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Development of Floating Rice Cultivation Technology in Community-Based Peat Swamp Land

Aris Slamet Widodo[1], Gatot Supangkat[1], Mulyono[1], Bahrul Ulum[2,✉]

[1] Universitas Muhammadiyah Yogyakarta, INDONESIA.

[2] Politeknik LPP Yogyakarta, INDONESIA

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Corresponding Author:
✉ aris.sw@umy.ac.id
(Aris Slamet Widodo)

ABSTRACT

Peat swamp farming has great potential to increase food security from local potential. One of the technological innovations of cultivation on peat swamp land is by applying floating rice cultivation. This study aims to assess the success rate of implementing floating rice cultivation technology on peat swamp land in East Kalimantan. The method used is participatory action research with the community in one of the villages in East Kalimantan, namely Minta Village, Penyinggahan District, West Kutai Regency. Floating rice was applied using a 1.5 x 6 m bamboo raft with a total of 40 rafts. The rice varieties used were SR (Sri Republik) Super Genjah 75 HST rice. The results of the study showed that the plant height reached 90 cm, with 32 tillers, and 32 floating rice panicles. The average grain yield was 30 grams/clump or equivalent to 5 tons/ha assuming land use efficiency of 80%. The obstacles in floating rice cultivation in peat swamp land are the presence of pests in the form of sundep in the growth phase and sparrows in the rice grain production phase. In an effort to accelerate the adoption of floating cultivation technology, intensive socialization and education are needed.

1. INTRODUCTION

Peat is a natural material that is formed naturally from plant remains that are imperfectly decomposed and accumulated in swamps (Paleckiene *et al*., 2021). The Peat Ecosystem is the arrangement of the elements of Peat which is a comprehensive whole that influences each other in forming balance, stability, and productivity (Presiden RI, 2014). Peatland is an ecosystem that is rich in water resources so that it functions as a water reserve for an area. Apart from being a water reservoir, peatlands also function as carbon stores. Because of the importance of the function of the existence of peat in the future, it is very important to protect its sustainability. About 83 percent of the 27 million hectares of peatland in Southeast Asia is in Indonesia, which is spread over the islands of Sumatra, Kalimantan and Papua (Anshori, 2016).

Based on the Decree of the Minister of Environment and Forestry Number SK 130 of 2017 concerning the Determination of the National Peat Ecosystem Function Map, East Kalimantan Province has a peat area of 342,351 ha which is divided into 16 Peat Hydrological Units (PHU). The PHU is spread over five regencies, namely Berau, Kutai Kartanegara, East Kutai, West Kutai and Paser Regencies with a percentage of protected peat functions of 51.50% and cultivated peat functions of 14.05%. The large area of the peat area of the districts of Kutai Kartanegara, East Kutai and West Kutai which is located in the middle of East Kalimantan Province, causes this peat area to be called the Middle Mahakam Peat. In the Middle Mahakam, limited peat areas are used for agriculture during the dry season in the border areas of rivers/lakes/swamps.

Peat swamp land is a land resource that can be a source of agricultural production growth with reliable cultivation technology (Susilawati *et al*., 2016). The development of peat swamp land agriculture has a great opportunity to increase food security that comes from local potential in accordance with one of the goals of the SDGs (Sustainable Development Goals) (Wandansari & Pramita, 2019). Studies on rebuilding and documenting agricultural knowledge and practices in peat swamp ecosystems are very important (Budiman *et al*., 2020). Improving technology and developing producer-friendly market relationships will facilitate the successful regeneration of sustainable peat swamp ecosystems (Samsudin *et al*., 2020).

In order to implement sustainable agriculture of peat swamp land in the Middle Mahakam, then create a demonstration plot (demplot) to test several paludiculture approaches that can be a learning tool to achieve better management practices on peatlands (Uda *et al*., 2020; Lupascu & Wijedasa, 2021). One of the technological innovations of cultivation on peat swamp land is by applying the floating rice farming system. Floating rice farming system is a rice cultivation technique that uses a raft as a planting medium on peat swamp land. Floating rice is one of the adaptation efforts to climate change for flood-prone areas or inundated swamps. If floating rice is developed in locations prone to flooding or swamps, there will be an increase in production and income for farmers (Prayoga *et al*., 2018). Of course, the floating rice farming system is a solution to overcome and utilize these conditions optimally. In addition, it is also expected to be a learning platform for rural communities to strengthen the capacity of farmers in sustainable peat swamp land management.

