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Comparative assessment of growth, yield, and economic performance of basmati rice under organic and natural farming systems

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Abstract

The present study was conducted during the kharif season of 2024 at the Organic Research Block, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India, to evaluate the effects of different organic and natural farming systems on the growth, yield, and economic performance of Basmati rice. The experiment was laid out in a randomized block design with five treatments and four replications comprising control, organic farming, natural farming, natural farming supplemented with 50% organic manure, and organic farming integrated with Beejamrit and Jeevamrit. The results revealed that farming practices significantly influenced crop growth, productivity, and profitability. Among the treatments, organic farming integrated with Beejamrit and Jeevamrit (T₅) recorded the highest plant height (112.9 cm), tiller density (302.7 m⁻²), dry matter accumulation (891.7 g m⁻²), biological yield (87.67 q ha⁻¹), grain yield (38.86 q ha⁻¹), harvest index (44.19%), gross returns (₹137,550 ha⁻¹), net returns (₹89,900 ha⁻¹), and benefit:cost ratio (2.89). However, its performance remained statistically at par with the organic farming treatment (T₂) for most growth and yield parameters. The findings suggest that integrating Beejamrit and Jeevamrit with organic farming enhances crop productivity and profitability and offers a sustainable and economically viable production strategy for Basmati rice under the agro-climatic conditions of the Upper Indo-Gangetic Plains.

Keywords: Basmati rice, organic farming, natural farming, Beejamrit, Jeevamrit, growth, grain yield, economics, sustainable agriculture, soil health

Introduction

Rice (*Oryza sativa* L.) is one of the world's most important cereal crops and serves as the staple food for more than half of the global population. It contributes approximately 21% of global per capita energy intake and about 15% of dietary protein, making it indispensable for global food and nutritional security (GRiSP, 2013; FAO, 2023) ^[10, 8]. The increasing global population and changing food consumption patterns are expected to raise rice demand substantially over the coming decades, necessitating sustainable production strategies capable of ensuring food security while conserving natural resources (FAO, 2023) ^[8].

Basmati rice is a premium-quality aromatic rice recognized worldwide for its distinctive fragrance, long slender grains, excellent cooking quality and superior eating characteristics. The characteristic aroma of Basmati rice is primarily attributed to the presence of 2-acetyl-1-pyrroline (Ashfaq *et al.*, 2015). India is the largest producer and exporter of Basmati rice, contributing nearly 70–75% of the global Basmati trade. The crop is mainly cultivated in the Indo-Gangetic Plains covering Punjab, Haryana, Uttarakhand, Himachal Pradesh, Jammu & Kashmir and western Uttar Pradesh, where favourable agro-climatic conditions produce high-quality grains (APEDA, 2025; DGCIS, 2025). The increasing international demand and premium market price have made Basmati rice one of India's most valuable agricultural export commodities, contributing significantly to farmers' income and national foreign exchange earnings (APEDA, 2025).

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The remarkable increase in rice production achieved during the Green Revolution was primarily due to the widespread adoption of high-yielding varieties, synthetic fertilizers, pesticides and irrigation technologies (John and Babu, 2021) ^[14]. Although these practices substantially enhanced crop productivity, their long-term indiscriminate use has resulted in deterioration of soil health, decline in soil biodiversity, nutrient imbalance, groundwater contamination, greenhouse gas emissions and accumulation of pesticide residues in agricultural produce (Seufert and Ramankutty, 2017; Lori *et al.*, 2017) ^[25, 17]. Consequently, there is increasing emphasis on sustainable farming systems capable of maintaining crop productivity while minimizing environmental degradation (Reganold and Wachter, 2016) ^[23].

Organic farming has emerged as an environmentally sustainable production system that promotes ecological balance through the use of organic nutrient sources, crop residues, green manures, biofertilizers and biological pest management while avoiding synthetic fertilizers and pesticides (IFOAM, 2023) ^[12]. Organic nutrient management improves soil organic carbon, microbial biomass, enzymatic activity, nutrient cycling and overall soil fertility, thereby enhancing crop productivity over the long term (Bhattacharya and Chakraborty, 2005; Lori *et al.*, 2017) ^[1, 17]. Farmyard manure (FYM), one of the most widely used organic nutrient sources, supplies essential macro- and micronutrients and improves soil physical, chemical and biological properties, including soil aggregation, water-holding capacity and root development (Sutaliya and Singh, 2005; Dejene and Lemlem, 2012). Similarly, green manure crops such as dhaincha (*Sesbania aculeata*) contribute considerable quantities of biologically fixed nitrogen and organic matter, thereby improving nutrient availability and soil productivity (Pandey *et al.*, 2007) ^[22].

