BIODIVERSITAS
Volume 21, Number 1, January 2020
Pages: 49-56

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d210108

Productivity of three varieties of local upland rice on swidden agriculture field in Setulang village, North Kalimantan, Indonesia

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Manuscript received: 21 September 2019. Revision accepted: 3 December 2019.

Abstract. *Merang OP, Lahjie AM, Yusuf S, Ruslim Y. 2020. Productivity of three varieties of local upland rice on swidden agriculture field in Setulang village, North Kalimantan, Indonesia. Biodiversitas 21: 49-56.* Swidden agriculture field is a dry land used by traditional farmers to cultivate some varieties of local upland rice intercropped with vegetables, tubers, and fruits. This rotational cultivation system utilizes the land for planting such food crops in one year period before it is left for fallow periods for years. This study aimed to assess the productivity of local upland rice varieties (i.e. Langsat rice, Telang Usan rice, and Pimping rice) cultivated on swidden agriculture field in regard to the fallow periods. This study was conducted in Setulang village, Malinau District, North Kalimantan Province and employed purposive sampling method using interviews of selected respondents and field observation. Among three varieties of rice in this study, Langsat rice had the longest fallow period with 17 years while Pimping rice had the shortest fallow period with 13 years, with the maximum production were 2,635 kg ha^{-1} and 1,670 kg ha^{-1}, respectively. Meanwhile, Telang Usan rice reached the maximum production on fallow period of 15 years with the total production of 2,208 kg ha^{-1}. Overall, of the three types of rice planted, the results show that the longer the fallow period, the higher the rice production and the shorter the fallow period, the lower the production. Each type of rice has a different amount of production, although it is planted during the same fallow period.

Keywords: Fallow period, rice yield, Setulang village, swidden, upland rice

INTRODUCTION

Rice plant (*Oryza sativa* L.) is a crop that produces rice and a staple food source. In Indonesia, rice is the main commodity to feed societies. Due to the increasing population, the demand for rice will continue to grow. Nurliza et al. (2017) reported that approximately 90% of the total population of Indonesia consume rice as staple food. Unfortunately, for almost three decades, domestic rice production has been insufficient in meeting the demand that continues to grow.

Swidden agriculture is a common land use management by traditional communities living in tropical regions, for example in Borneo, and is suitable to social typology in which there is a high interdependence between people and the environment (Inoue 2000). Sardjono (1990) stated that traditional forms of swidden agriculture reflect an optimum interrelation between the strategy to serve human needs and efforts to maintain ecological balance in tropical regions. In swidden agriculture, farmers cultivate field with staple food commodities, such as rice, for only one harvesting time in a year, and then they leave the land to naturally regenerate for years as fallow while they move to another field (Van et al. 2012). Generally, typical land being managed for swidden agriculture is secondary forest, while primary forest is preserved and not permitted for cultivation (Teegalapalli et al. 2016). According to Van et al. (2013), swidden agriculture system could be maintained in the long run when the farmers are able to adapt and to integrate with local environment as well as when they receive supports from other subsistence livelihood sources.

These practices can be further improved through agroforestry system to adapt to local socio-economic dynamics and environmental changes. Managing shifting cultivation and agroforestry reflect the reliance of local community on forest (Parrotta et al. 2016). As the Dayak Kodatan tribe in West Kalimantan had developed the Tengkawang, Durian, Diterocarpa and Rubber agroforestry systems all done after cultivation (Winarni et al. 2018). In East Kalimantan (Indonesia), it was carried out by the Dayak Benuaq tribe namely rubber, agarwood and *Shorea macrophylla* (Lahjie et al. 2018a). Likewise in West Kutai rubber, agarwood and dipterocarp (Lahjie et al. 2018b). Delivered by Budiharta et al. (2016) that the effort was a form of restoration activities carried out by local communities to meet household needs.

According to Heinimann et al. (2017), currently, the areas managed under swidden agriculture are about 280 million hectares throughout the world and are predicted to decrease in the future. If happens, this situation can reduce local food products including rice production which gives negative impacts on the income of traditional farmers (Wibowo et al. 2016). The challenges faced in increasing rice production on swidden agriculture lands include land processing that is still manual, it has a long period of harvesting, and there is fallow process that can take decades for one rotation period. Nonetheless, food crops (mainly rice) planted on these lands are genetically resistant to uncertain weather conditions, especially to drought (Afrida et al. 2016). Pests that usually attack shifting paddy fields are sparrows, grasshoppers, and wild boar. Sparrows and grasshoppers usually attack rice plants in the Maturation phase, namely the ripe stage of milk where the grain begins to be filled with a material similar to a milk-white solution until the rice begins to bend. Wild boar attack rice when the rice is ripe and yellowing. Prevention by farmers against wild boar is the making of snares on the edge of the field. Rice produced by back-shift farmers includes organic rice because they do not use chemical fertilizers.

