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The Cultivation of Melon on Swamp Floating Bed in Central Kalimantan, Indonesia

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ABSTRACT

Cultivating of melon particularly in Central Kalimantan has been widely undertaken by farmers, however, the yields have not been able to meet the melon needs of Central Kalimantan's community. One of the breakthroughs in overcoming the problem is by growing melons on swamp floating beds, known in Kalimantan as ambul technology. Ambul is growing media from decomposed floating aquatic plants, constructed with bamboo or wooden as a frame, that is let floating on waters. The ambul based on the consideration that the community lacks access to land for most of the year, which reduces opportunities for growing crops. The research design used was Split Plot Design with three kinds of aquatic plants as the main factor namely *Eichornia crassipes, Salvinia molesta, Eleocharis palustris*, and two melon varieties as subplot factors specifically Action 434 and Amanta. The results showed that the Amanta variety grown on *S. molesta* media produced the highest value of crop length on 1, 2, 3 weeks after planting (WAP). *S. molesta* was the best planting media for enhancing flowering by 11.43 days after planting (DAP) and weight of fruit was 3.18 kg per plant. The variety of Amanta also had the highest value of root dry weight of 1.33 g per plant and fruit weight of 2.08 kg per plant.

Keywords: Decomposed-Aquatic Plants; Floating Bed; Melon Varieties; Swamp

INTRODUCTION

Melon is one of the economically important fruit and is a source of vitamins and minerals to improve nutrition. Melon is in high demand in tropical markets especially in urban markets (Ibironke & Oyeleke, 2014). Melon production contributed only about 0.76 percent of the national fruit production (Direktorat Jenderal Hortikultura, 2015). According to agricultural indicators, although both of the area of harvest and production of melon increased from the previous year, the production only reached 121,949 tons with 8,632 Ha harvested areas in Indonesia (BPS, 2020). In Central Kalimantan, the harvested area is only about 66 ha in 2019, melon production reached 435 tons in 2018 (BPS of Kalimantan Tengah, 2020). The low production of melon is affected by some factors. Among the production factors, nutrients and water are the most factors that limiting to higher melon yields (Monteiro *et al*., 2014).

Swampland area in Indonesia reaches 33.4 million ha (Haryono *et al*., 2013) including peat swampland of around 14.9 million ha (Ritung *et al*., 2011). In Central Kalimantan, peat-swamp forests dominate swampland characterized by the poor nutritional condition. Of the entire existing swampland, about 5,720 ha of these are considered to have the potential for agriculture

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production (Ritung *et al*., 2011). The Arut Village floodplain is derived from the overflow of Kahayan River, a longest main river in Central Kalimantan. As a result, the land becomes unproductive for a long period of a year. It is indeed too difficult for the community to continue the agricultural practice. Besides, the land covered by almost aquatic plants and is not possible for planting activities. Floating agriculture by utilizing aquatic plants is possibly introduced to overcome such the problem. Hence, one of the solutions is the cultivation of melon on a swamp floating bed known as ambul.

Ambul is formerly adopted from the traditional practice of cultivation in the Bangkau Lake, South Kalimantan Indonesia. It is a hydroponics system like or soil-less culture. As planting media, the ambul is in a manner constructed from decomposed aquatic plants and let float on the surface of waters in the swampy area (Ardianor et al., 2007; Pantanella et al., 2011). The ambul concept is similar to Baira (Irfanullah *et al*., 2008 ; Forneck *et al*., 2015), floating agriculture (Assaduzzaman, 2004), Floating Island planting system (Schuck, 2005), floated-cultivation (Bernas *et al*., 2012), floating rafts technology (Marlina & Syafrullah, 2014), or floating treatment wetlands (Headley & Tanner, 2008 ; Bulut, 2011).

