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Research Article

Plant Growth-promoting Potential of Oil Palm Boiler Ash-based Organomineral Fertilizer for Green Mustard Cultivation Under Reduced Urea Dose in Ultisols

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Abstract.
This study aims to demonstrate the capability of Oil Palm Boiler Ash (OPBA)-based organomineral fertilizer (OMF) to maintain the growth, green biomass yield, and N uptake of green mustard under a reduced N application rate. This research was carried out from March to May 2021 in a research area in Bengkulu City with a Randomly Complete Block Design scheme and three replications. The treatment consisted of P_0 = control (without OMF or urea), P_1 = 200 kg urea ha^{-1}, P_2 = 325 kg OMF ha^{--1} + 50 kg urea ha^{--1}, P_3 = 650 kg OMF ha^{--1} + 50 kg urea ha^{--1}, P_4 = 975 kg OMF ha^{--1} + 50 kg urea ha^{--1}, and P_5 = 1300 kg OMF ha^{--1} + 50 kg urea ha^{--1}. The results showed that the growth and green biomass yield increased as the application rate of OMF increased. Treatment of P_5 produced the highest growth, green biomass yield, and N uptake, equivalent to P_2 treatment. The green biomass yield at P5 was 161% higher than that at P_0. Therefore, OMF has the potential to promote the agronomic performances of green mustard under 50% reduced N dose in Ultisols.

Keywords: slow release fertilizer, nutrient management, oil palm waste, organic pellet fertilizer, green mustard

1. Introduction

Green mustard belongs to the Brassicaceae family and is categorized as leafy vegetable along with pakchoy and kailan. These plants are popular as daily diet in Indonesia. Due to the leaves as its economical plant organ, green mustard plant needs more nitrogen fertilizer during the plant growth and development. In addition, green mustard is also short harvest commodity, the situation that pushes farmers to use high amount of inorganic nitrogen fertilizer.

Some sources of nitrogen for plants come from applying organic and inorganic fertilizers. Urea is a common nitrogen source in agriculture. Many studies showed that urea is used un-efficiently in plants and causes environmental problems [1]. For some decades, and it is still growing, methods to reduce negative impacts of inorganic fertilizers are updated such as go back to organic farming [2, 3] or LEISA system [4].

The accuracy of N fertilization is important considering that the Brassica family has a lower Nitrogen Use Efficiency (NUE) (only 33%) compared to cereal plants [5]. Agricultural plant production, including mustard greens, requires high amounts of N fertilizer [6] so improving the efficiency of N use in plants is an important key in increasing green mustard production.

The previous studies have led to the development of new fertilizers, which are commonly referred to as fertilizers with increased efficiency [7] such as organomineral fertilizers (OMF) and organic fertilizer based on sapropel [8].

Organomineral fertilizer is obtained through co-formulation of one or more inorganic fertilizers with one or more organic fertilizers and organic soil amendments into solid form. Oil palm boiler ash (OPBA) is organic source that could be used to produce OMF formula. Oil palm boiler ash presence abundant in Indonesia since this country is in the first position of oil palm production acreage in the world. The waste from Palm Kernel Shell (PKS), the biomass for OPBA, is predicted to be 15 million tons in 2020 to 2030 [9]. The usage of OPBA as single treatment is proved to increase the quality of chrysanthemum [10]. Meanwhile, boiler ash as part of organic mixture increased nutrient availability [11]. In 2017 [12] reported that N-based OMF can increase the efficiency of nutrient absorption, plant photosynthesis, and the presence of N in the plant life cycle compared to conventional N-based fertilizer. However, the information on the usage of boiler ash with nitrogen encapsulation is not available. Determining effective N fertilizer application doses is important in developing OMF for inorganic fertilizer supplementation. This research was conducted to determine the application dose of OMF-OPBA to increase growth, biomass yield of green mustard plants, N uptake, and N use efficiency.