Research on peat swamp land has been carried out by several researchers including Eni *et al*. (2016), Sulaiman *et al*. (2018), Triadi (2020), Rina & Noor (2021). The method used is related to peat swamp land restoration through rewetting and paludiculture methods. Swamp land management technology for food crops and horticulture in the context of adaptation to climate change. Rewetting peatlands can mitigate climate change and may be combined with management in the form of paludiculture (Tata, 2019; Jurasinski *et al*., 2020; Tanneberger *et al*., 2020). It is necessary to develop swamp land based on strengthening economic resources to support farmers' welfare. In addition, research on the technology of floating rice farming systems has been carried out by several researchers including Prayoga *et al*. (2018), Saleh (2019), Oktania *et al*. (2021). Floating rice cultivation technology as a farmer's innovation on the impact of climate change with a feasibility analysis is profitable and has good prospects for development in waterlogged land.

Based on this background, the purpose of this study is to apply floating rice cultivation technology in community-based peatlands in East Kalimantan. Research on the development of floating rice farming has great potential to increase agricultural productivity, overcome the challenges of climate change, and improve farmer welfare. With continued research and development, it is hoped that this system can be increasingly optimal and provide wider benefits to the community.

2. MATERIALS AND METHODS

The method used is participatory action research with the community in one of the villages in the Middle Mahakam, namely Minta Village, Penyinggahan District, West Kutai Regency, East Kalimantan Province (Figure 1). This participatory action research is a study activity carried out by involving the target community of the program to encourage community action in the sustainable use of peatlands. This participatory research emphasizes more on a qualitative approach by identifying the potential and opportunities for the use of peat swamp land with the community, taking sides with the needs and conditions of the community by applying floating rice technology (Rahmat & Mirnawati, 2020). The land conditions in this study were tidal agricultural land caused by the overflow of the Mahakam River with a depth of 1-2 meters. The use of agricultural land when submerged is used by the community to catch fish with traps. When the water recedes, the land is used for cultivating crops, especially rice plants with the risk of flooding again that is unpredictable.

Floating rice cultivation on peat swamp land in Minta Village is applied using bamboo rafts measuring 1.5 x 6 meters with a total of 40 rafts, so there is 360 m² of rice planting area on the raft. The peat swamp land area used is 400 m² with a land use efficiency of 80%. In one raft there are 180 planting holes using a 22 OZ plastic glass container. The design of the floating rice and raft scheme model was depicted by Figure 2 and 3.

