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Producing organic pot from cassava stem waste for water spinach (*Ipomea reptans* Poir) as waste management strategy

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Abstract. Cassava stem waste in Lampung Province has not been utilized to its maximum potential, so there is a need for an alternative treatment to process the cassava stem waste into a useful material. One way to do this is by turning the stem waste into an organic pot. There are several aims in this study, which are to design the composition of the raw materials and adhesives needed to develop organic pot for media to grow land variant of kangkung (*Ipomea reptans* Poir), second, to determine the physical properties of organic pots made from cassava stem waste raw material, coconut fiber, and tapioca adhesive. The raw materials used are cassava stem powder, coconut fiber, and tapioca adhesive with three levels of treatment, namely P1(60% cassava steam, 10% coconut coir, 30% adhesive), P2 (50% cassava steam, 10% coconut coir, 40% adhesive), and P3 (50% cassava steam, 20% coconut coir, 30% adhesive). Research results from 15 Organic pots with 3 levels of treatment P1, P2, P3, based on physical characteristics and planting test of the three organic pot treatments, can be penetrated by roots and fully decomposed after 23 days and show good growth.

1. Introduction

Cassava is developed in a tropical country to create roots and it is utilized primarily for human consumption but also for animal feed and starch extraction. Cassava has a high biomass production in suitable environmental conditions and a high capacity to adapt to abiotic and biotic stress, such as low fertility or water stress, where other cultures do not allow it. The upper part of the plant consists of thick and thin stems, petioles, and leaves, and the underground part consists of roots and seed stalks [1]. Cassava production was about 230 million tons in 2010, with an average productivity of 12.4 t ha1 on a wet basis (wb), making it the ninth most grown agricultural commodity by weight.Nigeria (54 million tons per year), Indonesia (24 million tons), Brazil (23.5 million tons), and Thailand (22.5 million tons) are the world's top producers [2].

Cassava is one of the commodities, which has an important role in agriculture. Cassava plants can be used for consumption, animal feed, industry (cassava, chips, tapioca, and flour), and new renewable energy materials [3]. Space between the tree by 1 m x 1 m can produce as many as 10,000 cassava stems per hectare. If the weight of cassava stems is around 0.3 kg, then every hectare of the harvested area of cassava produces 3 tons of cassava stem waste [4]. That amount of cassava stem waste became a problem for the community because the waste pile becomes the habitat for pests and diseases. So far, the community has handled the waste by burning it and thrown it away. Although effective at reducing the amount, this way of handling the waste is harmful to the environment. One solution for this problem is

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to utilize the waste as raw material, such as organic fertilizers, animal feed, composite boards, and organic pots.

An organic pot is a planting pot, which was made from organic material. It is degradable and eco-friendly. Using organic pot as a replacement for traditional pot made of plastic will reduce the amount of plastic waste produced. In addition, because the material used is cassava waste, it can help reduce the amount of waste. At the same time, it also increases the economic value of said waste. Other research saw the use of fiber made from palm oil waste [5]; the result shows that it has economic and environmental benefits.

Instead of fiber from palm oil waste, this research uses the powder made from cassava waste combined with coconut husk as the organic pot material. In making organic pots, one of the steps is to reduce the size of the cassava stem waste into tiny pieces. In this process, various sizes of cassava stem particles can be produced; the sizes of the is generally influenced by the particle size. This research aims to design the composition of raw materials and adhesives needed to develop organic pots as a growing medium for *Ipomea reptans* Poir and to determine the physical properties of organic pots made from raw materials of cassava stem waste, coconut husk, and tapioca.

2. Methods

This research was conducted from July to September 2019, which took place at the Laboratory of Agricultural Machine Tool Power and the Laboratory of Water and Land Resources Engineering, Department of Agricultural Engineering, Faculty of Agriculture, University of Lampung.

The tools used in this study were TEP-1 type cassava stem chopper, oven, bomb calorimeter, stopwatch, hammer mill, briquette screw press, digital calipers, stove, pan, clamp, desiccator, tray, measuring cup, stirrer, label paper, analytical scales, digital scales, tarpaulin, aluminum cups, buckets, rulers, stationery and Tyler Meinzer II sieve size 25. Meanwhile, the materials used include cassava stem waste (Kasetsart variant), coconut husk, tapioca flour, and water.

