Indian Journal of Agronomy **70** (2): 137–142 (June 2025)
DOI: 10.59797/ija.v70.i2.5594

Research Paper

Performance of liquid organic formulations in combination with vermicompost on yield, quality and economics of aromatic rice (*Oryza sativa*)

P. JODDAR[1], P.S. PATRA[2], S. KARKI[3], A. HOQUE[4], A.S. AHMED[5] AND B. PARAMANIK[6]

Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal 736 165

Receipt: December 2024; Received accepted: April 2025

ABSTRACT

The present experiment has been conducted at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Cooch Behar, West Bengal during *kharif* 2022 and 2023 to evaluate the effects of various organic liquid formulations on the yield, grain quality, soil health and economic viability of *Tulaipanji* rice cultivation. Treatment comprising of T_1, vermicompost @ 3 t/ha + Sanjivak 20% foliar spray (FS) at 45 days after transplanting (DAT); T_2, vermicompost @ 3 t/ha + Jivamrut 20% FS at 45 DAT; T_3, vermicompost @ 3 t/ha + Amrit Pani 20% FS at 45 DAT; T_4, vermicompost @ 3 t/ha + Panchgavya 20% FS at 45 DAT; T_5, vermicompost @ 3 t/ha + vermicompost tea 20% FS at 45 DAT; T_6, RDF (50-25-25 kg N-P-K kg/ha) and T_7 (Absolute control). The combined application of vermicompost and panchgavya has protuberant outcome on yield attributes and which ultimately facilitated in attainment of 16.30 and 7.39% higher grain and straw yield, respectively over 100% RDF. Application of vermicompost @ 3 t/ha and panchgavya 20% FS at 45 DAT also recorded highest milling (63.4%), head rice recovery (57.8%) and head rice yield (93.1%). Vermicompost and panchgavya also showed superiority in achieving 5.0, 3.96 and 4.40% higher protein, amylose and carbohydrate over 100% chemically treated plot. Concerning economics, application of vermicompost + panchagavya had the highest net returns ($959.30/ha) and benefit-cost ratio (1.26), making it the most profitable treatment. Overall, this study supports the use of organic formulations in *Tulaipanji* rice cultivation for enhanced productivity without compromising grain and soil quality.

Key words: Aromatic rice, Jivamrut, Panchagavya, Sanjivak, Vermicompost

Aromatic rice (*Oryza sativa* L.), known for its distinctive fragrance and superior grain quality, holds significant importance in the global rice market. Particularly in regions like India, aromatic rice varieties such as Basmati and other local cultivars are favored for their premium quality, flavor and high market value. West Bengal possesses an exceptionally rich genetic diversity of aromatic rice. Among these, the medium-grained aromatic cultivar *Tulaipanji* is highly favored in the domestic market for its superior quality and strong potential for international trade. However, farmers are gradually losing interest in cultivating local aromatic rice varieties due to their poor agronomic performance, low yields, and sensitivity to environmental conditions. Tulaipanji is primarily cultivated in a limited area within the Uttar Dinajpur district of West Bengal, India. Traditionally, farmers in the two Dinajpur districts grow this variety with minimal or no external inputs (Sen and Sarkar, 2010). The soil and climatic conditions of the *Terai* region of West Bengal have been reported to be highly suitable for cultivating several aromatic rice cultivars (Sinha *et al.,* 2009).

Conventional agricultural practices involving high chemical inputs have raised concerns over sustainability, environmental health and long-term soil fertility (Rathore *et al.,* 2024). Hence, there is a growing interest in organic farming methods, which emphasize natural soil conditioners, bio-fertilizers and organic formulations to ensure sustainable crop production while maintaining soil health.