Figure 1. Map and photos of research locations in Minta Village

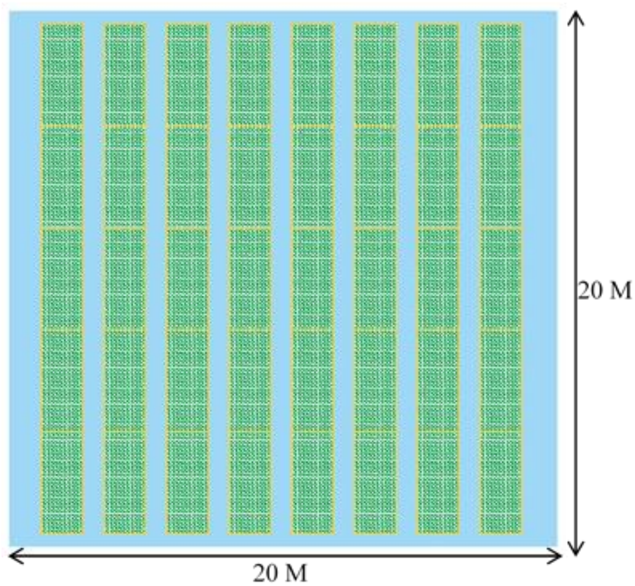

Figure 2. The design of the floating rice scheme seen from the top

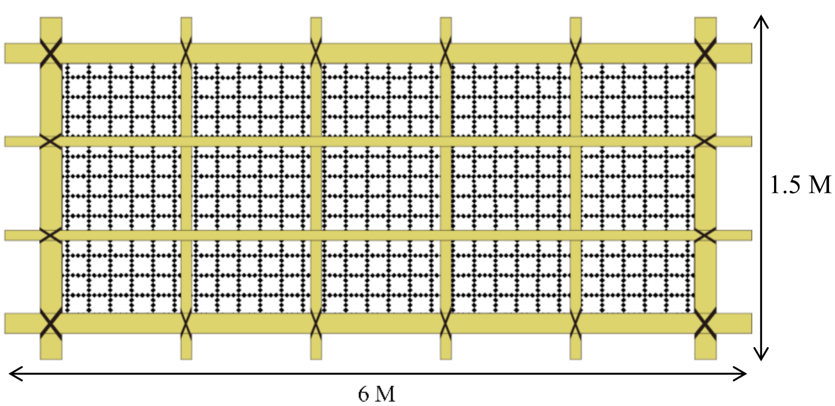

Figure 3. The sketch design of the floating rice media container raft

3. RESULTS AND DISCUSSION

The activities in the research were carried out by making demonstration plots for floating rice cultivation in peat swamp land that actively involved the community. The demonstration plot starts with the activity of making rafts to the process of cultivating floating rice.

3.1. Floating Rice Cultivation Practices in Peat Swamp Land

3.1.1. Floating Raft

The floating raft uses environmentally friendly materials such as bamboo with the principle of recycling. The first step is to make a floating raft by cutting whole bamboo in sizes of 1.5 meters and 6 meters, tied together in the form of a raft (rectangular). At the edges of the raft, 2 bamboo sticks each, and in the middle 1 longitudinal bamboo stick to strengthen the raft and help with buoyancy. Prepare bamboo that is split with a width of about 3 cm with a length of 1.5 meters, a total of 30 stems, installed at a distance of 20 cm without using nails with a technique of plaiting the edges using a similar piece of bamboo that is 6 meters long. Woven bamboo with a distance of 20 cm that has been arranged, placed on a raft, tied using a rope (without nails so that the bamboo is not damaged).

Figure 4. Floating rafts construction using bamboo for floating rice cultivation

3.1.2. Planting Media

Planting media for floating rice cultivation uses a sponge and plastic cups filled with peat soil, compost, mud, and lime. The first step is to prepare a white heart sponge material (the choice of white color is to reduce pests and diseases because it reflects light). The heart sponge is perforated with a diameter of 7 cm, with a distance between holes of 20 cm X 20 cm as many as 180 holes in one raft (Figure 5). The heart sponge is placed on a raft that has been given woven bamboo and tied with rope. Prepare a used plastic cup measuring 22 OZ that has been torn off the sides of 6-7 pieces to make it easier for rice roots to develop. Used plastic cups that have been torn are filled with planting media in the form of a mixture of 40% peat soil, 40% compost, and 17% mud. Then 3% ash/lime is added to neutralize the pH of the planting medium which was previously pH 4.5-5.0. Then the glass that has been filled with planting media and rice seeds is placed in the raft hole submerged in water more than 50% of the glass surface. Where the larger the plant, the more the glass of planting media will be submerged in water to maintain balance.

The location of the peat swamp floating rice demonstration plot in Minta Village is about 500 meters from the riverbank, so the availability of water is affected by the tides of the Mahakam River. Soil types include thin peat soil with a thickness of 20-40 cm at the maturity level of peat including sapris (ripe) and the underlying soil layer is clay.

Figure 5. Planting media for floating rice cultivation

Based on laboratory tests (Table 1), it is known that the pH is acidic, therefore the planting medium is given lime and organic fertilizer which aims to increase the pH of the organic matter content in the soil in order to improve the soil structure and increase the cation exchange capacity (CEC) of the soil.

Table 1. Results of laboratory analysis of peat swamp soil samples in Minta Village

Sample	KL (%)		pH	EC (mS)	C-organic (%)		N (%)	P (ppm)	K (ppm)		CEC
	0.5 mm	2.0 mm			C	MO			K-tsd	K total	cmol/kg
S1	5.87	5.78	4.5	0.42	19.78	34.11	0.33	913.04	6.66	383.99	48.87
S2	10.68	11.32	5.0	0.35	43.37	74.77	1.12	8.38	9.88	401.43	44.30

Note: S1 = peat soil sample I (1 km from the river); S2 = peat soil sample II (10 km from the river); KL = field capacity value; EC = electrical conductivity; C = carbon content; MO = C-organic content of soil without organic matter; K-tsd = status of availability of nutrients in the soil.

