

EFFECT OF NPK BIO-ORGANOMINERAL FERTILIZER ON RICE PLANT (ORYZA SATIVA L.) IN TEXTILE WASTE POLLUTED SOIL: PLANT GROWTH AND YIELD

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ABSTRACT

Pollution of agricultural land in Rancaekek caused by textile industry waste entering through irrigation water has resulted accumulation heavy metals in the soil and a decrease in rice yield productivity of only 2-4 t ha⁻¹. Overcoming this problem requires inputs in the form of fertilizers that can increase yield and plant growth. The objective of this experiment was to analyze the effect application of NPK Bio-organomineral fertilizer (NBO), which is a fertilizer that combines organic, inorganic, and biological agents on contaminated soil of textile industry waste planted with paddy rice plants on plant height, harvested dry unhusked rice, and 100-grain weight. Based on ANOVA test, the application of NBO fertilizer significantly affected the growth parameter, specifically plant height and yield parameters, such as harvested dry unhusked rice and 100 grain weight. Treatment F (NBO 500 kg ha⁻¹), showed the best results in the parameter of plant height at 56 DAT, whereas at 70 DAT, treatment C (NBO 125 kg ha⁻¹) is the best result. The best treatment on yield parameters is shown by treatment G (NBO 675 kg ha⁻¹) for harvested dry unhusked rice, while the best result for the weight of 100 grains was shown by treatment F (NBO 500 kg ha⁻¹). This study found that the application of NBO fertilizer, which is a combination of organic, inorganic, and biological agents, was able to increase the height and yield parameters of rice plants grown in soil polluted with heavy metals from textile industry waste.

Keywords: Organic matters, Slow-release fertilizer, Soil pollutant.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the main food in Indonesia. The high consumption of rice in Indonesia is indicated by more than 90% of Indonesian people relying on rice as the most important and main staple food (Paman et al., 2023). Other data showing Indonesia's high rice consumption is shown by Indonesia's average annual per capita rice consumption in 2023 of 80.9 kg/person (Ministry of Agriculture, 2023). This exceeds the average per capita rice consumption in Asia, which has the highest per capita consumption in the world, at more than 77 kg/person (Rahman & Zhang, 2023). Indonesia's average per capita rice consumption has great potential to increase, based on the country's growing population every year. Therefore, it is necessary to produce rice that can fulfill the consumption needs of the people in Indonesia.

Rice production in Indonesia, which is intended to meet the consumption needs of the Indonesian people, has experienced obstacles and problems, namely the decline in production in recent years. Rice production in Indonesia in 2024 of 53.14 million tons decreased by 838.27 thousand

tons compared to 2023, which was 53.98 million tons of harvested dry grain or if converted for food consumption in the form of rice in 2024 of 30.62 million tons, while in 2023 it was 31.10 million tons (Statistics Indonesia, 2025). Rice production in previous years as well, namely 2010-2019 has decreased by 1.6% in the last 10 years (Pudjiastuti et al., 2021).

There are many factors that influencing the decline of rice production in Indonesia. The problem of declining rice production is caused by several things, such as land conversion, decreasing number of farming families, pest problems, increasing population and demand for rice consumption, as well as damage to agricultural facilities and soil degradation (Masganti et al., 2020). One of the causes of damage to agricultural facilities and soil degradation is the contamination of agricultural land by various toxic contaminants. There are many possibilities that can cause these contaminants to enter agricultural land, one of which is through irrigation water. Agricultural soils in various regions around the world are polluted with toxic heavy metals such as Cd, Cu, Zn, Ni, Co, Cr, Pb, and As (Thakur et al., 2022). Some of these heavy metals are caused by industrial waste, one of which is the textile industry.

