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RESEARCH ARTICLE

ZEOLITE AND ORGANIC FERTILIZER APPLICATION TO THE IMPROVEMENT OF AVAILABLE P AND SOYBEAN *(Glycine max* L) SEED YIELD IN ALFISOLS

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ABSTRACT

The problem of low soybean yield on Alfisol is low soil fertility. The availability of P is often a constraint because the P element on the Alfisol soil is strongly bound by Al and Fe elements. Efforts to increase the availability of P element in Alfisols can be done by ameliorant of zeolite and organic fertilizer. This study objective was determined of zeolite and organic fertilizer in increasing of available P and soybean yield on Alfisols. A field experiment was conducted using Randomized Block Design consisting of two factors: a dose of zeolite (0 ton/ha, 2.5 ton/ha, and 5 ton/ha), and organic fertilizer (no organic fertilizer, quail, and cow manure 5 ton/ha respectively). The results showed that zeolite 5 ton/ha is the highest effect on the increasing of available P, pH, organic matter, and saturation base as big as 5.19, 5.21, 24.03, and 21.55 respectively, while cow manure is improved to organic matter and saturation base 26.17, and 21.38% respectively.The combination of zeolite and cow manure 5 ton/ha gave the highest yield on the number of pods (101 pods/plants), and the 1000 seeds weight is 153 g.

Keywords: Alfisols, Organic fertilizers, Soybean, Zeolite

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INTRODUCTION

The low soybean production was due to decreasing of fertile land caused by continuous use of inorganic fertilizer (Sinuraya, Barus, & Hasanah, 2015). Based on data from the Central Bureau of Statistics (Badan Pusat Statistik Indonesia) in 2015, soybean import in Indonesia was reached 2,260,000 tons per year. The efforts to increase soybean production in Indonesia to suppress imports were done through intensification, extensification, diversification, and rehabilitation. Intensification efforts are utilize the marginal land such as Alfisols (Yuniati, 2004). The research by Minardi (2002) concludes that alfisols chemically content very low criteria because of high acidity, poor pH buffering capacity, very low Cation Exchange Capacity (CEC), very low available P, low available K, low total Nitrogen, and low organic matter. The low availability of P elements in Alfisols was due to the high saturation of micro elements such as Al, and Fe which are the sources of acidity which cause low pH. The existence of high Al and Fe will absorb or bind P in the form of Al-P and Fe-P, those form unavailable for the plant, so plants lack P elements that interfere with its growth process (Abolfazli, Forghani, &

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Norouzi, 2012). Manure is a fertilizer derived from cattle stable waste mixed with food scraps and urine which contains of N, P, and K nutrients which can be used to improve soil fertility (Novizan, 2004). Selection of the manure type that will be made into organic material can be determined by the content of their nutrients. The value of the nutrient content of cow manure was relatively better than chicken manure (Pujisiswanto & Pangaribuan, 2008). Zeolite as a soil enhancer is a mineral of a hydrogenated aluminosilicate compound with a hollow structure and contains interchangeable alkali cations. Jaskunas, Subacius, & Rasa (2015). The zeolite ability as a molecular absorber and ion exchanger can be used in agriculture, to improve fertilizer efficiency, increase CEC soil, increase availability of Ca, K, and P ions and decrease Al content (Gaol, Hanum, & Sitanggang, 2014).

MATERIALS AND METHODS

This research was field experiment which was conducted on Alfisol dry land, Sukosari village, Jumantono, Indonesia (7^0 37' 49.9" S dan 110^0 56' 54.4" E). Laboratory analysis was done in Soil Chemistry and Soil Fertility Laboratory Faculty of Agriculture, Sebelas Maret University.

The study by experiment was conducted by using a Complete Randomized Block Design factorial with two factors. The factors are 3 doses of zeolite (0, 2.5, and 5 tons/ha) and 3 kinds of organic fertilizer (no organic fertilizer, quail, and cow manure) which each of them by dose 5 and 5 ton/ha. Each of combination treatment replicated 3 times so there are 27 experimental units. The study implementation are the preparation of plants by selecting good soybean seeds, blocks were made with a distance between blocks 30 cm and plot size 2m x 1m, zeolite and manure incubation was done 3 days before soybean planting. Planting of soybeans with a spacing of 20cm x 25cm. Plant maintenance includes watering, disease and pest control, and replacements. Harvesting is done on the final generative that is in the ripening period when the seed pods begin yellow. Laboratory analysis was conducted to analyze the fertilizer, initial and final soil. The observed variables including of pH (using 1: 2.5), organic materials (Walkey and Black), available P (Bray), base saturation (Ammonium Acetate Extract) (Tan, 2005) total pods number and weight of 1000 seeds. Data were analyzed by analysis of variance (ANOVA), if between the treatments or among the combination treatments significantly different continued by Duncan Multiple Range Test (DMRT) 0.05.

