

The effect of various dosages of fishbone flour and tofu slurry on chemical characteristic of alfisol and yield of leaf cabbage (*Brassica oleracea* var. *acephala*)

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Abstract. Soetedjo INP, Jansari EA, Ndiwa ASS. 2020. The effect of various dosages of fishbone flour and tofu slurry on chemical characteristics of alfisol and yield of leaf cabbage (*Brassica oleracea* var. *acephala*). *Trop Drylands* 4: 58-61. Alfisol is a type of soil that has been going through intensive weathering and development, resulting in leaching of nutrients such as N, P, and K. These conditions might be improved by application of organic matters such as various kinds of waste. Fishbone flour and tofu slurry are potential organic waste that might be applied to improve chemical characteristics of alfisol. This research aimed to determine a proper dosage waste of fishbone and tofu slurry in improving chemical characteristics of alfisol and yield of leaf cabbage (kalian or kale) (*Brassica oleracea* var. *acephala*). Factorial experiment was conducted in a Randomized Complete Block Design (RCBD) with 3 replications. The research treatments were two factors, i.e., kinds of organic waste (fishbone flour and tofu slurry) and various dosage applications (300 g polybag⁻¹, 400 g polybag⁻¹, 500 g polybag⁻¹). Observed data were subjected to Analysis of Variance (ANOVA) followed by a Duncan Multiple Range Test (DMRT) at 5% level. Observed variables included soil nutrient content (total nitrogen, available phosphorus, exchangeable potassium) and yield of leaf cabbage. Result of the research showed that there was no significant effect of either interaction of the two factors or the single factor treatment of organic waste on all observed data. However, dosage of organic waste application significantly affected nutrients content of alfisol that 500 g polybag⁻¹ produced a higher content of N, P, and K compared to other treatments. Similarly, application 500 g polybag⁻¹ of organic waste resulted in a higher fresh weight of leaf cabbage of 218.83 g polybag⁻¹.

Keywords: Alfisol, fishbone flour, organic waste, tofu slurry, yield, leaf cabbage

INTRODUCTION

Generally, alfisol and vertisol are two dominant soil types in dryland regions such as in East Nusa Tenggara. Alfisol has low content of nutrients such as N, P, K, C organic, Mo, Mg, and also Al, Fe, and Mn poisonings. Moreover, alfisol has medium to high bulk density, low to medium soil permeability, low water soil resistance, high sensitivity of erosion, and low soil microbe content (Harjowigeno 2015; Serangmo 2015). These conditions cause a low capability of the soil in supporting growth and yield of crops. Numerous ways have been practiced to improve capabilities of alfisol such as applying inorganic fertilizers. However, some studies showed that those practices increased soil compaction, and increased soil microbiology formation (Muyassir et al. 2012; Ramli et al. 2016). These conditions might be improved by application of organic fertilizer. Organic fertilizer might be able to improve physical, chemical, and biological characteristics of soil (Debosz et al. 2001; Abu-Zahra and Tahboub 2008).

One of the important sources of organic matter is household waste such as fishbone flour and tofu slurry (Anonymous 2010; Anas 2017). There are some parts of fish that are commonly unusable such as fishbone, fish head, fishtail, etc. Therefore, they might be a promising way to utilize fish waste such as fishbone as source of

organic fertilizer to minimize environmental impact on coastal areas while at the same time might improve soil physical, chemical, and biological properties. This is mainly because fishbone contains nitrogen, phosphorus, potassium, calcium, and magnesium (Asprilliani 2010).

Utilization of fishbone as organic fertilizer depends strongly on the fish fat content. A higher fat content might affect decomposing processes. FAO has set a standard criterion for fish fertilizer, i.e., it should contain at least nitrogen of 12%, phosphorus of 8%, and potassium of 6%. Moreover, fishbone flour also has a high calcium content of 2.42-2.53%, water content of 2.55- 3.76%, protein content of 16.60-17.51%, fat content of 3.51-6.26%, and ash content of 65.61-67.94%, phosphorus content of 11.34-17%, nitrogen content of 5.0-31.25% and potassium of (3.70-7.0) (Nabil 2015). Therefore, fishbone might be utilized as a potential organic fertilizer.

Tofu slurry is a solid waste produced by tofu industry which becomes an environmental problem if the waste is not managed properly. Meanwhile, some studies reported that tofu slurry has water content of 2.69%, crude protein by 27.09%, crude fiber by 22.85%, fat by 7.37%, ash by 35.02%, calcium by 0.5%, phosphorus by 0.2%, some nitrogen and C organic (Ariliani 2010; Amtiran 2017). Therefore, tofu slurry might potentially be utilized as organic fertilizer similar to fishbone.