West Java is one of the provinces in Indonesia with a high number of textile industry growth. According to data from the Statistics Indonesia (2023), the number of textile industries in West Java reached 1010 industries, positioning this province as one of those with the highest number of textile industries due to industrialization. One of the districts in West Java, precisely in Bandung Regency, specifically Rancaekek District is an area with a high number of textile industries, with 50% of the 80 industries in the area being textile industry (Handayani et al., 2022). This area was once known for its extensive paddy fields, but the amount of paddy fields is decreasing as the textile industry develops and the population grows. The conversion of most of the agricultural land in Rancaekek into an industrial area with no regard to environmental aspects has caused environmental pollution, especially to agricultural land where pollution has occurred since 1991 (Nugraha et al., 2017). This pollution enters through irrigation water sourced from the Cikijing River which is contaminated with various heavy metals, such as Cr and Pb from textile industry waste.

Heavy metals contained in textile industry effluents are caused by their use during the textile dyeing process. The dye is not all absorbed by the fabric, but about 11-16% is wasted through wastewater (Khan et al., 2022). Various heavy metals were found in Rancaekek rice fields, including Cr, Pb, Cu, and Hg with each of the highest values that have been tested in several soil samples in this district, namely the highest Cr of 174.7 ppm, Pb of 25.47 ppm, Cu of 90.91 ppm, and Hg of 92.2 ppm. Based on these heavy metal results, some heavy metals, such as Cr, Cu, and Hg are above the critical threshold, while Pb is below the critical threshold as listed in Table 1. The heavy metal Pb is indeed below the critical threshold, but it is still feared that over time it will continue to accumulate and potentially increase.

Table 1. Critical Thresholds of Heavy Metals in Soil and Plants

Elements	Soil Critical Threshhold (ppm)	Plants Critical Threshhold (ppm)
Ag	2	1-4
As	20-50	1-20
Aur	-	<1
Cd	3-8	4-200
Co	25-50	4-40
Cr	75-100	2-18
Cur	60-125	5-64
Hg	0,3-5	1-8
Mn	1500-3000	100-700
Mo	2-10	-
Ni	100	8-220
Pb	100-400	-

Source: (Alloway, 1995)

Heavy metals that accumulate in soil have the potential to cause impacts on soil, plants, and humans. Accumulation and deposition of heavy metals in the soil can cause imbalance in soil function, decrease in soil quality, and decrease in crop yields (Ma et al., 2022). The absorption of heavy metals into rice grains is a major concern in paddy fields. High accumulation in rice grains is one of the causes of carcinogenic effects in the human body (Mahmud et al., 2021). Continuous or long-term exposure to heavy metals can cause damage to the kidneys, brain, liver, skin, and heart and can become a systemic toxicant even though the level of exposure is low (Jomova et al., 2025). Another thing related to rice productivity, heavy metal exposure that occurs in rice fields in Rancaekek causes rice productivity to decrease by only 2-4 ha⁻¹ (Sudirja et al., 2017).

Overcoming this problem, fertilizers in balance composition with organic matter is needed required. Both fertilizers can increase rice yields due to an adequate supply of nutrients. The application of inorganic fertilizers will be more efficient when balanced with organic fertilizers because organic fertilizers contribute more in improving the chemical, biological, and physical properties of the soil (Oesman et al., 2020). This combination emphasizes the provision of the main macronutrients for plants, such as nitrogen (N), phosphorus (P), potassium (K). The fertilizer that is considered suitable for application is NPK bio-organomineral fertilizer (NBO fertilizer), which is a fertilizer containing N elements sourced from urea fertilizer, P from guano, K from oil palm empty fruit bunches with additional zeolite and activated charcoal content as mineral ingredients, and compost from cow dung and roasted husks combined with *Bacillus subtilis* bacteria as organic ingredients. These materials are formulated and combined with the hope of improving and supporting the growth and yield of rice plants in polluted soils.

