

## Influence of nutrient management options on growth and yield performance of basmati rice cultivars in the Indo-gangetic plains

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Received: August 2025; Revised accepted: December 2025

### ABSTRACT

A field experiment was conducted during the *Kharif* seasons of 2020 and 2021 at the research farm of Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Uttar Pradesh, to assess the performance of Basmati rice cultivars under various nutrient management options. The experiment was laid out in a split-plot design with three Basmati cultivars, viz. 'Pusa Basmati 1121', 'Pusa Basmati 1509', and 'Pusa Basmati 1718' in the main plots and 5 nutrient treatments, viz. Control, 100% Inorganic, Integrated Nutrient Management (INM), 100% Organic, and Jeevamrit (5%) in subplots, replicated thrice. Results revealed that Pusa Basmati-1121 consistently outperformed other varieties in plant height, effective tillers, dry matter accumulation, and yield-attributing traits. INM (50% organic + 50% inorganic) significantly enhanced vegetative and reproductive parameters, resulting in the highest grain yield (38.99 q/ha), panicle length (26.99 cm), filled grains per panicle (93.53), and harvest index (41.24%). In contrast, the Control and Jeevamrit (5%) recorded comparatively lower value. The application of Jeevamrit showed moderate higher fertility ratio and yield traits in comparison to control. The synergistic effect of INM supports balanced nutrient uptake, efficient biomass partitioning, and better grain development. The study was concluded that the combination of high-yielding varieties, viz. 'Pusa Basmati 1121' with INM offers a sustainable and productive strategy for Basmati rice cultivation in the Indo-Gangetic Plains.

**Key words:** Basmati Rice, Cultivars and Productivity, Jeevamrit, INM

Rice (*Oryza sativa* L.), grown on 43.8 million hectares in India and yielding more than 120 million tons annually, is the primary food for over 3.5 billion people worldwide. Basmati rice is differentiated from other rice varieties by its distinct aroma, long, thin grains, and high export value (Ministry of Agriculture and Farmers Welfare, 2023). It is especially important in the Indo-Gangetic Plains (IGP), which comprises the fertile areas of Punjab, Haryana, Uttar Pradesh, and Bihar (Singh *et al.*, 2020). This area contributes significantly to the domestic and international supply networks for Basmati rice. Despite the economic importance of Basmati rice growing in the IGP, excessive monocropping and reliance on chemical fertilizers have resulted in stagnant yields, soil nutrient depletion, and a loss in soil organic carbon (Tiwari *et al.*, 2019). According

to Pathak *et al.*, 2011, traditional nutrient management strategies frequently result in nitrogen imbalances and poor fertilizer-use efficiency, which over time damages the ecosystem and reduces agricultural productivity. Therefore, maintaining productivity and ensuring environmental sustainability necessitates appropriate nutrition management. In this context, organic farming has emerged as an appropriate choice since it increases soil fertility, soil organic carbon content, and preserves ecological balance while producing safe food (Pimentel *et al.*, 2005; Almaz *et al.*, 2017). Organic substances such as farmyard manure, vermicompost, and green manures increase soil microbial activity, nitrogen cycling, and moisture-holding capacity, all of which are important for rice yield (Basak *et al.*, 2021; Mahajan *et al.*, 2025). However, depending on only organic inputs may not always be sufficient to meet present varieties and their high nutrient requirements. As a result, integrated nutrient management (INM), which mixes organic and inorganic fertilizer sources, has gained popularity for increasing nutrient efficiency, crop yield, and soil health (Singh *et al.*, 2019; Chaudhary *et al.*, 2025). INM not only eliminates the need for chemical fertilizers, but it

