



EFFECT OF NPK FERTILIZER AND HUMIC ACID DOSAGE ON THE GROWTH AND YIELD OF PADDY RICE PLANTS (*Oryza sativa* L.)

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ABSTRACT

Repeated processing of rice fields affects soil quality and degradation, which in turn impacts rice production. Therefore, a combination of NPK and humic acid is needed to prevent a decrease in NPK and to improve soil structure. This article studies about the effect of NPK fertilizer dosage and humic acid on the growth and yield of paddy rice. The experimental design used was a Split Plots Design with NPK as the main plot and Humic Acid as the subplot with each treatment having 4 dose levels and each repeated twice. Main plot of NPK dosage consists of 0 kg ha⁻¹, 100 kg ha⁻¹, 200 kg ha⁻¹, and 300 kg ha⁻¹. The subplots of humic acid doses consist of 0 g ha⁻¹, 1500 g ha⁻¹, 3000 g ha⁻¹, and 4500 g ha⁻¹. The results showed that there was an interaction between the dose of NPK fertilizer and humic acid on plant height, number of tillers, root drop ratio, number of productive tiller, number of grains per panicle, percentage of filled grain, weight of harvested dry grain per hill, weight of dry grain harvest per plot, weight of milled dry grain per hill and weight of milled dry grain per plot, except for the weight of 1000 grains. The dose of NPK fertilizer as much as 206.30 kg ha⁻¹ and the dose of humic acid as much as 2.928 kg ha⁻¹ gave optimum results on the weight of dry milled grain which produced 6.15 kg per plot or equivalent to 10.250 tons ha⁻¹.

Key words : NPK Fertilizer Dose, Humic Acid Dose, Paddy Rice

INTRODUCTION

The need for food continues to increase every year due to the growing number of Indonesia's population. The agricultural sector holds a great responsibility to meet the needs of the population, facing challenges to meet the food needs of the population,

especially rice. Because rice is the staple food ingredient of the Indonesian population, efforts to increase rice production in Indonesia continue to be carried out through increasing soil fertility and rice productivity. Soil fertility is one of the important aspects in agriculture that has a direct effect on crop productivity. Soil fertility is the

ability of the soil to provide essential nutrients in balanced amounts and proportions for plant growth. This nutrient can be obtained by applying fertilizer to the soil. Fertilizer is a substance that is introduced into the soil with the aim of changing the physical, chemical and biological properties of the soil so that it becomes better for plant growth (Purba *et al.*, 2021).

Nutrients N, P, and K, are needed by rice plants. Nutrients N, P, and K, are essential macronutrients but are limited in their amounts in soil. To be able to provide high yields, additional chemical or inorganic fertilizers are needed because the supply of nutrients from the soil and other natural sources is insufficient. The lack of nutrients will result in a decrease in the quality of plant production (Made *et al.*, 2022). The advantages of compound fertilizer for rice plant cultivation include containing more than one nutrient so that rice plants get more than one nutrient per application, saving labor at the time of application, transportation, and cost of each existing nutrient unit, high efficiency in fertilizer use.

Today, farmers tend to use inorganic or chemical fertilizers for practical reasons in the cultivation of their crops. Aprilia *et al.*, (2020) stated that it is difficult for farmers to change their habits of using chemical fertilizers, this certainly affects the decrease in soil fertility and the decrease in production due to chemical fertilizer residues.

The addition of organic matter to the soil is very helpful in repairing soil that has been degraded because organic matter can bind nutrients that are easily lost and help provide soil nutrients. Humic acid is a derivative of organic

matter or the result of the decomposition of organic matter that is brownish-black, acidic, insoluble in acidic solvents, but soluble in alkaline solvents, and is a complex macromolecule. Humic acid plays a role in increasing soil nutrient content, increasing soil fertility, stimulating soil microorganisms more efficiently, remodeling organic matter, increasing soil moisture, increasing photosynthesis and chlorophyll concentration, and releasing nutrients so as to make them available to plants (Wanti Mindari *et al.*, 2022). According to Nuraini and Zahro (2020) this humic acid can improve root development and nutrient absorption, thereby increasing the number of seedlings, plant height, total number of seedlings and the number of productive seedlings in rice plants.