Utilization of both wastes as organic fertilizers depends strongly on how much dosage should be applied to improve the chemical properties of alfisol. This is mainly because various types of soil have different physical and chemical characteristics as reported by Tangketasik et al. (2012) and Hardjowigeno (2015). Some types of soil have high contents of clay with low content of some nutrients, and others have a low content of clay and moderate content of some nutrients. Excessive fertilizer dosage might result in unbalanced composition of some nutrients on the soil, which might cause a decrease in exchangeability of cation and anion, unavailable for supporting growth and yield of plant. Therefore, this research aimed to determine a proper dosage waste of fishbone and tofu slurry in improving chemical characteristics of alfisol and yield of leaf cabbage (kalian or kale) (*Brassica oleracea* var. *acephala*).

MATERIALS AND METHODS

This research was conducted in Kaniti Village, Subdistrict of Kupang Tengah, District of Kupang, East Nusa Tenggara Province, Indonesia from January to October 2019. The location of the research was dominated by alfisol. Materials of the research were fishbone flour and tofu slurry, leaf cabbage, etc.

The factorial research was designed on Randomized Complete Block Design (RCBD) with three replications. Variables of the research were kinds of organic waste (fishbone flour and tofu slurry), and various dosage of organic waste (0, 300, 400, and 500 g polybag⁻¹). Before planting, three soil samples were collected at 0-20 cm soil depth from each replicate area by using an auger and then these samples were mixed with each other to form a composite sample for each treatment. Each soil sample was mixed, then four replications were taken for measurements and analysis and the average readings were recorded. Also at the end of the experiment soil samples were collected in the same manner, as before planting, but replicates of each treatment were not mixed with each other, and analysis was done with four replicate samples, then average readings were recorded. Chemical characteristics of alfisol were measured before treatment and after harvest. Meanwhile, fresh dry weight of leaf cabbage was measured after harvesting.

Parameters measurements were total nitrogen by Kjeldahl method (AOAC 1975), available phosphate by Olsen method (Olsen 1954), exchangeable potassium by

Flame Photometer method (Hanway and Heidal 1969), and fresh dry weight of leaf cabbage.

All data measured were analyzed by Analysis of Variant (ANOVA) followed by Duncan Multiple Range Test (DMRT) 5% level.

RESULTS AND DISCUSSION

Total nitrogen

Result of the research showed that there were no interaction effects of kinds of organic waste and various dosages of organic waste on total nitrogen of alfisol. However, each of the single factors of kind of waste and dosage significantly affected total nitrogen of alfisol. Post hoc DMRT at 5% level showed that tofu slurry contained a higher content of total nitrogen than fishbone flour (Table 1). Meanwhile, application of both fertilizer by 400 and 500 g polybag⁻¹ resulted in a higher total nitrogen content as compared to application of fertilizer at 0 and 300 g polybag⁻¹.

This result showed that higher content of total nitrogen applied by tofu slurry was mainly due to organic waste of tofu slurry content was 2.72 % of total nitrogen while fishbone flour contained 2.04% of total nitrogen. Moreover, total nitrogen content of alfisol was 0.2 % (categorized low) before being treated by organic waste. As a result, by application both of organic waste, total nitrogen of alfisol increased significantly. Similarly, results were reported by some studies (Broadbent 1970; Banik 1982; Soetedjo 2018; 2019) that increased total nitrogen of soil depends strongly on nutrient content on the early condition of the soil. Nutrients content of the soil will be increased gradually by application of organic fertilizer if its nutrients were low. Moreover, an increase in nitrogen content at 500 g polybag⁻¹ of organic waste might increase number of microorganisms, improve soil microbacteria activities, improve soil porosity, decrease soil colloid, and improve cation exchangeable capacity. A number of studies (Granatstein et al. 1987; Soetedjo 2008; Beja et al. 2015) reported that increase in number and activities of soil microorganisms as result of various soil management could improve the availability of some nutrients (N, P, and K).

Available phosphor (ppm)

There was no interaction effect of kinds of organic waste and various dosages of organic waste on available phosphor of alfisol. However, the single factor treatment affected significantly the available phosphor of alfisol.