Organic amendments like vermicompost, Panchgavya, Jivamrut, Amritpani, and Sanjivak are gaining popularity as eco-friendly alternatives to synthetic fertilizers. Vermicompost, for instance, is a rich source of nutrients and improves soil structure, microbial activity and water

Based on a part of Ph.D. Thesis of the first author submitted to Uttar Banga Krishi Viswavidyalaya, Cooch Behar, West Bengal in 2023 (unpublished)

[2]**Corresponding author's Email:** parthaagro@gmail.com
[1,3,4,5]Research Scholar, Department of Agronomy, Uttar Banga Krishi Viswavidyalaya, Cooch Behar, West Bengal 736 165; [2]Assistant Professor, Agronomy, Regional Research Station, Terai Zone, Uttar Banga Krishi Viswavidyalaya, Cooch Behar, West Bengal 736 165; [6]Subject Matter Specialist, Soil Science, Dakshin Dinajpur Krishi Vigyan Kendra, Majhian, Uttar Banga Krishi Viswavidyalaya, West Bengal 733 133

retention capacity (Arancon *et al.,* 2003). Formulations like Panchgavya, made from cow-based ingredients, have been reported to stimulate plant growth and enhance yield (Selvaraj *et al.,* 2014), while Jivamrut, another cow dung and urine-based bio-stimulant, promotes microbial diversity and nutrient availability in soils (Bhaskar *et al.,* 2016). Amritpani and Sanjivak, lesser-known but potent organic solutions, are also believed to contribute to soil fertility and plant growth by enriching the microbial population and improving nutrient cycling (Sreenivasa *et al.,* 2010).

The combination of liquid organic formulations with vermicompost has been studied in various crops, but limited research exists on their combined effect in aromatic rice. Evaluating their impact on yield, grain quality and cost-effectiveness will help in optimizing organic nutrient management strategies for sustainable aromatic rice cultivation.

Given the growing demand for sustainable agricultural practices and high-quality aromatic rice, the present study aims to evaluate the performance of various liquid organic formulations combined with vermicompost on the yield and quality of aromatic rice. The study's objective is to assess whether these organic treatments can match or outperform conventional chemical fertilizers in terms of productivity while enhancing grain quality and preserving soil health. Additionally, this research seeks to provide a comparative analysis of different organic treatments to identify the most effective combination for aromatic rice cultivation.

MATERIALS AND METHODS

Field layout and experimental conditions

A field experiment was carried out at the Instructional farm of Uttar Banga Krishi Viswavidyalaya, Cooch Behar, West Bengal (Terai Zone) during *kharif* season of 2022 and 2023. The farm is located at $26^0 19' 86''$ N latitude and $89^0 23' 53''$ E longitude, at an elevation of 43 m above mean sea level and the land topography is medium low-land. The field was slightly acidic in reaction (*p*H 6.02), sandy loam in texture having high in organic carbon (0.58 %), low in available nitrogen (181.88 kg/ha), medium in available phosphorus (18.46 kg/ha) and high in available potassium (149. 65 kg/ha). The experiment was fitted out in Randomized Complete Block Design, with seven treatments replicated thrice. Treatments consisted of T_1, Vermicompost (VC) 3 t/ha + Sanjivak 20% foliar spray (FS) at 45 days after transplanting (DAT); T_2, VC 3 t/ha + Jivamrut 20% FS at 45 DAT; T_3, VC 3 t/ha + Amritpani 20% FS at 45 DAT; T_4, VC 3 t/ha + Panchgavya 20% FS at 45 DAT; T_5, VC 3 t/ha + vermicompost tea 20% FS at 45 DAT; T_6, 100 % RDF (50-25-25 kg N-P-K kg/ha) and T_7, Absolute control. All the organic formulation used in the experiment were prepared as per protocol of Sharma *et al.,* 2021. Tulaipanji was planted at a spacing of 25 cm × 20 cm and having a plot size of 10 m × 5 m. Vermicompost was incorporated into the soil 15 days earlier to final land preparations irrespective of treatments except for T_6 and T_7.

During the experimental period (June to December, 2022 and 2023) total amount of rainfall were 260.3 and 290.7 cm, average maximum and minimum temperature were 30.90 to 32.04 ºC and 18.59 to 22.03 ºC and the monthly mean maximum and minimum relative humidity varied from 91.66 to 90.15% whereas, while monthly mean minimum relative humidity varied from 74.85 to 78.84% respectively.

