Journal of Agriculture (JoA)
Volume: 4 | Number 02 | July 2025
E-ISSN: 2829-2421
https://doi.org/10.47709/joa.v4i02.6687

Evaluation of Agronomic Traits of Rice in Rice-Fish System Using Correlation and PCA

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Received: 2025-07-27
Accepted: 2025-07-31
Publication: 2025-08-01

Abstract
The rice-fish farming system is an integrated agricultural model that combines rice and fish cultivation in a single field, wherein fish feed has the potential to serve as an additional nitrogen (N) source for rice crops. This study aims to evaluate the effects of nitrogen content in fish feed on the agronomic characteristics of rice and to identify interrelationships between parameters using correlation analysis and Principal Component Analysis . The research was conducted in Laiya Village, Maros Regency, using the Inpari 32 rice variety and four fish feed treatments with varying nitrogen content: 0% (N0), 5% (N1), 7% (N2), and 9% (N3). Results showed that the differences between treatments were not statistically significant regarding the quantitative morphological characteristics of rice, although treatment N2 showed a tendency for the highest yield. Correlation analysis revealed strong positive relationships among the number of productive tillers, plant dry weight, and grain weight per plot. Meanwhile, Principal Component Analysis identified two principal components that explained most of the agronomic variation, with Plant Dry Weight, PT, Grain Weight per Plot, 1000-Grain Weight, and Panicle Length as dominant contributors. These results indicate that nitrogen management through fish feed has the potential to sustainably improve nutrient efficiency and rice productivity in rice-fish farming systems.

Keywords: Correlation; Fish; PCA; Nitrogen; Rice_Fish_System

Introduction

Sustainable agriculture integrates various components of the ecosystem to optimize productivity while minimizing negative environmental impacts (Abraham, Davies, & Akinwole, 2020; Farah Diana & Mahendra, 2021; Hasbi & Tunggal, 2021). The rice-fish system, which combines rice and fish cultivation in a single plot of land, represents a promising example of integrated farming (Diana, Mahendra, & Oktavinanda, 2022; Triyanti, Suryawati, Wijaya, Wardono, & Hafsaridewi, 2021). In this system, fish act as biological agents that help control pests and weeds while also providing additional nutrients for rice plants through their excretion (Merliana, Mulyatno Setiawan, & Budiraharjo, 2021; Riyanto, Anshori, Triwidyastuti, & Yustisia, 2021). The presence of fish in the rice field ecosystem contributes to an increase in nutrient availability—one of which is nitrogen (N), an essential element for rice plant growth (Lv, Yuan, Lv, & Zhou, 2020).

Nitrogen plays a central role in the synthesis of proteins, nucleic acids, and chlorophyll, all of which are crucial for both the vegetative and generative growth of rice plants (Rahmawati, 2017).

Journal of Agriculture (JoA)
Volume: 99 | Number 99 | Month Year
E-ISSN: 2829-2421
https://doi.org/10.47709/JoA.v1n1.2022

The provision of fish feed serves as one of the primary sources of nitrogen in the rice-fish farming system. Fish feed serves as one of the main nitrogen sources in the rice-fish farming system. The quality and quantity of the fish feed directly influence the nitrogen content available in the water and soil of the paddy field. However, the utilization of nitrogen from fish feed by rice plants is not always efficient. A portion of the nitrogen may be lost through denitrification, ammonia volatilization, or accumulation in sediment. Therefore, the indirect provision of nitrogen via fish feed represents an alternative approach within the rice-fish system whose effectiveness on crop performance needs to be evaluated. Accordingly, appropriate nitrogen management strategies are needed to maximize its benefits for rice growth and minimize the risk of environmental pollution.