In Central Kalimantan, the ambul is based on the consideration that the local community has lacked access to land due to inundated for most of the year, which reduces opportunities for growing crops. The ecological benefit to the aquatic ecosystem is also important recognized so far since this simple technology is able to reduce the expansion of covering densely floating aquatic plants on the swamp surface. Other advantages of *ambul* are not require watering due to water diffuses from the bottom, not need fertilizers so that organically, and a wise system in maintaining the balance of the swamp. The vegetable planting can be undertaken several times in one flood season, so it can increase farmer's income. Floating agriculture is very effective, especially to minimize crop damage when floods occur. Production of this low technology has the potential to increase productivity per unit of land without chemical fertilization treatment. Residue from floating agriculture after harvest is an organic material that is useful for the next planting process. Cost and profit estimates show that there is a positive relationship between net return (NR) and bed size of a floating garden. For bed size (4.3 x 1.2 x 0.9 m^3), the NR value is USD 111.55, and BCR is USD 3.67 (Forneck et al., 2015). Further, Forneck *et al*. (2015) reported that floating agriculture creates employment opportunities thereby reducing labor migration to urban areas since it provides jobs in rural areas. Floating agriculture is also beneficial to landless farmers due to flooding as it ensures better food security (Chowdhury & Moore, 2017).

The objectives of this study were (1) to evaluate the interaction between decomposed floating aquatic plants as planting media and melon varieties, (2) to evaluate the effect of aquatic plants and (3) the effect of varieties on melon growth and yield cultivated on ambul swamp floating bed.

MATERIALS AND METHODS

The research was conducted in Arut Bawah floodplain wetland in Palangkaraya, Central Kalimantan located at an altitude of 20-25 m above sea level from Januari until May 2015. The location of Arut is 2.20° S, 113.92° E. An artificial floating bed named *ambul* whose size was 9 x 10 m^2. The *ambul* was constructed using bamboo tied resembling raft so it could float. The floating media consisted various aquatic plants i.e *E.crassipes*, *S.molesta* and

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E.palustris. The piling up of aquatic plants on ambul as a planting media was done in reverse, shoot section below while the roots were above. The root sections then were chopped manually by chopper. The total expanse area of *E.crassipes*, *S.molesta* and *E.palustris* required to fill 9 x 10 m^2 ambul were 960 m^2, 2160 m^2 and 1850 m^2, respectively. The ambul media thickness was 50 cm. Before planting, the media was incubated for a month to form compost. Planting was done after the 10-days-old seedlings in nurseries with a spacing of 50 x 60 cm. Basic fertilizers in the early planting were 15 t/ha of chicken manure, meanwhile, at 1 to 7 weeks after planting (WAP) was given 200 kg/ha of NPK fertilizer and 2 t/ha of dolomite. Harvesting was executed at 65 days after planting (DAP) with fruit skin color turned yellowish. The research was conducted to follow Split Plot Design with three aquatic plants as the main factor and varieties as subplot factors. The aquatic plants included *E. crassipes*, *S. molesta* and *E. palustris*. The subplot factors were two varieties of melon, namely Action 434 and Amanta. Each combination of treatments classified as 4 groups in order to obtain 12 main plots and 24 subplots. Variables observed were plant length, flowering time, root dry weight, and fruit weight. Data was performed by analysis of variance in the level of 5%. If there was an effect on the treatment, it was then continued by Duncan Multiple Range Test (DMRT) at 5% error level.

RESULTS

Performance of Ambul with Melon

Visualization of melon cultivated on floating bed is presented in Figure 1. The exact location was under the Sukarno Bridge that connects the city of Palangka Raya with Bukit Rawi, Barito Selatan, and Gunung Mas. The floating bed was mobile like an island in the middle of the waters. The application of *S. molesta* as media of ambul based on the consideration that *S. molesta* is one of the many plants in the floodplain and its existence disrupts aquatic ecosystems as well as *E. crassipes* and *E. palustris*. The other aquatic plants were grasses, water spinach and limnocharis or sawah-lettuce which were potential to be used as growing media on floating beds. The depth reached approximately three meters located on the edge of the Kahayan river. The most common pest found in the cultivating of the melon float system was the rat.