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also enhances soil structure and biological activity, ensuring long-term sustainability (Ali *et al.*, 2019). Besides, the usage of liquid organic manures like Jeevamrit and Panchagavya, as well as bio-enhancers like liquid biofertilizers, has been shown to improve nutrient solubility, stimulate microbial activity, and increase plant growth and productivity (Subhashini and Sudhakar, 2017; Parihar *et al.*, 2020). In particular Jeevamrit enriches the rhizosphere with beneficial microorganisms, promoting nutrient mineralization and absorption efficiency (Datta *et al.*, 2021). These inputs are cost effective and environmentally sustainable, making them ideal for resource-poor farmers in the IGP. Because of genotype, environment, and management interactions, Basmati rice cultivars can perform significantly differently under different nutritional regimes. Therefore, changing agronomic procedures to enhance yield necessitates examining cultivar responses to various feeding strategies (Kumar *et al.*, 2022). This context informs the current study's goal, which is to assess the effects of various nutrient management strategies including inorganic, organic, integrated, and liquid manure-based approaches on the growth, yield, and yield components of different basmati rice cultivars in the Indo-Gangetic Plains. The findings will form the scientific foundation for developing resource-efficient, eco-friendly, and region-specific nutrient management strategies to improve the sustainability and profitability of Basmati rice agriculture.

## MATERIALS AND METHODS

The present study was carried out at Research farm of Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut Uttar Pradesh during rainy Kharif Season of 2020 and 2021. It comes under the North-western plain agro-climatic zone of Meerut. It is classified as semi-arid sub-tropical and experienced a rainfall of 331 mm and 833.50 mm during experiment. The soil of experiment site was sandy-loam in texture having pH-7.87, available nitrogen-179.4 kg/ha, available phosphorus 18.23 kg/ha, available potassium 271.49 kg/ha. The experiment was conducted in split plot design with three replication, comprising three basmati rice varieties in main plot, viz. V<sub>1</sub>, 'Pusa Basmati 1121'; V<sub>2</sub>, 'Pusa 1509' and V<sub>3</sub>, 'Pusa Basmati 1718' and 5 nutrient management options, viz. T<sub>1</sub>, (Control); T<sub>2</sub>, (100% Inorganic Fertilizer); T<sub>3</sub>, (INM-50% inorganic and 50% organic); T<sub>4</sub>, (100% Organic fertilizer through 1/3<sup>rd</sup> of each component, FYM + Vermi-compost + Poultry Manure); T<sub>5</sub>, (Low budget Natural Farming 5% jeevamrit) in sub plots. Twenty-five days old seedlings were transplanted at the spacing of 20 cm × 15 cm spacing with two seedlings/hill. At final puddling 40 kg phosphorus and 30 kg potash through DAP and MOP, respectively were applied as per treatments in T<sub>2</sub> (100% inorganic) and

in T<sub>3</sub> (50% inorganic + 50% organic sources) and in T<sub>4</sub> (100% organic) on the basis of nitrogen content of applied organic sources and in T<sub>5</sub> 5% jeevamrit solution applied. Nitrogen was applied @ 100 kg/ha through urea into 3 splits doses; half at the time of transplanting and remaining half at the time of maximum tillering and at panicle initiation stage equally as per the treatments. Organic sources of fertilizer, viz. FYM, vermi-compost, and poultry manure were applied 15 day before the transplanting of crop as per treatment and well mixed in the soil. Five hills were randomly selected and tagged for recording plant morphological parameters (plant height (cm), number of tillers/m and dry matter accumulation g/m<sup>2</sup>) at 30, 60 DAT and at harvest stage and for dry matter accumulation the plant sample from one meter row length was taken and dried in hot-air oven at 65°C till it attains constant weight and for number of effective tillers, panicle bearing tillers were recorded from 5 tagged/hills from each plot at the time of maturity and data were expressed as meter per square; Length of panicle (cm) selected panicle from five tagged plants from each plot and grouped into small, medium and large size. For recording observations, five panicles were selected from each plot to measure panicle length, and the average was expressed as panicle length. Filled and unfilled grains were counted from ten panicles/plot, and their averages were calculated to determine the number of filled, unfilled, and total grains/panicle. Fertility ratio was worked out as the proportion of filled grains to the total grains/panicle. Harvest index, the ratio of the economic yield and biological yield in percentage. The crop harvested from each net plot was bundled up separately and allowed for drying in sun and threshed individually plot-wise by using pedal operated paddy thresher. Cleaning of the grain was done after threshing and then dried in sun to a constant weight to record the final yield and grain straw, biological yield (grains + straw) was recorded in kg/plot and then converted into q/ha. All the parameters were subjected to statistical analysis with analysis of variance for split plot design. The evaluation of critical difference (CD) was done at 5% level of significance. (Panse, V.G., and Sukhatme, P. V. 1985)

