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Aggregate Stability and Soil Moisture Improvements Influenced by Chicken Manure Applied on Ultisol and Cabbage (*Brassica oleraceae* L.) Growth

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ABSTRACT

Cultivation problems on marginal Ultisol involved low soil organic matter content, low water holding capacity and low soil aggregate stability. These constraints determined cabbage growth because of root crop development limited and plant nutrient uptake inhibited. Application of chicken manure could overcome the marginal constraints through improving soil aggregate stability and soil moisture content on the marginal Ultisol as well as the cabbage growth increased. The purpose of this study was to evaluate the soil aggregate stability and soil moisture in Ultisol as affected by the chicken manure applied and the cabbage growth improvement. This study was conducted from December to February, 2021 at Agriculture Station, Faculty of Agriculture, University of Bengkulu lying on ±100 m above sea level. The experiment design used was Completely Random Block Design (CRBD) with the chicken manure applied involved 5 doses; 7.5 tons ha^{-1}, 15 tons ha^{-1}, 22,5 tons ha^{-1}, 30 tons ha^{-1}, and without the manure as a control treatment. From the variance analysis (ANAVA) in the level of 5%, the chicken manure applied was significantly influence the improvement of soil aggregate stability and soil moisture content as well as the cabbage growth. With Duncan Multiple Range Test (DMRT), the dose of 7.5 tons ha^{-1} gave the highest value of the soil aggregate and soil moisture improvement. Furthermore, the chicken manure application of 7.5 tons ha^{-1} improved significantly the cabbage stem diameter at the age of 15 days, 30 days, and 45 DAP. The 7.5 tons ha^{-1} manure applied also gave significantly a number of leaves at the age of 15 days and 30 DAP. The height of plant was significantly influenced when the cabbage growth 15 DAP with 15 tons ha^{-1}. In short, the chicken manure applied with 7.5 tons ha^{-1} gave the soil aggregate stability, the soil moisture, and cabbage growth improvement.

Keywords : cabbage, chicken manure, soil aggregate stability, soil moisture content

INTRODUCTION

Ultisols are one of the largest soil orders in Indonesia, with distribution reaching 45,794,000 ha or equal to 25% of Indonesia's land area (Subagyo *et al*., 2004). Ultisols generally have base saturation <35%, acid to very acidic reaction (pH 5-3.1), good drainage, fine to medium texture, low soil nutrient content, and clay CEC <12 me 100 g^{-1} clay (Hermawan *et al*. , 2014). The land area in Bengkulu Province reaches 706,000 ha. The area of these ultisols has considerable potential for agricultural development in Indonesia. Ultisols are categorized as unproductive because in general, this soil is poor in organic matter and nutrients (Bertham, 2002).

The quality of soil fertility can be improved by adding organic matter. Organic matter can improve the properties of Ultisols and can also increase crop yields. The addition of organic matter to the soil has a very important function in fertilizing the top soil layer, increasing the population of microorganisms in the soil, increasing the absorption of water by the soil, and overall improving the quality of soil fertility. Organic fertilization can mobilize nutrients that are already in the soil so that they are easily absorbed by plant roots (Mulyani, 2010). Aggregate stability is the ability of the soil to withstand forces that will damage it. Solid soil aggregates will maintain good soil properties for plant growth, such as porosity and water availability

longer than unstable soil aggregates (Rachman & Abdurachman, 2006). The main problems with the physical properties of ultisols are poor aggregate stability, moderate to slow permeability, and low water holding capacity (Munir, 1996). Increasing the size and stability of the aggregate will have a positive effect on other soil physical properties, including increasing water retention capacity and the amount of available water, macro and micropores, total porosity, soil aeration, and soil permeability and infiltration. In addition, the improvement of soil aggregates can reduce the sensitivity of the soil to erosion (Kurnia, 1996). Good aggregate stability will ensure the circulation of water so that the soil is not easily destroyed due to external pressure. According to Hakim *et al*. (1986). Ultisols are also easy to compact and have low porosity so that infiltration and percolation are low (Soepardi, 1983).

