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Aggregate Stability and Soil Moisture Improvement As Affected by Bokashi Application and Soil Tillages for Cabbage (*Brassica oleraceae* L) Cultivation on Ultisol

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ABSTRACT

The aims of this study were 1) to find optimum dose of bokashi applied for cabbage growth based on the improvement of the total soil aggregate stability, soil moisture content, soil pH, 2) to find soil tillage method for optimum growth of cabbage based on the improvement of the total soil aggregate stability, soil moisture content, soil pH, , and (3) to find interaction between dose of bokashi applied and soil tillage method for the optimum growth of cabbage. This research was conducted from March to June, 2020 in Muara Bangkahulu sub-district, Bengkulu City. The research location lies on ± 500 m above sea level with soil type of Ultisol. The research used Split plot design with 3 replications. The main plot was 3 soil tillage methods involved no tillage, minimum tillage (1 time hoe tillage), and intensive tillage (2 time hoe with 1 time rake), and the sub plot consist of 4 doses of bokashi involved 0 ton ha^{-1}, 5 tons ha^{-1}, (2,81 kg plot^{-1}), 10 tons ha^{-1}, (3,75 kg plot^{-1}), and 15 tons ha^{-1} (5,62 kg plot^{-1}). The research resulted there was interaction between the soil tillage method and the bokashi applied on the improvement on the total soil aggregate stability. An increasing dose of bokashi applied on all soil tillage treatments was followed by the increasing the total soil aggregate stability. Minimum- and intensive soil tillage methods gave better growth of cabbage in form of the plant height and the leaf number than no tillage to the cabbage growth. Bokashi applied with doses of 10 tons ha^{-1} and 15 tons ha^{-1} improved soil pH, soil moisture content, and the cabbage growth.

Keywords: *bokashi, cabbage, soil aggregate stability, soil tillage methods*

INTRODUCTION

Ultisol is one of the types of soil that is spread 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 reaction to very acid (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). Ultisols in Bengkulu Province have a cross-section of land in the form of flat to mountainous, slopes of 1-40%, with an area of 706,000 ha which is the second largest soil type after inceptisols. From this description, it can be concluded that the fertility potential of Ultisol is low to very low (Bengkulu Agricultural Research and Development, 2010).

Tillage is any mechanical manipulation of the soil to create good soil conditions for plant growth (Fuady, 2010). Soil cultivation aims to maintain aeration and soil moisture by plant needs, so that root growth and nutrient absorption by plant roots can take place properly. Soil processing methods can be grouped into 3, namely no-tillage, minimum tillage, and intensive tillage (Tyasmoro). *et al*., 1995). Tillage is needed to loosen the soil to produce a good root area for plants, but this work can cause long-term problems as a source of soil damage that can reduce soil productivity. Tillage can create conditions that favor seed germination that may be needed to combat weeds and pests that can potentially attack crops and also play a role in helping to control erosion. Tillage requires high energy inputs, which can come from human or animal labor. In a system without continuous tillage, organic residues from previous plants collect on the soil surface, so that there is greater microbial activity on the soil surface in soil without tillage when compared to complete tillage (Engelstad, 1997). This method can work well for plants grown according to arrays. Many plant residues on the soil surface do not interfere with germination and seed growth (Sutanto, 2002).

Bokashi fertilizer is an organic fertilizer produced from the fermentation of organic materials such as compost and manure by utilizing the help of decomposing microorganisms such as fermenting microbes or fungi. The result is solid fertilizer in a decomposed condition so that it contains more nutrients, both macro and micro, which are ready to be absorbed by plant roots immediately. The average content of bokashi fertilizer already includes macronutrients: N, P, K, Mg, S, Ca, and micro-nutrients Zn, B, Fe, Cu, Mn, Mo, and Cl. (Maria, 2013). Giving various doses of compost is expected to increase organic matter which will make the soil's physical properties good (Rohman *et al*., 2020). It is necessary to research improving the physical properties of the soil which will lead to optimal plant growth. This study will use cabbage plants grown in the lowlands to serve as indicators (Muyassir *et al*., 2012).

Ultisol soils have shallow solum, slow to moderate permeability, and weak aggregate stability so most of these soils have low water holding capacity and are sensitive to erosion. Vulnerability to erosion causes soil fertility to decrease more quickly, especially in the upper layers, and will accumulate in the lower layers. The application of organic matter into the soil must be carried out sustainably because organic matter is an important component to improve and improve the quality of soil properties. Organic matter can play a role in improving soil's physical properties (Geonadi, 2006).

