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Effect of NPK Bio-Organomineral Tablet Fertilizer on Harvest Index, Wet Weight, Dry Weight and Fertilization Efficiency in the Waste Contaminated Soil

Faris Aulia Rahman[1], Rija Sudirja[2], Emma Trinurani Sofyan[3]

[1] Soil Science Study Program, Faculty of Agriculture, Universitas Padjadjaran

[2] Department of Soil Science and Land Resources, Faculty of Agriculture, Universitas Padjadjaran

Jl. Raya Bandung Sumedang Km 21 Jatinangor

ABSTRACT: Contamination of rice fields due to industrial activities had an impact on reduced soil fertility, heavy metal contamination from industrial waste, and reduced rice yields. To overcomed this problem, this could be done by applied NPK Bio-organomineral tablet fertilizer. NPK Bio-organomineral tablet fertilizer was a modification of fertilizer made from urea, guano, palm oil empty fruit bunch charcoal, zeolite, activated charcoal, and biologically enhanced compost, turning the fertilizer into a slow-release form. The experiment aimed to investigate the impact of applied NPK Bio organomineral tablet fertilizer on harvest index, wet weight, dry weight and fertilization efficiency in the waste contaminated soil. This experiment was conducted from September 2023 to January 2024 at the Greenhouse Experimental Garden of Ciparanje, Jatinangor, and the Soil Fertility and Plant Nutrition Laboratory, Universitas Padjadjaran. The experimental design used was a Randomized Block Design (RBD) consisted of eight treatments and four replications, included control, NPK Phonska 100% recommendation 250 kg/ha, and 125; 250; 375; 500; 625; 750 kg/ha of NPK Bio-organomineral tablet fertilizer. The results of the experiment indicated that NPK Bio-organomineral tablet fertilizer had an impact on harvest index, wet weight, dry weight and fertilization efficiency in the waste contaminated soil. The optimal dose of NPK Bio-organomineral tablet fertilizer was 375 kg/ha, showed the most significant improvement on harvest index, wet weight, dry weight and fertilization efficiency in the waste contaminated soil.

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Corresponding Author: Faris Aulia Rahman

KEYWORDS: Slow-release fertilizer, rice production, industrial waste.

INTRODUCTION

The increase in the size of industrial areas directly reduces productive agricultural lands, which results in the emergence of marginal lands (contaminated with industrial waste). Agricultural activities on these marginal lands will face many biophysical problems, such as poor physical conditions, nutrient deficiencies, heavy metal poisoning, plant pests and diseases, and others (Mulyono *et al.,* 2010). One of the locations that has major problems of paddy fields is in the West Java region, especially Rancaekek Sub-district. Rancaekek Sub-district is known for its contaminated water environment and rice fields due to textile waste that was distributed through the river since 1994 (Sudirja *et al.,* 2017).

Cikijing River is an irrigation source that irrigates four administrative villages in Rancaekek Sub-district, namely Linggar Village, Jelegong Village, Bojongloa Village and Sukamulya Village. Monitoring results of the Cikijing River according to the calculation of the Water Pollution Index (IP) value have a polluted quality status with an IP value of 2.8146 which is included in group B, which means that it cannot be consumed for drinking water and household purposes (Sulistiowati & Wardhani, 2018). The high concentration of effluent from many textile industries has resulted in a decreased productivity of rice paddies. Paddy fields in Rancaekek Sub-district could previously produce 7.5 t/ha with harvest intensity of 2-3 times a year (Birry & Meutia, 2016). The productivity of the fields became 2-4 t/ha, with a harvest intensity of 1-2 times a year and there could even be crop failure (Sudirja *et al.,* 2017). There was a significant reduction in productivity of 67.1% to 91.2%.

In addition, the commonly used inorganic fertilizer by farmers in Indonesia is NPK fertilizer. The use of inorganic fertilizers in paddy fields only 30-40% can be utilized by agricultural plants (Kasno *et al.,* 2021). This loss occurred due to excessive use of fertilizers, which caused nutrients to be lost due to evaporation or leached into the layer below the reach of plant roots and resulted in contamination of groundwater and waters (Salam, 2020). Fertilizer efficiency can be improved by modified the form of fertilizer into slow-release fertilizer with additional organic matter.