## RESULTS AND DISCUSSION

### Growth Parameters

Significant differences were observed among Basmati rice cultivars for plant height, number of tillers, (Table 1) and effective tillers dry matter accumulation (Table 2). 'Pusa Basmati 1121' consistently recorded the highest plant height (85.01 cm), effective tillers (189.38 /m<sup>2</sup>), and dry matter accumulation (674.94 g/ m<sup>2</sup>) at harvest, followed by 'PB 1718', while 'PB 1509' recorded the lowest. The superior performance of 'PB 1121' can be attributed to its longer growth duration, greater leaf area, and enhanced

**Table 1.** Effect of different varieties and nutrient management options on plant height, number of tiller/m<sup>2</sup> of basmati rice cultivars

Treatment	Plant height (cm)						Number of tiller/m <sup>2</sup>											
	30 DAT		60 DAT		At harvest		30 DAT		60 DAT		At harvest							
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021						
<i>Varieties</i>																		
(V <sub>1</sub> ) 'Pusa basmati 1121'	51.77	52.81	52.29	73.96	78.77	76.365	82.32	87.69	85.005	86.19	84.87	85.53	208.98	218.69	213.84	187.86	196.59	192.23
(V <sub>2</sub> ) 'Pusa basmati 1509'	50.65	51.56	51.105	66.12	70.73	68.425	71.48	74.46	72.97	75.14	77.74	76.44	187.23	194.98	191.11	168.88	174.72	171.80
(V <sub>3</sub> ) 'Pusa basmati 1718'	51.4	52.2	51.8	73.93	78.19	76.06	74.61	81.9	78.255	78.91	80.07	79.49	191.58	205.89	198.74	177.35	179.96	178.66
SEM±	0.45	0.45	0.45	0.67	0.67	0.67	0.62	0.72	0.67	1.25	1.36	1.305	2.99	3.72	3.36	2.77	2.86	2.82
CD (P=0.05)	NS	NS	NS	2.7	2.72	2.71	2.53	2.91	2.72	5.04	5.52	5.28	12.09	15	13.55	11.16	11.53	11.35
<i>Nutrient Options</i>																		
(T <sub>1</sub> ) Control	49.26	50.16	49.71	59.87	62.7	61.285	64.53	72.23	68.38	61.56	60.21	60.885	141.33	163.1	152.22	133.44	140.23	136.84
(T <sub>2</sub> ) 100% Inorganic	52.46	53.38	52.92	77.3	83.57	80.435	84.55	86.18	85.365	90.17	90.86	90.515	223.03	229.55	226.29	202.66	204.2	203.43
(T <sub>3</sub> ) INM (50% OS* + 50% IS*)	53.42	54.52	53.97	78.83	85.72	82.275	89.27	89.84	89.555	90.84	92.66	91.75	227.11	231.66	229.39	204.17	208.25	206.21
(T <sub>4</sub> ) 100% Organic	50.88	52.4	51.64	73.85	77.22	75.535	77.61	81.98	79.795	88.24	92.93	90.585	220.6	232.34	226.47	198.31	208.86	203.59
(T <sub>5</sub> ) Jeevamrit (5%)	50.33	50.48	50.405	66.83	70.27	68.55	64.72	76.5	70.61	69.6	67.8	68.7	167.57	175.96	171.77	151.58	157.24	154.41
SEM±	1.14	1.16	1.15	1.62	1.74	1.68	1.76	1.84	1.80	2.19	2.31	2.25	5.79	5.96	5.88	6.22	6.49	6.36
CD (P=0.05)	NS	NS	NS	4.77	5.11	4.94	5.17	5.41	5.29	6.43	6.79	6.61	17	17.52	17.26	18.26	19.05	18.66

