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The Effects of Application of Chicken Bone Flour and Organic Matters on Phosphorus and Calcium Availability of Latosol and Growth of Maize

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Abstract.

Chicken bone is a by-product that causes bone heaps. Chicken bone contains 24-30% of Ca and 12-15% of P, so it can be used as a source of P and Ca, but not yet available. To dissolve it needs the addition of organic matter. Latosol is a soil that lacks of P and Ca. This study aims to determine the effect of application of flour from chicken bone waste and organic matters on availability of P and Ca of Latosol and growth of corn. The study was carried out in the greenhouse of UPN "Veteran" Yogyakarta Faculty of Agriculture, on January to April 2019. The study used a completely randomized design of two factors. The first factor is the dose of chicken bone flour, are without chicken bone flour (A0), chicken bone flour 2%(A1), 4% (A2), and 6% (A3). The second factors is organic matters, are without organic matter (B0), compost 3% by weight of the soil (B1), and manure 3% by weight of the soil (B2). Each treatment was replicated 3 times. Application of chicken bone flour had a significant effect in increasing pH H_2O, C-Organic, available-P, and available-Ca, plant height and plant dry weight. Application of various types of organic matter had a significant effect in increasing pH H_2O, C-Organic, available-P, available-Ca, plant height and plant dry weight. The combination of chicken bone flour and organic matters interacted each other in increasing available-Ca, while there are no interactions to affect pH H_2O, C-Organic, available-P, plant height and plant dry weight.

Keywords: chicken bone flour, organic matters, p, ca, latosol.

1. Introduction

Bone is a by product of chicken livestock. Every day slaughterhouses, food processing industries and chicken meat become processed feed products such as chicken filleting, nuggets, and chicken sausages produce chicken bones in large quantities. However, the utilization of bone has not been carried out optimally due to the low economic value of the bone, thus causing bone heaps. According to Rasyaf (2002), chicken bones contain 24-30% calcium and 12-15% phosphorus. Based on this composition, chicken bones can be used as a source of phosphorus (P) and calcium (Ca) for plants in the form of chicken bone flour.

The P element has a role in the metabolic process as well as a structural constituent of the molecule, while Ca has a role in strengthening plant tissues and supporting elongation of root cells, so the shortage of P and Ca is very influential on plant growth.

P and Ca salts contained in chicken bones are bound in soft matrix tissue consisting of organic material containing collagen fibers, and mucopolysaccharide gels (Piliang, 2004). Chicken bones as a source of mineral P and Ca, before use must be treated first. This is because bone mineral in the form of hydroxyapatite crystal ($Ca_{10}(PO_4)_6(OH)_2$) and calcium carbonate ($CaCO_3$) are components that are bound in the structure of bone collagen so that its presence is not yet available. The release of hydroxyapatite and calcium carbonate from the collagen structure of chicken bones can be immersed with an alkaline solution, one of which uses 4% NaOH with 48 hours of soaking (Rusmana et al, 2016).

Calcium hydroxyapatite is inorganic phosphorus that dissolves in an acidic solution (Jeng et al, 2008), so that P and Ca which are arranged in minerals can be released optimally it is necessary to add organic matter. Organic materials in the decomposition process will produce organic acids that can dissolve P and Ca (Rahayu, 2009). Organic matters can come from primary sources (plant tissue) in the form of compost and secondary sources (animal dung) in the form of manure. With the addition of organic matter, it is expected that the release of P and Ca from chicken bone flour can be optimal.

One of the plants that need P and Ca elements is corn, which is the most important food crop after rice and wheat. Corn (*Zea mays*) is an agricultural commodity that has a high agronomic value and is much sought after by farmers. This plant needs fertile, loose, well-drained soil, soil pH ranges from 5.6-7.0 (Syafruddin et al, 2015). For optimum growth, corn requires 100 kg P / ha and 30 kg Ca / ha (Mulyanto et al, 2015). Corn in Indonesia is grown from the lowlands to the highlands. With the shrinking of land in the lowlands, to stimulate corn production is done by utilizing land in the highlands. Latosol is a land that develops in the highlands, its spread is quite extensive in Indonesia and has the potential to grow corn. However, this land has obstacles including high acidity, causing low Ca solubility. The high Al and Fe which causes high P fixation so that its availability is low. This soil is also poor in organic matter, low cation exchange capacity, and low N, K, Ca and Mg nutrient availability. To overcome the above obstacles need to be manipulated so that Latosol can be used as a medium for growing corn. Manipulation that can be done is by giving chicken bone flour and organic matters in the form of compost and manure.