In Setulang village, Sub-district of Malinau Selatan Hilir, Malinau District, North Kalimantan Province, the utilization of dryland agriculture still has a large potential in increasing rice production if viewed in term of land extent. The community was of the opinion that the development of oil palm in Setulang would reduce the total area of rice on dry land, so that it would reduce the people's basic needs, because the financial value of oil palm had always declined in the past two decades. Besides that the development of high oil palm (20-40%) as in Setulang required high production costs, that for Setulang villages the landscape was different from East Kalimantan in general.

The wide impact of each head of household which at the time of 20 years ago had enough land area of 4 ha, now it was needed to become 7 ha in East Kalimantan. This was due to an increase in inflation of staple food prices by more than 8%, while oil palm actually decreases in price. The price of oil palm had decreased by 3.75% year^{-1}. In 2009 the price of oil palm was 1300 IDR, then in 2019, it became 900 IDR. Contrary to Santika et al. 2019 stated that oil palm was superior to dryland agriculture. It was true that the area owned by the head of the family was more than 30 ha household-^{1}, but it was safe in terms of food security if the minimum rotation period was 15 years.

This is because the area is dominated by dry land, but if the utilization of land is not in accordance with the needs of farmers (for example, land conversion into palm oil plantation) it can impact on reducing rice production at local scale. Most of Setulang villagers work as farmers where cultivation activities are to fulfill their food needs as well as part of their cultural identity. Therefore, even though intensive agriculture system with the use of modern technology has been introduced, the local communities in Setulang still do the traditional practices that have been done for a long time inherited from their ancestors from generation to generation. This reflects that for Dayak people, who is the majority in Setulang village, forest is not only a place for living but also a place that brings benefits in terms of social, cultural, and spiritual aspects which is managed using local wisdom and knowledge for their future generation (Ouédraogo et al. 2014; Camacho et al. 2015; Hutauruk et al. 2018a: Hutauruk et al. 2018b).

Swidden agriculture or also called rotational farming or shifting cultivation has the same pattern and stage of activity but has different local terms in each region. In Setulang village, this farming system is called *Omoq*. Stages (with local name) and length of time spent by farmers in Setulang village to complete one year of rice cultivation are as follows: (i) land survey, starting in April; (ii) slashing bushes and small trees (*midik*), starting from May to June; (iii) cutting down large trees (*nepeng*), starting in early July; (iv) chopping (*metok*), starting the second week of July; (v) burning land (*nutung*), starting the fourth week of August (end of August); (vi) The method of tugal (*mula*) is identified as making a hole 4 cm depth by using a wood stick with the size of 2 meters long and 4 cm diameter. The activity of tugal by using wood stick to plug into the ground is widely started by farmers in September; (vii) maintenance, starting mid-September to January; (viii) harvesting (*majau*), starting from February to March; (ix) post-harvesting (*lepa majau*), in the fourth week of March. According to Imang et al. (2004), Dayak Kenyah people do their rotational farming through 9 stages. However, the Bahau Dayak people in the village of Matalibaq generally manage their fields through 8 stages as follows: (i) slashing bushes and small trees; (ii) cutting down large trees; (iii) cutting fallen tree trunks to make them dry faster and had proper fires; (iv) burning of vegetation so that the soil was clean for planting and also to increase soil fertility through burning biomass; (v) preparation of planting by cleaning the residual branches of combustion; (vi) planting; (vii) weeding, (viii) harvesting.

This study aimed to assess the productivity of local upland rice varieties cultivated on swidden agriculture field in Setulang village in regard to the fallow periods. The reasons behind choosing this village were: (i) it has a long history of protecting and managing primary forest based on the cultural wisdom; (ii) it has innovative local knowledge in practicing more productive swidden agriculture; and (iii) recently the village is facing the pressures of activities like oil palm plantation expansion. We expect that the results of this study could provide insights to support local food security and to reduce poverty in Malinau District.