According to the above description, humic acid and NPK fertilizer are applied to rice plants in an attempt to boost their growth and yield. This is an area that warrants more research in order to determine the ideal dosage of humic acid and NPK fertilizer that will yield the highest weight of milled dry grain per plot in the swa rice plant.

RESEARCH METHOD

The research method used was a field experiment method conducted on the demonstration plot of the Baleendah Agricultural Extension Center (BPP), Wargamekar Village, Baleendah District, Bandung Regency. The research was carried out from January 17, 2024 to May 2, 2024. The altitude of the research site is 680 m above sea level. Based on rainfall data for the last 10 years, from 2011 to 2020 in Baleendah District it was 2457.9 mm/year according to Oldeman

(1975) included in areas with C2 rainfall type. The soil test results before the experiment had a moderate C-Organic content (2.2%), N (0.23%) Medium, C/N (10) Low, P₂O₅ (42.62 mg/100g) High, K₂O (21.37 mg/100g) moderate, with a neutral pH (6.9), and a dusty clay soil texture.

The ingredients used in this experiment were Sarinah rice varieties, Terahumic Humic Acid with a 60% content of > humic compounds, and NPK Phonska fertilizer (15:15:15), while other facilities were Urea fertilizer (46% N), BT-Plus vegetable pesticide (*bio insecticide*) and Metarizep (*bio insecticide*). The tools used in this experiment were hoes, gembor, pH meters, name signs, plant labels, measuring cups, digital scales, *moisture testers*, meters, sprays, cameras and stationery.

The environmental design uses *Split Plot* with 2 factors, namely the dose of NPK fertilizer (*main plot*) which consists of four levels; $n_0 = 0 \text{ kg ha}^{-1}$, $n_1 = 100 \text{ kg ha}^{-1}$, $n_2 = 200 \text{ kg ha}^{-1}$, $n_3 = 300 \text{ kg ha}^{-1}$ and four levels of humic acid dose (sub plot), namely $h_0 = 0 \text{ g ha}^{-1}$, $h_1 = 1500 \text{ g ha}^{-1}$, $h_2 = 3000 \text{ g ha}^{-1}$, $h_3 = 4500 \text{ g ha}^{-1}$. The data was processed with ANOVA at the level of 5% to see the effect of the treatment, the analysis is continued using the Least Significant Difference (LSD) with a level of 5% to find out difference between each treatment. The regression of the response surface uses the optimal point at the weight of the ground dry grain.

RESULTS AND DISCUSSION

Plant height and Number of tiller per plant

The analysis's findings, which are displayed in Table 1, indicated an interaction between the height of paddy rice plants at 30 DAP, 40 DAP, 50 DAP, and 60 DAP. According to the description, the plant grows taller when the NPK fertilizer dose is between 200 and 300 kg ha⁻¹ and the humic acid dose is between 3 and 4.5 kg ha⁻¹. The analysis's findings demonstrated an interaction with the quantity of paddy rice seedlings in Table 2 at the ages of 30, 40, 50, and 60 DAP. an increased number of seedlings at 30 DAP, 40 DAP, 50 DAP, and 60 DAP when 200 kg ha⁻¹ of NPK fertilizer and 3 kg ha⁻¹ to 4.5 kg ha⁻¹ of humic acid was applied. The analysis's findings demonstrated that the amount of grain per panicle, the number of productive tiller, the percentage of grain content per panicle, and the Root Extinction Ratio of rice field plants displayed in Table 3 were all impacted by the combination of humic acid and NPK fertilizer dosage. Between 200 and 300 kg ha⁻¹ of NPK fertilizer and 3 to 4.5 kg ha⁻¹ of humic acid were the ranges where the study found the highest ratio of root extinction. The range of 200 kg ha⁻¹ to 300 kg ha⁻¹ of NPK fertilizer combined with a dose of humic acid produced the most fruitful tiller in the experiment. NPK fertilizer dosages of 200–300 kg ha⁻¹ and humic acid dosages of 3–4.5 kg ha⁻¹ were associated with the highest number of productive tiller in the trial. Grain production per panicle was higher in the study when 200 kg ha⁻¹ of NPK fertilizer was applied along with 3–4.5 kg ha⁻¹ of humic acid. The NPK fertilizer dose of 200 kg ha⁻¹ combined with a humic acid dose of 3 kg ha⁻¹ to 4.5 kg ha⁻¹ had the highest percentage of grain content in the research.

