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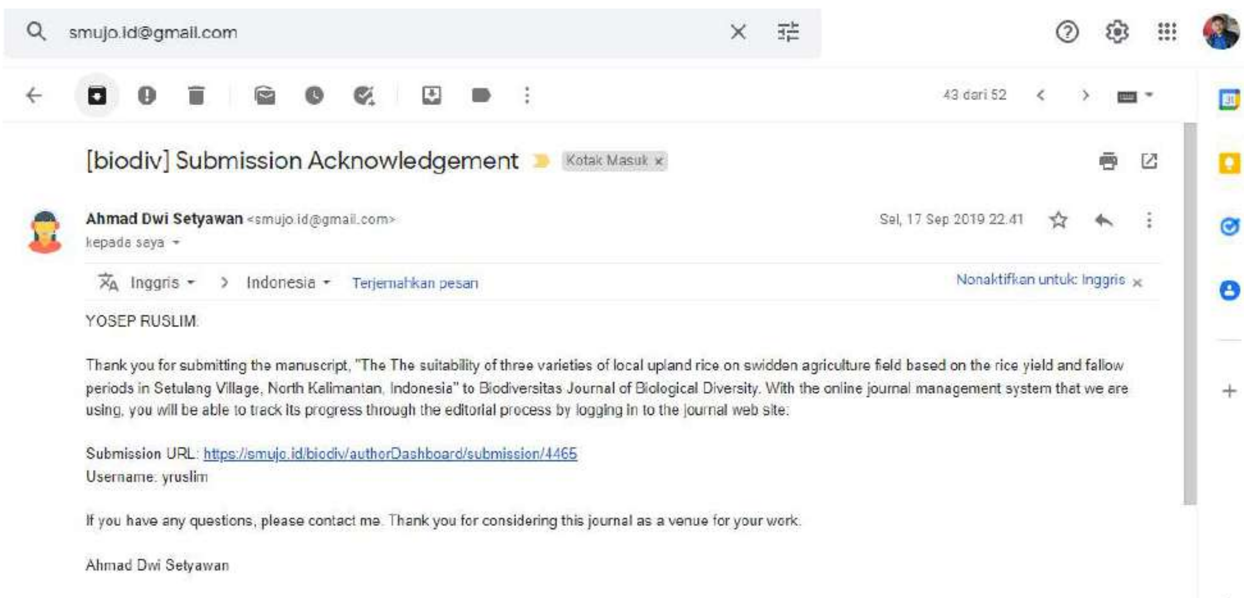

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The suitability of three varieties of local upland rice on swidden agriculture field based on the rice yield and fallow periods in Setulang Village, North Kalimantan, Indonesia

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Abstract. Swidden agriculture field is a dry land that is used by the field farmers to cultivate some varieties of local upland rice by using a polyculture system with some other crops such as corns, gingers, cucumbers, spinaches, and many others, however the rice remains as the main commodity. The swidden agriculture field cultivated by the farmers is only used for one harvest in a year before it is left for fallow periods for years. The present study was conducted to assess which local upland rice varieties that are suitable for the soil based on the rice yield on each fallow period. This study was conducted at Setulang village, Malinau regency, Kalimantan Utara. The study employed purposive sampling method to select the samples of the study. In this methodology, the samples were intentionally selected by the researchers based on every fallow period of fields as planned by the researchers. The data were analyzed descriptively and quantitatively through tables and calibration curves. The rice employed in this study included three varieties of local upland rice namely Langsat rice, Telang Usan rice, and Pimping rice. The findings showed that Langsat rice reached the maximum production on fallow period of 17 years with the total production of 2.635 kg ha^{-1}. In addition, Telang Usan rice and Pimping rice reached the maximum production on the fallow period of 15 years with the total production of 2.208 kg ha^{-1} and 2.075 kg ha^{-1} respectively.

Keywords: Fallow period of fields, rice yield, Setulang village, swidden agriculture field, upland rice

INTRODUCTION

Rice plant (*Oryza sativa* L.) is a crop that produces rice and a staple food source. In Indonesia, rice is a main commodity to support society food. Most of Indonesians have rice as the staple food every day. 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 the staple food. Unfortunately, for almost three decades, domestic rice production is incapable to meet the demand that continues to grow.

People in Setulang village have cultivated 7 varieties of local upland rice which includes 4 varieties of ordinary rice and 3 varieties of glutinous rice. The number of local upland rice varieties of swidden agriculture field is not proportional to the number of wetland rice varieties. Nurhasanah et al. (2016) also found 73 local rice cultivars consisting of 53 ordinary rice cultivars and 18 glutinous rice cultivars. The varieties of rice cultivated in upland fields are a source of life necessities for the local people (Weihreter 2014). In general, the farmers plant 5-8 varieties of rice by implementing polyculture system with other plants such as corns, canes, bananas, and many more (Hamdani et al. 2016). Based on the swidden agriculture system implemented by Dayak tribes, rice is planted with other crop plants (Siahaya et al. 2016).

Swidden agriculture field is a dry land used by the farmers to plant various kinds of local upland rice by applying polyculture farming system where the crops are planted together with various crop plants including corns, gingers, cucumbers, spinaches, and many others. However, the rice remains as the main commodity. The farmers cultivate swidden agriculture field for only one harvest in a year, and later they leave the land for years as fallow periods. After the field has been cultivated by the farmers for one harvest period, it will be left and abandoned to revert it to their natural vegetation, while they move to another field (Van et al. 2012). Generally, the land that is planted is the secondary forest, while the primary forest is no longer being cut down for cultivation (Teegalapalli et al. 2016).

Managing shifting cultivation and agroforestry is the society action that relies on the forest dependency (Parotta et al. 2016). Today, the area of swidden agriculture field is about 280 million hectares throughout the world and is predicted to decrease in upcoming years (Heinimann et al. 2017). Furthermore, Wibowo et al. (2016) stated that the change in a function of cultivation land can reduce the rice production which gives negative impacts towards the income of the farmers.

Swidden agriculture field is one of the applications of the forest and land management by the society who lives in a tropical area and is suitable to social typology in which there is a high interdependence between people and the environment (Dove 1993; Colfer et al. 1997; Inoue 2000). Sardjono (1990), maintains 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. These practices can be further improved through agroforestry to adapt to local socio-economic dynamics and environmental changes. Consumtion of non-wood forest products in the Setulang Forest can effectively decrease disturbance to Ketrok Protected Forest which provides ecofriendly services for the surrounding lives (Hutauruk et al. 2018b)

After the harvest period ends, the society will hold a ritual event which is thanksgiving worship and serve many kinds of traditional food to show their gratitude to God during the cultivation process 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, so they will get abundant harvest and hopefully crop failure might not happen. Hamdani et al. (2016) found this is different from Dayak Meratus. At the beginning of clearing land time, the people of Dayak Meratus always start by having the ritual ceremony. Ouédraogo et al. (2014); Camacho et al. (2015) reported that for Dayak people, a forest is not only a place of livelihood but also a place that brings advantages in terms of social, cultural, and spiritual aspects.

Most of Setulang village work as farmers where the cultivation activity is the source of the food need fulfilment and also a part of their cultural identity. Therefore, even though the fixed permanent agriculture system and the use of modern technology have been introduced, the residents of Setulang still do the practice that has been done for a long time by their ancestors from generation to generation. According to Van et al. (2013), the swidden agriculture system can be maintained in a long run when the farmers are able to adapt and to integrate with the local environment. Also, when they receive supports from the other subsistence**.**

Based on the problems above, the study of the suitability of local upland rice in swidden agriculture field is essential to be conducted depending on the yield and the fallow periods of the fields**.** Therefore, that particular varieties of upland rice can be cultivated in the appropriate field to support the local food security for Dayak tribes. Additionally, it is also expected to provide solutions and solve the food insecurity as well as poverty in Malinau regency, especially for Dayak society who works on swidden agriculture field.

MATERIALS AND METHOD

Study Area

This research was conducted in Setulang Village, Sub-district of Malinau Selatan Hilir, Malinau District, North Kalimantan Province. Desa Setulang is located in the creek of Setulang river and Malinau river. It is approximately ± 29 km from the Capital of Malinau District. The boundaries of the village, covering the northern border with the village of Sentaban, the south bordering Setarap Village, the east bordering TanjungLapang Village, and the West bordering with Paking Village. It has an area of 11.800 ha including *Tane' Ulen* forest, a 5,300 ha protected forest that is traditionally protected by the people of Setulang (Figure 1).

