Development Of High Yield Potential Cassava As Food Resources And Renewable Energy

Hanafi, Kahar Mustari, Inawaty Sidabalok, Jamila Messa

Abstract: The aim of this research is to obtain high potency cassava plant which can be developed as the latest food and energy resource in the form of bioethanol. The study was conducted on marginal land in Maros Regency, South Sulawesi Province, Indonesia, from March to November 2017. It was conducted in the form of a two-factor factorial experiment based on a randomized block design. Five cassava clones used were; Local, Malang 6, UJ-3, MLG10311, and Adira 4, applied microbial fertilizer + organic growth regulator. This study applies an environmentally friendly agricultural system and does not use chemicals, crops are harvested at 9 months of age. The results showed that cassava grown on marginal land with the input of microbial fertilizer + organic growth regulator can increase the productivity of the land and produce food in the form of an average tuber 40.66 tons, if converted into biofuels as alternative energy sources produced bioethanol as much as 6.161 L. The development of high yield potency cassava on marginal land with environmentally friendly farming system is an effort of sustainable environmental management.

Indexs Terms: Cassava plant, food, high yield, renewable energy

1. INTRODUCTION

Cassava (Manihot esculentum) is one of the staple food crops of more than 700 million people in the world, which is produced in the tropics (Rijssen et al., 2013)[1], is a cultivated plant that has long been known to the community for generations as a source of third carbohydrate after rice and corn. As a source of carbohydrate, protein and non protein such as nitrite, nitrate, and cyanogen compounds (Zvinavashe et al., 2011)[2], raw materials for industry, cosmetics, food and energy, cassava also can be processed into starch, glucose, fructose, sorbitol, citrid acid, monosodium glutamate and bioethanol (Oyeleke et al., 2012)[3]. Potential development of cassava in Indonesia is still very high considering the available land for cultivation is wide enough, especially in the form of dry land that is very potential for the development of cassava. In 2015, the area of cassava plant in Indonesia was 1.003.494 ha, with production of 23. 436.384 tons and productivity of 23.36 tons ha^{-1} (Central Bureau of Statistics, 2016)[4], far from the potential yield of several varieties of cassava that can reach 30 - 40 ton ha^{-1}. The low productivity of cassava is caused by: (a). Most farmers still use local varieties that are generally low in productivity, (b). The quality of the seeds used is often poor, (c). Cassava is mostly cultivated on dry land which is often consising of low fertility, (d). Plant management is done simply by simple input. To meet the needs of cassava then it needs to increase production that grows sustainably 5 - 7% year-1. This can be achieved through a 3 to 5% $year^{-1}$ productivity increase and an area expansion of 10 - 20% $year^{-1}$.

Increased production of cassava can be done through intensification, especially on the existing cassava production centers, and extensification to new development areas in dry and marginal areas. Development of various cassava clones that have adaptation and high yield potential depends on applied cultivation technology. Application of this technology tends to use high costs with increasing inputs as a result of decreased soil quality with continuous use of inorganic fertilizers without offset by the use of organic fertilizers. The use of inorganic fertilizers will encourage the increase of crop productivity, but in a relatively long period until now has caused side effects that make the agricultural lands become harder so it decreases productivity. Fertilization in marginal soils is more important as in Indonesia where rainfall and annual temperatures are relatively high and low soil carrying capacity due to low levels of soil organic matter (Kusuma, 2010)[5]. Soil microbial activity is directly related to soil organic matter. In fact, the levels of organic matter on marginal soils drop drastically and consequently microbial activity also declines as a result of increasingly limited energy sources for the microbes concerned. The introduction of microbes into the soil is considered more efficient in an effort to increase its activity rather than adding organic matter to the soil. Through this biofertilizer application the efficiency of nutrient supply increases and the use of chemical fertilizer doses can be reduced. Cassava plants require structured land crumbs, loose, and rich in organic materials or fertile soil. To overcome the condition of soil with low fertility level then an organic fertilization can be done on planting medium, one of which is organic liquid organic fertilizer which if given continuously in a certain time frame will make the soil quality better. The results of organox microbial quality test showed that this fertilizer contains organic C 21,42%, N total 0,84%, P_2O_5 0,96%, K_2O 1,16%, Cu 84,7 ppm, Zn 62,9 ppm, Mn 58,4 ppm, Fe 106,1 ppm dan B 62,7 ppm. It is also containing the microbe of Azospirillium sp 1,10 x 107 Mpn ml^{-1}, Pseudomonas sp 3,5 x 107 Cfu ml^{-1}, Rhizobium sp 3,3 x 108 Cfu ml^{-1}, Basillus sp 2,0 x 108 Cfu ml^{-1}, and Azotobacter sp 2,5 x 105 Cfu ml^{-1}. To obtain growth and optimal cassava production it can be combined with organic growth regulator substance Hormax containing Acetic Acid 108.56 ppm, Cytokinin (Kinetin 98,34 ppm and Zeatin 107,81 ppm), ABA 89,35 ppm, IBA 83,72 ppm, Giberelin (GA_3 118,40 ppm), Etilen 168 ppm, Traumalin Acid 212 ppm and Humic Acid 354 ppm (Supadno, 2016)[6]. The study aims to obtain high yield potency cassava plants that