Evaluating the agronomic characteristics of rice in the rice-fish system is essential to understand how interactions among the plant, fish, and environment affect rice productivity (Groenveld, Kohn, Gross, & Lazarovitch, 2019). Agronomic traits include various plant morphological characteristics that contribute to yield, such as plant height, plant dry weight, total tiller number, productive tillers, panicle length, 1000-grain weight, and grain weight per plot. Although these traits do not always show statistically significant differences between treated and control plants, correlation analysis can be used to identify relationships among rice agronomic traits, as well as their association with nitrogen levels derived from fish feed. In addition, Principal Component Analysis (PCA) can reduce data dimensionality and identify the most influential agronomic variables contributing to genetic variation in rice under the rice-fish system. A deeper understanding of rice agronomic characteristics and the factors influencing them will aid in the development of rice varieties that are both adaptive and high-yielding in rice-fish systems.

This study aimed to evaluate the agronomic characteristics of rice in a rice-fish system treated with nitrogen through fish feed. Furthermore, correlation and PCA analyses were conducted to understand the pattern of relationships among agronomic parameters and to identify the main components explaining agronomic variation in rice plants within this system.

Research Method

Nitrogen content analysis of the feed was carried out at the Feed Chemistry Laboratory, Faculty of Animal Science, and the Soil Chemistry and Fertility Laboratory, Faculty of Agriculture, Hasanuddin University. The rice cultivation was conducted in Laiya Village, Cenrana Subdistrict, Maros Regency, South Sulawesi, from October 2022 to January 2023. This study used Inpari 32 rice variety seeds and formulated fish feed with varying nitrogen levels: 0% (N0), 5% (N1), 7% (N2), and 9% (N3), as well as GIFT tilapia fingerlings.

Rice transplanting was performed after land preparation was completed. Seedlings of uniform height were selected and planted using the "jajar legowo" system with a 3:1 pattern (three rows of plants followed by one empty alley 40 cm wide). The spacing between rows was 20 cm, while spacing within a row was tighter at 10 cm. Each planting hole contained 3 to 5 rice seedlings. The fish were introduced 18 days after transplanting (DAT). Fish feed was administered once daily, spread into the empty rows of the legowo planting system to ensure full consumption by the fish. The feed requirements were calculated based on the plot size (30 m² per plot) and fish density (30 fish per plot) (Nasrul, Rasyid, & Saade, 2023).

Rice plant maintenance included regulating the water level within each plot. Weeds were allowed to grow within a reasonable threshold as a natural food source for fish, particularly in the control treatment (N0). Pest and disease control was carried out only when necessary, using botanical pesticides. Meanwhile, fish were consistently fed daily according to their respective treatment groups.

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Results and Discussion

Observations of rice quantitative morphological traits in the rice-fish farming system revealed that the application of fish feed with varying nitrogen contents did not significantly affect any of the agronomic parameters observed. These parameters included plant height (PH), plant dry weight (PDW), total tiller count (TPC), number of productive tillers (PT), panicle length (PL), 1000-grain weight (1000-GW), and grain weight per plot (GWPP). This was indicated by "ns" (not significant) values in the ANOVA analysis, suggesting that nitrogen treatment in fish feed had not significantly improved agronomic performance compared to the control.

Nonetheless, there was a positive trend observed in the N2 (7% N) and N3 (9% N) treatments, where average values of certain parameters such as grain weight per plot (8.97 kg in N2) and 1000-grain weight (24.70 g in N1 and 24.50 g in N3) were higher than those in other treatments. This indicates a potential for yield improvement with higher nitrogen concentrations in fish feed, even though the results have not reached statistical significance. The efficiency of nitrogen utilization in the rice-fish system depends heavily on the availability of mineral nitrogen that can be absorbed by the plants, as well as the interaction between biotic and abiotic components within the paddy ecosystem (Rusdiansyah & Saleh, 2017).

