Available at : https://ejournal.unib.ac.id/index.php/terrajournal ISSN 2621-0207
DOI : https://doi.org/10.31186/terra.7.2.103-109

TERRA
Journal of Land Restoration

Adaptation Test of Rice Varieties (*Oryza sativa* L. Var. Inpari) With Various Doses of NPK Fertilizer in Rice Field

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ABSTRACT

Food crop commodities play an important role in meeting food needs in Indonesia, along with the increasing population. In addition, crop yields also play an important role in spurring economic growth, as a source of foreign exchange, and a source of life for most of Indonesia's population. Rice productivity in rice field areas is currently still decreasing, therefore appropriate technology is needed to increase productivity. One of the efforts made is by using superior varieties (Inpari) that are in accordance with agro-ecosystem conditions or specific locations. This study was conducted with the aim of determining the effect of growth and yield of rice varieties on various doses of NPK fertilizer in rice field. This research was conducted in Sentono Village, Kalasan District, Sleman Regency, Special Region of Yogyakarta Province, Indonesia in March–July 2019. The experimental design used was Split Plot with NPK fertilizer doses (200 and 300 kg ha^{-1}) as the main plot and rice varieties (Inpari 6, Inpari 30, Inpari 32, Inpari 43, and Inpari 33) as subplots, and with 3 replications. The results showed no interaction between fertilizer doses and rice varieties. Inpari 42 with NPK fertilizer 300 kg ha^{-1} increased plant height, number of tillers productive, panicle length, number of filled grain/panicle, grain weight/clump, and production of dry grain. The highest production of dry grain was Inpari 42 (6.56 ton ha^{-1}), while the lowest production of dry grain was Inpari 30 with NPK fertilizer 200 kg ha^{-1} (4.35 ton ha^{-1}). These findings highlight the potential of specific variety-fertilizer combinations to optimize rice productivity and provide valuable insights for sustainable rice cultivation in Indonesia.

Keywords: fertilizer, food crop, organic, rice, rice field

INTRODUCTION

Rice (*Oryza sativa* L.) production is crucial in supporting global agriculture and national economic development (Wang *et al*., 2024), like us di Indonesia. Rice is a staple food for over half the world's population (Muthayya *et al*., 2014) with an annual yield of around 740 million tons and >160 million ha under cultivation (FAO, 2024). It provides around one fifth of worldwide human calorie intake (Duan *et al*., 2018). The use of quality seeds is a must in increasing rice productivity, because with quality seeds it is expected to be able to minimize the possibility of a decrease in crop quality and resistance to pests and diseases, which will affect the amount of production. However, in seed development, it not only functions as a material for planting purposes, but also functions as a means of carrying technologi-

cal innovation (Waluyo *et al*., 2022). Inpari is a rice variety that is widely used in Indonesia which is able to adapt well to tropical climates and produces quality seeds. Efforts to continue to find and develop superior varieties that have better adaptability to certain growing environments are one of the right policies for developing productive, effective, and efficient rice farming in the future. To achieve maximum results from the use of new varieties, a suitable growing environment is needed so that the potential yield and its advantages can be realized. The use of superior varieties with sufficient fertilization and irrigation technology components can contribute to rice grain yields of up to 75% (Abdullah *et al*., 2016).

Compound fertilizers such as NPK Phonska are one of the inorganic fertilizers that can be used very efficiently in increasing the availability of N, P, and K nutrients. NPK Phonska fertilizer (15:15:15) is one of the NPK fertilizer products that has been circulating in the market with a nitrogen content (N 15%), phosphate (P_2O_5 15%), potassium (K_2O 15%), sulfur (S 10%) 10%, and a maximum water content of 2%. The application of NPK Phonska fertilizer to rice plants is one of the management in increasing rice productivity in rice fields. This step also needs to be combined with the use of superior varieties to support the best phenotype. Application of NPK Phonska is a solution to increase soil nitrogen levels which has an impact on the reduction in rice grain yield as reported by Cai *et al*. (2023) and Gu *et al*. (2023). Nitrogen (N) has played a key role in increasing grain yield and ensuring adequate food for the world population through N fertilizer application, atmospheric N deposition, and soil N turnover (Chang *et al*., 2021; You *et al*., 2023; Zhang *et al*., 2024). In addition to nitrogen, other nutrients (phosphate, potassium, and sulfur) in the soil will also decrease due to intense agricultural activities or run-off can carry nutrients over land and eventually to surface water. Application of inorganic fertilizers such as NPK Phonska needs to be considered to reduce heavy metal pollution that can damage the environment (Yuan *et al*., 2024). The optimum dose needs to be considered on a threshold scale of use to maintain environmental health and increase rice grain production, because these two things have a major impact on people. The aim of this study was to determine effect of growth and productivity of rice varieties (var. Inpari) with different fertilizer doses management in rice field.