Figure 1. Melon on swamp floating bed

Length of Plants

There was an interaction between planting media and variety used on plant length at 1, 2, and 3 WAP ($p<0.05$) but not so with those at 4 WAP ($p>0.05$). At 4 WAP, plant length of melon only was affected by melon varieties ($p<0.05$). The Amanta variety produced the

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highest plant length (188.43 cm) and had significantly different from the length of the variety of Action 434. Application of *S. molesta* and Amanta variety produced the longest plant at age 1, 2, and 3 WAP by 14.6 cm, 43.13 cm and 114.35 cm, respectively. The use of *S.molesta* as a planting media in the form of compost also produced the highest melon plant length of both Amanta and Action 434 varieties (Table 1).

Table 1. Plant length (cm) of two varieties of melon at 1, 2, 3 and 4 WAP on ambul on various planting media

Observation Time (WAP)	Aquatic Plants	Melon Varieties	
		Action 434	Amanta
1	*E.crassipes*	11.7 a B	13.3 b B
	S.molesta	13.9 a C	14.6 b C
	E.palustris	9.3 a A	11.05 b A
2	*E.crassipes*	36.75 a B	38.65 b B
	S.molesta	40.93 a C	43.13 b C
	E.palustris	32.1 a A	35.93 b A
3	*E.crassipes*	106.6 a B	108.28 a B
	S.molesta	111.08 a C	114.35 a C
	E.palustris	90.15 a A	98.95 b A
4	*E.crassipes*	164.88	187.78
	S.molesta	202.18	211.1
	E.palustris	150.16	166.4
Average		172.55 a	188.43 b

Note : Numbers followed by capital and lowercase letters at the same age and column showed not the significant difference in DMRT level of 5%. Capital letters for media and lowercase letters for varieties. WAP=Week after planting

Flowering Time

Production of melon depends on a series of steps in reproductive development, flowering, fruit set and growth, maturation and ripening. In flowering time, there was no interaction between media used and melon variety ($p>0.05$). The only the aquatic plants as media exhibited flowering time of melon on ambul ($p<0.05$). The utilization of *S. molesta* as planting media accelerated the time of flowering on both Action 434 and Amanta (11.43 DAP) and significantly different from other planting media. The melon cultivated on ambul swamp floating bed would be flowering at 11.43 days on *S. molesta*, 12.29 days on *E. crassipes* and 12.49 days on *E. palustris*, respectively (Table 2).

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Table 2. Flowering time, root dry weight, and fruit weight of two varieties of melon on ambul on various planting media.

Aquatic Plants	Melon Varieties		Average
	Action 434	Amanta	
Flowering Time (day after panting)			
E.crassipes	12.33	12.25	12.9 B
S.molesta	11.93	10.93	11.43 A
E.palustris	12.58	12.40	12.49 B
Root Dry Weight (g)			
E.crassipes	1.14	1.36	1.25 B
S.molesta	1.40	1.72	1.56 C
E.palustris	0.72	0.92	0.82 A
Average	1.09 a	1.33 b	
Fruit Weight (kg)			
E.crassipes	2.35	2.83	2.59 B
S.molesta	2.98	3.38	3.18 B
E.palustris	1.75	2.08	1.92 A

Note : Numbers followed by same letters at the same column and parameter showed not the significant difference in DMRT level of 5%.

Root Dry Weight

In this experiment, the plant roots were not in contact with the bottom sediments or soil. Their access to nutrients depends on the nutrients contained within the floating bed, much like a hydroponic cultivation system. The analysis of variance results showed that there was no interaction between planting media and melon varieties (P>0.05). The single effect occurred either in the planting media or varieties treatment (P<0.05). The root dry weight of Amanta variety was higher than those of Action variety (1.33 g). The administration of *S. molesta* as planting media produced the highest root dry weight (1.56 g) compared to those treated with *E.crassipes* dan *E.palustris* (Table 2).