Natural farming has recently gained considerable attention as an alternative low-input agricultural production system. Originally proposed by Masanobu Fukuoka and subsequently promoted in India through Zero Budget Natural Farming (ZBNF) and Bharatiya Prakritik Krishi Paddhati (BPKP), natural farming emphasizes ecological processes, biodiversity conservation and the use of locally available biological inputs such as Jeevamrit, Beejamrit, mulching and cow-based formulations (NITI Aayog, 2021) ^[19]. Unlike conventional agriculture, natural farming minimizes dependence on external chemical inputs and aims to restore soil biological activity, reduce production costs and

improve environmental sustainability (Padhi *et al.*, 2023). However, scientific evidence regarding the comparative performance of natural farming under different agro-ecological conditions remains limited and further experimental validation is required (Padhi *et al.*, 2023).

Basmati rice is particularly suitable for organic and natural farming because its nutrient requirement is comparatively lower than that of coarse rice cultivars, while international consumers increasingly prefer residue-free and sustainably produced grains (Mathure *et al.*, 2010) ^[18]. Several long-term studies have reported improvements in soil organic carbon, nutrient availability, microbial activity, grain quality and sustainability under organic nutrient management in Basmati rice-based production systems (Kumawat *et al.*, 2024a; Sharma *et al.*, 2024) ^[15, 1]. Moreover, organic and natural farming practices contribute to carbon sequestration, biodiversity conservation, improved resource-use efficiency and climate resilience, making them important strategies for sustainable agricultural development (Reganold and Wachter, 2016; FAO, 2023) ^[23, 8].

Despite the growing interest in sustainable farming practices, comparative information on the growth, yield performance and economic viability of Basmati rice under organic and natural farming systems is still inadequate, particularly under the agro-climatic conditions of northern India. Since farmers' adoption of sustainable technologies largely depends on their profitability and productivity, a comprehensive evaluation of these farming systems is essential to identify economically feasible and environmentally sustainable production practices.

Materials and Methods

A field experiment was conducted during the kharif season of 2024 at the Organic Research Block of Sardar Vallabhbhai Patel University of Agriculture and Technology (SVPUAT), Meerut, Uttar Pradesh, India, to evaluate the growth, yield, and economic performance of Basmati rice under organic and natural farming systems. The experimental site is located at 29°08' N latitude and 77°69' E longitude with an altitude of 237 m above mean sea level, representing the semi-arid subtropical agro-climatic conditions of the Upper Indo-Gangetic Plains (fig.01). During the crop growing period, the maximum temperature ranged from 28.4 to 36.4 °C, while the minimum temperature varied from 11.3 to 27.4 °C. The total rainfall received during the season was 331 mm, and relative humidity ranged from 43.7 to 93.3%.

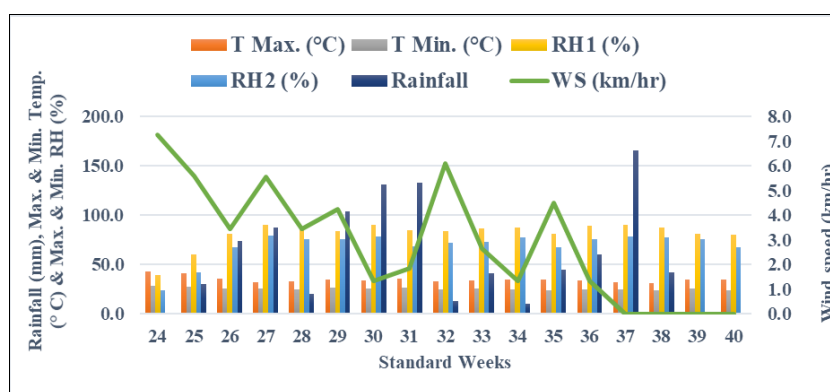


Fig 1: Mean weekly agro-meteorological data during crop period (Kharif season 2024)

