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**Submission date:** 07-Jul-2020 11:42AM (UTC+0700)

**Submission ID:** 1354439330

**File name:** IJEETC_5ccfecf804877-5-1.pdf (8.27M)

**Word count:** 4423

**Character count:** 22531

IJERST

# International Journal of Engineering Research and Science & Technology

ISSN : 2319-5991
Vol. 4, No. 2
May 2015

www.ijerst.com

Email: editorijerst@gmail.com or editor@ijerst.com

*Int. J. Engg. Res. & Sci. & Tech. 2015*

International Journal of Engineering Research and Science & Technology

*ISSN 2319-5991 www.ijerst.com*
*Vol. 4, No. 2, May 2015*


*Research Paper*

# FLOATING AGRICULTURAL SYSTEM USING PLASTIC WASTE FOR VEGETABLES CULTIVATION AT SWAMP AREA

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Agricultural land at South Sumatra is mostly consisted of lowland swamp and tidal lowland swamp which is water flooded during wet season so that farmers cannot conduct their farm enterprise. Therefore, an effort should be developed when agricultural land is flooded by water in order to obtain farmer income. An effort to obtain agricultural income during water flooding on agricultural land is by the application of floating cultivation for vegetables. This study objective was to develop locally specific technology on flooded lowland swamp, i.e., cultivation technology of floating organic vegetables and to utilize flooded lowland swamp into productive land for agricultural cultivation of organic vegetables. This study was conducted from January to May 2014 at Sakatiga Village, Indralaya Utara Subdistrict, Ogan Ilir District, South Sumatra Province. This study was a part of integrated research consisting of three applied researches of vegetable organic farming cultivation covering of curly red lettuce, mustard greens and red pepper. The method used in this study was Factorial Randomized Block Design with 9 treatment combination and three replications for each treatment as well as 5 sample plants. The observed parameters were consisted of raft types made from plastic waste of mineral water packaging (250 mL plastic cup waste raft, 600 mL plastic bottle waste raft and 1500 mL plastic bottle waste raft) and compost types (rush grass compost, wild lily grass compost and gegas grass compost). The results showed that 250 mL plastic cup waste raft gave better respond in term of growth and production for red pepper crop, whereas wild lily grass compost gave better respond in term of growth and production for all crops. Application of cultivation technology of floating organic vegetables on flooded lowland swamp had produced similar or even better yield than that of conventional cultivation system in dry land.

***Keywords:*** Floating organic vegetables, Raft, Lowland swamp grass, Flooded lowland swamp

## INTRODUCTION

Agricultural land at South Sumatra generally is consisted of lowland swamp and tidal lowland swamp. During high tide period, this agricultural

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land is flooded within relatively long period in the range of 3 months to more than 6 months, especially for lowland swamp area. Area of lowland swamp in South Sumatra was about 1.1 million ha and about 288,673 ha is utilized for food crop agriculture, especially for rice in which about 74,972 ha was located at Ogan Ilir District (BPS Kabupaten OI, 2013). According to Sutanto *et al.* (2007), the main problem frequently found on lowland swamp is uncontrolable water system because high tide water and low tide water periods can not be exactly determined which affect the initiation of planting season and frequently results in low yield of crops due to excessively high water that can damage the crops.

Rainfall occurrence at Ogan Ilir District for the last 20 years was occurred in October, November, December, March, April, May and June. The highest flooding was occurred in May with flooding depth of 3 m, whereas the decrease of water flooding was occurred in July, August and September and the lowest water flooding was occurred in August with water depth of 50 cm (Figure 1). This lowland swamp condition is represented by wet period (flooding) for several months or a year especially during wet period (rainy season) and water depth will be decrease or in dry condition during dry period (Noor, 2004).

Agricultural enterprise can not be conducted if land is flooded and farmers will leave their agricultural land. Therefore, this flooded lowland swamp should be utilized for agrcultural cultivation activities according to field condition for the whole season. Crop cultivation technology that can adapt to environmental condition (locally specific technology) is cultivation technology of floating organic crop. Vegetable planting effort can fulfill daily need of farmers and the surplus can be sold as additional family income. It is expected that application of organic farming system on vegetable cultivation can decrease production cost and reduce environmental pollution because no synthetic fertilizers and pesticides is used in this system. Instead, this system uses materials available in surrounding location as organic fertilizers and pesticides. Technological application for floating vegetable cultivation is suitable method to utilize lowland swamp potential in South Sumatra (Syafrullah, 2004).

