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Sustainable Integrated Nutrient Management Practices for Traditional Rice Production in Wayanad, Kerala: Yield and Quality Implications

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ABSTRACT

Background: Rice cultivation in Wayanad, Kerala, can greatly benefit from Integrated Nutrient Management (INM) practices that incorporate organic amendments. Traditional rice varieties in the region, known for their nutritional and cultural value, often face productivity constraints due to unsustainable input use. This study aimed to evaluate the potential of INM strategies to enhance yield and quality while promoting sustainable farming practices.

Methods: The research was conducted during the *Kharif* seasons of 2022 and 2023 using a split-plot design. Four traditional rice varieties-Kothampalarikkayama (V1), Rakthashali (V2), Njavara (V3) and Chennellu (V4)- were studied under seven different INM treatments. These treatments combined green manuring, farmyard manure (FYM) and varying levels of chemical fertilisers, including a treatment with 75% of the recommended nitrogen dose. Parameters such as panicle number, grain filling, kernel length and protein content were measured to assess performance.

Result: INM practices integrating organic inputs with reduced chemical fertilisers significantly improved soil health and crop performance. Kothampalarikkayama (V1) exhibited the highest yield and superior panicle traits. The most effective INM treatment was green manuring plus FYM with 75% recommended nitrogen-resulted in increased panicle number, better grain filling and improved kernel length and protein content. These outcomes highlight the potential of INM for enhancing both productivity and sustainability in traditional rice cultivation systems.

Key words: Integrated nutrient management (INM), Quality enhancement, Sustainable agriculture, Traditional rice varieties, Yield.

INTRODUCTION

Global agriculture faces growing challenges from climate change and declining soil health. Organic matter (OM) is essential for maintaining soil productivity, ecosystem services and agroecosystem resilience (Mensik *et al.,* 2019). The “4 per 1000” initiative, launched at COP21 in 2015, emphasized sustainable soil management to address climate change and food security. Although crop yields have increased over the past 50 years, rising food demand and shrinking farmland-due to urbanization and industrialization-underscore the need for more efficient and sustainable agricultural practices (Rahman *et al.,* 2020).

Rice (*Oryza sativa* L.) is a staple food for over half of the world’s population, providing essential carbohydrates, proteins and vitamins (Heinemann *et al.,* 2005). Global rice production reached about 496.40 million tons from 162.06 million hectares in 2019-2020 (Rashid *et al.,* 2024). Traditional rice varieties like Kothampalarikkayama, Rakthashali, Njavara and Chennellu have been cultivated for centuries and are integral to Kerala’s agricultural heritage. These varieties are valued for their unique flavours, textures, adaptability to local conditions and their contribution to the region’s cultural and culinary diversity. However, modern practices and environmental changes threaten their production, highlighting the need for sustainable methods to preserve genetic resources and enhance productivity. This shift has brought Integrated Nutrient Management (INM) to the forefront.

Integrated nutrient management (INM) combines organic and inorganic fertilizers to optimize soil fertility and crop productivity. It is especially important in regions with traditional farming, aiming to balance nutrient supply, minimize environmental impact and improve soil health (Woon-Jung *et al.,* 2022; Krishnakumar, 2005). Studies show organic inputs like farmyard manure (FYM) enhance soil’s

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physical, chemical and biological properties. Halemani (2004) reported that FYM reduces bulk density, increases infiltration and improves water holding capacity. Krishnakumar and Saravanan (2005) found FYM with neem cake enhances hydraulic conductivity and pore space. Gomiero *et al.* (2011) and Blanco-Canqui *et al.* (2015) noted organic practices reduce runoff and erosion and improve soil structure and water retention. For traditional rice, INM helps maintain soil fertility and support sustainability. FYM and vermicompost improve nutrient availability and microbial activity, boosting rice growth and yield (Sharma *et al.,* 2019; Singh and Stoskopf, 1971; Pillaiyar and Mohandoss, 1981). This research evaluates the impact of Integrated Nutrient Management (INM) on the yield and quality of traditional rice varieties in Wayanad, Kerala. The specific objectives are: Assess the impact of INM on soil properties-examine how different INM practices affect soil physical, chemical and biological traits, including bulk density, water holding capacity, nutrient availability and microbial activity.

Determine the effect of INM on rice yield

Analyze the influence of INM on growth, yield and yield components of traditional rice varieties.

Evaluate the influence of INM on rice quality

Investigate the effects of INM on grain quality, including size, shape, aroma and cooking traits.

Analyze economic implications

Assess the economic viability of INM in traditional rice farming, considering input costs, yield and market returns. This study aims to offer a comprehensive evaluation of how INM influences yield, quality and sustainability in traditional rice systems, contributing to sustainable agriculture in Kerala and similar agro-climatic regions.

MATERIALS AND METHODS

Experimental site and plant materials

The experiment was conducted on a farmer's field in Thomattuchal, Wayanad, Kerala, during the *Kharif* seasons of 2022 and 2023 (11.5695°N, 76.2197°E). Wayanad, with elevations ranging from 700 to 2100 m above mean sea level, features clay loam soil and favourable climatic conditions, including 244.1 mm rainfall and 81.26% relative humidity-ideal for rice cultivation. A split-plot design with three replications was used. Main plots included four traditional rice varieties-Kothampalarikkayama (V1), Rakthashali (V2), Njavara (V3) and Chennellu (V4)-selected for their historical and local adaptability. Subplots received seven integrated nutrient management (INM) treatments (N1 to N7) to evaluate effects on growth, yield and quality.

Different INM practices

Seven integrated nutrient management (INM) practices (N1 to N7) were applied to evaluate their influence on the growth, yield and quality of the selected traditional rice varieties. The INM practices were designed to combine organic and inorganic nutrient sources, aiming to optimize nutrient availability and improve soil health. The practices included in this study are given in Table 1.