2. Materials and Methods

The research was carried out as a field experiment in Bengkulu City, Indonesia. The treatment in this research was organomineral fertilizer made from encapsulation of urea with oil palm boiler ash and zeolite. All three ingredients were mixed and sieved using a 60 mesh sieve. Polyvinyl alcohol was used as binder. The mixture was then pressed to form tablet OPBA fertilizer. N content of the OPBA was 11.20%.

Six doses treatments in this experiment were P0 = 0kg ha^{-1}, P1 = 200kg urea ha^{-1}, P2 = 325kg OMF ha^{-1}, P3= 650kg OMF ha^{-1}, P4 = 975kg OMF ha^{-1}, P5 = 1300kg OMF ha^{-1}. Treatments P2 to P5 were subjected to 100 kg ha^{-1} of urea fertilizer (50% of the recommended dose), while TSP and KCl fertilizer were given at 150kg ha^{-1} and 100kg ha^{-1} respectively.

2.1. Field setting and plant establishment

The experimental area was cleared from weeds and other plant remains. The planting beds were set in 1.2 m x 1.2 m each bed with a distance of 50 cm between the beds. Drainage lines were set to allow excess water out of the planting beds.

The seeds of green mustard var. Tosakan were germinated in seedling trays using a medium mix of soil and chicken manure. The seedlings were maintained under shaded for 21 days before set out in the field.

Basic fertilizer (150 kg TSP ha-1 and 100 kg KCl ha-1) was applied to each treatment. Treatments of P2 to P5 were given 100 kg/ha of urea (50% of the recommended dose). Urea fertilizer is given twice at planting time and at 2 weeks after planting, while OMF was drenched at the same time of transplanting.

2.2. Data collection

Plant height and number of leaves were carried out at 7, 14, 21, 28 and 35 DAP, leaf area; plant fresh weight; plant fresh weight per plot; shoot fresh weight; leaf fresh weight; plant dry weight; root fresh weight; root dry weight; leaf N content; plant N uptake; and Nitrogen Use Efficiency (NUE).

The data obtained were analyzed statistically with Analysis of Variance (Anova) using the F test 5%. The Least Significant Different test were used to analyze mean comparison between treatments.

3. Result and Discussion

Testing of Anova showed that the treatments affected all observed variables except for root fresh weight. Further analysis using LSD test for growth and yield components was shown on Table 1 and Table 2 where an increase in the dose of OMF was followed by an increase in all plant growth variables.

TABLE 1: Mean values of plant height, number of leaves, and leaf area of green mustard.

Treatment	Plant height (cm)	Leaves number	Leaf area (cm^2)
P0	30.47c	7.33c	488.03d
P1	41.95a	15.67a	582.81 cd
P2	31.75bc	9.33b	643.83bcd
P3	35.19 bc	10.67b	736.36bc
P4	37.32ab	12.34a	928.53a
P5	43.84a	12.33a	778.08b

The number of leaves of green mustard tends to be in conjunction to the plant height, but not to the leaf area (Table 1). Leaf is photosynthetic organ of plant and source of energy for plant growth and development. Chlorophyll formation was found higher when plants utilize more Nitrogen [13]. Leaf area did not always related to the number of leaves since every area of leaf sheath contribute to the total plant leaf area [14].

TABLE 2: Mean values of root fresh weight, root dry weight, and plant dry weight of green mustard.

Treatment	Root fresh weight (g)	Root dry weight (g)	Plant dry weight (g)
P0	2.04 a	0.87 d	8.83 b
P1	3.83 a	1.76 a	15.07 a
P2	2.69 a	1.03cd	9.58 b
P3	3.10 a	1.37bc	14.17 a
P4	3.09 a	1.58ab	14.51 a
P5	3.69 a	1.77 a	14.68 a

This study revealed that high doses of OMF, those were 975kg and 1300kg, had the same effect as the treatment of urea (P1) both for root and plant dry weight as well as plant height (Table 2). This means that application of OMF at a dose of 975 - 1300 kg/ha and urea at a dose of 200 kg/ha have the same effectiveness in increasing plant growth. Similar result was found on celery growth and yield which was fertilized using

OMF tablet formula. There was no significant different between OMF formula and urea granule formula in enhancing celery growth and development [15].

