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# NUTRIENT INTEGRATION EFFECT ON SOIL NUTRIENT DYNAMICS OF BASMATI RICE IN WESTERN U.P., INDIA

**Yogesh Kumar*, Yogesh Kumar, Siddhant Tomar and Nitima Singh**

Department of Soil Science and Agricultural Chemistry, SVPUA & T, Meerut - 250 110, U.P., India.
*Corresponding author E-mail : yogeshkumarlike@gmail.com
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**ABSTRACT**

The goal of the current study is to determine how different nutrient management strategies affect the nutrient dynamics of basmati rice in western Uttar Pradesh (India). Experiments were conducted to examine soil nutrient dynamics under different farming systems and nutrient sources on basmati rice yield. It was conducted at the C.R.C. of the Sardar Vallabhbhai Patel University of Agriculture and Technology in Meerut (U.P.) during the 2022 *Kharif*. The characteristics of the soil of the test area are clay loam, slightly alkaline texture, unsalted-alkaline, low in organic carbon, nitrogen and phosphorus and high in potassium. Eleven treatments, *viz*., $T_1$ (control), $T_2$ (100:75:0 kg N P K ha$^{-1}$), $T_3$ (100:75:60 kg N P K ha$^{-1}$), $T_4$ (only F Y M @ 20 t ha$^{-1}$), $T_5$ (only V C @ 20 t ha$^{-1}$), $T_6$ (50:37.5:30 kg N P K ha$^{-1}$ with F Y M @ 20 t ha$^{-1}$), $T_7$ (50:37.5:30 kg N P K ha$^{-1}$ with V C @ 20 t ha$^{-1}$ ), $T_8$ (100:75:60 kg N P K ha$^{-1}$ with F Y M @ 10 t ha$^{-1}$), $T_9$ (100:75:60 kg N P K ha$^{-1}$ with V C @ 10 t ha$^{-1}$), $T_{10}$ (50:37.5:30 kg N P K ha$^{-1}$ with F Y M @ 10 t ha$^{-1}$) and $T_{11}$ (50:37.5:30 kg N P K ha$^{-1}$ with V C @ 10 t ha$^{-1}$) were tested in RBD with three replications. By adding 100:75:60 kg N P K ha$^{-1}$ with V C @ 10 t ha$^{-1}$, the absorption of rice grain and straw as well as nitrogen, phosphorus and potassium content was significantly increased. The amount of nutrients and their assimilation by the plant were significantly increased by applying both organic and inorganic fertilizer simultaneously. The rice crop also absorbed the most Nitrogen, Phosphorus and Potassium (100.9 ha$^{-1}$, 31.4 ha$^{-1}$ and 120.2 kg ha$^{-1}$), respectively, with the application of $T_9$.

***Key words :*** Basmati rice, Nutrients dynamics, FYM, VC.

## Introduction

Rice (*Oryza sativa*) belongs to Poaceae family. Rice is the second most widely consumed staple food in the world after wheat (Rami *et al*., 2010). It makes up roughly 40.92% of the nation's overall production of food grains and 44.07% of its cereal. The states of Uttar Pradesh, Bihar, West Bengal, Assam, Orissa and Madhya Pradesh account for over 63 percent of the world's rice land. The need for rice will rise annually, with projections indicating that 140 million tonnes would be needed by 2025. With an area of 56.91 lakh hectares, a yield of 116.20 lakh metric tonnes and a productivity of 2042 kg ha-1, Uttar Pradesh is the second-largest state in terms of rice production, after West Bengal (Anonymous, 2021-22). Small differences in scent might influence a consumer's favor or rejection of aromatic rice, which is regarded as a valuable product. The Indian subcontinent harbors a diverse range of fragrant rice varieties, with the northeast region representing the most abundant source of aromatic rice genetic variety from an agro-horticultural perspective. In the current globalized period, aromatic rice is especially important because of its distinct Flavour and financial worth (Dutta *et al*., 2022).