MATERIALS AND METHODS

Study area and period

This research was conducted in Setulang Village, Sub-district of Malinau Selatan Hilir, Malinau District, North Kalimantan Province, Indonesia. The research was carried out from April 2018 to March 2019. Setulang village is located between the creeks of Setulang river and Malinau river. It is approximately ± 29 km from the capital of Malinau District. It borders with Sentaban village to the north, Setarap village to the south, Tanjung Lapang village to the east, and Paking village to the west. It has an extent of 11,800 ha including *Tane' Ulen* forest, a 5,300 ha protected forest that has been traditionally protected by the people of Setulang (Figure 1).

The land management of swidden agriculture by Dayak farmers in Setulang village is that rice plants are intercropped with other crops, such as vegetables, sweet potatoes and fruits in which this method is common among Dayak tribes. In this study, we only considered the yield of rice production which is the main food crop in shifting cultivation. In general, farmers in Setulang village plant 5-8 varieties of rice by implementing polyculture systems with other plants such as corns, canes, bananas, and many more (Hamdani et al. 2016).

Procedures

We conducted preliminary study by reviewing previous research conducted in the area of study. We used purposive sampling method (Wirartha 2006) in selecting the participants of the study with the samples were the residents of Setulang village. Among 233 heads of family in the village, 35 persons (equal to 15% of total heads of family) were selected to participate in this study.

Data and information were collected through in-depth interviews with customary chief (*kepala adat*), customary figures (*tokoh adat*), and 35 swiddeners from indigenous Dayak Kenyah tribe who have been living there for over hundreds of years. Data and information collected pertain to the traditional wisdom and concept of managing forest and land, the concept and practices of conventional and senguyun system.

Data collection

Primary data collected in this study included the amount of rice yield, the fallow periods of the rice field, the varieties of upland rice: i.e. *Langsat* rice, *Telang Usan* rice, and *Pimping* rice. The data were obtained through interviews with a questionnaire and field observations. Interviews were conducted by asking prepared questions in a questionnaire with clarifications from the respondents when necessary.

We also conducted direct observation to see the village condition and the residents' activities in the field related to the object of the study. This method was aimed to get a clear picture of the situation that could be used to support the data collected from the interviews.

Data analysis

The data of the present study were presented descriptively and quantitatively. Total production was calculated based on the plot of fallow periods to get an estimate of potential production. The maximum rice yield was estimated based on the fallow period of the field by summing the average annual production. Average production (AP) and marginal production (MP) were calculated using the following formula (Van Gardingen et al. 2003):

$$AP = \frac{P_t}{t}$$

where AP =average production, P_t = total production at age t, t = age

$$MP = \frac{P_t - P_{t-1}}{T_{t-T_{t-1}}}$$

where,

MP = Marginal production (marginal product)
Pt = Total of production
$Pt\text{-}_1$ = Total of production age
T = Total of age