Data on yield attributes and yield precisely number of panicle/ sq. m, panicle length, number of filled grains/ panicle, test weight, grain yield and straw yield were recorded during the course of experimentation. From the sample plants, the number of panicle/ hills were counted at the time of harvesting and the average was taken and thereafter on the basis number of plants/sq. m, panicle/sq. m was worked out. The length of five randomly selected panicles was measured from five tagged plants and the average was worked out to get the panicle length. The total numbers of grains and filled grains from the panicle bearing tillers of the sample plants were counted. The mean was worked out to represent the total number of grains as well as filled grains/panicle. After shade drying the thousands of seeds drawn randomly from the panicles of the labelled plant and weighted by electronic balance in order to get test weight. Grain from the corresponding net plot area were sun dried for 4 days and then threshing was done. The grain weight of individual plot was recorded when the grain attended 14% moisture and was converted to tonnes/ha. After separating the grains, straw yield was measured. Harvest index was calculated as per formula given by Donald, 1962.

Grain quality attributes namely milling%, head rice recovery and head rice yield was worked out by the formula suggested by Devi *et al.* (2012).

$$\text{Milled rice recovery (\%)} = \frac{\text{Milled rice obtained (g)}}{\text{Total rough rice (g)}} \times 100$$

$$\text{Head rice recovery (\%)} = \frac{\text{Total head rice (g)}}{\text{Total rough rice (g)}} \times 100$$

$$\text{Head rice yield (\%)} = \frac{\text{Head rice recovery}}{\text{Milling recovery}} \times 100$$

Elongation ratio was determined by dividing the cumulative length of ten cooked kernels by ten uncooked kernels (Prakash *et al.,* 2002). Grain protein content was determined by multiplying the total nitrogen content as estimated by a conversion factor 6.25. The amylose content from rice powder was estimated by iodine-colorimetric methods (Sadasivam, 1996) by using starch potato as standard. Total carbohydrate content from rice powder was estimated by following Anthrone method (Sadsivam, 1996) using glucose as standard.

Organic carbon content in the soil was determined by the modified Walkley and Black method as outlined by Jackson (1973). Available nitrogen, phosphorus and potassium was assessed as per protocol of Jackson, 1967. Finally, economics of production system was calculated considering the prevalent market price of tulaipanji. The data were analysed using statistical software SPSS version-20. The pooled data from two years were statistically analyzed using the F-test following the standard procedure. For determination of critical difference at 5% level of significance Fisher and Yates (1963) table was consulted.

Table 1. Nutrient content of applied organic manures/formulations

Organic manures	Available N (%)	Available P_2O_5 (%)	Available K_2O (%)
Vermicompost	1.71	0.48	0.77
'Sanjivak'	0.55	0.18	0.58
'Jivamrut'	0.43	0.08	0.25
'Amrit pani'	0.08	0.05	0.04
'Panchgavya'	1.65	0.34	0.67
Vermicompost tea	0.25	0.14	0.34

RESULTS AND DISCUSSION

Effect on yield attributes and yield

The yield attributes and yield of *Tulaipanji* rice as influenced by different organic treatments were shown in table 2. Data presented in table showed that application of vermicompost @ 3 t/ha + panchgavya 20% FS at 45 DAT (T_4) produced significantly maximum number of panicles (284.4/m^2) and number of filled grains/panicle (68.5) as compared to absolute control treatment (T_7). The probable reason might be due consistent and optimal availability of nutrients throughout the growth period for better tillering as well as translocation of photosynthates. Panicle length and test weight were found non-significant.

Treatment receiving VC 3 t/ha + Panchgavya 20% FS at 45 DAT (T_4) expressively produced highest grain yield (2.14 t /ha) and straw yield (7.12 t /ha) which was followed by T_1 with 2.04 & 6.98; T_2 with 1.95 and 6.88 and T_5 with 1.90 and 6.72 t/ha. In general, organically amended plot performed better in terms of grain and straw yield as compared to 100% RDF. The affirmative response of organics may be attributed to the balanced nutrient availability and its encouraging effect on soil physical and biological properties causing in enhanced growth and yield attributes and finally higher grain yield. Panchgavya, a bio-enhancer made from cow-based products, is known to supply essential nutrients and stimulate microbial activity in the soil, promoting robust plant growth and higher yield potential (Ramesh *et al.,* 2010). Kalappanavar *et al.* (2010) and Patra and Sinha, 2014 also reported higher yield attributes and yield of wheat and groundnut with the application of panchgavya and other organic formulations.