The approach of integrating chemical fertilizers with organic manure is showing great promise in preserving crop output and improving soil health, which is negatively impacted by intensive farming and uneven fertilizer application (Dhaliwal *et al*., 2023). Compared to chemical fertilizer alone, the sequential application of both organic and inorganic sources of nutrients enhanced the crops' ability to absorb those nutrients (Debabrata and Mondal, 2010). It has also been demonstrated by results that integrated nutrition management raises yield and nutrient uptake (Mohanty *et al.*, 2013). When organic and inorganic fertilizers are used together, the efficiency of nutrient utilization can be increased. In addition to serving as a source of nutrients, organic fertilizers also supply micronutrients, alter the physical characteristics of the soil, and boost the effectiveness of applied nutrients (Pandey *et al.*, 2006). Using fertilizers and organic manures in conjunction with integrated nutrient management techniques can lower dependency on chemical inputs and improve the environmental and financial sustainability of agriculture. This study's primary goal was to ascertain the effects of various nutrient management techniques on the nutrient dynamics of Basmati rice crops.

## Materials and Methods

### Site specifications

At the CRC of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, U.P., a field experiment was carried out in Kharif 2022 to investigate the impact of various nutrient integration effects on the nutrient dynamics of Basmati rice in western U.P. (India). The experimental site is located at latitude of $29^0$ 40′ N and longitude of $77^0$ 42′ E and at an altitude of 237 meters above mean the sea level (MSL).

### Soil sample analysis

The characteristics of the soil of the test area are clay loam texture and has slightly alkaline pH of 7.80 using glass electrode pH meter (Jackson, 1973). A detailed assessment of soil composition has a low organic carbon content of 0.38, determined through Modified Walkley and Black method (Walkley and Black, 1934). The soil's EC was registered at 0.25 $dSm^{-1}$, measured using a Conductivity meter (Richards, 1954). Additionally, nutrient evaluations unveiled a low availability of nitrogen at 190.65 kg N $ha^{-1}$, determined via the Alkaline Permanganate method (Subbiah and Asija, 1956). Furthermore, a low phosphorous content of 18.5 kg P $ha^{-1}$ was established using Olsen's method (Olsen *et al.*, 1954), while high potassium availability at 275 kg K $ha^{-1}$ was recorded employing the Ammonium Acetate method (Hanway and Heidel, 1952).

### Factors and treatments

Eleven treatments, *viz.*, $T_1$ (Control), $T_2$ (100:75:0 kg NPK $ha^{-1}$), $T_3$ (100:75:60 kg NPK $ha^{-1}$), $T_4$ (Only FYM @ 20 t $ha^{-1}$), $T_5$ (Only VC @ 20 t $ha^{-1}$), $T_6$ (50:37.5:30 kg NPK $ha^{-1}$ with FYM @ 20 t $ha^{-1}$), $T_7$ (50:37.5:30 kg NPK $ha^{-1}$ with VC @ 20 t $ha^{-1}$), $T_8$ (100:75:60 kg NPK $ha^{-1}$ with FYM @ 10 t $ha^{-1}$), $T_9$ (100:75:60 kg NPK $ha^{-1}$ with VC@ 10 t $ha^{-1}$), $T_{10}$ (50:37.5:30 kg NPK $ha^{-1}$ with FYM @ 10 t $ha^{-1}$) and $T_{11}$ (50:37.5:30 kg NPK $ha^{-1}$ with VC @ 10 t $ha^{-1}$) were tested in RBD with three replication. The recommended dosage for each treatment was applied at the time of seeding, with 50% of the nitrogen applied as a basal dose and the remaining 50% applied in two equal portions through urea at the 30 and 60 DAS stages. Before seeding, the necessary amount of FYM and vermicompost according to treatments was also applied. For the experiment, PUSA Basmati-1 certified treated seed was employed.

### Nutrients analysis

Contents of nutrients under study *i.e.*, N, P and K determined in grains and straw at harvest using standard methods. Techniques as prescribed by micro-kjeldahl method (Jackson, 1967) for N, Vanadomolybdo - phosphoric acid yellow colour for P and flame photometric methods for K as described by Hanway and Heidel (1952).

### Statistical method

Eleven treatments tested in Randomized block design with three replications. ANOVA was the statistical technique used to examine the entire dataset (Panse and Sukhatme, 1978). The OPSTAT programme, created by CCS HAU, Hisar, India, was used to calculate the critical difference (CD). The careful use of statistical analysis guarantees the validity and dependability of the inferences made from the experimental data.