Table 2. The effect of various dosages of organic waste (fishbone flour and tofu slurry) on total nitrogen content of alfisol

Type of organic waste (T)	Total N (%)	Duncan range	Freq.
T1 (Fishbone flour)	0.25 a	0.05	2
T2 (Tofu slurry)	0.30 b	0.05	3

Note: Numbers followed by the same letter on the same column are not significantly different at Duncan Multiple Range Test of 5% level

Dosage of organic waste (T)	Total N (%)	Duncan range	Freq.
K0 (0 g polybag ⁻¹)	0.04 a	0.06	2
K1 (300 g polybag ⁻¹)	0.30 b	0.07	3
K2 (400 g polybag ⁻¹)	0.35 bc	0.07	4
K3 (500 g polybag ⁻¹)	0.41 c		

Note: Numbers followed by the same letter on the same column are not significantly different at Duncan Multiple Range Test of 5% level

Result of the research showed that tofu slurry resulted in a higher available phosphorus of alfisol than fishbone flour (Table 3). This was mainly due to a moderate available phosphorus content before study affected the ability of the soil to bind and release phosphorus to exchangeable complex of the soil. It seems that low content of available phosphorus of tofu slurry may greatly improve as compared to high content of available phosphorus of fishbone flour. Moreover, it showed that increasing dosage of organic waste up to 500 g polybag⁻¹ affected significantly the available phosphorus content of alfisol as compared to no application of organic waste (Table 4).

Higher content of available phosphorus of tofu slurry as compared to fishbone was mainly due to tofu slurry was likely easier to decompose than fishbone flour. The increasing available phosphorus of alfisol after being treated by the application of various dosages of organic waste was mainly due to decomposition process of organic waste produce humic and fluvic acids which bond tightly by amorph fraction becomes available to the soil (Chauhan et al. 1979; Mulyaningsih 2013; Amtiran 2017; Soetedjo 2018). Increasing available phosphorus might result in increasing source of energy for soil microorganisms to improve their activities in decomposing soil organic matter such as fishbone flour and tofu slurry. Some studies reported that soil microorganism activities increase gradually on well soil aeration, suitable pH, enough some nutrients, enough oxygen, and well available of carbon as source of their energy (Granatstein 1987; Hassink 1994). Some studies showed that there is a positive correlation between improving soil microorganisms and improving some nutrient availability (N, P, and K) (Hassink 1994; Fitri 2011).

Exchangeable potassium

Result of the research showed that interaction of kinds of organic waste and various dosages of organic waste did not significantly affect the exchangeable potassium of alfisol. Similarly, the same results hold for the single factor of kinds of organic waste. However, the single factor dosage of organic waste affected significantly the exchangeable potassium of alfisol. Result of Duncan Multiple Range Test (Table 5) showed that application of 400 - 500 polybag⁻¹ of organic waste produced the highest exchangeable potassium of alfisol. This was mainly due to some of potassium being lost as a result of characteristics

of potassium that moveable easily, some of this loss occurs during plant watering and some are lost through absorption by the plant. These processes significantly decreased soil exchangeable potassium. Therefore, increasing the dosage of organic waste of fishbone flour and tofu slurry might improve the availability and exchangeability of potassium on the soil (Novianantya 2016; Soetedjo 2019).

Moreover, increasing the availability of potassium is likely related to increases in nitrogen. Some studies showed that nitrogen acts synergistically with potassium, but it has an antagonistic action with phosphorus. Some studies showed that organic fertilizer could improve availability of soil microorganisms and could improve the availability of nutrients such as nitrogen, phosphorus, and potassium (Mertikawati et al. 2012; Zannah et al. 2014).

Fresh dry weight of leaf cabbage

Result of the research showed that interaction of kinds of organic waste and various dosage of organic waste and single factor treatment of kinds of organic waste did not affect significantly the fresh dry weight of leaf cabbage. These conditions significantly related to soil nutrient content in which most of the result showed that nitrogen, phosphorus, and potassium were not affected significantly by those treatments. However, the single factor of various dosage of organic waste affected significantly the fresh dry weight of leaf cabbage. This was mainly due to application of organic waste improve significantly nitrogen, phosphorus, and potassium of alfisol that are required to support growth and yield by kalia (Tables 1, 2, 3, 4, and 5).

A number of studies as reported by Soetedjo (2018; 2019) showed that improvement of total nitrogen content, available phosphorus, available potassium, C organic content, and pH resulted in improved yield of mungbean. Increasing total nitrogen content improved the growth and development during vegetative stage of plant as a result plant biomass might increase gradually. Meanwhile, increasing the availability of phosphorus stimulates development of plant to be more vigorous and might improve metabolism processes of plant along with increasing nitrogen content. Improving availability of potassium might improve resistance of plant to pests and diseases. Finally, improvement of metabolism processes supported by the availability of nutrients might affect a better yield of plant.