Cabbage (*Brassica oleracea* L) is one type of leaf-producing horticultural plant. Cabbage requires soil that is not muddy, fertile, rich in organic matter, and has a pH of about 5.5 to 6.5. Because it has a high nutritional content and economic value, this plant has the potential to be cultivated. The center of cabbage plants is in an area with an altitude of 500-1200 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.

Aggregate stability is very important for agricultural and plantation soils. Stable aggregates will create good conditions for plant growth. Aggregate can create a good physical environment for plant root development through its effect on porosity, aeration, and water holding capacity. In soils whose aggregates are less stable when exposed to disturbances, the soil aggregates will be easily destroyed. The fine grains of crushed will block the pores of the soil so that the bulk density of the soil increases, aeration is poor and permeability becomes slow. Aggregate stability also greatly determines the level of sensitivity of the soil to erosion (Yatno, 2011).

Vegetation growth requires a certain level of soil moisture. Therefore, it can be said that soil moisture at a certain level can determine the form of land use. Drought events that occur in an area are also more related to how much moisture is in the soil than the number of rain events that fall in that place. However, it should also be noted that high levels of soil moisture can cause problems in terms of harvesting agricultural or forestry products using mechanical tools (Asdak, 2004).

The contribution of soil moisture in a field will affect the results to be given, For agricultural land changes in soil moisture content conditions need to be considered whether it is very dry in the dry season or very wet in the rainy season so that later the condition of the soil can be used for optimal productivity levels and can maintain food production commodities. Knowing the difference in surface soil moisture can help optimize soil management in land use so that productivity can be maintained. (Sabaruddin, 2012).

This study aims to obtain the optimum dose of bokashi fertilizer in different types of tillage, get the right treatment and get the best dose of bokashi fertilizer in increasing the percentage of total stable aggregate, soil moisture, soil pH, and cabbage growth.

MATERIALS AND METHODS

This research was conducted from March 2021-June 2021 in Pekan Saturday Village, Selebar District, Bengkulu City. This study used the split-plot method with three repetitions. The main plot of tillage consisted of T_0: Control, T_1: 1 hoe, and T_2: 2 hoes. Subplots were given bokashi consisting of K_0: Control, K_1: 5 tons ha^{-1}, K_2: 10 tons ha^{-1}, and K_3: 15 tons ha^{-1}. The research was carried out in the form of making bokashi fertilizer, preparing planting media, planting using Sehati F1 seeds, fertilizing, and maintaining.

Seed preparation, Cabbage seeds used were the SEHATI F1 variety. The seeds to be planted are soaked in water for 30 minutes, then air-dried. Then, the seeds are spread in the nursery, then covered with a thin layer of soil, and covered again with banana leaves. After the seeds germinate, the banana leaf cover can be removed. while planting using open bed nursery media with a composition of soil and organic matter. At the time of seeding, the plants are simply watered with water, that is if the nursery media looks dry. After the plant has seeded 3-4 leaves, it is planted in open land that has been given basic fertilizers of N, P, K. Seedling continues until the plant reaches 4-6 leaves (1-month-old). Seedlings were planted in a single hole made with a spacing of 50 cm x 50 cm at a depth of 3 cm, in one plot there were 15 plants. Each planting hole is filled with one cabbage seed.

The variables observed in this study are Aggregate Stability (Valensky Method), Soil pH (Electrometric Method, Soil Moisture), Plant Height (Measured at the time of initial vegetative use using a rolling meter by measuring from the base of the stem to the tip of the highest leaf. Observations were made at the age of the plant 15 DAP, 30 DAP and 45 DAP), and the Number of Leaves (done by counting the number of leaves that have been formed perfectly, calculated at the age of the plant 15 DAP and 45 DAP).

Data from the observations were analyzed statistically with analysis of variance (ANOVA) if there were variables that showed a real effect because of the treatment, then continued with Duncan's Multiple Range Test (DMRT) at the 5% level.

RESULTS AND DISCUSSION

The results of the analysis of variance showed that tillage had a significant effect on the percentage of total stable aggregate, plant height at 30 and 45 DAP, and the number of leaves at 45 DAP. The application of bokashi fertilizer with different doses had a significant effect on the percentage of total stable aggregate, plant height at 30 DAP and 45 DAP, the number of leaf at 45 DAP, humidity at 45 DAP, and soil pH. Meanwhile, the interaction of tillage and bokashi dose only had a significant effect on the percentage of total stable aggregate (Table 1).

