ANALYSIS OF FACTORS AFFECTING RICE PRODUCTIVITY IN GAPOKTAN RUKUN MAKMUR, PURWOSARI VILLAGE, BABADAN SUB-DISTRICT, PONOROGO REGENCY

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ABSTRACT

Rice is a staple food for the majority of the Indonesian population, so its productivity is closely linked to food security and farmer welfare. Rice productivity at Gapoktan Rukun Makmur, Purwosari Village, Babadan Sub-district, Ponorogo Regency has shown a consistent decline over the past five years, from 7.25 tons/ha (2021) to 6.33 tons/ha (2025), despite the harvested area remaining relatively stable at 290.27 hectares, which is suspected to be influenced by rainfall, pest and disease (OPT) attacks, and inorganic fertilizer use. This study aims to analyze the factors affecting rice productivity at Gapoktan Rukun Makmur. This study used multiple linear regression with a sample of 69 farmers drawn from a population of 226 Gapoktan members, determined using the Slovin formula and proportional random sampling. Primary data were obtained through questionnaire-based interviews. The results show that rainfall, OPT attack intensity, and inorganic fertilizer use simultaneously have a significant effect on rice productivity (F-count 35.621, significance <0.001). Partially, OPT attacks and inorganic fertilizer use have a significant negative effect (significance <0.001), while rainfall has no significant effect (0.140). The R^2 value of 0.622 indicates that the three variables explain 62.2% of the variation in rice productivity. A sensitivity analysis further shows that OPT attacks produce the largest practical reduction in productivity, even though inorganic fertilizer use has the most statistically precise effect. This study recommends the implementation of Integrated Pest Management and balanced fertilization to sustainably improve rice productivity

KEYWORDS

Rice productivity, multiple linear regression, pest and disease attacks, inorganic fertilizer, Gapoktan

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INTRODUCTION

The agricultural sector is an important part of the Indonesian economy, particularly the food subsector, which contributes to national food security through the provision of staple commodities such as rice. Rice productivity is influenced by interrelated internal and external factors. Increasingly unpredictable rainfall makes it difficult for farmers to determine the right planting time, while also encouraging the growth of plant pests and diseases (OPT) due to excess humidity, and triggering lodging (fallen rice stalks) caused by heavy rain and strong wind. On the other hand, unbalanced use of inorganic fertilizer, particularly excessive urea, can disrupt soil nutrient balance, hinder grain filling, and increase the plant's vulnerability to lodging as well as pest and disease attacks.

Gapoktan Rukun Makmur, a joint farmer group in Purwosari Village, Babadan Sub-district, Ponorogo Regency, oversees five farmer groups with a total land area of 290.27 hectares that has remained relatively constant over the years. Gapoktan data show a consistent downward trend in rice productivity over the past five years, from 7.25 tons/ha in 2021 to 6.80 tons/ha (2022), 6.65 tons/ha (2023), 6.35 tons/ha (2024), and 6.33 tons/ha (2025). Since the harvested area has remained stable, this decline is suspected to be caused by other technical and environmental factors, rather than a reduction in planted area.

Previous studies have examined the factors affecting rice productivity from various approaches. Aditya et al. (2021) found that the relationship between annual rainfall and productivity is inconsistent across regions, while Lismawati et al. (2020) showed that fertilizer use and pest control are important determinants of rice productivity in irrigated paddy fields. However, most of these studies were conducted at the regency or provincial scale, and no study has yet simultaneously examined these three factors at the Gapoktan (joint farmer group) level under conditions of constant land area but continuously declining production, as is the case at Gapoktan Rukun Makmur.

Based on these conditions, this study aims to determine the production and productivity of rice at Gapoktan Rukun Makmur over three planting seasons, as well as to analyze the factors affecting rice productivity, namely extreme rainfall, pest and disease (OPT) attacks, and inorganic fertilizer use. The results of this study are expected to serve as a basis for evaluation by Gapoktan Rukun Makmur in efforts to sustainably improve rice productivity, while also contributing to the literature on rice productivity at the micro level of joint farmer groups.

RESEARCH METHOD

This study was conducted at Gapoktan Rukun Makmur, Purwosari Village, Babadan Sub-district, Ponorogo Regency, which was purposively selected because Babadan Sub-district is consistently one of the main rice-producing areas in Ponorogo Regency, one of the ten largest food barns in East Java. Primary data were obtained through structured interviews using questionnaires with Gapoktan member farmers, covering farmers' perceptions of extreme rainfall events, the intensity of OPT attacks, and inorganic fertilizer use during the most recent planting season. Secondary data were obtained from Gapoktan documentation, related institutions, and literature review.