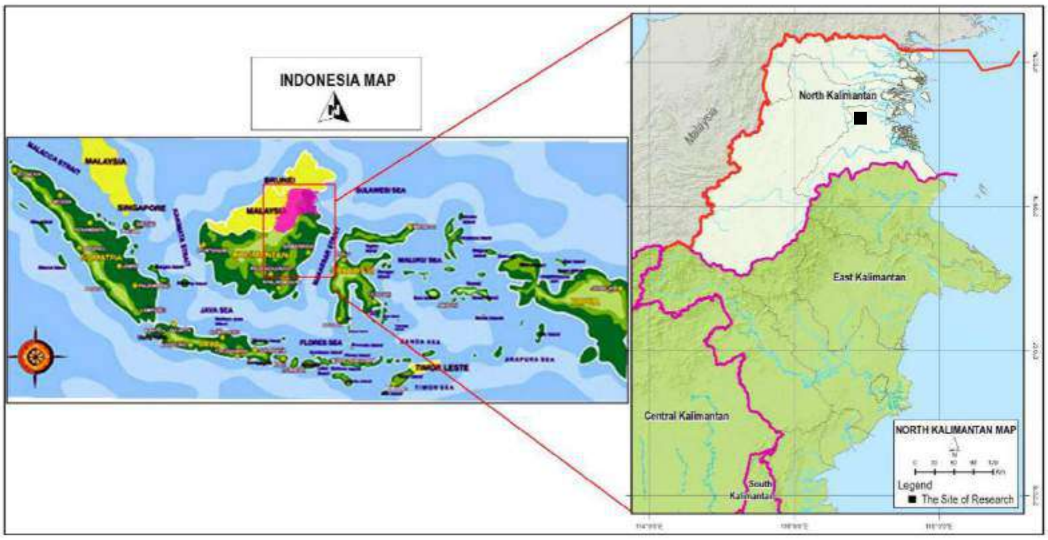

Figure 1. Setulang forest village location of South Malinau sub-district (■) (Hutauruk el al. 2018a).

Procedures

The present study employed a purposive sampling method in selecting the participants of the study. The samples were the residents of Setulang village who were selected purposively by the researcher. Among 233 heads of family, a quarter of them, or 35 heads of family, were selected to participate in this study. The use of purposive sampling method in this study was based on the statement by Wirartha (2006) explaining that in purposive sampling technique samples are intentionally selected by researchers.

Data Collection

In order to achieve the objectives of this study, the primary and secondary data were collected for the data analysis. The data collection procedures are described as follows:

Primary Data

The primary data of this study included the amount of rice yield, the fallow periods of the rice field, the varieties of upland rice namely Langsat rice, Telang Usan rice, and Pimping rice. The data were obtained through interviews with a questionnaire and field observations. The detail explanations of the data collection are explained as follows:

Interviews

The researcher asked some questions and clarifications from the respondents. The questions had already been prepared in a questionnaire by the researcher.

Field Observation

The researcher made a direct observation to see the village condition and the residents' activities in the field related to the object of the present study. It aimed to get a clear picture about the situation that could be used to support the data that were already collected before.

Data Analysis

The data analysis of the present study was presented descriptively and quantitatively. The analysis of the maximum rice yield was conducted based on the fallow period of the field by counting the average annual production. According to Van Gardingen et al. (2003), average product (AP) and marginal product (MP) can be summed up by using the following formula:

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

In which: AP =average product, 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_{-1} = Total of production age
T = Total of age

RESULTS AND DISCUSSION

The findings of the suitability of varieties of local upland rice on swidden agriculture field based on fallow periods of the field in Setulang village can be seen from their production as shown below.

Langsat rice

Langsat rice has an almost round shape and its seeds are larger than Telang Usan rice and Pimping rice. The number of Langsat rice seeds in 10 grams is 290 seeds. In general, people prefer this 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 harvest the ripening process is too fast so that the rice seeds and grains are drunk and result in crop failure.

Figure 2. Rice types of Langsat

Table 1. The total production of Langsat rice

Fallow Period (year)	TP (kg)	AP (kg)	MP (kg)
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

Table 1 shows that the yield of Langsat rice increased on every fallow period, starting from fallow period of 3 years to the 23 years. Average annual production started to increase on fallow period of 5 years until the fallow period of 15 years. However, the average annual production started to decrease after the fallow period of 17 years. The maximum production occurred on fallow period of 17 years with the total production of 2.635 kg ha^{-1}. Based on the finding, it can be concluded that the Langsat rice was suitable or worthy to be cultivated on the field with 17-year fallow period. The graph below shows the yield of Langsat rice based on the fallow periods.

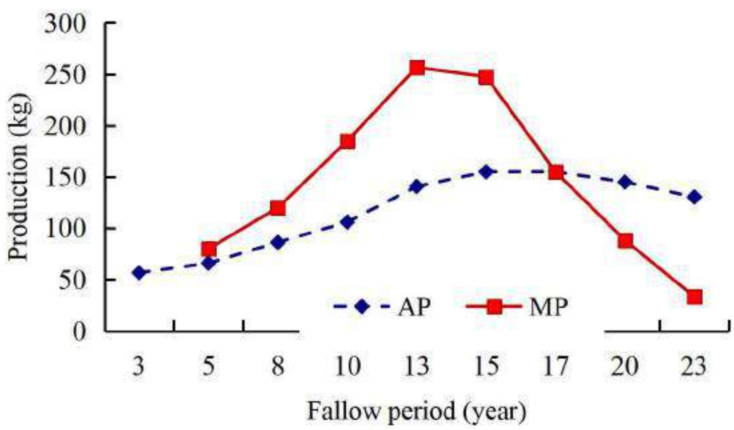

Figure 3. Graphic production rice types of Langsat based on the fallow period (year)

Telang Usan rice

Telang Usan rice has oval shape and its seeds are smaller than Langsat type rice and bigger than Pimping type rice. The number of Telang Usan rice seeds in 10 grams is 430 seeds.

Figure 4. Rice types of Telang Usan

Table 2. The total production of Telang Usan rice

Fallow Period (year)	TP (kg)	AP (kg)	MP (kg)
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

Table 2 shows that the yield of Telang Usan rice had an increase on each fallow period of the field, starting from fallow period of 3 years to 20 years. The average production started to increase on the fallow period of 5 years to the fallow period of 13 years, but it started to decrease after the fallow period of 15 years. The maximum production occurred on the fallow period of 15 years with the total production of 2.208 kg ha^{-1}. Thus, this type of rice was suitable or worthy to be cultivated on the field with fallow period of 15 years. The following graph shows the yield of Telang Usan rice based on its fallow period.

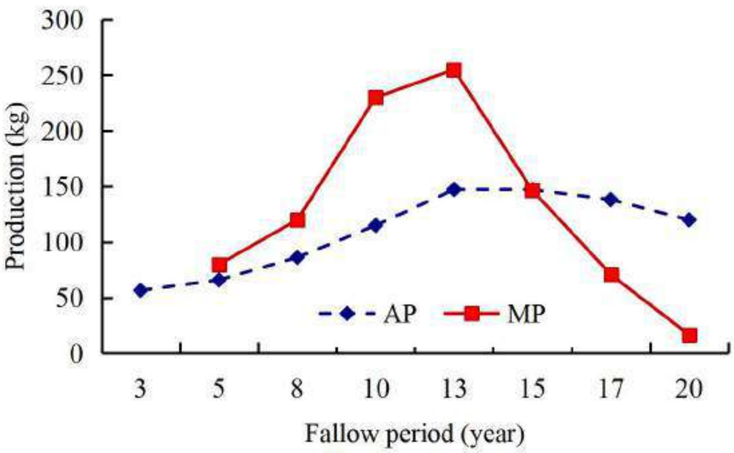

Figure 5. Graphic production rice types of Telang Usan based on the fallow period (year)

Pimping rice

Pimping rice seeds have a smaller shape than Telang Usan rice, but have a longer size. The number of Pimping rice seeds in 10 grams is 410 seeds.

Figure 6. Rice types of Pimping

Table 3. The Total Production of Pimping Rice

Fallow Period (year)	TP (kg)	AP (kg)	MP (kg)
3	150	50	-
5	300	60	75
8	670	84	123
10	1120	112	225
13	1800	138	227
15	**2075**	**138**	**138**
17	2250	132	88
20	2380	119	43

Table 3 shows that the yield of Pimping rice had an increase in amount on every fallow period, starting from fallow period of 3 years to 20 years. The average production started to increase on fallow period of 5 years until the fallow period of 13 years. Nevertheless, it started to decrease after the fallow period of 15 years. The maximum production occurred on the fallow period of 15 years with the total production of 2.075 kg ha^{-1}. In conclusion, Pimping rice was suitable or worthy to be cultivated on the field with fallow period of 15 years.

The graph below shows the yield of Pimping rice based on the fallow period.