**Table 2.** Effect of different varieties and nutrient management options on Effective tiller/m<sup>2</sup>, Dry-matter accumulation (g/m<sup>2</sup>) of basmati rice cultivars

Treatment	Effective Tiller/m <sup>2</sup>						Dry matter accumulation (g/m <sup>2</sup> )					
	30 DAT		60 DAT		At harvest		30 DAT		60 DAT		At harvest	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
<i>Varieties</i>												
(V <sub>1</sub> ) 'Pusa basmati 1121'	185.08	193.68	189.38	78.73	78.30	78.52	258.69	261.01	259.85	671.93	677.95	674.94
(V <sub>2</sub> ) 'Pusa basmati 1509'	166.38	172.14	169.26	67.27	67.27	67.27	218.28	224.25	221.27	566.96	582.47	574.72
(V <sub>3</sub> ) 'Pusa basmati 1718'	174.73	177.30	176.02	77.18	77.18	77.18	252.06	257.26	254.66	654.70	668.22	661.46
SEM±	3.15	2.89	3.02	0.71	0.71	0.71	2.33	2.37	2.35	6.06	6.16	6.11
CD (P=0.05)	12.73	11.66	12.20	2.86	2.87	2.87	9.42	9.56	9.49	24.46	24.84	24.65
<i>Nutrient Options</i>												
(T <sub>1</sub> ) Control	131.46	138.15	134.81	51.51	52.42	51.97	169.62	171.42	170.52	440.59	445.25	442.92
(T <sub>2</sub> ) 100% Inorganic	199.66	206.34	203.00	90.42	90.23	90.33	295.94	300.77	298.36	768.69	781.23	774.96
(T <sub>3</sub> ) INM (50% OS* + 50% IS*)	201.15	210.03	205.59	94.12	93.92	94.02	305.70	313.09	309.40	794.03	813.22	803.63
(T <sub>4</sub> ) 100% Organic	195.38	195.75	195.57	84.09	83.93	84.01	273.53	279.76	276.65	710.47	726.66	718.57
(T <sub>5</sub> ) Jeevamrit (%)	149.34	154.91	152.13	51.83	51.74	51.79	170.25	172.49	171.37	442.22	448.03	445.13
SEM±	5.22	5.03	5.13	1.79	1.79	1.79	5.85	5.96	5.91	15.19	15.48	15.34
CD (P=0.05)	15.32	14.79	15.06	5.26	5.25	5.26	17.17	17.50	17.34	44.62	45.46	45.04

\*IS-Inorganic sources, OS-organic sources

photosynthetic efficiency, leading to higher biomass production. Similar findings were reported by Kumar *et al.*, (2016), Yadav *et al.*, (2017), and Sharma *et al.*, (2018), who demonstrated that long-duration Basmati cultivars sustain photosynthetic activity longer, thereby accumulating more assimilates for growth and yield. Among nutrient management options, Integrated Nutrient Management (INM) (T3, 50% inorganic + 50% organic) produced the highest plant height (89.56 cm), number of tillers (206.21/m<sup>2</sup>), and dry matter (803.63 g/m<sup>2</sup>). This improvement is attributed to a continuous and balanced nutrient supply, improved microbial activity, and enhanced root development, which together promote nutrient uptake. Similar findings were reported by Prasad *et al.*, (2017), Nain *et al.*, (2018), and Verma *et al.*, (2021). The contribution of organic inputs like farmyard manure and vermicompost in improving soil organic carbon, cation exchange capacity, and microbial activity has been linked to improved rice growth (Meena *et al.*, 2020; Singh *et al.*, 2021). Furthermore, Sarkar *et al.*, (2020) observed that INM systems significantly improve leaf chlorophyll content and net photosynthesis, thereby explaining the observed growth advantage in the present study.