This study was conducted to analyze the effect of NBO fertilizer, which is a fertilizer that formulates various inorganic, organic, and biological agents with their respective abilities by applying it to heavy metal polluted soil planted with rice plant. This research is expected to be one of the steps to solve the problem of heavy metal pollution in paddy fields in Rancaekek by developing fertilizers from a combination of various ingredients that have never been tested and sold in general. In this study, the main focus that is expected from the application of NBO

fertilizer is that it can have an effect on increasing plant growth parameter is plant height and plant yield parameters, namely harvested dry grain weight and 100 grain weight.

2. MATERIALS AND METHODS

Location and Soil Samples

The experiment was conducted in the Greenhouse of Ciparanje Experimental Farm, Faculty of Agriculture, Universitas Padjadjaran, located in Jatinangor, Sumedang Regency, West Java at 798 meters above sea level (masl). Soil collection for the experiment was carried out in the rice fields of Jelegong Village, Rancaekek District, Bandung Regency whose irrigation was obtained from the Cikijing River which was polluted with heavy metals. The location for making NBO fertilizer was at the Cileles Experimental Field, Jatinangor, Sumedang Regency, West Java. In addition, inoculation of biological agents used in the formulation of NBO fertilizer, namely *Bacillus subtilis*, was carried out at the Soil Biology Laboratory, Faculty of Agriculture, Universitas Padjadjaran.

Soil from one of the paddy fields in Jelegong village as the soil sample tested was taken in a composite of 260 kg (250 kg for 25 experimental buckets and 10 for spare buckets). The soil was brought to the experimental site to be homogenized by stirring thoroughly, then put into buckets with a diameter of 20 cm as much as 10 kg per bucket, and fertilized for one week by giving water and stirring, then flooded with water as high as 3 cm.

Formulation and Process of NBO Fertilizer

The NBO fertilizer used contains N from urea fertilizer, P from guano derived from bat feces, K from empty palm bunches with additional zeolite and activated charcoal as mineral ingredients, and compost from cow dung and roasted husks combined with *Bacillus subtilis* bacteria as organic ingredients. The formulation ratio between NPK, zeolite, activated charcoal, and organic matter is 60:20:10:10. The process of making fertilizer is done by mixing all ingredients with a predetermined composition into a mixer and then printed using a tablet fertilizer printing machine. After the tablets are formed, it's important to ensure that they are not too brittle, making them easier to apply during application. The tablet size was uniformed following the lowest dose, which was 0.78 g (dosage NBO fertilizer 125 kg ha⁻¹) and for other dosage applications, the tablets are multiplied by the required quantity according to the predetermined dosage in the Table 2.

Table 2. Fertilizer Dosage Per Plant

Symbol	Treatment	Dosage (kg ha ⁻¹)
A	Control	0
B	NPK Phonska Fertilizer	250
C	NBO Fertilizer	125
D	NBO Fertilizer	250
E	NBO Fertilizer	375
F	NBO Fertilizer	500
G	NBO Fertilizer	625
H	NBO Fertilizer	700

Notes: The treatment (A) or control is the treatment without fertilizer application. Treatment B is a treatment with the application of NPK Phonska (15:10:12) at a dose of 250 kg ha⁻¹ based on the

recommended dose for Rancaekek location-specific paddy rice plants (Regulation of the Minister of Agriculture Number 13 of 2022 on the Application of N, P, K Fertilizer Dosages for Rice, Maize, and Soybean on Paddy Fields, 2022).

Experimental Procedure

Soil contaminated with heavy metals in each bucket was planted with two plants of Inpari 32 rice variety that had previously been germinated for 14 days. The soil is in a condition that is neither excessively wet nor dry for the application of NBO fertilizer at 3 DAT (day after transplanting). After that, the soil was irrigated every day to a height of 3-4 cm and maintained until the milk maturity phase (80 DAT) and at 81 DAT until the harvest was not irrigated with the aim of stimulating grain formation. Entering the age of 14 DAT, plant thinning was carried out and only 1 plant was left with the best growth. Measurement of growth parameters, namely plant height, was carried out every 2 weeks, starting from 14, 28, 42, 56, to 70 DAT. Harvesting was done at 102 DAT when 90-95% of the rice grains had turned yellow. All panicles were threshed and the grain was left, then the moisture content was measured using a grain moisture meter when it reached 27% and weighed as harvested dry grain. After that, the harvested dry grain was allowed to stand in the greenhouse in an open condition for two days, then measured the moisture content until it reached $\leq 14\%$ and separated in each treatment as many as 100 grains to be weighed and recorded as data on the weight of 100 grains of grain.