## Results and Discussion

### Nutrient content in grain and straw (%)

### Nitrogen, phosphorus and potassium content of rice grain (%)

Fig. 1 and Table 1 show the impact of various nutrient treatments on the amount of nitrogen, phosphorus and potassium in rice grains. Nitrogen, phosphorus and potassium content of rice grain were affected significantly by various treatments. The highest rice grain nitrogen (1.33%) was observed in $T_9$ (100: 75: 60 Kg NPK $ha^{-1}$ with VC 10 t $ha^{-1}$), which was significantly higher than the $T_3$ (100: 75: 60 Kg NPK $ha^{-1}$) and $T_2$(100: 75: 0 Kg NPK $ha^{-1}$), which is 1.19% and 1.16%, respectively. Highest phosphorus and potassium (0.43 and 0.39%, respectively) content was observed in $T_9$ (100: 75: 60 Kg NPK $ha^{-1}$ with Vermicompost 10 t $ha^{-1}$), which was comparable with $T_7$ (50: 37.5: 30 Kg NPK $ha^{-1}$ with Vermicompost 20 t $ha^{-1}$), which is 0.40 and 0.37%, respectively. While, lowest N content in grain (1.10 %), Phosphorous (0.25%) and Potassium content (0.21%) were found in control.

**Table 1 :** Effect of organic and synthetic fertilizer management treatments on nitrogen, phosphorus and potassium content (%) of rice.

| Treatments | Nitrogen content (%) | | Phosphorus content (%) | | Potassium content (%) | |
|---|---|---|---|---|---|---|
| | Grains | Straw | Grains | Straw | Grains | Straw |
| $T_1$ | 1.10 | 0.48 | 0.25 | 0.04 | 0.21 | 1.27 |
| $T_2$ | 1.16 | 0.51 | 0.27 | 0.06 | 0.23 | 1.37 |
| $T_3$ | 1.19 | 0.53 | 0.30 | 0.08 | 0.25 | 1.40 |
| $T_4$ | 1.14 | 0.50 | 0.26 | 0.05 | 0.22 | 1.35 |
| $T_5$ | 1.21 | 0.55 | 0.31 | 0.11 | 0.27 | 1.42 |
| $T_6$ | 1.25 | 0.57 | 0.33 | 0.12 | 0.30 | 1.44 |
| $T_7$ | 1.32 | 0.66 | 0.40 | 0.19 | 0.37 | 1.58 |
| $T_8$ | 1.29 | 0.61 | 0.37 | 0.15 | 0.35 | 1.55 |
| $T_9$ | 1.33 | 0.68 | 0.43 | 0.20 | 0.39 | 1.62 |
| $T_{10}$ | 1.27 | 0.59 | 0.35 | 0.14 | 0.33 | 1.52 |
| $T_{11}$ | 1.31 | 0.63 | 0.38 | 0.17 | 0.36 | 1.57 |
| **SEm±** | **0.04** | **0.02** | **0.01** | **0.005** | **0.01** | **0.05** |
| **CD at 5%** | **0.13** | **0.06** | **0.03** | **0.014** | **0.03** | **0.15** |