The sowing and harvesting details of these rice varieties are given in Table 2. All the cultural practices for traditional rice cultivation other than treatments were followed as per the recommendations of crop production guidelines (2020) of Kerala Agricultural University. Each INM practice was carefully monitored throughout the growing season to assess its impact on soil fertility, plant growth and ultimately, the yield and quality of the rice grains. The combination of organic and inorganic inputs was tailored to meet the nutrient requirements of the rice plants at different growth stages, ensuring balanced nutrient availability and minimizing the risk of nutrient leaching or deficiency.

Observation of yield and quality parameters

Data collection focused on both yield and quality parameters to provide a comprehensive assessment of the effects of the different INM practices on the traditional rice varieties. Fig 1 and Fig 2.

Yield-related characteristics that have been for traditional rice varieties across different INM strategies

Number of panicles per plant

At harvest, the number of panicles per plant was counted from tagged plants in each net plot and expressed as the number of panicles per hill.

Panicle length

Panicle length was measured from the collar to the tip of ten panicles per hill and the mean length was recorded in cm (Manickam *et al*., 2024).

Panicle weight (g)

Ten primary panicles from tagged plants of each treatment were weighed and the average weight was expressed in grams.

Number of filled and ill-filled grains panicle^{-1}

The filled and ill-filled grains panicle^{-1} were identified by pressing grains with a finger and counted separately (Yoshida, 1972) . The calculated values were expressed in numbers panicle^{-1}.

Sterility percentage

$$\text{Sterility percentage} = \frac{\text{Number of unfilled grains panicle}^{-1}}{\text{Total number of grains panicle}^{-1}} \times 100$$

Test weight

A sample of one thousand filled grains was selected from each net plot, weighed using an electronic balance and expressed in g.

Grain yield plant^{-1}

Total grains from each plant were collected, weighed and adjusted to 14% moisture content. The yield was expressed in grams per plant.

Grain yield

The harvested crop from each net plot was threshed, cleaned, sun-dried to 14% moisture (Yoshida, 1972) and weighed. Grain yield was expressed in kilograms per hectare.

Straw yield

Straw from each plot was sun-dried for two days and weighed. The straw yield was expressed in kilograms per hectare.

Harvest index (HI)

Calculated by the ratio of economic yield (grain yield) to biological yield (total biomass) as :

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}}$$ Juliano *et al.,* 1981

Assessment of quality parameters across different INM treatments

Kernel length breadth ratio before/after cooking

Five milled rice grains from each treatment were soaked in distilled water for 10-12 minutes, cooked for 15 minutes and then measured for length and breadth in mm (Devi, 2012).

Starch (amylose andamylopectin)

Amylose content was determined using the colorimetric method with potato starch as a standard (Singh and Gongwer 1982).

Protein content

Crude protein content was calculated by multiplying the total nitrogen content (obtained by the AOAC Kjeldahl method) with a conversion factor of 6.25.

Fiber content

Total dietary fiber was computed as the sum of insoluble dietary fiber (IDF) and soluble dietary fiber (SDF). It was estimated by:

Total dietary fiber = IDF + SDF values

Ash content

Two grams of ground rice samples were first heated on a hot plate and then in a muffle furnace at 550°C. Following this, the samples were cooled to below 200°C. They were then transferred to a desiccator and allowed to cool for 30 minutes. Once cooled, the samples were weighed in the desiccator and the weight of the ash was recorded.

Per cent of dockage

A 100 g paddy will be randomly collected from each sample. Stones, weeds and other extraneous materials were carefully sorted out. The weight of the extraneous materials is weighed and the per cent of dockage is computed using the equation.

$$\text{Dockage\%} = \frac{\text{Weight of dockage}}{\text{Weight of 100 samples}} \times 100$$

Hulling percentage

The hulling percentage represents the ratio of the weight of total brown rice to the weight of total rough rice, expressed as a percentage (Shamsuddin *et al.,* 1982). To determine this, rice samples are first cleaned and then 3 grams of the grain sample are hulled using a Satake Sheller. The weights of the de-hulled grains are then recorded. The calculation is performed using the following formula:

Hulling percentage =

$$\frac{\text{Weight of the de-husked kernel (kg ha}^{-1})}{\text{Weight of husked grain (g)}} \times 100$$

Milling percentage

The milling percentage is calculated as the ratio of the weight of total milled rice to the weight of total rough rice, expressed as a percentage (Gupta and Sharma, 1991). After hulling, the rice samples are milled and the weight of the milled rice is recorded. The formula used is:

$$\text{Milling percentage} = \frac{\text{Weight of milled grain (g)}}{\text{Weight of husked grain (g)}} \times 100$$

Head rice recovery percentage

The head rice yield is determined by manually separating whole grains and three-fourths grains. The percentage is calculated using the following formula:

$$\text{HRR (\%)} = \frac{\text{Weight of whole milled rice (g)}}{\text{Weight of rough rice (g)}} \times 100$$

Statistical analysis

The data collected on yield and quality parameters were subjected to statistical analysis to evaluate the significance of the effects of different INM practices and traditional rice varieties. Analysis of variance (ANOVA) was performed using AGRESS to determine the significance of differences among treatments. The mean values were compared using the Least Significant Difference (LSD) test at a 5% level of significance ($p<0.05$).

RESULTS AND DISCUSSION

The study on the impact of integrated nutrient management (INM) on the yield and quality of traditional rice varieties in Wayanad, Kerala, provides significant insights into how different nutrient management practices affect rice crop performance. The analysis, conducted over the *Kharif* seasons of 2022 and 2023, highlights the variations among rice varieties and their responses to distinct nutrient management strategies.