Before transplanting, composite soil samples were collected from the 0–15 cm soil depth and analyzed using standard procedures. The experimental soil was sandy loam in texture, slightly alkaline in reaction (pH 7.86) and non-saline (EC 0.23

dS m⁻¹). The soil contained 0.47% organic carbon, 216.25 kg ha⁻¹ available nitrogen, 15.18 kg ha⁻¹ available phosphorus, and 176.34 kg ha⁻¹ available potassium, indicating low organic carbon and nitrogen with medium phosphorus and potassium

status. Available micronutrient contents were 0.68 mg kg⁻¹ Zn, 6.25 mg kg⁻¹ Fe, 1.48 mg kg⁻¹ Cu, and 3.52 mg kg⁻¹ Mn. Soil texture was determined by the hydrometer method (Bouyoucos, 1962)^[5], soil pH and EC by Jackson (1967)^[13], organic carbon by Walkley and Black (1934)^[29], available nitrogen by Subbiah and Asija (1956)^[27], available phosphorus by Olsen *et al.* (1954)^[20], available potassium by Hanway and Heidel (1952), and DTPA-extractable micronutrients by Lindsay and Norvell (1978)^[16].

The experiment was laid out in a Randomized Block Design (RBD) with five treatments and four replications. The gross and net plot sizes were 112 m² (14 × 8 m) and 93.6 m² (13 × 7.2 m), respectively. The rice variety Pusa Basmati 1 was transplanted at a spacing of 20 cm × 10 cm with two seedlings per hill and a seed rate of 25 kg ha⁻¹. The treatments comprised: T₁: Control, T₂: Organic farming (FYM + biofertilizers + biological pest management), T₃: Natural farming (Beejamrit + Ghanjeevamrit + Jeevamrit + residue mulching + Neemastra), T₄: Natural farming + 50% organic manure, and T₅: Organic farming + Beejamrit + Jeevamrit.

Under organic farming treatments, well-decomposed farmyard manure (FYM) was incorporated into the soil 15 days before transplanting, while biofertilizers and biological pest management practices were adopted according to organic production standards (IFOAM, 2023)^[12]. Natural farming treatments were implemented following the principles of Bharatiya Prakritik Krishi Paddhati (BPKP) (NITI Aayog, 2021)^[19]. Seedlings were treated with Beejamrit, Ghanjeevamrit was applied as a basal nutrient source, and Jeevamrit was applied periodically during crop growth. Crop residues were used as mulch for moisture conservation and soil health improvement, whereas Neemastra was applied for eco-friendly pest management (Palekar, 2016).

Observations on plant height, tillers hill⁻¹, dry matter accumulation, leaf area index, effective tillers m⁻², panicle length, grains panicle⁻¹, 1000-grain weight, grain yield, straw yield, biological yield, and harvest index were recorded following standard procedures. Economic parameters including cost of cultivation, gross returns, net returns, and benefit–cost ratio were computed using prevailing market prices. The data were analyzed using analysis of variance (ANOVA) for RBD as described by Gomez and Gomez (1984)^[9], and treatment means were compared at the 5% level of significance ($P \leq 0.05$).

Results & Discussion

Effect on plant height, tiller production and dry matter accumulation at different growth stages

Organic and natural farming practices significantly influenced plant height, number of tillers, and dry matter accumulation throughout the crop growth period (Table 1). Plant height increased progressively from 30 DAT to harvest under all treatments. Among the treatments, Organic farming + Beejamrit + Jeevamrit (T₅) recorded the highest plant height at 30 DAT (30.9 cm), 60 DAT (58.8 cm), 90 DAT (106.6 cm), and at harvest (112.9 cm), and was statistically superior to the control, natural farming (T₃), and natural farming + 50% organic manure (T₄). However, T₅ remained statistically at par with Organic farming practice (T₂) at 60 DAT, 90 DAT, and harvest. The lowest plant height was consistently observed under the control (T₁). The enhanced plant height under T₅ may be attributed to the combined effect of organic nutrient sources and bio-enhancers such as Beejamrit and Jeevamrit, which improve soil microbial activity, nutrient mineralization, and the continuous availability of essential nutrients. Improved nutrient uptake

promotes chlorophyll synthesis, photosynthetic activity, and cell division, resulting in greater stem elongation and vigorous vegetative growth. Similar improvements in crop growth due to the application of Jeevamrit and other organic nutrient management practice.

The number of tillers was also significantly affected by the different farming practices. Treatment T₅ produced the maximum tiller density, recording 191.9, 320.9, 314.3, and 302.7 tillers m⁻² at 30, 60, 90 DAT, and harvest, respectively, which was statistically comparable with T₂ but significantly superior to the remaining treatments. In contrast, the control recorded the minimum tiller population throughout the crop growth period. Increased tillering under T₅ can be attributed to improved soil fertility, enhanced microbial activity, and a sustained supply of nutrients during the active vegetative phase, which favoured the initiation and survival of tillers. Organic amendments also improve soil structure, aeration, and moisture retention, thereby promoting root proliferation and efficient nutrient absorption. These findings are in close agreement with those reported by Ram *et al.* (2018) and Patel *et al.* (2024), who observed that bio-enhanced organic nutrient management significantly increased vegetative growth and tiller production through improved soil biological activity.