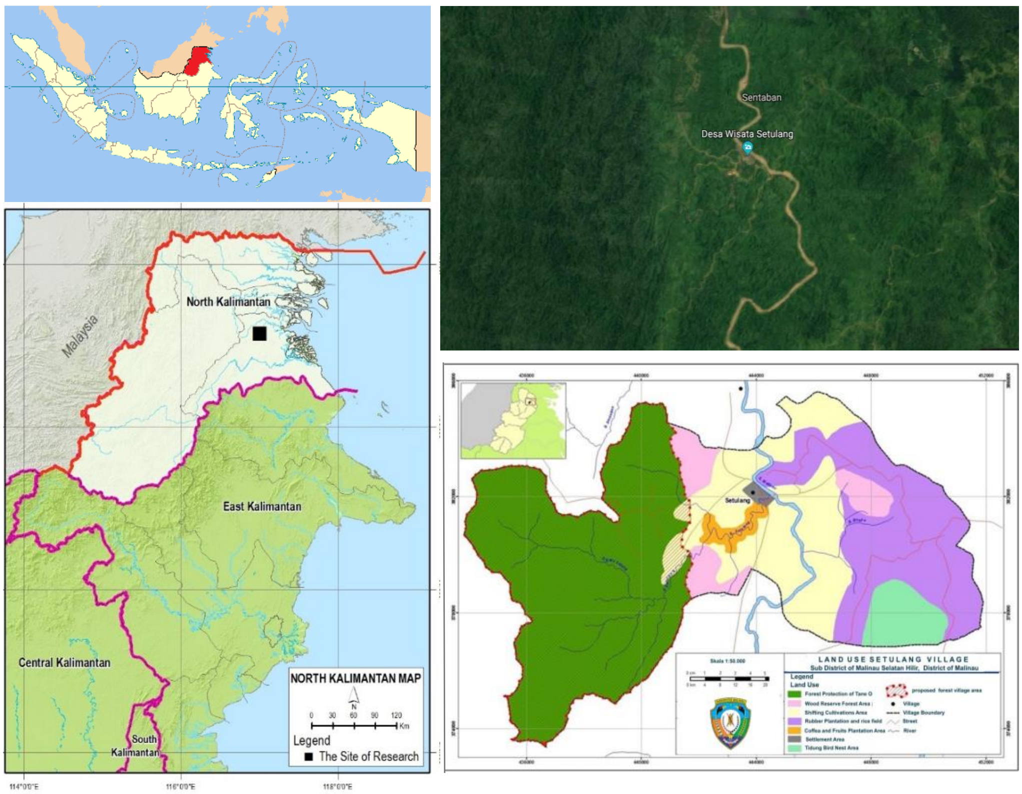

Figure 1. Setulang forest village location (■) of Malinau Selatan Hilir Sub-district, Malinau District, North Kalimantan, Indonesia

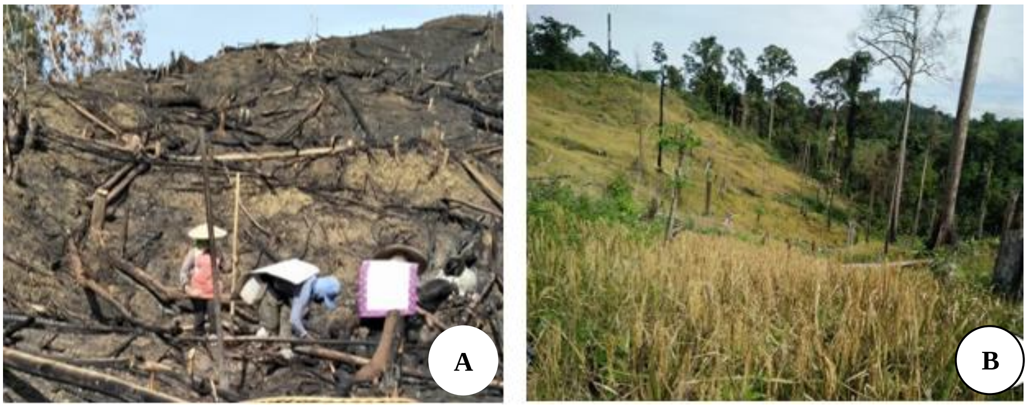

Figure 2. A. Preparing land by using tugal (*mula*), B. Landscape of dryland rice

A B C

Figure 3. Three types of local rice cultivars cultivated in Setulang village, Malinau District, North Kalimantan, Indonesia: A. Langsat; B. Telang Usan; C. Pimping

RESULTS AND DISCUSSION

Rotational farming system

The majority of Setulang villagers had livelihoods as rotational farmers. According to their indigenous culture, they own a large extent of land with various fallow periods, ranging from one year to 25 years. In managing the land from year to year, they used instincts and experience to determine what management stage to apply, for example, if the fallow period was more than 5 years, then the land was considered fertile and capable of producing good quality plants. Furthermore, farmers carried out a survey of the land to ensure that the conditions were proper or not to be managed. For example, if there were wild vegetation or trees with diameter of more than 5 cm above, then the land could be managed for cultivation. The farmers spent one year to complete one crop life cycle, starting from land clearing to post-harvest, then the next year they moved to another piece land that had been considered fertile after the fallow period, and so on (Figure 2).

After the harvesting period, the community will hold a ritual event that is thanksgiving worship and serve many kinds of traditional food to show their gratitude to God during the cultivation processes starting from the land clearing until the harvest time ends. Hastuti et al. (2017) mentioned that the ritual event in an agricultural system of Banjar tribes is called ‘Bahuma’. Bahuma ritual aims to ask blessings from God, hoping for abundant harvest and failure might not happen. Hamdani et al. (2016) found this is different from Dayak Meratus in which the ritual ceremony is conducted at the beginning of clearing land time.

