



The Impact of Suggested Dosage Percentage of NPK Fertilizer and Biofertilizer on the Growth and Production of Inpari 32 Rice Variety (*Oryza sativa* L.)

Lia Amalia¹, Danu Hamidi¹, Nunung Sondari¹, Tien Turmuktini¹, R. Budiasih¹

¹Magister Agrotechnology Department, Agriculture Faculty, Winaya Mukti University, Bandung, Jawa Barat, Indonesia

Corresponding author: liaamalia2.unwim@gmail.com

Abstract

Abstract. The study was conducted at the Agricultural, Fisheries, and Forestry Extension Agency (BP3K) in Cilamaya Wetan District, Karawang Regency, West Java, at an elevation of 8.9 m above sea level, from December 2022 to March 2023.

Aims. The research focuses on exploring how the recommended percentage of NPK fertilizer interacts with biological fertilizer to affect the growth and yield of the lowland rice variety Inpari 32 and to determine the ideal biological fertilizer for each NPK dose level that maximizes grain weight per plot.

Methods. The experimental design used was a factorial pattern, a Randomized Block Design with two factors and repeated three times. The first factor is the dose of NPK fertilizer (N), which includes three treatment levels, namely: $n_1 = 100\%$ of the suggested dose (500 g plot^{-1}); $n_2 = 50\%$ of the suggested dose (250 g plot^{-1}), and $n_3 = 25\%$ of the suggested dose (125 g plot^{-1}). The second factor is the biological fertilizer dose (H), which includes 3 treatment levels, namely: $h_1 = 0\%$ of the recommended dose (0 g plot^{-1}); $h_2 = 50\%$ of the recommended dose (15 g plot^{-1}), and $h_3 = 100\%$ of the recommended dose (30 g plot^{-1}).

Result. The experimental results indicated an interaction between the recommended percentage of NPK fertilizer and biological fertilizer regarding plant height and number of tillers aged 28 Days After Planting (DAP), 42 DAP, and 56 DAP, along with the number of productive tillers, panicle length, grain weight per panicle, grain weight per clump, and grain weight per plot. The highest grain weight per plot of 24.32 kg was attained at the advised NPK fertilizer dosage of 100%, along with the ideal recommended biological fertilizer dose of 66.10% ($r^2 = 0.92$).

Conclusion. The suggested NPK fertilizer dosage of 50% yielded the highest grain weight per plot of 23.77 kg, using the ideal recommended biological fertilizer amount of 60.19% ($r^2 = 0.90$).

Implication. With a suggested application of NPK fertilizer of 25%, the highest grain mass per plot of 23.15 kg at an ideal biological fertilization rate of 55.10% ($r^2 = 0.94$).

Keywords: NPK Dose, biofertilizer, Paddy, Rice



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INTRODUCTION

Rice (*Oryza sativa* L.) is a significant food staple alongside wheat and corn, and is extensively grown in Asia, particularly Indonesia. Rice serves as the primary staple food for a

large portion of the Indonesian population, supplying 45%-55% of the protein and 40%-80% of the total calories required by humans (Rahmatika et al., 2020; Ikhvani et al., 2022; Susanti et al., 2024; Khairunnisa et al., 2025).

In 2024, national rice production is projected to reach 53.14 million tons of dry milled grain, reflecting a 1.55% decline from 2023's 53.98 million tons (BPS, 2025). Inpari 32 rice is a variety of irrigated rice seed, derived from the Ciherang strain, noted for its greater pest resistance and has high yield potential (8.42 t ha⁻¹ dry milled grain) and is stable, suitable for various land and weather conditions, offering a soft rice flavor and is drought resilient (Saparto, 2021). Typically, enhanced rice field management is implemented with high inorganic fertilizers while neglecting organic materials. The application of inorganic fertilizers to the soil initially boosts its chemical fertility by supplying nutrients rapidly for plant growth; however, if applied excessively, it can harm the soil's chemical, physical, and biological fertility and hinder the absorption of micronutrients by plant roots, leading to impaired plant growth. Incorporating organic and biological fertilizers can enhance the soil's physical, chemical, and biological fertility and support the sustainability of the land environment (Kaya, 2018; Pawar & Suryawanshi, 2022).