2. Method

The research was carried out in the greenhouse of the UPN "Veteran" Yogyakarta Faculty of Agriculture in January 2019 to April 2019. The analysis of soil samples was carried out at the Laboratory of the Soil Faculty of Agriculture UPN "Veteran" Yogyakarta.

The materials used in this study consisted of F1 sweet corn hybrid seeds (Sweet Boy), Latosol from Tuksongo village, Borobudur District, Magelang, chicken bones from the Slaughterhouse in Muntilan, compost, manure, distilled water, 4% of NaOH, and chemical material for analysis in the laboratory. The equipment that will be used consists of; ovens, buckets, hoes, polybags, scales, stationery and tools for laboratory analysis.

The study was conducted with a completely randomized design method (CRD) consisting of two factors. The first factor is the measurement of chicken bone flour, consisting of 4 levels (Vebriyanti, 2011) are: A0 = without chicken bone flour, A1 = chicken bone flour 2% from compost/manure equivalent to 5,88 g/polybag, A2 = 4% chicken bone flour from compost /manure equivalent to 11,76 g/polybag, A3 = 6% chicken bone flour from compost/manure equivalent to 17,64 g/polybag. The second factor is the type of organic matters, consisting of 3 levels (Sari et al., 2017) are: B0 = without organic matter, B1 = compost 3% of soil weight equivalent to 294 g/polybag, and B2 = manure 3% of the weight of the soil equivalent to 294 g/polybag. Each treatment was repeated 3 times, so 36 treatments were obtained.

This research was conducted in 2 sets of treatments, namely for the corn growing media and for the analysis of P and Ca available of Latosol. Soil preparation is done by taking Latosol soil as deep as 20 cm in the village of Tuksongo, Borobudur District. After the soil has been dried, it is pounded and sieved with a 2 mm. Then put into a polybag as much as 9 kg of absolute dry weight or equivalent to 9,8 kg of wind dry soil for corn growing media, and as much as 1 kg of wind dry weight for the analysis of P and Ca available of Latosol.

The treatment is given by mixing 3% of organic matter of soil weight which is equal to 294 grams per polybag for corn growing media and 30 grams per polybag for analysis of P and Ca available of Latosol and chicken bone flour according to treatment. Organic matters that will be used are compost and manure. Then given water until field conditions are reached. Then the mixture of soil, organic matters, and chicken bone flour were incubated for 1 month. Soil moisture is maintained in the condition of field capacity, namely by weighing polybags. The difference between the weight of the polybag at the time of weighing and the original weight is the weight of water that must be added. After incubation ends, analysis of available P and Ca available of Latosol.

As a bioassay to determine the response of cultivated plants to soil conditions and treatments, planting of corn on soils in treated polybags. The corn seeds used are F1 (Sweet Boy) hybrid corn seeds which are selected in uniform size, then proceed with planting 3 seeds per planting hole per polybag.

At the age of 7 day after planting thinning leaves one of the best plants per polybag. Observation of plant height is done once a week by measuring plant height from the base of the stem to the longest leaf tip. Plants are maintained until reaching a maximum vegetative growth marked by the appearance of male flowers at the age of 45 day after planting.

After the maximum vegetative phase is achieved, the plant dry weight measurement is carried out by cutting the plant into 5 parts, aerated, then wrapped in paper. Then put it in the oven with a temperature of 60 ° C for 72 hours, after that it was weighed.

The parameters used before treatment were pH H_2O, pH KCl, KPK, C organic, P available, Ca available. The parameters after treatment are pH H_2O, C organic, P available, Ca available for soil samples and plant height and plant dry weight for plant growth.