Lowland swamp potential that has not been optimally utilized was consisted of grasses such as wild lily grass, gegas grass and rush grass. Lowland swamp grasses that are available in huge quantity and for the whole year can be utilized as organic fertilizer (compost). According to Muhakka *et al.* (2006), these grasses are organic matter that can be utilized as organic fertilizer (compost).

Planting media for cultivation technology of floating organic vegetable is consisted of soil and compost mixture placed on raft as container for planting media. Raw material for organic fertilizer (compost) which is available in huge quantity at study location was lowland swamp grass. Basic material for raft making is available in the study location in form of plastic waste of mineral water package. Based on relatively high potential of lowland swamp grasses and plastic waste as well as farmers condition at lowland swamp that is flooded during wet season, this study was conducted to solve the farmers problem in conducting crop cultivation (Syafrullah, 2011).

The objectives of this study were to obtain locally specific technology at flooded lowland swamp or wet land in form of floating organic vegetable cultivation, to utilize flooded lowland swamp into productive land for organic vegetable cultivation as well as to everlasting the environment through plastic waste utilization as basic material for raft making in activity of floating organic vegetable cultivation at lowland swamp during flooded condition.

## RESEARCH METHOD

This study was conducted from January to May 2014. The study location was at Sakatiga Village, Inderalaya Subdistrict, Ogan Ilir District, South Sumatra Province. Materials used in this study were seeds (curly red lettuce, mustard greens and red pepper), compost from lowland swamp grasses (wild lily, rush and gegas), EM-4, sugar, rice bran, manure and water. Equipmets used in this study were mattock, chopping kinfe, raffia fibre, hammer, tape, scales, plastic cup waste, 600 mL plastic bottle waste, 1500 mL plastic bottle waste, bamboo, bucket, hand sprayer, water dipper, writing utensils and others.

This study was a part of integrated research consisting of three applied researches of vegetable organic farming cultivation covering of curly red lettuce, mustard greens and red pepper. The method used in this study was Factorial Randomized Block Design with 9 treatment combination and three replications for each treatment as well as 5 sample plants. The treatments were consisted of raft types ($R_1$ = 250 mL plastic cup waste raft, $R_2$ = 600 mL plastic bottle waste raft and $R_3$ = 1500 mL plastic bottle waste raft) and compost types ($K_1$ = rush grass compost, $K_2$ = wild lily grass compost and $K_3$ = gegas grass compost).

There was three floating rafts used in this study which consisted of 250 mL plastic cup waste raft, 600 mL plastic bottle waste raft and 1500 mL plastic bottle waste raft. The raft development from mineral water plastic waste was done by collecting plastic cup waste and plastic bottle wastes and connecting them together with wire on rectangular raft made from wood having size of 2 m width and 3 m length. Subsequently, plastic sack was put below plastic cup followed by pouring of planting media.

Planting media used in this study in form of top soil and dry grasses mixture was put on the raft with thickness of 15 to 20 cm. Planting of curly red lettuce and mustard greens crops was done with planting space of 20 cm x 20 cm, whereas red pepper planting space was 40 cm x 50 cm. Fertilizer used in this study was solid organic fertilizer in form of lowland swamp grass composts that consisted of wild lily grass, rush grass and gegas grass with dose of 5 tons per hectare which was applied during planting. The supplement fertilizer was organic fertilizer made from several crop types which was dipped in water for 2 weeks period. Application of liquid organic fertilizer was done by dilluting 1 L of organic fertilizer in 10 L of water which was applied once in a week after planting.

Crop rearing or maintenance was conducted through prevention of pests and diseases attack by using self blending of organic pesticide made from several plants extraction that had specific hot, bitter and aroma characteristics which was stored for 2 weeks period. Application of organic pesticide was conducted by by dilluting 1 liter of organic pesticide in 10 L of water which was sprayed into crops 1 week after planting until harvesting period. Harvesting of curly red lettuce and mustard greens was done when crops were 30 to 45 days in age by withdrawing each crop. Harvesting of red pepper crop was done when it had 60 to 90 days in age by picking up the mature fruit that had dark red color. The observed parameters for vegetable crops of curly red lettuce and mustard greens were as follows: crop height (cm), leave numbers per plant (sheet), wet matter weight (g) and crop production per raft (kg). The observed parameters for vegetable crops of red pepper were as follows: crop height (cm), branch numbers (stem), total fruit numbers (fruit), fruit weight per plant (gram) and crop production per raft (kg).

