IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 13, Issue 10 Ser. II (October 2020), PP 59-67
www.iosrjournals.org

The Effect of Rice Husk Charcoal and Chicken Manure on Soil Chemical Properties and Yield of Satoimo*Colocasiaesculenta*(L.) Schott var. Antiquorum)

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Abstract
Background*: The research was aimed to know the effect of rice husk charcoal and chicken manure on soil chemical properties and the yield of Satoimo. The research was used 3 x 3 factorial randomized block design (RBD) with three replications. The first factor was rice husk charcoal consists of 0 ton ha^{-1}, 5 ton ha^{-1}, and 10 ton ha^{-1}. The second factor was the rates of chicken manure consists of 0 ton ha^{-1}, 5 ton ha^{-1}, and 10 ton ha^{-1}. The variables observed were soil chemistry properties, soil pH, total N, available P, and K-exchangable, tuber wet weight, number of tubers, tubers worth selling and crop yields. The result of the studied showed that the application of rice husk charcoal and chicken manure with rate 5 ton ha^{-1} was increased number of tubers. The application of rice husk charcoal and chicken manure with rate 10 ton ha^{-1} was increased K-exch. The application of rice husk charcoal with rate 10 t ha^{-1} and chicken manure with rate 5 t ha^{-1} was increased tuber wet weight, marketable yield weight, and ton ha^{-1} production of satoimo plants parameters.*
Keywords*: Satoimo, husk charcoal, manure, Andisol.*

Date of Submission: 17-10-2020 Date of Acceptance: 02-11-2020

I. Introduction

Satoimo (*Colocasiaesculenta* (L) *Schotvarantiqourum*) was a non-rice alternative food that has a small tuber size (Small corm taro) and was also known as Japanese taro or Safirataro which was traded internationally. The largest satoimo consuming country in the world, especially for staple food, was Japan. Nearly 50% of the Japanese population consumes satoimo as a staple food other than rice so that the need for satoimo reaches ± 360.000 ton ha^{-1}. Simultaneously, Japan's production capacity remains down to 250.000 ton ha^{-1}. It was because the land and environment were scarce and the farming was difficult all year round [21]. [8] said that Indonesia supplies about 25 ton of taro tubers per month, which equates to 39.700 ton annually or less than the goal of 40.000 tubers per year. Low taro tuber production in Indonesia was thought to be due to the fertility of soil, in particular of the Andisol, and to a lack of understanding of taro farmers.

The use of rice husk charcoal and chicken manure on Andisol soil was one of the attempts to increase taro production. The ability of rice husk charcoal as a nutrient release agent and an absorber was to be improved as it has a large surface and was about the same as the soil colloids. High adsorption potential for materials in solution or vapor was given by activated charcoal [17]. In addition to rice husk charcoal, the use of chicken manure as a supporting input for plants was because it has a relatively higher P nutrient content than other manure. Chicken manure has a strong influence on its nutrient content by the kind of concentrates given. Chicken manure can also provide plant manure with additional nutrients[33]. [3] showed that manure can increase the growth of plants, such as taro height and tuber weight. [12] stated that chicken manure was able to increase the growth and yield of *Corchorusolitorius* plants. Based on this description, it was necessary to research to determine the best dose of rice husk charcoal and chicken manure to improve soil chemical properties and yield of satoimo plants.

II. Materials and Methods

Experimental Site
The research was conducted in SukaMulia Village, farm of Aceh Agricultural Education and Training Center (BDP-Aceh), LembahSeulawah Sub district, Aceh Besar district with an altitude of 520 meters above sea level (asl) with Andisol soil ordo. The research was carried out between May and December 2018.
Materials and Experimental Design
The materials in this research were rice husk charcoal, chicken manure fertilizer, NPK Phoska fertilizer, and Satoimo taro seeds. The instruments used in this research include analytical scales and other materials

supporting this work, including laboratory measuring devices, soil-physical properties testing tools and soil chemical properties.

The experimental design was factorial randomized block design consists of 2 factors with 3 rates. The first factor was rice husk charcoal and chicken manure as second factor. The rates consisted of S_0 = 0 ton ha^{-1}; S_1 = 5 ton ha^{-1} (180 g plant^{-1}); S_2 = 10 ton ha^{-1} (360 g plant^{-1}) with three replications.