Effects of INM on yield parameters

The effects of integrated nutrient management (INM) on rice yield parameters were significant. Panicle numbers varied across rice varieties and INM practices. Kothampalarik kayama (V1) had the highest counts, with

14 and 16 in *Kharif* 2022 and 2023, respectively, while Chennellu (V4) had fewer, with 8 and 10. Among INM practices, green manuring + 75% recommended dose (RD) N + 25% N through farmyard manure (FYM) (N3) resulted in 12 and 14 panicles. The lowest counts were with Farmer's practice (N1), at 9 and 11. The interaction effect showed that Kothampalarikkayama under green manuring + 75% RD N + 25% N through Vermicompost + Biofertilizer (V1 N4) had the highest panicles (15 and 18), while Chennellu under Farmer's practice (V4 N1) had the lowest (7 and 8). Kothampalarikkayama (V1) also had the most filled grains per panicle, with 167 and 183, followed by Rakthashali (V2) with 142 and 162 and Njavara (V3) with 111 and 132. The best INM practice for filled grains was green manuring + 75% RD N + 25% RD N through FYM (N3), yielding 149 and 165 grains. The lowest count was with Farmer's practice (N1), at 119 and 136 grains. The highest number of filled grains was found in Kothampalarikkayama under green manuring + 75% RD N + 25% RD N through Vermicompost + Biofertilizer (V1 N4), with 187 and 205 grains, while Njavara under Farmer's practice (V3 N1) had the fewest, with 90 and 114

Hill-filled grains per panicle were highest in Kothampalarikkayama (V1) with 24 and 26 and lowest in Njavara (V3) with 16 and 19. Farmer's practice (N1) had the fewest filled grains (17 and 19), while green manuring + 75% RD N + 25% RD N through FYM (N3) had the most (21 and 23). This was due to enhanced photosynthesis and nutrient availability from organics (Das *et al.,* 2016). The highest filled grains were in V1 under green manuring + 75% RD N + 25% RD N through Vermicompost + Biofertilizer (V1 N4), with 26 and 29, while V3 under N1 had the least (13 and 17). Sterility was highest in V3 (14.38% and 14.40%) and lowest in V4 (14.34% and 14.29%). V1's higher performance suggests efficient nutrient partitioning for better grain filling, as per Singh and Gangwar (1982). V1 consistently outperformed others in yield and quality, likely due to INM didn't significantly affect sterility. Test weight was highest in Kothampalarikkayama (V1) at 11.0 and 12.08 g and lowest in Njavara (V3) at 7.30 and 8.69 g. The best INM practice, green manuring + 75% RD N + 25% RD N through FYM (N3), had 9.80 and 10.88 g, while Farmer's practice (N1) had the lowest, at 7.86 and 8.94 g. Panicle length was longest in Njavara (V3) at 19.35 and 21.42 cm and shortest in Rakthashali (V2) at 7.59 and 9.33 cm. Green manuring + 75% RD N + 25% RD N through FYM (N3) had the longest panicle (14.88 and 17.13 cm), while Farmer's practice (N1) had the shortest (11.33 and 13.19 cm).

Grain yield was highest in Kothampalarikkayama (V1) with 5.2 and 5.7 kg and lowest in Njavara (V3) with 3.4 and 4.1 kg. Best INM practice (N3) yielded 4.6 and 5.1 kg and Farmer's practice (N1) yielded the least at 3.7 and 4.2 kg. Kothampalarikkayama under green manuring + 75% RD N + 25% RD N through Vermicompost + Biofertilizer (V1, N4) had the highest yield (5.8 and 6.4 kg), while Njavara under Farmer's practice (V3, N1) had the lowest (2.8 and 3.5 kg).

Grain yield per hectare was highest for Kothampalarik kayama (V1) at 2623 and 2886 kg/ha, followed by Rakthashali (V2) at 2229 and 2554 kg/ha and lowest in Njavara (V3) at 1743 and 2075 kg/ha. The best INM practice, green manuring + 75% RD N + 25% RD N through FYM (N3), achieved 2341 and 2599 kg/ha. The lowest yield was under Farmer's practice (N1) at 1869 and 2135 kg/ha. Kothampalarikkayama under green manuring + 75% RD N + 25% RD N through Vermicompost + Biofertilizer (V1 N4) had the highest yield (2938 and 3220 kg/ha), while Njavara under N1 had the lowest (1421 and 1793 kg/ha). Yield differences were mainly due to variations in tiller production and key yield attributes like panicles per hill and filled grains per panicle, as noted by George, Bastian (George, 2005).

Table 1: Integrated nutrient management (INM) practices applied in this study.

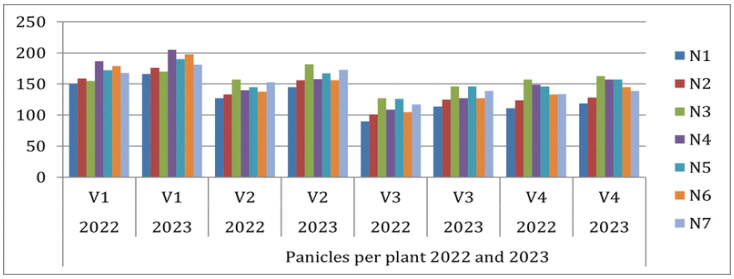
INM practice	Description
N1	Farmer's practice: RDF - 90:45:45 NPK kg ha^{-1}
N2	Green manuring + 75% RD of N + 25% RD N through Vermicompost
N3	Green manuring + 75% RD of N + 25% RD N through FYM
N4	Green manuring + 75% RD of N + 25% RD N through Vermicompost + Biofertilizer
N5	Green manuring + 75% RD of N + 25% RD N through FYM + Biofertilizer
N6	Green manuring + 100% RD of N + 25% RD N through Vermicompost + Biofertilizer
N7	Green manuring + 100% RD of N + 25% RD N through FYM + Biofertilizer

Note: P and K are applied as per recommendation. An absolute control plot (without N) was maintained separately for calculations.