#### Yield attributes

Reproductive traits varied significantly across varieties and nutrient treatments. PB-1121 exhibited superior (Table 3) panicle length (25.66 cm), filled grains per panicle (88.53), and test weight (23.81 g) (Table 4) compared with 'PB 1509' and 'PB 1718'. These traits directly contributed to higher yield potential by ensuring better spikelet fertility and grain development. Similar reports were made by Singh *et al.*, (2019), Yadav *et al.*, (2020), and Choudhary *et al.*, (2021), who emphasized that panicle size and spikelet filling efficiency are critical yield determinants in Basmati rice. Nutrient management again had a strong effect, with INM (T3) recording the highest panicle length (26.99 cm), filled grains (93.53), and total grains per panicle (114.28). INM also produced the highest fertility ratio (0.81) and test weight (25.43 g), suggesting better assimilate partitioning to the grains. Improved grain filling under INM is attributed to balanced nutrient availability that regulates hormonal activity, particularly cytokinins and auxins, which enhance spikelet fertility and grain development (Saha *et al.*, 2010; Das *et al.*, 2018; Mishra *et al.*, 2021). By contrast, the control and Jeevamrit (5%) treatments recorded the lowest values for most traits, indicating nutrient insufficiency. However, Jeevamrit maintained moderate fertility ratios, suggesting its potential role in organic or low-input systems when supplemented with other organic practices. Patel *et al.*, (2019), Raj *et al.*, (2021), and Thakur *et al.*, (2020) similarly observed that natural

**Table 3.** Effect of different varieties and nutrient management options on yield attributes of basmati rice cultivars

Treatment	Length of panicle (cm)			Filled grain/panicle			Unfilled grain/panicle		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
<i>Varieties</i>									
V <sub>1</sub> 'Pusa basmati 1121'	24.68	26.63	25.66	80.22	96.84	88.53	18.94	21.61	20.28
V <sub>2</sub> 'Pusa basmati 1509'	22.47	24.21	23.34	65.00	75.43	70.22	28.53	27.63	28.08
V <sub>3</sub> 'Pusa basmati 1718'	23.62	23.86	23.74	77.16	89.59	83.38	22.77	24.29	23.53
SEM±	0.02	0.13	0.08	1.25	1.26	1.26	0.20	0.20	0.20
CD (P=0.05)	0.09	0.54	0.32	5.06	5.10	5.08	0.82	0.80	0.81
<i>Nutrient Options</i>									
T <sub>1</sub> Control	20.81	23.58	22.20	53.51	65.95	59.73	31.30	32.36	31.83
T <sub>2</sub> 100% Inorganic	24.88	25.18	25.03	84.04	99.43	91.74	20.15	21.56	20.86
T <sub>3</sub> INM (50% OS* + 50 % IS*	26.58	27.39	26.99	85.73	101.32	93.53	20.28	21.23	20.76
T <sub>4</sub> 100% Organic	23.59	24.28	23.94	80.56	92.62	86.59	21.92	23.05	22.49
T <sub>5</sub> Jeevamrit (5%)	22.11	24.08	23.10	66.81	77.12	71.97	23.42	24.35	23.89
SEM±	0.03	0.34	0.19	2.28	2.14	2.21	0.53	0.51	0.52
CD (P=0.05)	0.09	1.00	0.55	6.70	6.30	6.50	1.57	1.51	1.54