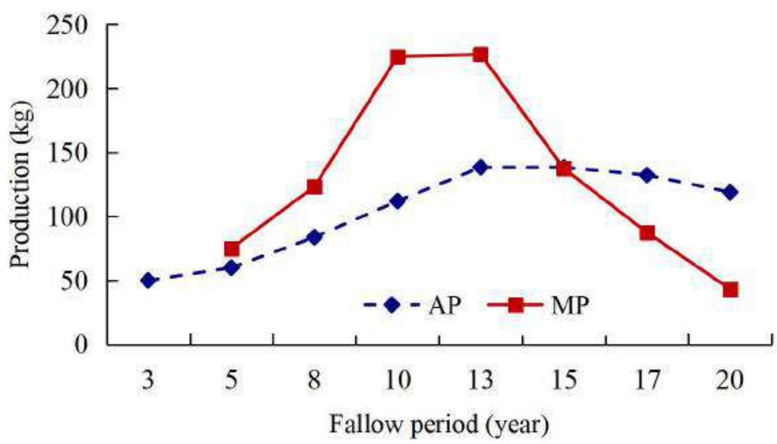

Figure 7. Graphic Production rice types of Pimping based on the fallow period (year)

All the tables and the graphs above show that the three varieties of local upland rice that were cultivated on every fallow period of the field had different yield. The lowest yield occurred on fallow period of 3 years, but after that it grew up on every fallow period. Generally, the shorter the fallow period is, the lower the yield will be. On the contrary, the longer the fallow period is, the higher the yield will be. It is in line with Dechert et al. (2004) that infertile soil should normally take fallow period of 7 to 15 years. In short, the longer the fallow period is, the higher the yield will be.

Cultivating local upland rice on unsuitable fallow periods will result in lower yield. On the other hand, as time goes by, such rice varieties will be extinct in the future. 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 are some good criteria in selecting varieties of rice to increase the yield. According to Syahbudin (2017), some issues that are normally found in cultivating upland rice such as the low soil fertility, the lack of irrigation, the use of organic fertilizer, and the low soil acidity.

In cultivating upland rice, farmers normally use varieties of local upland rice with a relatively longer life and low productivity. Purwanto et al. (2019) stated that one of the factors that hinder the development of local rice is because it takes a long period to crop and has a low productivity. In order to improve the agriculture products to be sustainable, we should not only focus on developing superior varieties of seeds but should also concern on its tolerance and the adaptability to the environment (Brummer et al. 2011; Meybeck et al. 2012). The lack of high quality seeds, fertilizers, irrigation costs, and human resources could give a significant impact towards the rice farmers' income (Islam et al. 2017).

In this study, the findings suggested that the rice yield in Setulang village could reach 2,635 ton ha^{-1}. The amount was still below the national average production that could reach 4 ton ha^{-1} (Syahbudin 2017). In addition, Munawwarah et al. (2016) revealed that the average production of upland rice cultivated in high land fields was 3,2 ton GKP-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 2,5 to 2,9 ton GKP-1 season-1 cultivation. Imang et al. (2018) expressed that weather, rainfall, pest, and plant disease could affect the agriculture production on swidden agriculture field. In addition, they also mentioned that the average production of swidden agriculture could reach 1.475 kg ha^{-1} in 2017. The amount was still considered lower than the previous term due to a long dry season.

Syakir (2019) stated that a big hope relied on the development of upland rice in supporting the achievement of the national rice production by looking at the availability of potential lands. In fact, the availability of the dry rice fields is bigger than the wet rice fields. The findings of the study suggested that Langsat rice was suitable or worthy to be cultivated on the fallow period of 17 years with a total production of 2.635 kg ha^{-1}. Meanwhile, Telang Usan rice and Pimping rice were suitable or worthy to be cultivated on the fallow period of 15 years with a total production of 2.208 kg ha^{-1} and 2.075 kg ha^{-1} respectively. Cultivating local upland rice on unsuitable fallow periods of the field resulted in the low rice yield. The low production could affect the extinction of local upland rice varieties in the future.

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

Abstract. Swidden agriculture field is a dry land that 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}. PLEASE ADD ONE OR TWO SENTENCE(S) TO CONCLUDE THE ABSTRACT EXPRESSING THE IMPLICATIONS OF THE RESULTS (YOU CAN EXTRACT FROM THE DISCUSSION).
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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 the 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 the 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 a 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 reflects the reliance of local community on forest (Parrotta et al. 2016).

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 production 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 which 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).

In Setulang village, Sub-district of Malinau Selatan Hilir, Malinau District, North Kalimantan Province, the utilization of dry land agriculture still has a large potential in increasing rice production if viewed in term of land extent. 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., 2018b).

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Swidden agriculture or also called rotational farming or shifting cultivation has the same pattern and stage of activity but has different local term 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) planting in a tugal way (*mula*), starting 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. Setulang village is located in 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 system with other plants such as corns, canes, bananas, and many more (Hamdani et al., 2016).

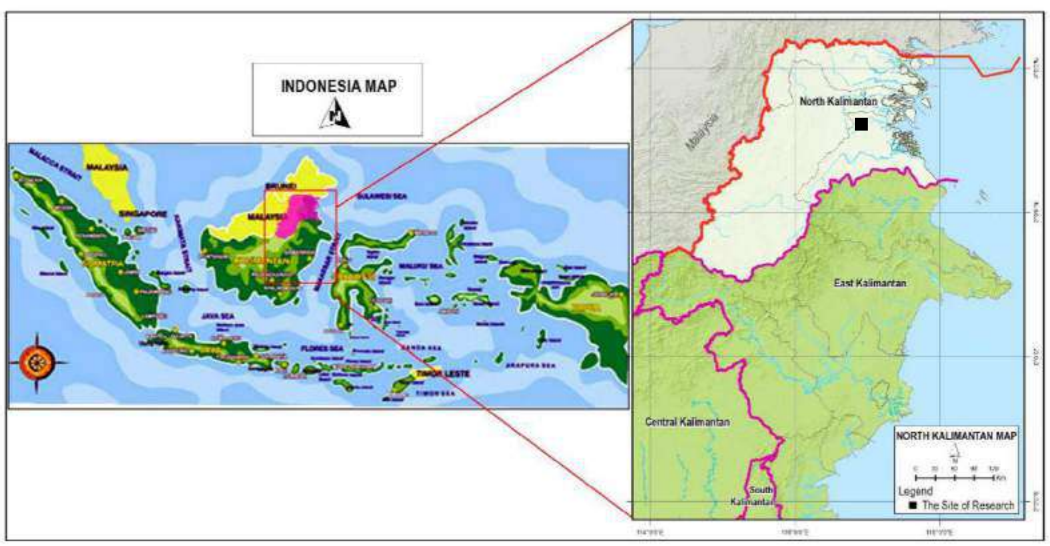

Figure 1. Setulang forest village location (■) of South Malinau sub-district (Hutauruk el al. 2018a).

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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 about the situation that could be used to support the data collected from the interviews.

Data analysis

The data of the present study was 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_{-1} = Total of production age
T = Total of age

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.

After the harvesting period, the community will hold a ritual event which 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

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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 2). Nurhasanah et al. (2016) found 73 local rice cultivars consisting of 53 ordinary rice cultivars and 18 glutinous rice cultivars. 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, the people preferred Langsat rice because the aroma was delicious and tasted good, but it cannot be planted in large quantities because when the rice was yellowish and ready to be harvested the ripening process was very quick until the rice seeds and grains were drunk, resulting 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.

Figure 2. Three types of local rice cultivars cultivated in Setulang village, Malinau District, North Kalimantan, Indonesia; (A) Langsat; (B) Telang Usan; (C) Pimping.

Total production of rice

Total production (TP) of Langsat, Telang Usan and Pimping rice cultivars increased with increasing periods of fallow land. Low production occured in lands with short fallow periods while high production occured 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 duing 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 the agricultural production, we should not only focus on developing superior varieties of seeds but should also concern on its tolerance and the 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, but 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.

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})

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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.

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.

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

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 4. The total production of Pimpng 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 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 (Figure 3), while Telang Usan crossing point is in fallow period of 15 years (Figure 4) and Pimping rice is in fallow period of 13 years (Figure 5). 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.

