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Zeolite Oil Palm Compost-Based Organomineral Fertilizer for Shallot Agronomic Performances and N Substitution

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ABSTRACT

Application of organomineral fertilizer (OMF), which is the product of the inclusion of zeolite and palm oil compost in urea needs to be studied to determine its appropriate dose for the growth and yield of shallots and N substitution. This pot experiment was conducted from October to December 2020 at the Teaching and Research Field of Agriculture Faculty and consisted of five treatments arranged in a completely randomized design with five replications. The treatments were (1) 1.0 g urea, (2) 0.5 g urea + 1.15 g OMF, (3) 0.5 g urea + 2.30 g OMF, (4) 0.5 g urea + 3.45 g OMF, and (5) 0.5 g urea + 4.60 g OMF. The results revealed that combined application of 0.5 g urea + 4.60 g OMF resulted in the highest values of plant height (30.60 cm), leaf amount (30.90), tuber fresh weight per clump (30.90 g), tuber dry weight per clump (24.3 g), and tuber diameter (16.25 mm). The incorporation of zeolite and palm oil compost in urea reduced the application rate of urea up to 50% without reducing the growth and yield of shallot. Thus, N fertilizer use can be enhanced if urea is co-applied with zeolite and palm oil compost.

Keywords : organic fertilizer, anorganik fertilizer, integrated nutrient management, slow release fertilizer

INTRODUCTION

Shallot (*Allium ascalonicum* L.) is categorized as one of the national strategic horticultural commodities in Indonesia. Demand for this commodity is very high, especially for household and industrial needs. However, domestic shallot production is not sufficient to meet all the demand, so imports of this commodity are inevitable. Annually, as much as 14% of the domestic needs were covered by imports due to low domestic shallot production. As an illustration, the national average shallot yield is about 10 tons ha⁻¹, while the potential yield can reach about 20 tons ha⁻¹ (Indonesia Statistical Agency, 2019). For this reason, it is necessary to increase shallot yield, including through fertilization.

Application of high doses of chemical N fertilizers, especially urea, is commonly practiced for shallot because this crop is highly responsive to

fertilizer application especially N and very sensitive to deficiency of N than most vegetables due to its short, shallow, and branchless root system (Brewster, 1994). In addition, urea acts as a source of readily available nutrient especially N; therefore, under adequate N supply, crop physiological processes showed a marked increase which is conceivably measured by vegetative growth attributes (Rezaei & Kafi, 2013).

Loss of N such as nitrate leaching (NO₃), nitrous oxide (N₂O) emissions, and ammonia (NH₃) volatility usually follows the excessive use of urea (Souza *et al.*, 2019; de Paula Pereira *et al.*, 2021). Among these environmental problems, the eutrophication of water bodies and the increase in greenhouse gasses, due to NO₂ and NO emission is considered the prominent impact (Saha *et al.*, 2021).

An alternative to the sole application of chemical N fertilizers is using organic fertilizers, especially those from decaying plant and animal waste. However, organic fertilizers have disadvantages in

terms of relatively low nutrient content and a mismatch between their nutrient supply and crop demand due to slow nutrient release rate (Chin *et al.*, 2018; Antille *et al.*, 2014). With these characteristics, higher amounts of organic fertilizer are generally applied to meet the nutritional requirement for maximum plant growth and yield (Roba, 2018).

One solution to this challenge is to modify urea characteristic of high water-solubility to a new fertilizer with a controlled release rate of N into the soil (Beigh *et al.*, 2020), including through encapsulation (Trenkel, 2010). Urea which has been encapsulated with organic matter and/or organic soil enhancers (such as zeolite) into solid form is called organomineral fertilizer (OMF) (Smith *et al.*, 2020). Dall'Orsoletta *et al.* (2017) reported that the use of organic materials such as poultry manure to encapsulate N fertilizers could control N loss. Beigh *et al.* (2020) also stated that encapsulation increases urea efficiency and synchronizes fertilizer N release in accordance with plant nutrient needs. Souri *et al.* (2018) suggested that as an encapsulant, the selected organic materials should be chemically capable of absorbing and trapping cations such as high amounts of ammonium, as a result of the hydrolysis of urea.

The specific organic residue potential to be used to encapsulate urea is oil palm empty fruit bunch (OPEFB) compost. This compost originated from the oil palm processing waste that has been decomposed through the composting process. It can be used as a source of organic matter for plants (Warsito *et al.*, 2016) as well as an organic encapsulant. In addition to organic waste, Dubey & Mailapalli (2019) reported that zeolite could be used as an encapsulating or coating material in developing controlled release fertilizers (CRF) due to low cost and its inherent cation exchange property that effectively controls the nutrient release rate.