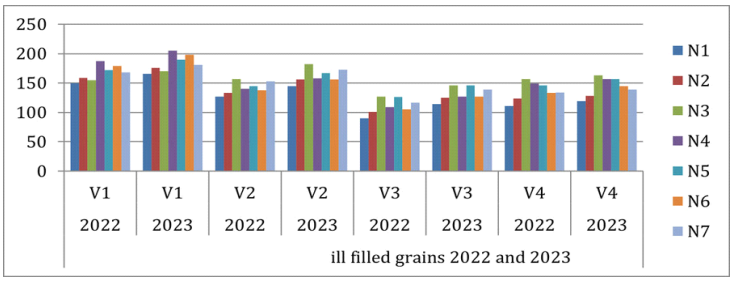
Table 2: Sowing and harvesting details.

Variety	Date of sowing	Date of harvest	Duration (Days)
Kothampalarik kayama	15-06-2023	14-10-2023	120-130
Rakthashali	15-06-2023	02-10-2023	110
Njavara	15-06-2023	04-09-2023	70-75
Chennellu	15-06-2023	16-10-2023	120-125

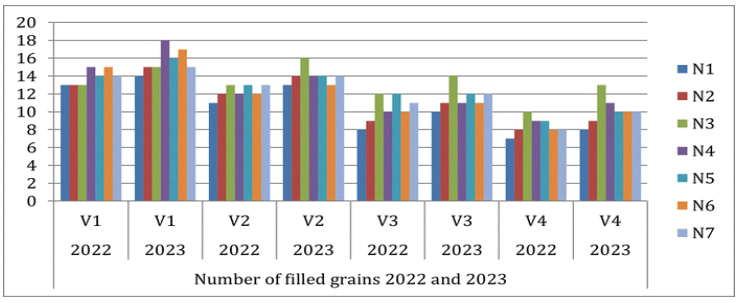
PANICLES PER PLANT



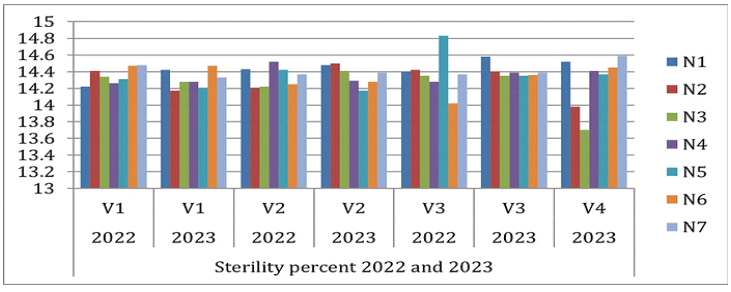
NUMBER OF ILL FILLED GRAINS



NUMBER OF FILLED GRAINS



STERILITY PERCENT



TEST WEIGHT

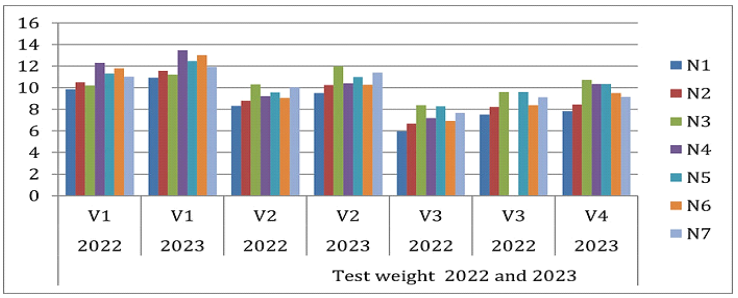


Fig 1: Continue ....