The study population consisted of 226 active member farmers of Gapoktan Rukun Makmur belonging to five farmer groups. The sample size was determined using the Slovin formula with a 10% margin of error, resulting in a sample of 69 farmers, which was then allocated across each farmer group using proportional random sampling and selected using simple random sampling.

The factors affecting rice productivity were analyzed using multiple linear regression, with the equation:

$$Y = a + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$$

where Y is rice productivity (tons/ha), X_1 is rainfall (a dummy variable: 1 = experienced an extreme rainfall event, 0 = did not experience one), X_2 is OPT attack intensity (%/ha), and X_3 is inorganic fertilizer use (tons/ha). Prior to regression testing, the data were tested using classical assumption tests, comprising the normality test (Kolmogorov-Smirnov), multicollinearity test (Variance Inflation

Factor), and heteroscedasticity test (scatterplot). Hypothesis testing was conducted through the F-test (simultaneous), t-test (partial), and coefficient of determination (R^2). A sensitivity analysis based on the 10th–90th percentile range of each variable was also performed to estimate the practical, field-level impact of each factor, as a complement to the statistical significance measured by the t-test.

RESULT AND DISCUSSION

Rice Production of Respondent Farmers

Total rice production (dry harvested grain/GKP) from the 69 respondent farmers over Before interpreting the regression coefficients, the model was tested against three classical assumptions to ensure the estimates are Best Linear Unbiased Estimators (BLUE): normality, multicollinearity, and heteroscedasticity.

Table 1. Normality Test Results (One-Sample Kolmogorov-Smirnov)

Indicator	Value
N	69
Mean	0.0000000
Std. Deviation	0.34312565
Test Statistic	0.089
Asymp. Sig. (2-tailed)	0.200

Source: Primary Data Processed, 2026

Table 1 shows an Asymp. Sig. value of 0.200, which exceeds the 0.05 threshold, indicating the residuals are normally distributed and the data can proceed to multiple regression testing.

Table 2. Multicollinearity Test Results

Variable	Tolerance	VIF
Rainfall	0.986	1.015
OPT Attack Intensity	0.965	1.036
Inorganic Fertilizer Use	0.954	1.050

Source: Primary Data Processed, 2026

Table 2 shows that all three independent variables have VIF values well below 10 and tolerance values above 0.10. This confirms that rainfall, pest and disease pressure, and fertilizer use operate as statistically independent influences on productivity rather than as overlapping proxies for one another a result that is scientifically plausible, since a farmer's exposure to extreme rainfall is not mechanically tied to how much fertilizer they apply or how severely their plot is attacked by pests. This independence is what allows the partial (t-test) coefficients reported later to be interpreted individually with confidence.

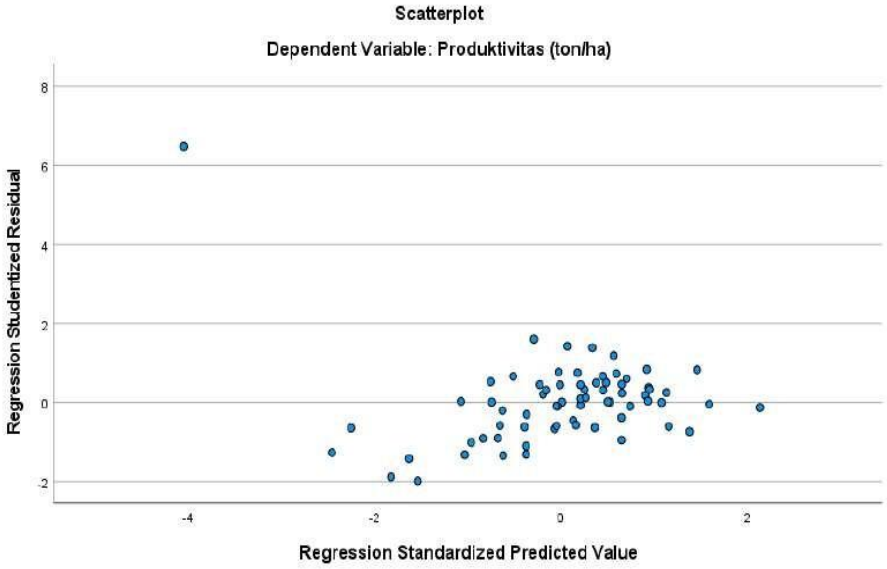


Figure 1. Heteroscedasticity Test (Scatterplot of Residuals)

The scatterplot of standardized residuals against predicted values shows the points scattered randomly above and below the zero line without forming a funnel or wave shaped pattern, with only one visible outlier. This indicates that the variance of the error term is constant across observations (homoscedastic), so the regression model does not suffer from systematic heteroscedasticity that would otherwise bias the standard errors and distort the significance tests reported below.