Table 3. The effect of fishbone flour and tofu slurry on available phosphorus content of alfisol

Type of organic waste (T)	Available P (ppm)	Duncan range	Freq.
T1 (Fishbone flour)	52.35 a	29.67	2
T2 (Tofu slurry)	79.40 b	31.14	3

Note: Numbers followed by the same letter on the same column are not significantly different at Duncan Multiple Range Test of 5% level

Table 4. The effect of various dosages of organic waste (fishbone flour and tofu slurry) on available phosphorus content of alfisol

Dosage of organic waste (T)	Available P (ppm)	Duncan range	Freq.
K0 (0 g polybag ⁻¹)	15.65 a	29.67	2
K1 (300 g polybag ⁻¹)	59.04 b	31.14	3
K2 (400 g polybag ⁻¹)	79.80 bc	32.03	4
K3 (500 g polybag ⁻¹)	109.02 c		

Note: Numbers followed by the same letter on the same column are not significantly different at Duncan Multiple Range Test of 5% level

Table 5. The effect of various dosages of organic waste (fishbone flour and tofu slurry) to exchangeable potassium content of alfisol

Dosage of organic waste (T)	Exchangeable potassium (me/100 g)	Duncan range	Freq.
K0 (0 g polybag ⁻¹)	0.48 a	0.24	2
K1 (300 g polybag ⁻¹)	0.74 b	0.25	3
K2 (400 g polybag ⁻¹)	0.88 bc	0.25	4
K3 (500 g polybag ⁻¹)	1.08 c		

Note: Numbers followed by the same letter on the same column are not significantly different at Duncan Multiple Range Test of 5% level

In conclusion, there was no interaction effect of kinds of organic waste and various dosages of organic waste on all observed parameters. However, each single factor treatment significantly affected total nitrogen content, available phosphorus, exchangeable potassium, and fresh dry weight of leaf cabbage. Tofu slurry significantly improved all nutrient content as compared to those of fishbone flour. Application of both organic waste (tofu slurry and fishbone flour) up to 500 g polybag⁻¹ of organic waste result in higher nutrient content compared to no application of organic waste. Similarly, application 500 g polybag⁻¹ of organic waste result in a higher fresh dry weight of leaf cabbage by 1.08 g.