Rice Husk Charcoal and Chicken Manure Application

The research was started with tuber preparation and land preparation, and seedlings were selected by sorting the seedlings that had begun to germinate so that they would grow evenly. Land preparation was carried out by cleaning the weeds that grow from the roots of the previous plant; then, the soil was processed using hoes along with making plots with a size of 120 cm x 300 cm as many as 27 plots. The application of rice husk charcoal and chicken manure were carried out according to the treatment a week before planting by mixing it in each planting hole. Phonska NPK fertilizer was given after the seeds were planted as an essential fertilizer at a rates of 15 g plant^{-1} through a hole in the side of the plant. Planting was done by removing plant seeds from the nursery when the plants were eight weeks old or having two leaves from the satoimo plant and each hole was planted with one seed per planting hole with a spacing of 60 cm x 60 cm with a total of 10 plants per plot. Maintenance was carried out by watering the entire plant in the morning and if the satoimo plant was dead, withered or damaged, it can be replanted. Stitching was done seven days after transplanting. Weed control was carried out simultaneously with the fertilization in 2 stages, at the age of the plant 16 to 20 weeks after planting. Harvesting was done after the age of the plant was six months after planting. The leaves are physically yellowish and the leaves are wilted. Harvesting was done by digging the plant tubers in the land. Then the tubers are cleaned of the remaining soil and washed.

Pre treatmentAnalysis of Soil Chemical Properties

Pre treatment soil analysis was carried out to find information regarding soil chemical properties. The research was conducted in SukaMulia Village, precisely in the Aceh Agricultural Training Center Complex, LembahSeulawahsubdistrict, AcehBesar district. The composite soil samples were taken before the research was carried out, the soil samples were taken by random method at five different points, then the soil was taken from the topsoil layer with a depth of 0 - 25 cm. Then the soil was sieved using a 2 mm sieve. The soil analysis was done at the Assessment Institute for Agricultural Technology, Aceh (BPTP Aceh), Laboratory. Analysis of the soil chemical properties of the pre treatment was on pH H_2O, Electrical conductivity, Organic C, total N. C/N ratio, available P, total K, K exchangable and CEC.

Analysis of Soil Chemical Properties

The final soil analysis was carried out after harvested the plants, which the soil sample was taken from each plot and analyzed based on the parameters below:

Soil pH

Analysis of soil pH (pH H_2O) was carried out using the Electrometric method at the age of 120 DAP (days after planted), precisely after harvesting.

Total N

Analysis of N-total was carried out using the Kjeldahl method at the age of 120 DAP, precisely after harvesting.

Available P

Analysis of available P was carried out using the Bray I method at the age of 120 DAP after harvested.

K-exchangable

The definition of K-exch was carried out using the 1 M Ammonium Acetate Extraction method at the age of 120 DAP after harvested.

Plant Generative Phase

Tuber Wet Weight (g)

Tubers per planting hole were harvested and separated from the stems and washed thoroughly. Furthermore, the wet weight of the tubers was weighed using analytical scales for each sample.

Marketable Yield Weight of Tubers (g)

Observation of marketable tuber weight was done by weighing the tubers that have been selected according to the criteria. The criteria were taken in the form of tubers that have physical characteristics, as seen from the shape and size they contain. The tubers that have been taken were then weighed as a whole from the tubers that have been selected in each sample plant.

Number of Tubers

The number of tubers was obtained by counting the number of tubers per planting hole for each sample.

Production

Observation of yield per hectare was done by adding up all the tubers produced in one bed by collecting each tuber that has been sorted as a whole and converted into units of ton ha^{-1}.

III. Result and Discussion

Pre treatmentAnalysis of Soil Chemical Properties

Analysis of soil chemical properties in the first phase was carried out during the study, namely pH (H2O), N-total, P-available, and K-exch in the soil. The analysis of soil chemical properties from the first phase was aimed to see the soil nutrient content before the research was conducted. The results of the pre treatment soil analysis in Table 1.