Fruit Weight

The provision of various aquatic plants as planting media had a significant effect on fruit weight (P<0.05), but there was no impact of variety on fruit weight (p>0.05). The highest fruit weight was generated by melon treated with *S. molesta* as planting media (3.18 kg per plant) and there was significantly different from others (Table 2).

DISCUSSION

To date, melon has never been cultivated floatingly in Central Kalimantan. The cultivation of ambul is only limited to several commodities. Ardianor *et al*. (2007) introduced an ambul to the community to cultivate cash crops in Sabuah Lake, Central Kalimantan. The same cultivation also was undertaken by Chotimah *et al*. (2014) in Arut Village by growing various vegetables such as cucumber, bitter gourd, squashlike vegetables/sponge luffa, eggplant, tomato, and okra. The growth and yield obtained by residents of the various vegetables were very satisfactory although the yields were only used to meet their daily needs of vegetables in the household. The cucumber yields reached 4 kg/plant, eggplant 3 kg/plant, tomato 1.5 kg/plant, and squashlike vegetable 4 kg/plant, respectively. Nevertheless, the farming analysis of some ambul's vegetables has not provided an economic advantage due to the cost to assemble of the ambul. In other words, the cultivated plant on ambul must have a high

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economic value such as chilies and melons. (Pantanella *et al.*, 2011) declared that productivity of cabbage (*Brassica campestris* L) in composted manure rafts and lettuce (*Lactuca sativa* L) in nutrient-rich ponds resulted in the same productivity in a high-input agricultural field.

On floating melon, plants grow and produce well. The variety of Amanta attained 188.43 cm plant height, whilst the Action 434 reached 172.55 cm at 4 WAP (Table 1). Simanungkalit et al., (2013) reported that the treatment with 45 g NPK fertilizer produced the longest shoot (200.24 cm) at 5 WAP on Action 434 on non-floating melon. Risyad & Ainun, 2015 reported that the height of non floating melon reached 168.66 cm with treatment of planting media and Agroboost biofertilizer and 416.83 cm with bokashi and KNO3 at 30 days after planting. The plant height in the ambul reached 202.18 cm and 211.1 cm in the varieties of Action 434 and Amanta with ambul media of *S.molesta*, respectively (Table 1). The use of organic materials as a medium of non-floating melon cultivation has been done (Risyad & Ainun, 2015; Mazuela & Urrestarazu, 2009; Bariyyah *et al.*, 2015; Amiroh, 2014) but not so with the use of organic material from decomposed-aquatic plants on floating melon.

The application of *S.molesta* compost on melon floating bed is suitable media due to the increasing all of the parameter observed whereas in some areas *S.molesta* cause the problems by its excessive growth (Chomchalow, 2011; European and Mediterranean Plant Protection Organization, 2017 ; Hussner *et al.*, 2017). In the size frame 9 x 10 m^2 of this ambul needs 2160 m^2 area of *S.molesta* with the result that this practice provides a biological control for this invasive aquatic weeds effectively. The *S.molesta* compost is suitable media compared with *E.crassipes* and *E.palustris* due to both nutrients and hormones content. This is because *S.molesta* has a softer morphology than *E.crassipes* and *E.palustris* so it is suspected that the protein and mineral content in *S.molesta* is more than that of *E.crassipes* and *E.palustris* and is easier to decompose well so that it is able to contribute elements nitrogen, phosphorus, and others. This phenomenon is in line with (Marlina & Syafrullah, 2014) report. Further, the dry matter of *S. molesta* contained 135 g/kg of lignin, 42 g/kg ether extract, 130 g/kg of ash and 132 g/kg of crude protein (Leterme et al., 2010 in Koutika & Rainey, 2015). The experiment of (Arthur *et al.*, 2007) detected that *S.molesta* compost consisted of the macronutrients (N, P, K, Na, Ca, Mg, Fe) and plant hormones (IAA and cytokinins).

