

# Optimizing Nutrient Uptake in Rice Crop through Integrated Organic Manure Application: A Comprehensive Analysis of Grain and Straw Composition

## Abstract

Rice (*Oryza sativa* L.) is the staple food of more than 60 percent of the world's population and is considered the "global grain". It is the main staple food in the Asia and the Pacific region. This study was conducted to ascertain the Impact of Various Treatment Combinations on the Nutrient Uptake of rice grains and straw. The field experiments were carried out at the research Farm of Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.) during Kharif, 2021-

The experiment was laid out in randomized block design with 3 replications having 8 treatments. The eight treatment combinations were: T<sub>1</sub> (Absolute Control), T<sub>2</sub> (Biodecomposed compost 1q/ha+50% RDF), T<sub>3</sub> (Biodecomposed compost 1.5q/ha+50% RDF), T<sub>4</sub> (Biodecomposed compost 1q/ha+50% RDF+Root dipping with biodecomposed compost wash 10ml/lit of water), T<sub>5</sub> (Biodecomposed compost 1.5q/ha+50% RDF+Root dipping with biodecomposed wash 10ml/lit of water), T<sub>6</sub> (Biodecomposed compost 1q/ha+50% RDF+foliar application of biodecomposed compost wash of 10ml/lit of water), T<sub>7</sub> (Biodecomposed compost 1.5q/ha+50% RDF+foliar application of biodecomposed compost wash of 10ml/lit of water), T<sub>8</sub> (100% RDF). As per findings, Nutrient uptake of N, P and K by grain of Rice varied from 44.32 kg ha<sup>-1</sup> to 77.03 kg ha<sup>-1</sup>, 11.90 kg ha<sup>-1</sup> to 20.85 kg ha<sup>-1</sup>, and 22.16 kg ha<sup>-1</sup> to 45.17 kg ha<sup>-1</sup>. In Rice straw, N, P and K uptake varied from 20.16 kg ha<sup>-1</sup> to 36 kg ha<sup>-1</sup>, 8.17 kg ha<sup>-1</sup> to 15.62 kg ha<sup>-1</sup>, and 66.67 kg ha<sup>-1</sup> to 100.55 kg ha<sup>-1</sup>.

The application of organic manure significantly influenced nutrient uptake, attributed to enhanced photosynthesis, increased biomass, and improved nutrient availability. The findings align with previous research, emphasizing the positive impact of organic manure on nutrient uptake in rice crops. These studies contribute valuable insights into optimizing agricultural practices for enhanced nutrient management and sustainable crop production.

**Keywords:** Nutrient uptake, Biodynamic compost, Organic Manures, Biomass

- 1. Introduction:** "Rice (*Oryza sativa* L.) is the staple food and main source of energy for more than three billion people around the globe, mostly consisting of South Asia and India whereas, it is

hemainsourceofdietarycarbohydratefor65%oftheIndianpopulation”(Patraetal.,2020).“Moreover,riceaccountsformorethan40%offood-grainproductioninIndia,providingdirectemploymentto70%ofpeopleinruralareas.Ricecultivationaccountsformorethan80%oftheNorth–EasternHimalayanregion’s totalcultivatedarea(7.8%ofIndia’s totalricecultivationarea)andcontributesignificantlytodomesticriceproduction”(Patraetal.,2020).“Atthegloballevel,riceisgrowninanareaofabout165millionhawithproductionof519milliontonnesrespectively”(FAO,2022).“InIndia,riceisthemostimportantandextensivelygrownfoodcropoccupying46.38mhaareawithproductionof130.29mtandproductivityof28.09qha<sup>1</sup>”(Agril.Statistics,2022).Agriculturefacesthedualchallengeofmeetingincreasingglobalfooddemandswhileminimizingenvironmentalimpact.Traditionalfarmingpracticesoftenrelyonsyntheticfertilizers,contributingtoildegredationandenvironmentalpollution.Biodynamiccompostisapromisingalternative,leveragingaholisticapproachto soilfertilityandplantnutrition.TheintegrationofvariousorganicmanuresresultedinhigherNPKuptake,potentiallyduetoincreasedmicrobialactivityandthereleaseoforganicacids.