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- *Hanafi: Dept. of Agrotechnology. Faculty of Agriculture University Islam Makassar.90245. South Sulawesi, Indonesia. E-mail: hanafisyam65@gmail.com*
- *Kahar Mustari: Dept. of Agrotechnology. Faculty of Agriculture, Hasanuddin University, Makassar.90245. South Sulawesi, Indonesia.*
- *Inawaty Sidabalok: Dept. of Agrotechnology. Faculty of Agriculture Ekasakti University, Padang.25116. West Sumatra, Indonesia.*
- *Jamila Messa: Dept. of Agrotechnology. Faculty of Agriculture University Islam Makassar.90245. South Sulawesi, Indonesia.*

can be developed as food resources and renewable energy in the form of bioethanol.

2. MATERIALS AND METHOD

The materials used were 5 clones cassava cutting, microorganism (Organox), plant growth regulator (Hormax), soil, manure, water and labels. The research was conducted in Moncongloe Village, Moncongloe Sub District, Maros Regency of South Sulawesi Province, from March to November 2017. Soil analysis was conducted at Soil Chemistry and Soil Fertility Faculty of Agriculture, Hasanuddin University. Analysis of yield of cassava yield was conducted at Laboratory of Animal Feed Chemicals, Faculty of Animal Husbandry of Hasanuddin University. The experiment was conducted in the form of a two factor factorial experiment based on a randomized block design. The first factors were 5 cassava clones (Local, Malang 6, UJ-3, MLG10311, and Adira 4. The second factor was the concentration of microbial fertilizer + organic growth regulator, namely: control, 40 + 20 L^{-1} water, and 60 + 30 L^{-1} water. There were 15 treatment combinations repeated 3 times, the size of the experimental plots 3.0 m x 3.0 m, the basic fertilization using cow manure 10 ton ha^{-1}, cut of cassava were cut with length 25 cm. Before planting, cassava cuttings were soaked into microbial fertilizer solution + organic growth regulator, according to treatment for 30 minutes, then planting cassava cuttings was done by soaking them into the soil upright position with a spacing of 0.8 m x 0.7 m. Plants responses were analyzed using Univariat Analisist and SPSS program for windows version 21. Test significant different between two middle values performed with the use of Duncan's multiple range test of 5 % level (Gomez and Gomez, 1984)[7].

3. RESULTS AND DISCUSSION

Based on the results of the analysis, it is found that the interaction between cassava clones with microbial fertilizer concentration + organically grown organism has a very significant effect on tuber weight per tree, peeled tuber weight per tree, total wet weight content, dry weight starch content, fresh peeled bioethanol content , fresh peeled tuber conversion into bioethanol, and conversion of fresh peeled tuber production ha^{-1} into bioethanol, while clones have a very significant effect on tuber production ha^{-1}.