There are several procedures conducted, which are:

1. The preparation of tools and materials
2. Reducing the size of cassava and coal stems. The size of the cassava stems is reduced by using a Type TEP-1 cassava stem chopper which produces chopped cassava stems. This cassava stem chopper is able to chop the stem in size range of > 0.5 cm, 0.2 $<x<$0.5 cm and ≤ 0.2 cm [3]. While, the coconut husk is 0.5cm long.
3. Drying the chopped cassava stems. Dry the chopped cassava stems in the sun until the moisture content reaches 8-12%. The drying length depends on the weather which are between 5-6 days
4. Phase 2 of reducing the cassava stem chopped size. In this phase, the chopped cassava stems then reduced the sized by using a hammer mill further reducing size of the cassava stem particles.
5. Sifting the particles of cassava stems and coal. The cassava stem particles were sieved using Tyler Meinzer II size 25 mesh.
6. Making tapioca adhesive; the material needed to make tapioca adhesive are tapioca flour and water. The manufacture of this adhesive uses a 1:10 ratio of tapioca flour and water. The manufacturing process is done by mixing tapioca flour and water which is placed on the pan, then heated on a burning stove, while stirring until it is even, thickened, and translucent.
7. Mixing of raw materials. The sifted cassava stem and coal particles are prepared, then put into the basin. After the adhesive is ready to use, mix it with the particles of cassava stems, coconut husk and tapioca adhesive. The percentage of weight for organic pot dough is seen in Table 1.
8. Organic pot molding. The readied mixture of cassava stems powder, coconut husk, and adhesive, then molded by using a manual press.
9. Drying the organic pot. After that, the organic pot is dried under the sun. The process of drying moisture content is to remove moisture content inside the briquettes
10. Testing the characteristics of the organic pot. The tests conducted on the organic pot are moisture content, density, shatter resistance index, water absorption, and organic pot planting test.

Table 1. Formulation of organic pot dough weights

Cassava Stem Waste	Mesh Size	Coconut Husk (cm)	Total Weight (g)	Organic Pot Dough Weight (g)			Total Weight (g)
				Cassava Stem	Coconut Husk	Adhesive	
Kasetsart	25	0.5	30	18	3	9	30
				15	3	12	30
				15	6	9	30

In Table 1. The weight formulation of organic pot dough is that the adhesive is made using tapioca flour and water. The ratio used is 1:10 with different weight of tapioca adhesive flour for each treatment.

3. Result and Discussion

3.1. Organic Pot

In this study, 15 organic pots with 3 treatments were produced, each of which had diameters of 6 cm on the top, 4 cm on the bottom, and 8 cm in height. The organic pots are composed of cassava stem powder, coconut husk, and tapioca adhesives kneaded together with a weight of 30 grams (100%). The raw materials were sieved using Tyler Meinzer II. The particle size of cassava stem powder used in all treatments is 25 mesh. The P1 treatment is the mixture of 60% cassava, 10% coconut husk, 30% adhesive, which produced a light brown color. In the P2 treatment, the mixture of 50% cassava, 10% coconut husk, 40% tapioca adhesive produced a dark brown color, and in the P3 treatment, 50% cassava, 20% coconut husk, 30% tapioca adhesive produced a light brown color almost the same as P1. The color difference is due to the different adhesive concentrations, with the organic pot's dry weight between 25 gr, 8 cm in height, 6 cm top diameter, and 4 cm bottom diameter.

Figure 1. Organic pot.

3.2 Water Content

Water content is one of the things that affect the quality of the organic pot. The testing of the moisture content in organic pots aims to determine the water content's level in the organic pot. Graph of the mean value of organic pot water content is provided in Figure 2.

