Rice (Oryza sativa L.) response to application of rice husk biochar-coated urea fertilizer

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Abstract. Rice husk charcoal produced from pyrolysis is widely tested as a coating material for slow release urea. Rice husk charcoal-coated urea is part of a smart fertilizer strategy for more sustainable dan resilient green rice production. This study was conducted to evaluate the effects of coated urea (CU) application at some dosage for specific West Nusa Tenggara Province environment. The pot experiment was arranged in Randomized Block Design with five treatment of coated urea at 25%, 50%, 75%, and 100% of 250 kg ha⁻¹ rate that compared to control at 100% non-coated urea. The Experiment conducted at Narmada Research Station of Assessment Institute of Agricultural Technology (AIAT) of West Nusa Tenggara Province – Indonesia from January to April 2020. The results showed that the CU application did not significantly increase rice yield and harvest index. The tiller number and percentage of filled spikelets tend to increase in proportion to the CU application rate. Although there were no significant differences in plant growth and yield component, yield at 75% CU treatment increased at about 14.03% higher than the control which was indicating possible efficient use of rice husk charcoal-coated urea fertilizer.

1. Introduction
Rice is the staple food in Indonesia with total production of 84 million tons in 2019 [1] and within the same period, rice culture produced a massive amount of agricultural waste which was about 50% of total rice production [2]. In the fact, most rice straw in Indonesia were burned during peak harvest season to catch next planting season. That practices not only contribute to higher glasshouse emissions but also lead to unsustainable agriculture practices. Only few amounts of rice straw are processed into fermented straw for cattle feeding, or it composted into organic fertilizer, and the husk is potential to produced biochar through pyrolysis process. In previous study, application of rice husk biochar on rainfed rice was improved harvest index of three rice varieties from 0.66 to 0.76 [3]. More studies reported the benefit of rice husk biochar as soil ameliorant to improve rice yield.

According to recent report by Jia et al. [4], rice straw biochar is one of potential materials for biochar-coated urea. Based on grey correlation analysis, rice straw biochar is practical and suitable for coated urea due to its high specific surface area, hydrophilic oxygen-containing functional group, and low pH. Coated urea is slow released N fertilizer to delay N availability for plant uptake post-application, while reduced N lost through ammonia volatilization [5]. In turn it will increase N use efficiency [6] and rice yield [7]. In addition, it will lower the impact on the environment by reducing greenhouse gas emissions [8].
Urea is the most important nitrogenous fertilizer in form of white crystalline solid that contains 46% of nitrogen. As a straight fertilizer, urea is considered an economic nitrogen source that functions to boost growth and yield of rice. Effect of urea fertilizer application varies depending on methods, timing, precise quantities, cultivation techniques, rice varieties and local environment. There are some tools developed to guide appropriate N fertilizer application such as site-specific N management [9] or integrated soil-crop system management [10]. However, there is limited guidance on application of modified urea fertilizer such as coated urea for slow released fertilizer. It appears that assessment on application of coated urea, especially when using local resources, needs to be done for each specific environment. This study was aimed to find out response of rice to coated urea application at some rates for specific environments of West Lombok.

2. Materials and methods
The experiment was conducted at Narmada Research Station (S 8°35’51” x E 116°13’8” at 154 m above sea level) of Assessment Institute for Agricultural Technology (AIAT) of West Nusa Tenggara Province, Indonesia, from January to April 2020. The set-up of pot experiment was a randomized complete-block design with nine replications for five treatments of coated urea at 25%, 50%, 75%, and 100% of 250 kg ha⁻¹ rate that compared to control at 100% non-coated urea. The rice husk biochar was ground and sieve (20-mesh) before blend to urea fertilizer produced by PT. Petrokimia Gresik to produce coated urea.

Three seedlings of Inpari 37 rice variety were transplanted into the pot at 15 days after sowing. The Soil type in the pot was sandy loam (sand 66%, silt 20%, clay 14%), and soil pH (a soil:water ratio of 1:5) was 6.45. The cation exchange capacity of the top soil (0-10 cm) was low at 0.07 cmol/kg. C-organic and macronutrients such as N-total, P₂O₅, K, Na, Ca and Mg was 0.30%, 0.17%, 9.45 ppm, 0.33 cmol/kg, 0.46 cmol/kg, 6.33 cmol/kg, and 1.09 cmol/kg respectively. Fertilizer application was N-P-K at recommended rate using Urea (250 kg ha⁻¹) and NPK-phonska (100 kg ha⁻¹). First fertilizer at 15 days after planting (DAP) was half of urea and all of NPK-phonska, and the second fertilizer was another half of urea. The crop was maintained under flooded conditions during experiment with no additional water for a week prior harvest.

Growth and yield component for plant height, tiller number, panicle number, percentage of productive tiller, dry weight above ground biomass, spikelet per hill, spikelet per panicle, percentage of filled spikelet, and 1000 grain weight data were collected at physiological maturity stage. Recorded data were analyzed statistically for variance different using STAR 2.0.1 (Statistic Tools for Agricultural Research). Difference among the treatment means was compared using Duncan multiple range test (DMRT) at 5% probability level [11].

