When the price of unfermented dry beans is valued 20.000 IDR, the revenue of cultivating side grafted cocoa reached between 24 – 40 millions IDR (Table 4). The lowest revenue was estimated in Soppeng district due to low productivity. Farmers in Central Sulawesi seem more optimistic than in South Sulawesi. They believed that rehabilitation their cocoa tree with recommended varieties can increase their income up to 31,5 millions IDR/ha/year and cocoa field rehabilitation through side grafting will improved the farmer's welfare.

Table 4. Total input cost, revenue and income of some rehabilitation districts

District	Total Input Cost (IDR/year/ha)		Revenue (IDR/year/ha)		Income (IDR/year/ha)	
	Before	After	Before	After	Before	After
Sidrap	2.250.000	7.250.000	7.500.000	32.000.000	5.250.000	24.750.000
Soppeng	2.700.000	6.820.000	5.000.000	24.000.000	2.300.000	17.180.000
North Luwu	2.700.900	8.634.000	12.000.000	32.000.000	9.299.100	23.366.000
Banggai	6.815.000	8.610.000	12.000.000	40.000.000	5.185.000	31.390.000
Parimo	4.050.000	8.500.000	12.000.000	40.000.000	7.950.000	31.500.000

Side grafting with recommended varieties normalizes the cocoa growth, and cures the VSD diseases. With a recommended cultivation technique, the productivity increases twice which followed by improve seed size. Several farmers informed that they will not demolish their cocoa farm or even clear new land for crop food.

Evaluation ofthe impact of side grafting on environment

It is very difficult to measure the impact of side grafting of cocoa on the environment especially when cocoa tree is intensively cultivated (Ntiamoah & Afrane, 2008). There is some negative impact of intensive cocoa production such as the use of pesticide and an-organic fertilizer which can lead to the destruction of part of the soil flora and fauna through physical and chemical deterioration (Cowell & Clift, 1997).

Cocoa production is also suspected to make the largest contribution to eutrophication which is mainly caused by leakage of nutrient during cultivation and cocoa plant disease because cocoa tree generates large amount of solid waste such pod husks. Such waste become significant source of disease when use as mulch inside the plantation (Ntiamoah &Afrane, 2008).

The use of more friendly input system which rely on integrated crop management involving high degree of biological control and environment manipulation of the major pest and disease; adequate soil fertility management through the use of solid waste as organic material as well high

yielding and pest resistant varieties as scion material are recommended to further enhance the environment.

Cocoa side grafting means “increasing the long term productivity of existing cocoa farm, restoring abandoned lands and mitigating climate change” (Rice & Greenberg, 2000). Carbon dioxide is the most important greenhouse gases due to its abundant concentration and superior ability to trap heat (Innocent & Gee, 2008). Cocoa tree can contribute to the carbon storage (Sonwa et al., 2009), therefore side grafting of cocoa can contribute to improve environment through carbon sequestration. Carbon sequestration is the process of transferring CO_2 from the atmosphere into the soil through crop residues and other organic solids, and in a form that is stable and not easily releases (Sundermeier et al., 2009). Carbon is primarily stored in the soil as soil organic matter. Such carbon sequestration will offsets carbon emissions from the use of fossil fuel, improve soil quality and in the long run agronomic productivity.

There were different reports on the ability of cocoa tree to fixe carbon. Gockowski et al. (1998) reported that mature cocoa tree (40 years old) fixed carbon at around 154 ton/ha; cocoa system of 15 – 25 years olds showed on average carbon amount of 111 and 132 ton/ha respectively, whereas Sonwa et al. (2009) published that plant associated with cocoa, cocoa trees, litter and roots store respectively 170, 13, 4 and 18 ton carbon/ha. Mosser et al. (2010) reported that cocoa can produce 2,76 ton/ha leaves; 22,32 ton/ha stem and braches and 5,74 ton/ha roots. It seems that the ability of cocoa tree to capture CO_2 is very high. With proper handling of organic waste at the plantation, side grafting can prolong the ability of capture carbon. A primary strategy in mitigating climate change is to adopt land use and agricultural management that will reduce greenhouse gas emission and increase carbon sequestration. Side grafting of unproductive cocoa due to poor farm maintenance practice, planting low yielding variety and ravages caused by pest and diseases seems to be an appropriate approach to mitigate climate change and optimize income in order to ensure food security and people welfare.

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