MATERIALS AND METHODS

This research was conducted in Sentono Village, Kalasan District, Sleman Regency, Special Region of Yogyakarta Province, Indonesia in March–July 2019. The experimental design used was Split Plot with NPK fertilizer doses are 200 kg ha^{-1} (P_1) and 300 kg ha^{-1} (P_2) as the main plot and rice varieties are Inpari 6 (V_1), Inpari 30 (V_2), Inpari 32 (V_3), Inpari 43 (V_4), and Inpari 33 (V_5) as subplots, and with 3 replications and 3 samples. Land cultivation is carried out perfectly (two times plowing and one time harrowing) according to needs and conditions. One week before land cultivation, solid organic fertilizer is spread evenly over the rice field as much as 2 ton ha^{-1}. Seedling is done when the plants are 15 days old with 3 seedlings/hole. Seedlings are planted at a depth of 2 cm from the surface of the soil. After seedling process, the rice plants are planted in open fields with planting distance is 25 cm × 25 cm. Irrigation water is at a maximum height of 3 cm. NPK Phonska is given gradually, namely 50 kg ha^{-1} at 1 and 3 weeks after planting (WAP). Therefore, the provision of NPK Phonska according to the research treatment is 200 and 300 kg ha^{-1} at 5 WAP. Pest control in rice uses insecticides (Incipio 200 SC) and plant diseases use fungicides (Score 250 EC). Chemicals with a concentration of 1,000 ppm were used to control pests and plant diseases. The time of rice harvest is 12 WAP and harvesting is carried out when >80% of the leaves have turned yellow and the seeds are ripe, cut the plant stem 30 cm above the ground surface. The standard operating procedure for rice cultivation follows Taryono *et al*. (2023) and Santosa *et al*. (2024) which have been modified. The variables observed in this research were plant height (cm), number of tillers productive, panicle length (cm), number of filled grain/panicle, number of empty grain/panicle, 1000 grain weight (g), grain weight/clump (g), and production of dry grain (ton ha^{-1}).

The observation data were analyzed using Analysis of Variance (ANOVA) 5%.The result of the ANOVA, which showed a significant difference, was tested with post-hoc analysis using Duncan's Multiple Range test (DMRT) 5%. Software used for data analysis was SPSS v.25.

RESULTS AND DISCUSSION

Paddy rice is a staple crop for much of the world's population. Fertilizers and superior seeds are

very important inputs to intensify rice production in rice fields. The doses of NPK Phonska fertilizer applied in this experiment were 200 and 300 kg ha^{-1}, and the superior rice seeds used were Inpari 6, Inpari 30, Inpari 42, Inpari 43, and Inpari 33.

Table 1. Mean of plant height (cm) with difference treatments

Variety	NPK fertilizers doses (kg ha^{-1})		Mean
	200	300	
Inpari 6	96.93	101.66	99.30 a
Inpari 30	93.73	95.40	94.57 ab
Inpari 42	96.00	100.46	98.23 a
Inpari 43	90.00	92.80	91.40 bc
Inpari 33	85.66	88.20	86.93 c
Mean	92.46 q	95.70 p	94.08 (-)

Notes: (+) = interaction; (-) = not interaction; the number followed by the same letter on the same row or column has no significant difference based on DMRT test with significant with α 5%

In Table 1, no significant interaction is observed between rice varieties and NPK fertilizer doses. However, significant differences are evident both among rice varieties and across NPK fertilizer doses. The different rice varieties tested in the field exhibit significant variations in plant height. Inpari 6 and Inpari 42 emerge as the superior varieties in terms of plant height, while an NPK fertilizer dose of 300 kg ha^{-1} proves more effective than 200 kg ha^{-1}.

According to Kanfany *et al*. (2014), plant height reached 91.5 cm under an NPK fertilizer application rate of 150–17.5–33 kg ha^{-1}. In comparison, a higher NPK fertilizer dose of 300 kg ha^{-1} yielded greater plant height, reaching 95.70 cm. Nitrogen, as a critical nutrient for plant growth, plays a pivotal role in the development of vegetative structures such as leaves and stems. It contributes to enhanced chlorophyll production, which is essential for photosynthesis, and accelerates plant growth through cell development.