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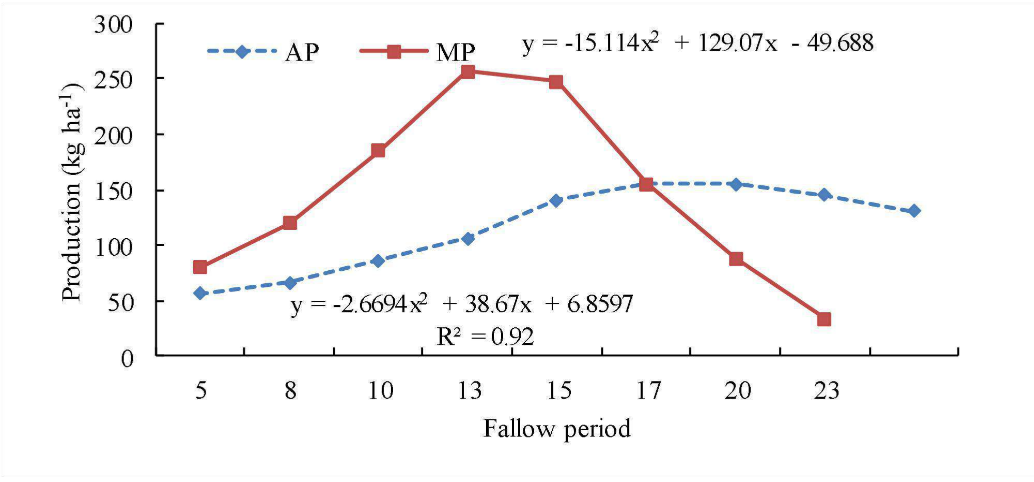

Figure 3. Production curves of Langsat rice based on the fallow period

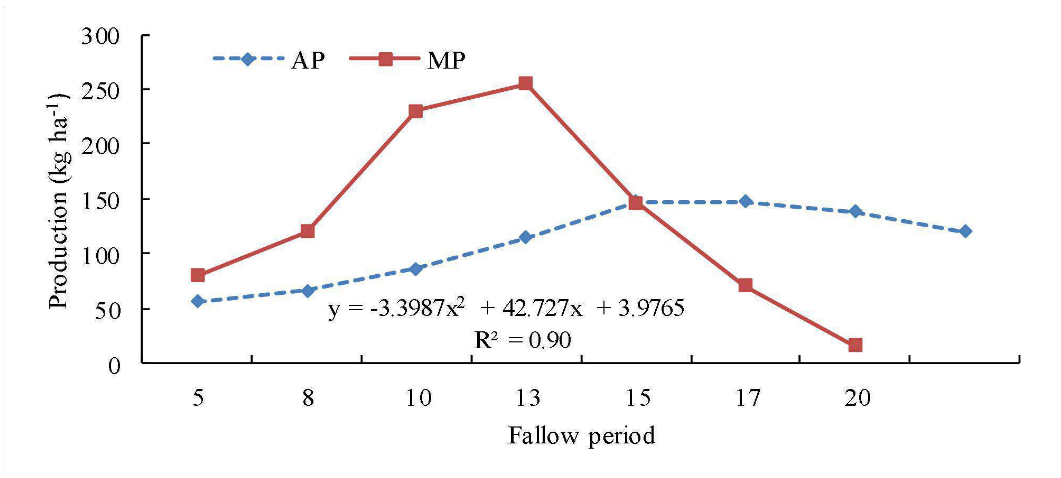

Figure 4 Production curves of Telang Usan rice based on the fallow period

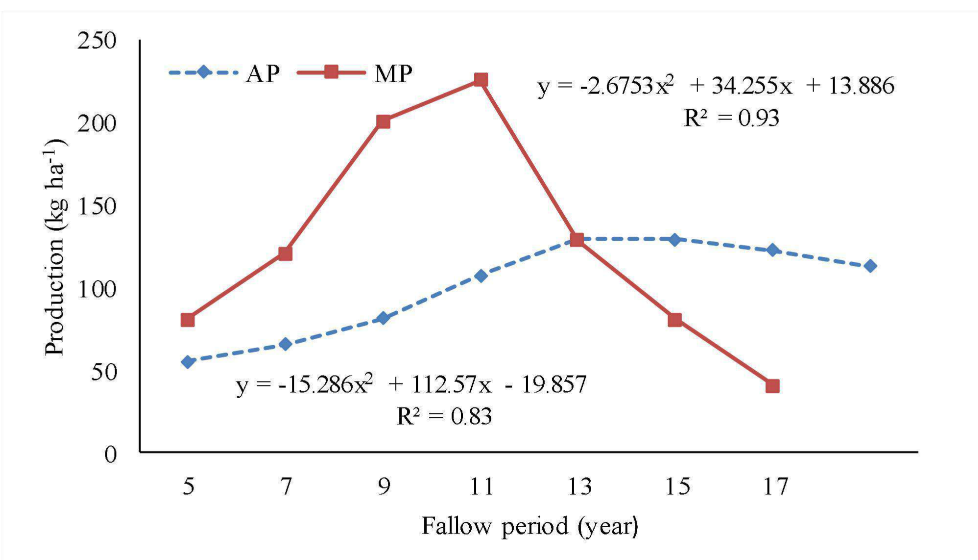

Figure 5. Production curves of Pimping rice based on the fallow period

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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 a 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.

In this study, the findings suggested that the rice 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 on 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.

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QUESTIONNARE OF SWIDDEN AGRICULTURE RESEARCH IN SETULANG VILLAGE

TOPIC : The Suitability of three varieties of local upland rice on swidden agriculture in Setulang Village, North Kalimantan, Indonesia

Data collection :

Malinau date and year
: . . . .
Name of reseacher
: . . . .
Location : . . . .

Respondent's biodata

Name of family head : . . . .
Age: . . . . . year
Tribe (Suku) : . . . .
Number of family member
Wife : . . . . person
Child : . . . . person
Other members : . . . . person

Land use system

1. How many years of experience have you been a shifting cultivator (swiddener)?
2. How wide land area have you used: .... ha
3. How long to make a field based on activities during the life cycle of rice plants:

a.
b.
c.
d.
e.
f.
g.

Land preparation :
Cuting:
Tree felling:
Land clearing and burning:
Planting:
Weeding:
Harvesting:
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Revised version of manusript

Participants Edit

Smujo Editors (editors)

Anisa Septiasari (aseptiasari)

YOSEP RUSLIM (yruslim)

Messages

Note	From
Dear Section Editor, Smujo Editor and Anonymous Referee I'm sending you revised version of our manuscript " The suitability of three varieties of local upland rice on swidden agriculture in Setulang Village, North Kalimantan, Indonesia". Thank you very much for your comments in order to refine our paper. All of the comments are very meaningfull. We have made change and responses by considering the reviewer. I hope the revised manuscript has met the requirements for publication.	yruslim 2019-11-14 02:35 PM

Thank you very much for all your valuable comments from the beginning

Coresponding author,

Yosep Ruslim

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Dear Sir, Received, with thanks.	aseptiasari 2019-11-15 04:44 AM
Dear Section Editor, Smujo Editor and Anonymous Referee I'm sending you a second revised version of our manuscript "Productivity three varieties of local upland rice on swidden agriculture field in Setulang Village, North Kalimantan, Indonesia". Thank you very much for your comments in order to refine our paper. All of the comments are very meaningful. We have made change and responses by considering the reviewer. I hope the revised manuscript has met the requirements for publication. Thank you very much for all your valuable comments from the beginning Corresponding author, Yosep Ruslim yruslim, A-06-NOV-SGB-The suitability of three varieties of local upland rice_InternalRev_edit(Nov 27)).doc	yruslim 2019-11-28 06:27 AM

The suitability of three varieties of local upland rice on swidden agriculture in Setulang Village, North Kalimantan, Indonesia

Abstract. Swidden agriculture field is a dry land that is used by the field farmers to cultivate some varieties of local upland rice by using a polyculture system with vegetables, tubers and fruits, however the rice remains as the main commodity. The swidden agriculture field cultivated by the farmers is only used for one harvest in a year before it is left for fallow periods for years. The present study was conducted to assess which local upland rice varieties that are suitable based on the rice yield on each fallow period. This study was conducted at Setulang village, Malinau regency, Kalimantan Utara. The study employed purposive sampling method to select the samples of the study. In this methodology, the samples were intentionally selected by the researchers based on every fallow period of fields as planned by the researchers. The data were analyzed descriptively and quantitatively through tables and calibration curves. The rice employed in this study included three varieties of local upland rice namely Langsat rice, Telang Usan rice, and Pimping rice. Among three varieties of rice in this study, Langsat rice varieties has the longest fallow period of 17 years while the Pimping rice has the shortest fallow period 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}.

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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 a main commodity to support society food. Most of Indonesians have rice as the staple food every day. 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 the staple food. Unfortunately, for almost three decades, domestic rice production is incapable to meet the demand that continues to grow.

Utilization of dry land as a turning field in Setulang Village, if viewed in terms of land area still had a large potential in increasing rice production because the area was dominated by dry land, but if the utilization was not in accordance with the needs of farmers, in this case land conversion occurs. can had an impact on reducing rice production. According to Heinimann et al. (2017), today, the area of swidden agriculture field is about 280 million hectares throughout the world and is predicted to decrease in upcoming years. Furthermore, Wibowo et al. (2016) stated that the change in a function of cultivation land can reduce the rice production which gives negative impacts towards the income of the farmers. The challenges faced in increasing rice production on dry land were land processing that was still manual, had a long harvest life and there was a process of fallow land. Behind these challenges, genetically rice planted on rotating backlands was resistant to uncertain weather conditions. Afrida et al. (2016) stated that rice cultivation on dry land was genetically resistant to drought.