Application vermicompost @ 3 t/ha + amritpani 20% FS at 45 DAT (T_3) and vermicompost @ 3 t/ha + vermicompost tea 20% FS at 45 DAT (T_5) were statistically at par with 100% chemically treated plot (T_6) in terms of grain yield. Absolute control treatment recorded statistically lowest panicle number (188.8/sq. m), filled grains (55.4) and grain yield (1.15 t/ha). This aligns with studies suggesting that bio-stimulants improve nutrient uptake,

Table 2. Yield attributes and yield of tulaipanji as influenced by organic liquid formulations (pooled data over the 2 years)

Treatment	Number of panicle/ sq.m	Panicle length (cm)	Filled grain/ panicle	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
T_1	271.1	20.4	66.8	15.70	2.04	6.98	22.63
T_2	266.6	20.1	64.7	15.65	1.95	6.88	22.09
T_3	235.5	19.8	60.8	15.57	1.87	6.67	21.93
T_4	284.4	20.8	68.5	15.82	2.14	7.12	23.06
T_5	255.5	19.9	63.3	15.62	1.90	6.72	22.01
T_6	233.3	19.7	59.7	15.54	1.84	6.63	21.72
T_7	188.8	19.1	55.4	15.22	1.15	4.28	21.21
SEm±	14.6	0.4	2.2	0.198	0.03	0.04	0.28
CD (P=0.05)	45.4	N S	6.9	N S	0.08	0.13	0.87

T_1, vermicompost @ 3 t/ha + Sanjivak 20% foliar spray (FS) at 45 days after transplanting (DAT); T_2, vermicompost @ 3 t/ha + Jivamrut 20% FS at 45 DAT; T_3, vermicompost @ 3 t/ha + Amrit Pani 20% FS at 45 DAT; T_4, vermicompost @ 3 t/ha + Panchgavya 20% FS at 45 DAT; T_5, vermicompost @ 3 t/ha + vermicompost tea 20% FS at 45 DAT; T_6, RDF (50-25-25 kg N-P-K kg/ha) and T_7 (Absolute control)

Table 3. Quality of tulaipanji as influenced by organic liquid formulations (pooled data over the 2 years)

Treatment	Milling (%)	Head rice recovery (%)	Head rice yield (%)	Cooking Coefficient	Elongation ratio	Protein Content (%)	Amylose Content (%)	Carbohydrate content (%)
T_1	62.8	57.8	92.0	2.7	1.51	8.5	25.4	77.3
T_2	62.4	56.7	91.2	2.6	1.52	8.4	25.2	76.6
T_3	62.1	55.0	90.8	2.4	1.48	8.3	24.7	75.0
T_4	63.4	57.8	93.1	3.0	1.53	8.6	25.4	77.9
T_5	62.1	57.6	89.5	2.5	1.49	8.4	24.8	75.7
T_6	61.5	54.4	87.2	2.3	1.48	8.2	24.5	74.6
T_7	61.3	53.1	86.7	2.8	1.49	8.1	23.7	73.8
SEm±	0.9	0.8	0.3	0.1	0.01	0.03	0.2	0.3
CD (P=0.05)	N S	2.6	1.0	0.2	0.02	0.08	0.5	1.0

T_1, vermicompost @ 3 t/ha + Sanjivak 20% foliar spray (FS) at 45 days after transplanting (DAT); T_2, vermicompost @ 3 t/ha + Jivamrut 20% FS at 45 DAT; T_3, vermicompost @ 3 t/ha + Amrit Pani 20% FS at 45 DAT; T_4, vermicompost @ 3 t/ha + Panchgavya 20% FS at 45 DAT; T_5, vermicompost @ 3 t/ha + vermicompost tea 20% FS at 45 DAT; T_6, RDF (50-25-25 kg N-P-K kg/ha) and T_7 (Absolute control)

ultimately resulting in a higher harvest index and yield/ha.

Effect on grain quality

Milling % did not vary significantly with the vermicompost in combination of liquid organic formulations as well as with inorganic fertilizer. This was probably being owing to better response for shelling, decent grain size and fewer number of unfilled grains achieved with the balanced supply of nutrients from vermicompost and panchgavya (Thakur and Kaur, 2018). Highest milling (63.4%), head rice recovery (57.8%) and head yield (93.1%) was observed with the application of vermicompost 3 t/ha with FS of panchgavya 20 % at 45 DAT. Head rice recovery is an inherent character of a variety but climatic conditions and post-harvest management play vibrant role and induce the grain damage during milling. Variances in head rice recovery and head yield with organic inputs were also noticed by Kumawat *et al.* (2009) and Patra *et al.* (2024).