\* IS – Inorganic sources, OS-organic sources

**Table 4.** Effect of different varieties and nutrient management options on yield attributes of basmati rice cultivars

Treatment	Total grain/panicle			Fertility ratio			Test weight (g)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
<i>Varieties</i>									
(V <sub>1</sub> ) 'Pusa basmati 1121'	99.17	118.46	108.82	0.80	0.81	0.81	22.74	23.81	23.28
(V <sub>2</sub> ) 'Pusa basmati 1509'	93.54	103.07	98.31	0.69	0.72	0.71	22.20	23.02	22.61
(V <sub>3</sub> ) 'Pusa basmati 1718'	99.93	113.88	106.91	0.76	0.78	0.77	22.53	23.59	23.06
SEM±	0.86	1.35	1.11	0.01	0.01	0.01	0.29	0.46	0.38
CD (P=0.05)	3.49	5.44	4.47	0.02	0.01	0.02	NS	NS	NS
<i>Nutrient Options</i>									
(T <sub>1</sub> ) Control	84.22	98.32	91.27	0.63	0.66	0.65	20.44	21.97	21.21
(T <sub>2</sub> ) 100% Inorganic	104.18	120.99	112.59	0.80	0.81	0.81	23.06	23.84	23.45
(T <sub>3</sub> ) INM (50% OS* + 50% IS*)	106.01	122.55	114.28	0.80	0.82	0.81	25.01	25.84	25.43
(T <sub>4</sub> ) 100% Organic	102.48	115.68	109.08	0.78	0.79	0.79	22.67	23.12	22.90
(T <sub>5</sub> ) Jeevamrit (5%)	90.23	101.47	95.85	0.74	0.76	0.75	21.26	22.58	21.92
SEM±	2.20	2.27	2.24	0.01	0.01	0.01	0.63	0.80	0.72
CD (P=0.05)	6.46	6.66	6.56	0.03	0.01	0.02	1.85	2.35	2.10

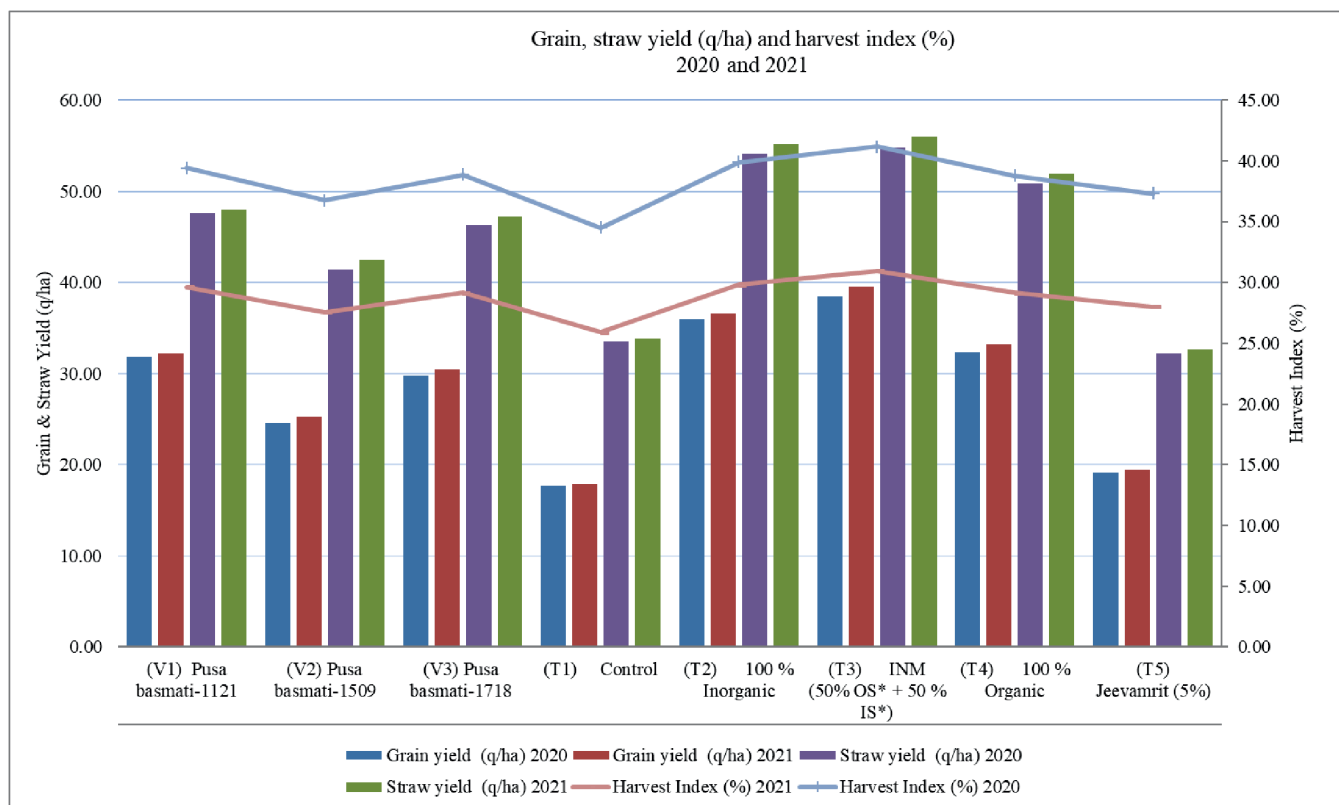
\* IS –Inorganic sources, OS-organic sources