Bio-decomposedcompostwashisproducedbyrepeatedlysprayingwateroncompost,allowingit toseepthroughandcollectingthewashedwater.Thisprocessisrepeateduntilonlyaminimalamountofwashedwaterremains,whichisthenutilizedascompostwash.Thismethod,knownasbiodynamiccomposting,isanexpeditedapproachto compostproductionconductedonthesurfaceratherthanintraditionalpits.Thecompostheapisenergizedusingspecificpreparationsto enhance nutrient content and accelerated decomposition. Built on a flat site, away from trees and water logging, the compost heap takes the form of a rectangle, typically 2m wide and 4m long, depending on biomass availability. A wind tunnel of flogs is placed lengthwise in the middle of the rectangle. It is a specially prepared organic material infused with diverse microorganisms. These microorganisms play a pivotal role in enhancing soil structure, fostering water retention, and increasing nutrient availability. Humic acid, a key component of humic compounds, plays a vital role in this process. Humic substances, created through the biological activity of microorganisms and the humification of plant and animal materials, influence plant development. The effects of humic chemicals on plant growth are determined by factors such as their source, concentration, molecular weight, and molecular fraction. By adding humic and fulvic acid to the soil, it is possible to see the beginning of root augmentation and improved root development (Pettit, 2004). “Macronutrients, such as nitrogen (N), phosphorus (P), and potassium (K

), are present in inorganic manure in varying proportions. These nutrients are crucial for plant growth, as nitrogen is essential for leaf and stem development, phosphorus promotes root growth and flowering, and potassium supports overall plant vigour and disease resistance. The balanced supply of these macronutrients in inorganic manure helps provide plants with the necessary elements for optimal growth and productivity. This can enhance soil nutrients due to enhanced soil microbial activity, improving soil physical and chemical properties” (Adekiya *et al.*, 2019). “The slow and gradual release of N from organic manure is an advantage over sole chemical fertilization for achieving higher NUE, grain yield, and quality of rice. Organic manures are fractionated based on their solubility characteristics to extract humic and fulvic acids from humus” (Shirisha, 2002, Kareta *et al.*, 2012 and Ramalakshmi *et al.*, 2013). This research aims to investigate the impact of diverse treatment combinations on nutrient uptake in rice crops. The study focuses on nitrogen, phosphorus, potassium, and protein content in rice grains and straw. With the rising global population, understanding the relationships between different treatments and nutrient composition is crucial for informed agricultural practices, aimed at improving nutrient utilization and ensuring sustainable crop production. Keeping these in view, the research was carried out to find out the use of urban solid waste compost as a source of nutrients for rice crop. The research was conducted.

## 2. Materials and Methods:

The field experiment was conducted during the Kharif season 2021 at Agricultural Research Farm of Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.). The experiment was laid out in randomized block design having 8 treatments (Table 1) as per the recommended dose of fertilizer (RDF) applied through Urea, DAP and MOP as per treatments. Half dose of nitrogen and full dose of phosphorus and potassium were applied basally. The remaining half N dose was applied in two equal splits once at tillering and rest at panicle initiation stages. However, bio-dynamic compost was applied at root dipping just before transplanting and foliar application at 30 DAT (Days After Transplanting) in standing crop.

**Table 1: Details of treatment**

Treatment No.	Treatment details
T <sub>1</sub>	Absolute Control
T <sub>2</sub>	BioDynamic Compost 1 q/ha + 50% RDF

<b>T<sub>3</sub></b>	BioDynamiccompost1.5q/ha+50% RDF
<b>T<sub>4</sub></b>	T <sub>2</sub> +RootdippingwithBioDynamiccompostwash10ml/litofwater
<b>T<sub>5</sub></b>	T <sub>3</sub> +RootdippingwithBioDynamiccompostwash10ml/litofwater
<b>T<sub>6</sub></b>	T <sub>2</sub> +foliarapplicationofBioDynamiccompostwashof10ml/litofwater
<b>T<sub>7</sub></b>	T <sub>3</sub> +foliarapplicationofBioDynamiccompostwashof10ml/litofwater
<b>T<sub>8</sub></b>	100% RDF

**2.1. Nutrient Analysis:** Available nitrogen in soil was determined using the alkaline potassium permanganate method by **Subbaiah and Asija (1956)**. The procedure involved distilling 20 g of soil with 0.32%  $\text{KMnO}_4$  and 2.5%  $\text{NaOH}$ , absorbing ammonia gas in 4% boric acid (pH 4.5), and back titrating with 0.02  $\text{NH}_2\text{SO}_4$ . Results were converted to  $\text{kg ha}^{-1}$ .