From the explanation of the issues above, one of the measures that can be taken to overcome the problem of paddy field contamination in Rancaekek Sub-district is through the application of NPK Bio-organomineral tablet fertilizer. NPK Bio-organomineral tablet fertilizer is a modification of compound inorganic fertilizer based on urea (as a nitrogen source), guano (as a phosphate source), palm bunch charcoal (as a potassium source), zeolite, activated charcoal and compost with the addition of *Bacillus subtilis* as a biological agent. The right formula and dosage of NPK Bio-organomineral tablet fertilizer are supposed to increase harvest index, wet weight, dry weight and fertilizer efficiency in the waste contaminated soil.

MATERIAL AND METHODS

Location

This experiment was conducted in the greenhouse and laboratory. The greenhouse used was the Ciparanje Experimental Garden Greenhouse, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor. The greenhouse is located at an altitude of ± 700 meters above sea level. The paddy soil for the experiment was collected from the paddy field of Jelegong Village, Rancaekek District, Bandung Regency, West Java.

Experimental Design

The experimental design used was experimental method with Randomized Block Design (RBD). The experimental factors tested in this experiment were control treatment (without fertilizer application), NPK Phonska 100% recommendation treatment (250 kg/ha) and six NPK Bio-organomineral tablet fertilizer dose treatments (Table 1).

Table 1. Application Dose of NPK Bio-organomineral Tablet Fertilizer

Symbol	Treatments	Dose (kg/ha)
A	Control (No fertilization)	0
B	NPK Phonska 100% (Recommendation)	250*
C	NPK Bio-organomineral Tablet	125
D	NPK Bio-organomineral Tablet	250
E	NPK Bio-organomineral Tablet	375
F	NPK Bio-organomineral Tablet	500
G	NPK Bio-organomineral Tablet	625
H	NPK Bio-organomineral Tablet	750

Note: * Determined the fertilizer dose based on the recommendation of NPK fertilizer 15:10:12 on site-specific paddy fields in Rancaekek District of 250 kg/ha (Ministry of Agriculture Indonesia, 2022)

Experimental Setup

The production processed of NPK Bio-organomineral tablet fertilizer uses materials such as urea, guano, palm bunch charcoal, zeolite, activated charcoal, and bio-agent compost with a formula ratio of 60:20:10:10 (urea + guano + palm bunch charcoal : zeolite: activated charcoal : bio-agent compost). The fertilizer is then blended in a mixer machine for 5 minutes until well mixed. The fertilizer formula is pressed using a tablet fertilizer press. The soil sampled was first dried and cleaned of weeds. Each treatment pot was filled with 10 kg of soil and mixed with 4 liters of water until the water level reached 4 cm from the soil surface. The planting of rice seedlings was done after seeding the rice seeds for 14 DAP (days after planting). Fertilizer application was done in muddy soil conditions by sinking the fertilizer 3 cm deep in the soil. The calculation of harvest index, wet weight, dry weight and fertilizer efficiency was done during the harvest of the paddy plants at 120 DAP (days after planting).

Parameter and Statistical Analysis

Parameters used in this experiment included harvest index, wet weight, dry weight and fertilizer efficiency. Analysis of the significance of differences in the effect of treatment means used ANOVA analysis at the 95% confidence level. If the difference in treatment means had a significant effect, the test was continued with Duncan's Multiple Range Test at the 5% real level.

Harvest Index calculation formula:

$$\mathbf{HI} = \frac{\textit{Dry Weight of Rice Grain}}{\textit{Dry Weight of Paddy Plants}}$$

Relative Agronomic Effectiveness (RAE) is used to calculate the efficiency of fertilization application. The formula:

$$\text{RAE} = \frac{\textit{The Result of Fertilizer being Tested} - \textit{Control Treatment}}{\textit{NPK Recommendation (Phonska)} - \textit{Control Treatment}} X\ 100\%$$

RESULTS

Harvest Index

The analysis of variance showed that the effect of the dose of NPK Bio-organomineral tablet fertilizer had no significant effect when compared to the control. The average results of harvest index calculation on rice plants are presented in Table 2.