No significant interaction is observed between rice varieties and NPK fertilizer doses. However, significant differences are evident both among rice varieties and across NPK fertilizer doses, as shown in Table 2. An NPK fertilizer dose of 300 kg ha^{-1} is identified as the optimal level for promoting the production of productive tillers, while Inpari 42 stands out as the superior rice variety compared to others.

Higher levels of fertilizer application have also been associated with extended vegetative growth, as reported by Kanfany *et al*. (2014). This effect is attributed to the availability of sufficient nutrients that can be efficiently absorbed by plants. Moreover, the presence of organic materials containing micronutrients plays a crucial role in supporting growth and optimizing nutrient uptake (Alavian *et al*., 2015). Nutrients, particularly macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), are essential for plants. When supplied in adequate and balanced amounts, they significantly influence plant development during both vegetative and generative growth phases.

Table 2. Mean number of tillers productive with difference treatments

Variety	NPK fertilizers doses (kg ha^{-1})		Mean
	200	300	
Inpari 6	12.06	13.06	12.56 b
Inpari 30	11.33	11.93	11.63 d
Inpari 42	12.73	13.66	13.20 a
Inpari 43	12.20	13.33	12.76 b
Inpari 33	11.73	12.73	12.23 c
Mean	12.01 q	12.94 p	13.82 (-)

Notes: (+) = interaction; (-) = not interaction; the number followed by the same letter on the same row or column has no significant difference based on DMRT test with significant with α 5%

An interaction is observed between rice varieties and NPK fertilizer doses, as well as a significant difference among NPK fertilizer doses, as shown in Table 3. However, no significant differences are detected between rice varieties alone. The NPK fertilizer dose of 300 kg ha^{-1} demonstrates the highest efficacy, producing a panicle length of 25.69 cm. The combination of the Inpari 6 variety with NPK fertilizer at 300 kg ha^{-1} yields the best result, achieving a panicle length of 27.53 cm.

The influence on crop yield is not solely determined by fertilizer application but is also significantly affected by the variety of rice. This is because each variety exhibits unique genetic, morphological, and physiological characteristics. Such differences influence plant responses to environmental conditions and resource inputs. According to Alavian *et al*. (2015), these variations are likely due to the genetic traits of each superior variety, including their capacity to adapt to specific environmental factors, which leads to differing levels of performance and yield outcomes.

Table 3. Mean of panicle length (cm) with difference treatments

Variety	NPK fertilizers doses (kg ha^{-1})		Mean
	200	300	
Inpari 6	25.86 ab	27.53 a	26.70
Inpari 30	25.20 bc	25.80 ab	25.50
Inpari 42	23.53 cd	24.73 cd	24.13
Inpari 43	23.26 d	24.00 cd	23.63
Inpari 33	24.26 cd	26.40 ab	25.33
Mean	24.42 q	25.69 p	25.06 (+)

Notes: (+) = interaction; (-) = not interaction; the number followed by the same letter on the same row or column has no significant difference based on DMRT test with significant with α 5%

Table 4 indicates that there is no interaction between rice varieties and NPK fertilizer doses. However, significant differences are observed between the rice varieties and among the NPK fertilizer doses. The optimal NPK fertilizer dose for producing the highest number of filled grains per panicle is 300 kg ha^{-1}, while the Inpari 42 variety demonstrates superior performance compared to other rice varieties.

Table 4. Mean number of filled grain/panicle with difference treatments

Variety	NPK fertilizers doses (kg ha^{-1})		Mean
	200	300	
Inpari 6	133.06	133.00	133.03 b
Inpari 30	100.93	108.00	104.46 d
Inpari 42	165.66	170.40	168.03 a
Inpari 43	144.06	142.80	143.43 b
Inpari 33	109.00	125.53	117.26 c
Mean	24.42 q	25.69 p	133.24 (-)

Notes: (+) = interaction; (-) = not interaction; the number followed by the same letter on the same row or column has no significant difference based on DMRT test with significant with α 5%

Prasetya (2014) reported that the greater the nutrient absorption by plants, the higher the potential for yield development. An increase in fertilizer dose tends to enhance plant growth and productivity. Nutrients, particularly N, P, and K, play essential roles in the generative growth phase of plants. Nitrogen is crucial for the synthesis of carbohydrates, proteins, fats, and other organic compounds. Meanwhile, phosphorus contributes significantly to the formation and development of generative structures, such as flowers and grains. Potassium also supports various physiological processes, including enzyme activation, photosynthesis, and water regulation, which are vital for optimizing plant growth and yield.