Table 1. Effect of NPK and Humic Acid Fertilizer Dosage on Rice Crop Height at the Age of 30 DAP, 40 DAP, 50 DAP, and 60 DAP

NPK Fertilizer Dosage (N) (kg ha ⁻¹)	Humic Acid Dosage (H) (kg ha ⁻¹)															
	h ₀ (0)				h ₁ (1.5)				h ₂ (3.0)				h ₃ (4.5)			
	Plant Height 30 DAP (cm)						Plant Height 40 DAP (cm)									
n ₀ (0)	52.58	a	53.16	a	58.34	a	62.77	a	72.82	a	75.05	a	82.37	a	88.62	a
	A		A		B		B		A		A		B		B	
n ₁ (100)	63.03	b	64.60	b	68.24	b	65.90	a	88.99	b	91.19	b	96.34	b	93.03	a
	A		AB		B		AB		A		AB		B		AB	
n ₂ (200)	67.46	c	69.75	c	70.08	b	72.00	b	95.24	c	98.47	c	98.93	b	101.64	b
	A		A		A		A		A		A		A		A	
n ₃ (300)	66.94	bc	68.97	c	70.25	b	64.50	a	94.50	c	97.37	c	99.18	b	89.66	a
	AB		AB		B		A		AB		B		B		A	
	Plant Height 50 DAP (cm)						Plant Height 60 DAP (cm)									
n ₀ (0)	72.82	a	75.05	a	82.37	a	88.62	a	83.89	a	85.87	a	94.24	a	101.39	a
	A		A		B		B		A		A		B		B	
n ₁ (100)	88.99	b	91.19	b	96.34	b	93.03	a	101.81	b	104.33	b	110.22	b	106.44	b
	A		AB		B		AB		A		AB		B		AB	
n ₂ (200)	95.24	c	98.47	c	98.93	b	101.64	b	108.96	c	112.66	c	113.19	b	116.29	c
	A		A		A		A		A		A		A		A	
n ₃ (300)	94.50	c	97.37	c	99.18	b	89.66	a	108.12	c	111.41	c	113.47	b	101.39	a
	AB		B		B		A		AB		B		B		A	

Remarks: The average number marked with the same capital letter (horizontal direction) and the same lowercase letter (vertical direction) shows an intangible difference according to the Least Significant Difference (LSD) test at a real level of 5 %.

Table 2. Effect of NPK and Humic Acid Fertilizer Dosage on the Number of Tiller of Rice Field Plants at the Age of 30 DAP, 40 DAP, 50 DAP, and 60 DAP

NPK Fertilizer Dosage (N) (kg ha ⁻¹)	Humic Acid Dosage (H) (kg ha ⁻¹)															
	h ₀ (0)				h ₁ (1.5)				h ₂ (3.0)				h ₃ (4.5)			
	Number of Saplings (stems) 30 DAP						Number of Saplings (stems) 40 DAP									
n ₀ (0)	13.90	a	15.10	a	16.90	a	18.40	a	16.60	a	17.90	A	19.80	a	21.50	a
	A		AB		BC		C		A		AB		BC		C	
n ₁ (100)	19.50	b	20.10	b	20.70	b	20.60	a	21.50	b	22.10	B	22.80	b	22.50	a
	A		A		A		A		A		A		A		A	
n ₂ (200)	21.00	b	21.80	c	23.30	c	25.20	b	23.00	b	24.00	C	25.70	c	27.70	b
	A		A		AB		B		A		A		AB		B	
n ₃ (300)	20.70	b	22.40	c	22.80	c	19.50	a	22.80	b	24.70	C	25.10	c	21.50	a
	AB		B		B		A		AB		B		B		A	
	Number of Saplings (stems) 50 DAP						Number of Saplings (stems) 60 DAP									
n ₀ (0)	18.20	a	19.40	a	21.40	a	23.10	a	19.60	a	20.30	A	22.40	a	24.10	a
	A		AB		BC		C		A		A		AB		B	
n ₁ (100)	23.20	b	23.80	b	24.60	b	24.30	a	24.20	b	24.80	bc	26.20	b	25.30	a
	A		A		A		A		A		A		A		A	
n ₂ (200)	24.80	b	25.80	c	27.70	c	29.90	b	25.90	b	27.00	C	28.90	c	31.20	b
	A		A		AB		B		A		AB		BC		C	
n ₃ (300)	24.60	b	26.50	c	27.00	c	23.10	a	25.70	b	27.70	C	28.20	c	24.10	a
	AB		B		B		A		AB		B		B		A	

Remarks: The average number marked with the same capital letter (horizontal direction) and the same lowercase letter (vertical direction) shows an intangible difference according to the Least Significant Difference (LSD) test at a real level of 5 %.