Table 1.*Tuber weight per tree (kg) 5 cassava clones at concentrations of microbial fertilizer + organic growth regulators*

Clones	Concent.(Organox+Hormax)ml L^{-1} water			CV DMR α 0.05
	0 + 0	40 + 20	60 + 30	
Local	1.99^{b}_{z}	2.94^{a}_{yz}	2.30^{ab}_{y}	0.72
Malang 6	1.92^{a}_{z}	2.12^{a}_{z}	2.09^{a}_{y}	
UJ-3	2.70^{b}_{y}	3.60^{a}_{y}	3.42^{ab}_{x}	
MLG 10311	2.72^{b}_{y}	4.87^{a}_{x}	3.44^{b}_{x}	
Adira 4	3.82^{a}_{x}	4.12^{a}_{y}	3.30^{b}_{x}	
CV DMR α 0.05 = 0.69				

Note: *Values followed by the same letter in row (a,b) or column (x,y,z) are not significantly different (DMRT P<0.05).*

Duncan's multiple range test (DMRT) results α 0.05 in Table 1 shows the interaction between MLG10311 and microbial 40ml L^{-1} water + organic growth regulator 20 ml L^{-1} water yields the highest tuber weight per tree (4.87 kg) significantly different from other treatments. The interaction between clone Malang 6 with microbial fertilizer 0 ml L^{-1} water + organic growth regulators 0 ml L^{-1} water produces the lowest tuber weight per tree (1.92 kg), not significantly different from the interaction between Malang 6 clone with microbial fertilizer 40 ml L^{-1} water + organic growth regulators 20 ml L^{-1} water. The cassava grows from the secondary thickening of the adventive fibers, the increase of starch content with the age of harvest caused by the root of cassava plant from the center of the stem that has elongated shape, cylinders and tapered continuous enlargement during the growth. When enlargement begins, the root of the barn stops functioning as a nutrient and water absorbing organ, so the roots of starch roots cause tuber size to grow during growth (Rubatzky and Yamaguchi, 1998)[8]. As it gets older on harvesting, bulbs become hardened and woody, cassava is hardened and woody because it contains many non starch components such as fiber and lignin, fibers composed of cellulose and hemicellulose.

Table 2. *The weight of peeled tuber per tree (kg) 5 cassava clones at the concentration of microbial fertilizer + organic growth regulator substance*

Clones	Concent.(Organox+Hormax)ml L^{-1} water			CV DMR α 0.05
	0 + 0	40 + 20	60 + 30	
Local	1.75^{b}_{z}	2.51^{a}_{yz}	2.01^{ab}_{y}	0.70
Malang 6	1.68^{a}_{z}	1.86^{a}_{yz}	1.83^{a}_{y}	
UJ-3	2.32^{b}_{y}	3.15^{a}_{y}	3.07^{a}_{x}	
MLG 10311	2.23^{c}_{y}	4.22^{a}_{x}	3.08^{b}_{x}	
Adira 4	3.38^{ab}_{x}	3.56^{a}_{xy}	2.77^{b}_{x}	
CV DMR α 0.05 = 0.66				

Note: *Values followed by the same letter in row (a,b) or column (x,y,z) are not significantly different (DMRT P<0.05).*

Duncan's multiple range test results α 0.05 in Table 2, showing the interaction between clones MLG10311 with microbial fertilizer 40 ml L^{-1} water + organic growth regulators 20 ml L^{-1} air yielding the highest peeled tuber weight per tree (4.22 kg) was significantly different from other treatments. The interaction between clone Malang 6 with microbial fertilizer 0 ml L^{-1} water + organic growth regulators 0 ml L^{-1} water yields the lowest peeled tuber weight per tree (1.68 kg) was significantly different from other treatments. The main storage organ of cassava is the growing root. Root enlargement does not occur in the whole roots, only about 3 - 15 roots that will become tubers, depending on the environmental conditions and the type of cultivar the plant. At the age of 25-40 days after planting, the process of starch accumulation has actually occurred in almost all types of cultivars, but it can only be seen significantly when the root of the plant has a thickness of about 5 mm or in general has been 2-4 months after planting (Cock et al., 1979). Tubers in cassava are the roots of plants that undergo cell division and enlargement, which then serves as a container of the excess of photosynthesis produced by plants in the leaves. Once the roots become tubers, the root main functions as nutrient and water absorber on the soil will be less. The size and shape of the tubers is strongly influenced by the type of varieties and environmental conditions.