Table 1. Quantitative Morphological Traits of Rice in the Rice-Fish System under Nitrogen Fish Feed Treatments

Treatments	Observation Parameters							Description
	PH (cm)	PDW (g)	TPC	PT	PL (cm)	1000-GW (g)	GWPP (kg)	
N0	84.90	22.53	12.00	10.30	19.40	19.10	7.40	ns
N1	84.10	22.00	13.10	12.40	19.90	24.70	8.07	ns
N2	87.90	34.70	14.95	12.60	18.40	21.60	8.97	ns
N3	89.30	27.89	13.10	12.10	19.80	24.50	8.40	ns

NB: N0 (0% nitrogen), N1 (5% nitrogen), N2 (7% nitrogen), N3 (9% nitrogen), PH (Plant Height), PDW (Plant Dry Weight), TPC (Tiller per Clump), PT (Productive Tellers), PL (Panicle Length), 1000-GW (1000-Grain Weight, GWP (Grain Weight per Plot).

Correlation analysis presented in Figure 1 provides critical insights into the relationships among quantitative morphological parameters of rice within the rice-fish system under nitrogen treatments via fish feed. Correlation analysis is used to determine the strength and direction of the relationship among traits and is a common statistical approach in agronomic studies for evaluating potential phenotypic linkages. This statistical approach is widely used in agronomic studies to evaluate the potential interrelationship between phenotypic traits in plants (Garko, Dawaki, Yawale, Mohammed, & Yaroson, 2020).

The correlation analysis (Figure 1) revealed strong and positive relationships among several agronomic parameters. For instance, grain weight per plot (GWPP) showed a high correlation with the number of productive tillers (PT) and plant dry weight (PDW). This indicates that increases in plant biomass and productive tillers contribute directly to yield. These findings support earlier studies suggesting that an optimized rice-fish system can enhance plant performance through the additional nutrient input provided by fish activity (Nataraja et al., 2021).

From the correlation visualization, a significant positive relationship was identified, especially between productive tillers (PT) and grain weight per plot (GWPP), with a correlation coefficient (r) approaching +0.8. This implies that a greater number of productive tillers correlates with a

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https://doi.org/10.47709/JoA.v1n1.2022

higher yield potential. Previous research also indicates that productive tillers are a key contributor to yield components in rice (Hastini, Suwarno, Ghulamahdi, & Aswidinnoor, 2019; Sadimantara et al., 2021; Wardana & Hariyati, 2010). Therefore, proper management aimed at increasing productive tillers becomes a critical factor in improving rice productivity within the rice-fish system.

In addition, there was a strong correlation between plant dry weight (PDW) and both total tiller number (TPC) and panicle length (PL). This suggests that an increase in vegetative biomass is associated with enhanced reproductive development, particularly in panicle formation. Physiologically, this phenomenon can be explained by the fact that plants with greater biomass accumulation generally have higher photosynthetic capacity, enabling them to allocate more resources for the formation of reproductive organs (Tando, Pengkajian, Pertanian, & Tenggara, 2018).

Nonetheless, plant height (PH) showed relatively weak correlations with yield-related parameters such as 1000-grain weight (1000-GW) and grain weight per plot (GWPP). This suggests that plant height is not a key determinant of yield performance in the rice-fish system. Consequently, breeding efforts should not overly prioritize this parameter. These findings align with literature stating that selection based on plant height often fails to provide significant advantages in yield and may even increase lodging risk in certain rice varieties (Sitaresmi, Suwarno, Rumanti, Ardie, & Aswidinnoor, 2019).

Meanwhile, 1000-grain weight (1000-GW) exhibited a moderate correlation with both panicle length and the number of productive tillers. This correlation suggests that grain filling and quality may be indirectly influenced by plant architecture, particularly the density and distribution of panicles. However, this relationship remains moderate, indicating that other factors such as nutrient intake, photosynthetic activity, and the efficiency of assimilate transport likely also play important roles. Nevertheless, the correlation remains within a moderate range, implying that other factors—such as nutrient uptake, photosynthetic activity, and the efficiency of assimilate transport—likely play important roles. Overall, the correlation results provide a strong foundation for identifying key parameters that can serve as selection indicators in rice-fish systems, particularly in the context of nitrogen management via fish feed. The strong association between PDW, PT, and GWPP suggests that cultivation strategies aimed at increasing productive tillers and vegetative biomass accumulation are likely to have a direct impact on improving yield.