Table 3. Effect of NPK and Humic Acid Fertilizer Dosage on Root Extinction Ratio, Number of productive Tillers, Number of Grains per Panicle and Percentage of Grain Content

NPK Fertilizer Dosage (N) (kg ha ⁻¹)	Humic Acid Dosage (H) (kg ha ⁻¹)							
	h ₀ (0)	h ₁ (1.5)	h ₂ (3.0)	h ₃ (4.5)	h ₀ (0)	h ₁ (1.5)	h ₂ (3.0)	h ₃ (4.5)
	Root Extinction Ratio				Number of productive saplings			
n ₀ (0)	11.04 a	11.32 a	11.85 a	12.10 a	13.50 a	14.10 a	15.90 a	17.00 a
	A	A	A	A	A	A	AB	B
n ₁ (100)	11.73 ab	12.01 ab	12.69 ab	12.21 a	17.20 b	17.60 b	18.60 b	17.90 a
	A	A	A	A	A	A	A	A
n ₂ (200)	12.48 b	13.03 bc	14.12 c	15.37 b	18.30 b	19.10 bc	20.70 c	21.80 b
	A	AB	BC	C	A	A	AB	B
n ₃ (300)	12.42 b	13.37 c	13.64 bc	11.66 a	18.20 b	19.60 c	20.00 bc	17.10 a
	AB	B	B	A	AB	B	B	A
	Number of grains per panicle				Percentage of grain content			
n ₀ (0)	143.87 a	152.67 a	158.02 a	167.78 b	67.13 a	77.63 a	80.35 a	85.31 b
	A	AB	AB	B	A	B	BC	C
n ₁ (100)	169.43 b	172.78 b	180.57 b	176.39 b	86.15 c	87.85 b	91.82 b	89.69 b
	A	A	A	A	A	A	A	A
n ₂ (200)	176.67 b	176.29 b	180.50 b	199.96 c	89.83 c	89.64 b	91.78 b	94.76 c
	A	A	A	B	AB	A	AB	B
n ₃ (300)	151.53 a	169.51 ab	168.25 ab	143.09 a	77.05 b	83.65 ab	85.55 a	72.76 a
	AB	C	BC	A	AB	B	B	A

Remarks: The average number marked with the same capital letter (horizontal direction) and the same lowercase letter (vertical direction) shows an intangible difference according to the Least Significant Difference (LSD) test at a real level of 5 %.

Table 4. Effect of NPK and Humic Acid Fertilizer Dosage on the Weight of 1000 Grains of Rice Crop

Treatment	Weight 1000 grains (g)
<u>NPK Fertilizer Dosage (N) :</u>	
n ₀ (0 kg ha ⁻¹)	25.97 a
n ₁ (100 kg ha ⁻¹)	27.04 a
n ₂ (200 kg ha ⁻¹)	28.22 a
n ₃ (300 kg ha ⁻¹)	27.80 a
<u>Humic Acid Dosage (H):</u>	
h ₀ (0 kg ha ⁻¹)	27.36 a
h ₁ (1.5 kg ha ⁻¹)	27.48 a
h ₂ (3.0 kg ha ⁻¹)	26.89 a
h ₃ (4.5 kg ha ⁻¹)	27.30 a

Remarks: The average number marked with the same capital letter (horizontal direction) shows an intangible difference according to the Least Significant Difference (LSD) test at a real level of 5 %.