Table 3. *Tuber production ha^{-1} (ton) 5 cassava clones at the concentration of microbial fertilizer + organic growth regulators*

Clones	Concent.(Organox+Hormax)ml L^{-1} water			Average
	0 + 0	40 + 20	60 + 30	
Local	36.19	42.60	38.25	39.01^{ab}
Malang 6	34.13	36.78	35.43	35.45^{b}
UJ-3	34.02	40.11	38.12	37.42^{b}
MLG 10311	41.29	47.16	42.85	43.77^{ab}
Adira 4	40.90	52.60	49.48	47.66^{a}
CV DMR α 0.05 = 9.87				

Note: *Values followed by the same letter in column (a,b) are not significantly different (DMRT P<0.05).*

Duncan's multiple range test results α 0.05 in Table 3, shows that the clones of Adira 4 produce the highest average yield of tuber (47,66 tons), significantly different from other treatments. Clone Malang 6 produced the lowest ha-^{1} tuber production (35.45 tons), not significantly different from UJ-3 treatment. The average production of cassava tubers reached 40.66 tons ha-^{1}, showing the results of this study has exceeded the national cassava productivity of 23.36 tons ha-^{1}. Unlike plants in general, the growth of leaves and roots as source and sink in cassava occur simultaneously, resulting in competition in getting photosynthesis (IITA, 2008)[10]. Thus, if above ground growth is more dominant then underground plant growth will be hampered. Cassava is one type of tuber that is also suspected to have a relationship pattern between the degree of aging, hardness and starch content. This is in accordance with Abbot and Harker (2001)[11] and Wills et al. (2005) which stated that with increasing levels of aging of tubers will be harder in texture due to increasedstarch content, but if too old the fiber content increases while starch content decreases. Timing of cassava harvests varies with variety and usefulness. Harvest time ranges from 9 to 12 months. For the purposes of making tapioca, ideally cassava is harvested when the stalk content is high. If the harvest time is too long, the cassava is hardened and woody because it contains many non starch components such as cellulose, hemicellulose and lignin.

Table 4. *Total sugar content of wet weight (%) 5 cassava clones on the concentration of microbial fertilizer + organic growth regulator substance*

Clones	Concent.(Organox+Hormax)ml L^{-1} water			CV DMR α 0.05
	0 + 0	40 + 20	60 + 30	
Local	0.26^{b}_{w}	$0,65^{a}_{v}$	$0,27^{b}_{z}$	
Malang 6	0.27^{c}_{w}	$0,48^{a}_{x}$	$0,33^{b}_{x}$	
UJ-3	0.42^{c}_{v}	$0,61^{a}_{w}$	$0,56^{b}_{v}$	0.02
MLG 10311	0.42^{c}_{v}	$0,65^{a}_{v}$	$0,52^{b}_{w}$	
Adira 4	0.25^{b}_{w}	$0,30^{a}_{v}$	$0,30^{a}_{v}$	

Note: *Values followed by the same letter in row (a,b) or column (v,w,x,y,z) are not significantly different (DMRT P<0.05).*

Duncan's multiple range test results α 0.05 in Table 4, shows the interaction between local clones with microbial fertilizer 40 ml L-^{1} water + organically grown organizer 20 ml L-^{1} water produced the highest total wet weight (0.65%), was not significantly different from the interaction between MLG 10311 clone and microbial fertilizer 40 ml L-1air + organically grown 20 ml L-^{1} water and significantly different from other treatments. The total sugar content is the amount of sugar (as glucose) that is naturally present in tubers and sugars from chemically starchy hydrolysis. High-grade cassava clones do not always have high total sugar content because they depend on the degree of ease of hydrolysis of starch to sugar and its natural sugar content. The higher the total sugar content of the fresh tuber, the lower the tuber weight required in making bioethanol.