Highest protein content of 8.6% was achieved with the application of vermicompost 3 t/ha with FS of panchgavya 20% at 45 DAT which was statistically at par with vermicompost 3 t/ha + sanjivak 20% FS at 45 DAT (8.5 %). Enhancement of protein content with the application of panchgavya and sanjivak were due to higher nitrogen availability particularly during the grain filling process. Singh and Swarup (2013) showed that organic inputs like vermicompost and panchgavya increase protein levels in rice grains. Highest amylose content of 25.4% was achieved with the application of vermicompost and panchgavya. Quality enhancements through organics were reported by Anuja and Archana (2012) and Patra *et al.* (2012). Rice is carbohydrate rich food and almost 85% of the energy provided by the rice derives from its carbohydrates. All organically amended plots recorded comparatively higher carbohydrate than 100% RDF. Combined application of vermicompost 3 t/ha and panchgavya 20% FS at 45 DAT recorded highest carbohydrate (77.9%). Besides nutrients, presence of enzymes and plant growth hormones in organic formulations helped in promoting healthier and denser grains (Thakur and Kaur, 2018). Application of vermicompost helped in improvement of protein, carbohydrate and starch content of aromatic rice (Patra *et al.,* 2023).

Effect on soil chemical properties

The organic carbon content and nutrient availability in post-harvest soil were higher in organic treatments as compared to treatment fertilized chemically, suggesting these formulations contribute to sustained soil fertility. Vermicompost in combination with jivamrut and vermicompost tea raised soil *p*H to some extend whereas rest of the treatments were almost at par with initial soil *p*H (Fig. 1). Significantly higher available nitrogen (172.7 kg/ha), phosphorus (17.4 kg/ha) and potassium (160.6 kg/ha) were recorded with the application of vermicompost 3 t/ha with

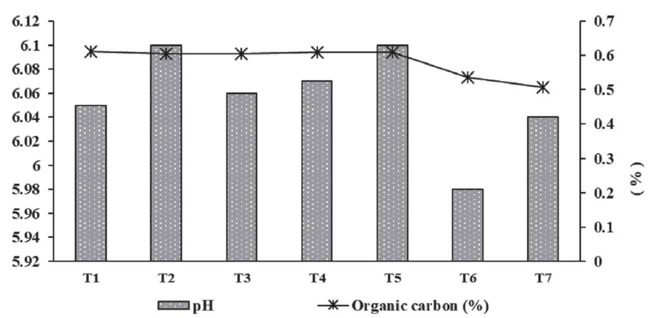

Fig. 1. Effect of liquid organic formulation on soil pH and organic carbon after harvesting of crop (pooled data over years)

FS of panchgavya 20% at 45 DAT (T_4), vermicompost @ 3 t/ha along with FS of sanjivak 20% at 45 DAT (T_1) and vermicompost @ 3 t/ha + Jivamrut 20 % FS at 45 DAT (T_2) respectively (Fig. 2). Organic inputs helped in retaining moisture, supporting beneficial microbial populations, and preventing nutrient leaching, which collectively boost soil health (Sharma *et al.,* 2014 and Lal, 2004). Since continuous chemical fertilization often leads to nutrient imbalance and soil degradation, integrating organic inputs can be a sustainable strategy to maintain productive soil over time.

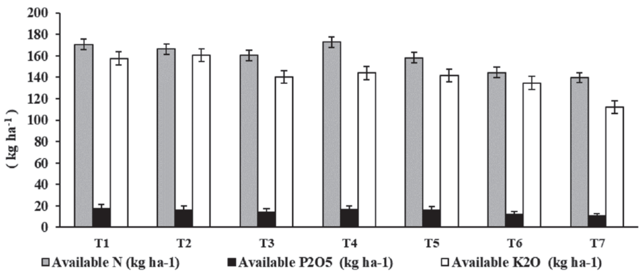

Fig. 2. Effect of liquid organic formulation on available N, P & K of soil after harvesting of crop (pooled data over 2 years)

Economics of production system

Highest gross return to the tune of \$1722.20/ha was observed with the application of vermicompost 3 t/ha along with foliar spray of panchgavya 20% at 45 DAT (T_4) followed by \$1648.30/ha (T_1), \$1582.80/ha (T_2), \$1542.80/ha (T_5), \$1520.40/ha (T_3) and \$1286.70/ha (T_6). Higher gross return was simply because of higher comparable grain and straw yield. Control plot (T_7) recorded lowest gross return of \$808.90/ha.