Table 5. Effect of NPK and Humic Acid Fertilizer Dosage on Weight of Dry Grain Harvested per Clump, Weight of Harvested Dry Grain per Plot, Weight of Dry Ground Grain per Clump and Weight of Milled Dry Grain per Plot

NPK Fertilizer Dosage (N) (kg ha ⁻¹)	Humic Acid Dosage (H) (kg ha ⁻¹)															
	h ₀ (0)				h ₁ (1.5)				h ₂ (3.0)				h ₃ (4.5)			
	Weight of dry grain harvested per clump								Weight of harvested dry grain per plot							
n ₀ (0)	45.12	a	50.06	a	56.61	a	60.33	a	4.19	a	4.82	a	5.34	a	5.81	a
	A		AB		BC		C		A		B		C		C	
n ₁ (100)	60.96	b	62.24	b	65.96	b	63.62	a	5.66	b	5.99	b	6.35	b	6.12	a
	A		A		A		A		A		AB		B		AB	
n ₂ (200)	64.69	b	67.65	c	73.36	c	74.95	b	6.22	c	6.51	c	7.06	c	7.21	b
	A		AB		BC		C		A		A		B		B	
n ₃ (300)	64.64	b	69.59	c	71.01	c	60.54	a	6.22	c	6.70	c	6.83	c	5.80	a
	AB		B		B		A		AB		BC		C		A	
	Weight of dry ground grain per clump								Weight of milled dry grain per plot							
n ₀ (0)	42.09	a	45.04	a	50.94	a	54.28	a	3.87	a	4.32	a	4.95	a	5.21	a
	A		AB		BC		C		A		A		B		B	
n ₁ (100)	54.85	b	56.00	b	59.35	b	57.24	a	5.27	b	5.38	b	5.70	b	5.49	a
	A		A		A		A		A		A		A		A	
n ₂ (200)	58.20	b	60.86	c	66.00	c	67.43	b	5.59	b	5.84	c	6.34	c	6.47	b
	A		AB		BC		C		A		A		B		B	
n ₃ (300)	58.15	b	62.61	c	63.89	c	55.26	a	5.58	b	6.01	c	6.13	bc	5.21	a
	AB		B		B		A		AB		BC		C		A	

Remarks: The average number marked with the same capital letter (horizontal direction) and the same lowercase letter (vertical direction) shows an intangible difference according to the Least Significant Difference (LSD) test at a real level of 5 %.

Root Extinction Ratio, Number of productive Tillers, Number of Grains per Panicle and Percentage of Grain Content

The analysis's findings demonstrated that the amount of grain per panicle, the number of productive tillers, the percentage of grain content per panicle, and the Root Extinction Ratio of rice field plants displayed in Table 3 were all impacted by the combination of humic acid and NPK fertilizer dosage. Between 200 and 300 kg ha⁻¹ of NPK fertilizer and 3 to 4.5 kg ha⁻¹ of humic acid were the ranges where the study found the highest ratio of root extinction. The range of 200 kg ha⁻¹ to 300 kg ha⁻¹ of NPK fertilizer combined with a dose of humic acid produced the most fruitful tiller in the experiment.

NPK fertilizer dosages of 200–300 kg ha⁻¹ and humic acid dosages of 3–4.5 kg ha⁻¹ were associated with the highest number of productive tiller in the trial. Grain production per panicle was higher in the study when 200 kg ha⁻¹ of NPK fertilizer was applied along with 3–4.5 kg ha⁻¹ of humic acid. The NPK fertilizer dose of 200 kg ha⁻¹ combined with a humic acid dose of 3 kg ha⁻¹ to 4.5 kg ha⁻¹ had the highest percentage of grain content in the research.

Weight 1000 Grains

The results of the analysis showed that there was no interaction between the dose of NPK fertilizer and humic acid on the weight of 1000 grains of grain. In terms of independent effects,

the results of the analysis are shown in Table 4.

Weight of Dry Grain Harvested per Clump, Weight of Harvested Dry Grain per Plot, Weight of Dry Ground Grain per Clump and Weight of Milled Dry Grain per Plot

The analysis's findings demonstrated that the weight of harvested dry grain per clump, weight of harvested dry grain per plot, weight of milled dry grain per clump, and weight of harvested dry grain per plot—all of which are displayed in Table 5—interacted with the dosage of humic acid and NPK fertilizer. In the study, a 200 kg ha⁻¹ NPK fertilizer dose combined with a 3–4.5 kg ha⁻¹ humic acid dose resulted in a larger weight of harvested dry grain per clump. The results of the analysis showed that the dosage of NPK fertilizer and humic acid interacted with the weight of harvested dry grain per plot, weight of harvested dry grain per clump, weight of harvested dry grain per plot, and weight of milled dry grain per clump, all of which are shown in Table 5. A higher weight of harvested dry grain per clump was obtained in the study when a 200 kg ha⁻¹ NPK fertilizer dose was coupled with a 3–4.5 kg ha⁻¹ humic acid treatment.