This study underscores the importance of selecting appropriate fertilizer doses and rice varieties to maximize yield potential while emphasizing the physiological significance of essential nutrients in supporting plant development.

Table 5. Mean number of empty grain/panicle with difference treatments

Variety	NPK fertilizers doses (kg ha^{-1})		Mean
	200	300	
Inpari 6	12.33	8.47	10.40 bc
Inpari 30	15.60	15.60	14.03 b
Inpari 42	16.13	17.20	16.67 b
Inpari 43	23.33	23.46	23.40 a
Inpari 33	6.80	6.460	6.63 c
Mean	24.42 q	25.69 p	14.22 (-)

Notes: (+) = interaction; (-) = not interaction; the number followed by the same letter on the same row or column has no significant difference based on DMRT test with significant with α 5%

There is no interaction between varieties and NPK fertilizer doses (Table 5). However, there is a significant difference between rice varieties and between NPK fertilizer doses. NPK fertilizer 300 kg ha^{-1} is the best fertilizer dose to produce the number of empty grains/panicles, while Inpari 43 is the worst rice variety compared to other varieties. Yafizham & Lukiwati (2019) stated that K can reduce empty grain/panicle. The provision of NPK Phonska fertilizer can affect rice plant yields because it is related to the increased availability of K in the soil and the absorption of K by plants. In addition, the availability of N and P in the soil. These three macro elements are very important nutrients needed by plants, where the interaction of these three elements will be able to support better rice yields.

Table 6 shows that there is no interaction between rice varieties and NPK fertilizer doses. However, significant differences are evident between the rice varieties and among the NPK fertilizer doses. The application of 300 kg ha^{-1} of NPK fertilizer is identified as the optimal dose to achieve the highest 1000-grain weight. Among the tested rice varieties, Inpari 6 and Inpari 33 are the most effective in pro-

ducing superior grain weights compared to other varieties.

The potassium (K) component in NPK Phonska fertilizer plays a vital role in enhancing crop productivity. Potassium contributes to root development, enabling plants to absorb nutrients more efficiently. It also supports the formation of fuller and denser seeds, facilitates the synthesis of proteins and carbohydrates, reduces grain loss, and ensures the production of high-quality grains. Additionally, potassium serves as an enzyme activator, aiding in critical biochemical processes within the plant.

Fertilizers are essential inputs for intensifying rice production. As Kanfany *et al*. (2014) reported, a 1000-grain weight of 25.4 g was achieved with the application of 75–8.75–16.5 kg ha^{-1} of NPK fertilizer. However, when the fertilizer dose was increased to 300 kg ha^{-1}, the grain weight improved significantly to 26.46 g. This demonstrates the importance of optimizing fertilizer doses to maximize yield while highlighting the critical role of potassium in enhancing grain quality and overall crop performance.

These findings emphasize that the strategic application of fertilizers, coupled with the selection of high-performing rice varieties, can significantly improve rice yield and grain quality in intensive production systems.

Table 6. Mean of 1000 grain weight (g) with difference treatments

Variety	NPK fertilizers doses (kg ha^{-1})		Mean
	200	300	
Inpari 6	28.18	28.18	28.18 a
Inpari 30	27.04	27.19	27.11 b
Inpari 42	24.48	24.43	24.45 c
Inpari 43	23.46	23.85	23.65 c
Inpari 33	28.86	28.66	28.76 a
Mean	26.40 q	26.46 p	26.43 (-)

Notes: (+) = interaction; (-) = not interaction; the number followed by the same letter on the same row or column has no significant difference based on DMRT test with significant with α 5%

Table 7 demonstrates that there is no interaction between rice varieties and NPK fertilizer doses. However, significant differences are observed between rice varieties and among NPK fertilizer doses. The application of 300 kg ha^{-1} of NPK fertilizer is identified as the optimal dose for maximizing grain weight per clump. Among the rice varieties tested, Inpari 42 and Inpari 43 exhibit superior performance compared to other varieties, producing higher grain weights.

