



The Agronomic Performance of Rice Seeds Coated with N-Enriched Organomineral Fertilizer

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Authors' contributions

This work was carried out in collaboration between both authors. Author JP designed the study, technical aspects of seed coating, constructs the outline and wrote the first draft of the manuscripts. Author AAKS performed the statistical analysis and managed the literature searches for seed treatments. Both authors read and approved the final manuscript.

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ABSTRACT

Seed coating with silicate rock-basis organomineral fertilizer (OMF) was proposed as an appropriate method to improve the productivity and profitability of rice farming. This research aimed to evaluate the growth and yield components of rice grown from coated seeds with N-enriched OMF. The coated seeds of two rice varieties, i.e., Trisakti (T) and Nutri Zinc (NZ) were tested in separate experimental sets. A randomized block design was applied for each experiment with the treatment consisting of non-coated seed (NCS), coated seeds containing 4.5% N (CS-1), 7.8% N (CS-2), and 9.0% N (CS-3) in 3 blocks. The coating material of OMF was a mixture of 90% basaltic rock and 10% rock phosphate, enriched with N accordingly to the treatment; and the weight ratio of seed to OMF was about 1:16. The coated seeds were planted directly to the ground (without sowing and transplanting steps), and only NCS was fertilized with NPK (15:15:15) equivalent to 300 kg. ha⁻¹. Results reveal that there was no significant difference in growth components (number of tillers and the weight of top-biomass) and quality of rice grains (weight of 1,000 grains) for the plants of coated and non-coated seeds. Enriching OMF with N up to 9% consistently improved the total yield of rice. Therefore, seed coating with OMF containing about 9% N was an appropriate method to optimize rice yield.

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1. INTRODUCTION

Seed industries have applied seed coating technology for decades aimed mainly to improve the productivity and profitability of farming. Most of the seed coatings, however, were designed to protect the seeds from the attack of soil-borne pathogens [1]. Consequently, the used coating materials contained various pesticides including fungicides and rodenticides [2,3,4], with supplementary plant nutrients [5], or zeolite [6]. Because exposing toxic pesticides to farming land can develop pest resistance and create various negative-ecological effects, the use of synthetic pesticides as the seed coating material should be avoided [7]. This is a major challenge for seed industries to develop coated seeds with more environmentally friendly materials.

Referring to the above case, we developed the coated seed of rice with local abundance and environmentally friendly materials, which was silicate rock-based-organomineral fertilizer (OMF), by applying different approach. Improving the productivity and profitability of farming was not by protecting the seeds or plants from the attack of pests and pathogens, but by maximizing the healthiness and resistance of plants to biotic and abiotic stresses using OMF. Practically, the plants were supplied with proportional essential and functional (Si) nutrients in form of OMF.

The components of OMF were mainly the finely ground basaltic and some phosphatic rocks, enriched with nitrogen substances. The OMF was designed as the main source of all plant-essential nutrients to support the optimum plant growth and yield and supply a functional nutrient of silicate (Si) to maximize the resistance of plants to biotic and abiotic stresses [8,9,10] without additional fertilizer. In addition, the OMF may also act as a remediate agent for disordered plant-growing media such as acidic [11] or salt-affected [12] soils.

Rice is a non-legume plant requiring a large amount of nitrogen (N) for optimum growth [13]. On the other hand, enriching the coating material with a high concentration of N fertilizers (e.g., urea) may create a technical problem in the

coating process. It was because covering the seeds with materials containing a high concentration of N may toxify and stop the coated seed germination. In addition, the thickness of coated material may limit oxygen availability for the seed-embryonic tissue [14] delaying the germination process. Thus, the appropriate concentration of N as well as the thickness and suitable procedure of coating process must be found.

Results of a greenhouse assessment for the performance of the coated seeds of rice with OMF [15] showed that adding N to the coating material up to 2.5% was not sufficient to gain optimum growth and yield. Following up on that finding, this present research was intended to find out an appropriate method of adding enough N to the coating material (OMF), so that the plants from the coated seeds grow and yield optimally without additional N fertilizer.

The main objective of this research was to find out the most suitable amount of N added to the coating material (OMF), by evaluating the growth and yield components of the OMF-coated seeds compared to those of the non-coated seeds.