RESULTS AND DISCUSSION

Initial Soil Characteristic

Soil fertility level in Jumantono area was low category indicated by 1.93% organic content (low), pH H_2O 5.4 (acid), available P 4.45 ppm (very low) and base saturation 14.32% (very low). The low organic matter is one of the main constraints for soil productivity (Joghan, Ghalavand, Aghaalikhani, Gholamhoseini, & Dolatabadian, 2010). Provision of zeolite and organic fertilizer is necessary to increase the chemical fertility so that plants can grow well and high production so profitable.

Characteristics of Zeolite and Organic Fertilizer

The organic content of quail manure is 17.56 % with total N 1.32% and in cow manure 19.94% with total N 1.40%. So, C/N two kinds of those fertilizers are 13.30 and 14.24. According to Cordovil, Coutinho, Goss, & Cabral (2005) that low C/N ratios mineralize sufficient N to satisfy plant growth, otherwise, high C/N ratio indicates immobilization then the nutrient content is slightly available for

plants. The CEC value in the zeolite is 128.20me/100g so this meets the criteria of technical requirement of the Minister of Agriculture Regulation Number 70 (CEC of zeolite at least 120me/100g).

Soil pH

Zeolite fertilization 5 tons/ha was increased the pH 5.21% compared than without zeolite (Table 1). This explanation of that is zeolite undergo silicate hydrolysis produce ions OH^- resulting in increased soil pH (Juliana, Sariffudin, & Jamilah, 2015). Soil pH was greatly affected the availability of P in the soil, under the acid conditions P compound in the form of Al-P and Fe-P. The results of Lahuddin, Sitorus, & Yanti (2010) stated that if there is an increase in pH, toxic elements such as Al and Fe was reduced.

By correlation test between soil pH and basic saturation there as a positive correlation (r = 0.56, p = 0.00). This means that the increasing of pH increasing basic saturation too. Low base saturation means high H-ion content=that can be used as an indicator soil fertility. Very fertile soil if the base saturation more than 80%.

Available P

The use of zeolite significantly effects to the available P (p = 0.04) (Table 1). An increasing of available P 5.19% by 5 ton/ha zeolite dose because of the increasing of soil pH. Soil pH greatly affects to the available P in the soil under acid conditions P compound in the form of Fe-P (Novriani, 2010). According to Syamsiyah, Suhardjo, & Andriyani (2009) zeolite can increase P uptake by changing the condition of unavailable P to be available P. Zeolites are not classified as fertilizers so zeolite administration should be followed by appropriate fertilizer dosage as a nutrient provider. Correlation between soil pH and available P is positive, rather close (r = 0.43, p = 0.02), that means increasing of soil pH, increasing of available P too.

Organic Matter

Zeolite 2.5 and 5 ton/ha significantly effect to the increasing of organic matter (Table 3). Zeolite 5 tons/ha was increased the organic matter by 24.03% compared than no zeolite treatment. This is in accordance with the statement of Al-Jabri (2009) that the administration of ameliorants in acid soils can increase organic matter. Without the administration of zeolite, the soil temperature around roots increases dramatically, which results in the rapid oxidation of organic matter and its availability in the soil cannot be maintained any longer.

Cow manure treatment of 5 ton/ha has highest organic material value, that the increasing of organic matter 26.17% compared than without organic fertilizer. The addition of organic fertilizer can increase the organic matter content in the soil. This is in accordance with the statement of Eghball (2002), that the application of organic fertilizers can lead to increasing levels of nutrients and organic matter of the soil.

Organic matter positively correlated to the P^- available (r = 0.61, p = 0.00), that mean increasing in organic matter will be followed by an increasing in available P. This occurs because the soil organic matter binds Al and Fe so that both are no longer binding P (Jayadi, Rasyid, & Ahmad, 2017). Organic matter is a soil enhancer that releases nutrients needed by plants such as N, P and S (Utami & Handayani, 2003).