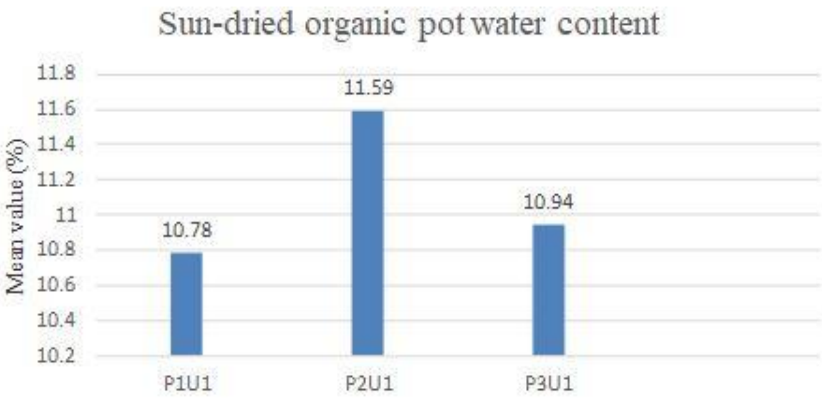

Figure 2. Graph of the mean value of sun-dried organic pot water content

In Figure 2, it can be seen that treatment P1 with the content of 60% cassava stem powder, 10% coconut husk, 30% adhesive, has the lowest water content, which is 10.78%. The highest amount of water content can be found in P2 treatment with the content of 50% cassava stem powder, 10% coconut husk, 40% tapioca adhesive, which is 11.59%. The results showed that an increase in water content with higher adhesive concentration. This is due to the addition of water content from the adhesive itself. According to Sudiro and. Suroto [6] large particle sizes absorb less water than smaller particle sizes.

3.3. Density

Organic pot density testing aims to prevent brittleness in organic pots. The analysis of the physical properties of the organic pot parameter density test shows that the interaction of the adhesive content factor has no significant effect on the density test at the 5% level, which is presented in (Table 2).

Table 2. Analysis of variance test on the effect of the adhesive level to the moisture content of sun-dried organic pot

	df	SS	MS	F	Significance F
Correlation	2	7.8284	1.1463	0.05	0.1573
Error	12	2.2925	0.4610		
Total	14	10.1173			

Explanation: Not significantly affected

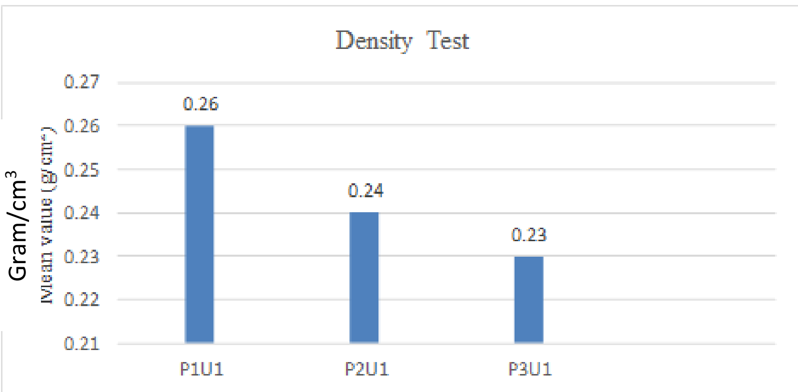

Figure.3 Graph of the average density value of organic pots.

Figure 3 shows the results of the average value of the sample P1, P2, P3. The highest density was found on P1 at 0.26 g/cm³, while the lowest density was found on P3 at 0.23 g/cm³. Density is the ratio between the weight and the volume of the organic pot that affects the organic pot's quality. The density is influenced by the size and the homogeneity of the material that makes up the organic pot itself. Density can also affect the compressive stability, high density can produce a strong/good organic pot, while a low-density organic pot will easily crumble because the larger the air cavity or the gap that oxygen can pass through.

3.4. Shatter Resistance Index

The shatter resistance index is carried out by dropping the organic pot from a height of 1 meter; this test aims to determine the organic pot's resistance. The results show that the adhesive content factor's interaction has no significant effect on the density test at the 5% level, which is presented in (Table 3).