Data Analysis

The experimental data will be analyzed using SmartstatXL application for variance ANOVA test. Previously, the data obtained will be carried out Shapiro-Wilk normality test to find out how the distribution of the data, whether normal or not. If the data does not spread (distributed) normally, data transformation will be carried out. If the results obtained have a significant effect, a further multiple range test will be carried out Duncan with significance level of 5% using the SmartstatXL application.

3. RESULTS AND DISCUSSION

Plant Height

The effect of fertilizer application NBO on plant height at 14, 28, 42, 56, and 70 DAT varied (Table 3). Based on ANOVA, plant height at 14, 28, and 42 DAT was not significantly different. A different outcome was observed at 56 and 70 days after planting (DAT), where the NBO fertilizer had a significant effect on plant height. This was evidenced by treatment F (NBO fertilizer kg ha^{-1}) at 56 DAT and treatment C (NBO fertilizer 125 kg ha^{-1}) at 70 DAT.

Table 3 Results of Statistical Analysis of Plant Height 14, 28, 42, 56, and 70 DAT

Treatment	Average Plant Height				
	14 DAT	28 DAT	42 DAT	56 DAT	70 DAT
A	36.43	58.75	74.50	90.20 ab	95.63 ab
B	36.53	60.00	71.88	89.40 a	92.55 a
C	33.63	57.88	75.63	96.63 b	101.38 abc
D	33.50	57.00	70.25	93.45 ab	100.90 abc
E	30.93	51.63	68.75	96.00 ab	98.03 ab
F	36.73	60.13	76.38	103.00 c	108.13 c
G	36.13	56.88	73.25	96.55 b	102.83 bc
H	33.40	59.63	70.75	94.10 ab	102.83 bc

Notes: Mean values followed by the same letter are not significantly different according to Duncan's Further Test at 0.05 level of significance and the values without letter notations indicate that, based on the ANOVA test, they did not show significance at the 5% level.

Regarding the growth parameter, namely plant height at 14, 28, and 42 DAT no significant differences were observed across all treatments, presumably due to the slow-release characteristics of the NBO fertilizer which shows that in the early growth phase the release of nutrients is not yet complete and can be considered as an advantage of this fertilizer which better controls the release of nutrients. The slow-release characteristic of this fertilizer comes from the contribution of zeolite as one of its constituent ingredients. Zeolites slow down the nitrification process, so that leaching into deeper soil is less intense (Soltys et al., 2020). The choice of tablet form in this NBO fertilizer makes it one of the factors for the slow release of this fertilizer. Slow release fertilizers are often produced in the form of rods or tablets because of the morphological characteristics of compaction and matrix that contribute to a slower and controlled release of nutrients (Priya et al., 2024).

Treatment F (NBO fertilizer 500 kg ha⁻¹) showed a significant difference in plant height compared to the control and treatment B (recommended NPK fertilizer) at 56 DAT. Meanwhile, at 70 DAT, treatment C (NBO fertilizer 125 kg ha⁻¹) had a significant effect on plant height. This condition is presumed to occur because the period coincides with the maximum vegetative phase, which occurs at 60-70 DAT. This is related to the ability to absorb one of the nutrients that play a major role in plant growth, namely N. N uptake in plants increases in the maximum vegetative or maximum tillering stage until the heading stage (Aker et al., 2024). The NBO fertilizer contains zeolite, which can reduce nitrogen volatilization and leaching when combined with inorganic fertilizer, thus increasing the efficiency of the applied fertilizer. This significantly impacts various processes and phases in the plant, including growth (Mondal et al., 2021).