DISCUSSION

Plant height, the number of tiller, the ratio of root extinction, the number of productive tiller, the number of grains per panicle, the percentage of grain content per panicle, the weight of harvested dry grain per clump, the weight of harvested dry grain per plot, the weight of milled dry grain per clump, and the weight of harvested milled dry grain per plot were

all impacted by the treatment of the dose of NPK fertilizer and humic acid.

NPK fertilizer given together with humic acid is able to provide a balanced supply of nutrients to plants between the generative and vegetative phases. NPK fertilizers and humic acid are able to provide a balance of nutrients, both macro and micro, that affect plant growth. Plants that are optimal in absorbing nutrients are able to provide higher plant growth and development compared to plants that are not supplied with added nutrients (Hardiyanti *et al.*, 2022).

Rice plants can produce more proteins and carbs by increasing their photosynthesis with NPK fertilizer. The production of flowers, fruits, and seeds depends on P's role as one of the components of protein. In plant growth, element K is involved in metabolic processes such as respiration and photosynthesis. While rice plants require element K at the time of panicle release, plants require P throughout panicle production, which activates seed filling and speeds up seed ripening. Applying humic acid enhances the physical and chemical characteristics of the soil and stimulates plant uptake of nutrients (Islam *et al.*, 2021).

Humic acid and NPK fertilizers work in tandem to improve soil fertility, growth, and rice crop yields. While humic acid raises the soil's cation exchange capacity (CEC), which makes minerals like nitrogen, phosphorous, and potassium more accessible and less likely to be lost through leaching or evaporation, NPK fertilizers supply vital nutrients like these elements. The combination of humic acid with NPK

fertilizer can increase the efficiency of fertilizer use, so that plants can absorb more nutrients with the same amount of fertilizer or even less (Nuraini *and* Zahro, 2020).

In the vegetative phase, the application of NPK fertilizer and humic acid interacts with the parameters of plant height, number of tiller and root extinct ratio. Humic acid has the ability to bind nitrogen as a ligand so that it forms a complex that stores nutrients temporarily in the soil and can be released when plants need them. Humic acid can inhibit urease activity, thereby reducing nitrogen release due to evaporation and increasing soil nitrogen availability (Nuraini *and* Zahro, 2020). The presence of nitrogen available in the soil allows plants to absorb large amounts of nitrogen.

The use of N fertilizers with humic acid can reduce the loss of NH_4 (ammonia) in the soil by increasing NH_4^+ and NO_3^- availability. This has an impact on increasing the efficiency of NPK fertilizer use and reducing environmental pollution. The carboxyl group (-COOH) in K-humates can bind to NH_4^+ . The N element in NPK fertilizer added with humic acid shows slow release of NH_4^+ , the interaction in the N humic bond involves covalent bonds and hydrogen bonds. The covalent bond between the aromatic group in humic acid and the amide group in N forms a stronger aromatic compound amide which makes it more difficult for the element N to *fast release*, while the presence of hydrogen bonds in the dipolar water molecule can bind the element N and element K. With the slow release of soil nutrients due to humic acid, plants can absorb

more nutrients, so that it causes plant growth (vegetative phase) to become larger.

In the generative phase, plant development will focus on the formation of flowers and seeds. In line with the statement Lukmansyah *et al.*, (2020) that humic acid can help plant metabolic processes and increase the rate of photosynthesis. So, if the rate of photosynthesis is high, it can produce high assimilate materials as well and result in the translocation process to the seed can run well.

Phosphorus (P) is necessary for the growth and development of roots as well as the development of seeds and fruits (Bertani, 2023). Furthermore, phosphorus is a component of ATP, RNA, DNA, proteins, and a number of enzymes. While RNA and DNA dictate a plant's genetic characteristics, ATP is crucial for the energy transfer process. Phosphorus has an important role in providing the chemical energy needed in all plant metabolic activities. Almost all phosphorus in the soil is not available to plants. When given as a fertilizer, phosphorus often becomes unavailable due to fixation, resulting in reduced availability of P for plants.