Table 3. Analysis of variance test of the effect of adhesive on the organic pot to the shatter resistance index

	df	SS	MS	F	Significance F
Correlation	2	0.46997333	0.23498667	0.05	0.2854
Error	12	2.02240000	0.16853333		
Total	14	2.49237333			

Explanation: Not significantly affected

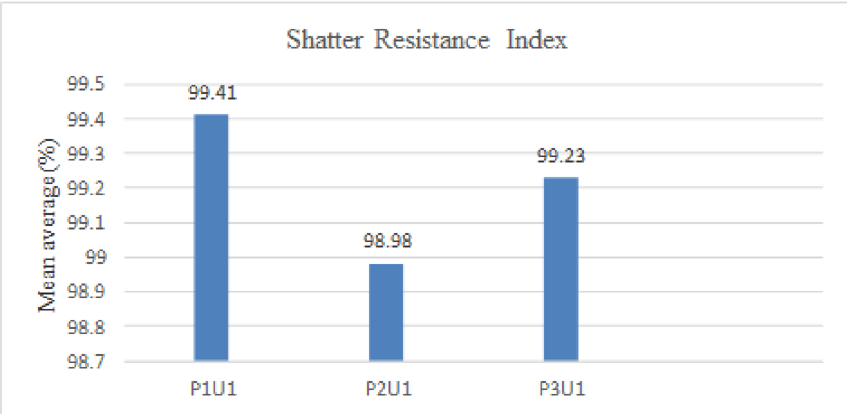

Figure 4. Graph of the average value of organic pot shatter resistance index

Figure 4 shows that the highest shatter resistance index value is P1 99.41% (0.59% crumbled) while the lowest is at P2 98.98% (1.2% crumbled). The smaller the consistency value (crumbled percentage), the higher the organic pot's flexural strength. Likewise, the higher the density value, the shatter resistance index also increased.

According to Budi et al. [7], based on the result of the testing of organic pots' strength, the addition of tapioca adhesive can increase the flexural strength and decrease the stiffness (more elastic). The high amount of cellulose contained in cassava stems and coconut husk also gives them strong properties, making them ideal for organic pot.

3.5. Water Absorption Test

The water absorption test was conducted by soaking the pot inside three transparent plastic containers, each filled with 1 liter of water. The data was obtained by observing the length of time taken until the organic pots were broken down and destroyed by the water and compared with each other. The soaking test was necessary to determine the pot's resistance level when it is applied in the field exposed to water.

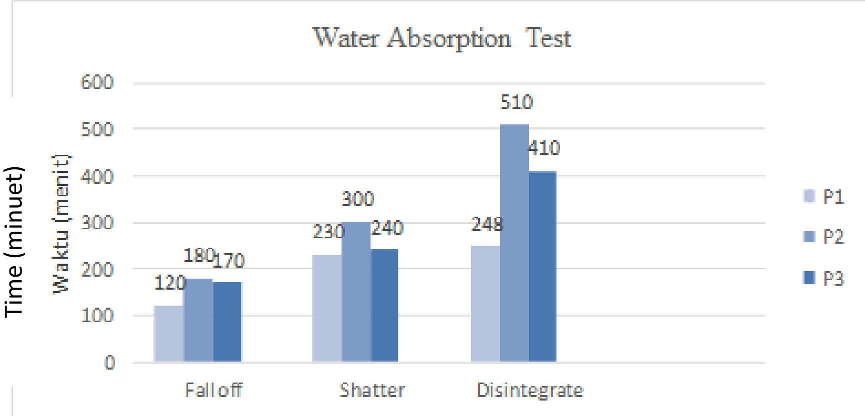

Figure 5. Graph of the average value of water absorption test.

The results show that P2 has the longest absorption time with a duration of 510 minutes and the shortest, P1, with a duration of 248 minutes; this indicates that the greater the amount of adhesive used, the lower the water absorption gets. This is because tapioca adhesive closes the capillary cavity so that water is not easily absorbed by the organic pot [8].

Organic pot is made from materials that easily absorb water and steam. However, if the air around the pot gets dry, the organic pot will lose water until it returns to equilibrium. The factors that affect the high and low water absorption of the organic pot are the presence of channel capillaries that connect the empty space, the volume of the empty space between the pots, and the pot surface area that is not covered with adhesive [8].

3.6. Organic Pot Planting Test with Ipomea reptans Poir

The test was conducted by planting the organic pot with *Ipomea reptans* Poir. Three seeds were planted in each planting medium, organic pots then planted in the polybag, which contains 1.5 kg of soil with a ratio between soil and organic fertilizers (new organitrofos) 1: 3, (100%) where 1 kg of soil (70%) combined with 0.5 kg of fertilizer (30%), and watered 2 times a day, in the morning and evening this continue until 23 days, the pots that show the best growth then selected.