Dry matter accumulation increased steadily with crop age and was significantly influenced by the various farming practices. The highest dry matter accumulation was recorded under T₅, with values of 27.2, 314.2, 650.5, and 891.7 g m⁻² at 30, 60, 90 DAT, and harvest, respectively, followed closely by T₂. The control treatment produced the lowest dry matter accumulation at all growth stages. The greater biomass production under T₅ may be attributed to enhanced photosynthetic efficiency, improved nutrient availability, and sustained physiological activity resulting from the integrated application of organic manures, Beejamrit, and Jeevamrit. These inputs stimulate beneficial microbial populations responsible for organic matter decomposition and nutrient cycling, thereby ensuring a continuous supply of macro- and micronutrients throughout crop growth. Consequently, plants accumulate greater assimilates and produce higher biomass than those grown under nutrient-deficient conditions. Similar observations have been reported by Kumar *et al.* (2025) and Patel *et al.* (2026), who concluded that Jeevamrit-based organic nutrient management significantly improves biomass accumulation by enhancing soil microbial diversity and nutrient transformation processes.

Among all the treatments, organic farming alone (T₂) also performed remarkably well and remained statistically at par with T₅ for several growth parameters, indicating that a well-managed organic production system can sustain optimum crop growth. However, the addition of Beejamrit and Jeevamrit further improved crop performance, suggesting that these liquid organic formulations enhance nutrient-use efficiency through increased microbial activity and biological nutrient cycling. Although natural farming (T₃) significantly improved crop growth over the control, its performance remained inferior to the organic-based treatments, possibly due to comparatively lower availability of readily mineralizable nutrients. The application of 50% organic manure along with natural farming (T₄) improved growth over natural farming alone, indicating that supplementary organic nutrient sources are beneficial in overcoming nutrient limitations under natural farming systems.

Effect on Yield, Harvest Index and Economics

Organic and natural farming practices significantly influenced biological yield, grain yield, straw yield, harvest index, and

economic returns of the crop (Table 2). Among the treatments, Organic farming + Beejamrit + Jeevamrit (T_5) produced the highest biological yield (87.67 q ha^{-1}), grain yield (38.86 q ha^{-1}), straw yield (48.81 q ha^{-1}), and harvest index (44.19%). However, T_5 remained statistically at par with Organic farming practice (T_2) for all yield attributes, as the differences between the treatments were smaller than the critical difference (CD) at the 5% level. The lowest biological yield (42.21 q ha^{-1}), grain yield (15.06 q ha^{-1}), straw yield (27.15 q ha^{-1}), and harvest index (35.48%) were recorded under the control (T_1). Compared with the control, T_5 increased biological yield, grain yield, and straw yield by approximately 108, 158, and 80%, respectively.

The remarkable improvement in yield under T_5 can be attributed to enhanced vegetative growth, greater tiller production, and higher dry matter accumulation observed during the earlier growth stages, which ultimately resulted in increased assimilate production and efficient translocation towards the developing grains. The combined application of organic nutrient sources with Beejamrit and Jeevamrit likely enhanced soil microbial activity, accelerated nutrient mineralization, and ensured a continuous supply of essential macro- and micronutrients throughout the crop growth period. Improved soil physical properties, greater root proliferation, and enhanced photosynthetic efficiency further contributed to superior biomass production and grain filling. Similar findings have been reported by Patel *et al.* (2024), who observed that Jeevamrit enhanced microbial activity and nutrient availability, leading to improved crop productivity. Likewise, Ram *et al.* (2018) reported that bio-enhancers used in organic farming stimulate beneficial microorganisms responsible for nutrient cycling and sustained crop growth.

Harvest index was also significantly influenced by the farming practices and ranged from 35.48 to 44.19%. The highest harvest index was recorded under T_5 (44.19%), followed closely by T_2 (44.04%), both of which were significantly superior to the control but statistically comparable with each other. The higher harvest index under integrated organic management indicates improved partitioning of photosynthates from vegetative organs

to reproductive structures, resulting in enhanced grain production relative to total biomass. This suggests that the integrated application of organic nutrient sources with microbial formulations not only increased biomass production but also improved the efficiency of assimilate translocation during grain development.