Table 2. Effect of NPK Bio-organomineral Tablet Fertilizer on Harvest Index

Symbol	Treatments	Harvest Index
A	Control (No fertilization)	0,46 ± 0,05 a
B	NPK Phonska 100% (Recommendation) 250 kg/ha	0,48 ± 0,05 a
C	NPK Bio-organomineral tablet 125kg/ha	0,55 ± 0,03 a
D	NPK Bio-organomineral tablet 250 kg/ha	0,52 ± 0,04 a
E	NPK Bio-organomineral tablet 375 kg/ha	0,55 ± 0,03 a
F	NPK Bio-organomineral tablet 500 kg/ha	0,58 ± 0,07 a
G	NPK Bio-organomineral tablet 625 kg/ha	0,58 ± 0,07 a
H	NPK Bio-organomineral tablet 750 kg/ha	0,54 ± 0,11 a

Note: The same letter behind the number indicates that it is not significantly different according to Duncan's Multiple Range Test ($p<0,05$)

Wet Weight and Dry Weight

The results of analysis of variance include plant wet weight and dry weight of rice plants showed the effect of the dose of NPK Bio-organomineral tablet fertilizer which had a significant effect when compared to the control. The average wet weight and dry weight of rice plants per plant is presented in Table 3.

Table 3. Effect of NPK Bio-organomineral Tablet Fertilizer on Wet Weight and Dry Weight

	Treatments	Wet Weight (g)		Dry Weight (g)	
A	Control (No fertilization)	88,75± 8,54	a	16,95 ± 1,61	a
B	NPK Phonska 100% (Recommendation) 250kg/ha	147,50 ± 3,27	b	26,93 ± 4,32	b
C	NPK Bio-organomineral tablet 125kg/ha	130,00 ± 7,07	ab	23,42 ± 1,21	ab
D	NPK Bio-organomineral tablet 250 kg/ha	172,50 ± 2,20	b	30,49 ± 3,38	b
E	NPK Bio-organomineral tablet 375 kg/ha	187,50 ± 8,41	b	31,97 ± 6,36	b
F	NPK Bio-organomineral tablet 500 kg/ha	166,25 ± 3,51	b	27,16 ± 3,01	b
G	NPK Bio-organomineral tablet 625 kg/ha	163,75 ± 2,75	b	25,05 ± 3,50	b
H	NPK Bio-organomineral tablet 750 kg/ha	146,25 ± 8,45	b	28,06 ± 6,92	b

Note: The same letter behind the number indicates that it is not significantly different according to Duncan's Multiple Range Test ($p<0,05$)

Fertilization Efficiency (Relative Agronomic Effectiveness)

The results of the analysis of variance showed that the treatment of NPK Bio-organomineral tablet fertilizer dose significantly affected the relative agronomic effectiveness compared to the control treatment. The results of the calculation of the RAE (Relative Agronomic Effectiveness) value of the application of NPK Bio-organomineral tablet fertilizer are presented in Table 4.

Table 4. Effect of NPK Bio-organomineral Tablet Fertilizer on Relative Agronomic Effectiveness

Symbol	Treatments	Relative Effectiveness (%)	Agronom
A	Control (No fertilization)	0,00 ± 0,00	a
B	NPK Phonska 100% (Recommendation) 250 kg/ha	100,00 ± 0,00	ab
C	NPK Bio-organomineral tablet 125kg/ha	144,18 ± 32,58	bc
D	NPK Bio-organomineral tablet 250 kg/ha	199,96 ± 71,12	bc
E	NPK Bio-organomineral tablet 375 kg/ha	265,87 ± 99,08	c
F	NPK Bio-organomineral tablet 500 kg/ha	229,95 ± 54,83	c
G	NPK Bio-organomineral tablet 625 kg/ha	204,05 ± 94,92	bc

H	NPK Bio-organomineral tablet 750 kg/ha	180,16 ± 83,55	bc

Note: The same letter behind the number indicates that it is not significantly different according to Duncan's Multiple Range Test ($p<0,05$)

DISCUSSION

NPK Bio-organomineral tablet fertilizer in this experiment focused on increased harvest index, wet weight, dry weight and fertilizer efficiency. The application of this fertilizer was able to increased harvest index, wet weight, dry weight and fertilizer efficiency in rice plants that were grown in the contaminated soil when compared to the control treatment.