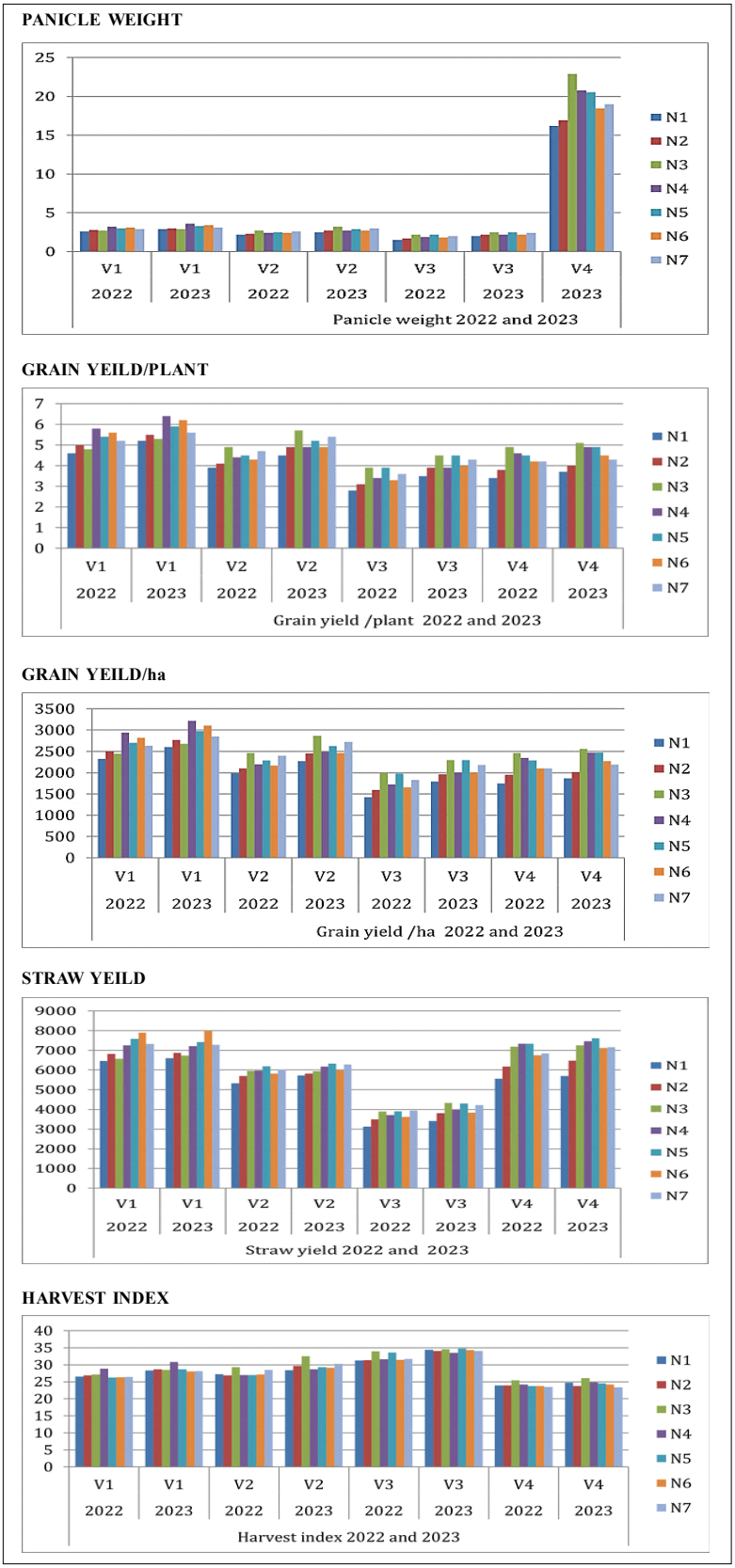
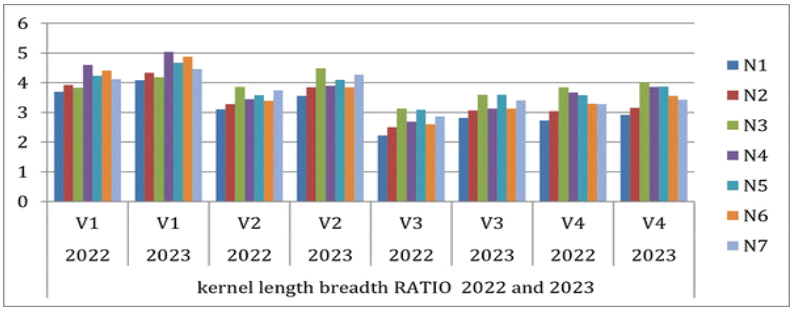
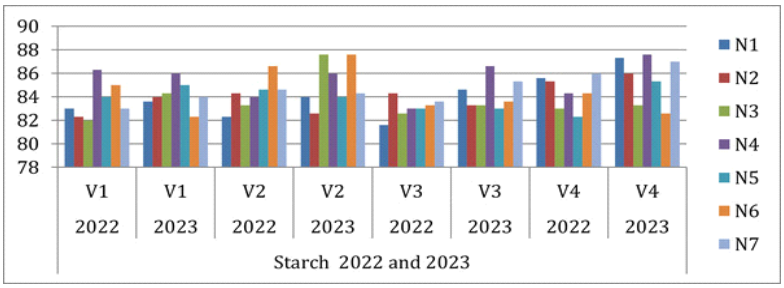


Fig 1: Yield-related characteristics that have been for traditional rice varieties across different INM strategies during *kharif* 2022 and 2023.

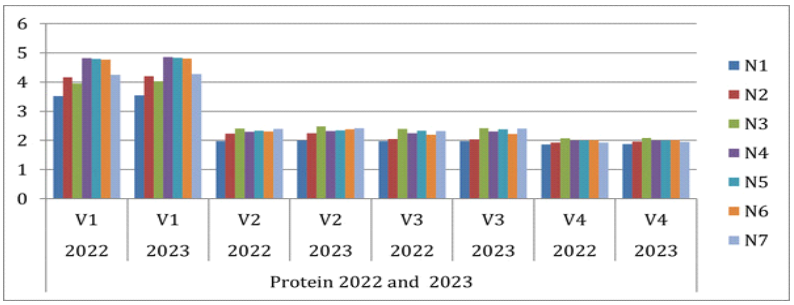
KERNEL LENGTHBREADTH RATIO



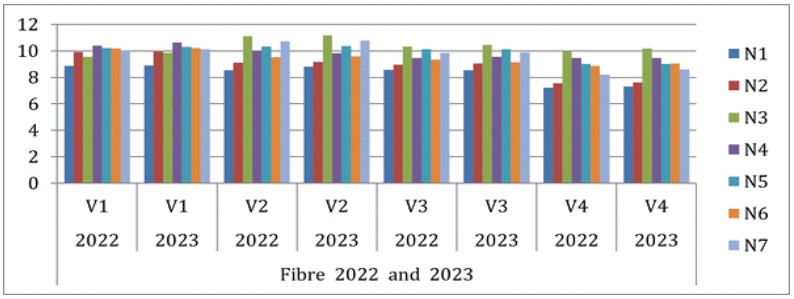
STARCH



PROTEIN



FIBRE



ASH

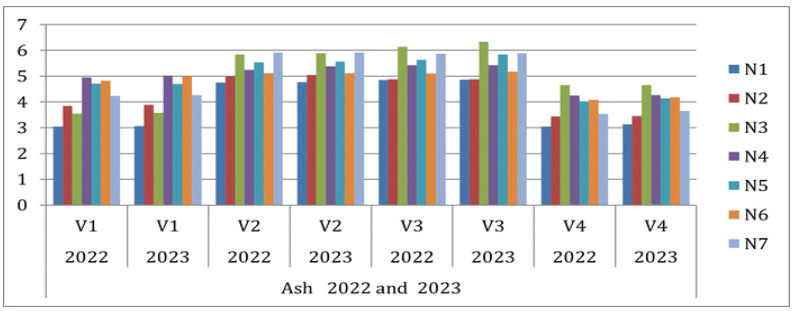


Fig 2: Continue ....