Simultaneous Test (F-Test)

Table 3. F-Test Results

Source	df	Sum of Squares	Mean Square	F	Sig.
Regression	3	98.165	32.722	**35.621**	<0.001*
Residual	65	59.709	0.919		
Total	68	157.874			

Source: Primary Data Processed, 2026.
*Significant at α = 0.05

Table 3 shows an F-count of 35.621, far exceeding the F-table value of 2.746 (df1 = 3, df2 = 65) at Sig. <0.001. This confirms the research hypothesis that rainfall, OPT attacks, and inorganic fertilizer use jointly and significantly determine rice productivity at Gapoktan Rukun Makmur. The scientific basis for this joint effect lies in how the three factors interact biologically rather than acting in isolation: unpredictable extreme rainfall raises humidity, which in turn accelerates pest and pathogen development, while inaccurately dosed fertilizer weakens the plant's physiological resistance to both climatic stress and pest pressure (Kusmiyati et al., 2022). The regression sum of squares (98.165), accounting for the majority of total variation (157.874), indicates that this three-factor interaction, rather than unmeasured randomness, is the dominant source of yield variability observed in the field.

Partial Test (T-Test) and Regression Equation

Table 4. Multiple Linear Regression Coefficients

Variable	Coefficient	Std. Error	t-count	Sig.
Intercept	21.049	0.662	**31.779**	<0.001*
Rainfall (X_1)	−0.516	0.345	**−1.495**	0.140
OPT Attack Intensity (X_2) −13.758		2.599	**−5.294**	<0.001*
Inorganic Fertilizer Use	−0.385 (X_3)	0.041	**−9.291**	<0.001*

Source: Primary Data Processed, 2026.
*Significant at α = 0.05 Based on Table 4, the regression equation is formulated as:

$$Y = 21.049 - 0.516X_1 - 13.758X_2 - 0.385X_3 + \varepsilon$$

The OPT attack coefficient (−13.758) means that every one-percentagepoint increase in attack intensity per hectare is associated with a 13.758 tons/ha reduction in productivity, holding rainfall and fertilizer use constant. This is not merely a statistical artifact: pest damage to rice particularly from brown planthoppers and stem borers, which farmers reported as frequently attacking together during the vegetative and generative phases directly destroys the plant tissue responsible for grain filling, so yield loss compounds rather than merely delays. This mechanism explains why the effect is significant and why its magnitude is the largest among the three variables, consistent with Wagiyanti et al. (2024), who found that the timeliness and consistency of control measures, rather than pest presence alone, determine the extent of yield loss.

The fertilizer coefficient (−0.385) indicates that productivity declines as inorganic fertilizer application increases a counterintuitive direction, since fertilizer is conventionally expected to raise yield. This negative sign is best explained by over-application rather than fertilizer use itself being harmful: field interviews found that dosing decisions were based on habitual practice rather than soil testing, and several farmers believed that applying more fertilizer would automatically produce better results. Excess nitrogen from urea promotes vegetative growth (leaf and stem) at the expense of grain filling, while unbalanced dosing over time can degrade soil structure and disrupt the microbial activity responsible for natural nutrient cycling (Nopriani et al., 2023). This explains both why the coefficient is negative and why its effect is statistically significant despite fertilizer being an input farmers actively control.

Rainfall (X_1), coded as a dummy variable for extreme rainfall events, shows a negative coefficient (−0.516) but is not statistically significant (Sig. = 0.140 > 0.05). This means the null hypothesis is accepted for this variable: extreme rainfall, as experienced and reported by farmers, does not have a proven statistical effect on productivity, even though its direction is consistent with field expectations. The explanation lies in the timing mismatch between rainfall events and the plant's critical growth stages. Qudriyah et al. (2022) found that rainfall during the flowering and grain filling phases has a far larger yield impact than rainfall at other growth stages, meaning that the mere occurrence of an extreme rainfall event without regard to which growth phase it coincides with does not consistently translate into yield loss. This differs from Arinda et al. (2025), who found a strong positive correlation between rainfall and productivity in Serdang Bedagai Regency; the discrepancy suggests that rainfall's effect on productivity is highly context dependent on local cropping calendars and drainage conditions, rather than a universal relationship.