Table 5. *Dry starch content level (%) 5 cassava clones at the concentration of microbial fertilizer + organic growth regulator substance*

Clones	Concent.(Organox+Hormax)ml L^{-1} water			CV DMR α 0.05
	0 + 0	40 + 20	60 + 30	
Local	65.43^{b}_{w}	68.99^{a}_{w}	65.26^{c}_{z}	
Malang 6	64.29^{c}_{x}	70.24^{a}_{v}	69.26^{b}_{v}	
UJ-3	62.42^{c}_{v}	66.04^{a}_{v}	65.81^{b}_{v}	0.03
MLG 10311	62.40^{c}_{v}	64.72^{b}_{z}	66.44^{a}_{x}	
Adira 4	66.40^{c}_{v}	68.29^{a}_{x}	66.69^{b}_{w}	

Note: *Values followed by the same letter in row (a,b,c) or column (v,w,x,y,z) are not significantly different (DMRT P<0.05).*

Duncan's multiple range test results α 0.05 in Table 5, shows the interaction between clone Malang 6 with microbial fertilizer 40 ml L-^{1} water + organically grown organizer 20 ml L-^{1} water produced the highest dry weight (70,24%), was significantly different from other treatments. Starch is the main component of cassava which is used as a source of energy for food and feed as well as its functional properties as thickener, filler and stabilizer in food products. In addition, starch is needed as raw material in cosmetic industry, glue, paper, detergent, sugar modification, organic acid (Tonukari, 2004)[13], chemical industry, pharmaceutical, paper and textile (Mweta et al., 2008)[14]. Level of starch increases with increasing age of harvest, the longer the cassava is harvested then the higher level of cassava starch produced. Increased levels of starch is caused more and more starch granules formed in the tubers (Nurdjanah, Susilawati and Sabatini, 2007)[15].

Table 6. Bioethanol content of fresh peeled tuber (ml kg-^{1}) 5 cassava clones at concentrations of microbial fertilizer + organic growth regulators

Clones	Concent.(Organox+Hormax)ml L^{-1} water			CV DMR α 0.05
	0 + 0	40 + 20	60 + 30	
Local	147^{b}_{z}	150^{a}_{z}	150^{a}_{z}	
Malang 6	148^{c}_{z}	155^{a}_{x}	153^{b}_{v}	
UJ-3	151^{b}_{v}	153^{a}_{v}	152^{a}_{v}	1.69
MLG 10311	152^{b}_{v}	155^{a}_{x}	154^{a}_{x}	
Adira 4	154^{a}_{x}	155^{a}_{x}	155^{a}_{x}	

Note: *Values followed by the same letter in row (a,b) or column (x,y,z) are not significantly different (DMRT P<0.05).*

Duncan's multiple range test results α 0.05 in Table 6, shows the interaction between clone Malang 6 with microbial fertilizer 40 ml L-^{1} water + organically grown organizer 20 ml L-^{1} water yields highest fresh peeled bioethanol content (155 ml kg-^{1}), was not significantly different with interaction between clones MLG10311 with microbial fertilizer 40 ml L-^{1} water + organic growth regulator 20 ml L-^{1} water, interaction between clone Adira 4 with microbial fertilizer 40 ml L-^{1} water + organic growth regulator 20 ml L-^{1} water and microbial fertilizer 60 ml L-^{1} water + organic growth regulator 30 ml L-^{1} water.