Available phosphorus was assessed following **Olsen et al., (1954)** method. In a 150 ml flask, 2.5 g of air-dry soil was mixed with P-free activated charcoal, Olsen's reagent ( $\text{NaHCO}_3$ , pH 8.5), and shaken. Color development was measured at 660 nm using a spectrophotometer, with values converted to  $\text{kg ha}^{-1}$ .

For available potassium determination, soil extraction utilized neutral ammonium acetate (pH 7.0) following **Hanway and Heidal (1952)**. Potassium levels in the extract were measured using a flame photometer, and results were converted to  $\text{kg ha}^{-1}$ .

**2.2. Protein content (%):** Protein content (%) in grain was worked out by multiplying the nitrogen content in grain by factor 6.25 (**A.O.A.C., 1970**).

**2.3. Nutrient uptake:** For the analysis of nutrient uptake, plant shoot samples underwent acid extraction for nitrogen estimation, following **Humphries' micro Kjeldahl method (1956)**, expressed as a percentage on a dry weight basis. For phosphorus, the triple acid extraction method by **Jackson et al., (1962)** was employed, and results were presented as a percentage on a dry weight basis. Potassium levels were determined using flame photometry on a triple acid extract, as per **Jackson et al., (1962)**, expressed as a percentage on a dry weight basis.

Nutrient uptake/removal in grain and straw of the crops were recalculated in  $\text{kg ha}^{-1}$  about yield  $\text{ha}^{-1}$

by using the following formula (**Jackson et al., 1967**)

$$\text{Nutrient uptake (kg/ha)} = \text{Nutrient content (\%)} \times \text{yield (q/ha)}$$

**2.4. Statistical Analysis:** The observations recorded during the investigation were tabulated and analyzed statistically to draw a valid conclusion. The data were analyzed as per the standard procedure.

cedure for “Analysis of Variance” (ANOVA) as described by Gomez and Gomez (1984). The standard error of mean (SEM $\pm$ ) was computed in all cases. The difference in the treatment mean was tested by using critical difference (CD) or least significant difference (LSD) at 5% level of probability.

### 3. Results and Discussion:

#### 3.1. Nitrogen content in grain and straw (%)

The concentration of nitrogen in both grains and straw of Rice, as presented in Table 2. The N concentration of grain varied from 1.12 to 1.33%. The highest grain N concentration 1.33% was observed in treatment T<sub>7</sub>. Conversely, the lowest nitrogen content (1.12%) in grains was observed in treatment T<sub>1</sub> (Control). These findings align with those reported by Bisht *et al.* (2013). In straw, the N concentration ranged from 0.37 to 0.47%. The highest nitrogen content in straw (0.47%) was observed in treatment T<sub>7</sub>. These findings are consistent with the research of Satish *et al.* (2011) and Ramalakshmi *et al.* (2012).

#### 3.2. Nitrogen uptake by grain and straw (Kgha<sup>-1</sup>)

The nitrogen uptake in rice grain exhibited a range from 44.32 Kgha<sup>-1</sup> to 77.03 Kgha<sup>-1</sup>, as indicated in Table 3. The highest nitrogen uptake in rice grains was observed in treatment T<sub>7</sub> (77.03 Kgha<sup>-1</sup>), statistically comparable to T<sub>5</sub> (74.41 Kgha<sup>-1</sup>). Conversely, the lowest nitrogen uptake in rice grains was recorded in the control plot T<sub>1</sub> (44.32 kg/ha). In the case of rice straw, nitrogen uptake ranged from 20.16 Kgha<sup>-1</sup> to 37.6 Kgha<sup>-1</sup>. The highest nitrogen uptake in rice straw occurred in T<sub>5</sub> (37.6 Kgha<sup>-1</sup>), statistically at par with T<sub>7</sub> (35.36 Kgha<sup>-1</sup>), while the lowest nitrogen uptake was observed in the control plot T<sub>1</sub> (20.16 Kgha<sup>-1</sup>). The variation in nitrogen uptake in both grains and straw across different treatments was primarily attributed to yield differences and, to some extent, to the nitrogen content in grains and straw. The application of organic manures provided sufficient nutrients for enhanced photosynthesis, resulting in increased nitrogen uptake in both grains and straw, contributing to the overall nitrogen uptake. The higher NPK uptake can be attributed to increased yields in treatments, as reported by Kumari *et al.* (2013), and supported by similar findings from Satish *et al.* (2011) and Ramalakshmi *et al.* (2012).