Table No. 1. Analysis result of soil chemical properties before treatment

Parameter	Value	Criteria
Soil Texture - Sand (%) - Silt (%) - Clay (%)	 40.11 35.11 24.78	Clay
pH (H_2O)	6.60	Neutral
Electrical conductivity (ds/m^{-1})	0.01	Very low
C-organic (%)	1.83	Low
Total N (%)	0.22	Moderate
C/N	8.38	Low
Available P ($mg\ g^{-1}$)	43.40	Very High
Total K ($mg\ g^{-1}$)	28.79	Moderate
K-exch ($cmol\ kg^{-1}$)	0.68	High
CEC ($cmol\ kg^{-1}$)	29.90	High

The results of soil analysis (Table 1) showed that the soil type Andisol soil which has a fraction of sand (40.11%), silt (35.11%) and clay (24.78%). The characteristics of Andisol were neutral pH (6.60), low C-organic content (1.83%), moderate total N (0.22%), low C/N ratio (8.38), P-available on very high soil (43.40 $mg\ kg^{-1}$), moderate total K content (28.79 $mg\ kg^{-1}$), high K-exch content (0.68 $cmol\ kg^{-1}$) and CEC which was classified as high criteria (29.90 $cmol\ kg^{-1}$). The results of the analysis indicate that the Andisol soil has a clay texture following the triangular soil texture criteria, and this soil has high fertility. This was in line with the opinion of [14] which states that Andisol soil has a high soil cation exchange capacity. However, the Andisol soil at the location of this study has shortcomings, namely low organic C and C/N ratio, so it was necessary to add rice husk charcoal and manure to correct these deficiencies.

The Effect of Rice Husk Charcoal and Chicken Manure on Soil pH (H_2O)

The variance analysis result showed that the application of rice husk charcoal and chicken manure did not have a significant effect on soil pH. The average of pH (H_2O) due to the effect of application of rice husk charcoal and chicken manure on Table 2.

Table No. 2: The average pH (H_2O) of soil due to the effect of rice husk charcoal and chicken manure on satoimo plant

Rice husk charcoal	pH (H_2O)	Criteria
Control	4.83	Acid
5 t ha^{-1}	4.79	Acid
10 t ha^{-1}	5.03	Acid
Chicken manure		
Control	4.86	Acid
5 t ha^{-1}	4.83	Acid
10 t ha^{-1}	4.97	Acid

Based on Table 2, it showed that soil pH rate decline after application of plants and it changes the pH criteria of the soil from neutral, before it was planted (as shown in Table 1, to acid (as shown in Table 2) after it was planted. This was in line with [18] who stated that soil pH decline was caused by the existence of plant roots and plant respiration itself to give out CO_2 gas.

Charcoal husk application or chicken manure of 5 ton ha^{-1} to soil can cause the soil pH to decline a little. However, the soil that did not get the application of charcoal husk or chicken manure did not get the decline in soil pH. That means, the application of charcoal husk or chicken manure up to 10 ton ha^{-1} can cause a little incline of soil pH when compared to the soil without the application of charcoal husk. However, the range of the pH was still in the same Acid category. According to [24]. (2011), the use of bio-char derived from rice husks showed that the application of biochar husk can increase soil pH.

Then in Table 2, it showed that the highest soil pH can be seen on the soil that get the application of chicken manure of 10 ton ha^{-1} In the analysis, it can be seen that the soil pH at the pre treatment was 6.6, and its pH declined as much as 1,6 after the application of charcoal husks. This drop of pH rate was assumed from the CO_2 release by the satoimo plant root. From the soil analysis result before the treatment was given, the Andisol soil pH had the criteria of neutral. However, at the last soil analysis of Andisol soil pH, the criteria had become acid. [9] mentioned that the low pH was caused by the dissolved base cations that held big role in the acid rate of the soil. Generally, the organic materials in soil hold a big role in the nutrients and the change of soil pH[33]. From the study result, it shows that the decline of soil pH due to the application of rice husk charcoal and chicken manure did not influence the growth and yields of satoimo plants. The best pH rate for satoimo plants was actually around 5.5 – 7.0.

The Effect of Rice Husk Charcoal and Chicken Manure on N- total

From the variance analysis result, it showed that the application of rice husk charcoal and chicken manure results did not have signifcant effect on N-total.