The economic analysis revealed considerable variation among the farming practices. Although T_5 incurred the highest cost of cultivation ($\text{₹}47,650 \text{ ha}^{-1}$) due to the additional application of Beejamrit and Jeevamrit, it generated the highest gross returns ($\text{₹}137,550 \text{ ha}^{-1}$), net returns ($\text{₹}89,900 \text{ ha}^{-1}$), and benefit:cost (B:C) ratio (2.89). These values were closely followed by T_2 , which recorded gross returns of $\text{₹}131,962 \text{ ha}^{-1}$, net returns of $\text{₹}85,987 \text{ ha}^{-1}$, and a B:C ratio of 2.87. The control treatment recorded the lowest economic returns, with gross returns of $\text{₹}56,175 \text{ ha}^{-1}$, net returns of $\text{₹}30,325 \text{ ha}^{-1}$, and a B:C ratio of 2.17. The significantly higher profitability under T_5 was primarily due to its substantially higher grain and biological yields, which more than compensated for the increased cultivation cost. These findings indicate that integrating organic farming practices with Beejamrit and Jeevamrit is not only agronomically advantageous but also economically viable for sustainable crop production.

Conclusion

Organic and natural farming practices significantly improved the growth, yield, and profitability of basmati rice compared with the control. Among the treatments, Organic farming + Beejamrit + Jeevamrit (T_5) recorded the highest plant height, tiller density, dry matter accumulation, grain yield (38.86 q ha^{-1}), biological yield (87.67 q ha^{-1}), harvest index (44.19%), net returns ($\text{₹}89,900 \text{ ha}^{-1}$), and B ratio (2.89). Organic farming alone (T_2) performed statistically at par with T_5 for most parameters, while natural farming (T_3) and natural farming with 50% organic manure (T_4) showed moderate improvements over the control. Overall, integrating organic farming with Beejamrit and Jeevamrit proved to be the most effective and economically viable approach for sustainable basmati rice production.

Table 1: Effect of organic and natural farming systems on plant height, tiller production and dry matter accumulation of Basmati rice at different growth stages

Treatments	Plant height (cm)				Number of tillers (m^{-2})				Dry matter accumulation (g m^{-2})			
	30 DAT	60 DAT	90 DAT	Harvest	30 DAT	60 DAT	90 DAT	Harvest	30 DAT	60 DAT	90 DAT	Harvest
T_1 Control	16.3	34.3	68.2	76.9	120.3	212.1	205.4	198.4	19.6	231.1	478.1	437.1
T_2 Organic farming practice	26.2	55.7	101.6	108.6	187.3	316.3	306.3	286.4	26.4	306.1	631.9	864.7
T_3 Natural farming practice	23.3	48.9	89.9	99.7	176.4	294.4	288.4	276.3	23.8	275.4	569.5	708.9
T_4 Natural farming + 50% Organic manure	25.9	52.8	97.7	102.8	180.7	307.4	301.5	280.5	25.1	292.4	604.8	764.8
T_5 Organic farming + Beejamrit + Jeevamrit	30.9	58.8	106.6	112.9	191.9	320.9	314.3	302.7	27.2	314.2	650.5	891.7
SEm ($\pm$)	0.6	1.3	2.4	2.6	4.4	7.5	7.3	6.9	0.9	7.6	14.9	11.1
CD ($P = 0.05$)	1.9	3.9	7.4	8.1	13.5	23.1	22.5	21.4	2.8	23.4	45.9	34.3

Table 2: Effect of organic and natural farming systems on yield, harvest index and economic performance of Basmati rice

Treatments	Yield (q ha^{-1})				Economics			
	Biological	Grain	Straw	Harvest index (%)	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
T_1 Control	42.21	15.06	27.15	35.48	25,850	56,175	30,325	2.17
T_2 Organic farming practice	84.97	37.17	47.80	44.04	45,975	131,962	85,987	2.87
T_3 Natural farming practice	69.39	29.15	40.24	41.67	38,125	104,449	66,324	2.74
T_4 Natural farming + 50% Organic manure	74.98	33.12	41.86	43.20	42,130	117,323	75,193	2.78
T_5 Organic farming + Beejamrit + Jeevamrit	87.67	38.86	48.81	44.19	47,650	137,550	89,900	2.89
SEm ($\pm$)	1.11	0.90	0.48	0.37	—	2,836	2,836	0.03
CD ($P = 0.05$)	3.43	2.77	1.47	1.13	—	8,736	8,736	0.10