Harvest index describes the ratio of photosynthate translocated to the generative part of the plant in the form of grain. Harvest index is the ratio between economic yield (grain) and dry weight of biological yield (dry weight of biomass), which is influenced by the amount of photosynthate translocation (Safriyani *et al.,* 2018). The higher the harvest index indicates that the photosynthate in the canopy is translocated to the seeds, which will increase the grain yield produced. An increase in harvest index will be followed by an increase in grain yield (Wangiyana & Lawian, 2018). The harvest index of rice plants has a range of 0.46-0.58 and shows an increased trend with the treatment of NPK Bio-organomineral tablet fertilizer doses up to a dose of 500 kg/ha. According to Yang & Zhang (2010), that the range of rice harvest index values is usually 0.17-0.56 with an optimal index of 0.41-0.49 is a number that is good enough as a harvest index for rice plants.

Growth is expressed as an increase in size that reflects the increase in protoplasm characterized by the increase in plant dry weight (Sitompul *et al.,* 2014). Dry weight is a measure of plant growth and development because dry weight reflects the accumulation of organic compounds successfully synthesized by plants. Plant dry weight reflects the nutritional status of a plant and is also an indicator that determines whether a plant's growth and development is good or bad so that it is closely related to nutrient availability (Afrida *et al.,* 2017). While the fresh weight of the plant is the weight of the plant after harvesting before the plant withers and loses water, besides that the fresh weight of the plant is the total weight of the plant which shows the results of the metabolic activity of the plant itself (Salisbury and Ross, 1995).

The treatment of NPK Bio-organomineral tablet fertilizer dose affected the wet grain weight per plant which is thought to be a result of the NPK reaction that takes place slowly releasing N, P, and K elements into the soil which are absorbed by plants (Sasminto & Sularno, 2018). Urea which is contained in NPK Bio-organomineral tablet fertilizer supported the growth and production of rice plants. This is based on the research of Iswahyudi *et al.* (2018), the application of high doses of NPK fertilizer can increase plant height growth, especially urea fertilizer which can accelerate plant vegetative growth. N nutrients in plants function as a constituent or basic ingredient of protein and chlorophyll formation. N nutrients function to make plant parts become greener, contain a lot of green grains (in the process of photosynthesis) and accelerate plant growth (increase plant height, number of tillers, increase leaf size and grain size, improve plant and grain quality, increase rice protein content, increase wet and dry weight of plants) (Toiman *et al.,* 2019). The optimal availability of nitrogen, phosphorus, potassium and magnesium nutrients for plants can increase chlorophyll, where with an increase in chlorophyll, photosynthetic activity will increase which produces more assimilates which will support plant dry weight (Sitorus *et al.,* 2014).

Relative Agronomic Effectiveness (RAE) is the percentage of increased yield using a fertilizer compared to the percentage of yield using standard or recommended fertilizers (Subandi *et al.,* 2016). The treatment of NPK Bio-organomineral tablet fertilizer doses that showed an increase in the RAE value in this experiment was due to the content of slow release substance in the form of zeolite in NPK Bio-organomineral tablet fertilizer. Zeolite can temporarily capture fertilizer nutrients so that it will not be washed away and will be released back to be absorbed by plant roots (Juarsah, 2016). Zeolite has an open framework with a network of pores that have a negatively charged surface that can prevent the leaching of NH_4^+ nutrients in urea fertilizer and K^+ cations out of the root area (Yuarsah *et al.,* 2018).

CONCLUSION

NPK Bio-organomineral tablet fertilizer is effective on increased harvest index, wet weight, dry weight and fertilization efficiency in the waste contaminated soil. Application of NPK Bio-organomineral tablet fertilizer 325 kg/ha is the most optimal dose on increased harvest index, wet weight, dry weight and fertilizer efficiency (Relative Agronomic Effectiveness) in the waste contaminated soil.

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