To determine the effect of treatment with variance (ANOVA) and to determine the comparison between treatments using Duncan Multiple Range Test (DMRT) at 5% level.

3. Research Results and Discussion

Based on the results of the chemical analysis of Latosol before handling (Table 1) submitted from Tuksongo Village, Borobudur District, Magelang, the chemical properties of Latosol were obtained. Chemical properties parameters that include pH H_2O, pH KCl, organic C, cation exchange capacity (CEC) of soil, P available, Ca available. The results of the soil analysis before implementation are the basis for discussion and approval of the land after the grant.

Table 1. Latosol Analysis Results before Treatment

Soil Properties	Values	Rate (PPT,1983)
pH		
a. H_2O	5.5	Acid
b. KCl	5.3	Acid
C-organic (%)	1.95	Low
CEC (me %)	9.47	Low
P- available (ppm)	9.05	Very low
Ca- available (%)	0.708	Very low

Table 1 shows that there are chemical fertility constraints of Latosol including the soil reaction (pH H_2O) around 5,5 which has acidity. This is because Latosols often wash base cations such as Ca, Mg, K, and Na which are replaced by Fe, H^+ and Al^{3+} (Foth, 1994). Organic C is 1,95% which is low rank. The cation exchange capacity value of this soil is 9,47 me%, this value is relatively low due to the lack of organic matter in the soil (Foth, 1994). The available P element is classified as very low at 9,05 ppm. This is because Al and Fe in acid soils are relatively high. Al and Fe can bind P so that the availability of P is reduced and not available (Damanik et al., 2010). Ca is available on this soil is very low at 1,14 me% because Ca has high mobility so it is easily leached.

Table 2. The Analysis Results of Chicken Bone Flour, Compost, and Manure.

Parameters	Chicken bone flour	Compost	Manure
C-organic (%)	15.34	18.39	15.39
P-total(%)	12.73	5.82	2.07
Ca-total(%)	23	0.19	0.53

From Table 2 it is known that the analysis of chicken bone meal shows that it has an organic C value of 15.34 %. The total P content in chicken bone flour is 12.73 % and the Ca-total value is 23 %. The C-organic content in compost is higher at 18.39 % while that of manure is 15.39 %. The total P-total in compost was 5,82 % and 2,07 % manure. The level of Ca in compost is 0.19 % and manure 0.53 %.

From table 3, the results of analysis of variance of 5% significance level can be seen that application of chicken bone flour and organic matters have a significant effect on increasing the availability of Latosol P, pH H_2O, and C-organic. This condition indicates that the chicken bone flour and organic matters application plays a role in increasing these parameters.

The application of 6% chicken bone flour from organic matter (A3) has a significantly higher H_2O pH than the treatment without chicken bone flour (A0) and chicken bone flour treatment 2% (A1), but not significantly different from the 4% chicken bone flour treatment. (A2). The treatment without chicken bone flour (A0) was not significantly different from the treatment of chicken bone flour 2% (A1). This means that chicken bone flour starting from A2 treatment significantly increases the pH (H2O) of Latosol. This is because the Ca content of chicken bone flour is 23%. Calcium contained in flour can be used as an alternative mixing, which works in increasing soil pH (Lestari, 2015). By applying chicken bone flour which has high Ca content into the soil, a chemical reaction will occur which produces OH- ions.

Table 3 The effect of chicken bone flour and organic matter application on pH H_2O, C-organic, and P-available.

Treatment	pH H_2O	C-organic (%)	P-available (ppm)
Chicken bone Flour			
A0	5.92 c	2.38 b	31.48c
A1	5.98 bc	2.46 ab	40.20b
A2	6.11 ab	2.54 ab	45.15ab
A3	6.27 a	2.59 a	51.47a
Organic matters			
B0	5.94 q	2.07 r	35.79 q
B1	6.15 p	2.79 p	44.24 p
B2	6.12 p	2.62 q	46.19 p
Interaction	(-)	(-)	(-)