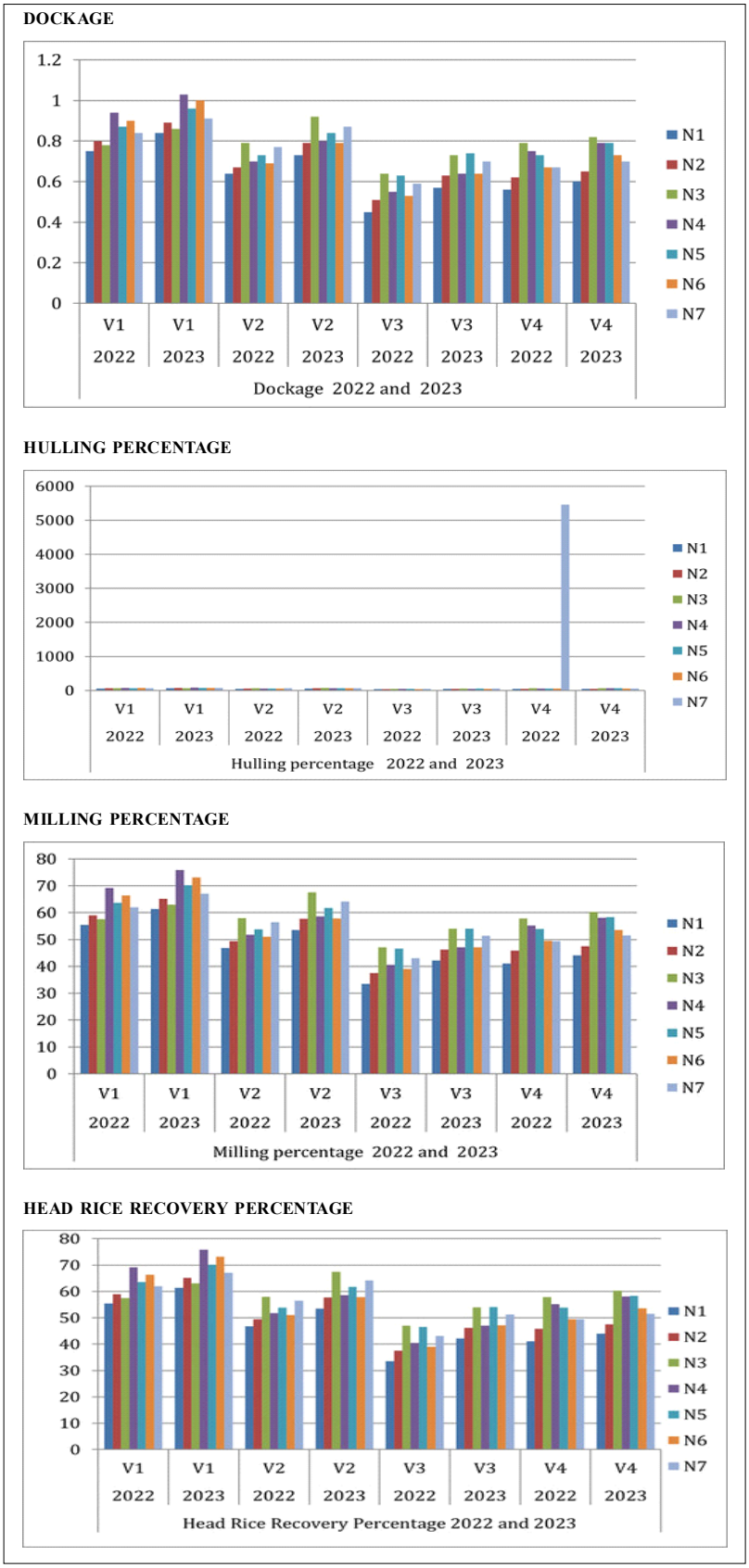


Fig 2: Assessment of quality parameters across different INM treatments.

Straw yield was highest in Kothampalarikkayama (V1) at 7130 and 7156 kg, followed by Chennellu (V4) at 6743 and 6964 kg and lowest in Njavara (V3) at 3670 and 3982 kg. The highest straw yield under INM was with green manuring + 75% RD N + 25% RD N through FYM + Biofertilizer (N5), at 6256 and 6413 kg. The lowest was under N1, at 5116 and 5359 kg. Interaction effects showed the highest straw yield in Kothampalarikkayama under green manuring + 100% RD N + 25% RD N through Vermicompost + Biofertilizer (V1 N6) at 7898 and 7982 kg, while the lowest was in Njavara under N1 at 3131 and 3418 kg. The harvest index was highest in Njavara (V3) at 32.14% and 34.24%, followed by Rakthashali (V2) at 27.57% and 29.71% and lowest in Chennellu (V4) at 24.07% and 24.52%, aligning with Kumar *et al.* (2001); Kusutani *et al.* (2000), who linked straw yield to plant growth.

Among INM practices, green manuring + 75% RD of N + 25% RD N through FYM (N3) resulted in the highest harvest index (28.96% and 30.44%). The lowest was in Farmer's practice (N1), with 27.21% and 28.97%. Njavara with green manuring + 75% RD of N + 25% RD N through FYM (V3 N3) had the highest harvest index (33.96% and 34.62%), while Chennellu under the same practice (V4 N3) had the lowest (22.67% and 23.85%). Data on yield parameters are in table. Behera and Pany, (2021) support the benefits of INM in improving straw and biological yields.