Another problem that ultisol soils have is the low level of soil moisture which can have an impact on decreasing plant growth. Soil moisture content is often referred to as the water content (moisture) contained in the soil pores (Ritawati *et al*., 2015). Low soil moisture content is a major environmental factor that will inhibit plant growth. Severe water stress conditions cause inhibition of plant photosynthesis (Charloq & Setido, 2005) because water is needed by plants for various plant functions, namely as a solvent and medium for chemical reactions, medium for transport, and medium that provides turgor to plant cells (Gardner *et al*., 1991). The low amount of water causes limited root development, thus interfering with the absorption of nutrients by plant roots (Anggraini *et al*., 2009). In addition, water stress in plants reduces plant cell water potential and turgor so that cell enlargement decreases which cause growth inhibition and reproductive failure (Lisar *et al*., 2012). One of the efforts that can improve the stability of the aggregate and increase the moisture content of the ultisol soil is the application of organic fertilizer.

Organic fertilizers have functions including 1) providing macro (N, P, K, Ca, and S) and micronutrients such as Zn, Cu, Mo, Co, B, Mn, and Fe even in small amounts, 2) increasing the cation exchange capacity (CEC) of the soil, 3) can form complex compounds with metal ions such as Al, Fe, and Mn, 4) improve soil structure, because organic matter can bind soil particles into stable aggregates, 5) and improve size distribution soil pores so that groundwater holding capacity increases and air movement (aeration) in the soil becomes better (Barus, 2011). Therefore, the application of organic fertilizer into the soil is very necessary so that the plants that grow in the soil can grow well (Subroto, 2009). One of the potential organic fertilizers is chicken manure. Chicken manure has good potential because, in addition to playing a role in improving the physical, chemical, and biological properties of soil, chicken manure also contains higher N, P, and K when compared to other manures (Muhsin, 2003). Based on the analysis results, chicken manure contains Nitrogen (N) 2.44%, Phosphorus (P) 0.67%, Potassium (K) 1.24%, and C-Organic 16.10%.

The content of N, P, and K contained in chicken manure has high nutrient levels, so chicken manure can improve fertility levels in problematic soils, and can increase crop production yields. This is to the opinion of Mayadewi (2007) that manure can indeed increase the availability of nutrients for plants that can be absorbed from the soil.

Cabbage (*Brassica oleracea* L.) is one of the leaf-producing horticultural plants. Cabbage requires soil that is not muddy, fertile, rich in organic matter, and has a pH of about 5.5 to 6.5. The high nutritional content and economic value make this plant very potential to be cultivated. The center of cabbage plants is in an area with an altitude of 500 m - 1200 m above sea level (masl) (Ramli, 2010). Horticultural cultivation systems in the highlands that do not pay attention to conservation aspects are currently vulnerable to environmental damage. The importance of efforts to anticipate natural damage and decreased production of horticultural crops, it is necessary to develop the cultivation of horticultural crops which are generally planted in the highlands so that they can be cultivated in the lowlands.

MATERIALS AND METHODS

The research was carried out from December 2020 to February 2021 in the Agricultural Zone of the University of Bengkulu at an altitude of ± 100 meters above sea level.

The materials used in this research activity consisted of chicken manure and cabbage seeds. Furthermore, the tools used are a hoe, sickle, ruler, tissue, bucket, filter, analytical scale, digital scale, Pressure Plant Apparatus, raffia rope, hand sprayer, label, bamboo, plastic folder, waring, oven, camera, and stationery.

This study used a Randomized Completely Block Design (RCBD). The treatment in this study was the dose of chicken manure which consisted of 5 levels, namely : P_0 = Control, P_1 = 7.5 tons ha^{-1} (2.81 kg $plot^{-1}$), P_2 = 15 tons ha^{-1} (5.62 kg $plot^{-1}$), P_3 = 22.5 tons ha^{-1} (8.43 kg $plot^{-1}$), and P_4 = 30 tons

ha^{-1} (11.25 kg/plot). Each treatment was repeated 3 times so that 15 experimental units were obtained and each plot measured 1.5 m x 2.5 m. The implementation of the research includes the stages of Planting Media Preparation, Planting, and Plant Maintenance.