## RESULTS AND DISCUSSION

The results showed that all floating raft types and lowland swamp grass compost types used in this study gave diverse crop growth yield and crop production for all crops. Treatment of raft made from 250 mL plastic cup waste and wild lily grass compost on curly red lettuce gave higher values for all observed parameters than that of other floating raft types and lowland swamp grass composts with average values as follows : the highest crop height of 24.44 cm, leave numbers of 9,16 sheets, wet matter weight per crop of 21.77 g and crop production per raft of 20,48 kg (Table 1).

Treatment of raft made from plastic cup waste and wild lily grass compost on mustard greens crop gave higher values for all observed parameters than that of other floating raft types and lowland swamp grass composts with average values as follows: the highest crop height of 24,53 cm, leave numbers of 9,71 sheets, wet matter weight per crop of 95,98 g and crop production per raft of 17.70 kg (Table 2).

Treatment of raft made from 1500 mL plastic cup waste and wild lily grass compost on red pepper crop gave higher values for all observed parameters than that of other floating raft types and lowland swamp grass composts with average values as follows: the highest crop height of 74.44 cm, fruit numbers per crop of 23.08 fruits, total fruit weight per crop of 451.34 g and crop production per raft of 15,50 kg (Table 3).

Results from 3 types of organic vegetable crop showed that treatment of wild lily grass compost gave higher growth respond and production than

**Table 1: The Growth and Production Analysis of Lettuce Crop**

| Treatment combination | | Crop height (cm) | Leave numbers (sheet) | Fresh weight/crop (gram) | Total Production /raft (kg) |
|---|---|---|---|---|---|
| Raft of 250 ml plastic cup waste | K1 | 23.3 8 | 7.85 | 19.99 | 18.67 |
| | K2 | 24.44 | 9.16 | 21.77 | 20.48 |
| | K3 | 22.83 | 7.12 | 18.55 | 19.15 |
| Raft of 600 ml plastic bottle waste | K1 | 23.26 | 5.64 | 17.66 | 17.33 |
| | K2 | 22.83 | 6.46 | 16.88 | 19.20 |
| | K3 | 21.83 | 5.94 | 15.32 | 18.45 |
| Raft of 1500 ml plastic bottle waste | K1 | 21.82 | 5.28 | 17.92 | 16.89 |
| | K2 | 21.94 | 6.28 | 15.66 | 18.50 |
| | K3 | 21.33 | 6.52 | 16.11 | 17,10 |

**Table 2: The growth and production analysis of mustard greens**

| Treatment combination | | Crop height (cm) | Leave numbers (sheet) | Fresh weight/crop (gram) | Total Production /raft (kg) |
|---|---|---|---|---|---|
| Raft of 250 ml plastic cup waste | K1 | 23.63 | 8.60 | 92.68 | 14.35 |
| | K2 | 24.53 | 9.71 | 95.98 | 17.70 |
| | K3 | 23.83 | 8.86 | 90.53 | 15.78 |
| Raft of 600 ml plastic bottle waste | K1 | 21.83 | 8.86 | 88.53 | 14.78 |
| | K2 | 22.33 | 8.86 | 82.16 | 15.02 |
| | K3 | 21.10 | 7.00 | 82.48 | 14.37 |
| Raft of 1500 ml plastic bottle waste | K1 | 21.10 | 8.00 | 82.48 | 13.37 |
| | K2 | 22.90 | 8.06 | 79.83 | 14.96 |
| | K3 | 22.17 | 8.13 | 79.22 | 14.38 |

**Table 3: The Growth and Production Analysis of Red Pepper**

| Treatment combination | | Crop height (cm) | Branch numbers (sheet) | Total Fruit Numbers/ crop Fruits | Total Fruit Weight/ Crop (gm) | Total Production /raft (kg) |
|---|---|---|---|---|---|---|
| Raft of 250 ml plastic cup waste | K1 | 63.24 | 6.66 | 20.66 | 464.63 | 10.94 |
| | K2 | 65.54 | 6.80 | 21.33 | 372.48 | 13.20 |
| | K3 | 61.34 | 6.00 | 21.91 | 384.17 | 12.52 |
| Raft of 600 ml plastic bottle waste | K1 | 71.65 | 6.33 | 21.33 | 353.48 | 12.60 |
| | K2 | 73.24 | 7.22 | 22.66 | 414.37 | 14.93 |
| | K3 | 68.88 | 7.00 | 21.66 | 382.85 | 13.48 |
| Raft of 1500 ml plastic bottle waste | K1 | 69,45 | 8.00 | 22.33 | 393.48 | 14.30 |
| | K2 | 74.34 | 8.70 | 23.08 | 451.54 | 15.75 |
| | K3 | 73.78 | 7.00 | 22.16 | 432.58 | 14.90 |