Humic acid has the ability to bind cations such as aluminum (Al) and iron (Fe) through the process of chelation. These cations usually combine with phosphorus in a form that is not available to plants. Humic acid helps release phosphorus by binding to Al and Fe, making it more available to plants. Humic acid can increase the release and solubility of inorganic P that is insoluble. With regard to the availability of P in the soil (H_2PO_4^- and HPO_4^-), the application of humic acid

can overcome the problem of P fixation in acidic soils. According to Ampong *et al.*, (2022) Humic acid can increase the soil cation exchange capacity and increase the availability of nutrients for plants. This is related to the ability of humic acid to reduce the solubility level of Fe^{2+} . The less the soil Fe^{2+} level, the more the plant's ability to absorb nutrients P. This P nutrient is a macronutrient that is very essential in the formation of grain and increasing production.

In addition to phosphorus, potassium is also one of the macroelements that is very important for plants, especially in the generative phase. Potassium serves as a root growth stimulant, improves plant metabolism, as well as fruit formation and seed filling (Alfy *and* Handoyo, 2022). The availability of K in the soil is influenced by the position of the

exchange site of potassium ions in the soil and the ratio of K activity to the activity of Ca and Mg in a balanced state in acidic soils (Salam, 2020). According to Tomaso (2020) nutrients K in the soil are in large quantities, but those used by plants are water-soluble or interchangeable forms of K (in colloidal soils). On the other hand, K is lost from the soil because it is absorbed by plants and washed by rainwater (*leaching*). Echo (2021) stated that by adding humate material in the application of fertilizer, fertilizer is more efficient so that it is easily absorbed by plants.

The yield of milled dry grain is the weight of the grain after drying. The weight of milled dry grain is one of the parameters used to determine the high and low productivity of crops and describes the quality of the land used.

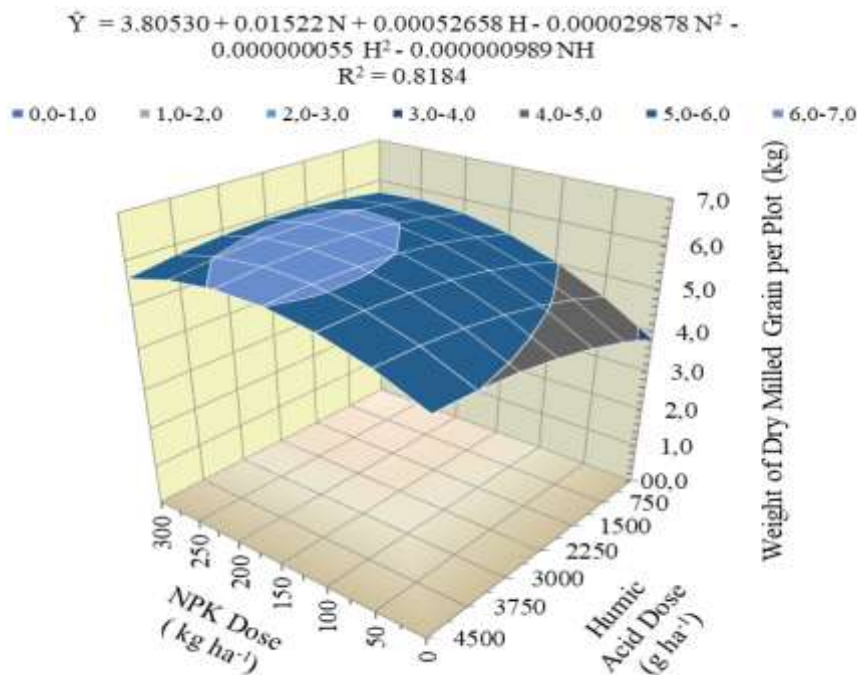


Figure 1. Yield Response / Weight of Dry Milled Grain per Plot Due to Dose of NPK and Humic Acid Fertilizer

To determine the optimal dose of NPK (N) fertilizer and the optimal dose of Humic Acid (H) that provide the maximum yield/weight of milled dry grain of paddy rice plants per plot, an analysis was carried out by quadratic regression (response surface model $\hat{Y} = 3.80530 + 0.01522 N + 0.00052658 H - 0.000029878 N^2 - 0.000000055 H^2 - 0.000000989 NH$. $R^2 = 0.8184$).