Before usage, the soil first dried under the sun for 1 week, and then the soil and the fertilizer were sifted using a 3mm sieve to remove any impurities such as grassroots, stones, and others. Then weighed 1 kg of soil and 0.5 kg of fertilizer before mixing them together and put them into a transparent polybag.

3.6.1. Plant height. One of the growth indicators that usually observed is the plants' height. This is because plants' height is an immediate sign of plants' growth [9]. In the crop test analysis of plants' height parameter, the results show that the adhesive content factor does not significantly affect the height of the plants at the 5% level, it is presented in (Table 4).

Table 4. Analysis of variance test of the effect of adhesive on the height of plants

	df	SS	MS	F	Significance F
Correlation	2	0.5320	0.2660	0.05	0.9562
Error	12	71.0640	5.9220		
Total	14	71.5960			

Explanation: Not significantly affected

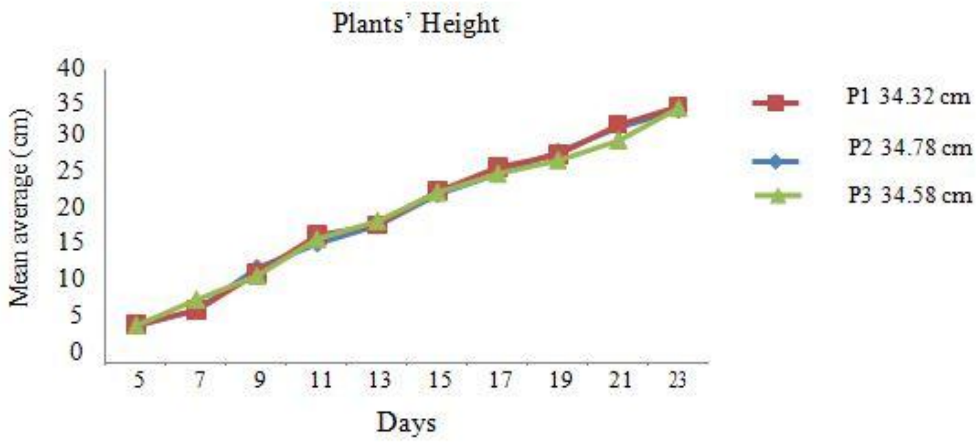

Figure 6 Graph of the average plants' height

According to Indrioko et al. [10], root growth affects the plant's growth, and this is because, with the formation of roots, the plant will be able to absorb nutrients from the growth media. *Ipomea reptans* Poir experienced an increase in growth from day five until harvest. The data is presented in (Figure 6). At P1 the average plant height is 34.32 cm, at P2 the height is 34.78 cm, while at P3 the height is 34.58 cm. Availability of absorbable nutrients in plants is also one factor that can affect the growth rate and plant development [11]. This plant's average height is higher than research conducted by Mayani et al. [12], in which the same plant aged at 3 weeks after planting and using 4 kg/plot straw compost yielded only an average plant height of 32.5 cm.

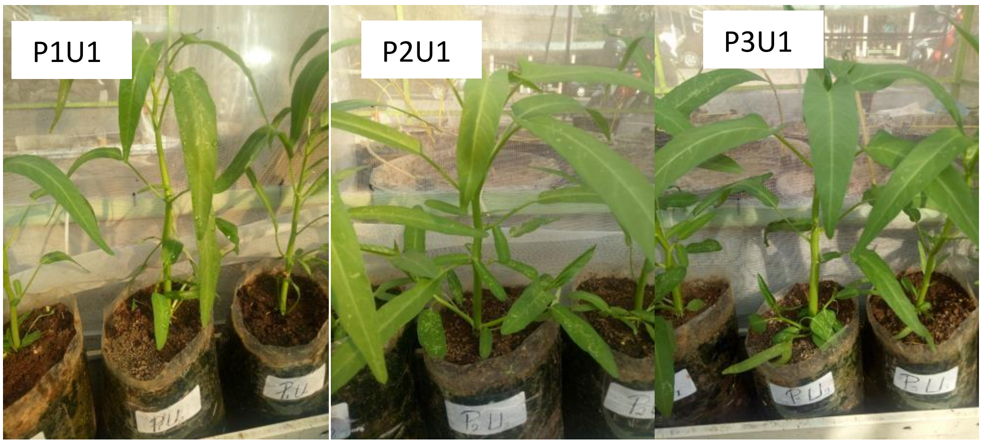

Figure 7. The height of *Ipomea reptans* Poir.