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Figure 1. Correlation analysis results of quantitative morphological traits of rice in a rice-fish system treated with nitrogen-containing fish feed.

The Principal Component Analysis (PCA) presented in Figure 2 aims to reduce the dimensionality of data obtained from various observed agronomic characteristics of rice and to identify combinations of key variables that most significantly contribute to total population variation. PCA is a valuable multivariate statistical tool in agronomic studies, as it allows for the grouping of variables based on their contribution to phenotypic diversity, especially when multiple variables are interrelated. PCA transforms the original variables into a smaller number of uncorrelated variables called principal components (PCs) (Tinungki & Sunusi, 2018).

The PCA results indicated that the first two principal components (PC1 and PC2) explained a large proportion of the total data variance—approximately 47–55% for PC1 and 20–25% for PC2 (this should be adjusted according to actual values shown in Figure 2). The cumulative contribution of these two components typically exceeds 70%, making them sufficiently representative in explaining the variation structure of the agronomic traits.

PC1 was predominantly formed by variables such as plant dry weight (PDW), productive tillers (PT), and grain weight per plot (GWPP). This indicates that PC1 represents the productivity dimension related to biomass and yield. Thus, PC1 can be interpreted as the productivity component, where a higher PC1 score reflects better agronomic performance in terms of grain yield. PC2 was defined by 1000-grain weight (1000-GW) and panicle length (PL), relating to grain quality and panicle size. Therefore, PC2 can be interpreted as the quality and reproductive size component. Treatments with high PC2 scores tended to produce heavier grains and longer panicles.

Mapping individual treatments (N0–N3) within the two-dimensional PCA space showed a relatively scattered distribution, indicating different contributions of each treatment to the two principal dimensions. For instance, the N2 treatment (7% nitrogen) was positioned toward the extreme end of PC1 and close to PC2, suggesting that this treatment excelled not only in productivity but also showed potential for better grain quality. The N2 treatment occupied a relatively extreme position along the PC1 axis and was close to PC2, indicating that this treatment not only excelled in productivity but also potentially offered better grain quality. Conversely, the control treatment (N0) was concentrated in the area with low scores on both components, reinforcing the finding that without additional nitrogen input from fish feed, plant growth and yield were limited.

Identifying the traits that contribute significantly to PC1 and PC2 allows researchers to focus cultivation strategies on these specific variables. In this case, plant dry weight, number of productive tillers, and grain weight per plot emerge as key parameters that may serve as selection indicators or targets for improvement in nitrogen-based rice-fish systems. Moreover, PCA helps to filter out variables that may be redundant or have a minor influence on overall variation. For example, plant height (PH) did not exhibit high loading in either of the principal components, indicating that it is less informative for differentiating treatment performance. This aligns with the earlier correlation discussion, which also highlighted the weak relationship between PH and yield-related parameters.

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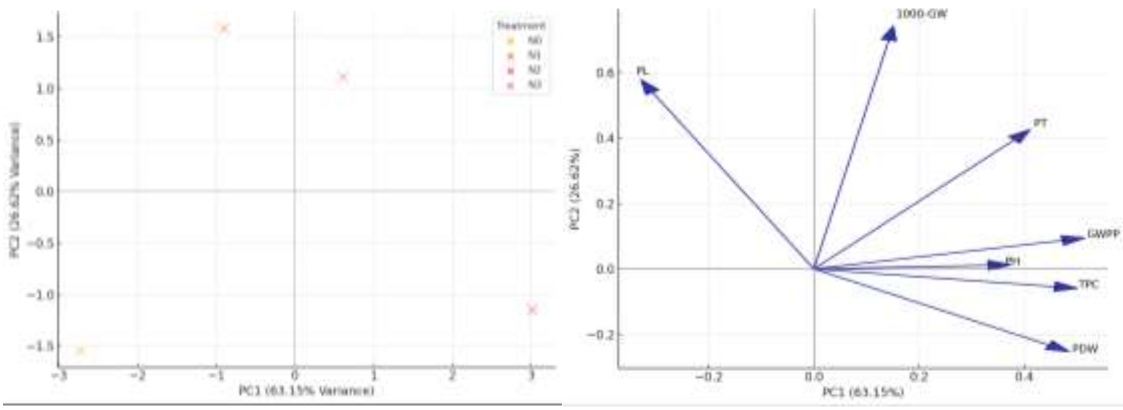