Biofertilizer is an inoculant that contains active living organisms that can boost microbial populations and enhance specific microbial activities to improve the availability of nutrients plants can absorb. Incorporating biofertilizer will naturally enhance the levels of macro and micronutrients, thereby decreasing the reliance on NPK fertilizers (Fatimah *et al.*, 2025; Mulyani et al., 2025; Moe et al., 2019; Radzi and Hisyamuddin, 2021; Suryadi, et al., 2022; Hapsah et al., 2024; Ghofar et al., 2025; Peng et al., 2020; Fitriatin et al., 2021; Made et al., 2022; Akhmad et al., 2024; Oktaviani et al., 2025). The application of inorganic fertilizers, along with comprehensive and balanced biofertilizers, enhances soil fertility and ultimately boosts rice productivity (Gusmiatun & Marlina, 2019; Ngui et al., 2024; Mendy et al., 2025). Enhancing sustainable land productivity can be achieved by increasing the use of biofertilizers, which are fertilizers that contain living organisms that boost soil fertility. Biofertilizers can mobilize, enhance, and convert unavailable nutrients into accessible forms using biological mechanisms. Decomposers, or decomposing microorganisms, are classified as biofertilizers because they actively transform unavailable or bound nutrients into organic compounds, which are then made available via mineralization or decomposition. Biological fertilizers offer significant promise for organic-based agriculture that emphasizes environmental sustainability (Marlina et al., 2025; Purwanto et al., 2025). The collection of biological fertilizers holds significant promise for comprehensive organic agriculture (sustainable agriculture), which encompasses: nitrogen-fixing organisms (both symbiotic and non-symbiotic), phosphorus-solubilizing microorganisms, potassium-solubilizing microorganisms, microbes that synthesize phytohormones aiding plant growth (plant growth-promoting rhizobacteria), microbes responsible for organic matter breakdown (decomposers), and microbes functioning as biological agents (Fitriatin et al., 2019; Subhalakshmi et al., 2025).

MATERIALS AND METHODS

The application of inorganic and biological fertilizers can positively impact rice field soil, creating an effective medium that supports optimal plant growth and development.

Nutrient availability is crucial for plant growth and development, supporting metabolic processes, such as photosynthesis, which enhances the production of photosynthates that are then distributed throughout the plant. The experiment utilized Inpari 32 variety rice seeds, NPK compound fertilizer (Phonska), and biological fertilizer. The tools utilized include a tractor, hand sprayer, C-organic and soil pH measuring instrument, hoe, rice threshing machine, sickle, meter, stationery, ruler, calculator, analytical scale, sample paper, sample plastic, stationery, and documentation equipment

This experiment was conducted three times using a Randomized Block Design (RBD) factorial pattern with two factors: three levels of biological fertilizer and three levels of NPK fertilizer, and repeated three times. Nine treatment combinations were randomly arranged in experimental plots measuring 5 meters by 4 meters in each replication. Analysis of variance and second-order polynomial regression equations (quadratic) with the following equation estimate model were used to test the ideal biological fertilizer dose at each level of NPK fertilizer dose that produced the maximum weight of rice grain per plot of paddy fields :

$$\hat{Y}_{h-ni} = b_0 + b_1X_1 + b_2X_1^2$$

Description:

\hat{Y}_{h-ni} = The yield of paddy rice of the Inpari 32 variety as a result of the biological fertilizer dosage at each NPK fertilizer dose level

b_0 = Intercep Value

b_1 = the linear Coefficient value

X_1 = the linear effect of the biological fertilizer dose

b_2 = the quadratic coefficient value

X_1^2 = the biological fertilizer dose's quadratic effect

The form of the quadratic regression equation estimator model was calculated using Excel 2021; the "Doolittle shortened" approach (Vincent Gaspersz, 1992) was used to calculate the shape of the quadratic regression equation estimator model. Additionally, the accuracy of the suitable quadratic regression model as an estimator model was tested using an analysis of variance. To find the ideal biofertilizer dosage at each NPK fertilizer dose level that produced the highest grain weight per plot of Inpari 32 rice fields, the proper equation form was converted into a curve.

OBSERVATION RESULTS

1) Plant Height, Tiller Count, and 1000 Grain Weight

The analysis's findings showed that plant height, the number of rice tillers at 14 DAP, and 1000-grain weight did not interact with the percentage of the recommended NPK and biofertilizer dose (Table 1).