Previous studies reported that application of encapsulated urea with vermicompost and zeolite at 45.71 g pot⁻¹ (12 tons ha⁻¹) increased green onion growth and yield attributes and reduced the application rate of urea up to 50% (Siregar, 2020). Similarly, Silitonga (2021) reported that application of encapsulated urea with Azolla compost and zeolite at 844 kg ha⁻¹ resulted in the highest green onion fresh weight.

From various literature reviews, studies on the application of encapsulated urea with OPEFB compost and zeolite in shallots have not been widely carried out. Therefore, this work aimed to determine the maximum rate of encapsulated urea with OPEFB compost and zeolite for the growth and yield of shallots.

MATERIALS AND METHODS

Experiment Site and Research Design

The research was conducted from October to December 2020 at the Teaching and Research Field of Agriculture Faculty located at the outskirts of Bengkulu University campus, Bengkulu, Indonesia, with an altitude of about 15 m above sea level (asl) and Ultisos soil type (Soil Research Institute, 2009). Based on meteorological data collected from the nearest Bengkulu Climatology Station, the average daily temperature during the field study in September, October and November 2020 was 26.8 °C, 26.6 °C and 26.7 °C, respectively. The average humidity ranges from 84.4%, 84.6% and 86.3% and the average light intensity is 65.7%, 53.3% and 35.1%.

This pot experiment used top soil collected from the Teaching and Research Field. The top soil was prepared by clearing weeds and hoeing the soil to a depth of 20 cm. The soil is then dried in the sun for two days to lower the moisture content. After drying, the soil was sieved using a 1 cm sieve for removing the litter when taking soil in the field. As much as 10 kg of the top soil was then used to fill the plastic pot.

Soil chemical properties were determined before the experiment (1 week before planting). Soil pH was measured using pH meter at ratio 1:2.5 of soil and distilled water, soil total nitrogen using Kjeldahl Method, exchangeable Al using titration method after extertaion of 1N KCl, organic-C using Walkly and Black Method, cation exchange capacity (CEC) using 1N ammonium acetate extraction, and soil bulk density using ring sample method. The results of soil analyses were as follows: pH H₂O (4.86; acid), C-organic (2.08%; medium), N (0.2%; medium), C/N (10.4; medium), P₂O₅ Bray I (5.46 ppm; very low), K-dd (0.32 cmol kg⁻¹; very low), and soil bulk density (0.98 g cm⁻³; good). N content of OMF was 10.08%.

The results of soil analysis before planting revealed that the soil was classified as acidic with a pH value of 4.86. The most suitable soil pH for shallot is pH with an acidity level ranging from 6.0 to 6.8. Therefore, before planting, 24.53 g polybag⁻¹ of dolomite lime was added to achieve a pH of 6.0 which was suitable for the growth and development of shallot.

This study had five treatments managed in a completely randomized design with five replications; therefore, 25 experimental units were used. The treatments were (1) 1.0 g urea per 10 kg of soil or 200 kg urea ha⁻¹, (2) 0.5 g urea + 1.15 g OMF per 10 kg of soil or 100 kg urea ha⁻¹+225 kg OMF ha⁻¹),

(3) 0.5 g urea + 2.30 g OMF per 10 kg of soil or 100 kg urea ha⁻¹ + 450 kg OMF ha⁻¹), (4) 0.5 g urea + 3.45 g OMF per 10 kg of soil or 100 kg urea ha⁻¹ + 675 kg OMF ha⁻¹, and (5) 0.5 g urea + 4.60 g OMF per 10 kg of soil or 100 kg urea ha⁻¹ + 900 kg OMF ha⁻¹.

Organomineral fertilizer preparation and crop management

The stage of preparing OMF began with milling OPEFB compost, urea, and zeolite. The mashed material was then sieved through a 60 mesh sieve and mixed evenly in a ratio of 2:1:1. The mixture was added with 2% polyvinyl alcohol as an adhesive, manually molded into a tablet form, then air-dried before use.

The Bima Brebes shallot variety obtained from shallot bulb breeders, Brebes Regency, Central Java was used in this study. Before planting, the top third of the seedling was cut in order to accelerate shoot growth. The seeds were soaked in 80% mankozeb fungicide solution for 5 minutes, the air-dried for 5 minutes, and then planted. The seedlings were planted upright in the plastic pot with the incision facing up.