Table No. 3. The average score of N-total due to the effect of rice husk charcoal and chicken manure to satoimo plant

Rice husk charcoal	N-total (%)	Criteria
Control	0.23	Moderate
5 t ha^{-1}	0.23	Moderate
10 t ha^{-1}	0.24	Moderate
Chicken manure		
Control	0.23	Moderate
5 t ha^{-1}	0.24	Moderate
10 t ha^{-1}	0.23	Moderate

Table 3 showed that N-total tends to be at its best on the application of rice husk charcoal of 10 ton ha^{-1}. Table 3 also showed that N-total tends at its best on the application of chicken manure of 5 ton ha^{-1} where the N-total actually increased from 0.22% (Table 1) on pre treatment analysis to be 0.24 %. However, the criterion was still at the moderate level. This proves that the application of charcoal and chicken compost up to 10 ton ha^{-1} are still not enough to improve N-total of satoimo plants grown on Andisol soil. According to [34], the addition of biochar does not improve the N on all types of soil. The application of biochar can actually decrease the nitrogen loss through the wash-up process; therefore the nitrogen in soil improves[34]. The addition of biochar and rice husk charcoal can significantly improve soil porosity[32]. [1]tates that nitrogen was the essential nutrient for plants to form its leaves. The increase N-total due to the application of rice husk charcoal and chicken manure does not affect the satoimo plant yields based on the criteria of soil analysis result.

The Effect of Rice Husk Charcoal and Chicken Manure on P- Available

The variance analysis result showed that the treatment of rice husk charcoal and chicken manure didn't affect significantly on the P-available. The average of P-available due to the effect of rice husk charcoal and chicken manure on Table 4.

Table No. 4 The average of P-available due to the effect of rice husk charcoal and chicken manure on satoimo plants

Rice Husk Charcoal	P-available (ppm)	Criteria
Control	32.57	Very High
5 t ha^{-1}	33.65	Very High
10 t ha^{-1}	33.57	Very High
Chicken manure		
Control	32.52	Very High
5 t ha^{-1}	34.41	Very High
10 t ha^{-1}	32.86	Very High

Table 4 showed that P-available tends to be at its highest on the application of rice husk charcoal of 5 ton ha^{-1}. The high rate of P on Andisol soil due to mineral Amorf in a form of allophan was the mineral component from Andisol because of the high rate of Al and Fe [2]. Therefore, the use of rice husk charcoal cannot change the P-available in Andisol soil but the first soil analysis in this study on the soil P-available showed a very high category. According to [15], the addition of rice husk charcoal can improve P in soil. This was because the rice husk charcoal contains SiO_2 and P derived from the process of combustion through the burning in high temperature [10].

Moreover, Table 4 showed that P-available tends to be at its best on the application of chicken manure of 5 ton ha^{-1}. The P contained in the soil always showed its highest composition on each of the plants. The P contained in the soil will decrease when the P-available in the soil was actually from other sources of P, and it will keep decreasing when P-available improves [22]. [26]stated that the addition of compost will give a positive effect on the P solubility in soil. Chicken manure contains various macro nutrients like N, P, and K, and micro nutrients. This was in line with the statement of [18] that chicken manure in its mineralization process will produce complete plant nutrients like N, P, and K.

The Effect of Rice Husk Charcoal and Chicken Manure on K-exch

The variance analysis result showeds that the application of rice husk charcoal and chicken manure has a real impact on the K-exch parameter. The average K-exch due to the effect of the application of rice husk charcoal and chicken manure on Table 5.

Table 5 showed that the best rate of K-exchcan be seen on the application of rice husk charcoal of 10 ton ha^{-1}, which was different from control. However, it was not that different when compared to the application of rice husk charcoal of 5 ton ha^{-1}. This proves that the addition of rice husk charcoal of 10 ton ha^{-1} can improve K-exch rate in soil. The stated that the incline rate of soil K composition was closely related to the direct effect of the application of organic and inorganic fertilizer[27]. On the initial condition, the soil K-ex rate was 0.68 cmol kg^{-1}, and after having a treatment in the research, the soil K-exch became 0.56-0.59 cmol kg^{-1} . According to [28], the soil K-exch rate of 0.6 –1.0 cmol $kg^{-1}$was considered in high criteria, while the soil K-exch rate of 0.4-0.5 was considered medium. Therefore, the application of rice husk charcoal can change the rate of soil K-exch from high criteria on the beginning of analysis to medium criteria on the end of the research.

Table No. 5 The Average K-exch due to the effect of rice husk charcoal and chicken manure to satoimo plant.