Effects of INM on grain quality parameters

The study provides insights into the quality parameters of traditional rice varieties, focusing on physical, cooking and biochemical traits. Significant differences were observed in kernel length, breadth and L/B ratio, influencing appearance and milling quality. The L/B ratio remained stable with INM practices, with Njavara (V3) showing a medium grain shape and Kothampalarikkayama (V1) a slender one, preferred in premium markets for higher milling quality (Biswas *et al.,* 1992). Amylose content affects rice texture, while gelatinization temperature and aroma enhance cooking properties. Starch content remained stable across practices, but protein content was highest in Kothampalarikkayama (V1) and lowest in Chennellu (V4), with green manuring practices boosting protein levels. Fiber quality varied significantly, with Kothampalarikkayama (V1) showing the highest values, particularly with green manuring + farmyard manure. Rakthashali, treated with green manuring + 75% RD N + 25% RD FYM, had higher fiber content, affecting cooking and eating properties (Rathna-Priya *et al.,* 2019). The lowest fiber quality was in the farmer's practice.

Ash content varied significantly, highest in Njavara (V3) and lowest in Chennellu (V4), with green manuring + FYM enhancing levels, while the farmer's practice yielded the least. Dockage percentage was highest in Kothampalarik kayama (V1), especially with green manuring + FYM and lowest under farmer's practice. Hulling percentage also varied, highest in Kothampalarikkayama (V1) and lowest in Njavara (V3), aligning with the desirable >70% standard (Bisne and Sarawgi 2008). Milling and head rice recovery percentages followed similar trends, with Kothampalarik kayama (V1) leading and Njavara (V3) trailing, both enhanced by green manuring + FYM and lowest under farmer's practice (Nandhini *et al.*, 2025).

Overall, quality traits varied among varieties, with Kothampalarikkayama (V1) showing superior hulling, grain shape and milling qualities. Varieties like Njavara (V3) and Rakthashali offered distinct qualities suited to specific culinary needs. These insights highlight the importance of INM in improving both yield and grain quality to meet diverse consumer demands (Paramesh *et al.,* 2023; Udhaya *et al.,* 2025).

CONCLUSION

This study underscores the vital role of integrated nutrient management (INM) in improving yield and quality of traditional rice varieties in Wayanad, Kerala. Kothampalarik kayama (V1) emerged as the most responsive variety, showing superior yield and quality under INM, particularly with green manuring combined with FYM and vermicompost. Njavara (V3) and Rakthashali (V2) also showed unique strengths, such as longer panicles and higher fiber content, respectively. The findings highlight the potential of combining organic and inorganic nutrients to enhance rice productivity and meet diverse consumer needs. Future research should focus on refining INM strategies to further improve efficiency and quality in traditional rice cultivation.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Conflict of interest

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REFERENCES

Behera, H.S. and Pany, B.K. (2021). Impact of inorganic nitrogenous fertilizers and farmyard manure combination on grain, straw, biological yield and harvest index of rice (*Oryza sativa* L.). *J. Pharmacogn Phytochem.* **10(5):** 257-260. doi:10.22271/phyto.2021.v10.i5c.14230.

Bisne, R. and Sarawgi, A.K., (2008). Agromorphological and quality characterization of Aromatic group from aromatic rice germplasm of Chhattisgarh. *Bangladesh Journal of Agriculture Research*. **33(3):** 479-492.

Biswas, S.K., Banu, B., Kabir K.A., Begum, F. and Choudhury, N.H. (1992). Physicochemical properties of modern and local rice varieties of Bangladesh. *Bangladesh Rice J.* **3(1 and 2):** 128-131.

Blanco-Canqui, H., Shaver, T.M., Lindquist, J.L., Shapiro, CA., Elmore, R.W., Francis, C.A. and Hergert, G.W. (2015). Cover crops and ecosystem services: Insights from studies in temperate soils. *Agron J*. **107(6):** 2449-2474. doi: 10.2134/agronj 15.0086.

Das, K.N., Basumatary, A. and Ahmad, S. (2016). Targeted yield precision model assessment for rice-rice crop sequences in farmers' fields in humid, sub-tropical northeastern India. *J. Soil Sci. Plant Nutr*. **16:** 31-47.

Devi, M.G. (2012). Nitrogen management to improve the nutrient uptake, yield and quality parameters of scented rice under aerobic culture. *International Journal of Applied Biology and Pharmaceutical Technology.* **3(1):** 340–344.

George, S.P. (2005). Evaluation of aromatic rice varieties in Wayanad, Kerala. *J. Trop. Agric*. **43:** 67-69.

Gomiero, T., Pimentel, D. and Paoletti, M.G. (2011). Environmental impact of different agricultural management practices: Conventional vs. organic Agriculture. *CRC Crit. Rev. Plant Sci.* **30(1-2):** 95-124. doi: 10.1080/07352689.2011.554355.

Gupta, A.K. and Sharma. R.S. (1991). Effect of plant spacing and fertility level on grain yield of early medium indica rice (*Oryza sativa* L). *Indian Journal of Agronomy*. **44(2):** 310-312.

Halemani, H.L. (2004). Effect of organics on cotton productivity and physico-chemical properties of soil. International Symposium on Strategies for Sustainable Cotton Production-A Global Vision. pp. 174-180.

Heinemann, R.J.B., Fagundes, P.L., Pinto E.A., Penteado, M.V.C. and Lanfer-Marquez, U.M. (2005). Comparative study of nutrient composition of commercial brown, parboiled and milled rice from Brazil. *Journal of Food Composition and Analysis*. **18(4):** 287-296. doi: 10.1016/j.jfca.2004.07.005.