Table 1 shows that the age at 14 HST, plant height, and the number of tillers were not significantly affected by the application of the prescribed doses of NPK and biological fertilizer. This is because, when NPK fertilizer was applied as a novel treatment at 14 DAP, it had not yet decomposed, and the plants were unable to absorb it. Although biofertilizer was applied at 7 DAP, it may not have been able to supply the plants with nutrients. In order for each treatment to have no independent effect on the number of tillers and plant height at 14 DAP. When compared to other treatments, the application of 100% NPK fertilizer and 100%

biofertilizer separately produced the maximum weight of 1000 grains. Live microorganisms such as Azospirillum sp., Rhizobium sp., Pseudomonas fluorescens, Trichoderma harzianum, and Aspergillus niger are present in FloraOne biofertilizer, which also provides vital nutrients. This fertilizer also contains essential nutrients (PT. Centra Biotech Indonesia, 2025).

Table 1. Impact of NPK Fertilizer Dosage and Biofertilizer Dosages on Inpari 32 Rice Variety Plant Height and Tiller Count at 14 DAP and 1000 Grain Weight

Treatment	Plant Height (cm)	Tiller Count (pieces)		Weight of 1000 Grains (g)	
<u>NPK Fertilizer Dosage (N):</u>					
n ₁ (100 %)	19,23 a	5,67	a	25,98	c
n ₂ (50 %)	18,74 a	5,33	a	24,62	b
n ₃ (25 %)	19,67 a	5,00	a	22,16	a
<u>Biofertilizer Dosage (H):</u>					
h ₁ (0 %)	18,78 a	5,00	a	23,68	a
h ₂ (50 %)	19,29 a	5,44	a	23,82	a
h ₃ (100 %)	19,58 a	5,56	a	25,26	b

Description: Duncan's multiple range test at a 5% level of significance indicates that there is no significant difference between the average numbers with the same letter.

Plant Height and Number of Tillers at Age 28 DAP, 42 DAP, and 56 DAP, Number of Productive Tillers, Panicle Length, Grain Weight per Panicle, Grain Weight per Clump, and Grain Weight per Plot of Inpari 32 Variety Rice Fields showed an interaction between the recommended dose of NPK fertilizer and biofertilizer, according to the analysis's findings (Table 2).

Table 2. Impact of NPK Fertilizer and Biofertilizer Dosage on Inpari 32 Variety Paddy Plant Height, Number of Tillers at Ages 28, 42, and 56 DAP, Number of Productive Tillers, Panicle Length, Grain Weight per Panicle, Grain Weight per Clump and Grain Weight per Plot

Observation Variables:	NPK Fertilizer Dosage (N)	Biofertilizer Dosage (H)		
		h ₁ (0 %)	h ₂ (50 %)	h ₃ (100 %)
1.Plant Height :		----- cm -----		
28 HST (cm)	n ₁ (100 %)	33,67 a A	37,17 b B	38,00 a B
	n ₂ (50 %)	37,87 b A	39,13 b A	38,33 a A
	n ₃ (25 %)	34,67 a A	36,00 a AB	37,00 a B

42 HST (cm)	n ₁ (100 %)	49,02 b	51,95 a	51,13
		A	B	B
	n ₂ (50 %)	47,13 a	50,61 a	49,38
		A	B	B
	n ₃ (25 %)	46,79 a	50,54 a	45,22
		A	B	A
56 HST (cm)	n ₁ (100 %)	51,55 a	54,88 b	54,16 b
		A	B	B
	n ₂ (50 %)	49,74 a	52,61 a	52,25 b
		A	B	B
	n ₃ (25 %)	49,50 a	53,56 ab	47,83 a
		A	B	A
2. Number of Tillers:		----- pieces -----		
28 HST	n ₁ (100 %)	12,07 b	12,73 a	12,47 b
		A	B	AB
	n ₂ (50 %)	11,53 a	12,40 a	12,13 b
	A	B	B	
n ₃ (25 %)	11,47 a	12,47 a	11,13 a	
		A	B	A
42 HST	n ₁ (100 %)	18,80 b	19,87 a	19,60 b
		A	B	B
	n ₂ (50 %)	18,07 a	19,40 a	18,93 b
		A	B	B
	n ₃ (25 %)	17,93 a	19,40 a	17,33 a
		A	B	A
56 HST	n ₁ (100 %)	28,87 b	30,60 b	30,20 b
		A	B	B
	n ₂ (50 %)	27,73 ab	29,33 a	29,13 b
		A	B	B
	n ₃ (25 %)	27,60 a	29,87 ab	26,67 a
		A	B	A
3. Number of Productive Tillers :		----- pieces -----		
	n ₁ (100 %)	17,27 b	18,27 a	18,07 b