The results showed that the dose of bokashi fertilizer formed a positive linear relationship with the percentage of total stable aggregate in all tillage. Each tillage has a positive linear line with different degrees of dependence, where the more intensive the tillage, the more inclined the degree of slope of the positive linear line is. This means that the more intensive the tillage, the higher the response of the percentage of the total stable aggregate of the soil to the dose of bokashi fertilizer. The influence of tillage affects the decomposition process in the soil so that the organic matter in the soil increases. According to Yulnafatmawita (2004) that changing soil physical conditions due to processing causes the organic matter content to change as well.

Table 1. Summary of analysis of variance

Variable	F value			CV(%)
	Soil tillage	Dose bokashi	Interaction	
Total soil aggregate stability	17.86*	75.47*	8.04*	4.49
Plant height				
15 DAP	0.40 ns	2.61 ns	0.65 ns	7.48
30 DAP	7.96*	9.18*	1.65 ns	10.81
45 DAP	17.19*	6.51*	0.69 ns	13.89
Leaf number				
15 DAP	2.87 ns	2.10 ns	0.67 ns	17.17
30 DAP	1.39 ns	2.54 ns	2.45 ns	15.81
45 DAP	18.59*	11.98*	1.15 ns	10.27
Soil moisture				
15 DAP	1.43 ns	1.71 ns	1.63 ns	6.76
30 DAP	3.17 ns	1.43 ns	1.51 ns	3.75
45 DAP	4.88 ns	12.28*	1.58 ns	2.78
Soil pH	0.44 ns	6.33*	0.98 ns	7.26

Note : Note : * = significant ; ns = non-significant

Bokashi dose forms a positive linear relationship with the percentage of total stable aggregate in all tillage used, which means that the higher the dose of bokashi given, the higher the percentage of total stable aggregate, either without tillage or with 1 hoe or 2 times processing. hoe and harrow (Figure 1). This is because the higher the dose of bokashi given, the higher the organic matter content in the soil. Furthermore, the organic matter will produce humus which plays a very important role as a binding agent for soil grains. In line with the research results of Nurida & Law (2009); Mustoyo *et al*. (2013); and Yulnafatmawita *et al*. (2008) who reported that organic matter can improve soil physical properties, one of which is the stability of soil aggregates.

Organic matter has an important role in determining the stability of soil aggregates, this is because: (1) organic matter has a strength or other charges that can unite primary grains into secondary grains, (2) decomposition of organic adhesives around secondary grains can unite each other as cement or wrapping, and (3) secondary granules are then combined and covered with mold threads to form a stable and crumbly soil structure (Junedi & Arsyad, 2010).

Tillage affected the growth of cabbage plants which included plant height at the age of 30 DAP and 45 DAP, and the number of leaves at 45 DAP. Tillage with one hoe resulted in the highest plant height and the highest number of leaves, although it was not significantly different from that with 2 hoes + harrowing, but it was significantly different from that without soil which produced the lowest plant height and number of leaves. This is because tillage can create good soil structure conditions for root development, so that roots can absorb available nutrients which in turn will increase cabbage growth.

According to Suwardjono (2004) that a good soil structure makes the roots develop well so that the area of absorption of nutrients is wider. The smooth process of absorption of nutrients by plants, especially diffusion, depends on the supply of groundwater which is related to the water holding capacity of the soil. These components can stimulate the photosynthesis process optimally so that it can increase plant growth. The results of research by Sutapradja (2008) that tillage by hoeing to a depth of 30 cm can increase the growth and yield of cabbage compared to without tillage.

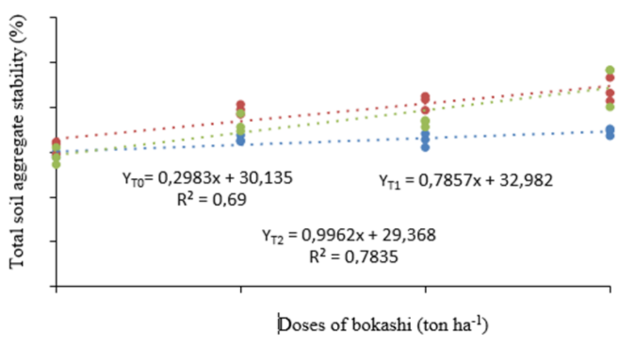

Figure 1. The relationship between bokasi dose and percentage of total stable aggregate at different tillage