3.2 Harvesting Dry Unhusked Rice

Based on (Table 4), statistical tests were conducted on all eight treatments and four replications to measure the yield parameter is harvested dry unhusked rice. Harvested dry unhusked rice showed that treatment H (NBO fertilizer 750 kg ha⁻¹) was the treatment with the highest average and significantly different from all treatments, except treatment G (NBO fertilizer 625 kg ha⁻¹). This shows that increasing the dose of NBO fertilizer can increase the yield of dry harvested grain.

Table 4 Statistical Analysis Result of Harvested Dry Unhusked Rice

Treatment	Average Harvested Dry Unhusked Rice
A	24.18 a
B	28.38 a
C	39.65 b
D	43.05 bc
E	56.38 d
F	50.05 cd
G	59.43 de
H	66.68 e

The NBO fertilizer is formulated from a combination of inorganic and organic materials. There is an increase in the weight of harvested dry unhusked rice with the application of both inorganic and organic fertilizers. The combination of organic and inorganic fertilizers can improve soil health, reduce inorganic inputs and most importantly increase crop yields (Anisuzzaman et al., 2021). The yield of harvested dry grain weight also increased due to the application of organic materials that can stimulate an increase in macro nutrients in the form of N, P, and K (Yuniarti et al., 2020).

3.3 Weight of 100 Grains

In the 100-grain weight parameter, treatment H (NBO fertilizer 750 kg ha⁻¹) showed the highest average and significantly different from the other treatments, except treatment F (NBO fertilizer 500 kg ha⁻¹), as shown at Table 5. Through these results indicate an increase in yield from the addition of NBO fertilizer doses. The results that did not significantly affect the parameters H and F, indicate that the treatment dose F (NBO fertilizer 500 kg ha⁻¹) is an effective dose in increasing the weight of 100 grains.

Table 5 Statistical Analysis Result of Average Weight of 100 Grains

Treatment	Average Weight of 100 Grains
A	2.53 a
B	2.65 a
C	2.70 ab
D	2.55 a
E	2.65 a
F	2.85 bc
G	2.68 a
H	2.90 c

This result found that application of NBO fertilizer can effect of weight of 100 grains as a yield parameter due to the combination organic, inorganic contained within it. According by Murnita & Taher (2021), the application of a combination of organic and inorganic fertilizers showed significantly different results on the weight of 1000 grains of rice due to the role of organic fertilizers as a complement to inorganic fertilizers in meeting the nutritional needs of the plants, rather than as a substitute. This is also in line with the results of research Kakar et al., (2020), a combination of organic materials combined with inorganic materials N and K. Both materials,

namely organic and inorganic materials combined have advantages and complement each other compared to only one of the ingredients alone in increasing rice yield, one of which is 100-grain weight. The results of high rice yield components after the application of a combination of organic and inorganic materials are related to a balanced and sustainable supply of nutrients that can increase nutrient uptake that supports high rice yields (Iqbal et al., 2021).

4. CONCLUSION

The application of NPK bio-organomineral fertilizer (NBO) significantly affects to increased the growth parameters, namely plant height at 56 and 70 DAT, and yield parameters, such as harvested dry unhusked rice and the weight of 100 grains. The optimal doses varied for different parameters. For plant height at 56 DAT, the best result was shown by treatment F (NBO 500 kg ha⁻¹), while at 70 DAT, the best result was shown by treatment C (NBO 125 kg ha⁻¹). For yield parameters, the best result for harvested dry unhusked rice was shown by treatment G (NBO 675 kg ha⁻¹), while the best result for the weight of 100 grains was shown by treatment F (NBO 500 kg ha⁻¹). This indicates that different parameters require varying nutrient levels from the applied fertilizer. This study found that the application of NBO fertilizer, which is a combination of organic, inorganic, and biological agents, was able to increase the height and yield parameters of rice plants grown in soil polluted with heavy metals from textile industry waste.

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