Types of rice

People in Setulang village cultivated 7 varieties of local upland rice which included 4 varieties of ordinary rice and 3 varieties of glutinous rice. Nonetheless, at present only three types are dominantly cultivated by farmers, namely Langsat, Telang Usan and Pimping rice types (Figure 3). Nurhasanah et al. (2016) found 73 local rice cultivars consisting of 53 ordinary rice cultivars and 18 glutinous rice cultivars in East Kalimantan. The varieties of rice cultivated in upland fields are the source of life necessities for local people (Weihreter 2014).

Langsat rice had a nearly spherical shape and the seeds were bigger than Telang Usan and Pimping rice. It weighed 34.4 grams for 1,000 of rice seeds. In general, people prefer Langsat rice because the aroma is delicious and tastes good, but it cannot be planted in large quantities because when the rice is yellowed and ready to be harvested the ripening process of rice seeds on the tree is too fast so panicles and grains become rotten and result in crop failure.

Telang Usan rice had oval shape and its seeds were smaller than Langsat type rice but bigger than Pimping type rice. The weight of Telang Usan rice in 1,000 seeds was 23.26 grams. Pimping rice seeds had a small and long shape. Its size was smaller than Telang Usan type rice but it had a longer shape. Pimping rice weighed 24.39 grams in 1,000 seeds.

Total production of rice

Total production (TP) of Langsat, Telang Usan, and Pimping rice cultivars increased with increasing periods of fallow land. Low production occurred in lands with short fallow periods while high production occurred in lands with long fallow periods. The low production was likely influenced by the low level of soil fertility since there was process of reconditioning of soil nutrients generated from vegetation that grows naturally on the fallow land. This is in line with the study by Dechert et al. (2004) that infertile soil should normally take fallow period of 7 to 15 years.

In the management of rotational farming, instead of using chemical fertilizers the farmers utilized ash from burning above-ground vegetation on the land, which has been regenerating during the fallow period. Therefore, before the farmer decided the land to be managed, the farmer must be able to ensure that the land was highly productive. According to Syahbudin (2017), some issues that were normally found in cultivating upland rice include the low soil fertility, the lack of irrigation, the use of organic fertilizer, and the low soil acidity. The lack of high-quality seeds, fertilizers, irrigation costs, and human resources could give a significant impact on the rice farmers' income (Islam et al. 2017). In order to improve the sustainability of agricultural production, we should not only focus on developing superior varieties of seeds but should also concern about its tolerance and adaptability to the environment (Brummer et al. 2011; Meybeck et al. 2012).

Although the three cultivars of rice had experienced increase in production along with the increase of fallow period, each cultivar had different level of production. According to Kadidaa et al. (2017) and Hossain et al. (2015), the number of productive tillers, the number of grains in each panicle, and the panicle length were some good criteria in selecting varieties of rice to increase the yield.

The average production (AP) year^{-1} of Langsat rice increased from the fallow period of 3 years to 17 years, then after the fallow period of 17 years to 23 years, the average production per year and the marginal production (MP) declined (Table 2). Maximum production was in the fallow period of 17 years with a total production of 2,635 kg ha^{-1}, where the average annual production decreased at 155 kg ha^{-1} year^{-1} and the marginal production also decreased at 155 kg ha^{-1}. Based on these results, it could be concluded that Langsat rice is feasible to be cultivated in the fallow period of 17 years.

We found that Telang Usan rice average production per year increased during the fallow period of 3 years to 15 years, while after period of 15 years the average production per year and marginal production declined (Table 3). The maximum production of Telang Usan rice was in the fallow period of 15 years with 2,208 kg ha^{-1}, where the average annual production decreases at 147 kg ha^{-1} year^{-1} and also the marginal production decreased at 147 kg ha^{-1}. It could be concluded that the Telang Usan rice is suitable to be cultivated on land with a fallow period of 15 years.

The average annual production of Pimping rice increased starting from the fallow period of 3 years to 13 years, while after the fallow period of 13 years the average production per year and marginal production declined, where the average annual production decreased at 128 kg ha^{-1} year^{-1} and marginal production decreased at 128 kg ha^{-1} (Table 4). The maximum production of Pimping rice was in the fallow period of 13 years with total production of 1,670 kg ha^{-1}, suggesting that the cultivation of Pimping rice is best on land with a fallow period of 13 years.