Table 2. The effect of soil cultivation on plant growth

Soil tillage	Plant growth		
	Plant height (cm)	Plant height (cm)	Number of leaf
	30 DAP	45 DAP	45 DAP
Control	11.38 b	13.63 b	10.54 b
1 hoe	14.60 a	18.22 a	13.08 a
2 hoes	14.57 a	17.62 a	12.33 a

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

The results showed that the application of bokashi fertilizer at doses of 5, 10, and 15 tons/ha resulted in an insignificant difference in soil pH but higher than the soil pH without bokashi fertilizer application. There is a tendency that soil pH increases with increasing doses of bokashi fertilizer (Table 3). Decomposed organic matter will release organic compounds, either in the form of organic acids or base cations (Siregar et al, 2017). Organic matter that has been decomposed will produce OH- ions which can neutralize the activity of H+ ions. Organic acids will also bind Al^{3+} and Fe^{2+} which can form complex compounds (chelates) so that Al3+ and Fe2+ are not hydrolyzed again which will increase soil pH (Bayer et al, 2001).

In addition to increasing soil pH, Bokasi fertilizer was also able to increase soil moisture, where the application of Bokashi fertilizer at a dose of 15 tons ha^{-1} resulted in the highest soil moisture at 32.22%, which was not significantly different at a dose of 10 tons ha^{-1}, but significantly different at a dose of 5 tons ha^{-1} and 0 ton ha^{-1}. On the other hand, without bokashi fertilizer application, the lowest soil moisture was 30.22% which was not significantly different from the application of bokashi at a dose of 5 tons ha^{-1}, but significantly different at a dose of 10 tons ha^{-1} and 15 tons ha^{-1} (Table 3). This is because the bokashi fertilizer given can increase the water content in the soil so that soil moisture also increases. In line with Agam (2014) that increasing the dose of organic fertilizer can also increase the available water content. This increase can be caused by an improvement in soil structure by organic matter

Organic matter helps bind clay grains to form larger grain bonds thereby increasing the air spaces between grain bonds. The more organic matter content, the more water in the soil will increase. Organic matter in the soil can absorb water 2–4 times its weight which plays a role in water availability (Schjønning *et al*., 2007). In addition, the research results of Intara *et al*. (2011) showed that the application of organic matter can reduce the rate of evaporation that occurs in the soil and can increase soil water content and available water capacity.

The results showed that the growth of cabbage which included plant heights of 30 DAP and 45 DAP and the number of leaves of 45 DAP gave a significantly different response between the doses of Bokashi fertilizer given. At the age of 30 DAP, the application of Bokashi fertilizer at a dose of 10 tons ha^{-1} produced higher plants than other doses, although it was not significantly different at doses of 5 and 15 tons ha^{-1}, but significantly different at a dose of 0 tons ha^{-1}. Furthermore, when the plants were 45 DAP, the application of 15 tons ha^{-1} of Bokashi fertilizer produced taller plants and more leaves than other doses. In general, it was seen that the increase in bokashi

Table 3. Effect of bokashi fertilizer dosage on soil characteristics

Doses of Bokashi (ton ha-1)	Soil characteristics	
	pH	Soil moisture (%) 45 DAP
0	4.49 b	30.22 b
5	4.97 a	30.33 b
10	5.11 a	31.78 a
15	5.11 a	32.22 a

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

This is because the bokashi fertilizer given can increase soil pH (Table 3). An increase in soil pH will be followed by an increase in the availability of nutrients for plants. In line with the results of previous studies that the addition of organic matter can improve soil chemical properties, namely increasing soil pH, soil organic C (Fikdalillah *et al*., 2016), nutrient uptake of N, P, and K (Afandi *et al*., 2015).

Table 4. Effect of bokashi fertilizer dosage on plant growth

Doses of Bokashi (ton ha-1)	Plant growth		
	Plant height (cm)		Number of leaf (leaf)
	30 DAP	45 DAP	45 DAP
0	11.43 b	13.98 c	9.94 b
5	13.53 a	15.95 bc	12.11 a
10	14.61 a	17.69 ab	12.83 a
15	14.49 a	18.33 a	13.06 a

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

CONCLUSION

The response of the percentage of the total stable aggregate of the soil to the dose of Bokashi fertilizer is influenced by tillage, the more intensive the tillage, the higher the response of the percentage of the total stable aggregate to the dose of Bokashi fertilizer. Tillage with 1 hoe and 2 hoes + harrowed produces taller plants and more leaves than without tillage. Application of bokashi fertilizer at doses of 10 and 15 tons ha^{-1} resulted in higher soil pH and soil moisture, as well as taller plants and more leaves.