TABLE 3: Mean values of plant fresh weight per plot, plant fresh weight, and leaf fresh weight of green mustard.

Treatment	Plant fresh weight per plot (g)	Plant fresh weight (g)	Leaf fresh weight (g)
P0	2964.72 e	82.35 e	47.35 f
P1	7795.80 a	216.55 a	187.89 b
P2	3601.60 d	100.04 d	86.15 e
P3	5557.20 c	154.37 c	147.81 d
P4	7262.76 b	201.74 b	164.00 c
P5	7741.20 a	215.03 a	201.91 a

TABLE 4: Mean values of N content, N uptake, and NUE of green mustard.

Treatment	N content (%)	N uptake (%)	NUE
P0	30.47c	7.33c	
P1	41.95a	15.67a	10.13 a
P2	31.75bc	9.33b	3.37 d
P3	35.19 bc	10.67b	6.86 bc
P4	37.32ab	12.34a	7.59 b
P5	43.84a	12.33a	6.09 c

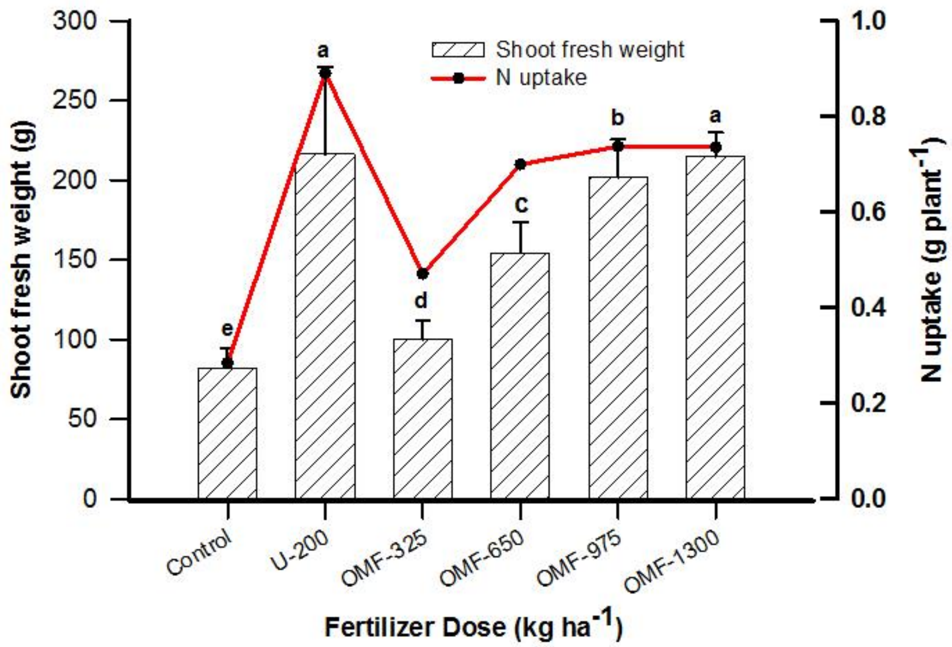

Figure 1: Plant fresh weight and its relation to N uptake under different dose of OMF.