The farmers cultivate swidden agriculture field for only one harvest in a year, and later they leave the land for years as fallow periods. After the field has been cultivated by the farmers for one harvest period, it will be left and abandoned to revert it to their natural vegetation, while they move to another field (Van et al. 2012). Generally, the land that is planted is the secondary forest, while the primary forest is no longer being cut down for cultivation (Teegalapalli et al. 2016).

Swidden agriculture field is one of the applications of the forest and land management by the society who lives in a tropical area and is suitable to social typology in which there is a high interdependence between people and the environment (Inoue 2000). Sardjono (1990), maintains 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. These practices can be further improved through agroforestry to adapt to local socio-economic dynamics and environmental changes.

Most of Setulang village work as farmers where the cultivation activity was the source of the food need fulfilment and also a part of their cultural identity. Therefore, even though the fixed permanent agriculture system and the use of modern technology had been introduced, the residents of Setulang still did the practice that had been done for a long time by their ancestors from generation to generation. Managing shifting cultivation and agroforestry is the society action that relies on the forest dependency (Parrotta et al. 2016). Ouédraogo et al. (2014); Camacho et al. (2015) reported that for Dayak people, a forest was not only a place of livelihood but also a place that brings advantages in terms of social, cultural, and spiritual aspects. According to Van et al. (2013), the swidden agriculture system could be maintained in a long run when the farmers were able to adapt and to integrate with the local environment. Also, when they receive supports from the other subsistence.

Reverse farming activities for each region had the same pattern and stage of activity, but had different local terms. The term local rotating agriculture behind this research site in Setulang Village was called Omoq. Stages and local istila and length of time spent by farmers in Setulang Village to complete one year of the life cycle of rice plants: (i) Land survey, starting in April; (ii) cutting bushes and small trees (midik), starting from May to June; (iii) cutting down large trees (nepeng), starting in early July; (iv) chopped (metok), starting the second week of July; (v) burn land (nutung), starting the fourth week of August (end of August); (vi) Planting in a tugal way (mula), starting in September; (vii) maintenance, starting mid-September to January; (viii) harvesting (majau) starts from February to March; (ix) postharvest (lepa majau), the fourth week of March. According to Imang et al. (2004), Dayak Kenyah people open their fields through 9 stages. However, the Bahau Dayak people in the village of Matalibaq generally open their fields through 8 stages, as follows: (i) cutting 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.

The land use system of shifting fields by Dayak farmers in Setulang village is that rice plants are intercropped with other crops such as vegetables, sweet potatoes and fruits, but in this study we only counted the yield of rice production which is the main commodity crop in shifting activities. In general, the farmers plant 5-8 varieties of rice by implementing polyculture system with other plants such as corns, canes, bananas, and many more (Hamdani et al., 2016). Based on the swidden agriculture system implemented by Dayak tribes, rice is planted with other crop plants (Siahaya et al. 2016). The natural resources managed by the Dayak people used knowledge and local wisdom, so that the forest can be settled by future generation (Hutauruk et al. 2018b).

The study of the suitability of local upland rice in the swidden agriculture field was essential to be conducted depending on the yield and the fallow periods of the fields**.** Therefore, that particular varieties of upland rice could be cultivated in the appropriate field to support the local food security. Additionally, it was also expected to provide solutions and solve the food insecurity as well as poverty in Malinau regency.

MATERIALS AND METHODS

Study Area

This research was conducted in Setulang Village, Sub-district of Malinau Selatan Hilir, Malinau District, North Kalimantan Province. Desa Setulang is located in the creek of Setulang river and Malinau river. It is approximately ± 29 km from the Capital of Malinau District. It borders on Sentaban Village in the north, Setarap Village in the south, Tanjung Lapang Village in the east, and Paking Village in the west. It had an area of 11.800 ha including *Tane' Ulen* forest, a 5,300 ha protected forest that was traditionally protected by the people of Setulang (Figure 1).

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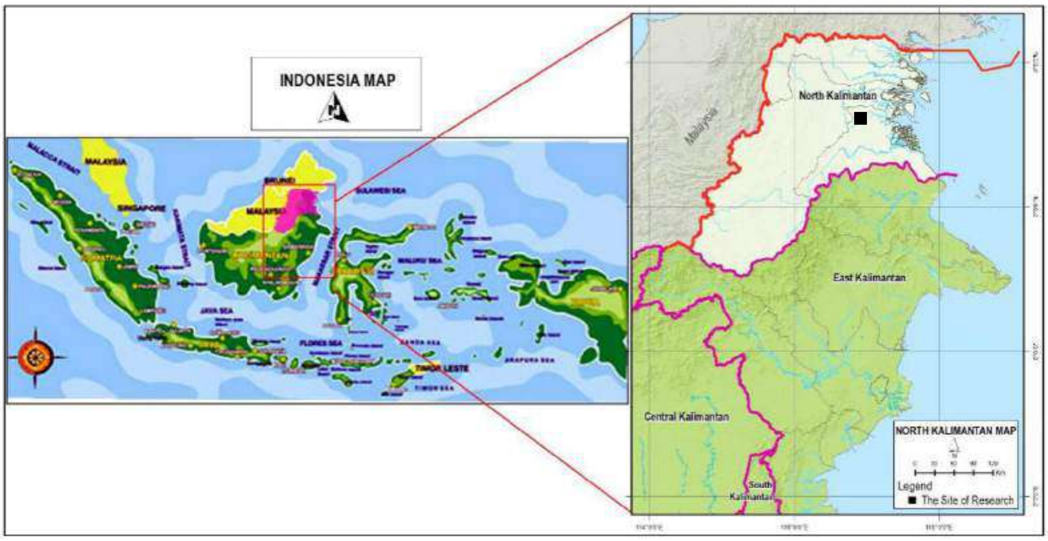

Figure 1. Setulang forest village location (■) of South Malinau sub-district (Hutauruk el al. 2018a).

Procedures

This research began with a preliminary study, in the form of tracing information about research activities which had been previously conducted in the area of research and other information related to the purpose of this research. Then, literature search was done to review previous research results and strengthen basic research data. The present study employed a purposive sampling method in selecting the participants of the study. The samples were the residents of Setulang village who were selected purposively by the researcher. Among 233 heads of family (15% of them), or 35 heads of family, were selected to participate in this study. The use of purposive sampling method in this study was based on the statement by Wirartha (2006) explaining that in purposive sampling technique samples are intentionally selected by researchers.

Data was gathered from indigenous Kenyah Dayak community who lived here for over hundreds of years. The reasons behind choosing this village are: i) it has a long history of protecting and managing primary forest based on the cultural wisdom, ii) it has innovative local knowledge belong to the practice of more productive swidden agriculture, and iii) recently the village is facing the pressures of activities like oil palm plantation expansion. Data and information were collected through in-depth interviews with Customary Chief (Kepala Adat), Village Chief (Tokoh adat), and 35 swiddeners. 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

In order to achieve the objectives of this study, the primary and secondary data were collected for the data analysis. The data collection procedures are described as follows:

Primary Data

The primary data of this study included the amount of rice yield, the fallow periods of the rice field, the varieties of upland rice namely Langsat rice, Telang Usan rice, and Pimping rice. The data were obtained through interviews with a questionnaire and field observations. The detail explanations of the data collection are explained as follows:

Interviews

The researcher asked some questions and clarifications from the respondents. The questions had already been prepared in a questionnaire by the researcher.

Field Observation

The researcher made a direct observation to see the village condition and the residents' activities in the field related to the object of the present study. It aimed to get a clear picture about the situation that could be used to support the data that were already collected.

Tabel 1. Form of field data collection

No	Primary data	Methods
1	Research site	Interviewed with questionaire and field observation
2	Land area	
3	Fallow peiods of rice field	
4	Varieties of local upland rice	
5	Interviews with customary chief (kepala adat), village chief (tokoh adat), and swiddeners	

Data Analysis

The data analysis of the present study was presented descriptively and quantitatively. Total production is calculated based on the plot of fallow periods to get an estimate of potential production The analysis of the maximum rice yield was conducted based on the fallow period of the field by counting the average annual production. According to Van Gardingen et al. (2003), average product (AP) and marginal product (MP) can be summed up by using the following formula:

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

In which: AP =average product, 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-$_1$ = Total of production age
T = Total of age

RESULTS AND DISCUSSION

Rotation field land use system

The majority of Setulang villagers had livelihoods as rotational farmers, according to their cultural culture, they own a lot of land with different fallow periods, ranging from one year to 25 years. The system they use to determine the land to be managed was only based on their instincts and experience from year to year, that is, if the fallow period was more than 5 years, the land was considered fertile and capable of producing good quality plants. Furthermore, farmers carry out a survey of the land to ensure that the conditions were proper or not to be managed with indicators if there was already vegetation or trees that grow wild with a diameter of 5cm above, the land could be managed again.