Juliano, B.O., Perez, C.M., Blakeney, A.B., Castillo, T., Kongseree, N., Laignelet, B., Lapis, E.T., Murty, V.V.S., Paule, C.M. and Webb, B.D. (1981). International cooperative testing on the amylose content of milled rice. *Starch/Stärke*. **33:** 157-162. https://doi.org/10.1002/star.19810330504.

Krishnakumar, S. (2005). Microbial population and enzymatic activity as influenced by organic farming. *Res. J. Agric Biol. Sci.* **1(1):** 85-88.

Kumar, V., Kumar, D., Singh, Y.V. and Raj, R. (2001). Effect of iron fertilization on dry-matter production, yield and economics of aerobic rice (*Oryza sativa*). *Indian Journal of Agronomy.* **60(4):** 547-553. doi: 10.59797/ija.v60i4.4491.

Kusutani, A., Cui, J., Toyota, M. and Asanuma, K. (2000). Studies on the varietal differences of harvest index and morphological characteristics of rice. *Japanese Journal of Crop Science.* **69(3):** 359-364. doi: 10.1626/jcs.69.359.

Mensik, L., Hlisnikovsky, L. and Kunzova, E. (2019). The State of the Soil Organic Matter and Nutrients in the Long-Term Field Experiments with Application of Organic and Mineral Fertilizers in Different Soil-Climate Conditions in the View of Expecting Climate Change. In: Organic Fertilizers-History, Production and Applications. [Larramendy, M.L., Soloneski, S. (Eds.)]; IntechOpen: London, UK. pp. 23-42. doi: 10.5772/intechopen. 86716.

Manickam, S., Suganthy, M., Sunitha, R., Jansirani, R., Krishnan, R. and Ganesh, R. (2024). Evaluation of traditional varieties of rice (*Oryza sativa* L.) for yield under organic production system. *Indian Journal of Agricultural Research*. **58(6):** 1187-1192. doi: 10.18805/IJARe.A-5852.

Nandhini, Y., Lokanadhan, S., Lourduraj, C.A., Thavaprakash, N. and Ramalakshmi, A. (2025). Influence of rice establishment methods affecting the cooking quality of traditional landraces in South India. *Agricultural Science Digest.* **45(3):** 380-387. doi: 10.18805/ag.D-5711.

Paramesh, V., Kumar, P., Bhagat, T., Nath, A.J., Manohara, K.K., Das, B., Desai, B.F., Jha, P.K. and Prasad, P.V.V. (2023). Integrated nutrient management enhances yield, improves soil quality and conserves energy under the lowland rice-rice cropping system. *Agronomy.* **13(6):** 1557. doi: 10.3390/ agronomy13061557.

Pillaiyar, P. and Mohandoss, R. (1981). Cooking qualities of parboiled rices produced at low and high temperatures. *J. Sci Food Agric.* **32(5):** 475-480. doi: 10.1002/jsfa.2740 320508.

Rahman, M.M., Alam, M.S., Kamal, M.Z.U. and Rahman, G.K.M.M. (2020). Organic sources and tillage practices for soil management', in resources use efficiency in agriculture. Springer Singapore. 283-328. doi:10.1007/978-981-15-6953-1_9.

Rashid, Md. M., Begum, S., Manir, M.R., Islam, M.S., Shalahuddin, A.K.M., Jahan, A., Musha, Md. M.h. and Hasan, Md.A. (2024). Yield maximization of rice (*Oryza sativa*) through integrated nutrient management. *Asian J. Res. Crop Sci.* **9(2):** 44-53. doi: 10.9734/ajrcs/2024/v9i2266.

Rathna-Priya, T.S., Eliazer-Nelson, A.R.L., Ravichandran, K. and Antony, U. (2019). Nutritional and functional properties of coloured rice varieties of South India: A review. *Journal of Ethnic Foods*. **6(1):** 11. doi: 10.1186/s42779-019-0017-3.

Shamsuddin, A.M., Islam, M.A. and Hossain, A. (1982). Comparative study on the yield and agronomic characters of nine cultivars of rice. *Bangladesh J. Agri.Sci.* **15(1):** 121-124.

Sharma, S., Padbhushan, R. and Kumar, U. (2019). Integrated nutrient management in rice-wheat cropping system: An evidence on sustainability in the Indian subcontinent through Meta-analysis. *Agronomy.* **9(2):** 71. doi: 10.3390/agronomy 9020071.

Singh, I.D. and Stoskopf, N.C. (1971). Harvest index in cereals. *Agron. J.* **63(2):** 224-226. doi: 10.2134/agronj1971.00021 962006300020008x.

Singh, S. and Gongwer, B. (1982). Comparative studies on production potentials in traditional tall and improved rice cultivars. *J. Andaman Sci. Assoc*. **5(1):** 81-82.

Udhaya, A., Radhamani, S., Kumar Senthil, G., Ravichandhran, V., Janaki, P. and Manonmani, S. (2025). Effect of integrated nutrient management practices on physiology and yield of improved traditional rice variety (Black Kavuni). *Agricultural Science Digest*. **45(2):** 215-221. doi: 10.18805/ag.D-6054.

Woon-Jung, C., Hee-Myong, R., Young-Dae, C., Jeong-Han, K. and Sun-Ho, Y. (2022). Natural 15 N abundances of maize and soil amended with urea and composted pig manure. *Plant Soil.* **245:** 223-232.

Yoshida, S. (1972). Physiological aspects of grain yield. *Annu. Rev. Plant Physiol.* **23(1):** 437-464. doi: 10.1146/annurev. pp.23. 060172.002253.