Basic fertilizers (half dose of urea according to the treatments, 0.75 TSP per pot (150 kg TSP ha⁻¹), and 0.51 KCl per pot (100 kg KCl ha⁻¹) were applied three days before planting. Another half dose of urea was applied at 21 days after planting (DAP). OMF was given three days before planting at a dose according to the treatment. Fertilization is done by making grooves with a distance of 7-10 cm from the planting hole and putting the fertilizer into the whole as deep as 5 cm. Other crop management was done as necessary according to the standard procedures for shallot management.

Harvesting was done by pulling the whole plants carefully at the age of 65 days after planting when the leaves had turned yellow, the tubers had emerged to the soil surface, and the tuber layer turned into a red color.

Data collection was made on growth attributes including plant height, leaf number per clump, shoot fresh and dry weight, and yield and its components including bulb diameter, number of bulb per clump, bulb fresh weight per clump, and bulb dry weight per clump.

Statistical analysis

Before performing analysis of variance (ANOVA), all data were tested for the normality with the Shapiro-Wilk normality test ($P < 0.05$). After passing the test, the data was analyzed using analysis of variance to evaluate the effect of OMF

dose. When the results were significant ($P < 0.05$), the Least Significant Different at 5% level was used to distinguish the mean value between the treatments. All statistical analysis were carried out using SPSS version 21.0 for Windows (SPSS Inc.). All graphical presentations and the adjustment of the correlation coefficients were conducted with Sigma Plot version 12.5 for Windows (Systat Inc.).

RESULTS AND DISCUSSION

Plant height and leaf number are classified as the main indicators of plant growth. The rise in the values of these attributes indicates a normal early shallot growth. Figure 1 and 2 demonstrate changes in the two growth attributes at 2 to 6 weeks after planting (WAP) as influenced by zeolite oil palm compost-based organomineral (OMF). As illustrated in Fig. 1 and 2, plant height and leaf number increase every week irrespective of treatments applied. However, plant height and leaf number in soil treated exclusively with urea at 2 – 4 WAP increased more rapidly than those in soil treated with OMF. After 4 WAP, the increase in plant height and leaf number was constant. According to Gardner *et al.* (2017), the availability of sufficient N plays a role in accelerating the plant growth, especially stems and leaves. The rapid availability of this nutrient was due to the faster release characteristic of urea than OMF. This characteristic caused its nutrient more available than OMF for early growth of shallot. The slow release characteristic of OMF had been reported by previous studies (Latifah *et al.*, 2017; Mumbach *et al.*, 2019).

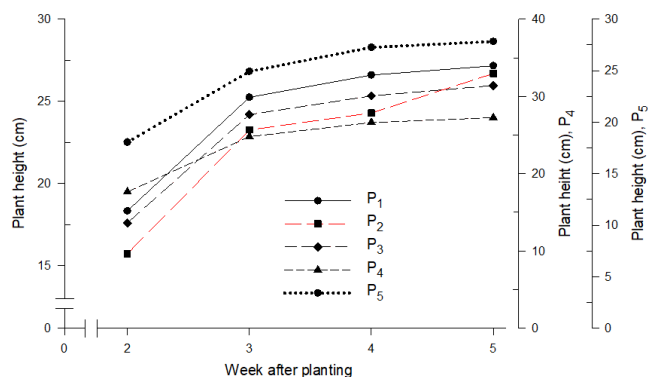


Figure 1. The development of plant height at 2 to 5 weeks after planting (WAP) as influenced by zeolite oil palm compost-based organomineral (OMF).

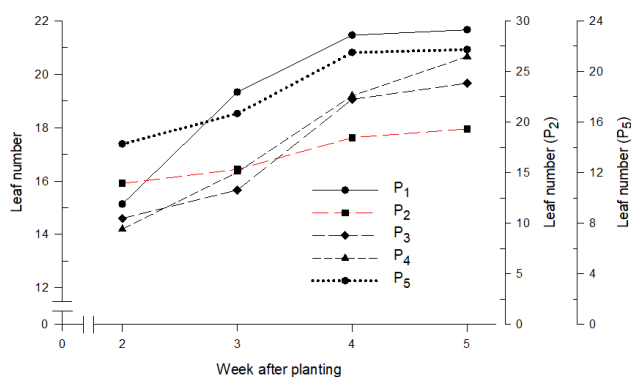


Figure 2. The development of leaf number at 2 to 5 weeks after planting (WAP) as influenced by zeolite oil palm compost-based organomineral (OMF).