Base Saturation

Zeolite administration was significantly effected (p = 0.02) to the base saturation (Table 1). Addition of zeolite can increase the amount of K, Ca, Mg and Na in the soil so increase CEC. Zeolite administration was

increased 21.55% basic saturation compared than no zeolite.

Increasing base saturation was caused by increasing of interchangeable cations (Ca-dd, Mg-dd, K-dd, Na-dd) in the soil. These cations will be absorbed in the soil complex due to the zeolites effect. This is consistent with the statement of Gaol et al. (2014)that the ability of zeolites as molecular absorbers and ion exchangers can be used in agriculture, to increase the availability of Ca, K, and P ions.

Provision of organic fertilizer has an effect on the base saturation. Administration of cow manures of 5 tons/ha gave an increase of 21.38% compared than without organic fertilizer. Organic fertilizer is a potential source of organic material with its presence available in the environment and affordable. The chemical function of organic fertilizer is to provide macro and micro nutrients. Organic fertilizers can increase the soil base saturation and can form complex compounds with metal ions such as Al, Fe, and Mn (Siregar & Hartatik, 2010).

Number of soybean pods

The interaction between the dose of zeolite and manure type had significantly effect (p = 0.00) to the total pod content (Figure 3). The number of pod increases with increasing zeolite dose, 56 (no zeolite) to the highest is 74 by 5 ton/ha. Quail treatment higher than zeolite, even though added zeolite 2.5 ton/ha there is no significantly increase than quail only. The number of pod increases significantly if to the quail added zeolite 5 tons/ha (obtain 74). Fertilization by cow manure significantly increases to the pod number (the increasing higher than by zeolite and quail). The highest pod number obtained by cow fertilizer added by zeolite 5 tons/ha (101 pods per plant). This is in line with the Samuli, Karimuna, & Sabaruddin (2012) that cow manure in addition to improving soil conditions is also able to supply the nutrients needed by plants. The production component was determined by the pods number and the weight of pod content. The higher component value, the higher the productivity. The correlation test affirms that pods total were positively correlated with soil organic matter (r = 0.59, p = 0.00). This is because the organic matter from manure can increase the number of soybean pods (Ramadhani, Silvina, & Armaini, 2016).

Table 1. Effect of zeolite on pH, available P, Organic Material, and Bases Saturation

Dose of Zeolite (tons/ha)	pH	available P (Ppm)	Organic Materials (%)	Base Saturation (%)
0	5.75a	4.62a	2.58a	52.79a
2.5	5.78a	4.74ab	2.98b	56.22
5	6.05b	4.86b	3.2b	64.17b

The numbers followed by the same letters show no significant difference in the DMRT 0.05

Table 2. Influence of Organic Fertilizer Type to the Organic Material, and Bases Saturation

Type of Organic Fertilizer (ton/ha)	Organic Materials (%)	Base Saturation (%)
Without Fertilizers	2.56a	51.39a
Quail 5 tons/ha	2.98b	59.42b
Cow 5 tons/ha	3.23b	62.38b

The numbers followed by the same letters show no significant difference in the DMRT 0.05