Rice Husk Charcoal	K-exch (cmol kg^{-1})	Criteria
Control	0.54 a	Moderate
5 t ha^{-1}	0.56 ab	Moderate
10 t ha^{-1}	0.59 b	Moderate
Chicken Manure	0,04	
Control	0.53 a	Moderate
5 t ha^{-1}	0.57 a	Moderate
10 t ha^{-1}	0.59 b	High
HSD	0.04	

Note: The number followed by the same letters on the same column was not significantlydifferent on the rate of 5% (Test HSD test $_{0,05}$)

Table 5 showed that the best K-exchcan be found on the application of chicken manure of 10 ton ha^{-1}, which was completely different to the control and the application of 5 ton ha^{-1}. Besides that, the application of chicken manure of 5 - 10 ton ha^{-1} showed the improvement of K-exch when compared to control. This was assumed due to the nutrient addition of Potassium from chicken manure applied to the soil. This was in line with the statement of [11] who say that chicken manure consists of 0.75% N and 0.45% Potassium. Thus, the application of chicken manure can increase the K-exch content on Andisol soil.

Tuber Wet Weight and Marketable Yield Weight

The variance analysis result showed that the application of rice husk charcoal and chicken manure have a significant effect on tuber wet weight. Moreover, those two applications also have significant effect on satoimo marketable yield weight. The average of tuber wet weight and marketable yield weight due to the effect of rice husk charcoal and chicken manure on Figure 1.

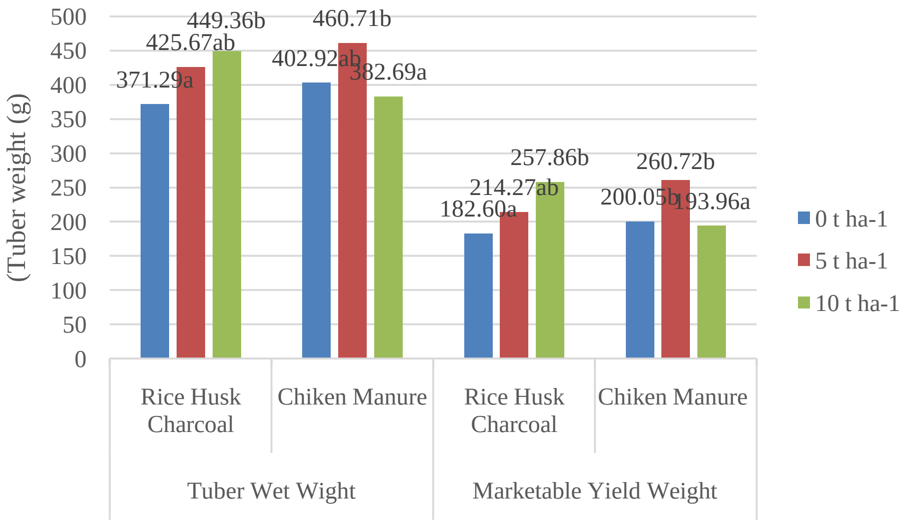

Figure 1. The average of tuber wet wight and marketable yield weight due to the effect of rice husk charcoal and chicken manure

Figure 1 showed that the bet result of tuber wet weight can be found on the application of rice husk charcoal of 10 ton ha^{-1} which was completely different to the application of rice husk charcoal of ton ha^{-1}, but it was not much different when compared to the application of rice husk charcoal of 5 ton ha^{-1}. According to [20] the inappropriate application of rice husk charcoal can impact negatively on the wet weight of chili plants. Therefore, rice husk charcoal and chicken manure can generate great tubers with high productivity on the medium with nutrients contained in the plants.

Moreover, Figure 1 also showed the result of best tuber wet weight can be found on the application of chicken manure of 5 ton ha^{-1} which was completely different to the application of chicken manure of 10 ton ha^{-1}, but it was not that different when compared to the application of chicken manure of 0 ton ha^{-1}. This was assumed that the addition of rice husk charcoal and chicken manure can improve the structure of soil as the medium where the plant was grown. Thus, the soil medium with the addition of rice husk charcoal and chicken manure have good porosity with adequate amounts of air and water, so that it can improve the tuber wetwight of satoimo plants. This was in line with the statement mentioned by [19] that taro plants need to grow on soil with adequate amounts of water; when water was not adequately provided; taro plants will find it hard to grow.

Figure 1 also showed that the best marketable yield weight can be found on the application of rice husk charcoal of 10 ton ha^{-1} which was completely different to the application of rice husk charcoal of 0 ton ha $^{-1}$, but it was not much different with the application of rice husk charcoal of 5 ton ha^{-1}. This was in compliance with the statement who said that tuber wet weight was influenced by plant dry weight where the higher the plant dry weight, the higher the tuber yields produced[30].