2. MATERIALS AND METHODS

2.1 Coating Materials and Process

The coating material of OMF and its chemical composition were like that used in the previous research [15]. The OMF consisted of basaltic rocks (90%) and rock phosphate (10%). Those rocks were mixed and finely ground with a horizontal-ball mill machine for 30 minutes producing very fine particles having a median diameter (D_{50}) of 22 μm . Three types of coated seeds were prepared with different concentrations of N in the coating material (see Table 1). The binding solution for the first layer was Tapioca starch solution (1%), and for the second layer was urea + Orrin. Besides binding material, Orrin was functioned also as a supplementary nutrient source and a converting agent of urea ($(\text{NH}_2)_2\text{CO}$) to NH_4^+ limiting volatilization of N during the coating process. The rice seeds of Trisakti (T) and Nutri Zinc (ZN) varieties were used in this experiment.

Table 1. The composition of seed coating material used in this experiment

Type of Coated Seed	Seeds (g)	OMF (g)	Binding solution	
			1 st layer	2 nd layer
CS-1	250	4,000	Starch sol. (1%)	50 g urea + 150 mL Orrin ⁾
CS-2	250	4,000	Starch sol. (1%)	75 g urea + 150 mL Orrin
CS-3	250	4,000	Starch sol. (1%)	100 g urea + 150 mL Orrin

⁾ The trademark of a liquid-silicate rock fertilizer with the matrix solution of citric acid, pH 3.5

The process of seed coating used a 150-L stainless steel rotary drum that was horizontally rotated at the speed of 80 - 100 rpm. The seeds (250 g) were coated with OMF in two layering steps by using the binding solutions described in Table 1. For the first coating layer, the third part (about 1,500 g) of OMF was applied step-by-step in sequence with spraying the starch solution to cover the seeds. The remaining OMF was applied to the seeds in the same method but using the binder of urea + Orrin. The coated seeds were dried with a hand dryer (< 40° C) in the rotating drum for about 30 minutes, then were taken out from the drum, dried completely under sunray to reach constant moisture (< 10%), and stored in a closed container. Before planting, the produced coated seeds were tested for their germination rate in a growth chamber. Results of the test confirmed that the coated seeds used in this research were very good – germinated > 95%.

2.2 Experimental Setting

The experiment was conducted on an irrigated paddy soil classified as Oxyaquic Hapluderts in Keruak Village - Central Lombok Regency, Indonesia. The soil was clay textured (46% clay), having a low content of total C-organic (1.2%) and total N (0.02%); the Olsen-extractable P₂O₅ was 16 mg. kg⁻¹, the acidity was about neutral (pH 7.2); the cation exchange capacity of the soil was 36.2 cmol. kg⁻¹, and the exchangeable K, Ca, Mg, and Na respectively were 0.14, 32.4, 4.4, and 0.1 cmol. kg⁻¹.

The agronomic performances of the coated seeds of each variety were tested in separate experimental sets. A randomized block design was laid out for each experimental set with the treatment consisting of non-coated seed (NCS), CS-1, CS-2, and CS-3 in 3 blocks. The size of an experimental unit (plot) was 5 m x 5 m, and between plots were separated by a 50-cm borderline. The soil was mechanically cultivated by plugging, mudding, smoothing, and allowed to equilibrate for two days in a saturated condition.

The seeds were planted directly onto the saturated ground without germination or transplanting steps. Five seeds were planted per planting point with a spacing of 25 cm x 25 cm. The water level in each plot was maintained at 1 – 5 cm over the soil surface accordingly to the growing stage of the plants. Only the non-NCS plants were fertilized with NPK (15:15:15) at the rate equivalent to 300 kg. ha⁻¹. Harvesting was done 110 days after planting.

2.3 Data and Statistical Analyses

The main collected data (parameters) were the number of productive tillers, the weight of top-dry biomass, and whole and 1,000 grains. The analysis of variance (ANOVA) was carried out for each set of data, and the parameters significantly affected by the treatment were further evaluated with the least significant difference (LSD) method at $\alpha = 0.05$.