		A	B	B
	n ₂ (50 %)	16,53 a	17,53 a	17,40 b
		A	B	B
	n ₃ (25 %)	16,33 a	17,60 a	16,00 a
		A	B	A
4. Panicle Length		----- cm -----		
	n ₁ (100 %)	19,67 a	21,60 b	21,20 b
		A	B	B
	n ₂ (50 %)	19,53 a	21,50 b	20,20 b
		A	C	B
	n ₃ (25 %)	19,27 a	20,60 a	20,00 a
		A	C	B
5. Grain Weight per Panicle		----- g -----		
	n ₁ (100 %)	1,98 b	2,15 b	2,11 b
		A	C	B
	n ₂ (50 %)	1,95 b	2,13 b	2,01 a
		A	B	A
	n ₃ (25 %)	1,92 a	2,04 a	1,99 a
		A	C	B
6. Grain Weight per Clump		----- g -----		
	n ₁ (100 %)	81,00 a	89,00 c	87,27 b
		A	C	B
	n ₂ (50 %)	80,50 a	87,30 b	83,33 a
		A	C	B
	n ₃ (25 %)	79,67 a	85,17 a	82,63 a
		A	C	B
7. Grain Weight per Plot		----- kg -----		
	n ₁ (100 %)	22,01 a	24,18 c	23,71 b
		A	C	B
	n ₂ (50 %)	21,87 a	23,72 b	22,94 a
		A	C	B
	n ₃ (25 %)	21,64 a	23,14 a	22,15 a
		A	C	B

Description: Duncan's multiple range test at a 5% significance level indicates that there is no significant difference between the average figures indicated with the same capital letters (horizontal direction) and the same lower case letters (vertical direction)

Table 2 shows that, compared with other treatments, the treatment levels of the required dose percentage for NPK fertilizer (50%) and biological fertilizer (50%) yielded higher plant height at 28 DAP. Compared with other treatments, the prescribed dose percentages of NPK fertilizer (100%) and biological fertilizer (50%) at 42 and 56 DAP resulted in greater plant height. Compared with other treatments, the 100% NPK fertilizer and 50% biological fertilizer combination produced more tillers at 28, 42, and 56 DAP. Since NPK is an inorganic fertilizer that enhances soil chemical characteristics, it is hypothesized that a reaction to the application of biological and NPK fertilizers began at age 28 DAP. The nutrient N is crucial throughout the vegetative growth phase, particularly as the number of tillers and plant height increase. When biological fertilizer is applied at 28 DAP, microorganisms begin to aggressively dissolve soil nutrients, which facilitates the plant's vegetative growth.

At the prescribed dose of 100% NPK fertilizer and 50% biofertilizer, there were more productive tillers, longer panicles, heavier grain per panicle, heavier grain per clump, and heavier grain per plot. This is consistent with the findings of the Manullang et al. (2025) study, which found a significant interaction between NPK dose and organic biofertilizer combinations on plant production and growth. Interestingly, administering 50% of the suggested NPK dose, along with *Azotobacter* sp. + *Pseudomonas* sp., resulted in yields that were either equal to or higher than those from the full NPK dose. These results demonstrate the feasibility of using biofertilizers instead of chemical fertilizers, offering an environmentally friendly approach to rice cultivation. The number of productive tillers, panicle length, grain weight per panicle, grain weight per clump, and grain weight per plot are all affected by the combination of NPK and biological fertilizer doses. The use of biological and NPK fertilizers is thought to have a synergistic effect on the rise in plant P levels and plant P uptake. The soil used in the experiment usually had low fertility, particularly in the concentration of accessible soil P, which was 23 mg kg⁻¹, according to the results of the soil study conducted before the experiment. Such soil fertility indicates that NPK fertilizer and biological fertilizer work together to raise soil and plant P levels. This demonstrates that NPK fertilizer is crucial for increasing the amount of P available in the soil.