3.1.3. Rice Variety

The rice variety of SR (Sri Republik) Super Genjah 75 HST was used with the advantage of a very short harvest age, namely 72 to 75 days after planting. SR Super Genjah rice has a productivity level of 4-6 ton/ha. The method of seeding rice seeds was conducted by using a seedling tub.

3.1.4. Planting

Rice seeds that have been sown were planted (Figure 6) at the age of 8-10 days by immersing them as deep as 1 cm in the planting medium with the root position forming the letter "L". Each glass only 1 rice seed so that the number of rice tillers is more. Then the glass that has been filled with planting media and rice seeds is placed in the raft hole submerged in water more than 50% of the glass surface. Where the larger the plant, the more the glass of planting media will be submerged in water to maintain balance (Figure 7).

3.1.5. Maintenance

Fertilization is done using liquid organic fertilizer (POC) by spraying evenly on the top and bottom surfaces of rice leaves (Figure 8). Fertilization is done when the plant is 2 weeks old until the rice grains are full. Concentration (fertilizer dilution) 1:10. Weeding is done periodically by manual method, removing weeds that interfere with rice plants. Pest control is carried out by means of an IPM (integrated pest management) system.

Figure 6. Planting for floating rice cultivation

Figure 7. Glass containing planting media and rice plants

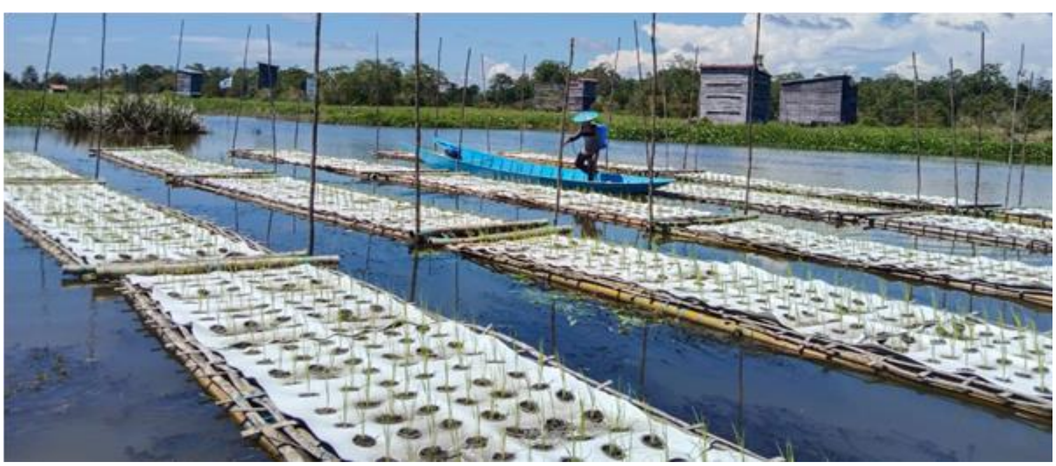

Figure 8. Spraying liquid organic fertilizer

3.1.6. Harvesting

Floating rice harvest can be done when the rice plant is 75 days after planting. Harvesting is done after the rice has yellowed, 90%-95% of the grain in the rice panicles is yellow or golden (Figure 9). The rice harvesting technique is done manually by slashing. The access requires boat for transportation due to swamp land. The harvested paddy was then threshed manually to get rice grains (Figure 10).

Figure 9. Floating rice paddy ready for harvest

Figure 6. Yield of rice grains of floating cultivation

3.2. Observation of Floating Rice

Observations of floating rice were carried out in the growth phase and production phase, by directly observing the condition of the rice plants. There are several parameters that need to be observed in the growth phase, namely plant height, number of tillers, number of panicles, weeds, pests and plant diseases. The parameters observed were carried out from when the plants were 2 weeks to 8 weeks old with observation intervals of once every 2 weeks in 3 repetitions. The following table shows the results of observations of plant height, number of tillers, and number of panicles of floating rice plants (Figure 7).