Alavian *et al*. (2015) noted that differences in rice varieties contribute to the diversity of plant phenotypes. These variations can result from genetic differences inherent to each variety or environmental factors influencing plant growth and development. The genetic composition of each variety plays a crucial role in determining its phenotypic expression, which includes growth, yield, and other agronomic traits. Furthermore, the interaction between genetic factors and environmental conditions where the plants are cultivated significantly impacts plant performance.

Differences in grain yield among varieties are primarily attributed to the genetic traits of each line. Yield is a complex trait controlled by numerous genes, including cumulative, duplicate, and dominant genes, which are heavily influenced by environmental conditions. These genetic and environmental interactions create diversity in yield performance among varieties. This underscores the importance of understanding both genetic and environmental factors to optimize yield potential in rice production.

The findings highlight the need for a tailored approach to fertilizer application and variety selection, considering genetic characteristics and environmental adaptability, to achieve optimal crop performance in varying agroecological conditions.

Table 7. Mean of grain weight/clump (g) with difference treatments

Variety	NPK fertilizers doses (kg ha^{-1})		Mean
	200	300	
Inpari 6	32.70	37.93	35.30 abc
Inpari 30	27.24	32.91	30.08 c
Inpari 42	36.02	41.04	38.53 a
Inpari 43	34.16	37.91	36.03 a
Inpari 33	30.58	34.58	32.58 bc
Mean	32.14 q	36.87 p	34.50 (-)

Notes: (+) = interaction; (-) = not interaction; the number followed by the same letter on the same row or column has no significant difference based on DMRT test with significant with α 5%

Table 8 reveals that there is no interaction between rice varieties and NPK fertilizer doses. However, significant differences are observed between rice varieties and among NPK fertilizer doses.

The application of 300 kg ha^{-1} of NPK fertilizer is identified as the most effective dose for maximizing dry grain production. Among the varieties tested, Inpari 6, Inpari 42, and Inpari 43 show superior performance in grain yield compared to other varieties.

Table 8. Mean production of dry grain (ton ha^{-1}) with difference treatments

Variety	NPK fertilizers doses (kg ha^{-1})		Mean
	200	300	
Inpari 6	5.46	6.06	5.76 a
Inpari 30	4.35	5.26	4.80 b
Inpari 42	5.22	6.56	5.89 a
Inpari 43	5.76	6.06	5.91 a
Inpari 33	4.89	5.53	5.21 ab
Mean	5.14 q	5.89 p	5.51 (-)

Notes: (+) = interaction; (-) = not interaction; the number followed by the same letter on the same row or column has no significant difference based on DMRT test with significant with α 5%

These findings confirm the critical role of NPK fertilizers in enhancing rice grain yield, as supported by Kanfany *et al*. (2014). Phosphorus (P) plays a fundamental role in the energy supply and transfer necessary for various biochemical processes in rice plants. One of its key functions is to accelerate grain development and maturation, thereby contributing to increased grain weight. Potassium (K), on the other hand, facilitates the formation of sugars, starches, and various enzymes, which are vital for increasing the number of grains per panicle and enhancing the percentage of filled grains (Yafizham & Lukiwati, 2019).

The application of balanced and adequate amounts of NPK fertilizer not only improves grain production but also optimizes physiological processes critical to crop performance. Nitrogen (N) supports vegetative growth by promoting leaf area expansion and chlorophyll synthesis, which are essential for photosynthesis. Meanwhile, P and K elements work synergistically to support both vegetative and generative phases,ensuring better grain quality and yield stability.

These results underscore the importance of integrating proper fertilizer management and the selection of high-performing rice varieties to achieve optimal productivity in rice farming systems. Tailoring fertilizer doses based on crop needs and environmental conditions can further maximize yield potential while maintaining sustainable agricultural practices.

CONCLUSION

The results of the research that has been done can be concluded that in the combination of treatment between NPK dose treatment and types of rice varieties, only panicle length occurs interaction, while plant height, number of tillers productive, number of filled grain/panicle, number of empty grain/panicle, 1000 grain weight, grain weight/ clump, and production of dry grain do not interact. Therefore, in doses treatment of NPK Phonska, the interaction occurs is the number of tillers productive and panicle length. Then, in the variety treatment, the interaction occurs in plant height, number of tillers productive, panicle length, number of filled grain/panicle, number of empty grain/panicle, 1000 grain weight, grain weight/clump, and production of dry grain. These findings highlight the potential of specific variety-fertilizer combinations to optimize rice productivity and provide valuable insights for sustainable rice cultivation in Indonesia.

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