that of other lowland swamp grasses compost. This was due to the fact that nutrients content of wild lily grass compost was higher than that of other lowland swamp grasses. It is predicted that wild lily grass has wide and thick leaves which is easier to experience decomposition process. This is in accordance to premise from Muhakka *et al.* (2006) which stated that crops having wide and soft leaves morphologically are easier to be decomposed because they have high protein content. This was supported by laboratory analysis results which showed that wild lily grass compost had N-total 2.03 (%), P-bray 143.30 ppm and K-dd 4.5 me/100 g. Rush grass compost had 1.55 (%), P-bray 98.73 ppm and K-dd 3.01 me/100 g, whereas gegas grass compost had N-total 1.10 (%), P-bray 67.48 ppm and K-dd 2,08 me/100 g.

Treatment of 250 mL platic cup waste raft on curly red lettuce and mustard greens gave higher growth respond and production than that of other floating rafts. This was due to the fact that some roots of curly red lettuce and mustard greens on 250 mL plastic cup waste raft had touch water surface below the lower part or base of raft so that crops were received sufficient water for their growth. This condition is ideal environment for curly red lettuce and mustard greens so that their growth and production were better than that of other rafts.

According to Ahmed *et al.* (2002), the availability of water in roots region for hydrophyte plants or some mesophyte plants does not create a problem because these plants can be adapt to this condition. This is due to availability of aerenchyme tissue at roots section so that roots can supply oxygen into other parts of plant. Aerenchyme development is considered as one of important aspect for plant morphology adaptation due to water flooding in surrounding of roots. Furthermore, Peeters *et al.* (2002) stated that sub-optimal environment such as water flooding occurrence can accelerate the formation of etylene. Etylene has important role in growth, protection and sustaining of plants in respond to sub-optimal environment. Plants can sustain their life on flooding condition due to the increase of etylene content. The damage on roots due to water flooding can also decrease roots activity as organ that has function to absorb water and minerals (Ojeda *et al.*, 2004).

Based on conversion of average production in ton per hectare, then crops production had the following figures. Average production for curly red lettuce per raft had magnitude of 28.48 kg with raft area of 6 $m^2$. There was 1600 rafts in 1 ha so that production per hectar was 1600 multiplied by 20.48 kg and divided by correction factor of 20% which yield production of 26.2 ton/ha. Lettuce crop production at dry land was about 25 ton/ha (Williams and Peregrine, 1993) so that curly red lettuce production on raft was higher than that of production at dry land or conventional cultivation. Average production for mustard green per raft had magnitude of 17.70 kg with raft area of 6 $m^2$. There was 1600 rafts in 1 ha so that production per ha was 1600 multiplied by 17.70 kg and divided by correction factor of 20% which yield production of 22.6 ton/ha. Mustard greens crop production at dry land was about 22 ton/ha (Williams and Peregrine, 1993) so that mustard greens production on raft was similar to the production at dry land or conventional cultivation.

This is due to the fact that application of organic fertilizer (compost) capable to provide nutrients for crops and is supported by planting media that had sufficient available water for the growth and production of curly red lettuce and mustard greens. According to Darwin *et al.* (2007), impact of compost (bokashi) application on planting media was capable to increase nutrients availability within planting media which subsequently capable to increase the growth and production of crops. Moreover, Sutanto (2006) had stated that application of compost or organic fertilizer which contains nitrogen element at vegetative phase would affected the increase of crop growth. Furthermore, Pangaribuan *et al.* (2011) had explained that compost (bokashi) application would added nutrients availability within soil if water availability is exist in sufficient quantity in planting media.

Treatment of 1500 mL plastic bottle waste raft on red pepper gave higher growth respond and production than that of other floating rafts. This was due to the fact that 1500 mL plastic bottle waste raft had better floating capability than that