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REFERENCES

- Abu-Zahra TR, Tahboub AB. 2008. Effect of organic matter sources on chemical properties of the soil and yield of strawberry under organic farming conditions. *World Appl Sci J* 5 (3): 383-388.
- Amtiran TDK. 2017. Pemanfaatan Limbah (Limbah Tahu dan Limbah Rumah Tangga) dengan Dosis Berbeda Terhadap Perbaikan dan Perubahan Sifat Kimia Tanah Vertisol Asal Naibonat dan Hasil Tanaman Cabai. [Hon. Thesis]. Fakultas Pertanian, Universitas Nusa Cendana. [Indonesian]
- Anas SA. 2017. Pertumbuhan dan Kadar Kalsium Tanaman Selada (*Lactuca sativa*) dengan Pemberian Pupuk Organik Cair (POC) berbahan Limbah Ampas dan Tulang Ikan Lele. [Hon. Thesis]. Fakultas Keguruan dan Ilmu Pendidikan, Universitas Muhammadiyah Surakarta. [Indonesian]
- AOAC. 1975. Official Methods of Analysis Association of Official Agricultural Chemists, 12th ed. AOAC, Washington DC.
- Aprilliani IS. 2010. Pemanfaatan Tulang Ikan Patin (*Pangasius hypophthalmus*) Pada Pembuatan Cone Es Krim. [Hon. Thesis]. Fakultas Perikanan dan Ilmu Kelautan, Institut Pertanian Bogor. [Indonesian]
- Banik SBK, Dey. 1982. Available phosphate content of an alluvial soil as influenced by inoculation of some isolate phosphate solubilizing microorganisms. *Plant Soil* 69 (3): 353-364. DOI: 10.1007/BF02372456
- Beja D, Mella WII, Soetedjo, IN P. 2015. Sistem tebas bakar dan pengaruhnya terhadap komponen fisik kimia tanah serta vegetasi pada ladang dan lahan bera (Studi Kasus di Desa Pruda Kecamatan Waiblama Kabupaten Sikka Provinsi Nusa Tenggara Timur. *Jurnal Keteknikan Pertanian* 3 (2). DOI: 10.19028/jtep.03.2.%25p [Indonesian]
- Broadbent FE. 1970. Variables affecting a value as measure of soil nitrogen availability. *Soil Sci* 10 (1): 19-29. DOI: 10.1097/00010694-197007000-00004
- Chauhan BS, Steward JWB, Paul EA. 1979. Effect of carbon additions on soil labile inorganic, organic, and microbially held phosphate. *Can J Soil Sci* 59 (4): 387-396. DOI: 10.4141/cjss79-044
- Debosz K, Petersen SO, Kure LK, Ambus P. 2001 Evaluating effects of sewage sludge and household compost on soil physical, chemical and microbiological properties. *Appl Soil Ecol* 19: 237-248. DOI: 10.1016/S0929-1393(01)00191-3
- Granatstein DM, Bezdicek DF, Cochran VL, Elliott LE, Hammel J. 1987. Long-term tillage and rotation effects on soil microbial biomass, carbon and nitrogen. *Soil Biol Fertl Soil* 5: 265-270. DOI: 10.1007/BF00256912
- Hanway J, Heidal HS. 1969. Soil Analysis and Methods Used in Iowa State College Soil Testing Laboratory. *Iowa Agric* 57: 1-31.
- Hardjowigeno SH. 2015. Ilmu Tanah. Akademika Pressindo, Jakarta. [Indonesian]
- Hassink. 1994. Effect of soil texture on the size of the microbial biomass and on the amount of C and N mineralized / unit of microbial biomass in Dutch grassland soils. *Soil Biol Biochem* 26: 1573-1581. DOI: 10.1016/0038-0717(94)90100-7
- Mertikawati I, Suyono AD, Djakasutami S. 2012. Pengaruh berbagai pupuk organik terhadap beberapa sifat fisik, kimia vertisol dan ultisol serta hasil padi gogo. Konggres Nasional VII, HITI, Bandung. [Indonesian]
- Muyassar, Supardi, Saputra I. 2012. Perubahan sifat fisik inceptisol akibat/bedaan jenis dan dosis pupuk organik. *Jurnal LENTERA* 12 (1): 150369. [Indonesian]
- Nabil M. 2015. Pemanfaatan Limbah Tulang Ikan Tuna (*Thunnus* sp.) sebagai Sumber Kalsium dengan Metode Hidrolisis Protein. [Hon. Thesis]. Program Fakultas Perikanan dan Ilmu Kelautan, Institut Pertanian Bogor. [Indonesian]
- Novianantya. 2016. Perbaikan Produksi Ubi Jalar dengan Memanfaatkan Kompos Tepung Tulang Ikan, Gliricidia dan Tithonia serta *Trichoderma* sp. [Thesis] Universitas Brawijaya. [Indonesian]
- Olsen SR, Cole EV, Watanabe FS, Dean LA. 1954. Estimation of Available P in Soil by Extraction with Sodium Bicarbonate. US Department of Agriculture, Washington DC.
- Ramli AK, Paloloang, Rajamudin, UA. 2016. Perubahan sifat fisik tanah akibat pemberian pupuk kandang dan mulsa pada /tanaman terong ungu (*Solanum melongea* L), Entisol, Tondo Palu. *Agrotekbis* 4 (2): 160-167. [Indonesian]
- Serangmo. 2015. Kajian beberapa sifat fisik tanah vertisol dan alfisol akibat pemberian tiga macam bahan dasar pupuk orga-dec serta hasil baby buncis. *Buletin Leguminosae* 12 (2): 34-40. [Indonesian]
- Soetedjo INP. 2018. Use of active powder to improve carrying capacity vertisol an alfisol on dryland farming system. Proc. of the International Conference on Food, Agriculture and Natural Resources. DOI: 10.2991/fanres-18-2018.28.
- Soetedjo IN.P. 2008. Study the use of straw paddy as mulch to improve water use efficiency and soil nutrients content. *J Dry Land Farm Syst* 16: 31-38.
- Soetedjo INP, Benggu YE, Nguru E. 2019. Use active powder of cassava in various time applications to improve carrying capacity of vertisol and alfisol on dryland farming systems. *Intl J Innov Creativity Change* 5 (3): 327-342.
- Tangketasik A, Wikarniti NM, Soniari NN, Narka IW. 2012. Kadar bahan organik tanah pada tanah sawah dan tegelan di Bali serta hubungannya dengan tekstur tanah. *Agrotrop* 2 (2): 101-107. [Indonesian]
- Zannah SA, Budiyo G, Mulyono D. 2014. Pemanfaatan bahan organik dalam perbaikan beberapa sifat tanah pasir Pantai Selatan Kulon Progo. *J Agro Sci* 3 (1): 31-40. DOI: 10.18196/pt.2015.037.31-40 [Indonesian]