Table 7. *Converting fresh tuber peeled into bioethanol (kg L-^{1}) 5 cassava clones at concentrations of microbial fertilizer + organic growth regulators*

Clones	Concent.(Organox+Hormax)ml L^{-1} water			CV DMR
	0 + 0	40 + 20	60 + 30	α 0.05
Local	6.8^{a}_{x}	6.7^{b}_{x}	6.7^{b}_{x}	
Malang 6	6.8^{a}_{x}	6.5^{b}_{y}	6.5^{b}_{z}	
UJ-3	6.6^{a}_{y}	6.5^{b}_{y}	6.6^{b}_{x}	0,1
MLG 10311	6.6^{a}_{y}	6.5^{b}_{y}	6.5^{b}_{z}	
Adira 4	6.5^{a}_{z}	6.5^{a}_{y}	6.5^{a}_{z}	

Note: *Values followed by the same letter in row (a,b) or column (x,y,z) are not significantly different (DMRT P<0.05).*

Duncan's multiple range test results α 0.05 in Table 7 shows the interaction between local clones and Malang 6 with microorganism 0 ml L-^{1} water + organic growth regulator 0 ml L-^{1} water resulted conversion of fresh peeled peel into highest bioethanol (6, 8 kg L-^{1}), was significantly different from other treatments.

Table 8. *Conversion of fresh peeled tuber into bioethanol (L ha-^{1}) 5 cassava clones at concentrations of microbial fertilizer + organic growth regulators*

Clones	Concent.(Organox+Hormax)ml L^{-1} water			CV DMR
	0 + 0	40 + 20	60 + 30	α 0.05
Local	5.247^{b}_{x}	6.354^{a}_{y}	5.653^{a}_{y}	
Malang 6	5.147^{a}_{y}	5.384^{a}_{y}	5.328^{a}_{y}	
UJ-3	5.619^{a}_{x}	5.964^{a}_{y}	5.746^{a}_{y}	1.123
MLG 10311	6.282^{a}_{x}	7.108^{a}_{x}	6.305^{a}_{y}	
Adira 4	6.250^{b}_{x}	7.951^{a}_{x}	7.607^{a}_{x}	

Note: *Values followed by the same letter in row (a,b) or column (x,y) are not significantly different (DMRT P<0.05).*

Duncan's multiple range test results α 0.05 in Table 8, shows that interaction between Adira 4 clone and microbial fertilizer 40 ml L-^{1} water + organically grown organizer 20 ml L-^{1} water resulted in conversion of fresh peeled tuber production into the highest bioethanol (7,951 L ha-^{1}), not significantly different from the interaction between Adira 4 clone and microbial fertilizer 60 mL L-^{1} water + organic growth regulator 30 mL L-^{1} water resulted in conversion of fresh peeled tuber production to bioethanol of 7,607 L ha-^{1}, interaction between clones MLG 10311 with microbial fertilizer 40 mL L-^{1} water + organically grown organizer 20 mL L-^{1} water resulted in conversion of fresh peeled tuber production into bioethanol as much as 7,108 L ha-^{1}, interaction between MLG 10311 clone with microbial fertilizer 0 mL L -^{1} water + Organic growth regulator 0 mL L-^{1} water produces conversion of fresh peeled tuber production to bioethanol as much 6,282 L ha-^{1}, interaction between UJ-^{3} clone with microbial fertilizer 0 mL L-^{1} water + organic growth regulator 0 mL L-^{1} water produces a conv the yield of fresh tuber peeled into bioethanol of 5,619 L ha-^{1}, and was significantly different from other treatments. High potential productivity of clones is important to consider in the development of cassava as a bioethanol feedstock. The average conversion value of 6.6 kg of fresh tuber to produce 1 L of 96% bioethanol is assumed at a total sugar content of 30% and a fermentation ratio of 90%. This means it takes <6.6 kg of total sugar content of> 30% to produce 1 L of 96% bioethanol. The smaller the conversion value, the more desirable because the number of tubers required to produce 1 L of bioethanol is less. The conversion value of cassava to bioethanol was determined by total sugar content of tubers, sugar fermentation ratio to bioethanol, and the distillation efficiency of bioethanol obtained (8 - 11%) to 96% bioethanol (highest bioethanol content used as benchmark in this study).