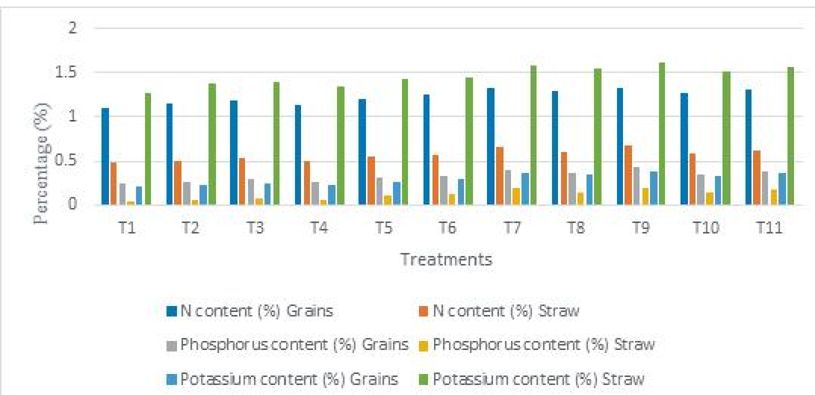


**Fig. 1 :** Nitrogen, phosphorus and potassium content of rice grain and straw (%).

The NPK levels in the soil and rice plant uptake were positively impacted by an integrated strategy to nitrogen management. Numerous variables, including the balanced application of fertilizers, increased nutrient availability, improved soil fertility from organic inputs and increased activity of soil-secreting microorganisms that boost nutrient content and uptake, could be responsible for this (Knapp *et al*., 2010).

## Nitrogen, phosphorus and potassium content in straw (%)

Fig. 1 and Table 1 show the impact of various nutrient treatments on the amount of nitrogen, phosphorus and potassium in rice straw. Nitrogen, phosphorus and potassium content in straw were affected significantly by various treatments. Among the different nutrients treatments lowest nitrogen (0.48%), phosphorus (0.04%) and potassium (1.27%) were found in control treatment. The highest nitrogen content (0.68%) was observed in $T_3$ (100: 75: 60 Kg NPK ha$^{-1}$) was comparable to $T_7$(50: 37.5: 30 Kg NPK ha$^{-1}$with Vermicompost 20 t ha$^{-1}$) and $T_{11}$ (50: 37.5: 30 Kg NPK ha$^{-1}$ with Vermicompost 10 t ha$^{-1}$), which is 0.66 and 0.63%, respectively significantly superior than the rest treatments. The highest phosphorus content (0.20%) found with the application of $T_9$ (100: 75: 60 Kg NPK ha$^{-1}$ with Vermicompost 10 t ha$^{-1}$) was at par with $T_7$ (50: 37.5: 30 Kg NPK ha$^{-1}$ with Vermicompost 20 t ha$^{-1}$), which is (0.19%) significantly superior than the rest treatments. The highest potassium content (1.62%) found with the application of $T_9$(100: 75: 60 Kg NPK ha$^{-1}$ with Vermicompost 10 t ha$^{-1}$) which was at par with $T_7$ (50: 37.5: 30 Kg NPK ha$^{-1}$with Vermicompost 20 t ha$^{-1}$ and $T_{11}$ (50: 37.5: 30 Kg NPK ha$^{-1}$with Vermicompost 10 t ha$^{-1}$), which is 1.58 and 1.57% respectively and they were significantly higher than the remaining treatments. Plant nutrient uptake can be made more efficient by including organic and inorganic sources in the right amounts. The rice straw may contain more nitrogen as a result of this enhanced efficiency.

Furthermore, the grains accumulated more N and P than the straw, whereas the K trend was the opposite. Kumar and Singh (2008) have also reported that rice absorbs nutrients more favourably when NPK is applied. In addition to having the highest dry matter assimilation and nutrient content, the crop with the highest accumulation also had the maximum uptake of the majority of nutrients.

**Table 2 :** Effect of organic and synthetic fertilizer management treatments on nitrogen, phosphorus and potassium uptake (kg ha$^{-1}$) of rice.

| Treatments | Nitrogen uptake (kg ha$^{-1}$) | | Phosphorus uptake (kg ha$^{-1}$) | | Potassium uptake (kg ha$^{-1}$) | |
|---|---|---|---|---|---|---|
| | Grains | Straw | Grains | Straw | Grains | Straw |
| $T_1$ | 29.5 | 22.8 | 6.7 | 1.9 | 5.6 | 60.2 |
| $T_2$ | 40.9 | 30.4 | 9.5 | 3.6 | 8.1 | 81.8 |
| $T_3$ | 46.3 | 31.8 | 11.7 | 4.8 | 9.7 | 84.0 |
| $T_4$ | 39.0 | 29.1 | 8.9 | 2.9 | 7.5 | 78.6 |
| $T_5$ | 47.2 | 33.2 | 12.1 | 6.6 | 10.5 | 85.6 |
| $T_6$ | 49.0 | 34.8 | 12.9 | 7.3 | 11.8 | 87.8 |
| $T_7$ | 55.0 | 41.6 | 17.2 | 12.2 | 15.6 | 99.5 |
| $T_8$ | 53.0 | 38.1 | 15.2 | 9.4 | 14.4 | 96.9 |
| $T_9$ | 57.5 | 43.4 | 18.6 | 12.8 | 16.8 | 103.4 |
| $T_{10}$ | 51.9 | 36.5 | 14.3 | 8.7 | 13.5 | 93.9 |
| $T_{11}$ | 54.4 | 39.6 | 15.8 | 10.7 | 14.9 | 98.6 |
| **SEm±** | **1.8** | **1.3** | **0.5** | **0.3** | **0.5** | **3.2** |
| **CD at 5%** | **5.3** | **3.7** | **1.5** | **0.8** | **1.3** | **9.3** |