### 3.3. Protein content in grain (%)

The examination of data concerning protein content in grains, as presented in Table 2, indicates that various treatment combinations influenced the outcomes. The protein concentration of grain varied from 7.0 to 8.3%. The highest protein content in grains (8.31%) was associated with treatment T<sub>7</sub>, significantly surpassing T<sub>1</sub> and statistically comparable to T<sub>5</sub> and T<sub>6</sub>. In contrast, the lowest protein content (7.00%) was noted in treatment T<sub>1</sub> (Control). Additionally, **Balabramani et al. (1989)** reported a significant increase in protein content in groundnuts with the application of humic acid (HA).

### 3.4. Phosphorus content in grain and straw (%)

The data presented in Table 2 concerning phosphorus content in grains as well as straw indicate the influence of various treatment combinations. The phosphorus content in grain varied from 0.30 to 0.36%. The maximum phosphorus content in grains (0.36%) was observed with treatment T<sub>7</sub>, significantly exceeding T<sub>1</sub> and statistically comparable to T<sub>5</sub> and T<sub>6</sub>. In contrast, the minimum phosphorus content (0.30%) in grains was noted in treatment T<sub>1</sub> (Control). These results are consistent with the findings of **Monda et al. (2016)**. In straw, the P concentration varied from 0.15 to 0.19%. The highest P content in straw (0.19%) was observed in treatments T<sub>7</sub> and T<sub>5</sub>, statistically comparable to T<sub>4</sub> and T<sub>6</sub>.

### 3.5. Phosphorus uptake by grain and straw (kg ha<sup>-1</sup>)

The phosphorus uptake in rice grains displayed a range from 11.90 kg ha<sup>-1</sup> to 20.85 kg ha<sup>-1</sup>, as presented in Table 3. The highest phosphorus uptake in rice grains was observed in treatment T<sub>7</sub> (20.85 kg ha<sup>-1</sup>), statistically comparable to T<sub>5</sub> (20.60 kg ha<sup>-1</sup>), while the lowest phosphorus uptake occurred in the control plot T<sub>1</sub> (11.90 kg ha<sup>-1</sup>). In the case of rice straw, phosphorus uptake varied from 8.17 kg ha<sup>-1</sup> to 15.62 kg ha<sup>-1</sup>. The highest phosphorus uptake in rice straw was recorded in T<sub>7</sub> (15.62 kg ha<sup>-1</sup>), statistically at par with T<sub>5</sub> (15.53 kg ha<sup>-1</sup>), and the lowest phosphorus uptake was found in the control plot T<sub>1</sub> (8.17 kg ha<sup>-1</sup>). “The increased nutrient uptake observed with organic manure application can be attributed to the solubilization of native nutrients, chelation of complex intermediate organic molecules produced during the decomposition of added organic manures, and the mobilization and accumulation of different nutrients in various plant parts”. **Mohapatra et al. (2008)**. Additionally, the application of bio-

fertilizers further facilitate the increased availability of nitrogen and phosphorus in the soil, enhancing their uptake by plants.