3. Results and discussion
The effect of coated urea application was significantly affecting plant growth as shown in Table 1. The growth parameter that significantly affected was tiller number and panicle number per hill, however, plant height, percentage of productive tiller, and dry weight of above ground biomass were not significantly different between treatments.

In general, plant growth was better at higher dosage of urea. The highest number of tillers was produced at 100% dosage of coated urea at 33.56 tiller which was similar other treatment except at the lowest rate at 25% of dosage. Although the tiller number was similar between 100% coated and non-coated urea, the increase number of tillers was about 17.24% higher when coated urea was applied. Furthermore, tiller number in 100% non-coated urea was close to value in 50-75% coated urea. Trend of the data in panicle number was similar to the tiller number where value in 100% coated urea was consistently higher than 100% non-coated urea.

These data indicate the efficient use of slow released nitrogen in coated urea to support plant growth. There was linier correlation between dry weight biomass to tiller number and spikelet number (Fig. 1). The slow release in coated urea is continuously available N inadequate amount throughout growing season, and synchronized to crop requirement pattern in the field [12]. Efficient use of N will
be improved root structure [13], increased activity of nitrate reductase and glutamine synthetase, and delayed leaf senescence in late growth stages [12].

**Table 1.** Effect of coated urea application at some rates on plant height, tiller number, panicle number, percentage of productive tiller, and dry weight above ground biomass of Inpari 37 rice variety

| Treatment                  | Plant height (cm) | Tiller number | Panicle number | Percentage of productive tiller | Dry weight biomass (g plant⁻¹) |
|----------------------------|-------------------|---------------|----------------|---------------------------------|--------------------------------|
| Control (non-coated) 100%  | 106.44            | 27.22ab       | 26.00ab        | 94.40                           | 122.98                         |
| Coated urea 100%           | 107.89            | 33.56a        | 32.89a         | 97.56                           | 141.71                         |
| Coated urea 75%            | 105.33            | 28.56a        | 27.00ab        | 93.84                           | 136.46                         |
| Coated urea 50%            | 108.33            | 28.11ab       | 27.11ab        | 96.52                           | 124.67                         |
| Coated urea 25%            | 109.00            | 28.11b        | 25.89b         | 96.17                           | 134.20                         |
| CV (%)                     | 5.95              | 31.82*        | 33.75**        | 4.32                            | 29.61                          |

*Values followed by different letter in the same column were significantly different at P≤0.05 (*) or highly significant different at P≤0.01 (**) probability level according to DMTR test.

**Figure 1.** Linear correlation between dry weight biomass and tiller number (a) and spikelet number (b) of Inpari 37 rice variety

In this pot experiment, plant height of Inpari 37 was ranged between 105 cm to 109 cm. That height was close to average height of Inpari 37 at about 111 cm [14]. However, there was potential height of Inpari 37 to 136.7 cm when grown on-field environment as the comparison to pot experiment. Descriptive analysis of Inpari 37 grown in pot and field can be seen in Fig. 1. Dense population in close spacing of on-field rice was likely affecting higher plant height, percentage of productive tiller, percentage of filled spikelet, and 1000 grain weight. In contrast, rice grown in pot produced higher tiller number, panicle number, biomass weight, and total spikelet due to less competition in wider spacing.

Spikelet and grain weight was significantly affected by coated urea treatment, while the spikelet number per panicle was similar between treatments. The highest spikelet number per hill produced in application of 100% coated urea. In the same dosage, non-coated urea produced 14.78% lower number of spikelets. However, this common urea has high number of spikelets per panicle but the 1000 grain weight was the lowest. With percentage of filled spikelet at 52.69%, 100% non-coated urea was likely having high unfilled spikelet and less optimal grain development. Furthermore, most values in 100% non-coated urea were between values in 50% - 75% coated urea treatment.
Table 2. Effect of coated urea application at some rates on spikelet number, percentage of filled spikelet, and 100 grain weight of Inpari 37 rice variety

| Treatment          | Spikelet hill | Spikelet panicle | Filled spikelet (%) | 1000 grain weight (g) |
|--------------------|---------------|------------------|---------------------|-----------------------|
| Control (uncoated) | 3990.89ab     | 151.76           | 52.69b              | 19.87a                |
| Coated urea 100%   | 4682.89a      | 146.60           | 45.36b              | 21.64ab               |
| Coated urea 75%    | 4061.00ab     | 151.75           | 61.45ab             | 22.43ab               |
| Coated urea 50%    | 3549.33ab     | 132.47           | 56.07b              | 23.10ab               |
| Coated urea 25%    | 4125.56ab     | 150.39           | 43.62b              | 23.19ab               |
| CV (%)             | 34.40*        | 13.08            | 22.92**             | 12.18*                |

1) Values followed by different letter in the same column were significantly different at P≤0.05 (*) or high significant different at P≤0.01 (**) probability level according to DMTR test.

4. Conclusion
In conclusion, growth and yield of rice tend to increase in proportion of fertilizer rate. Although there were no significant differences in plant growth and yield component, coated urea at 75% of dosage (250 kg/ha) was increased the yield at about 14.03% higher than the control in which indicating possible efficient use of rice husk charcoal-coated urea fertilizer.

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Contributorship
Authors in this paper were contribute equally in conception and design of research experiment, data collection, analysis, data interpretation, drafting the article, paper revision and final approval.

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