In managing a piece of land, farmers spend 1 year to complete one crop life cycle, which starts from land clearing to post-harvest, then the next year moves to work another land that had been considered fertile during the fallow period, and so on. it was used in rotation every year.

After the harvest period ends, the society will hold a ritual event which is thanksgiving worship and serve many kinds of traditional food to show their gratitude to God during the cultivation process 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, so they will get abundant harvest and hopefully crop failure might not happen. Hamdani et al. (2016) found this is different from Dayak Meratus. At the beginning of clearing land time, the people of Dayak Meratus always start by having the ritual ceremony.

Types of rice

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

Langsat rice had a nearly spherical shape and the seeds were bigger than Telang Usan and Pimping rice. In 1,000 rice seeds weigh 34.4 grams. In general, people prefer Langsat rice because the aroma was delicious and tastes good, but it cannot be planted in large quantities because when the rice was yellowed and ready to be harvested the ripening process was too fast until the rice seeds and grains were drunk and result in crop failure. Telang Usan rice had oval shape and its seeds were smaller than Langsat type rice and bigger than Pimping type rice (Figure 2). 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 its shape was longer. Pimping rice weight in 1,000 seeds was 24.39 grams.

Figure 2. Three types of local rice in Setulang village Malinau Regency, North Kalimantan, Indonesia. A. Rice types of Langsat, B. Rice types of Telang Usan, C. Rice types of Pimping

Total production and production Maximum was based on the period of vacant land

Total production (TP) of langsat, Telang Usan and Pimping rice types increased with increasing periods of fallow land. Low production occurs during short fallow periods and high production occurs during long fallow periods. Low production was influenced by the low level of soil fertility, where the level of land fertility was affected by the fallow period because during the process of fallow land during the process there was also the process of returning nutrients to the land through vegetation that grows naturally on the land. It was in line with Dechert et al. (2004) that infertile soil should normally take fallow period of 7 to 15 years.

In the management of rotating fields, farmers did not use chemical fertilizers, farmers only utilize ash from burning biomass available on the land during the fallow period, so before the farmer determines the land to be managed, the farmer must be able to ensure that the land was able to produce high productivity. According to Syahbudin (2017), some issues that were normally found in cultivating upland rice such as the low soil fertility, the lack of irrigation, the use of organic fertilizer, and the low soil acidity. In order to improve the agriculture products to be sustainable, we should not only focus on developing superior varieties of seeds but should also concern on its tolerance and the adaptability to the environment (Brummer et al. 2011; Meybeck et al. 2012). The lack of high quality seeds, fertilizers, irrigation costs, and human resources could give a significant impact towards the rice farmers' income (Islam et al. 2017).

Although the three types of rice had both experienced an increase in production while increasing the period of fallow land, but each type had a different level of production. Physical differences were also seen in these three types of rice, namely the shape and size and weight of each seed were different. 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.

Types of rice Langsat average production (AP) year-^{1} had increased since the fallow period of 3 years to 17 years, then after the fallow period of 17 years to 23 years of average production per year and marginal production (MP) had begun to decline. Maximum production were in the fallow period of 17 years with a total production of 2.635 kg ha-1, where the average annual production decreases at 155 kg ha-1 year-1 and marginal production (MP) also decreases at 155 kg ha^{-1}. From the results obtained in Table 2 it could be concluded that the type of langsat rice was feasible to be cultivated in the fallow period of 17 years.

Table 2. The total production of Langsat rice

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.

Telang rice types Usan average production (AP) per year had increased since the fallow period of 3 years to 15 years, after the fallow period of 15 years average production per year and marginal production (MP) had begun to decline. Maximum production of Telang Usan rice types were in the fallow period of 15 years with a total production of 2,208 kg ha^{-1}, where the average annual production decreases at 147 kg ha^{-1} $year^{-1}$ and also marginal production (MP) decreases at 147 kg ha-1. It could be concluded that the Telang Usan rice type was suitable to be cultivated on land with a fallow period of 15 years (Table 3).

Table 3. Telang Usan types rice production based on the fallow period of land

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

Average annual production (AP) in Pimping rice species had increased since the fallow period of 3 years to 13 years, after the fallow period of 13 years of average production per year and marginal production (MP) had begun to decline, where the average annual production decreased at 128 kg ha^{-1} year-1 and marginal production (MP) decreased at 128 kg ha^{-1}. The maximum production of Pimping rice was in the fallow period of 13 years with a total production of 1,670 kg ha^{-1}, thus the cultivation was cultivated on land with a fallow period of 13 years (Table 4).

Table 4. Pimping types rice production based on the fallow period of land

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

Rice production on the turning rice field was lower than that of sawa rice, therefore the local government of the Malinau District advises farmers to plant sawa rice on wetlands, but due to the limited area of wetlands owned by farmers in Setulang village so farmers tend to use land dry to plant rice with a rotating field system. Purwanto et al. (2019) stated that one of the factors that hinder the development of local rice was because it takes a long period to crop and had a low productivity. According to Sheil (2002), that Setulang village has ultisol soil was a nutrient-poor soil, especially organic matter. These heavily leached soils are acid (soil average pH is 4.5) and have low inherent fertility with only 20% base saturation.

In this study, the findings suggested that the rice 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}season-1 cultivation. Imang et al. (2018) expressed that weather, rainfall, pest, and plant disease could affect the agriculture production on swidden agriculture field. In addition, they also mentioned that the average production of swidden agriculture could reach 1.475 kg ha^{-1} in 2017. The amount was still considered lower than the previous term due to a long dry season.

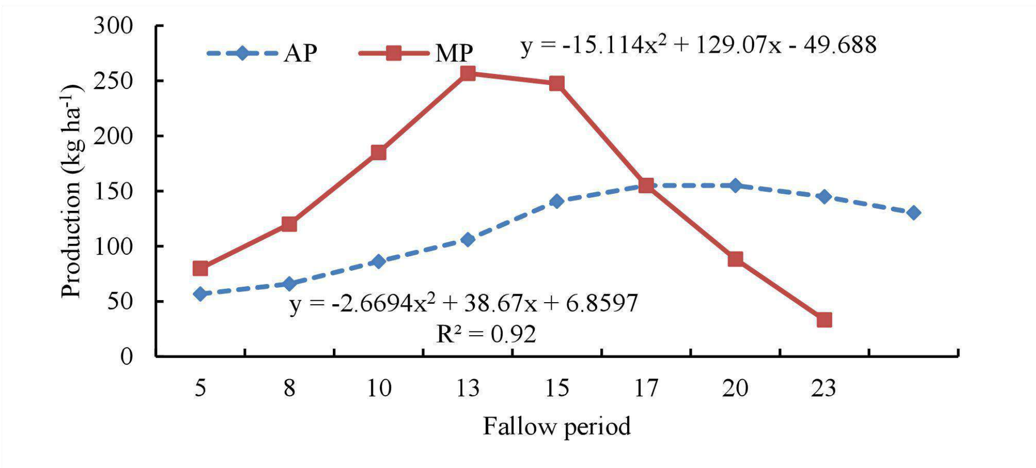

Figure 3. Graphic production rice types of Langsat based on the fallow period

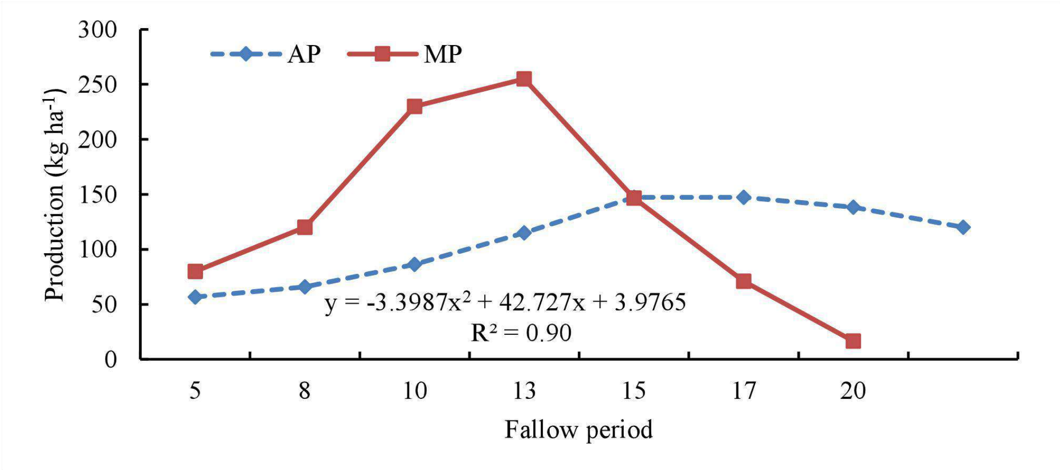

Figure 4. Graphic production rice types of Telang Usan based on the fallow period