3.6.2. The amount of leaves. In the crop test of leaves number parameters, the results show that the adhesive content factor has no significant effect on the number of leaves at the 5% level. The data are presented in (Table 5).

Table 5. Analysis of variance test on the effect of adhesive to the number of the leaf blade

	df	SS	MS	F	Significance F
Correlation	2	34.5333	17.2667	0.05	0.5825
Error	12	366.4000	30.5333		
Total	14	400.9333			

Explanation: Not significantly affected

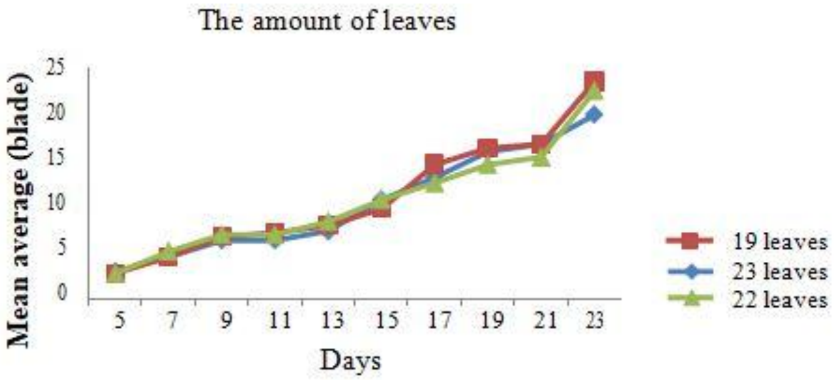

Figure 8. Graph of the average number of leaves

From the results, it can be seen that P2 has the highest number of leaves which is 22 blades, while P1 has the lowest number of leaves which is 19 blades, and then in the middle P3 has 22 leaves. This is due to growth, and the number of leaves is influenced by the sunlight received and the availability of the nutrient amount. Habrian [13] states that the number of leaves is related to plant height. The higher the plant, the more stem segments will be; this is where the leaves emerge. Gardner et al. [14] argued that the stems are composed of the segments that stretch between the stems stolon where the leaves grow. The number of stolon and segments is the same as the number of leaves..

The average number of leaves on plants used in this research is far more than that of the study conducted by Mayani et al. [12] on the same plants aged 3 weeks after planting while using a straw compost media of 4 kg/plot, yielded an average of the number of leaves 10 strands. The amount of sunlight the plant receives, the plant would respond by increasing the number of leaf blades [14]. Nitrogen also plays an essential role in growth organs such as leaf formation [15].

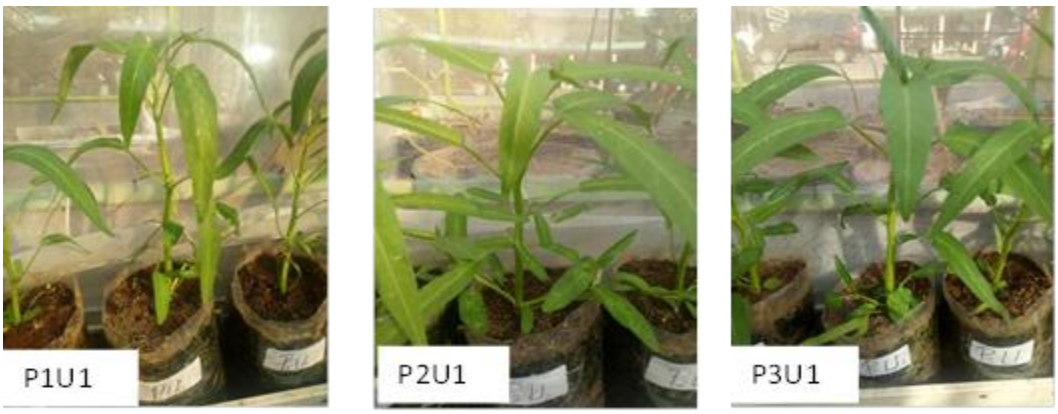

Figure 9. The amounts of leaves on 3 treatments

3.6.3 Roots' length
The results show that the adhesive amount had no significant effect on the roots' length at the 5% level in the root length analysis. The data is presented in (Table 6)