Soil samples were taken compositely at 15 points with a depth of 0 – 20 cm. The soil sample was then air-dried for 2-3 days, then the soil was sieved with a 0.5 mm sieve. Plant samples were taken randomly from each plot as much as 10% of the plant population, sampling of cabbage plants was carried out before fruiting (forming a circle), the first adult leaves from the head of the plant, and plant samples will be taken at 08.00 or 17.00

Variables observed included Aggregate Stability, Instantaneous Moisture Content, Plant Height (cm), Number of Leaves (strands), and Diameter of Stem Base (cm). Observational data were analyzed statistically with analysis of variance (ANAVA) at the 5% level. To get the best dose of chicken manure on the percentage of total soil aggregate, moisture content, stem diameter at 15 DAP, 30 DAP, and 45 DAP, the number of leaves at 15 DAP and 30 DAP, and plant height at 15 DAP, further tests were carried out DMRT level 5%.

RESULTS AND DISCUSSION

The dose of chicken manure significantly affected the percentage of total soil aggregate, instantaneous moisture content, stem diameter at 15 DAP, 30 DAP, and 45 DAP, the number of leaves at 15 DAP and 30 DAP, and plant height at 15 DAP, but had no significant effect on the number of leaves at 45 DAP and plant height at 30 DAP and 45 DAP (Table 1).

Effect of Chicken Manure on Soil Physical Properties

The results showed that the application of chicken manure at a dose of 7.5 tons ha^{-1} to 30 tons/ha resulted in the percentage of total stable aggregates being not significantly different. Furthermore, the control resulted in the percentage of total stable aggregate that was not significantly different from the application of chicken manure at a dose of 7.5 tons ha^{-1}, and 22.5 tons ha^{-1}. Furthermore, the application of chicken manure at a dose of 7.5 tons ha^{-1}, 22.5 tons ha^{-1} and 30 tons ha^{-1} resulted in non-significantly different levels of instantaneous moisture. Meanwhile, the control produced instantaneous moisture content which was significantly different from all doses of chicken manure tested. Based on this, it can be seen that the application of chicken manure at a dose of 7.5 tons ha-1 has been able to increase the percentage of total stable aggregate and instantaneous moisture content, namely 37.33% and 32.42%, respectively. Increasing the dose of chicken manure above 7.5 tons ha^{-1} did not significantly increase the percentage of total stable aggregate and instantaneous moisture content based on the DMRT test at 5% level (Table 2).

Table 1. Summary of the value of analysis variance

Variable	F-value	F-table 5%	CV (%)
Soil aggregate stability	5.15*	3.84	8.93
Instantaneous moisture content	7.47*	3.84	5.89
Stem diameter			
15 DAP	4.70*	3.84	10.43
30 DAP	5.31*	3.84	14.54
45 DAP	5.38*	3.84	16.39
Number of leaves			
15 DAP	5.22*	3.84	8.3
30 DAP	6.81*	3.84	7.12
45 DAP	2.50 ns	3.84	10.96
Plant height			
15 DAP	13.07*	3.84	6.59
30 DAP	3.03 ns	3.84	12.8
45 DAP	2.31 ns	3.84	16.13

Note : * = significant ; ns = non-significant

Table 2. Effect of chicken manure doses on soil aggregate stability and Instantaneous moisture content

Chicken manure doses (ton ha^{-1})	Soil aggregate stability (%)	Instantaneous moisture content (%)
0	33.00 b	26.59 c
7.5	37.23 ab	32.42 ab
15	44.20 a	30.55 b
22.5	39.53 ab	32.34 ab
30	43.46 a	34.23 a

Note : The numbers followed by different letters in the same column are significant different at Duncan Multiple Range Test

The increase in the percentage of total stable aggregate was due to chicken manure being able to bind soil particles so that the soil aggregate was more stable. In line with the results of research by Widodo & Kusuma (2018) composting can increase aggregate stability, reduce soil density, and increase soil pores. Furthermore, Nenobesi *et al*. (2017) added that the provision of manure compost can increase the stability of soil aggregates because the compost that has been decomposed can bind soil grains so that the soil becomes loose, the more soil aggregates are formed, and the more stable. The results of research by Ramli *et al*. (2016) and Hermawan (2020) also showed that the application of organic matter in the form of manure was able to increase the stability of soil aggregates.