3. RESULTS AND DISCUSSION

3.1 The Growth Components

The number of productive tillers per hill and the weight of top-dry biomass were presented in Table 2. In addition, it was observed that the coated seeds germinated 3 – 5 days later than the non-coated ones; and there was no indication of N-deficient symptoms of plant leaf (data are not shown in this paper).

Statistically, there were no significant differences in growth performance (number of productive tillers and weight of dry-top biomass) between rice plants from the non-coated and coated seeds, either for the Trisakti or Nutri Zinc varieties. As shown in Table 2, the number of productive tellers per plot was about 35, and the weight of dry-top biomass per plot was about 17.5 kg. Based on the plant growth data, it may be interpreted that the effect of seed coating with OMF on the growth components of rice was similar to that for the application of synthetic fertilizer (NPK 300 kg. ha⁻¹).

Table 2. The number (mean \pm Sdev) of tillers and weight of top-dry biomass for Trisakti and Nutri Zinc Varieties

Type of Seeds	Number of Productive Tillers per Hill ¹⁾		Top-Dry Biomass (kg.plot ⁻¹)	
	Trisakti	Nutri Zinc	Trisakti	Nutri Zinc
NCS	(34.3 \pm 1.2)	(34.3 \pm 1.0)	(17.7 \pm 0.5)	(17.8 \pm 1.5)
CS-1	(36.1 \pm 0.5)	(34.6 \pm 1.0)	(18.0 \pm 0.4)	(18.2 \pm 0.4)
CS-2	(35.1 \pm 1.0)	(34.7 \pm 0.7)	(18.6 \pm 0.7)	(18.8 \pm 0.4)
CS-3	(37.6 \pm 1.1)	(34.9 \pm 0.7)	(18.7 \pm 0.4)	(19.4 \pm 0.3)

¹⁾ Average values from 20-randomly sub-sampled plant hills

Table 3. The weights (mean \pm Sdev) of whole and 1,000 grains for Trisakti and Nutri Zinc Varieties

Type of Seeds	Weight of Whole Grains (kg. plot ⁻¹) ¹⁾		Weight of 1,000 Grains (g)	
	Trisakti	Nutri Zinc	Trisakti	Nutri Zinc
NCS	(14.42 \pm 1.56) a	(14.22 \pm 1.28) a	(28.59 \pm 0.71)	(26.83 \pm 0.62)
CS-1	(13.72 \pm 0.70) a	(14.17 \pm 0.76) a	(28.17 \pm 0.85)	(26.91 \pm 1.01)
CS-2	(15.74 \pm 0.37) b	(15.38 \pm 0.33) ab	(26.03 \pm 1.34)	(27.09 \pm 0.67)
CS-3	(16.52 \pm 0.48) c	(16.73 \pm 0.64) b	(28.52 \pm 0.96)	(26.52 \pm 0.96)
LSD _{$\alpha=0.05$}	0.77	1.28	-	-

¹⁾ The values followed by the same letters are not significantly different based on the analysis of LSD _{$\alpha=0.05$}

3.2 Yield Components

The yield components, i.e., the weights of whole grains per plot of 25 m² and 1,000 grains, were presented in Table 3. Results of analysis of variance showed that the quantity of rice yield for non-coated seeds was significantly different from that for the coated seeds, but there was no significant effect of the different types of seeds on the quality of rice grain (weight of 1,000 grains).

As shown in that Table 3, the rice yields were consistently improved by the increases of N concentration in the coating material OMF; and the highest yields were gained by the plants of CS-3, which were about 16.6 kg. plot⁻¹ (equivalent to 6,640 kg. ha⁻¹). Based on the results, coating the rice seeds with OMF containing about 9% N was a suitable method to optimize production.

4. CONCLUSION

The growth components (number of tillers and weight of biomass) and grain quality (weight of 1,000 grains) of the rice plants grown from the non-coated seeds were similar to those for the coated seeds with the N-enriched OMF. On the other hand, adding N up to 9% to the coating material (OMF) improved the grain yield of rice

plants from the coated seeds, and the seed coating method was a suitable method to optimize production. By planting the OMF-coated seeds, farmers may gain optimum yield without applying additional fertilizers.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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