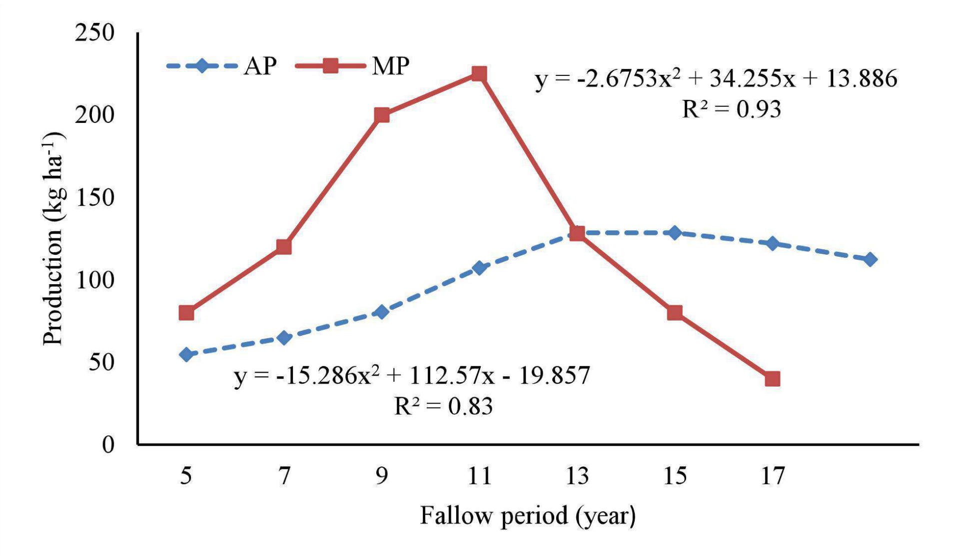

Figure 5. Graphic production rice types of Pimping based on the fallow period

There was a relationship between marginal production (MP) and average production (AP), ie if marginal production was more than average production, average production would rise. Conversely, if marginal production falls, average production would also fall. Therefore the marginal production line would cut the average production at the point of maximum average production and would show the areas of production which would determine the most productive area.

To achieve maximum production of Langsat type of rice having crossing point at 17 years fallow (Figure 3), Telang Usan type of intersection point was in fallow period of 15 years (Figure 4) while production of Pimping type of rice was in fallow period of 13 years (Figure 5). Type of Langsat rice, Telang Usan and Pimping had different amounts of production. The highest production was produced by Langsat rice type while the lowest production was produced by Pimping rice.

Comment

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QUESTIONNARE OF SWIDDEN AGRICULTURE RESEARCH IN SETULANG VILLAGE

TOPIC : The Suitability of three varieties of local upland rice on swidden agriculture in Setulang Village, North Kalimantan, Indonesia

Data collection :
Malinau date and year : . . . .
Name of reseacher : . . . .
Location : . . . .

Respondent's biodata

1. Name of family head : . . . . Age: . . . . . year
2. Tribe (Suku) : . . . .
3. Number of family member
   a. Wife : . . . . person
   b. Child : . . . . person
   c. Other members : . . . . person

Land use system

1. How many years of experience have you been a shifting cultivator (swiddener)?
2. How wide land area have you used: .... ha
3. How long to make a field based on activities during the life cycle of rice plants:
   a. Land . . . . month
   b. preparation : . . . . month
   c. Cuting: . . . . month
   d. Tree felling: . . . . month
   e. Land clearing . . . . month
   f. and burning: month
   g. Planting: month
   Weeding:
   Harvesting:

5. What is the work system that you do in the fields?
   a. Work shift group
   b. Self-employed
   c. Salary

6. What is the status of the land that you manage:
   a. Self-owned
   b. Rent
   c. State land

7. Have you ever planted Langsat, Telang Usan and Pimping rice? ...
8. How many parcels of land do you work on?
9. Fill in the table below based on the experience and field activities had done:

No	Fallow period (years)	Total rice production (how many cans)			Information
		Langsat	Telang Usan	Pimping	

1	3				
2	5				
3	8				
4	10				
5	13				
6	15				
7	17				
8	20				

Uncorrected Proof

Participants

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

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Abstract. *Merang OP, Lahjie AM, Yusuf S, Ruslim Y. 2019. Productivity of three varieties of local upland rice on swidden agriculture field in Setulang village, North Kalimantan, Indonesia. Biodiversitas 20: xxxx*. Swidden agriculture field is a dry land that 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 the 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 the 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 a 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 reflects 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 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 production including rice production which gives negative impacts on the income of traditional farmers (Wibowo et al., 2016). The challenges faced in increasing rice productionon swidden agriculture lands include land processing that is still manual, it has a long period of harvesting, and there is fallow process which 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 dry land 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. Beside 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 0.58% year^{-1}. In 2007 the price of oil palm was 1500 IDR, then in 2017 it became 850 IDR. Contrary to Santika et al. 2019 stated that oil palm was superior to dry land 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 term 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 woodstick with the size of 2 meters long and 4 cm diameter. The activity of tugal by using woodstick to plugged 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. The research was carried out from April 2018 to March 2019. Setulang village is located in 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 system 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 about the situation that could be used to support the data collected from the interviews.

Data analysis

The data of the present study was 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_{-1} = Total of production age
T = Total of age

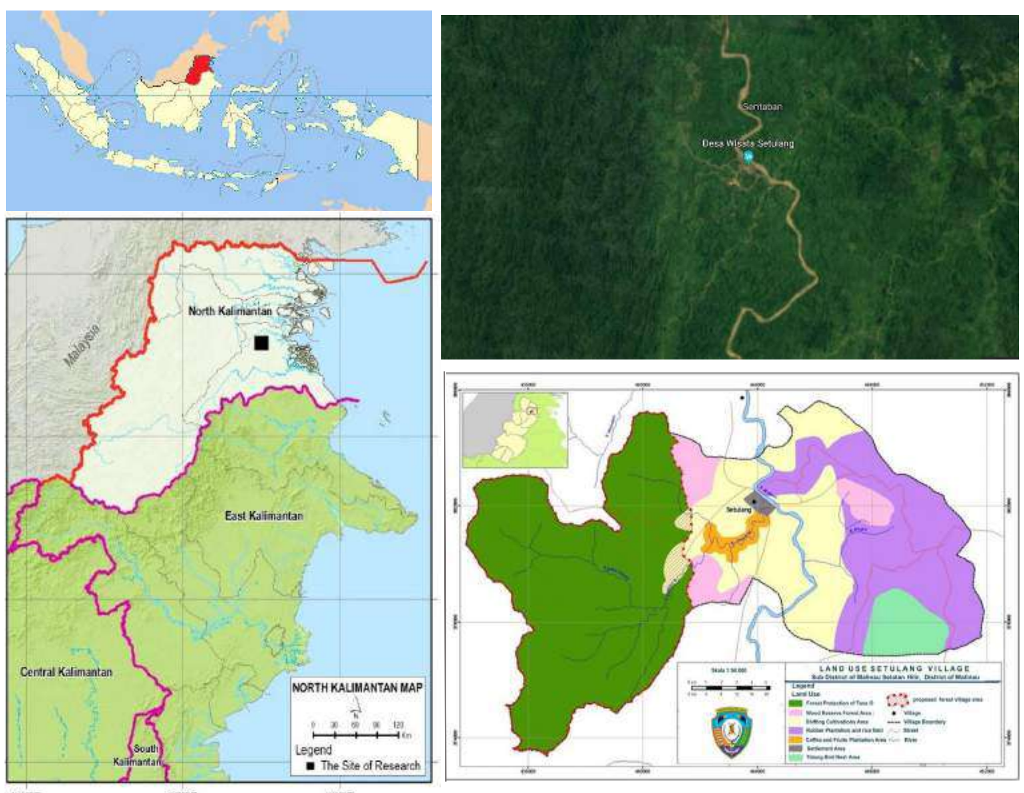

Figure 1. Setulang forest village location (■) of South Malinau sub-district.

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

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.

After the harvesting period, the community will hold a ritual event which 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 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 occured in lands with short fallow periods while high production occured 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 the agricultural production, we should not only focus on developing superior varieties of seeds but should also concern on its tolerance and the 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, but 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.

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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 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 a 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 per hectare 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 ha^{-1} $year^{-1}$ $household^{-1}$, rice became 3,400 kg $year^{-1}$ household The need for rice in each household. was 140 kg $year^{-1}$ (5 people), so the need for household was 700 kg $year^{-1}$, so there was a surplus of 2,700 kg ha^{-1}. Of the total surplus, 2 tons was 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, chilli, 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 oppurtunity for future coal mining activities.