References

Afandi, F. N., Siswanto, B. & Nuraini, Y. (2015). Pengaruh pemberian berbagai jenis bahan organik terhadap sifat kimia tanah pada pertumbuhan dan produksi tanaman ubi jalar di Entisol Ngrahkah-Pawon, Kediri. *Jurnal Tanah dan Sumberdaya Lahan*, 2(2), 237-244.

Asdak, C. (2004). Hidrologi dan Pengelolaan Daerah Aliran Sungai. Cetakan Ketiga (revisi). Gadjah Mada University Press., Yogyakarta.

Engelstad, O.P. (1997). Teknologi dan Penggunaan Pupuk. Edisi Ke tiga. Gadjah Mada University Press., Yogyakarta.

Fuady, Z. (2010). Pengaruh sistem olah tanah dan residu tanaman terhadap laju mineralisasi nitrogen tanah. *Jurnal Ilmiah Sains dan Teknologi.* 10(1), 94-101.

Fikdalillah, Basir, M. & Wahyudi, I. (2016) Pengaruh pemberian pupuk kandang sapi terhadap serapan fosfor dan hasil tanaman sawi putih (*Brassica pekinensis*) pada Entisols Sidera. *Agrotekbis*, 4(5), 491-499.

Hermawan, A., Sabaruddin, S., Marsi, M., Hayati, R., Warsito, W. (2014). Perubahan jerapan P pada Ultisol akibat pemberian campuran abu terbang batubara kotoranAyam. *Sains Tanah, Jurnal Ilmu Tanah dan Agroklimatologi*, 11(1), 1-10.DOI: *http://dx.doi.org/10.15608% 2Fstjssa.v11i1.198*.

Junedi, H. & Arsyad, A. R. (2010). Pemanfaatan kompos jerami padi dan kapur untuk memperbaiki sifat fisik tanah Ultisol dan hasil kedelai (*Glycine max* L.Merill) musim tanam kedua. *Jurnal Ilmu Tanah dan Lingkungan,* 10(1), 35-41.

Maria, E.K. (2013). Pengaruh pemberian bokashi terhadap pertumbuhan vegetatif dan Produksi rumput Gajah (*Pennisetum purpureum*). *Jurnal Ilmu Hewani Tropika*, 2(2), 40-45.

Muyassir, Sufardi & Saputra, I. (2012). Perubahan sifat fisika Inceptisol akibat perbedaan jenis dan dosis pupuk organik. *Lentera*, 12(1), 1-8.

Ramli. (2010). Respon varietas kubis (*Brassica olaracea*) dataran rendah terhadap pemberian berbagai jenis mulsa. *J. Agroland*, 17(1) 30-37.

Rohman, A. N., Barchia, M. F. & Murcitro, B. G. (2020). Effect of biourine on N uptake and cabbage (Brassica oleraceae L) growth on lowland Ultisol. *TERRA : Journal of Land Restoration*, *3*(2), 39–44. DOI: *https://doi.org/ 10.31186/terra.3.2.39-44*

Sabaruddin, L. (2012). Agroklimatologi Aspek-aspek Klimatik untuk Sistem Budidaya Tanaman. Alfabeta, Bandung.

Subagyo, H., Suharta, N. & Siswanto, A.B. (2004). Tanah-tanah Pertanian di Indonesia. Pusat Penelitian Tanah dan Agroklimat, Bogor.

Sutanto, R. (2002). Penerapan Pertanian Organik . Kanisius, Yogyakarta.

Suwardjo, H. & Dariah, A. (1995). Teknik olah tanah konservasi untuk menunjang pengembangan pertanian lahan kering yang berkelanjutan. Pros. Seminar Nasional.V : 8-13. Bandar Lampung.

Tyasmoro, S.T., Suprayoga, B. & Nugroho, A. (1995). Cara pengelolaan lahan yang berwawasan lingkungan dan budidaya tanaman sebagai upaya konservasi tanah di DAS brantas hulu. Pros. Seminar Nasional.Budidaya Pertanian Olah Tanah Konservasi. Bandar Lampung.

Yatno, E. (2011). Peranan bahan organik dalam memperbaiki kualitas fisik tanah dan produksi tanaman. *Jurnal Sumberdaya Lahan*, 5(1), 11-18.