Description: Average followed by the same letter in the same row or column shows there is no significant difference based on Duncan's Multiple Range Test at the level of 5%.
A0: Without chicken bone flour
A1: 2% Chicken bone flour from organic matter
A2: 4% chicken bone flour from organic matter
A3: 6% chicken bone flour from organic matter
B0: without organic matter
B1: compost 3% by weight of the soil
B2: manure 3% by weight of the soil

The application of compost organic material (B1) has a higher H2O pH value than without organic material (B0), but it is not significantly different from manure (B2). The application of organic matter can increase the pH (H_2O) of Latosol. This is in accordance with research conducted by Minardi, et al (2011) that the addition of organic matter can increase soil pH due to the exchange of anion ligands anion resulting from the decomposition of organic matter especially fulvic acid against OH- free at the exchange location so that it affects the increase in the number of OH^-.

Treatment of chicken bone meal 6% (A3) was significantly higher than without chicken bone flour, but it was not significantly different from chicken bone flour 2% (A1) and 4% (A2). The treatment without bone meal (A0) was not significantly different from chicken bone flour 2% (A1) and 4% (A2). This is because chicken bone flour is composed of extracellular matrix (organic and inorganic matrix. The organic matrix in chicken bone flour is a source of carbon. Therefore, the addition of chicken bone flour can increase C-organic (Maftuhin et al., 2015). Compost (B1) is significantly higher than that of manure (B2) and without organic matter (B0). Manure (B2) is significantly higher than without organic matter (B0). This is because the C-organic content in compost is greater at 18.39% while the C-organic content in manure is 15.39%. This is because compost is an organic fertilizer from the mineralization of several organic materials. By adding compost to the soil it will automatically increase the source of organic carbon in the soil which will ultimately increase the organic C content of the soil (Pane et al., 2018).

The application of chicken bone flour 6% from organic matter (A3) was significantly higher than chicken bone flour 2% (A1), 4% from organic material (A2) and without chicken bone flour (A0). the application of chicken bone flour 4% from organic material (A2) was not significantly different from the treatment of chicken bone flour 2% (A1), but it was significantly different from the treatment without chicken bone flour (A0), while chicken bone flour 2% was not significantly different from the treatment without chicken bone flour (A0). This means that the more chicken bone flour the higher P-available Latosol is available. Chicken bone flour has a high total P content which is valued at 42.73%. Compost (B1) is significantly higher than without organic matter (B0), but not significantly different from manure (B2). This means that the addition of organic matter plays a role in increasing P available Latosol. This is because organic matter influences the availability of P directly through the mineralization process or indirectly by assisting the release of fixed P. The process of mineralization of organic matter results in the release of P minerals (PO_4^{3-}), through the action of organic acids or chelating compounds from the decomposition. Resulting in the release of phosphates that bind with Al and Fe which are not soluble into dissolved form. Besides, organic matter will reduce phosphorus sorption because humic acid and fulvic acid function to protect sesquioxide by blocking the exchange site. Then, the addition of organic matter can activate the decomposition process of native soil organic matter and form a phospho-humate and phospho-fulvate complex that can be exchanged and is more available to plants, because phosphate is absorbed in organic matter weakly (Atmojo, 2003)

Table 4. Effect of chicken bone flour application and organic matters on Ca-available (me%)

Organic matters	Chicken bone flour dose				Average
	A0	A1	A2	A3	
B0	1.24b q	1.47b q	3.04b p	2.15b pq	1.98
B1	2.40 ab r	3.71 a q	4.49a pq	5.33a p	3.98
B2	2.46a qr	2.35b r	3.50ab q	4.87a p	3.26
Average	2.03	2.47	3.68	4.12	(+)

Description: Average followed by the same letter in the same row or column shows there is no significant difference based on Duncan's Multiple Range Test at the level of 5%.
A0: Without chicken bone flour
A1: 2% Chicken bone flour from organic matter
A2: 4% chicken bone flour from organic matter
A3: 6% chicken bone flour from organic matter
B0: without organic matter
B1: compost 3% by weight of the soil
B2: manure 3% by weight of the soil

From the results of variance it can be seen that both the treatment of chicken bone flour and the provision of organic material have a significant effect on the increase in Ca-available soil and the interaction between the two. This means that chicken bone flour and organic matter play a significant role in increasing levels of Ca-available soil. In the best combination of chicken bone flour and organic matter the treatment occurs in chicken bone flour 6% from organic matter and compost 3% (A3B1), but not significantly different from the combination of 6% chicken bone flour treatment from organic matter and 3% manure (A3B2). The higher the dose of chicken bone flour that is given along with organic matter, the higher the Ca content available in the soil.