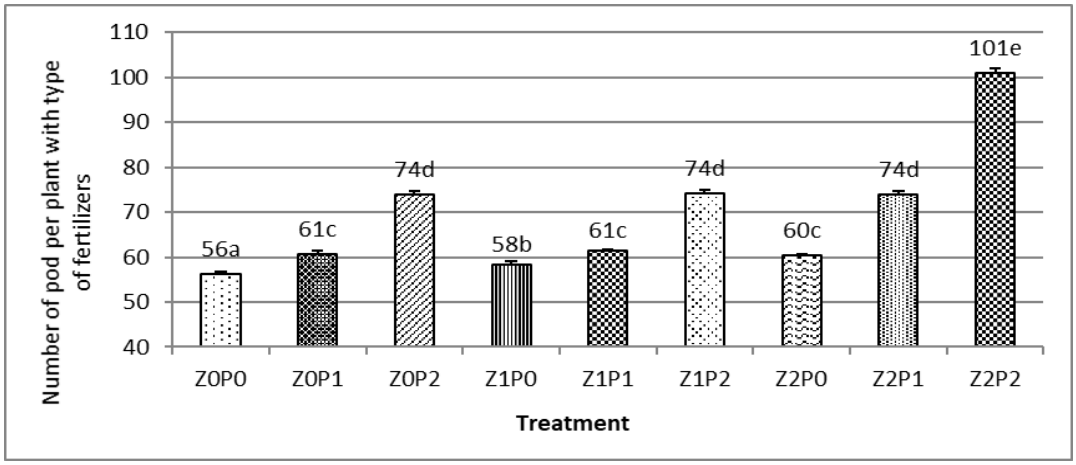

Figure 3. Effect of Interaction of Zeolite Dose and Organic Fertilizer Type on the Pods Number (The numbers followed by the same letters show no significant difference in the DMRT test of 5%)

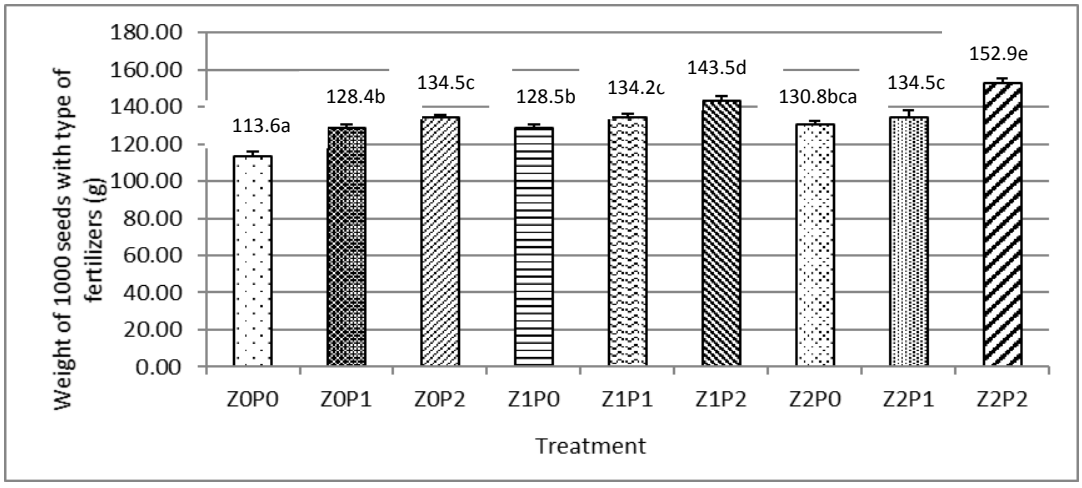

Figure 4. Effect of Interaction of Zeolite Dose and Organic Fertilizer Type on 1000 Seeds Weight (The numbers followed by the same letters shown no significant difference in the DMRT test of 5%)

The weight of 1000 seeds

Figure 4 indicates that the administration of zeolites and organic fertilizers has a significant effect on seed weight. The weight of 1000 seeds increases with increasing zeolite dose, 113.58 g (no zeolite) to the highest is 130.83 g by 5 ton/ha. Fertilizer by quail manure higher than zeolite, even though added zeolite 5 ton/ha there is no significantly increase than quail only. Cow manure significantly increases the weight of 1000 seeds which is the increasing higher than by zeolite and quail). The highest weight of 1000 seeds obtained by cow fertilizer added by zeolite 5 ton/ha, 153g. Cow manure has high N, P, K nutrients that can be absorbed by plants in sufficient quantities (Nurlisan, Rasyad, & Yoseva, 2014). The correlation test results affirms that the 1000 seeds weight was positively correlated with the pods number ($r = 0.84$, $p = 0.00$) and available P ($r = 0.48$, $p = 0.01$). The pods formed on the plant will be filled by photosinates which will then form the seeds. The more the number of pods and

seeds per plant then greater the seeds weight (Harun & Ammar, 2001). P Element plays a role in increasing the filling of soybean seeds so that with the administration of high P will increase the weight of soybean seeds.

CONCLUSIONS

1. The interaction between the administration of zeolite and cow manure of 5 tons/ha gives the highest yield in the pods total is 101 pods/plants and weight of 1000 seeds is 153 g.
2. Administration of zeolite was influenced by increasing of available P of 5.19%, pH of 5.21%, organic matter of 24.03%, and base saturation of 21.55%.

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