Table 6. Analysis of variance test on the effect of adhesive on the root length

	df	SS	MS	F	Significance F
Correlation	2	0.4013	0.2007	0.05	0.9715
Error	12	83.1960	6.9330		
Total	14	83.5973			

Explanation: Not significantly affected

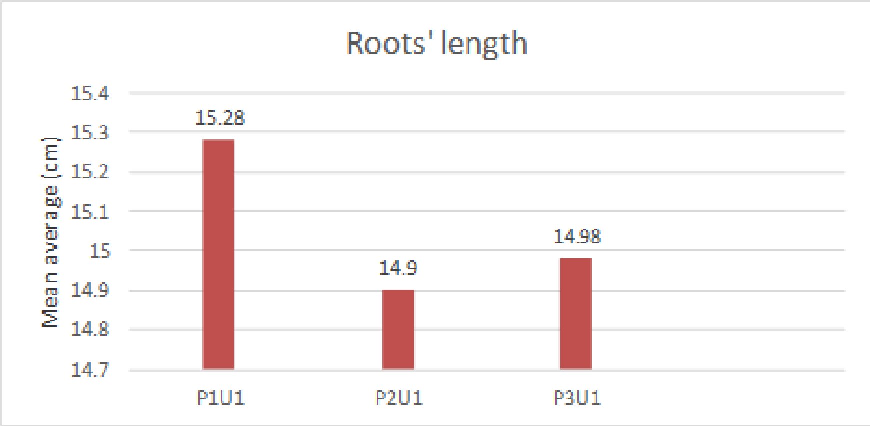

Figure.10 Graph of the average value of the root length

From the results of organic potted planting tests with *Ipomea reptans* Poir, the highest average root length can be found on P1 15.28 cm, while the lowest is P3 14.96 cm. Roots are vegetative organs of plants that can to grow and develop well if growth supporting factors such as sunlight, water, space to grow, and nutrient needs are met. Nitrogen elements contained in organonitrophic fertilizers and tapioca adhesive help the development of roots. This is consistent with Mas'ud [16] statement that root development depends on the availability and supply of nutrients

Figure.11 Plant roots' length

3.7. Organic Pot Planting Test Results

From the results of the tests with *Ipomea reptans* Poir with 1 experimental factor which is tapioca adhesive concentration which consisted of 3 levels of treatments which are P1 60% cassava stem powder, 10% coconut husk, 30% adhesive, P2 50% cassava stem powder, 10% coconut husk, 40% tapioca adhesive, and P3 50% cassava stem powder, 20% coconut husk, 30% tapioca adhesive. Figure 19 shows 15 samples of organic pots made from cassava stem, coconut husk, and tapioca glues and Plant-tested using *Ipomea reptas* Poir for 23 days, 3 treatments decomposed completely in the soil. The plants' roots can grow out from the organic pot; from these observations, we can conclude that organic pots are suitable for application in the field.

Figure 12. Organic pot planting test results

4. Conclusion

This study's conclusions are: Cassava stems powder, coconut husk, adhesive with 3 different concentrations (30%, 40%, 30%) can be used as raw material for making organic pots. Statistically, adhesive concentration had no significant effect on moisture content, hardiness test, density test, and planting test parameters (plant height, number of leaves, roots' length). There are 3 different treatments used in this research, P1 60% cassava stem powder, coconut husk 10%, adhesive 30%, P2 powder of cassava stems 50%, coconut husk 10%, tapioca adhesive 40%, P3 50% cassava stem powder, 20% coconut husk, adhesive tapioca 30%, with each treatment repeated 3 times. The planting test conducted on the pots shows that the roots can penetrate the pot, also the pot can be decomposed completely after 23 days, and it can support the development of the plants.

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