The addition of organic matter helps in dissolving Ca in chicken bone flour which is still in the form of calcium hydroxyapatite so that it is not yet available. Calcium hydroxyapatite can dissolve in acidic solutions. Organic matter produces organic acids such as citric acid, oxalate, humic, and fulvic which can release these bonds so that Ca becomes available (Jeng et al., 2008). The addition of Ca from chicken bone flour can increase the availability of energy sources for microorganisms in organic matter to carry out biological activities. The interaction between chicken bone flour and organic matter which is given in increasing Ca available shows that the two factors tested influence each other.

Table 5. The effect of chicken bone flour and organic matter application on plant growth

Treatment	Plant height	plant dry weight
Chicken bone Flour		
A0	168.44b	55.59b
A1	173.44ab	66.58ab
A2	176.89ab	66.7ab
A3	182.11a	72.72a
Organic matters		
B0	166.83q	46.93 q
B1	179.92p	72.04 p
B2	178.92p	77.25 p
Interaction	(-)	(-)

Description: Average followed by the same letter in the same row or column shows there is no significant difference based on Duncan's Multiple Range Test at the level of 5%.
A0: Without chicken bone flour
A1: 2% Chicken bone flour from organic matter
A2: 4% chicken bone flour from organic matter
A3: 6% chicken bone flour from organic matter
B0: without organic matter
B1: compost 3% by weight of the soil
B2: manure 3% by weight of the soil

From the results of variance can be seen that the provision of chicken bone flour and organic matter significantly affected the height of corn plants and plant dry weight, but there was no interaction between the two.

In Table 5 it can be seen that the application of 6% chicken bone flour from organic matter (A3) is significantly higher than without chicken bone flour, but it is not significantly different from chicken bone flour 2% (A1) and 4% from organic material (A2). In the application of organic matter, compost (B1) is the best treatment although it is not significantly different from manure. This is due to an increase in the availability of P (Table 3) and Ca (Table 4) and organic C (Table 3) in the soil which results in better plant growth. According to Sutanto (2005), the element P has a role in the metabolic process and as a structural constituent of molecules, Ca has a role in strengthening plant tissues and supporting elongation of root cells, while organic matter as an energy source for soil microorganisms can release nutrients for plants. Increasing the availability of nutrients in the soil can increase metabolic processes so that plant growth is good.

Increased dry weight can also be caused due to an increase in available P (Table 3) due to treatment. This is because P plays an important role in vegetative and generative plant growth. The P element plays a role in the formation of energy sources for every living cell, thus these nutrients increase photosynthesis. Photosynthesis which is respected with various organic compounds formed will be stored in plant stem tissue, in this case used for enlargement of stems and leaves (Marschner, 1995). Besides, an increase in plant dry weight can also be caused by an increase in available Ca (Table 4) due to treatment. Ca has a good effect on the development of stems, root tips, and root hairs. Ca is mainly needed in the shooting area in cell division. The element Ca also plays a role in the synthesis of new cell walls (Caldwell and Hwang in Marschner, 1995).

4. Conclusion

a. The application of chicken bone flour fertilizer has a significant effect on increasing the pH of H_2O, C organic, available P, available Ca of Latosol, and plant growth in the form of plant height and dry weight of corn plants.

b. The application of organic matters significantly increases the pH H_2O, C organic, available P, available Ca, and plant growth in the form of plant height and plant dry weight.

c. The application of chicken bone flour and organic matter interacts in increasing available Ca and there is no interaction with pH H_2O, organic C, P is available Latosol and plant growth in the form of plant height and plant dry weight.

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