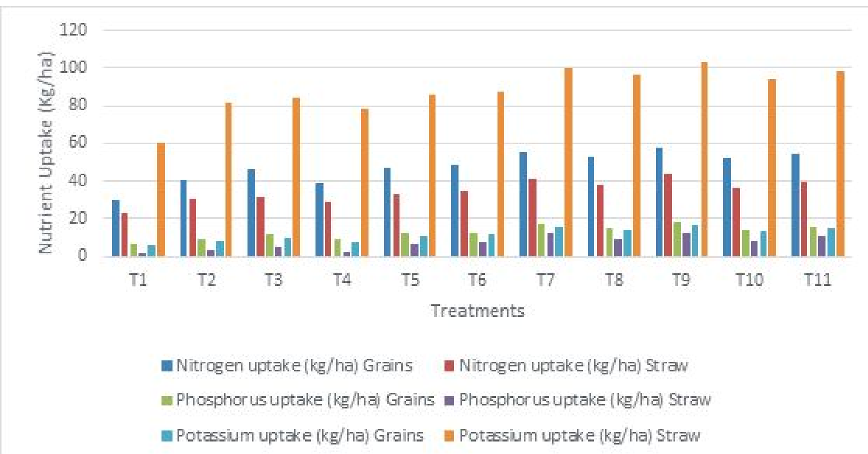


**Fig. 2 :** Nitrogen, phosphorus and potassium uptake by grain and straw (kg ha$^{-1}$).

## Nutrient uptake in grain and straw (kg ha$^{-1}$)

### Nitrogen, phosphorus and potassium uptake by grain (kg ha$^{-1}$)

Fig. 2 and Table 2 shows the results about how various nutrient treatments affect rice grain uptake of nitrogen, phosphate and potassium. The uptake of potassium, phosphorus and nitrogen was considerably impacted by the different treatments. Regardless of the treatments, the crop generally accumulated more phosphate and nitrogen in the grain than in the straw, whereas the opposite trend was observed for potassium. Among the different nutrients treatments significantly lowest nitrogen (29.5 kg ha$^{-1}$), phosphorus (6.7 kg ha$^{-1}$) and potassium (5.6 kg ha$^{-1}$) was found in control treatment. The highest nitrogen (57.5 kg ha$^{-1}$) was observed in 100: 75: 60 Kg NPK ha$^{-1}$ + Vermicompost 10 t ha$^{-1}$ which was comparable with 50: 37.5: 30 Kg NPK ha$^{-1}$ with Vermicompost 20 t ha$^{-1}$ (55.0 kg ha$^{-1}$), 50: 37.5: 30 Kg NPK ha$^{-1}$ with Vermicompost 10 t ha$^{-1}$ (54.4 kg ha$^{-1}$) and 100: 75: 60 Kg NPK ha$^{-1}$with FYM 10 t ha$^{-1}$ (53.0 kg ha$^{-1}$). While significantly higher than the remaining treatments. The highest phosphorus and potassium (18.6 kg ha$^{-1}$ and 16.8 kg ha$^{-1}$, respectively) uptake was observed in 100: 75: 60 Kg NPK ha$^{-1}$ with Vermicompost 10 t ha$^{-1}$, which was comparable with 50: 37.5: 30 Kg NPK ha$^{-1}$ with Vermicompost 20 t ha$^{-1}$ (17.2 kg ha$^{-1}$ and 15.6 kg ha$^{-1}$, respectively) and significantly higher than the remaining treatments. In rice plants, the N and P uptake in the grain is typically higher than that in the straw. This is because the grain serves as the primary storage organ for nutrients accumulated during the plant's life cycle. Rice plants prioritize nutrient allocation to the developing grains to ensure the production of viable and nutrient-rich seeds. While the grain receives a higher proportion of nutrients, the straw also plays a role in nutrient cycling and contributes to the overall nutrient dynamics in the ecosystem. Integrated nutrient management practices aim to optimize nutrient use efficiency, considering both grain and straw components, to ensure sustainable and productive agricultural systems.