**Figure 1: Average Monthly Rainfall During 20 Years (1990- 2010) At Ogan Ilir District, South Sumatra Province**

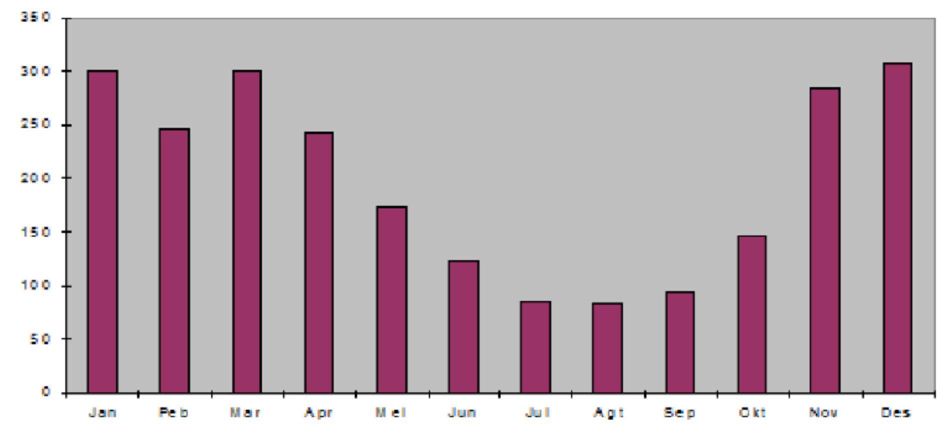


**Table 4: Initial Soil Chemical Properties Before Planting**

| No | Type of analysis | The Result of the analysis | Criteria |
|---|---|---|---|
| 1. | pH $H_2O$ (1:1) | 4,21 | Acid |
| 2. | pH KCl (1:1) | 3,51 | |
| 3. | C-organik (%) | 4,61 | Average |
| 4. | P-Bray I (ppm) | 10,15 | Low |
| 5. | Na-dd (me $100g^{-1}$) | 0,44 | Low |
| 6. | K-dd (me $100g^{-1}$) | 0,06 | Low |
| 7. | Ca-dd (me $100g^{-1}$) | 4,90 | Low |
| 8. | Mg-dd (me $100g^{-1}$) | 0,59 | Low |
| 9. | KTK (me $100g^{-1}$) | 19,05 | Medium |
| 10. | H-dd (me $100g^{-1}$) | 13,06 | |

Description: Results of analysis Laboratory Chemsitry, Biology and Soil Fertility. Faculty of Agriculture Unsri Inderalaya (2013)

**Table 5: The Content of Nutrients in the Compost**

| Compost | N-total (%) | P Bray (ppm) | Kdd (me $100g^{-1}$) |
|---|---|---|---|
| Swamp lilySwamp purunSwamp kumpai | 1,931,111,03 | 143,3098,7367,48 | 4,503,012,08 |

Description: Results of analysis Laboratory Chemsitry, Biology and Soil Fertility. Faculty of Agriculture Unsri Inderalaya (2013).

of other rafts so that planting media was not in contact with water surface or planting media was not flooded by water. This condition is in accordance to growing requisite of red pepper

crop that can not tolerate excessive water availability within its planting media. According to Liao and Lin (2001), red pepper crop can not tolerate water flooding that disturb roots metabolism. This condition explain the better growth and production of red pepper crop using 1500 mL plastic bottle waste raft than that of other floating rafts. Moreover, Armstrong *et al*. (2002) explained that good condition of planting media was the one that was in field capacity condition.

Visser *et al*. (2003) showed that red pepper crop is very sensitive toward water flooding because flooding condition would quickly increase ABA compound in xylem and increase of flooding period would decrease the growth of leaves.

Based on conversion of average production in ton per hectare, then red pepper production had the following figures. Average production for red pepper crop per raft had magnitude of 15.75 kg with raft area of 6 $m^2$. There was 1600 rafts in 1 ha so that production per hectar was 1600 multiplied by 15.75 kg and divided by correction factor of 20% which yield production of 20.2 ton/ha. Red pepper crop production at dry land was about 20 ton/ha (Williams and Peregrine, 1993) so that red pepper crop production on raft was similar to chilly production at dry land or conventional cultivation. According to Gonzales and Cooperband (2002), application of organic fertilizer (bokashi) would improve the physical, chemical and biological characteristics of soil so that roots of crop are capable to penetrate planting media and to absorb nutrients. Good soil characteristics also increase the nutrients content within planting media which results in increase of crop growth and production. Moreover, Isnaini (2005) had explained that application of organic fertilizer (bokashi) was good effort in maintaining soil fertility in term of physical and chemical fertilities which increase availability of nutrients resulting in increase of crop growth and production. Therefore, it is logic that red pepper crop production planted on floating raft with limited planting media had similar magnitude to red pepper crop production planted by using conventional method at dry land.

## CONCLUSION

It can be concluded from the study results that raft type made from 250 mL plastic cup waste gave better growth and production respond for curly red lettuce and mustard greens, whereas raft type made from 1500 mL plastic bottle waste gave better growth and production respond for red pepper crop. Compost made from wild lily grass gave better growth and production respond for all crops. Technology application of floating organic vegetable cultivation on flooded lowland swamp gave similar yield or even tend to be higher than that of conventional cultivation at dry land.

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International Journal of Engineering Research and Science Technology
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