Table 2. The total production of Langsat rice according to the fallow period

Fallow Period (year)	TP (kg ha^{-1})	AP (kg ha^{-1} year^{-1})	MP (kg ha^{-1})
3	170	57	
5	330	66	80
8	690	86	120
10	1060	106	185
13	1830	141	257
15	2325	155	248
17	2635	155	155
20	2900	145	88
23	3000	130	33

Note: TP = total production, AP = average production, MP = marginal production.

Table 3. The total production of Telang Usan rice according to the fallow period

Fallow Period (year)	TP (kg ha^{-1})	AP (kg ha^{-1} year^{-1})	MP (kg ha^{-1})
3	170	57	-
5	330	66	80
8	690	86	120
10	1150	115	230
13	1915	147	255
15	2208	147	147
17	2350	138	71
20	2400	120	17

Note: TP = total production, AP = average production, MP = marginal production

Table 4. The total production of Pimping rice according to the fallow period

Fallow Period (year)	TP (kg ha^{-1})	AP (kg ha^{-1} year^{-1})	MP (kg ha^{-1})
3	164	55	-
5	324	65	80
7	564	81	120
9	964	107	200
11	1414	129	225
13	1670	128	128
15	1830	122	80
17	1910	112	40

Note: TP = total production, AP = average production, MP = marginal production

There was relationship between marginal production and average production, i.e. if the marginal production was higher than the average production, then the average production would rise. Conversely, if the marginal production has fallen, the average production would also fall. Therefore the marginal production line would cross the average production at the point of maximum average production and would show the most productive fallow period.

To achieve maximum production of Langsat rice, the curves have crossing point at 17 years fallow period (Figure 4), while Telang Usan crossing point is in fallow period of 15 years (Figure 5) and Pimping rice is in fallow period of 13 years (Figure 6). Based on these crossing points, Langsat rice, Telang Usan, and Pimping had different production pattern in which the highest yield was produced by Langsat rice while the lowest production was by Pimping rice.

The results of our study demonstrate that rice production from rotational cultivation on dry land is lower than wet/irrigated land rice cultivation system (*sawah*). As such, the local government of Malinau District advised farmers to plant rice on irrigated land. But, due to the limited area of wetlands owned by farmers in Setulang village, they tended to use dry land to plant rice with rotational cultivation system. Purwanto et al. (2019) stated that one of the factors that hinder the development of local rice is because it takes a long period before being harvested and has low productivity. According to Sheil (2002), Setulang village has ultisol soil, implying it has poor nutrients, especially in organic matter. These heavily leached soils are acid (with pH of 4.5) and have low inherent fertility with only 20% of base saturation.

Based on the value of production in the fallow period of 17 years, grain production was 2,635 kg ha^{-1} $year^{-1}$, with an area of land that was cultivated in an area of 2 ha, the total grain production was 5,270 kg $year^{-1}$ $household^{-1}$, rice became 3,400 kg $year^{-1}$ household. The need for rice in each household was 140 kg $year^{-1}$ $person^{-1}$, so the need for household (5 persons) was 700 kg $year^{-1}$ so there was a surplus of 2,700 kg ha^{-1}. Of the total surplus, 2 tons were sold for other needs such as education, clothing, health, recreation, and others. Therefore, they were generally not affected by the economic crisis that was commonly experienced by urban communities such as layoffs, inflation of prices of basic necessities and others.

Side production other than rice was 11.76% of the total financial value of rice production during fallow period 17 years at 3,400 kg ha^{-1} $year^{-1}$ household. Assuming an average price of rice per kg of 15,000 IDR, the vegetable value of 6,000,000 IDR. Some by-products which were harvested earlier than rice were cucumbers, tomatoes, chili, corn, pumpkins harvested during weeding. The financial value of this by-product was the same as the value needed for weeding, so it could replace the value of working day people (weeding was 80 days with a value of 75,000 IDR day^{-1} $person^{-1}$ for a 2 ha land area, then weeding became 40 day^{-1} $person^{-1}$ ha^{-1}).

This swidden cultivation field activity was a hereditary generation from generation to generation and its production was able to meet the food needs of the community of Setulang Village were: i) This activity would continue to be sustainable because in addition to hereditary activities it was also supported by geographical location in the highlands; ii) People were not interested in modern agriculture because they were used to swidden cultivation techniques and were also accustomed to consuming organic field rice because they do not use chemical fertilizers; iii) The government assesses shifting cultivation must be maintained; iv) Landscape after most of it was between 20-40%, while palm oil production was required below 30 % due to cheaper production costs. As for the area has no coal potential, so there is no opportunity for future coal mining activities.