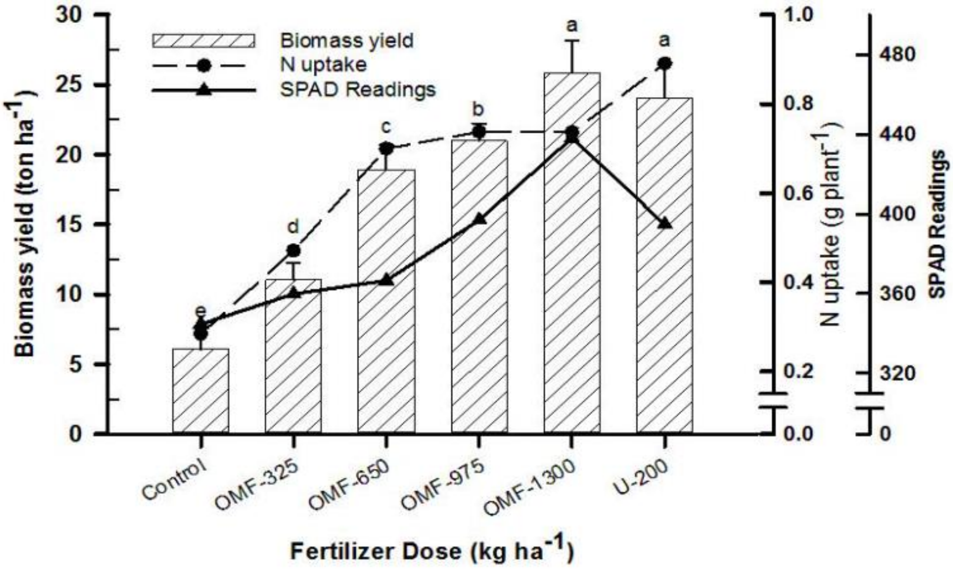

Figure 2: Relationship between plant biomass, N uptake, and leaves greenness under different dose of OMF.

The yield variables showed that OMF at different doses had a significant effect on biomass yield (leaf fresh weight, plant fresh weight, and plant fresh weight per plot). Increasing the dose of OMF resulted in increasing these three variables (Table 3). In relation with N uptake, the plant fresh weight was in line to the uptake of nitrogen (Figure 1). The OMF treatment at 1300 kg/ha produced the highest fresh leaf weight (201.91 g), which is 7.5% higher than control urea 200 kg/ha. In contrast to fresh weight per plant and fresh weight of plants per plot, plants treated with 1300kg/ha produced the highest values for these two variables, but was not significantly different from conventional urea treatment. This showed that OMF produces biomass equivalent to that treated with conventional urea and better than other treatments. Similar results were reported by other researchers that OMF doses also had a significant effect on increasing the biomass yield of mustard leaves [16].

An increase in root biomass and supported by an adequate supply of nutrients, especially N, then had an effect on N nutrient uptake. Dosing OMF had a significant effect on leaf N content (Table 4). The lowest leaf N content was observed in the treatment without fertilizer (P0), while the leaf N content when applying urea 200 kg/ha (P1) was not significantly different from the OMF dose of 325 kg/ha (P2), 650 kg/ha (P3), 975 kg/ha (P4), and 1300 kg/ha (P5) (Figure 2). This indicates that urea encapsulated in oil palm boiler ash as OMF is prospective as slow release fertilizer. Boiler ash is considered appropriate because it fulfills the four conditions [17] in choosing the packaging material e.i. 1) cheap price, 2) biodegradable and renewable, 3) non-toxic, and 4) available in abundance. With its porous nature and large surface area, boiler ash can absorb and retain (retention) NO_3^- and NH_4+ from urea mineralization so that urea can release N elements into the soil gradually, controlled and in sync with plant needs.

Based on the dry weight of the plant and the N content, the N uptake value was produced. The results showed that giving OMF doses had a significant effect on N uptake. Increasing the OMF dose increased N uptake. but it is not significantly different from P3, P4, and P5. Nutrient uptake is a reflection of the availability of nutrients in the soil. High N uptake causes the amount of N available for protein synthesis in growth to be higher [13]. The higher the N uptake, the growth of mustard greens increases, which is shown, among other things, by increasing plant biomass yields. The existence of the same response pattern between N uptake and mustard biomass yield to increasing OMF doses indicates a positive correlation between the two variables. On their research with rice [18] reported that there was a very significant positive correlation between N uptake in straw and grain biomass and grain yield in the 19 upland rice genotypes tested.

4. Conclusion

Application organomineral fertilizer at a dose of 1300 kg/ha was able to provide the highest growth, biomass yield of mustard plants and N uptake, equivalent to giving urea at a dose of 200 kg/ha, with an increase of 59.81% compared to without fertilizer for biomass yield. This dose of organomineral fertilizer was the best for fertilizing N on mustard greens in soil with a moderate total N content (0.26%).

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