Based on the fingerprints of the various regression tests are real and in detail are presented in Appendix 13 with the corresponding regression equations as follows: $\hat{Y} = 3.80530 + 0.01522 N + 0.00052658 H - 0.000029878 N^2 - 0.000000055 H^2 - 0.000000989 NH$; $R^2 = 0.8184$. From this equation, the maximum yield value of milled dry grain per plot is 6.15 kg with an optimal dose of NPK fertilizer of 206.30 kg ha⁻¹ and an optimal dose of humic acid of 2.928 kg ha⁻¹ with a determination coefficient value (R^2) = 0.8184, this shows that 81.84% of the yield/weight of milled dry grain per plot is determined by the application of NPK fertilizer and humic acid and 18.16% is determined by factors others that affect it. For more details as seen in Figure 1.

From Figure 1, we can see that the optimal dose of NPK fertilizer of 206.3 kg ha⁻¹ and the optimal dose of humic acid of 2.928 kg ha⁻¹ produced a maximum of 6.15 kg of milled dry grain per plot of 6.15 kg or equivalent to 10.250 tons ha⁻¹.

The recommended dose of NPK fertilization for the West Java region is 250 kg ha⁻¹. With an optimal dose of 206.3 kg ha⁻¹ for NPK fertilizer, it means reducing the use of NPK fertilizer dosage as recommended by

43.7 kg ha⁻¹ or reducing the NPK fertilizer dose by 17.48%. With this optimal dose, it produces dry milled grain per plot that exceeds the potential yield of the Sarinah variety rice in the description. This is in line with the statement Lestari (2021), that the application of humic acid can improve the efficiency and performance of fertilizers so that plant growth can be maximized.

Based on the description above, we can see that NPK fertilizer treatment given at the same time as the application of humic acid can increase the absorption of nutrients in rice plants various growth phases, namely, the vegetative growth phase to the generative growth phase (Nuraini and Zahro, 2020). In addition, the addition of humic acid can make the nutrients available to plants easily absorbed by plants so that production results will be maximized (Putra *et al.*, 2024). In the observation parameter of 1000 grains, the treatment of NPK fertilizer and humic acid showed no interaction. This is because the shape and size of 1000 grains of rice with the Sarinah variety are uniform. The height and weight of 1000 grains of rice depends on the dry matter in the grain resulting from the process of photosynthesis which is used for grain filling (Huda *et al.*, 2024). The average result of the weight of 1000 seeds in each treatment during harvest got relatively the same result. This is suspected because the availability of seed size in plants is more supported due to genetic factors than environmental factors. This is reinforced by the statement Meliawati *et al.*, (2023) which states that the weight of 1000 grains are one of them

is influenced by plant genetic factors. The weight of 1000 grains have a high heritability, which means that this trait is strongly influenced by genetics and can be passed down to offspring and attached to the variety. Research results Kurniawan *and* Azmi, (2021) shows that the application of NPK fertilizer and humic acid at all levels of treatment gives unreal results because the weight of these 1000 grains is influenced by genetics in this case the variety.

CONCLUSION

Every observation parameter—plant height, number of seedlings, root extinction ratio, number of productive seedlings, number of grains per panicle, percentage of grain content, weight of harvested dry grain per clump, weight of harvested dry grain per plot, weight of milled dry grain per clump, and weight of milled dry grain per plot—showed an interaction between the dose of NPK fertilizer and humic acid, with the exception of the weight of 1000 grains of grain, which showed no interaction between the two substances. 206.30 kg ha⁻¹ of NPK fertilizer and 2.928 kg ha⁻¹ of humic acid were the optimum dosages, resulting in a maximum of 6.15 kg of dry milled rice per plot, or 10.250 tons ha⁻¹.

SUGGESTION

To get better rice crop yields in areas that have the same type and land conditions as this experiment, it is recommended to apply a dose of NPK fertilizer of 206.30 kg ha⁻¹ and Humic Acid of 2.928 kg ha⁻¹, if the inappropriate dose will affect the

growth rate and yield of paddy rice crops. To obtain more complete information about the dosage of NPK and Humic Acid fertilizers, it is recommended that further research be conducted on different environmental factors, soils and seasons.

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