### 3.6. Potassium content in grain and straw (%)

The analysis of data about potassium content in grains as well as straw, presented in Table 4, highlights the influence of various treatment combinations. The Potassium content in grain varied from 0.61 to 0.79%. The maximum potassium content in grains (0.79%) was observed with treatment T<sub>5</sub>, significantly surpassing T<sub>1</sub> and statistically comparable to T<sub>7</sub> and T<sub>6</sub>. Conversely, the minimum potassium content in grains (0.61%) was noted in treatment T<sub>1</sub>. In straw, the Potassium content in straw varied from 1.15 to 1.28%. The maximum potassium content in straw (1.28%) was observed with treatment T<sub>7</sub>, significantly surpassing T<sub>1</sub> and statistically comparable to T<sub>5</sub>, and statistically comparable to T<sub>6</sub>. In contrast, the minimum potassium content in straw (1.15%) was noted in treatment T<sub>1</sub>. These findings are consistent with the results reported by **Kumari et al. (2013)**.

### 3.7. Potassium uptake by grain and straw (kg ha<sup>-1</sup>)

The potassium uptake in rice grain exhibited a range from 22.16 kg ha<sup>-1</sup> to 45.17 kg ha<sup>-1</sup>, as outlined in Table 3. The highest potassium uptake in rice grains was observed in treatment T<sub>7</sub> (45.17 kg ha<sup>-1</sup>), statistically comparable to T<sub>5</sub> (44.41 kg ha<sup>-1</sup>), while the lowest potassium uptake occurred in the control plot T<sub>1</sub> (22.16 kg ha<sup>-1</sup>). In the case of rice straw, potassium uptake ranged from 66.67 kg ha<sup>-1</sup> to 105.28 kg ha<sup>-1</sup>. The highest potassium uptake in rice straw was found in T<sub>7</sub> (105.28 kg ha<sup>-1</sup>), statistically at par with T<sub>5</sub> (103.81 kg ha<sup>-1</sup>) and the lowest potassium uptake was recorded in the control plot T<sub>1</sub> (66.67 kg ha<sup>-1</sup>). The increased uptake of potassium in both grain and straw may be attributed to the application of organic nitrogen sources, which released more NH<sub>4</sub><sup>+</sup> and NO<sub>3</sub><sup>-</sup> in the soil. This, in turn, occupied the selective exchange sites in the 2:1 layer clay mineral, replacing the K<sup>+</sup> ions from these exchange sites. Consequently, this led to the highest available potassium concentration in the soil solution, resulting in greater absorption by rice. The similarity in ionic radii of nitrogen and potassium ions could contribute to this phenomenon. The control treatment exhibited the lowest nitrogen, phosphorus, and potassium uptake. **Bindra and Thakur (1996)** reported increased nitrogen, phosphorus, and potassium uptake in grain and straw due to manuring.

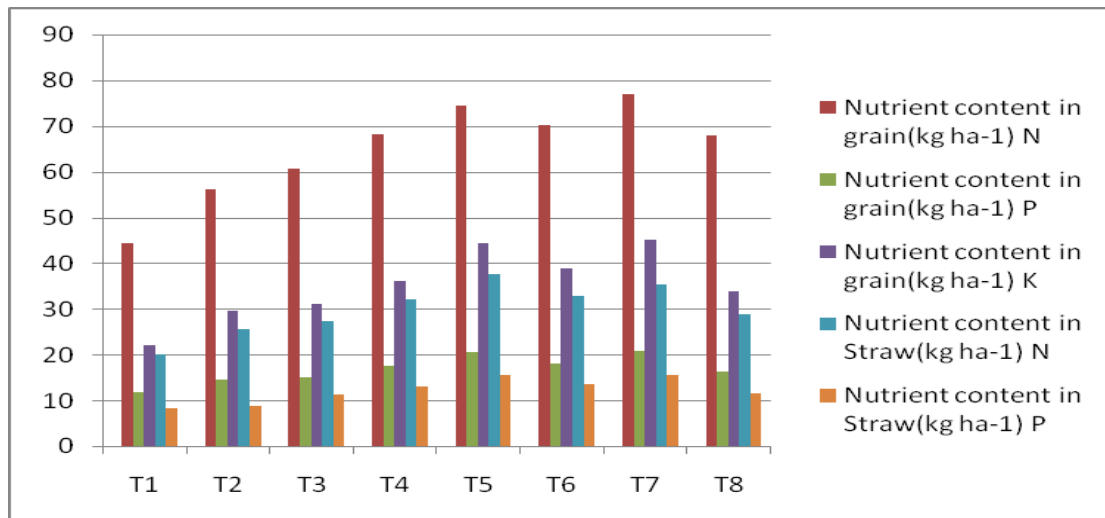
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**Table2:EffectofdifferenttreatmentsonN,PandKconcentrationbygrainandstrawofricecrop.**