farming inputs like Jeevamrit improve soil microbial activity but are insufficient to sustain high productivity in cereals unless integrated with other nutrient sources.

### Yield

The influence of varietal and nutrient management options on grain and straw yields was significant (Fig. 1). 'PB 1121' produced the highest grain yield (32.03 q/ha) and straw yield (47.82 q/ha), followed by 'PB 1718', while 'PB 1509' was recorded the lowest yields. Its superior performance is attributed to higher tillering ability, panicle length, and grain filling efficiency. Similar conclusions were reported by Sharma *et al.*, (2018), Singh *et al.*, (2019), and Chauhan *et al.*, (2021), who noted that Basmati rice yield is strongly associated with harvest index, panicle productivity, and spikelet fertility. Nutrient management treatments showed that INM (T3) recorded the maximum grain yield (38.99 q/ha), straw yield (55.38 q/ha), and harvest index (41.24%) (Fig. 1). The yield advantage under INM is explained by sustained nutrient release, improved soil aggregation, and enhanced nutrient-use efficiency, which ensured better assimilate supply during grain filling (Pandey *et al.*, 2020; Kumar *et al.*, 2022). Organic components in INM also enhance soil enzymatic activities such as dehydrogenase and phosphatase, which improve nutrient cycling and availability (Meena *et al.*, 2020; Singh *et al.*, 2021). Conversely, control and Jeevamrit (5%) treatments recorded the lowest yields, reflecting inadequate nutrient supply for high-yielding Basmati cultivars. However, application of Jeevamrit (5%) role in enhancing microbial activity and maintaining soil fertility in low-input systems cannot be overlooked (Raj *et al.*, 2021; Thakur *et al.*, 2020). Importantly, the results reinforce earlier findings that exclusive dependence on organic or natural farming inputs may compromise yield potential, but when used in combination with inorganic fertilizers, they significantly improve productivity while sustaining soil health (Verma *et al.*, 2021; Kumar *et al.*, 2022).

On the basis of two-year study revealed that different cultivar and nutrient options strongly influenced the growth and yield of Basmati rice in the Indo-Gangetic Plains. 'Pusa Basmati 1121' consistently outperformed 'PB 1509' and 'PB 1718', recorded higher tillering, panicle traits, grain filling, and maximum grain yield (32.03 q/ha). Its advantage lies in longer growth duration and better assimilates partitioning. Among nutrient options, integrated nutrient management (50% inorganic + 50% organic) proved most effective, giving the highest grain yield (38.99 q/ha) and improving soil health, followed by 100% inorganic fertilizer whereas, control and jeevamrit (5%) produced the lowest yields, indicating inadequate nutrient supply. Farmer suggestion: Adoption of Pusa Basmati-1121 with



**Fig. 1.** Effect of different varieties and nutrient management options on Grain, Straw yield (q/ha) and Harvest index (%) of basmati rice cultivars

integrated nutrient management is recommended for maximizing yield and sustaining soil fertility in the Indo-Gangetic Plains.

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