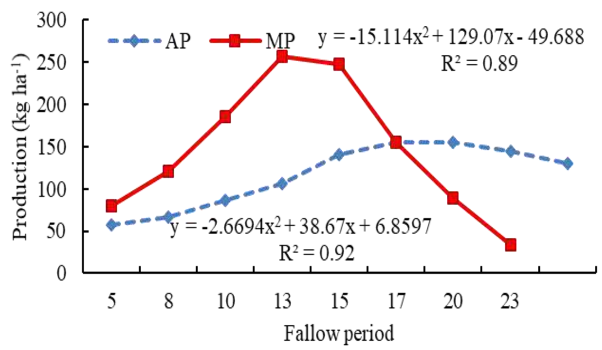

Figure 4. Production curves of Langsat rice based on the fallow period

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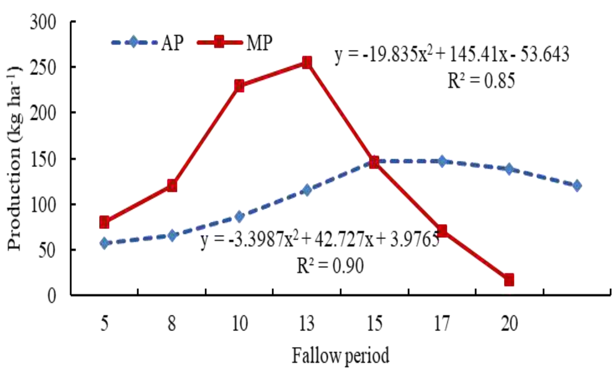

Figure 5. Production curves of Telang Usan rice based on the fallow period

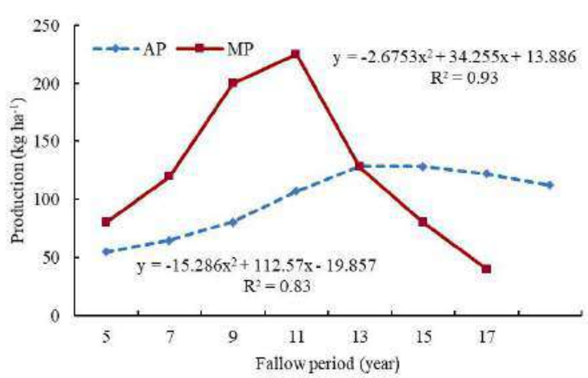

Figure 6. Production curves of Pimping rice based on the fallow period

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 more less 2,000 ha, with 232 households, with a fallow period of at least 10 years. More less 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 rice 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 on 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.

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

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Abstract. *Merang OP, Lahjie AM, Yusuf S, Ruslim Y. 2019. Productivity of three varieties of local upland rice on swidden agriculture field in Setulang village, North Kalimantan, Indonesia. Biodiversitas 20: xxxx*. Swidden agriculture field is a dry land that 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 the 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 the 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 a 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 reflects 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 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 production including rice production which gives negative impacts on the income of traditional farmers (Wibowo et al., 2016). The challenges faced in increasing rice productionon swidden agriculture lands include land processing that is still manual, it has a long period of harvesting, and there is fallow process which 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 dry land 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. Beside 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 dry land 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 term 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 woodstick with the size of 2 meters long and 4 cm diameter. The activity of tugal by using woodstick to plugged 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.

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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. The research was carried out from April 2018 to March 2019. Setulang village is located in 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 system 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 about the situation that could be used to support the data collected from the interviews.

Data analysis

The data of the present study was 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_{-1} = Total of production age
T = Total of age

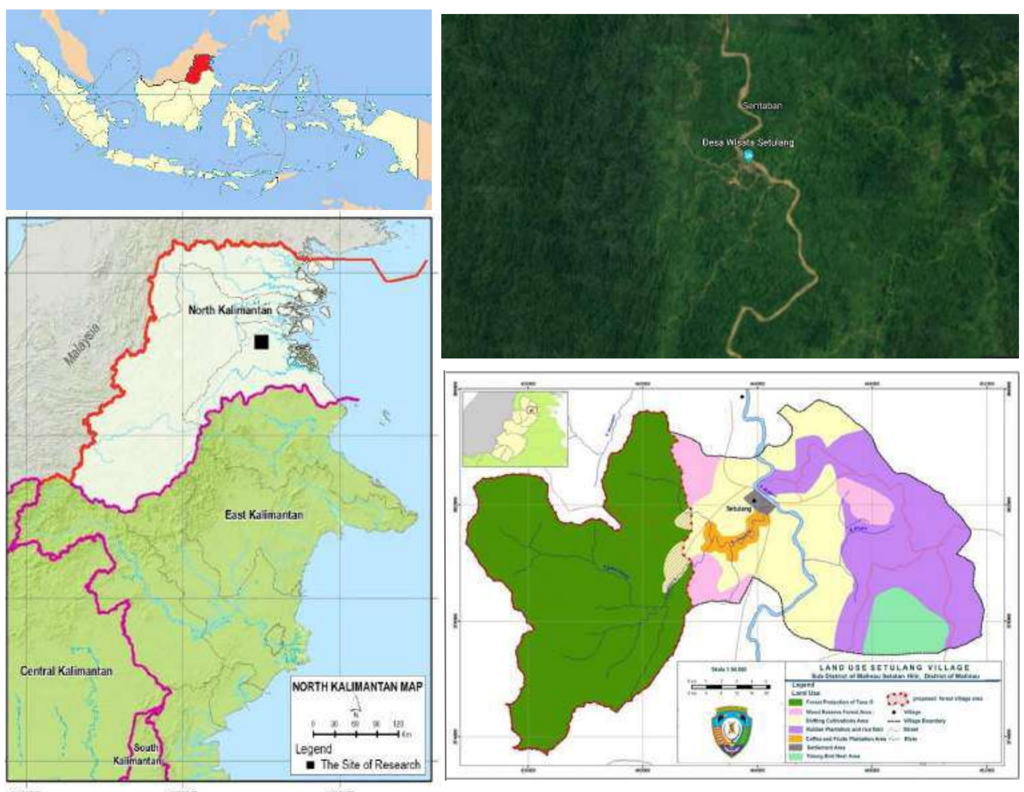

Figure 1. Setulang forest village location (■) of South Malinau sub-district

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

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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 which 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 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 occured in lands with short fallow periods while high production occured 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 the agricultural production, we should not only focus on developing superior varieties of seeds but should also concern on its tolerance and the 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, but 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.

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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

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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 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 a 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 was 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, chilli, 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 oppurtunity for future coal mining activities.

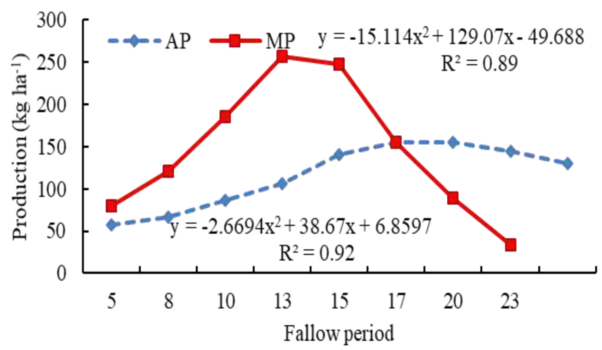

Figure 4. Production curves of Langsat rice based on the fallow period

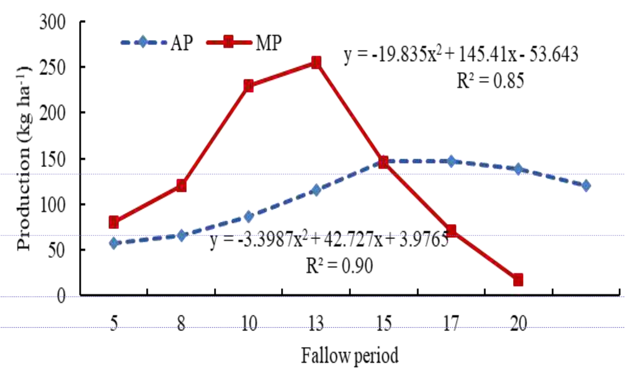

Figure 5. Production curves of Telang Usan rice based on the fallow period

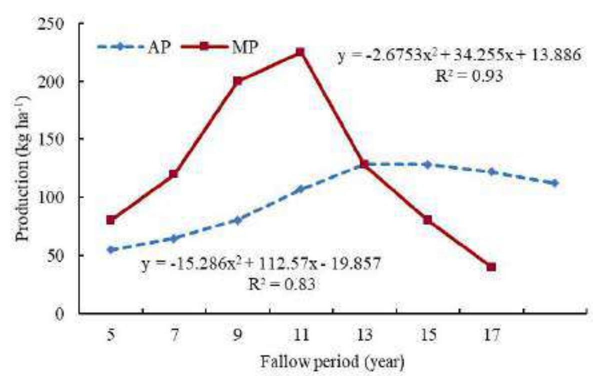

Figure 6. Production curves of Pimping rice based on the fallow period

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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 more less 2,000 ha, with 232 households, with a fallow period of at least 10 years. More less 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 on 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.

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Title

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

Abstract

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.