The increase in moisture content was because the chicken manure given was organic material which had a role in increasing the total soil pores so that the soil water content increased. In line with the statement of Lawenga *et al*. (2015) that manure will undergo a decomposition process and gradually produce humus. The interaction of humus with soil particles will create a more stable soil structure and enlarge the pore space. Furthermore, the results of research by Prasetyo *et al*. (2014) and Sumarni *et al*. (2010) showed that the application of manure on agricultural land had a significant effect on the physical properties of the soil, namely a decrease in bulk density and an increase in soil porosity and soil moisture content.

Cabbage Plant Growth Pattern

Growth is the process of increasing the size of plant organs as a result of plant metabolism which is influenced by environmental factors in the planting area such as water, sunlight, and nutrients in the soil (Irdiani *et al*., 2002). The growth of cabbage, which includes stem diameter, number of leaves, and plant height, was observed from plants aged 15 DAP to 45 DAP which are presented in Figures 1, 2, and 3. In general, the growth pattern of plant height, stem diameter, and the number of leaves increased with increasing growth. plant age. The results of research by Rosita *et al*. (2005) also showed that plant growth increased with increasing plant age.

The results showed that the number of leaves continued to increase at each observation time. At the age of 15 DAP, it was seen that the application of manure at a dose of 7.5 tons ha^{-1} – 30 tons ha^{-1} resulted in the same stem diameter, several leaves, and plant height. However, at the age of 30 and 45 days after planting, it was seen that the application of chicken manure at a dose of 30 tons ha^{-1} resulted in higher stem diameter, number of leaves, and height. Meanwhile, without giving chicken manure, the stem diameter, number of leaves and height tended to be lowest at each observation time.

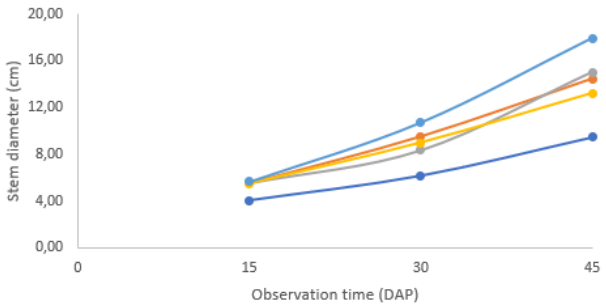

Figure 1. The growth pattern of stem diameter due to chicken manure application

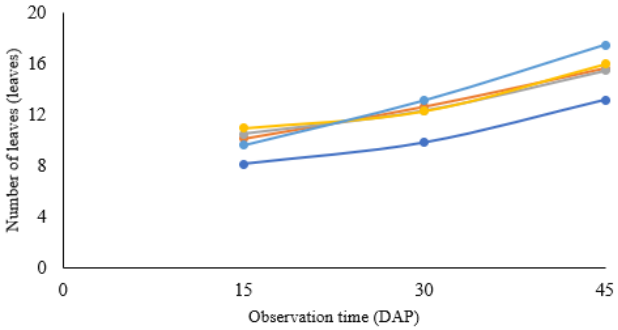

Figure 2. The growth pattern of number of leaves due to chicken manure application

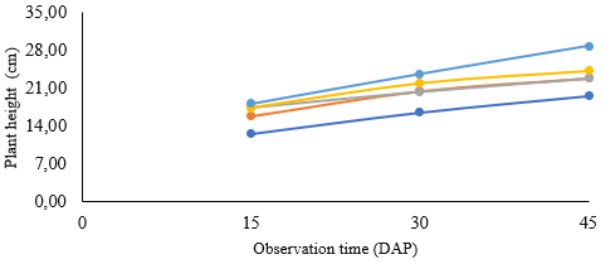

Figure 3. The growth pattern of plant height due to chicken manure application

Effect of Chicken Manure on Cabbage Growth

Soil with high total stability of stable aggregates will make it easier for plant roots to penetrate the soil so that the uptake of water and plant nutrients increases which causes the diameter of the stem to increase. By Widodo & Kusuma (2018) the addition of compost can cause loose soil structure and soil pores to increase, making it easier for plant roots to develop. Increased root development will have an impact on increasing plant growth, one of which is stem diameter. Furthermore, the higher the soil moisture

content, the better the growth of stem diameter will be. According to Manan *et al*. (2015) that the level of water availability is closely related to the process of absorption of nutrients by plants in the metabolic process. Plants respond to the available water availability by increasing vegetative growth such as stem diameter.