The analysis of variance demonstrates that OMF application markedly influenced plant height, leaf number, fresh tuber weight, dry tuber weight, tuber diameter, but no impact on leaf fresh weight, leaf dry weight, and tuber number (Table 1). The integrated application of urea and OMF at 4.60 g or 900 kg ha⁻¹ increased the height of shallot and comparable with the height of plant treated with the exclusive application of urea. The highest dose resulted in the plant height of 30.6 cm, which was still within the description range of the Bima variety's (25-44 cm). The lowest plant height (23.90 – 24.30 cm) was achieved at application rate of between 1.15 - 2.30 g OMF per 10 per 10 kg of soil or 225 - 450 kg OMF ha⁻¹. This increase in plant height was attributed to the rise in N availability from urea to plants with the use of zeolite (Latifah *et al.*, 2017). Latifah *et al.* (2017) further stated that N availabil-

ity from OMF was improved through temporary retention on the exchange sites of the clinoptilolite zeolite.

In addition to increasing plant height, the addition of OMF also increased leaf number (Table 1). The number of leaves can act as an indicator of plant development. Plants depend primarily on leaves as photosynthetic organs. Consequently, if the number of leaves production is low, so is the quantity of photosynthate produced (Gastal & Lemaire, 2002). OMF application at 4.60 g or 900 kg ha⁻¹ induced the highest leaf number of 30.90, which was comparable with the leaf number produced by the exclusive application of urea. Whereas that at 1.15 g or 225 kg ha⁻¹ produced the lowest (only 20.86 leaves). These results implied that the combined application of OMF with a half dose of urea did not show any difference in the growth of shallot with the application of a full dose of urea. Thus, the incorporation of zeolite and oil palm compost in urea reduced the application rate of urea up to 50% without reducing the growth shallot. The similar results were also reported by Siregar (2020) and Silitonga (2021) in green onion.

Adequate nutrition and water and balance with a high leaf number will accelerate photosynthesis, producing more photosynthate as energy to support cell division and enlargement. Consequently, shallot yield will increase, indicated by bulb diameter, bulb fresh weight per clump, and bulb dry weight per clump (Tabel2). Similar to other shallot growth attributes, OMF application at a rate of 4.60 g or 900 kg ha⁻¹ (P₅) gave the highest bulb diameter (16.25 mm), the highest bulb fresh weight per clump (30.90 g), and the highest bulb dry weight per clump (24.30 g).

Table 1. Effect of OMF application rate on the growth components of shallot.

Treatments	Plant height (cm)	Leaf number	Leaf fresh	Leaf dry
			weight	weight
			(g)	(g)
P ₁ (100 % of urea dose)	31,40 a	27,13 ab	10,56	1,68
P ₂ (50% of urea dose + 25% of OMF dose)	24,30 b	20,86 c	10,87	1,63
P ₃ (50% of urea dose + 50% of OMF dose)	23,90 b	26,83 ab	11,58	1,63
P ₄ (50% of urea dose + 75% of OMF dose)	30,10 a	25,06 ab	11,74	1,65
P ₅ (50% of urea dose + 100% of OMF dose)	30,60 a	30,90 a	12,75	1,81

Note : P₁ (1.0 g urea per 10 kg of soil or 200 kg urea ha⁻¹), P₂ (0.5 g urea + 1.15 g OMF per 10 kg of soil or 100 kg urea ha⁻¹ + 225 kg OMF ha⁻¹), P₃ (0.5 g urea + 2.30 g OMF per 10 kg of soil or 100 kg urea ha⁻¹ + 450 kg OMF ha⁻¹), P₄ (0.5 g urea + 3.45 g OMF per 10 kg of soil or 100 kg urea ha⁻¹ + 675 kg OMF ha⁻¹), and P₅ (0.5 g urea + 4.60 g OMF per 10 kg of soil or 100 kg urea ha⁻¹ + 900 kg OMF ha⁻¹).