Figure 2. Results of the Principal Component Analysis (PCA) of rice quantitative morphological traits in the rice-fish system under nitrogen fish feed treatment.

Nevertheless, it is important to note the limitations of this study, particularly the small scale of the experiment and potential environmental variations that may have influenced nitrogen dynamics in the rice field. It is recommended that future research utilize N-15 isotope tracing to track the nitrogen pathway from fish feed to plant tissue and be conducted on a larger field scale to enhance the external validity of the results.

Conclusion

This study concludes that the application of fish feed with varying nitrogen content in a rice-fish farming system did not statistically significantly affect rice agronomic traits. However, there was a noticeable performance improvement trend under the 7% nitrogen (N2) treatment, particularly in plant dry weight, number of productive tillers, and grain yield per plot. Correlation analysis showed strong positive relationships among these parameters, underscoring their importance in determining yield, whereas plant height proved to be a less relevant indicator.

PCA effectively reduced data dimensionality and identified two principal components—productivity and quality aspects—with PDW, PT, GWPP, 1000-GW, and PL as the dominant variables. These findings suggest that nitrogen management through fish feed in rice-fish farming systems has the potential to improve nutrient efficiency and crop yield and merits further investigation using advanced approaches.

References

Abraham, O. V., Davies, O. A., & Akinwole, A. O. (2020). Fertilizer management and nutrient use efficiency on rice paddy in integrated system. *African Journal of Agricultural Research*, *15*(2), 323–329. https://doi.org/10.5897/ajar2019.14218

Diana, F., Mahendra, M., & Oktavinanda, G. (2022). Minapadi productivity with a combination of legowo technology and local fish. *E3S Web of Conferences*, *339*, 0–3. https://doi.org/10.1051/e3sconf/202233901004

Farah Diana, & Mahendra. (2021). Different Combinations Of Legowo And Endemic Fish On Rice And Fish Productivity In Minapadi System. *International Journal of Science, Technology & Management*, *2*(5), 1505–1511. https://doi.org/10.46729/ijstm.v2i5.330

Garko, D. M. S., Dawaki, K. D., Yawale, M. A., Mohammed, I. B., & Yaroson, A. Y. (2020). Correlations Among Grain Yield, Yield and Weed Attributes of Maize (Zea Mays L.) As Influenced By Weed Control Method and Poultry Manure Rate in Kano State Nigeria.

International Journal of Research -GRANTHAALAYAH, *8*(4), 275–284. https://doi.org/10.29121/granthaalayah.v8.i4.2020.15

Groenveld, T., Kohn, Y. Y., Gross, A., & Lazarovitch, N. (2019). Optimization of nitrogen use efficiency by means of fertigation management in an integrated aquaculture-agriculture system. *Journal of Cleaner Production*, *212*, 401–408. https://doi.org/10.1016/j.jclepro.2018.12.031

Hasbi, & Tunggal, T. (2021). Paddy-fish integrated agricultural system to increase income and food security. *IOP Conference Series: Earth and Environmental Science*, *782*(2). https://doi.org/10.1088/1755-1315/782/2/022019

Hastini, T., Suwarno, W. B., Ghulamahdi, M., & Aswidinnoor, H. (2019). Short communication: Correlation and regression among rice panicle branches traits. *Biodiversitas*, *20*(4), 1140–1146. https://doi.org/10.13057/biodiv/d200428