S.No.	Treatmentcombination	Content/Concentration(%)					
		Grain				Straw	
		N	P	K	Protein	N	P
1	Control	1.12	0.3	0.61	7	0.37	0.15
2	Biodynamiccompost1qha <sup>-1</sup> +50%RDF	1.19	0.31	0.63	7.4	0.38	0.14
3	Biodynamiccompost1.5qha <sup>-1</sup> +50%RDF	1.24	0.31	0.64	7.7	0.39	0.16
4	T2+RootdippingwithBiodynamiccompostwash10mlit <sup>-1</sup> ofwater	1.28	0.33	0.68	8	0.42	0.17
5	T3+RootdippingwithBiodynamicwash10mlit <sup>-1</sup> ofwater	1.32	0.35	0.79	8.2	0.46	0.19
6	T2+foliarapplicationofBiodynamiccompostwashof10mlit <sup>-1</sup> ofwater	1.28	0.33	0.71	8	0.43	0.17
7	T3+foliarapplicationofBiodynamiccompostwashof10mlit <sup>-1</sup> ofwater	1.33	0.36	0.78	8.3	0.47	0.19
8	100%RDF	1.25	0.32	0.66	7.81	0.4	0.16
SEm±		0.017	0.005	0.009	0.109	0.006	0.002
C.Dat5%		0.051	0.016	0.029	0.332	0.017	0.006

**Table3:Effectofdifferenttreatmentsontotalnutrientuptakebyricecrop.**

S.No.	Treatments combination	Nutrient uptake (Kgha <sup>-1</sup> )					
		Grains			Straw		
		N	P	K	N	P	K
T <sub>1</sub>	Control	44.32	11.9	22.16	20.16	8.17	66.67
T <sub>2</sub>	Biodynamic compost 1 qha <sup>-1</sup> + 50% RDF	56.05	14.6	29.67	25.57	8.86	79.43
T <sub>3</sub>	Biodynamic compost 1.5 qha <sup>-1</sup> + 50% RDF	60.78	15.07	31.12	27.23	11.17	72.57
T <sub>4</sub>	T <sub>2</sub> + Root dipping with Biodynamic compost wash 10 ml lit <sup>-1</sup> of water	68.09	17.55	36.17	31.99	12.95	92.17
T <sub>5</sub>	T <sub>3</sub> + Root dipping with Biodynamic wash 10 ml lit <sup>-1</sup> of water	74.41	20.6	44.41	37.6	15.53	103.81
T <sub>6</sub>	T <sub>2</sub> + foliar application of Biodynamic compost wash of 10 ml lit <sup>-1</sup> of water	70.2	18.1	38.94	32.74	13.45	100.55
T <sub>7</sub>	T <sub>3</sub> + foliar application of Biodynamic compost wash of 10 ml lit <sup>-1</sup> of water	77.03	20.85	45.17	35.36	15.62	105.28
T <sub>8</sub>	100% RDF	67.97	16.35	33.73	28.8	11.55	86.66
SEm±		0.891	0.226	0.47	0.407	0.163	1.178
C.D.		2.728	0.693	1.439	1.246	0.498	3.609



**Fig:1**Effect of different treatments on uptake of nitrogen, phosphorus, and potassium ( $\text{kg ha}^{-1}$ ) in grain and straw of rice.

**4. Conclusion:** In conclusion, the study underscores the significant positive impact of organic manure application, particularly in treatment T<sub>7</sub>, on nutrient composition and uptake in rice grains and straw. The results emphasize the efficacy of integrated organic manure strategies in enhancing nitrogen, phosphorus, potassium, and protein content. The observed variations in nutrient uptake are linked to increased yield and improved nutrient availability facilitated by organic manure. The competitive uptake of nitrogen and potassium ions further contributes to the overall nutrient enhancement. These findings offer crucial insights for advancing sustainable agricultural practices and optimizing nutrient management in rice cultivation.

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