Highest net return of \$959.30/ha was also found with the combined application of vermicompost 3 t/ha and panchgavya 20% FS at 45 DAT (T_4) trailed by T_1 (\$ 920.80/ha), T_2 (\$ 855.70/ha), T_5 (\$815.90/ha) and T_3 (\$ 794.80/ha). Higher net return was simply due to more gross return. With the rising costs of chemical fertilizers and environmental concerns organic treatments offer a more sustainable and cost-effective alternative. The higher economic return from organic rice production, coupled with the premium price that organic produce commands, further supports the choice of these organic treatments (Tiwari and Upadhyay, 2012).

Lowest net return of \$291.30/ha was found in absolute control plot (T_7). Sole reliance of chemical fertilizer (T_6) recorded net return of \$708.70/ha. Kundu *et al.* (2016) reported highest net return with substitution of 50 % recommended nitrogen through vermicompost. According to Fig. 3, application of vermicompost 3 t/ha along with Sanjivak 20% FS at 45 DAT (T_1) fetched highest net production value (NPV) of 1.27 which was almost equal with T_4 (1.26). Despite of lower gross return compared to T_2, T_3

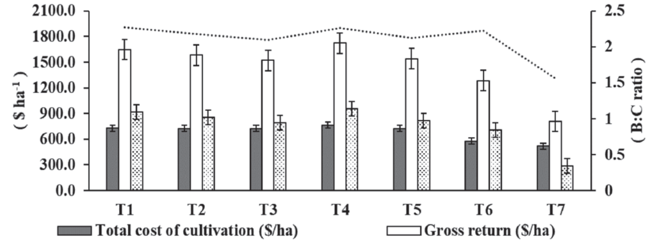

Fig. 3. Liquid organic formulation on economics of aromatic rice

and T_5, sole application of chemical fertilizer (T_6) recorded higher NPV (1.23) was due lower cost of cultivation as well as proportionately higher net return.

This study highlights the beneficial effects of organic liquid formulations, particularly Panchgavya, in Tulaipanji rice cultivation. Treatments combining vermicompost with panchgavya showed significant improvements in yield attributes, grain quality and soil health. Likewise, application of vermicompost along with panchgavya had the highest net return and benefit-cost ratio, making it both profitable and environmentally sustainable. Thus, integrating vermicompost organic liquid formulations in aromatic rice cultivation presents a viable approach to achieving both ecological and economic goals in agriculture.

REFERENCES

Anuja, S. and Archana, S. 2012. Effect of organic nutrients on yield and quality of bitter gourd. *International Journal of Agricultural Sciences* **8**(1): 205–208.

Arancon, N.Q., Edwards, C.A., Atiyeh, R. and Metzger, J.D. 2003. Effects of vermicompost produced from food waste on the growth and yields of greenhouse peppers. *Bioresource Technology* **93**(2): 139–144.

Bhaskar, M., Swamy, G. and Reddy, S.R. 2016. Jivamrut: A low-cost alternative to synthetic inputs. *International Journal of Agricultural Sciences and Research* **6**(3): 55–58.

Devi, M.G., Reddy, S.T., Sumati, V., Pratima, T. and John, K. 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.

Fisher, R.A. and Yates, F. 1963. Statistical Tables for Biological, Agricultural and Medical Research. *Oliver & Boyd, Edinburgh and London* **6**(42): 146.

Jackson, M.L., 1967. Soil Chemical Analysis Prentice-Hall of India Private Limited, New Delhi, pp. 205.

Jackson, M.L., 1973. Soil Chemical Analysis Prentice-Hall of India Private Limited, New Delhi, pp. 498.

Kalappanavar, I.K. Patidar, R.K. and Kulkarni, S. 2010. Management strategies of leaf rust of wheat caused by *Puccinia recondita* f. sp. tritici Rob. ex. Desm. *Karnataka Journal of Agricultural Sciences* **21**(1): 21–25.