### Nitrogen, phosphorus and potassium uptake by straw (kg ha$^{-1}$)

Fig. 2 and Table 2 show the results about how different nutrient treatments affect rice straw's uptake

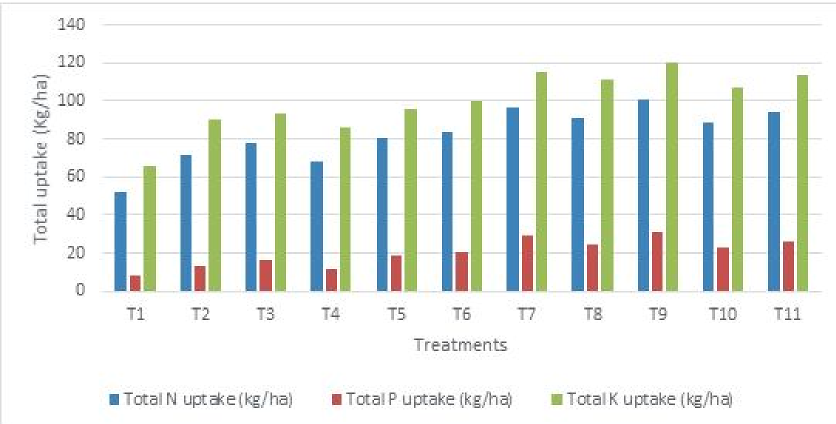


**Fig. 3 :** Total nitrogen, phosphorus and potassium uptake in grain and straw (kg ha$^{-1}$).

**Table 3 :** Effect of organic and synthetic fertilizer management treatments on total nitrogen, phosphorus and potassium uptake (kg ha$^{-1}$) of rice.

| **Symbol** | **Total N uptake (kg ha$^{-1}$)** | **Total P uptake (kg ha$^{-1}$)** | **Total K uptake (kg ha$^{-1}$)** |
|---|---|---|---|
| **$T_1$** | 52.3 | 8.6 | 65.8 |
| **$T_2$** | 71.4 | 13.1 | 89.9 |
| **$T_3$** | 78.1 | 16.5 | 93.7 |
| **$T_4$** | 68.1 | 11.8 | 86.1 |
| **$T_5$** | 80.4 | 18.7 | 96.2 |
| **$T_6$** | 83.8 | 20.3 | 99.6 |
| **$T_7$** | 96.6 | 29.1 | 115.0 |
| **$T_8$** | 91.1 | 24.6 | 111.3 |
| **$T_9$** | 100.8 | 31.3 | 120.2 |
| **$T_{10}$** | 88.4 | 23.0 | 107.4 |
| **$T_{11}$** | 93.9 | 26.4 | 113.5 |
| **SEm ±** | **3.1** | **0.8** | **3.7** |
| **CD at 5%** | **8.9** | **2.3** | **10.6** |

of nitrogen, phosphate and potassium. The uptake of potassium, phosphorus and nitrogen was considerably impacted by the different treatments. The rice straw in the control treatment absorbed nitrogen, phosphorus and potassium at much lower rates than the other three treatments 22.8, 1.9 and 60.2 kg ha$^{-1}$, respectively.