Then, Figure 1 also showed that the best marketable yield weight can be found on the application of chicken manure of 5 ton ha^{-1} which was completely different to the application of chicken manure of 10 ton ha^{-1}, but not that much different to the application of chicken manure of 0 ton ha^{-1}. This was assumed that the application of chicken manure application was appropriate to the all observed treatments that the satoimo plant can produce a good number of yields with good quality especially in its tuber wet weight. The result on the field showed that the application of chicken manure of ton 10 tha^{-1} can turn the soil to be acid that then decreases the productivity of the plants. Therefore, liming needs to be done to prepare appropriate soil for plants to grow. Soil cation exchange capacity (CEC) was a chemical characteristic that closely related to soil fertility. Soil with low CEC finds it hard to absorb water and air because its less amount of nutrient caused by the washed off. Thus, the plant will find it hard to grow and that will have an effect on its productivity [5]. Therefore, the application of rice husk charcoal and chicken manure can help plants to produce great tubers and cause high productivity for the soil medium because of its provided nutrients for plants to grow.

The number of tubers

The variance analysis showed that the application of rice husk charcoal has significant result on the number of tuber yields of the satoimo plant. However, the application of chicken manure did not showed the same result; it did not showed significant change of the number of tuber yields of the satoimo plants. The parameter average of tuber number due to the effect of rice husk charcoal and chicken manure at Figure 2.

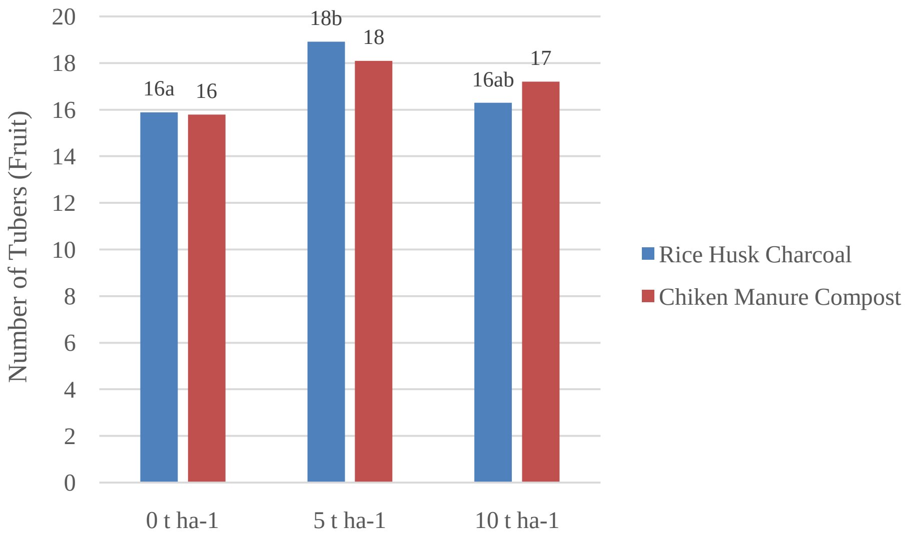

Figure 2. The average number of tuber after the application of rice husk charcoal and chicken manure.

Figure 2 showed that the best number of tubers was found at the soil with the application of rice husk charcoal of 5 ton ha^{-1} that showed a significant difference when compared to the one without the application of rice husk charcoal 0 ton ha^{-1}. Apparently, the difference was not significant when it was treated with rice husk charcoal of 10 ton ha^{-1}. The application of rice husk charcoal showed that it can improve the number of tuber yields of satoimo plants. This may be caused by the capability of rice husk charcoal of improving the structure and pores of soil that can eventually improve the number of tuber yields of satoimo plant. Moreover, it was presumably that the rice husk charcoal provides C for soil that will improve the quality of satoimo taro plants. The parameter of tuber number showed that the application of rice husk charcoal can increase the number of tuber yield of satoimo plants. This may be due to the application of rice husk charcoal that can improve the structure and pores of soil that then increase the number of satoimo yields. Then, Firgure showed that the highest number of tuber parameters can be seen on the application of chicken manure of 5 ton ha^{-1}. [6] stated that the less use of compost can cause plants to produce fewer tubers. [16]mentioned that there are two factors that can influence the tuber forming which were internal and external factors; internal factor consists of plant hormone and external factor consists of the length of day, temperature, moisture, and plant nutrient.