Kumawat, R.N., Mahajan, S.S. and Mertia, R.S. 2009. Growth and development of groundnut (*Arachis hypogaea L*) under foliar application of panchgavya and leaf extracts of endemic plants. *Indian journal of Agronomy* **54**(3): 324–331.

Lal, R. 2004. Soil carbon sequestration impacts on global climate change and food security. *Science* **304**(5,677): 1,623–1,627.

Patra, P.S. and Sinha, A.C. 2012. Studies on organic cultivation of groundnut (*Arachis hypogaea* L.) in Cooch Behar. *Indian journal of Agronomy* **57**(4): 26–29.

Patra, P.S. and Sinha, A.C. 2014. Growth, net photosynthesis and seed yield of groundnut (*Arachis hypogaea* L) as influenced by organic sources of nutrients. *Legume research* **37**(5): 520–528.

Patra, P.S., Mondal, P., Sarkar, A. and Choudhury, A. 2023. Productivity and Quality of Aromatic Rice (*Oryza sativa* L.) Varieties under Varying Level of Vermicompost. *International Journal of Bio-resource and Stress Management* **14**(7): 1,009–1,015.

Patra, P.S., Saha, R., Ahmed, A. S., Kanjilal, B., Debnath, M.K., Paramanik, B., Hoque, A., Kundu, A., Adhikary, P., Biswas, A., Dey, P. and Biswas, A. 2024. Enhancing aromatic rice production through agronomic and nutritional management for improved yield and quality. *Scientific Reports* **10**(1,038): 65–76.

Ramesh, P., Panwar, N.R., Singh, A.B. and Ramana, S. 2010. Effect of organic manures and crop residues on productivity, quality, and soil health in dryland rice. *Indian Journal of Agronomy* **55**(4): 263–267.

Rathore, S.S., Patel A., Shekhawat, K., Babu, S., Upadhyay, P.K and Singh, R. K. 2024. Optimizing nutrient management for sustaining sugarcane yield through integration of biochar, digested sludge, liquid slurry and ash applications with inorganic fertilizers. *Indian Journal of Agronomy* **69**(3): 344-347. DOI: 10.59797/ija. v69i3.5533

Sadasivam, S. 1996. Biochemical Methods. New Age International, New Delhi, pp. 272.

Selvaraj, P.K., Thirukumaran, K. and Kannan, R.L. 2014. Role of Panchagavya in organic farming: A review. *Agricultural Reviews* **35**(3): 256–261.

Sen, D. and Sarkar, N.C. 2010. High Intensity Transplanting Increases Yield in Indigenous Aromatic Rice, Tulaipanji-a Case Study. *International Journal of Bio-resource and Stress Management* **1**(1): 40–42.

Sharma, P., Singh, S. and Kumar, V. 2014. Long-term effects of organic amendments on soil properties and microbial activities in rice-wheat cropping systems. *Soil and Tillage Research* **138**: 100–108.

Sharma, S.K., Jain, D., Choudhary, R., Jat, G., Jain, P., Bhojiya, A.A., Jain, R. and Yadav, S.K. 2021. Microbiological and enzymatic properties of diverse *Jaivik Krishi* inputs used in organic farming. *Indian Journal of Traditional Knowledge* **20**(1): 237–243.

Singh, S. and Swarup, A. 2013. Effect of organic amendments on rice yield and grain quality. *Agricultural Research* **2**(3): 187–194.

Sinha, A.C., Kairi, P., Patra, P.S. and De., B. 2009. Performance of aromatic rice varieties under terai region of West Bengal. *Journal of Crop Weed* **5**(1): 283–285.

Sreenivasa, M.N., Naik, S.N. and Bhat, S.N. 2010. Organic liquid formulations: Biopesticides and biofertilizers. Organic Agriculture in India: Problems and Prospects.

Thakur, R. and Kaur, H. 2018. Enhancement of rice quality through organic farming methods. *Journal of Food Quality* **41**(1): 45–50.

Tiwari, R. and Upadhyay, R. 2012. Cost-effectiveness of bio-fertilizers and organic inputs in rice cultivation. *Asian Journal of Agriculture and Rural Development* **2**(4): 516–522.