By dissolving inorganic phosphates found in the soil, such as Fe-P, Al-P, and Ca-P, Phosphate-solvent microbes (bacteria such as *Pseudomonas fluorescens* and *Azotobacter*) can produce organic acids, inorganic acids, H₂S, release protons from NH₄, and produce siderophores and exopolysaccharides. Biofertilizers can increase the amount of available P in the soil (Pane et al., 2022). Therefore, the secretion of organic compounds by phosphate-solubilizing microbes and the synthesis of phosphatase enzymes in the presence of organic acids (organic compounds) can be the mechanism of dissolving NPK fertilizers, particularly phosphate, because the chelating process takes place to make P available for plants once more.

By increasing the amount of available P in the soil, NPK and biological fertilizers work together to increase the volume of plant roots. This increases plant P absorption, which in turn increases the number of productive tillers, panicle length, grain weight per panicle, grain weight per clump, and grain weight per plot. According to Satyaprakash et al. (2017), phosphorus plays a significant role in root development, stem strengthening, flower and seed formation, energy production, storage reactions, root growth, cell division and enlargement,

resistance to plant diseases, and the conversion of sugar into starch. This is closely linked to the function of P, which is crucial for plants.

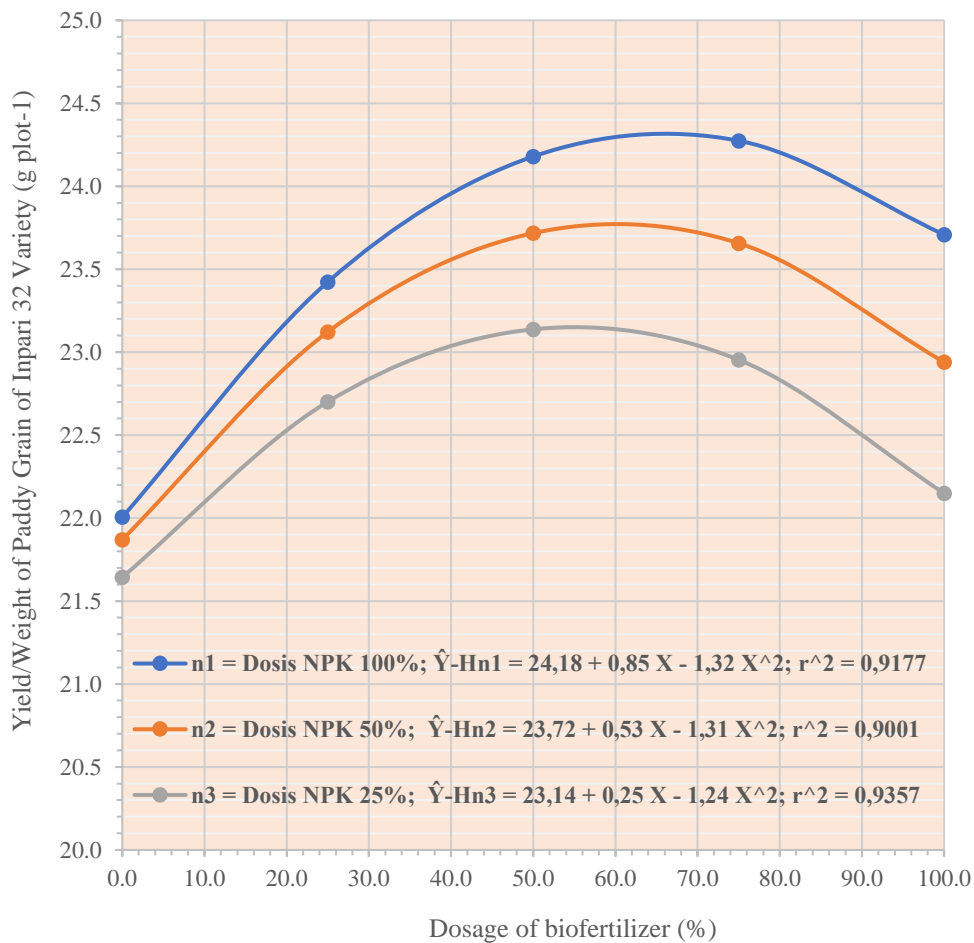


Figure 1. Grain Weight per Plot Response Curve to Various Biofertilizer Doses at Every NPK Fertilizer Dosage Level