In addition, the increase in stem diameter is due to chicken manure containing several nutrients needed by plants such as N, P, and K. This is in line with Musnamar (2009) that chicken manure has the highest nutrient value compared to other manures because the liquid part is mixed with the solid part. Furthermore, the results of research by Nurani & Tyasmoro (2020) also showed that the application of chicken manure was able to increase the stem diameter of cabbage plants.

Table 3. Effect of chicken manure doses on stem diameter

Chicken manure doses (ton ha^{-1})	Stem diameter (mm)		
	15 DAP	30 DAP	45 DAP
0	4.03 b	6.15 b	9.45 c
7.5	5.55 a	9.53 a	14.45 ab
15	5.55 a	8.35 ab	15.03 ab
22.5	5.47 a	8.98 a	13.23 abc
30	5.67 a	10.72 a	17.92 a

Note : The numbers followed by different letters in the same column are significant different at Duncan Multiple Range

The increase in the number of leaves is due to manure being able to increase soil fertility so that plants absorb more nutrients, especially those that can stimulate the formation of new plant organs, one of which is leaves. According to Sutedjo (2010), a plant will grow and thrive if the nutrients needed are present and available in sufficient form and are in a suitable form to be absorbed by root hairs. Furthermore, Sari *et al*. (2016) and Meriyanto *et al*. (2017) reported that the effect of chicken manure had a significant effect on increasing the number of cabbage leaves. Damanik *et al*. (2011), stated that chicken manure contains three times more nitrogen than other manures. This content can increase the growth and development of more plant leaves compared to other manures. The results of Diana *et al*. (2020) also showed that the application of chicken manure was able to increase the number of leaves of cabbage plants. However, the results of Nainggolan's research (2020) show that up to a dose of chicken manure up to 15 tons ha^{-1} has not been able to significantly increase the growth of long bean plants.

According to Bustami *et al*. (2012) which states that plant growth and production will reach the optimum if the supporting factors supporting the growth are in optimal condition, balanced elements, the right dose of fertilizer, and the required nutrients are available to plants. Provision of fertilizers that are by the dosage and needs can increase plant growth, on the contrary excessive application will reduce plant growth.

Tabel 4. Effect of chicken manure doses on number of leaves

Chicken manure doses (ton ha^{-1})	Number of leaves (leaves)		
	15 DAP	30 DAP	45 DAP
0	8.17 b	9.83 b	13.17
7.5	10.17 a	12.67 a	15.67
15	10.50 a	12.33 a	15.50
22.5	11.00 a	12.33 a	16.00
30	9.67 ab	13.17 a	17.50

Note : The numbers followed by different letters in the same column are significant different at Duncan Multiple Range Test 5%

Table 5. Effect of chicken manure doses on plant height

Chicken manure doses (ton ha^{-1})	Plant height (cm)		
	15 DAP	30 DAP	45 DAP
0	12.58 c	16.50	19.55
7.5	15.90 b	20.52	22.90
15	17.45 ab	20.40	22.88
22.5	17.40 ab	21.95	24.23
30	18.20 a	23.67	28.82

Note : The numbers followed by different letters in the same column are significant different at Duncan Multiple Range Test 5%

CONCLUSION

The application of chicken manure at a dose of 7.5 tons ha^{-1} has been able to increase the stability of the total stable aggregate of the soil and the instantaneous moisture content.

The application of chicken manure at a dose of 7.5 tons ha^{-1} was able to increase the diameter of cabbage stems at 15 DAP, 30 DAP, and 45 DAP, and the number of leaves at 15 DAP and 30 DAP. . Furthermore, the application of chicken manure at a dose of 15 tons ha^{-1} was able to increase the height of cabbage plants aged 15 DAP.

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