Coefficient of Determination (R^2)

Table 5. Coefficient of Determination

Indicator	Value
Multiple R	0.789
R Square	**0.622**
Adjusted R Square	0.604
Standard Error	0.958

Source: Primary Data Processed, 2026

Table 5 shows an R^2 of 0.622, meaning the three variables jointly explain 62.2% of the variation in rice productivity, while the remaining 37.8% is attributable to factors outside the model, such as land area, seed variety, labor, and pesticide use (Ardhianti & Ariyani, 2024). This relatively high explanatory power for a three variable field-survey model indicates that rainfall, OPT attacks, and fertilizer use are not merely correlated with productivity but capture a substantial share of the underlying mechanism driving the observed decline, supporting the hypothesis set out in the introduction that these three factors are central though not exhaustive determinants of the productivity trend at Gapoktan Rukun Makmur.

Sensitivity Analysis

Because statistical significance measures precision rather than practical magnitude, a sensitivity analysis was conducted using the 10th–90th percentile range of each variable to estimate real-world impact.

Table 6. Sensitivity Analysis of Rice Productivity to Each Variable

Variable	Low Condition	High Condition	Regression Coefficient	Productivity Change (tons/ha)	% of Average
Rainfall (X_1)	Not extreme (0)	Extreme (1)	-0.516	-0.516	-9.30%
OPT Attack (X_2)	17.90%	27.70%	-13.758	-1.345	-24.20%
Fertilizer (X_3)	0.18 ton/ha	1.04 ton/ha	-0.385	-0.332	-6.00%

Source: Primary Data Processed, 2026

Table 6 shows that, despite having the smallest t-count, OPT attack intensity produces the largest real-world productivity loss (24.2% of the average), because the actual variation in attack severity among farmers in the field is far wider than the variation in fertilizer dosage. This finding is scientifically important: it shows that statistical significance and field-level priority are not the same thing fertilizer use has the most precisely estimated effect (highest t-count), but pest and disease pressure has the greatest practical consequence for the Gapoktan's overall yield, meaning pest control should be treated as the primary operational priority even though fertilizer correction remains statistically important.

Discussion in Relation to Previous Studies

Taken together, these findings answer the research hypothesis: rice productivity at Gapoktan Rukun Makmur is jointly determined by rainfall, pest and disease pressure, and fertilizer practice, but the individual contribution of each factor differs sharply once biological mechanism is considered. Compared with Lismawati et al. (2020), who found that pest control and fertilizer use are dominant determinants of paddy productivity in irrigated systems in Ciamis Regency, the present findings reinforce that conclusion at a

smaller, Gapoktan level scale, while adding a methodological refinement: by measuring OPT and fertilizer as continuous field observed intensities rather than binary presence/absence, this study is able to show that their negative direction stems from a saturation mechanism pest damage compounding tissue loss, and fertilizer excess disrupting nutrient balance rather than from input scarcity, which is the more common assumption in productivity studies that treat inputs as uniformly yield enhancing. This distinction is the principal scientific contribution of the present findings and directly supports the recommendation that Integrated Pest Management and balanced, soil-test-based fertilization, rather than simply increasing input volume, are the appropriate interventions for reversing the productivity decline documented at Gapoktan Rukun Makmur.

CONCLUSION

Rainfall, OPT attack intensity, and inorganic fertilizer use simultaneously have a significant effect on rice productivity at Gapoktan Rukun Makmur (F-count 35.621; Sig. <0.001), with an R^2 of 0.622, indicating the model explains 62.2% of the variation in productivity. Partially, only OPT attacks (t = −5.294; Sig. <0.001) and inorganic fertilizer use (t = −9.291; Sig. <0.001) have a significant negative effect, while rainfall (t = −1.495; Sig. = 0.140) has no significant effect. The sensitivity analysis further shows that OPT attacks produce the largest practical reduction in productivity (−24.2% of the average), followed by extreme rainfall (−9.3%) and fertilizer use (−6.0%), indicating that statistical significance and fieldlevel priority do not always align. Based on these findings, the implementation of Integrated Pest Management and balanced, soil test based fertilization should be the top priority for Gapoktan Rukun Makmur to sustainably improve rice productivity, without neglecting the importance of adapting to rainfall variability.

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