The highest bulb yield in P₅ treatment might be due to OMF providing longer nutrient (especially N) availability and resisting nutrient (especially N) from leaching, as stated by Haq *et al.*, (2012). Haq *et al* (2012) further reported that the solubility of urea coated with starch-acrylic was 25 times longer than that of urea without coating. According to Hartatik *et al.*, (2020) the inclusion of zeolite in urea made urea in OMF have a lower level of solubility than urea without zeolite inclusion. Meanwhile, Gardner *et al.* (2017) stated that higher photosynthesis leads to more food storage. The existence of oil palm compost fraction in OMF caused the fertile and loose soil, which promoted the formation of larger bulb. These results also explained that the combined application of OMF with a half dose of urea did not show any difference in shallot yield with the addition of a full dose of urea. Thus, the incorporation of zeolite and oil palm compost in urea reduced the application rate of urea up to 50% without reducing the yield of shallot. The similar results were also reported by Siregar (2020)

and Silitonga (2021) in green onion.
Correlation between Growth and Yield Components of Shallot

Correlation analysis was carried out on growth and yield variables. The value of the correlation coefficient (r) between these components are presented in Table 3. Positive correlation indicates that the observed characters have a close relationship. The correlation coefficient expresses the strength of the relationship between variables. The correlation coefficients ranged between 0.02 and 0.99. A correlation coefficient of zero indicates no relationship between the two correlated variables. When the correlation value approaches +1, an improvement in one variable will follow another. The correlation analysis revealed a positive correlation between growth and shallot yield attributes (Table 3). Growth attributes especially leaf was positively related to tuber number, fresh and dry tuber weight with r values of 0.65, 0.99 and 0.77, respectively. Thus, with an increase in leaf number, the fresh weight of shallot bulbs also enlarged.

Table 2. Effect of OMF application rate on the yield components of shallot

Treatments	Tuber number per clump	Fresh weight of tuber per clump (g)	Dry weight of tuber per clump (g)	Tuber diameter (mm)
P ₁ (100 % of urea dose)	6,93	19,5 b	14,25 b	12,85 b
P ₂ (50% of urea dose + 25% of OMF dose)	6,33	19,73 b	13,33 b	12,57 b
P ₃ (50% of urea dose + 50% of OMF dose)	6,26	18,7 b	13,36 b	13,30 b
P ₄ (50% of urea dose + 75% of OMF dose)	6,73	22,31 b	16,24 b	13,99 ab
P ₅ (50% of urea dose + 100% of OMF dose)	6,53	30,90 a	24,3 a	16,25 a

Note : P₁ (1.0 g urea per 10 kg of soil or 200 kg urea ha⁻¹), P₂ (0.5 g urea + 1.15 g OMF per 10 kg of soil or 100 kg urea ha⁻¹ + 225 kg OMF ha⁻¹), P₃ (0.5 g urea + 2.30 g OMF per 10 kg of soil or 100 kg urea ha⁻¹ + 450 kg OMF ha⁻¹), P₄ (0.5 g urea + 3.45 g OMF per 10 kg of soil or 100 kg urea ha⁻¹ + 675 kg OMF ha⁻¹), and P₅ (0.5 g urea + 4.60 g OMF per 10 kg of soil or 100 kg urea ha⁻¹ + 900 kg OMF ha⁻¹). The mean followed by the same letter in the same column showed not significantly different in the 5% LSD test.

Table 3. Correlation analysis between variables

Variable	PH	LN	LFW	LDW	BN	BFW	BDW	BD
PH	1							
LN	0,737**	1						
LFW	0.050ns	0.034ns	1					
LDW	0.021ns	0.092ns	0.932**	1				
BN	0.066ns	0.244ns	0.623**	0.703**	1			
BFW	0.199ns	0.312ns	0.765**	0.747**	0.651**	1		
BDW	0.239ns	0.331ns	0.721**	0.696**	0.571**	0.987**	1	
BD	0.269ns	0.208ns	0.499*	0.428*	0.079ns	0.709**	0.768**	1

Note: PH= plant height, LN= leaf number, LFW= Leaf fresh weight, LDW= Leaf dry weight, BN= Bulb number, BFW= Bulb fresh weight, BDW= Bulb dry weight, BD= Bulb diameter, ns= non-significant difference, * = Significant difference at the 5% probability level, and **= Significant difference at the 1% probability level

CONCLUSION

The utilization of OMF formulated from encapsulated urea with oil palm compost and zeolite increased plant height and number of leaf for the growth and fresh weight of tubers per clump, dry weight of tuber per clump, and tuber diameter for the yield of shallots. The combined application of 0.5 g urea + 4.60 g OMF gave rise to the highest values of shallot growth and yield. The combined application of OMF with a half dose of urea did not show any difference with the application of a full dose of urea. Thus, the incorporation of zeolite and palm oil compost in urea reduced the application rate of urea up to 50% without reducing the growth and yield of shallot.

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