The weight of grain per plot is influenced synergistically by the application of biological and NPK fertilizers. The curve in Figure 1 shows that the highest grain weight per plot is achieved with the larger dose of biological fertilizer, up to the optimal limit, at the prescribed NPK fertilizer dose levels of 100%, 50%, and 25%. The weight of grain per plot tends to decline when the biological fertilizer dose exceeds the ideal dose limit. This shows that applying a higher dose of biological fertilizer than the adequacy level has resulted in a loss in grain weight per plot. The overabundance of nutrients is assumed to be the reason for the decline in yield. The overabundance of macro- and micronutrients in the soil is assumed to be the cause of the decline in production. Particularly micronutrients, which plants require in comparatively small amounts and which, if present in excess, will be hazardous to plants, ultimately reducing yields. The Law of Diminishing Return Yield increase states that when biological and NPK fertilizers are administered in an illogical (incorrect dosage) manner, the yield will always decline. The plants will exhibit signs of poisoning if the soil’s nutrient levels surpass the adequacy limit. This will affect the growth of the plant’s organs and ultimately reduce crop output.

Quadratic regression analysis was used to determine the optimal biofertilizer dose (H) that yields the highest grain weight per plot at each NPK fertilizer dose (N). The response curve for grain weight per plot in Figure 1 illustrates how quadratic regression was tested using analysis of variance.

The following explanation is possible based on the curve in Figure 1 :

At a 100% (n_1) NPK fertilizer dose:

$$\hat{Y}\text{-Hn1} = 24.18 + 0.85 X - 1.32 X^2; (r^2 = 0.92)$$

With an optimum biofertilizer dose of 66.10% of the recommended dose and a coefficient of determination (r^2) = 0.92, this equation yields an estimated maximum grain weight of 24.32 kg plot⁻¹. This indicates that 92% of the grain weight per plot is determined by the application of biofertilizer, and 8% is determined by other factors.

• At a 50% (n_2) NPK fertilizer dose:

$$\hat{Y}\text{-Hn2} = 23.72 + 0.53 X - 1.31 X^2; (r^2 = 0.90)$$

With an optimum biological fertilizer dose of 60.19% of the recommended dose and a coefficient of determination (r^2) = 0.90, this equation yields an estimated maximum grain yield of 23.77 kg per plot. This indicates that 90% of the grain weight per plot is determined by the provision of biological fertilizer, and 10% is determined by other factors that influence it. is determined by the provision of biological fertilizer, and 10% is determined by other factors.

• At a 25% (n_3) NPK fertilizer dose:

$$\hat{Y}\text{-Hn3} = 23.14 + 0.25 X - 1.24 X^2; (r^2 = 0.94)$$

From this equation, the estimated maximum grain weight is 23.15 kg per plot-1, with an optimum biofertilizer dose of 55.10% of the recommended dose, and a determination coefficient (r^2) = 0.94. This shows that 94% of the grain weight per plot is determined by the provision of biofertilizer, and 6% is determined by other factors that influence it. The goal of any endeavor in rice farming is to maximize yield in accordance with its genetic potential. Without additional assistance, such as proper fertilizer dosages, each variety's genetic potential will not be able to produce at its best.

CONCLUSION

1. Plant height, the number of tillers aged 28 DAP, 42 DAP, and 56 DAP, the number of productive tillers, panicle length, grain weight per panicle, grain weight per clump, and grain weight per plot all interacted with the dosage of NPK fertilizer and biological fertilizer. Plant height, the number of tillers at 14 DAP, and the weight of 1000 grains did not show any interaction between the NPK and biological fertilizer doses.
2. The greatest grain weight (24.32 kg plot⁻¹) was attained with the ideal dose of biological fertilizer of 66.10% ($r^2 = 0.92$) at the prescribed dose percentage of NPK fertilizer of 100%. The greatest grain weight (23.77 kg plot⁻¹) was attained with the ideal dose of biological fertilizer of 60.19% ($r^2 = 0.90$) at the recommended dose percentage of NPK fertilizer of 50%. The maximum grain weight (23.15 kg plot⁻¹) with an ideal biological fertilizer dose of 55.10% ($r^2 = 0.94$) at the prescribed dose percentage of NPK fertilizer of 25%.

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