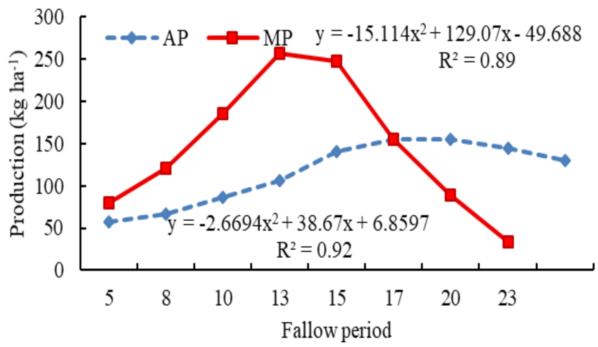

Figure 4. Production curves of Langsat rice based on the fallow period

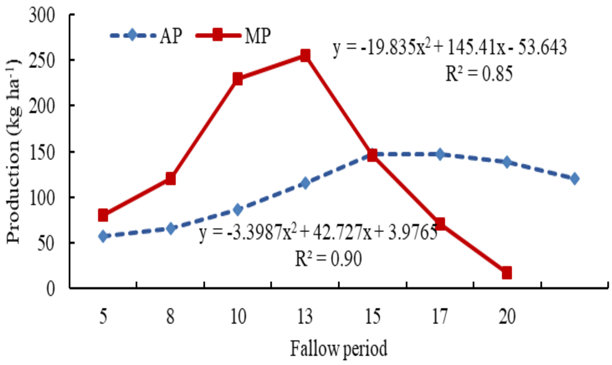

Figure 5. Production curves of Telang Usan rice based on the fallow period

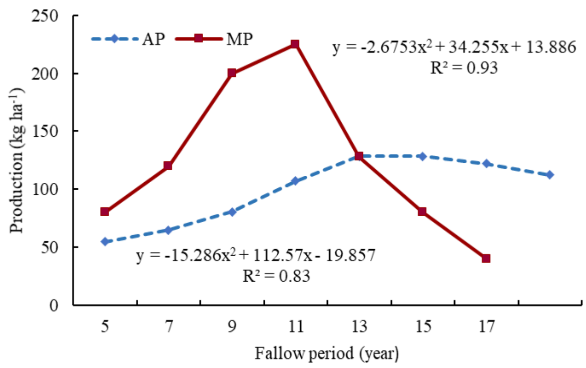

Figure 6. Production curves of Pimping rice based on the fallow period

There was a palm oil mill in 2012 in Tanjung Lapang Malinau Barat with the company name Bukit Borneo Sejahtera company with an operating permit area of 14,326 ha and a capacity of 10 tons per hour, but subsequently because there was no supply of raw material for palm oil, the factory no longer operated, so in 2017 it moved to Sebuku, Nunukan. The community already understood that the Setulang area would not produce oil palm like other regions in East Kalimantan. The total potential dry land area was less than 2,000 ha, with 232 households, with a fallow period of at least 10 years. Less than 10% of the local farmers develop cocoa around their homes and sell it to cocoa collectors who come to the village to be sent to Sabah, Malaysia.

In this study, the findings suggested that the grain yield in Setulang village could reach 2,635 kg ha^{-1}. In addition, Munawwarah et al. (2016) revealed that the production of upland rice cultivated in high land fields was 3,200 kg ha^{-1}, whereas the yield of the upland rice cultivated along the bank of Mahakam river with an altitude of 0-10 meters above the sea level could reach 2,500 to 2,900 kg ha^{-1} per each cultivation season. Imang et al. (2018) stated that weather, rainfall, pest, and plant disease could affect the production of swidden agriculture field. In addition, they also mentioned that the average production of swidden agriculture could reach 1,475 kg ha^{-1} in 2017. This amount was still considered lower than the previous year due to a long dry season.

ACKNOWLEDGEMENTS

The researchers would like to send their highest appreciation to the Faculty of Forestry, Mulawarman University, Samarinda, Indonesia for the unstoppable supports. On the other hand, the author would also like to share their gratitude to the residents of Setulang village who had facilitated and participated in our study. We would like to express our gratitude to Umbar Sujoko and Ahmat Wijaya for his help in creating the map of the study site. In addition, the author thanks to Sudarman and Budi Setiawan for editing the English in this manuscript. We thank anonymous reviewer for constructive feedback.

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