The switch to reproductive development is clearly controlled by endogenous and several environmental condition. There is recent evidence that flowering time is controlled by genes. These genes affect the hybrid vigor and thus are likely to impact on yield. In all seed crops, the floral transition is a key developmental switch that determines the production of dry matter (Jung & Müller, 2009). Melon cultivation utilized of *S. Molesta* as a media floatingly was able to shorten the flowering time of plants. The first time of Amanta variety flowering at 10.93 DAP meanwhile the Action variety flowering at 11.93 DAP (Table 2). The flowering time is faster than the findings (Syafi'i, 2005). Melons are grown with a drip irrigation hydroponic system with GA3 treatment. The flowers will appear for the first time in 18 DAP.

In correlation studies with melon, fruit weight has been reported to be positively correlated with plant length (r = 0.59) (Taha et al., 2003). The results of this study also tend to follow the pattern of these correlation. The application of *S.molesta* induced both plant length (Table 1) and heaviest fruit weight at 3.38 kg in the Amanta variety (Table 2). In non-floating, fresh weight of melon gains

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approximately 1815 g per plant (Sari *et al*., 2012), 1244 g (Park & Seo, 2012), 1.64 kg (Surtinah, 2017), 2.68 kg (Makful *et al*., 2013), 1792 g (Asao *et al*., 2013), 1.17 kg (Mustaqim *et al*., 2016), and 1.52 kg (Deus *et al*., 2014) in the field. The Action 434 reportedly reached only the weight of 1.59 kg (Deus *et al*., 2014). At various altitudes, the Apollo variety is the most suitable for the lowland and highlands with yields of 0.56 kg per plant (Afandi *et al*., 2013). The potential conventional soil cultivation melon weight of Action 434 and Amanta was 2.2 kg per plant and 3.5 kg per plant, respectively (Personal communication: PT. Tanindo Subur Prima and PT. East West Seed Indonesia). The fruit weight in the experiment achieved 2.98 kg per plant of Action 434 and 3.38 kg per plant of Amanta arranged one fruit per plant (Table 2).

Soilless culture in the form of a float tray system involves the use of media substrates the use of aquatic plant compost media provide advantages such as enabling root growth and improved germination rates (Wisdom *et al*., 2017). The root dry weight of 1.09 g of Action and 1.33 g of Amanta. The weighty root was pointed by impacted *E.crassipes*, *S.molesta* and *E.palustris* as a media of melon swamp foating bed 1.25 g, 1.56 g, and 0.82 g, respectively (Table 2). At the whole ecosystem scale, fine root biomass was negatively related to nutrient availability, however, Neatrour (2005) reported within floodplain ecosystem which is the greatest NO_3-N and NH_4-N variability and nutrient undistributed spatially, the correlation was weak. Soil nutrient availability may control fine root biomass at the ecosystem scale in the wetland ecosystems. Visually, the growth of melon roots penetrated in the shallow layer (<20 cm) on the ambul. There seems to avoid contact with the surface of the swamp water. Sharma *et al*. (2017) argued that in melon irrigated crops, the distribution of root in the soil profile might not represent the effectiveness of root. Furthermore, genotypic differences are very responsible for the melon ability to adjust root distributions pattern across soil depth.

CONCLUSION

There was no interaction between both melon variety used and decomposed floating aquatic plant types on ecotechnology ambul cultivation. The decomposed floating aquatic plants of *S.molesta* as a media is recommended to be applied as a soil replacement media for melon on swamp floating bed cultivation. The make use of melon varieties is a major factor that must be considered. Among the two varieties, Amanta is the variety supporting for swamp floating bed cultivation evidenced some plant growth and yield indicators observed.

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