The highest nitrogen and phosphorous uptake (43.4 and 12.8 kg ha$^{-1}$ respectively) was found in 100: 75: 60 Kg NPK ha$^{-1}$ with Vermicompost 10 t ha$^{-1}$ which was comparable with 50: 37.5: 30 Kg NPK ha$^{-1}$ with Vermicompost 20 t ha$^{-1}$ (41.6 and 12.2 kg ha$^{-1}$ respectively) and significantly higher than the remaining treatments. Treatments, the crop generally accumulated more potassium in the straw than in the grain. The highest potassium uptake (103.4 kg ha$^{-1}$) was found with the application of 100: 75: 60 Kg NPK ha$^{-1}$ with Vermicompost 10 t ha$^{-1}$ which was comparable with 50: 37.5: 30 Kg NPK ha$^{-1}$ with Vermicompost 20 t ha$^{-1}$ (99.5 kg ha$^{-1}$), 50: 37.5: 30 Kg NPK ha$^{-1}$with Vermicompost 10 t ha$^{-1}$ (98.6 kg ha$^{-1}$) and 100: 75: 60 Kg NPK ha$^{-1}$ with FYM 10 t ha$^{-1}$ (96.9 kg ha$^{-1}$), while significantly higher than the remaining treatments.

**Total nitrogen, phosphorus and potassium uptake in grain and straw (kg ha$^{-1}$)**

Fig. 3 and Table 3 show the results pertaining to the impact of various treatments on the total nitrogen, phosphorous and potassium uptake by rice crops. The intake of potassium, phosphorus and nitrogen overall was greatly impacted by a variety of micronutrient treatments. Among the various nutritional treatments, the control treatment had considerably reduced total nitrogen, phosphorus and potassium uptake (52.3, 8.6 and 65.8 kg ha$^{-1}$, respectively). The highest nitrogen and phosphorus uptake (100.8 and 31.3 kg ha$^{-1}$, respectively) was observed in 100: 75: 60 Kg NPK ha$^{-1}$with Vermicompost 10 t ha$^{-1}$, which was comparable with 50: 37.5: 30 Kg NPK ha$^{-1}$ with Vermicompost 20 t ha$^{-1}$ (96.6 and 29.1 kg ha$^{-1}$, respectively) and significantly higher than the remaining treatments. The highest total potassium uptake (120.2 kg ha$^{-1}$) found with the application of 100: 75: 60 Kg NPK ha$^{-1}$ with Vermicompost 10 t ha$^{-1}$ which was comparable with 50: 37.5: 30 Kg NPK ha$^{-1}$with Vermicompost 20 t ha$^{-1}$ (115.0 kg ha$^{-1}$), 50: 37.5: 30 Kg NPK ha$^{-1}$with Vermicompost 10 t ha$^{-1}$ (113.5 kg ha$^{-1}$) and 100: 75: 60 Kg NPK ha$^{-1}$ with FYM 10 t ha$^{-1}$ (111.3 kg ha$^{-1}$) while significantly higher than the remaining treatments. According to Singh *et al*. (2021), target yield-based integrated nutrient management was also responsible for rice's much greater estimated N, P and K uptake (131.2, 22.8 and 90.9 kg/ha, respectively) than it was with 100% NPK fertilizer (126.1, 21.3 and 90 kg/ha). One likely explanation is that nutrients from INM treatments have better demand-supply synchronization than nutrients from NPK fertilizer treatments. Due to a delay in the quick release of nutrients from applied fertilizer and the subsequent uptake of nutrients, low nutrient utilization efficiency was the outcome of uncontrollable significant losses of nutrients from the soil-plant system in fertilized plots (Cameron *et al*., 2012). However, the added FYM's slow breakdown over years, which would cause a gradual release of NPK nutrients, could be the cause of the somewhat smaller yield fluctuation in INM plots. According to Knapp *et al*. (2010), the addition of FYM, VC and paddy straw may have increased soil microbial activity, which in turn promoted plant development and improved the nutritional content and absorption in grain and straw.

## Conclusion

The application of nutrients in combination enhanced plant nutrient accumulation as well as the nutrient status of the soil. In terms of crop production and N uptake, the addition of vermicompost combined with 100:75:60 Kg NPK $ha^{-1}$ ($T_9$) produced better results than $T_7$ and $T_8$, in that order. The crop's nutritional status and vegetative development were both enhanced by the vermicompost's increased N content. Also, the yield component of basmati exhibited positive correlation with soil nutrient status, which was due to the improved soil properties resulting from the combined application of organic and inorganic nutrients.

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### Competing interests

Authors have declared that no competing interests exist.

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