Production

The variance analysis result showed that the application of rice husk charcoal and chicken manure have a significant effect on satoimo yield production. The average result of satoimo yield due to the effect of the application of rice husk charcoal and chicken manure on Figure 3.

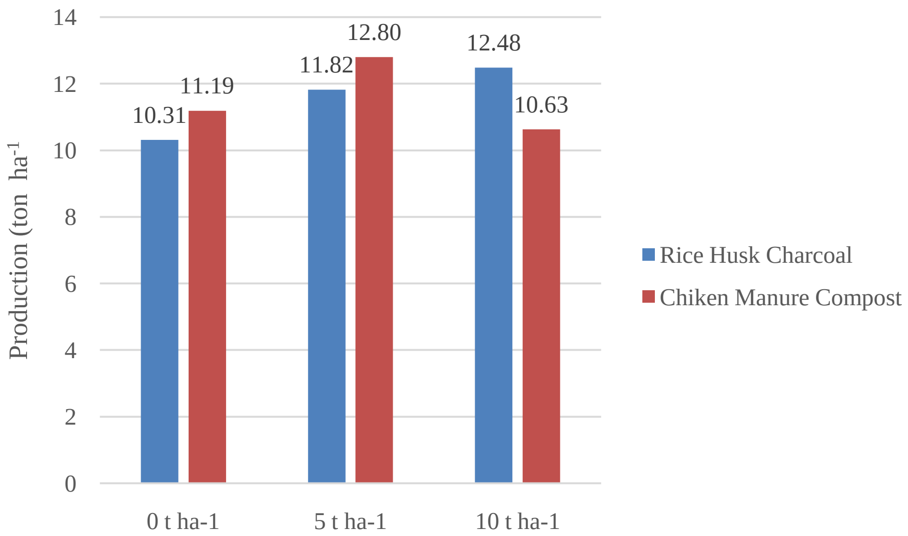

Figure 3. The Average of ton ha^{-1} production with the application of rice husk charcoal and chicken manure .

Figure 3 showed that the best production of ton ha^{-1}can be seen on the application of rice husk charcoal of 10 ton ha^{-1} which was completely different from the control group, but was not that different when compared to the application of 5 ton ha^{-1}. Furthermore, Figure 9 showed that the best production of satoimo plant can be found on the application of chicken manure of 5 ton ha^{-1} which was not significantly different to the application of chicken manure of ton ha^{-1} , but it was significantly different to the application of chicken manure of 10 ton ha^{-1}.

Based on the study result, it was found that the total production on the application of rice husk charcoal of 10 ton ha^{-1} was 12.48 ton ha^{-1}, but on the application of chicken manure of 5 ton ha^{-1} was 12.80 ton ha^{-1}. The research result also shows that every plant yield has the capability of adjusting to different mediums where satoimo plants are grown. Overall, the growth and yields of satoimo plants tend to be more effective on the application of rice husk charcoal of 10 ton ha^{-1} which was combined with chicken manure of 5 ton ha^{-1}. According to [4], the average production of satoimo plants was at 3.27 kg ha^{-1}, however, the productivity of satoimo taro was 14.47 kg ha^{-1} that can be classified as low production. [31]said that the production rate depends on cultivar, cultivation technique, environmental factor plant bed, and harvesting age.

Satoimo plants do not have a clear period to ripe because the tubers will keep growing and the satoimo plants have different harvesting periods. This was in line with the statement of [29]. [23] stated that the decrease of taro production was because of the conventional system in growing it. The research result of (2016) showed that the harvest yields of taro can reach up to 12.77 ton ha^{-1} when compared to the application on control group of 5.62 ton ha^{-1}. Meanwhile, in this research the productivity of satoimo plants that get the application of chicken manure of 5 ton ha^{-1} results up to 12.80 ton ha^{-1} which is in the moderate category.

IV. Conclusion

The result of the studied showed that the application of rice husk charcoal and chicken manure with rate 5 ton ha^{-1} was increased number of tubers. The application of rice husk charcoal and chicken manure with rate 10 ton ha^{-1} was increased K-exch. The application of rice husk charcoal with rate 10 t ha^{-1} and chicken manure with rate 5 t ha^{-1} was increased tuber wet weight, marketable yield weight, and ton ha^{-1} production of satoimo plants parameters.

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