Lv, W., Yuan, Q., Lv, W., & Zhou, W. (2020). Effects of introducing eels on the yields and availability of fertilizer nitrogen in an integrated rice–crayfish system. *Scientific Reports*, *10*(1), 1–8. https://doi.org/10.1038/s41598-020-71884-0

Merliana, A., Mulyatno Setiawan, B., & Budiraharjo, K. (2021). Economic Efficiency of Regular Rice Farming and Mina Padi Production Factors. *SOCA: Jurnal Sosial, Ekonomi Pertanian*, *15*(3), 531. https://doi.org/10.24843/soca.2021.v15.i03.p10

Nasrul, M., Rasyid, B., & Saade, E. (2023). Effect of different feed nitrogen on nutrient flow, performance, and productivity in the minapadi system. *IOP Conference Series: Earth and Environmental Science*, *1230*(1). https://doi.org/10.1088/1755-1315/1230/1/012218

Nataraja, T. H., Naika, R., Shankarappa, S. K., Reddy, K. V., Abdelmohsen, S. A. M., Al-Harbi, F. F., … Abdelbacki, A. M. M. (2021). Productivity of paddies as influenced by varied rates of recommended nutrients in conjunction with biofertilizers in local landraces. *Agronomy*, *11*(6), 1–19. https://doi.org/10.3390/agronomy11061165

Rahmawati, R. (2017). Effect of Nitrogen Fertilizer on Growth and Yield of Maize Composite Variety Lamuru. *Agrotech Journal*, *2*(2), 36–41. https://doi.org/10.31327/atj.v2i2.310

Riyanto, D., Anshori, A., Triwidyastuti, K., & Yustisia. (2021). The Optimization of Irrigated Rice Field and Improvement of Land Productivity Throught Development of Rice-Shrimp (Macrobrachium rosenbergii) Cultivation Technology on Bantul Regency. *E3S Web of Conferences*, *316*, 1–16. https://doi.org/10.1051/e3sconf/202131603014

Rusdiansyah, R., & Saleh, M. (2017). Response of two local rice cultivars to different doses of nitrogen fertilizer in two paddy fields. *Agrivita*, *39*(2), 137–144. https://doi.org/10.17503/agrivita.v39i0.572

Sadimantara, G. R., Febrianti, E., Afa, L. O., Leomo, S., Muhidin, & Brahmiyanti, C. W. (2021). Performance of the agronomic traits of six advanced promising lines of red rice (oryza sativa l grown on the paddy field. *IOP Conference Series: Earth and Environmental Science*, *681*(1). https://doi.org/10.1088/1755-1315/681/1/012033

Sitaresmi, T., Suwarno, W., Rumanti, I. A., Ardie, S. W., & Aswidinnoor, H. (2019). AGRIVITA Parameters and Secondary Characters for Selection of Tolerance Rice Varieties u nder. *Agrivita*, *41*(2), 372–384.

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E-ISSN: 2829-2421
https://doi.org/10.47709/JoA.v1n1.2022

Tando, E., Pengkajian, B., Pertanian, T., & Tenggara, S. (2018). Review: efficiency efforts and increasing nitrogen availability in the soil and nitrogen uptake in lowland rice plants (Oryza sativa L.), *18*(2), 171–180.

Tinungki, G. M., & Sunusi, N. i. (2018). Penerapan Sparse Principal Component Analysis dalam Menghasilkan Matriks Loading yang Sparse. *Jurnal Matematika Statistika Dan Komputasi*, *15*(2), 42. https://doi.org/10.20956/jmsk.v15i2.5568

Triyanti, R., Suryawati, S. H., Wijaya, R. A., Wardono, B., & Hafsaridewi, R. (2021). Assessment of the success factors influencing of rice-fish farming innovation village to support food security. *IOP Conference Series: Earth and Environmental Science*, *892*(1). https://doi.org/10.1088/1755-1315/892/1/012052

Wardana, R., & Hariyati, I. (2010). Pengairan Macak-Macak Serta Penambahan, 208–212.