References

1. Agricultural and Processed Food Products Export Development Authority. Basmati export statistics 2024-25. New Delhi: Government of India; 2025.
2. Rehman AU, Junaid MD, Abbas A, Tabassum J, Ali Q, Ashfaq M, *et al.* Exploring genetic variation and genetic components under salinity stress among Basmati and non-Basmati rice (*Oryza sativa* L.) cultivars. *Discov Plants*. 2024;1(1):22.
3. Badman HG. Core sampler method for bulk density determination. 1942.
4. Bhattacharyya P, Chakraborty G. Current status of organic farming in India and other countries. 2005.
5. Bouyoucos GJ. Hydrometer method improved for making particle size analyses of soils. *Agron J*. 1962;54(5):464-465.
6. Mengistu DK, Mekonnen LS. Integrated agronomic crop managements to improve tef productivity under terminal drought. In: *Water Stress*. Vienna Tech; 2011. p. 235-254.
7. Directorate General of Commercial Intelligence and Statistics. Export-import data bank. Kolkata: Government of India; 2025.
8. World Food and Agriculture Organization of the United Nations. The state of food and agriculture 2023. Rome: FAO; 2023.
9. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd ed. New York: John Wiley & Sons; 1984.
10. Global Rice Science Partnership. Rice almanac. 4th ed. Los Baños, Philippines: International Rice Research Institute; 2013.
11. Das A, Biswas DR, Das D, Sharma VK, Das R, Ray P, *et al.* Assessment of potassium status in soils under different land use systems of Assam. *Indian J Agric Sci*. 2019;89:1077-1081.
12. International Federation of Organic Agriculture Movements. The principles of organic agriculture. Bonn: IFOAM; 2023.
13. Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall of India; 1967.
14. John DA, Babu GR. Lessons from the aftermaths of green revolution on food system and health. *Front Sustain Food Syst*. 2021;5:644559.
15. Kumawat A, Kumar D, Shivay YS, Yadav D, Sadhukhan R, Gawdiya S, *et al.* Sustainable basmati rice yield and quality enhancement through long-term organic nutrient management in the Indo-Gangetic Plains. *Field Crops Res*. 2024;310:109356.
16. Lindsay WL, Norvell W. Development of a DTPA soil test for zinc, iron, manganese, and copper. *Soil Sci Soc Am J*. 1978;42(3):421-428.
17. Lori M, Symnaczik S, Mäder P, De Deyn G, Gattinger A. Organic farming enhances soil microbial abundance and activity: A meta-analysis and meta-regression. *PLoS One*. 2017;12(7):e0180442.
18. Mathure S, *et al.* Basmati rice: Genetics, breeding and quality characteristics. *J Plant Biochem Biotechnol*. 2010;19:1-9.
19. NITI Aayog. Natural farming in India. New Delhi: NITI Aayog; 2021.
20. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular No. 939. Washington (DC): U.S. Department of Agriculture; 1954.
21. Pant H, Swaroop D, Singh MK, Verma J, Pandey PR. Environment and agriculture: New technological applications. Prayagraj: Society of Biological Sciences and Rural Development; 2024.
22. Pandey N, Verma AK, Tripathi RS. Integrated nutrient management in transplanted hybrid rice (*Oryza sativa*). *Indian J Agron*. 2007;52(1):40-42.
23. Reganold JP, Wachter JM. Organic agriculture in the twenty-first century. *Nat Plants*. 2016;2:15221.
24. Richards LA. Diagnosis and improvement of saline and alkali soils. USDA Agriculture Handbook No. 60. Washington (DC): U.S. Department of Agriculture; 1954.
25. Seufert V, Ramankutty N. Many shades of gray: The context-dependent performance of organic agriculture. *Sci Adv*. 2017;3:e1602638.
26. Kumawat A, Kumar D, Shivay YS, Pooniya V, Madhu M, Yadav D, *et al.* Long-term organic nutrient management for boosting growth characteristics, yield and monetary returns of basmati rice (*Oryza sativa* L.) production in the Indo-Gangetic Plains of India. *Biol Agric Hortic*. 2026:1-23.
27. Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. *Curr Sci*. 1956;25:259-260.
28. Kumar A. Efficacy of organic and inorganic sources of nutrients in direct seeded basmati rice [dissertation]. Hisar: Haryana Agricultural University; 2020.
29. Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Sci*. 1934;37(1):29-38.

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