Figure 7. Observation of floating rice plant growth

The results of observations (Table 2) showed that the plant height reached 90 cm, with a total of 32 tillers, and the number of floating rice panicles reached 32 panicles. The results of field observations can be seen in Figure 9. Rice growth is in good condition, because the age of the rice seedlings is in accordance with environmental conditions. Based on Nasrudin *et al*. (2023) research, it is known that the use of 14-day-old seedlings when the rice plants are 2 and 6 weeks old produces more tillers than 21-day-old seedlings. Hikmah & Pratiwi (2019) stated that the older the age of the seedlings, the more it will inhibit growth and can reduce grain yields.

Table 2. Observations of plant height, number of tillers, and number of floating rice panicles

Week	**Plant height (cm)**			**Number of tillers**			**Number of panicles**		
	1st	**2nd**	**3rd**	**1st**	**2nd**	**3rd**	**1st**	**2nd**	**3rd**
2	20	23	25	2	3	3	-	-	-
4	38	40	42	15	15	15	-	-	-
6	65	70	72	30	32	32	-	-	-
8	88	90	90	30	32	32	32	32	32

The results of Mujiyo *et al*. (2022), showed that floating rice cultivation gave the best results with a plant height of 94 cm, number of tillers of 21, and produced the highest rice yield of 14.16 ton/ha. Floating rice systems can provide more sustainable livelihoods for farmers and greater food system security (Dumaresq *et al*., 2020). These results suggested that the developed floating rice-culture system showed a good potential as a holistic management approach in terms of nutrient reduction, rice production for further use as feed and for bloom control (Srivastava *et al*., 2017).

Based on the observations found weeds in rice plants (Figure 8) which are controlled by mechanical means that is pulled out. Even though the media has been sterilized, there are still other factors that cause weeds in the floating farming system, namely air, wind, and insects that carry weed seeds. There is also a pest in the form of sundep in the growth phase of the rice plant, which is 4 weeks of age. Sundep pest control is carried out by spraying insecticides in the form of furadan. In addition, there is a pest attack of sparrows that eat rice grains in the production phase, which is 8 weeks of age. Of course this is very detrimental to the harvest that will be produced. The control method used to prevent sparrows is to install nets on floating rafts, thus closing the rice plant area (Figure 9).

Based on observations of floating rice grain yields with an average of 30 grams/clump or 5.4 kg/raft and equivalent to 5 tons/ha with an assumption of 80% land use efficiency. Of course, the yield of harvested grain is already high when compared to the productivity value of SR Super Genjah rice which has a productivity level of 4-6 tons/ha. The research Riptanti *et al*. (2019), shows that the average productivity of harvested dry rice grain (GKP) by using drums as buoyancy medium reaches 11.58 ton/ha, while by using bamboo reaches 12.60 ton/ha. The production result is higher productivity than surrounding farmlands, amounting only to 7–9 ton/ha. The yield of floating rice is more or less the same when compared to the yield of local farmers' rice fields. Floating rice cultivation can be used as a solution to reduce crop failure in flood-prone areas (Mujiyo *et al*., 2022).

Figure 8. Weeds on floating rice plants

Figure 9. Installation of nets to prevent sparrows

4. CONCLUSION

Floating rice cultivation in Minta Village can be applied by the community of Minta Village, according to the techniques presented and taught. The floating rice demonstration plot on peat swamp land was applied using a 1.5 x 6 m bamboo raft with a total of 40 rafts on an area of 400 m². The rice varieties used were SR (Sri Republik) Super Genjah 75 HST rice. The results of observations were that the plant height reached 90 cm, with a total of 32 tillers, and the number of floating rice panicles reached 32 panicles. The results showed that the average grain yield was 30 g/clump or equivalent to 5 ton/ha with the assumption of 80% land use efficiency. The obstacles in floating rice cultivation in peat swamp land are the presence of pests in the form of sundep or deadhearts (*Scirpophaga innotata*) during the growth and sparrows in the grain production phase.

The floating farming system is very much in line with the Sustainable Development Goals (SDGs). This system offers innovative solutions to several global challenges related to food, environment, and society. This system enables food production on high-risk agricultural land, such as tidal land that is often flooded. Although this system uses water, its use is relatively more efficient compared to conventional farming systems. In addition, this system can help maintain water quality by preventing soil erosion and reducing pesticide use. In an effort to accelerate the adoption of floating cultivation technology, intensive socialization and education are needed. Conduct regular counseling to farmers about the benefits, cultivation methods, and use of media that are easily obtained locally such as bamboo and used plastic cups. Show farmers directly how to plant floating rice and the results that can be achieved.

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