4. CONCLUSION

Based on the results of research that has been implemented, it can be concluded that: The addition of input production and improvement of cultivation techniques using microbial fertilizer + organic growth hormone, and adjusting to the condition of the season at the time of planting and harvesting needs to be done to improve cassava productivity. Cassava crops harvested at 9 months of age can produce an average tuber of 40.66 tons ha^{-1}, and if converted into bioethanol it can produce as much as 6,161 L ha^{-1}. This research proves that environmental management efforts, especially for the development of high yielding cassava plants as food resources and bioethanol renewable energy can be done with environmentally friendly farming system in marginal land on a continuous basis.

REFERENCE

[1]. Fredrika W. Jansen van Rijssen, E. Jane Morris, and Jacobus N. Eloff, 2013. Food Safety: Importance of Composition for Assessing Genetically Modified Cassava (Manihot esculenta Crantz). J. Agricultural Food Chemistry, 61, 8333−8339.

[2]. Zvinavashe, E., Elbersen, H.W., Slingerland, M., Kolijn, S. and Sanders, J. P. M. 2011. Cassava for food and energy: exploring potential benefits of processing of cassava into cassava flour and bioenergy at farmstead and community levels in rural Mozambique. Biofuels, Bioproducts and Biorefining 5 (2): 151–164.1275. Journal of Dairy Science 86(11): 3405-3415.

[3]. Oyeleke, S.B., Dauda, B.E.N., Oyewole, O.A., Okoliegbe, I.N., and Ojebode, T.; 2012. Production of Bioethanol From Cassava and Sweet Potato Peels. Advances in Environmental Biology, 6(1):241-245.

[4]. Central Bureau of Statistics, 2015. Indonesia in Figures. National Bureau of Statistics. Jakarta, Indonesia.

[5]. Kusuma H.I. 2010. Liquid Organic Fertilizer. PT Surya Pratama Alam. Yogyakarta, Indonesia.

[6]. Supadno W., 2016. Explores the Multifunctional Potential Of Organic Fertilizers, Biological Fertilizers, and Growth Hormones / Aphrodisiacs. CV Bangkit Jaya Abadi, Jakarta, Indonesia.

[7]. Gomez, A.K. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research. An International Rice Research Institute Book. Second Edition, John Willey and Sons, New York.

[8]. Rubatzky, V.E. dan Yamaguchi. 1998. Vegetable World: Principles, Production and Nutrition. Volume 1. Bogor Agri-cultural Institute. Bandung.

[9]. Cock, J.H. Franklin D, Sandoval G, and Juri P. 1979. The Ideal Cassava Plant For Maximum Yield. Crop Sci. J. 19: 271-279.

[10]. IITA. 2008. Research guide 55 physiology of cassava. www.iita. org/cms/details/trn_mat/irg55/irg552.html-23(8 Oktober 2013)

[11]. Abbot, J.A. and Harker, F. R. 2001. Texture. The Horticulture And Food Research Institute of New Zealand Ltd. New Zealand.

[12]. Wills, R.B.H. Lee, T.H. Graham, D. McGlason, W.B. and Hall, E.G. 2005. Postharvest: An Introduction to the Physiology and Handling of Fruit and Vegetables. 2nd ed. AVI Publ.Co.USA.

[13]. Tonukari, N.J. 2004. Cassava and The Future Starch. Electronic J. of Biotechnology 7(1).

[14]. Mweta, D. E., Labuschagne, M.T. Koen, E. Benesi, I.R.M. and Saka, J.D.K. 2008. Some Properties Of Starches From Cocoyam (Colocasia esculenta) and Cassava (Manihot esculenta Crantz.) Grown in Malawi. African J. of Food Sci. 2:102-111.

[15]. Nurdjanah, S., Susilawati dan M. R. Sabatini. 2007. Prediction of Cassava (Manihot esculenta) Starch Content At Various Ages of Harvest Using a Penetrometer. Jurnal. Teknologi dan Industri Hasil Pertanian. 12(2).